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

(PHASE Ⅰ)

FEBRUARY 1991

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

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

The JICA and MMAJ sent to Kenya a survey team headed by Mr. Masakazu Kawai from August 8 to December 10, 1990.

The team exchanged views with the officials concerned of the Government of Kenya and conducted a field survey in the Mombasa 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 relation between our two countries.

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

February 1991

Kensuke Yanagiya
President
Japan International Cooperation Agency

Genichi Fukuhara
President
Metal Mining Agency of Japan

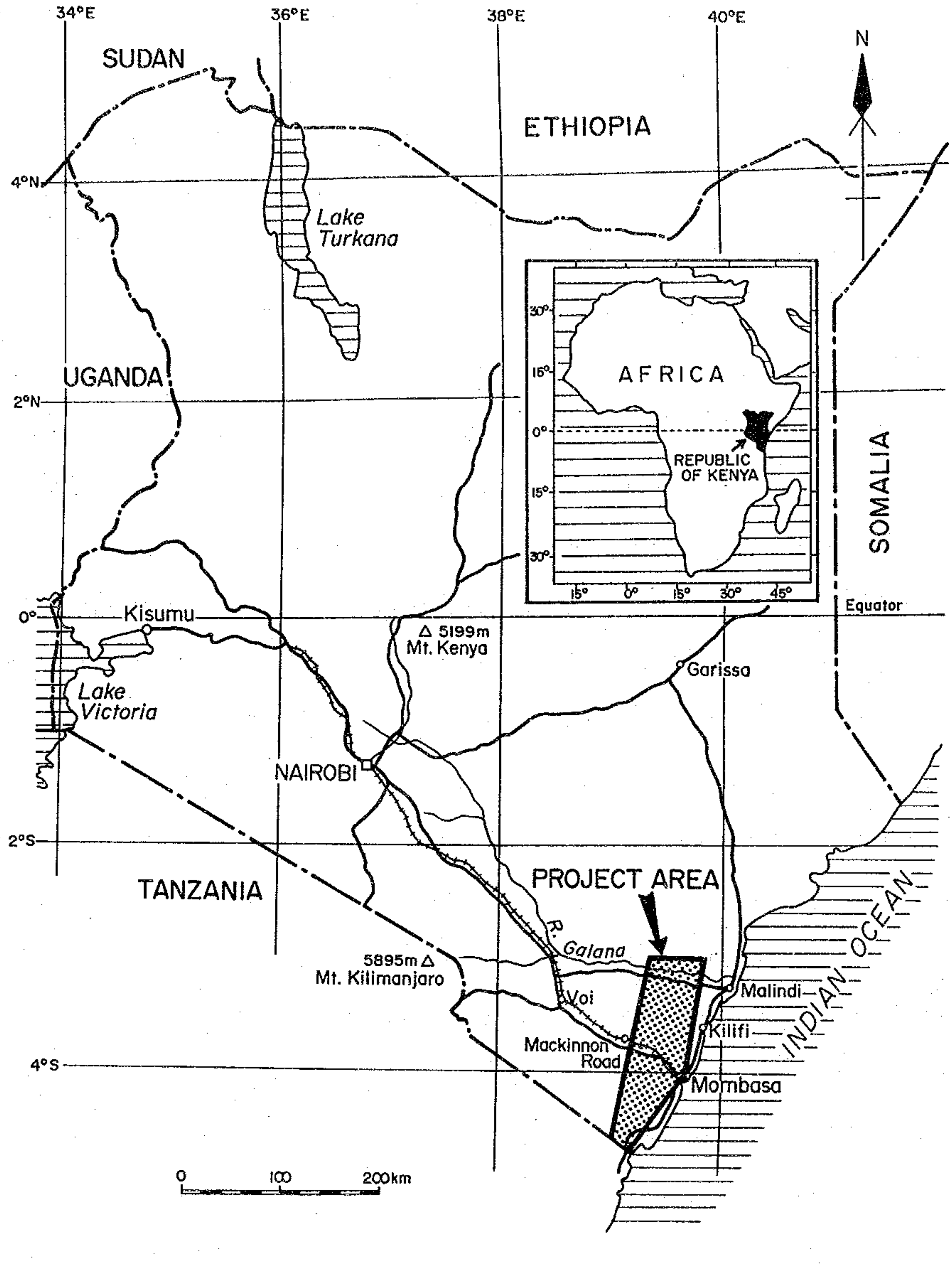

Figure 1 Index Map of Kenya Showing Location of the Mombasa Area

SUMMARY

Geological and Geochemical investigations, covering an area of about 9,000 km^2, were conducted from August to December 1990. These investigations were part of the Mineral Exploration in the Mombasa area, Kenya.

The primary aim of this survey was to study the mineral deposits and showings of the Mombasa area. In conjunction with the mineral exploration, a secondary aim to assemble as much geological information as possible to provite the geologic background needed to assess the nature and potential of the mineral deposits.

The work included geological data analysis, and as part of field work, geological survey and geochemical prospecting.

The geological data analysis was done at Mines and Geological Department, Nairobi, required about a month to complete before starting the field work. The results of the analysis contain the followings; (1) Selection of 15 mineral occurrences to be investigated as part of the field work, (2) compilation of the geological maps (1:100,000; 4 sheets) of the Mombasa area and (3) listing of published references and unpublished data.

The results of the field survey lead to the following conclusions.

(1) In the Mrima Hill-Jombo Hill area, rare earth oxides together with niobium are moderately concentrated in residual soils derived from the Mrima Hill carbonatite plug. This mineralization appears to be one of significant resources of this kind in the world. However, the mining right authorized by the Government of Republic of Kenya belongs to a foreign private company at the present time, though no commercial exploitation has ever been tried seriously.

(2) The fault-controlled hydrothermal lead-zinc-silver-barite mineralization appears to be related to the major coast-parallel faults. The mineral assemblage and the structural settings of this type of mineralization suggest that an appropriate analogue would be lead-zinc mineralization of the Mississippi valley type. The significant mineralization known to date in the survey area occurs at Vitengeni, Kinangoni, Mwachi River and Lunga Lunga. Of these occurrences, the Vitengeni and the Kinangoni deposits are currently being mined, the former for barite and the latter for lead. Any indications for this type of mineralization should not be looked over, particulary when they are located in the proximity at these occurrences.

(3) The results of the pan-concentrated stream sediment sampling indicate that most of anomalous values in either of the analyzed elements appear to align along the major coast-parallel faults. Of these anomalous values, those located in the proximity of the known mineralization may be of interest, for examples polymetalic anomalies around Vitengeni, a gold anomaly near town of Ganze, copper lead and/or zinc anomalies around Kinangoni, and Au and/or Cu anomalies around Mkang'ombe.

(4) The results of the soil geochemical survey for the selected 5 prospects were generally disappointing except for the Mrima Hill-Jombo Hill and Mkang'ombe areas. The soil samples of the Mrima Hill-Jombo Hill area, the Mrima Hill in particular, indicated outstandingly high contents in Au, Cu Pb, Zn, Mn, Fe and S, in comparison with those of other areas. In the Mkang'ombe area, one of the soil samples yielded an exceptionally high value in Au, which could be an indication for gold mineralization.

Based on the results, it is recommended that to carry out the following work for further work.

(1) The Mrima Hill is an interesting prospect not only for rare earth elements and niobium but also for base and precious metals according to the results of the soil geochemistry. However, no further work is recommended in this scheme of the project when the mining right belongs to a foreign private company.

(2) Of the geochemical anomalies of the pan-concentrated stream sediment samples, 4 areas are selected for further investigation, namely the Vitengeni, the Ganze (The upstream of Mulungu Wa Mawe river, far west of Kilifi), the Kinangoni, and the Mkang'ombe. The former 3 areas are located in the proximity to the major coast-parallel faults and their areas for investigation should include the major faults and the upstreams of the localities of the anomalous samples.

(3) This year's prospecting of the selected mineral occurrences failed to locate any specific target for further detailed investigation. The above 4 targets which are selected on the basis of the results of the pan-concentrate stream sediment geochemistry should cover rather wide areas, say a few hundreds square kilometres, because only 100 samples were collected for an area of some 9,000 km^2. Accordingly the investigation for these targets will be of semi-regional or semi-detailed nature.

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PART I

GENERAL

1. Introduction

1-1 Project Objectives

The main objectives of this project is to explore and to assess the mineral potential of the Mombasa area.

1-2 Purpose and Scope of Report

This geological survey and geochemical prospecting was part of the mineral exploration in Mombasa area, Republic of Kenya agreed upon between Ministry of Environment and Natural Resources of Republic of Kenya and the Japan International Cooperation Agency and the Metal Mining Agency of Janpan.

The primary aim of this survey was to study mineral occurrences of the Mombasa area. A number of mineral showings and geochemical anomalies have been reported in the area, including niobium, rare earths, lead, zinc, copper, gold, iron, manganese, and barites. Some of mineral showings are being mined at the present time.

In conjunction with the field campaign, the geological data analysis was done to provide the geologic background necessary for assessing the nature and potential of the mineral deposits.

The geological and geochemical survey was conducted to obtain more complete information on the nature, content, extent, and potential of the mineral deposits in the area.

As a supplement to the study of mineral occurrences, geological check traverses and pan-concentrate sampling were made to collect geological and geochemical information throughout the area. As part of the field work, fifteen previously reported mineral occurrences were prospected namely; (1) Mrima Hill-Jombo Hill, (2) Kinangoni, (3) Vitengeni, (4) Jaribuni, (5) Kiwara Hill, (6) Goshi, (7) Chang'ombe, (8) Mwachi River, (9) Mkundi, (10) Lunga Lunga, (11) Mwena, (12) Gadini, (13) Mwereni, (14) Mkang'ombe, and (15) Mangea-Kwa Dadu were located, studied, and sampled. Soil geochemical survey was conducted in the five selected mineral occurrences: (1) Mrima Hill-Jombo Hill, (2) Kinangoni, (3) Mkundi, (4) Mkang'ombe, and (5) Mangea-Kwa Dadu.

Laboratory work included microscopic study of thin and polished sections, whole rock chemical analyses, chemical analyses of mineralized samples, X-ray diffractometry of mineralized/altered rock samples, electron probe micro-analysis of ore minerals, Pb-Pb isotope age determination, and geochemical analyses of pan-concentrated stream sediment samples and soil samples.

During this year's campaign, it was tried to obtain satellite images with satisfactory quality for a tectonic interpretation. However, the effort ended unsuccessful unfortunately.

Field work for this report were made by three Japanese and five Kenyan geologists from August 10 to December 6, 1990. Bibliographic study and data compilation were made principally in Nairobi for a month preceded the field work.

Base maps used for the field work were the Survey of Kenya 1:50,000 topographic sheets, all enlarged to a scale of 1:25,000 and 1:10,000.

1-3 Project Staff and Field Survey Team

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2. Geography

2-1 Location and Access

The Mombasa area is situated in the coastal belt/Kenya between Malindi and the Tanzanian border; the boundaries towards the east and the west pass through the points 39° 50' 20" E/3° 00 S, 39° 41' 50" E/4° 00 S and 39° 11' 00" E/4° 09' 20" S; and 39° 21' 30" E/3° 00' S and 39° 02' 50" E/4° 03' 30" S (Fig. 1).

A road network is very well developed and provides with good accesses to various localities in the area.

All-weather hard-surface roads include the Nairobi-Mombasa road (A109), Mombasa-Malindi road (B8), and Mombasa-Lunga Lunga road (A14). And all weather gravel roads extend from Kinango to several villages to the north, east, and south. Other seasonal (dry-season only) roads follow most of the villages.

2-2 Topography and Drainage

The Mombasa area is divided into four physiographic units closely related to the four groups of sedimentary rocks comprising the area. These units are (1) The Coast plain, composed of the Pleistocene deposits, (2) The Foot Plateau, which very nearly coincides with the Jurassic deposits, (3) The Coastal Range, and (4) The Nyika (scrub plain), which is underlain by the Duruma Sandstones in the area.

The Coast Plain, comprising the late Cenozoic formations, rarely exceeds 3 to 5 km in width and generally lies below the 30 m contour. The seaward margin of the plain is composed of the Pleistocene coral reef. Behind the Coast Plain the ground rises rapidly, and often more or less abruptly, to the Foot Plateau that stands at an elevation of from 70 to 140 m. A second steep ascent, this time of the order of 150 m or more, takes one up on to the Coast Range, locally known as the Shimba Hills. This horst-like eminence, composed of Mazeras Sandstone with a capping of Shimba Grit, forms the dominant physiographic feature of the area. Apart from a few isolated summits, the highest of which attains a altitude of just over 400 m. This feature is due to the resistant grit capping that protects the more easily eroded underlying sandstones. From the western edge of the Coast Range the topography drops steeply to the Nyika which, starting from about the 180 m contour, rises gradually to about 300 m on the western boundary of the area. It extends for many kilometers north-west of the area and is underlain largely by Mozambiquian System rocks.

The drainage in the area is integrated into four river systems, namely the Galana, Kilifi, Mombasa, and the southern part of the area. The Galana (Sabaki) river enters the area in the north-west and follows an easterly course for a distance of 90 km before leaving the eastern margin on its way to the sea. The Galana flows throughout the year, and its channel varies in width between one and two hundred meters. The tributaries of the Galana are short. When the water level is at a minimum, ribs of sedimentary rocks can be seen in the bed of the stream at many localities. The Vitengeni (Rare) river and its tributaries flow in Kilfi. The main rivers, the Kambeni, Ngeyeni, Mambome, and Cha Shimba all flow in Mombasa through the central part of the area. The southern part of the area is mainly drained by the Ramisi, Mwena, and Umba.

2-3 Climate and Vegetation

In the Kenya coast, the year starts dry and remains so until March, when rainfall gradually increases. A fairy rapid increase occurs through April and builds up to its maximum in May. After this it decreases steadily, although significant amounts are still recorded in October and November. During December it begins to fade away altogether with minimal rainfall in January and February.

Monthly average temperature and rainfall are shown in Table 1.

Table 1 Monthly Average Temperature and Rainfall

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Maximum Temperature (°C)	32	32	33	31	29	29	28	28	29	30	31	32
Average Minimum 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

Vegetation along the warm wet coastal belt is rich with coconut woodland, bush, and tall savanna grassland. Dense true equatorial forest occurs in pockets on Arabuko Sokoke forest, Shimba hills, Mrima hill, and Jombo hill. Mangrove swamps line river valleys and inlets along this mainly coral coast.

3. Previous Work

3-1 Previous Work

The early geological information from the Kenya coast is that of Baron von der Decken, 1869; J. Thomson, 1879; W. Gibson, 1893; S. von Reichenbach, 1896; J.W. Gregory, 1896; and E.E. Walker, 1903.

In 1905, H.B. Muff of the Geological Survey of Great Britain was commissioned to examine the geology of the East African Protectorate, and his report was published in 1908. He was the first to establish a detailed stratigraphical succession of the coastal sediments. Muff recognized that the rocks dip gently, and become progressively younger, towards the coast.

In 1909, Daque classified the Duruma Sandstone as the British East African representative of the African Sandstone, a non-marine, Pre-Bathonian formation extending from Egypt to South Africa.

In 1919, J.W. Gregory paid a second visit to Kenya and soon after published his famous book on the geology of East Africa (1921). Four chapters were devoted to the coastal geology of Kenya.

The general geology in Mombasa-Kwale area, Kilifi area, Malindi area, and Hadu-Fundi Isa area were contained in the reports and maps of the Mines and Geological Department: P.V. Caswell, 1953; P.V. Caswell, 1956; A.O. Thompson, 1956; L.A.J. Williams, 1962 respectively.

Brief descriptions of the mineral occurrences of Kenya are contained in the geological bulletins of Mines and Geological Department: W. Pulfrey, 1954; W. Pulfrey, 1960; C.G.B. Du Bois, 1966; J. Walsh, 1969; C.G.B. Du Bois, 1970.

Aeromagnetic and radiometric airbone survey were conducted by the Kenya government on the Mombasa area in 1977. The results of the aeromagnetic and radiometric surveys have been filed in Mines and Geological Department. These geophysical data have not been assessed either qualitatively or quantitatively.

The latest mineral exploration and an assessment of the known and possible mineral resources of the coastal belt south of Mombasa were done in 1978 by Kenya/Austria Joint Mineral Investigation Project.

Geological maps at a scale of 1:50,000 provide with a comprehensive background for the geology of the coast area. These maps were produced in the North and South Coast Mapping Projects conducted jointly by the Mines and Geological Department and the British Technical Cooperation in 1985.

3-2 Geologic Setting

The generalized geological map (Figure 2) shows the generalized geologic and tectonic trends of the Mombasa and its suburbs. The geologic formations of the area range in age from Precambrian to Quaternary and include sedimentary, igneous, and metamorphic rocks and unconsolidated material (Figure 3).

The principal rock units in the area are the Mozambiquian restricted to the northwest of the Mombasa area; Paleozoics and Mesozoics occupy an extensive area and the Tertiary and youger sediments are mainly distributed on the coast belt.

Crystalline rocks of the Mozambiquian are principally gneisses and schists.

Paleozoic sediments of Permian age are found in the western area. The Paleozoic sediments and the overlying Triassic rocks (Kambe Formation and Mtomkuu Formation) comprise a series of grits, sandstones and shales. While the younger Jurassic rocks are usually marine limestones and shales. The Permo-Triassic rocks (Duruma Group: Taru Formation, Maji ya Chumvi Formation, Mariakani Formation, and Lower Member of Mazeras Formation) of this area are correlated to the Karroo System of the southern Africa but much finer grained in general than equivalent rocks in other African Karroo trough. The sediments are dissimilar to the fluvial sequences dominated by pulses of coarse sediment caused by basin margin tectonisms that characterise other African Karroo basins. Facies changes appears to be apparent from south-west to north-east rather than from west to east. Tertiary and Pleistocene sediments of non-volcanic origin are on the coast of the area. Raised coral reefs along the coast are of Pleistocene age.

Intrusions in the Paleozoic and Mesozoic sediments of the area are few in number. Intrusions of Jombo Hill and the neighbouring hills are alkaline in composition but Mrima hill is the site of a carbonatite intrusion. Basic dikes are found as satellites of alkaline intrusions.

Coast parallel faults are extensively developed in the directions of NNE-SSW to NE-SW, and the major ones of them border the Mazeras sandstone and the Kambe limestone for a long distance along the coast. Cross cutting the major coast parallel structure, faults and fractures of

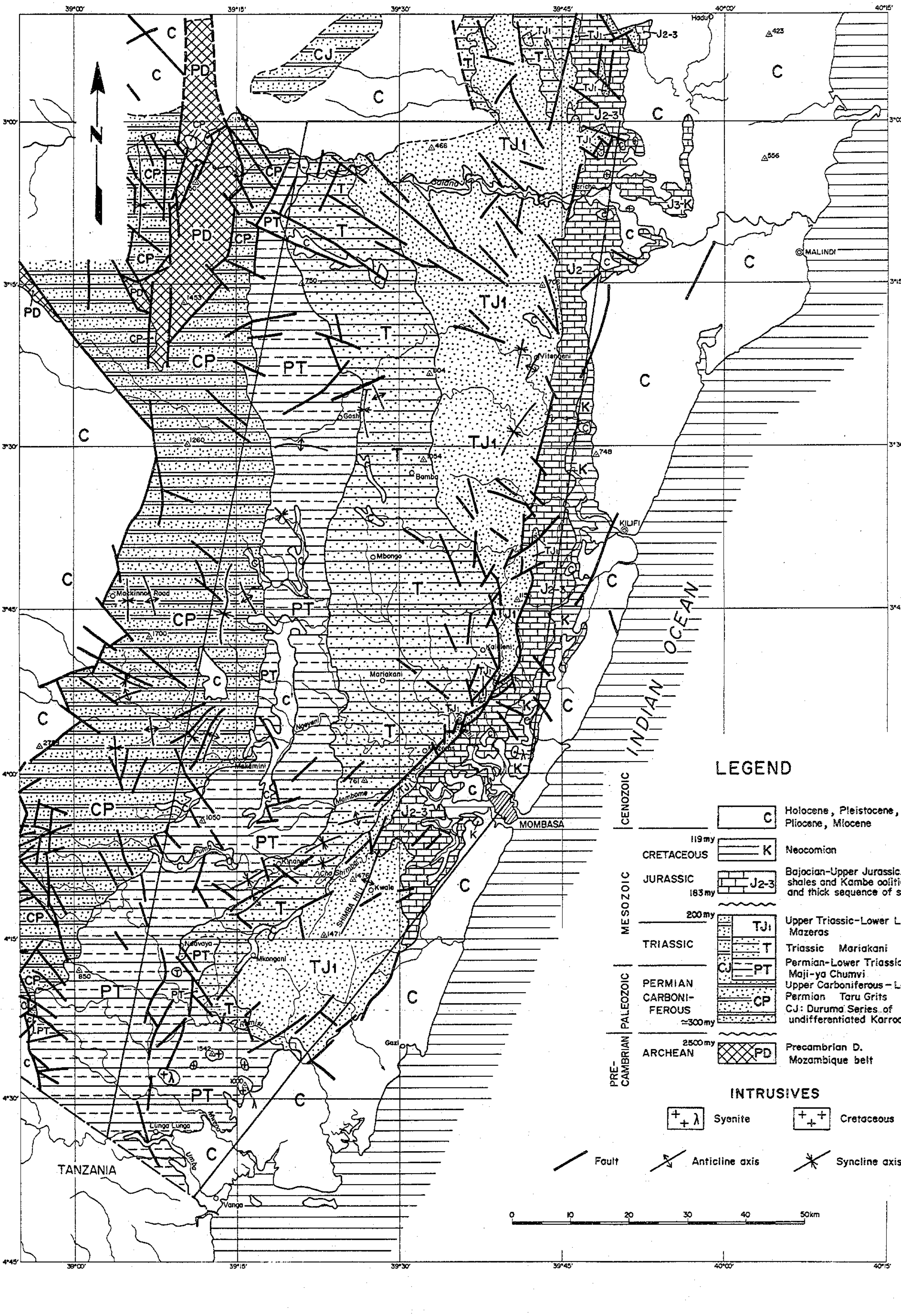
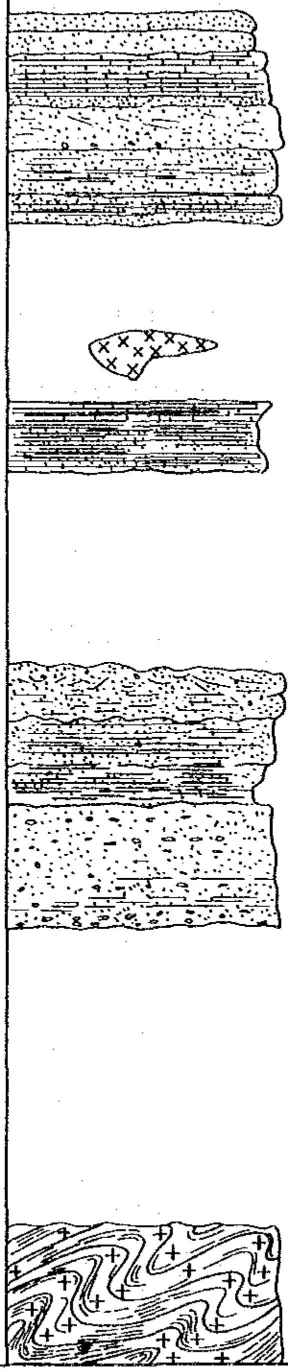


Figure 2 Generalized Geological Map of the Mombasa Area



ERA	PERIOD/SUB-PERIOD		AGE (Ma)	LITHOLOGY	STRATIGRAPHY	TECTONIC EVENTS	MINERAL OCCURRENCES
	Quaternary	Holocene		alluvium colluvium dune sands sands reef			
			0.01				
Cenozoic		Pleistocene					
			1.64				
	Neogene	Pliocene		sands	Magarini Fm.	Faulting	
		Miocene		ss,(sh/marl)	Marafa Fm.		
	Tertiary			ss,(ls/sh)	Baratum Fm		
			23.5				
	Paleogene	Oligocene Eocene Paleocene					Mkang'ombe, Mkundi: Pb-Zn-Cu
			65				
	Cretaceous	Senonian				Alkaline igneous intrusion	Mrima Hill: Niobium/ Rare earths
			89				
			119				
		Gallic		sh,(ls) sh,(ss)	Mtomkuu Fm.	Faulting	
			132				
		Neocomian		sh/ss/ls			
Mesozoic			146				
	Jurassic	Malm					
			157				
		Dogger					Limestone: (Pb-Zn)
			178	ls,(sh)	Kambe Fm.		
		Lias	183			Major faulting Up-doming	Kinangoni, Vitengeni: Pb-Zn-Ag
			200				
			208	ss(cs.gd)	Mazeras Fm.		
	Triassic	Tr3 Tr2 Scythian		ss,sh	Mariakani Fm.		
			245	sh,silt st	Maji ya Chumvi Fm.	Subsidence	
	Permian	Zechstein Rotliegen. Pennsylv.			Druma Group (Karroo)		
			290	grits	Taru Fm.		
Paleozoic	Carboniferous		300			Initial faulting	
			362.5				
	Devonian						
			408.5				
	Silurian						
			439.0				
	Ordovician						
			510				
	Cambrian						
			570				
Precambrian	Proterozoic						
			2,500				
	Archean			gneisses schists etc.	Mozambique Belt	Mozambiquian orogeny	

Figure 3 Geological Sequence of the Mombasa Area

other trends are also well developed and most of them are younger than the major coast parallel faults.

The lead-zinc-silver-barite mineralization, typically represented by the Kinangoni and the Vitengeni, appears to be controlled by structures trending NNE-SSW to NE-SW.

The mineralization of this type as well as major geochemical anomalies in these and related elements, appears to occur proximal to the major coast parallel faults.

3-3 History of Mining

The Mombasa area has long been known to contain mineral showings of niobium, rare earths, lead, zinc, copper, gold, iron and manganese. The Vitengeni deposit was intermittently worked for galena in the 1920s, 1940s and 1950s. Niobium and rare earths in Mrima Hill, 80 km south-west of Mombasa has long been explored since the early 1950s. Some twenty geochemical anomalies for lead, zinc, manganese and/or copper were identified in the Mombasa area by the Kenya-UK project. Lead in Kinangoni has been mined on a small scale since 1970. A new gold occurrence has been reported (Tole, M.P., 1989) at Mkundi, 65 km south-west of Mombasa.

Vitengeni

Vitengeni mine is approximately 75 km due north of Mombasa. This mine was discovered in 1919 and development began in 1922.

The deposit consists of a series of steeply dipping galena-bearing veins of barites emplaced in sandstones, siltstones, and mudstones of the Mariakani and Mazeras Sandstone group.

Galena constituted approximately 2.5% of the ore which was treated to give concentrations containing between 82 and 85%. Untill 1929, ores between 7,000 and 8,000 tons were extracted and yielded 209 tons of concentrates which were exported to Europe. The metallic lead obtained from these is estimated at 176 tons, in addition to about 1,420 oz of by-product silver.

The deposit was worked for galena in the 1920s, re-examined in the early 1940s and again in the 1950s. Unfortunately the reserves, averaging 2.5% PbS and 200 grams of Ag per tonne, were insufficient to justify further development.

Attention was turned to the barites potential in the 1960s and reworking the old lead mine dumps were retreated and yielded a small tonnage of barite annually. Although only a little over 5,000 tonnes has been produced untill 1966, mainly to supply local markets.

Mrima Hill

A carbonatite intrusion with economic potential occur at Mrima Hill, 80 km southwest of Mombasa. Interest was first shown in the deposit after the Mines and Geological Department had completed a prospecting program for niobium in the early 1950s which indicated reserves of 30 million tonnes averaging 0.7% Nb_2O5. Anglo American Prospecting Co., (Africa) Ltd. started a comprehensive exploration program in 1955 together with metallurgical test to establish a viable method of recovering the niobium, but in 1957 it gave up its exploration licence. The reason for this was because the deposit was low grade and the friable nature of the pyrochlore crystals which led to sliming on treatment, made the deposit uneconomic.

Further work in the 1960s by the Mines and Geological Department, together with ore beneficiation tests by Warren Spring Laboratory of the UK, did not provide the breakthrough necessary to stimulate commercial exploitation of Mrima Hill at a time when a higher grade deposit was being exploited at Araxa in Brazil. The occurrence of rare earth concentration in parts of Mrima Hill was of greater significance, however, and the deposit was re-examined by various mining companies. Rhone Poulenc was the most persistent and carried out a comprehensive exploration of the Mrima in 1968, followed up by successful metallurgical tests to recover the rare earths. In 1979 the company was given right to develop the deposit by the Kenya Government. However, no significant progress has been made to date.

Kinangoni

Kinangoni mine is approximately 25 km north of Mombasa. Kinangoni lead deposits have been known for several decades. Prospecting by the Mines and Geological Department, using geochemical methods and diamond drilling, has proved an ore body at Kinangoni Hill. Indicated reserves are a minimum of 930,000 tons at a grade of 8.9% lead, 0.58% zinc and 4.25 oz/ton silver. Exploitation of the deposit was expected to start late in 1970.

A major demand for pure lead make Kinangoni ore commercially viable. Since 1983, the deposits have been mined by Kenya Lead Mining Company a subsidiary of Associated Battery Manufacturers (ABM)/Chloride Metals Ltd (CM).

The mine, so far the largest deposit identified anywhere in Kenya, was once exploited by a Romanian company, who closed the operations many years ago because they could not refine the complex ore in small volumes simply and cheaply.

Meanwhile, ABM started making batteries in 1965, relying on imported raw materials. In 1978, the parent UK company, Chloride Group PLC established a lead smelting and refining plant at Athi River, operated by CM, to recycle scrap from old batteries and save on imports. The smelting plant was expanded by 250% in March, 1985. ABM has been fully self sufficient in lead ore producing 150,000 batteries per year since 1987. The company is now gearing up for exports.

The mining operation capital at Kinangoni now stands at KShs 25 million, saving foreign exchange to the tune of KShs 15 million a year. About 1,500 tonnes per year of 60-70% lead concentrate is produced at the mine. The ore concentrate is refined to 99% purity at Athi. Mining at Kinangoni was open cast but an underground mining plan has been studied since 1989.

Geochemical prospecting

The lead-zinc deposits of the Mombasa area have received considerable attention since 1964, including exploration, drilling, and both underground and opencast mining. Following a regional 1:50,000 scale mapping project jointly conducted by the Mines and Geological Department and the British Technical Coopertion, some twenty geochemical anomalies for lead, zinc, manganese and/or copper were identified. The department instituted the Coast Base Metals Project to conduct ground follow up mainly soil sampling to investigate some of these anomalies, the most important of which are located around Mwachi, Mazeras, Mariakani and Chasimba. This work has been under way since 1980/81 and is now data analyses and reporting stage.

Gold

A speck of gold was found at Jombo in 1893 but this has never raised more than historical interest.

Occurrence of gold, pyrite, galena, chalcopyrite, and malachite have been reported from surface rocks at the Mukundi hot springs northeast of Jombo Hill (Tole, M.P., 1989).

4. Discussion of Results

4-1 Structure, Metallogeny and Ore-control

The most prominent structures in the Mombasa area are the major coast parallel faults trending in the directions of NNE-SSW to NE-SW, which border the Mazeras sandstone and the Kambe limestone for a long distance parallel to the coast line. Faults of other directions are also well developed and cut cross the major coast parallel faults at many places.

The mineral showings can be divided into the following groupings: (1) carbonatite plug containing niobium and rare earths; (2) veins containing lead, zinc, barites with several associated metals including gold, silver, and copper; and (3) miscellaneous mineral showings containing iron and manganese.

Intrusions in the Mesozoic sediments of the area are few in number. Intrusions of Jombo Hill and the neighbouring hills are alkaline in composition but Mrima Hill is the site of a carbonatite intrusion. Manganese, pyrochlore, and rare earths are found on Mrima Hill. Rare earth oxides in Mrima Hill are associated with the minerals monazite and gorceixite, which, together with pyrochlore, have their concentration in residual soils derived from the carbonatite.

The most suitable analogue of the lead-zinc (barite) showings in the Mombasa area may be the Mississippi Valley-type mineralization. The known lead-zinc-barites veins are generally N-S trending but an appreciable degree of control is exercised by E-W trending cross-cutting fractures. These fault/fracture zones, which are the loci of significant mineralization, extends for some 160 km parallel to the coast. Fracturing is widest, most extensive, and gives rise to the thickest veins in the coarsest grained sandstones. Due to fault movement continued post vein emplacement, the veins themselves have become brecciated or subordinate new veinlets parallel and sub-parallel to their margins have been produced.

4-2 Mineral Potential

According to the geological data analysis 15 prospects were selected for ground examination in this year's campaign. The examination indicated that 8 prospects would be of interest in various degrees, namely the Mrima Hill-Jombo Hill, the Vitengeni, the Kinangoni, the Mwachi River, the Mkundi, the Lunga Lunga, the Mkang'ombe, and the Mangea-Kwa Dadu (Figure 4 and Table II-2-3 in Chapter II).

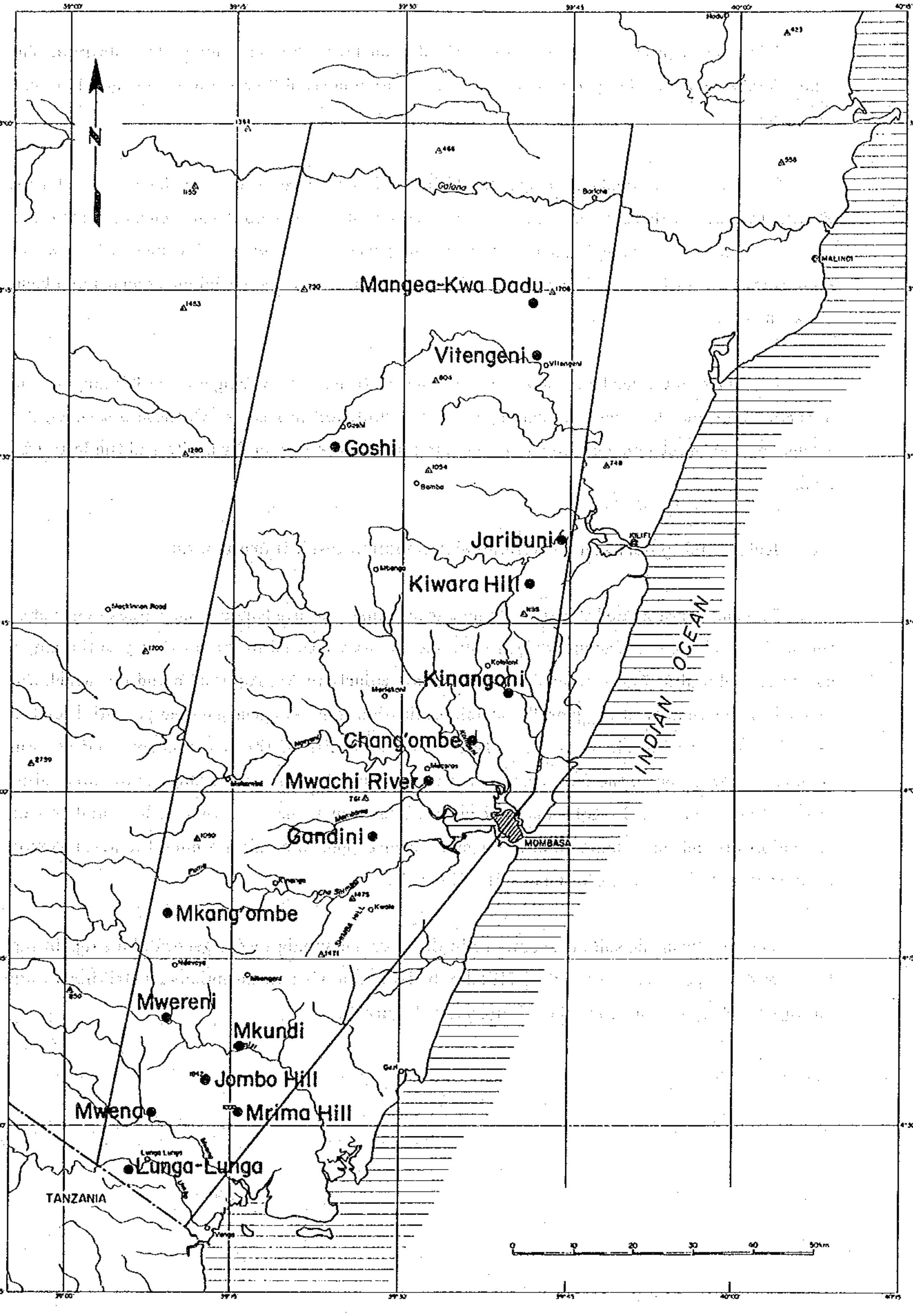


Figure 4 Map Showing Mineral Occurrences in the Mombasa Area

Of these, 5 prospects, the Mrima Hill-Jombo Hill, the Kinangoni, the Mkundi, the Mkang'ombe and the Mangea-Kwa Dadu, were subsequently followed up by soil geochemical sampling.

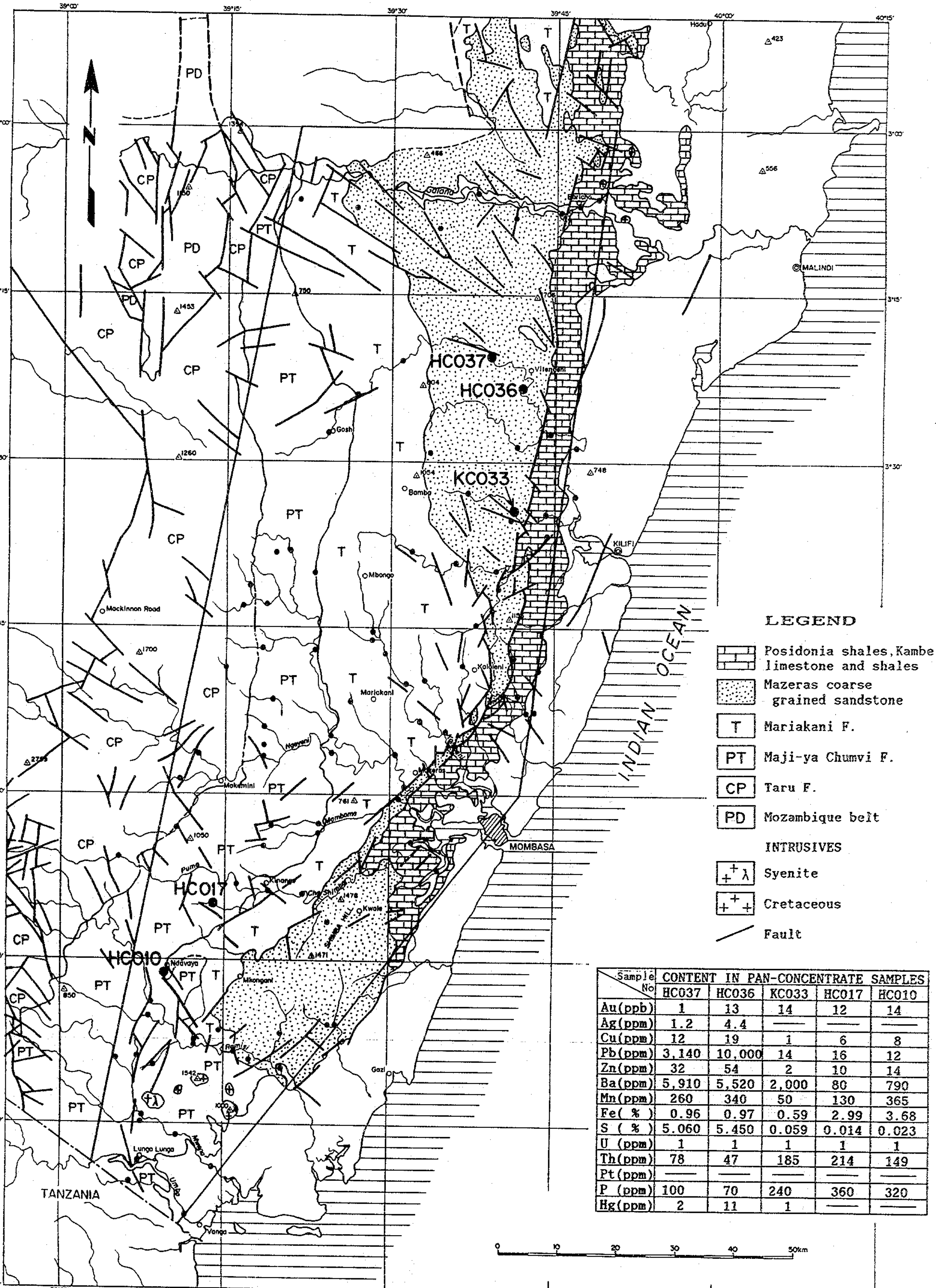
The Mrima Hill-Jombo Hill area, the Mrima Hill in particular, has long been known for its significant mineralization in niobium and rare earths in residual soils derived from the carbonatite body. According to the results of the soil geochemistry with high values in Au, Pb and Zn in comparison with the other areas, the Mrima Hill may have potential for precious and base metals as well.

In regard to the lead-zinc-silver-barite mineralization, the Vitengeni, the Kinangoni, the Mwachi River and the Lunga Lunga appear to be significant prospects. Of these prospects, the Vitengeni and the Kinangoni are currently being mined, the former for barite and the latter for lead.

4-3 Relationship between Geochemical Anomalies and Mineralization

The pan-concentrated stream sediment geochemistry located anomalous values in either of the analyzed elements. The anomalous values are mostly located in the proximity to the major coast parallel faults. Those anomalous values, particularly in Au, Ag, Pb, Zn and Ba, which are located in the vicinity of the significant mineralization, may suggest possible potential for the lead-zinc-silver-barite mineralization. Based on the results of the pan-concentrated stream sediment geochemistry, the following anomalies may be of interest; the polymetalic anomalies around the Vitengeni, the gold anomaly near the town of Ganze, the copper, lead and/or zinc anomalies around the Kinangoni and the gold and/or copper anomalies around the Mkang'ombe taking account of a high gold value in soils (Figure 5).

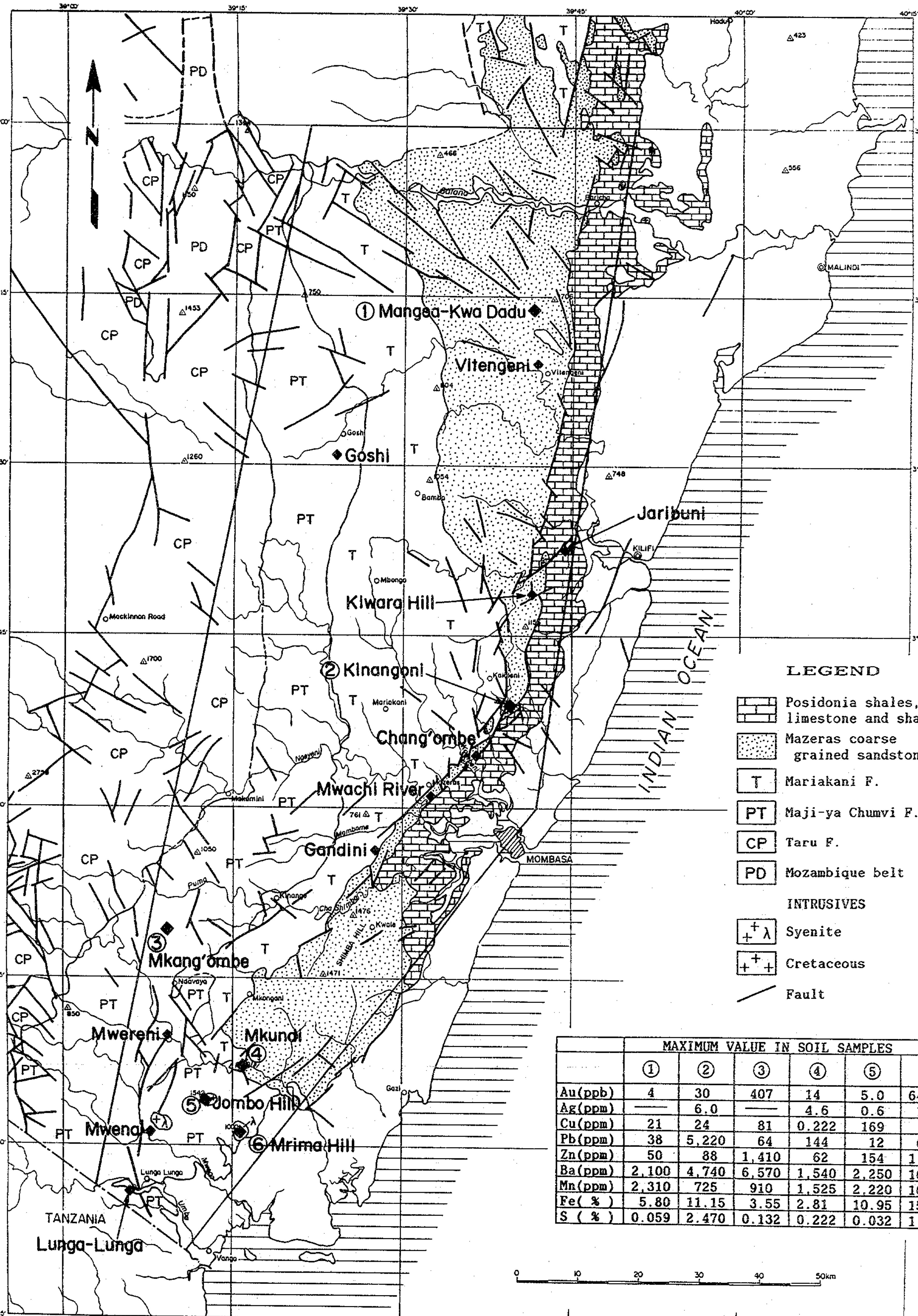
The results of the soil geochemistry in this year's campaign were generally disappointing for other 4 prospects than the Mrima Hill-Jombo Hill area with an exception of a strikingly high Au value (407 ppb) obtained in the Mkang'ombe (Figure 6).



Sample No	HC037	HC036	KC033	HC017	HC010
Au(ppb)	1	13	14	12	14
Ag(ppm)	1.2	4.4	—	—	—
Cu(ppm)	12	19	1	6	8
Pb(ppm)	3,140	10,000	14	16	12
Zn(ppm)	32	54	2	10	14
Ba(ppm)	5,910	5,520	2,000	80	790
Mn(ppm)	260	340	50	130	365
Fe(%)	0.96	0.97	0.59	2.99	3.68
S (%)	5.060	5.450	0.059	0.014	0.023
U (ppm)	1	1	1	1	1
Th(ppm)	78	47	185	214	149
Pt(ppm)	—	—	—	—	—
P (ppm)	100	70	240	360	320
Hg(ppm)	2	11	1	—	—

CONTENT IN PAN-CONCENTRATE SAMPLES

Figure 5 Geochemical Map Showing Pan-concentrated Stream Sediment Survey Results



MAXIMUM VALUE IN SOIL SAMPLES	①	②	③	④	⑤	⑥
Au(ppb)	4	30	407	14	5.0	64.0
Ag(ppm)	—	6.0	—	4.6	0.6	1.0
Cu(ppm)	21	24	81	0.222	169	55
Pb(ppm)	38	5,220	64	144	12	626
Zn(ppm)	50	88	1,410	62	154	1,955
Ba(ppm)	2,100	4,740	6,570	1,540	2,250	10,000
Mn(ppm)	2,310	725	910	1,525	2,220	10,000
Fe(%)	5.80	11.15	3.55	2.81	10.95	15.00
S (%)	0.059	2.470	0.132	0.222	0.032	1.890

Figure 6 Geochemical Map Showing Soil Survey Results

5. Conclusions and Recommendations

5-1 Conclusions

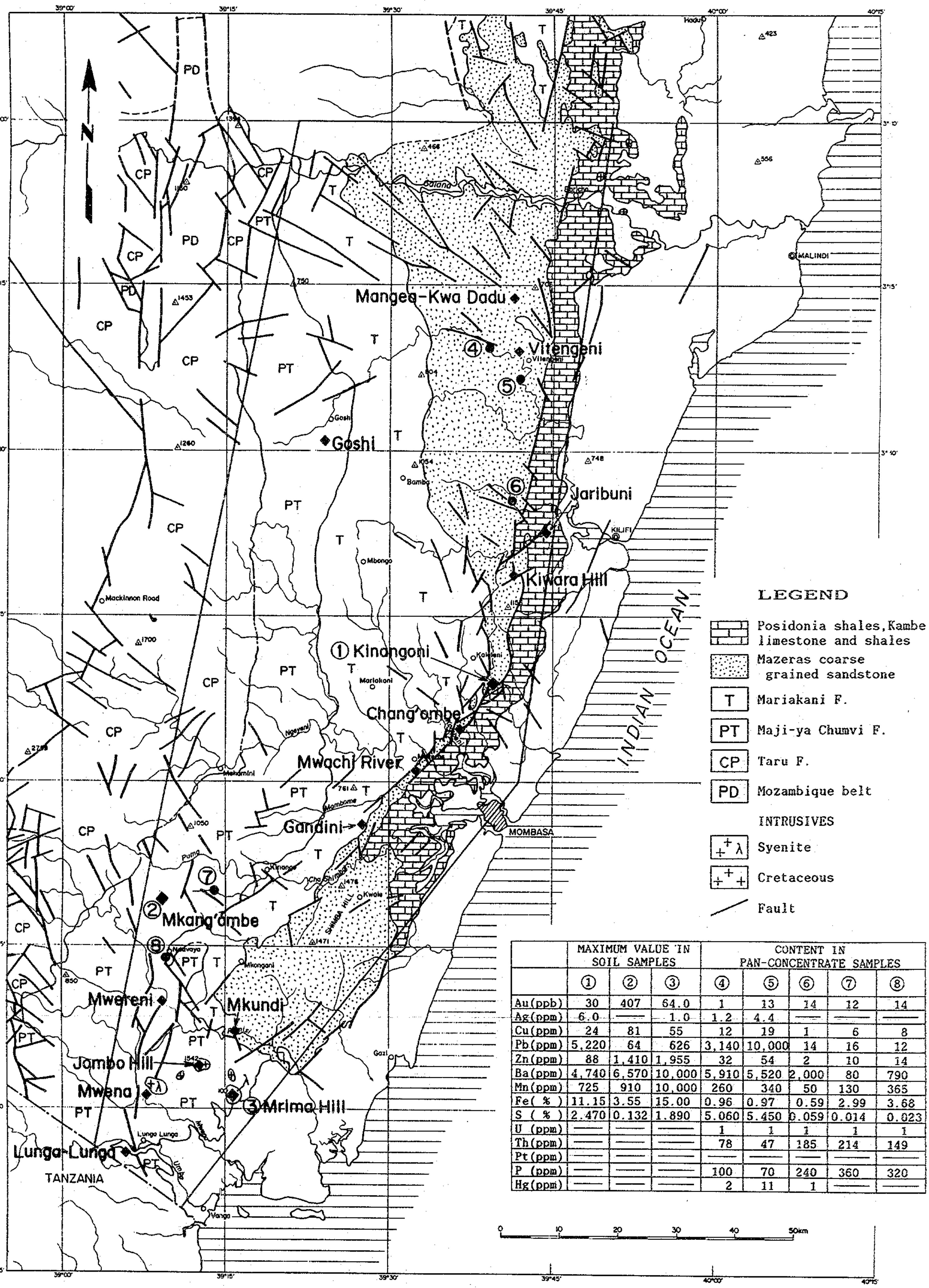
The results of the present survey lead to the following conclusions.

(1) In the Mrima Hill-Jombo Hill area, rare earth oxides together with niobium are moderately concentrated in residual soils derived from the Mrima Hill carbonatite plug. This mineralization appears to be one of significant resources of this kind in the world. However, the mining right authorized by the Government of Republic of Kenya belongs to a foreign private company at the present time, though no commercial exploitation has ever been tried seriously.

(2) The fault controlled hydrothermal lead-zinc-silver-barite mineralization appears to be related to the major coast parallel faults. The mineral assemblage and the structural settings of this type of mineralization suggest that an appropriate analogue would be lead-zinc mineralization of the Mississippi valley type. The significant mineralization known to date in the survey area occurs at Vitengeni, Kinangoni, Mwachi River and Lunga Lunga. Of these occurrences, the Vitengeni and the Kinangoni deposits are currently being mined, the former for barite and the latter for lead. Any indications for this type of mineralization should not be looked over, particularly when they are located in the proximity at these occurrences.

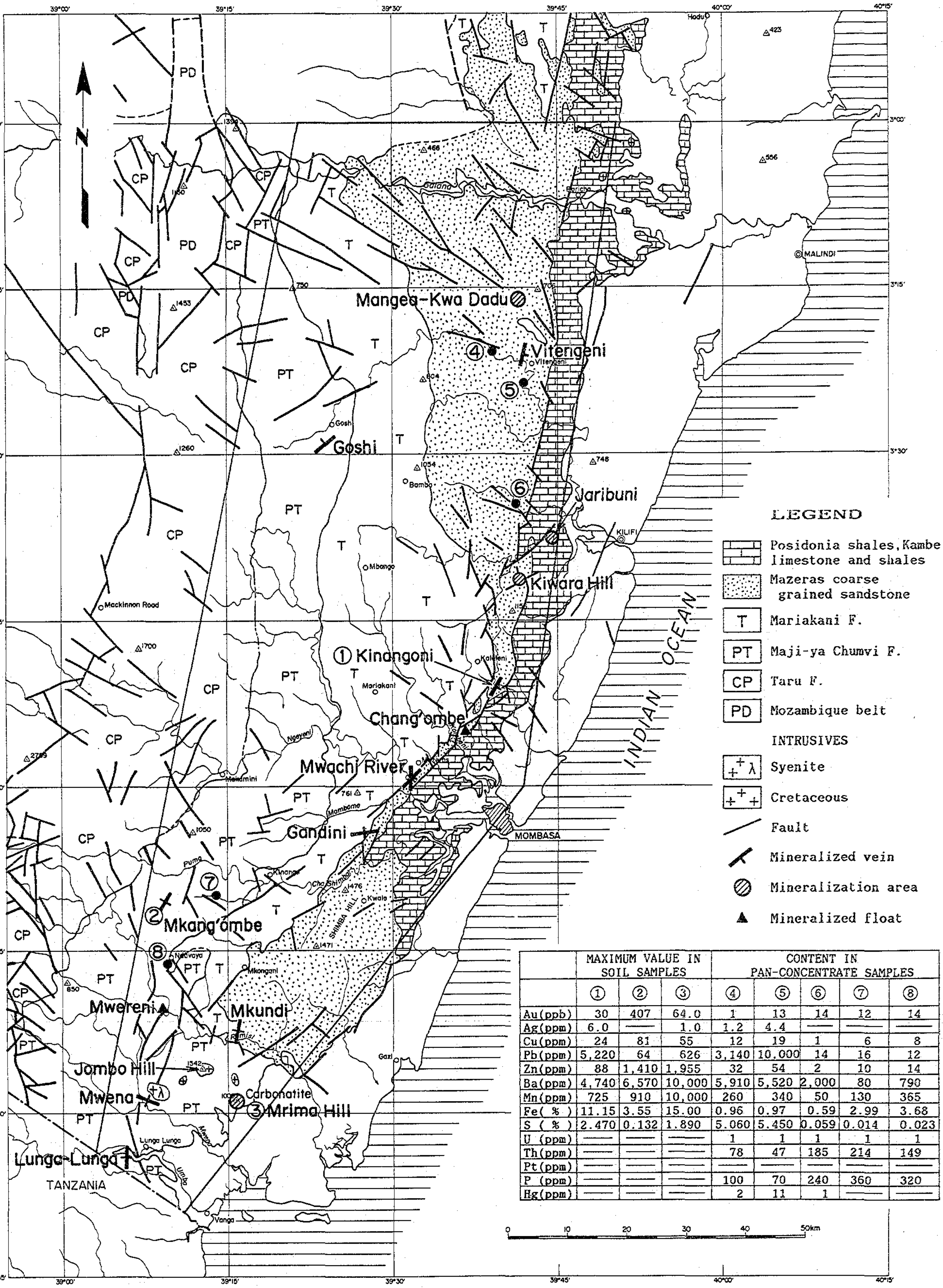
(3) The results of the pan-concentrated stream sediment sampling indicate that most of anomalous values in either of the analyzed elements appear to align along the major coast-parallel faults. Of these anomalous values, those located in the proximity of the known mineralization may be of interest, for examples polymetalic anomalies around Vitengeni, a gold anomaly near town of Ganze, copper, lead and/or zinc anomalies around Kinangoni, and Au and/or Cu anomalies around Mkamg'ombe (Figures 7 and 8).

(4) The results of the soil geochemical survey for the selected 5 prospects were generally disappointing except for the Mrima Hill-Jombo Hill and Mkang'ombe areas. The soil samples of the Mrima Hill-Jombo Hill area, the Mrima Hill in particular, indicated outstandingly high contents in Au, Cu Pb, Zn, Mn Fe and S, in comparison with those of other areas. In the Mkang'ombe area, One of the soil samples yielded an exceptionally high value in Au, which could be an indication for gold mineralization (Figures 7 and 8).



	MAXIMUM VALUE IN SOIL SAMPLES			CONTENT IN PAN-CONCENTRATE SAMPLES				
	①	②	③	④	⑤	⑥	⑦	⑧
Au(ppb)	30	407	64.0	1	13	14	12	14
Ag(ppm)	6.0	—	1.0	1.2	4.4	—	—	—
Cu(ppm)	24	81	55	12	19	1	6	8
Pb(ppm)	5,220	64	626	3,140	10,000	14	16	12
Zn(ppm)	88	1,410	1,955	32	54	2	10	14
Ba(ppm)	4,740	6,570	10,000	5,910	5,520	2,000	80	790
Mn(ppm)	725	910	10,000	260	340	50	130	365
Fe(%)	11.15	3.55	15.00	0.96	0.97	0.59	2.99	3.68
S (%)	2.470	0.132	1.890	5.060	5.450	0.059	0.014	0.023
U (ppm)	—	—	—	1	1	1	1	1
Th(ppm)	—	—	—	78	47	185	214	149
Pt(ppm)	—	—	—	—	—	—	—	—
P (ppm)	—	—	—	100	70	240	360	320
Hg(ppm)	—	—	—	2	11	1	—	—

Figure 7 Geochemical Map of the Mombasa Area



	MAXIMUM VALUE IN SOIL SAMPLES			CONTENT IN PAN-CONCENTRATE SAMPLES				
	①	②	③	④	⑤	⑥	⑦	⑧
Au(ppb)	30	407	64.0	1	13	14	12	14
Ag(ppm)	6.0	—	1.0	1.2	4.4	—	—	—
Cu(ppm)	24	81	55	12	19	1	6	8
Pb(ppm)	5,220	64	626	3,140	10,000	14	16	12
Zn(ppm)	88	1,410	1,955	32	54	2	10	14
Ba(ppm)	4,740	6,570	10,000	5,910	5,520	2,000	80	790
Mn(ppm)	725	910	10,000	260	340	50	130	365
Fe(%)	11.15	3.55	15.00	0.96	0.97	0.59	2.99	3.68
S (%)	2.470	0.132	1.890	5.060	5.450	0.059	0.014	0.023
U (ppm)	—	—	—	1	1	1	1	1
Th(ppm)	—	—	—	78	47	185	214	149
Pt(ppm)	—	—	—	—	—	—	—	—
P (ppm)	—	—	—	100	70	240	360	320
Hg(ppm)	—	—	—	2	11	1	—	—

Figure 8 Geological and Geochemical Interpretation Map of the Mombasa Area

5-2 Recommendations

Based on the results, it is recommended that to carry out the following work for further work.

(1) The Mrima Hill is an interesting prospect not only for rare earth elements and niobium but also for base and precious metals according to the results of the soil geochemistry. However, no further work is recommended in this scheme of the project at the present time when the mining right belongs to a foreign private company.

(2) Of the geochemical anomalies of the pan-concentrated stream sediment samples, 4 areas are selected for further investigation, namely the Vitengeni, the Ganze (The upstream of Mulungu Wa Mawe river, far west of Kilifi), the Kinangoni, and the Mkang'ombe. The former 3 areas are located in the proximity to the major coast-parallel faults and their areas for investigation should include the major faults and the upstreams of the localities of the anomalous samples.

(3) This year's prospecting of the selected mineral occurrences failed to locate any specific target for further detailed investigation. The above 4 targets which are selected on the basis of the results of the pan-concentrate stream sediment geochemistry should cover rather wide areas, say a few hundreds square kilometres, because only 100 samples were collected for an area of some 9,000 km^2. Accordingly the investigation for these targets will be of semi-regional ore semi-detailed nature.

PART II

DETAIL

1. Bibliographic Study and Data Compilation

In conjunction with the mineral exploration, a secondary aim to assemble as much geological information as possible to provite the geologic background needed to assess the nature and potential of the mineral deposits.

The geological data analysis was done at Mines and Geological Department, Nairobi, required about a month to complete before starting the field work. The results of the analysis contain the followings; (1) Selection of 15 mineral occurrences to be investigated as part of the field work, (2) compilation of the geological maps (1:100,000; 4 sheets) of the Mombasa area and (3) listing of published references and unpublished data (Table 2, Appendix I-1 and I-2).

During this year's campaign, it was tried to obtain satellite images with satisfactory quality for a tectonic interpretation. However, the effort ended unsuccessful unfortunately.

2. Geological and Geochemical Survey

2-1 Survey Method

As part of the field work, field check traverses, geological prospecting of mineral occurrences, geochemical pan-concentrated stream sediment sampling and soil sampling were made in the area of the present survey.

The field check traverses were made to collect geological information throughout the area and samples for petrography. Locations of the rock samples are shown in Figure 9.

An index map of the 15 mineral occurrences is shown in Figure 4. Geological maps on the scale 1:25,000, tape-compass survey maps and geological sketch maps of the mineral occurrences prepared as part of the field work. In order to obtain basic information on the metals content of the mineral occurrences, samples were collected of altered and mineralized rocks. Locations of the samples analyzed are shown in Figure 10.

100 pan concentrated stream sediment samples were collected throughout the Mombasa area. Locations of the samples collected are shown in Figures 5 and GC-2.

769 soil samples collected from 5 selected areas. An index map of the soil geochemical survey areas is shown in Figures 6, GC-4, 5, 7, 8, 9 and 11.

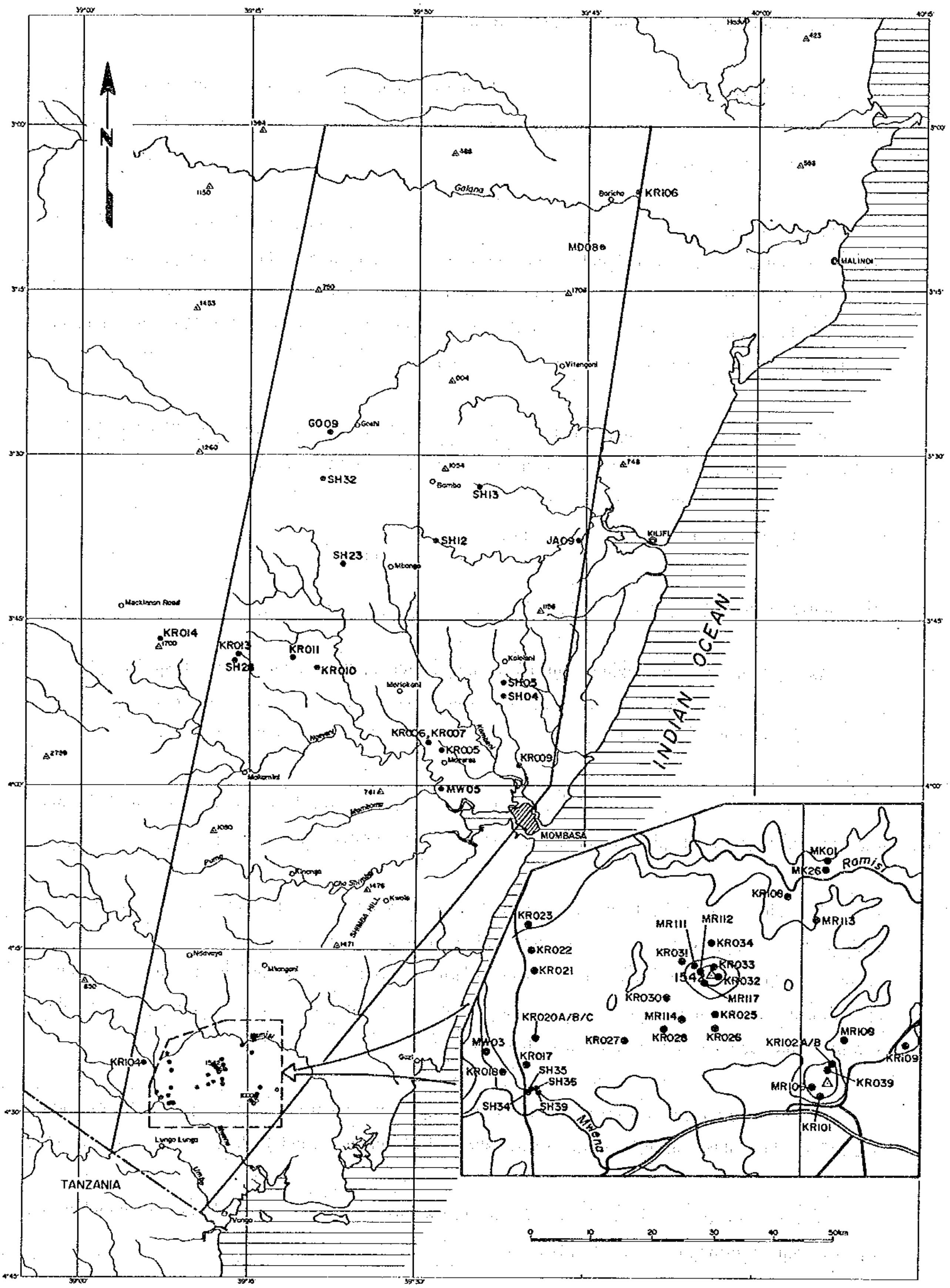


Figure 9 Map Showing Locations of Analyzed Rock Samples

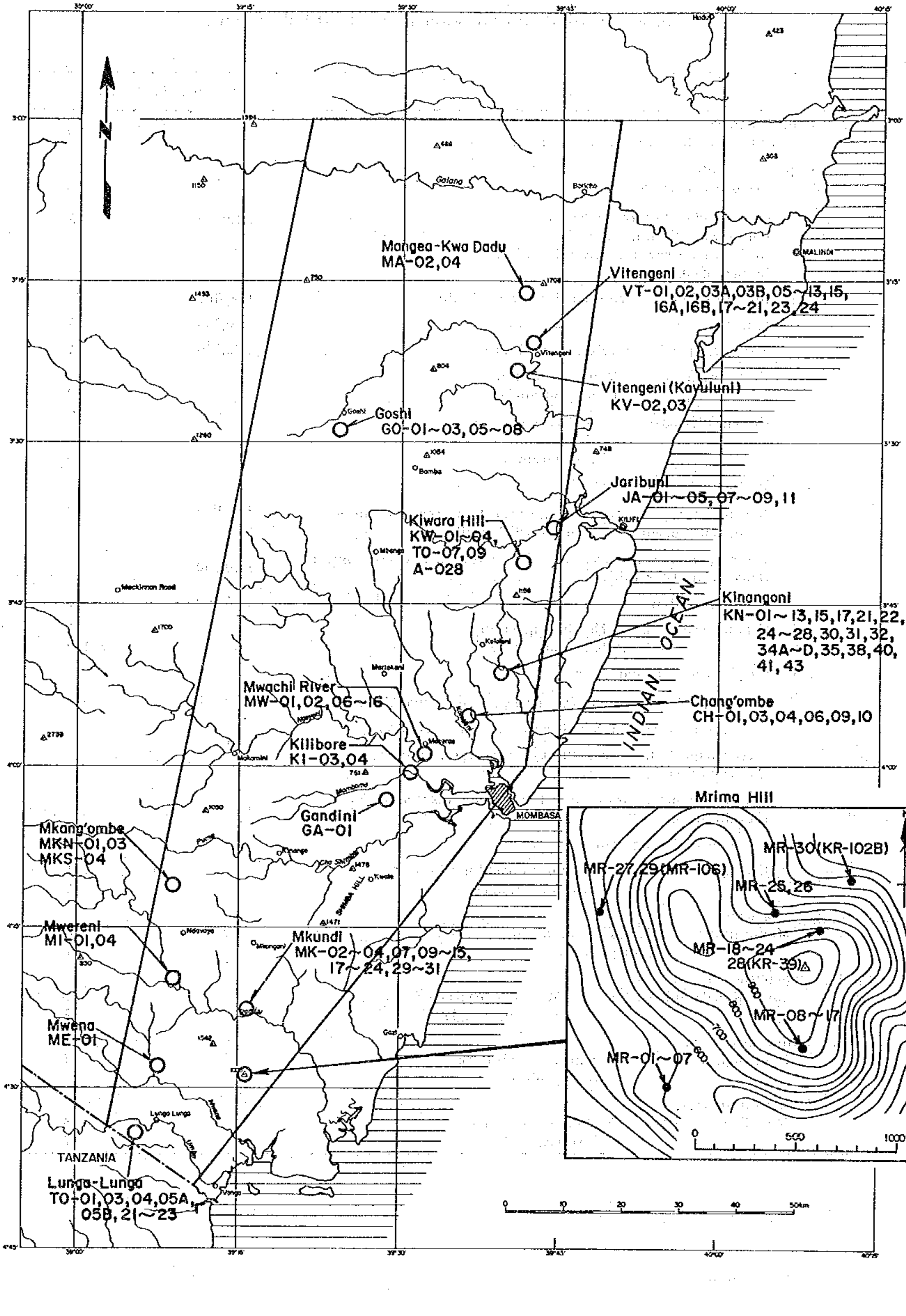


Figure 10 Map Showing Locations of Analyzed Ore Samples

Table 2 Published Reference and Unpublished Data

Title		Copies and/or Sheets
1. Published references: DIALOG GEOREF (#89) (35 copies are obtained)		120
2. Unpublished data:		
2-1 Geological maps and reports		
Colony and Protectorate of Kenya, Industry and Communications, Geological Survey of Kenya (1952-1959), Library of MGD	1:125,000	8
British Technical Cooperation Program (1977-1980)	1:50,000	26
Kenya-Austria Mineral Exploration Project	1:50,000	3
Kenya-Austria Mineral Exploration Project	1:25,000	1
Geological maps; Mombasa quadrangle		76
Kilifi quadrangle		68
Geological reports; Mombasa quadrangle		60
Kilifi quadrangle		68
Voi quadrangle		88
2-2 Geochemical maps and reports		
North-western part of the Mombasa area Stream sediment survey. Mines and Geological Department (1977-1980)	1:50,000	6
Central part of the Mombasa area, Soil survey Mines and Geological Department (1979-1982)	1:50,000	6
Mine ares, Soil survey	1:10,000	10
Geochemical maps; Mombasa quadrangle		91
Kilifi quadrangle		103
2-3 Geophysical maps and reports		
Radiometric (air-borne) survey, Government of Kenya (1958)		
Magnetic (air-borne) survey, Government of Kenya (1977)		
Electromagnetic (air-borne) survey for underground water, Government of Kenya (1977)		
Gravity (ground) survey for modeling of Jombo alkalline rocks Nairobi University		
IP survey at Kinangoni mine		
Geophysical maps; Mombasa quadrangle		41
Kilifi quadrangle		22
3. Mining notes;		
Mining notes: Mombasa quadrangle		18
Kilifi qudrangle		1
4. Unpublished drilling data;		
Unpublished drilling data: Mombasa quadrangle		1
Kilifi quadrangle		9
5. Hydrological data;		
Hydrological data: Mombasa quadrangle		4
Kilifi quadrangle		14
6. Miscellaneous data;		
Miscellaneous data: Mombasa quadrangle		8
Kilifi quadrangle		17

2-2 Geology of the Mombasa Area

The geology of the Mombasa area are shown on Plates 1, 2, 3 and 4. The maps used for this compilation were the Kenya-UK mapping project sheets (22 sheets) at a scale of 1:50,000, reduced to a scale of 1:100,000. The geological sequence with stratigraphic nomenclature are shown on Figure 3.

The principal rock groups in the Mombasa area are the Mozambiquian, found only in the north westward of the area; the Paleozoic and mesozoic, occupy large tracts of the area; and the Tertiary and younger sediments and igneous rocks.

Mozambiquian System

Crystalline rocks of the Mozambiquian System form small outcrops in the northwest of the area. They are principally gneisses and schists.

Paleozoic and Mesozoic

The most widespread unit is a sequence of Paleozoic to Mesozoic rocks in the area. These will be discussed chronologically from the oldest to the most recent.

Taru Formation

The Taru Formation are a thick sequence of massively-bedded, coarse-grained, poorly-sorted gray debris flow deposits, in many ways typical of the broadly glaciogene sediments which mark the start of Karroo sedimentation throughout central and southern Africa in Permo-Carboniferous times.

Maji-ya-Chumvi Formation

The Maji ya Chumvi Formation succeeds the Taru Formation conformably, and with considerable indication of similar depositional environments in its lowermost Member, although it fines upwards and the basal sequence shows evidence of periodic disiccation. The basal beds pass up into a poorly-exposed sequence of fine silty sandstones, the coarser Members of which form subdued ridges, oriented approximate N-S. Grain sizes are always restricted to fine sand and silt, with the coarsest grains reaching only medium sand size. Within the lower part of the Formation there is evidence of a marine incursion.

Mariakani Formation

The lithological boundary which marks the base of the Mariakani Formation is taken to be a change in bedding thickness and the first occurrence of spherical redox speckling or mottling throughout the sandstones as a whole. The Mariakani Formation are characterized by their small range of grading and dominantly fine grain size for a moderately-thick sandstone sequence.

Mazeras Formation

The Mazeras Formation which includes the Mazeras Sandstone and Shimba Grits, displays both unconformable/disconformable contacts with the Mariakani and is locally in faulted contact with it. It is perhaps the most typical of the Formations when compared with other African Karroo basins. Its coarse-grained arkoses and sub-arkoses include granule conglomerates. These are, typically, bleached and are characterised by large-scale trough cross-bedding with well-graded foresets. Silicified fossil wood occurs, both in the sandstones but also in this shale units which occur within this Formation. More regularly interbedded fluvial fining-up sequences with reddened and mottled shale units are well exposed on the main road to Kwale as the road climbs up the eastern scarp of the Shimba Hills. These form the rather dissected hills which parallel the Mombasa coastline and are most commonly faulted on their eastern margins, where they are in contact with the overlying Jurassic sandy limestones of the Kambe Formation.

Close to the Mazeras/Kambe contact, where unfaulted, there is a transitional rock group of calcareous sandstones, sandy limestones and rare micritic limestones.

Kambe Formation

The overlying Kambe limestone, although locally showing brecciated reef structures and fauna, have at their base a bedded sequence of decimetre-scale limestones and shales with calcareous nodules. Oolitls and oncolites are present in these, but the scattered and broken nature of the gastropods and bivalves plus only a very small amount of reef debris points to a considerable reworking of shoreline deposits and redeposition in a rapidly-deepening basin. Sediments in this basin are often turbiditic and consist of finer-grained shales and mudstones (the Mtomkuu Formation) and where exposed give rise to the gentle and sometimes flooded topography parallel to the coastline. Although dominated by shales, the Formation also includes thin beds of sandstone, which have many of the characteristics of turbidite sandstones. The shales worked for the cement factory at Bamburi contain nodules with a good ammonite fauna, believed to be Callovian in age.

Tertiary and Pleistocene sediments

Tertiary and Pleistocene sediments of non-volcanic origine are common on the coast. Raised coral reefs along the coast are of Pleistocene age.

Igneous rocks

Intrusions in the Paleozoic and Mesozoic sediments of the area are few in number. At Jombo and the neighbouring hills, intrusions are alkaline in composition but Mrima Hill is the site of a carbonatite intrusion. Monchiquites, a variety of lamprophyres are found as satellites of alcalline rocks.

Structure

The Mesozoic sedimentary rocks dip gently, and become progressively younger, towards the coast.

The faults of the area shown on Figure 2, Plates 1, 2, 3 and 4 are north-northeast and northwest trending normal faults.

The Mazeras Sandstone contains the first indication of local tectonism and coarsening of the clastic input. Its coarse nature controls sizes of fractures that parallel the newly developing Jurassic basin fractures that are the main locus of lead-zinc-barites mineralization.

2-3 Geological Prospecting of Mineral Occurrences

Some 20 mineral occurrences were initially studied on the basis of the existing data and 15 of them 279 km^2 in total areas, were selected for geological investigation with traverses of approximately 400 line km. Geochemical soil sampling was also carried out on some of the mineral occurrences. The results of the geological investigation are summarized in Table II-2-3.

Summary of the investigation results of ore showings in the project area by the current work is as follows:

i) The types of mineralization in the project area is classified into five types; mineralization associated with carbonatite ore, of vein type, of dissemination - stratiform type, of residual type and of eluvial type.

ii) The mineralizations associated with carbonatite is observed only in the Mrima Hill area, where the intrusive carbonatite body is heavily weathered at its top to form a secondarily

Table II-2-3 Investigation Results of Mineral Occurrences

	Survey Area	Location			Administration	Metal of Minerals	Country Rock	Mineralization				Occurrence, etc.	Previous Work Research and Mining Activity
		Survey of Kenya, Map	UTM Co-ord.					Type	Ore Minerals	Gangue Minerals	Alteration etc.		
			X	Y									
		(1:50,000)											
1.	Mrimo Hill - Jombo Hill	Msambweni & Ndavaya	5_{21} ~ 5_{33}	95_{13} ~ 95_{03}	Msambweni Division, Kwale District	Nb, REE, Th	Carbonatite in Sandstone of Maji ya Chumvi Formation	Carbonatite (Residual)	Pyrochlore, Gorciexite, Monazite, Apatite	—	Weathered, Enriched	Ferruginous and manganiferous residual deposit with an average thickness of several to several hundreds feet, occurs in the form of filling up depression of karst topography. Formed by weathering on the surface of carbonatite body. Ore minerals, such as pyrochlore, gorceixite, are discernible predominantly with minor monazite.	Exploration and ore reserve culculation were made during 1950s~1970s
2.	Kinangoni	Mazeras	5_{71} ~ 5_{75}	95_{76} ~ 95_{72}	Kaloleni Division, Kilifi District	Pb, Ag	Sandstone of Mazeras Formation	Vein (Stock work)	Galena, Anglesite, Sphalerite, Chalcopyrite, Ag-minerals	Quartz, Barite	Silicification, Argillization	Brecciation and mineralization are localized by a system of normal fault (hanging wall and foot-wall), bounding a fissure zone in sandstone of Mazeras Formation. Vein and Breccia (network) mineralization with argentiferous-galena, which is mainly replaced to anglesite, are predominant. Silber contained sulfide minerals, such as argentite, tetrahedrite, stromeyerite, jalpaite are identified.	Open cast and underground mining is being operated. Production: 120 ton Pb conc./month Grade: 60~70% Pb Workers: 150
3.	Vitengeni	Vitengeni	5_{76} ~ 5_{79}	95_{32} ~ 95_{27}	Kilifi District	Ba, (Pb)	Sandstone of Mazeras Formation	Vein	Barite, Galena, Sphalerite, Chalcopyrite	Quartz	Argillization, Silicification	Ore bodies are of lenticular-shaped veins, which are distribued as echelon veins. Barytes are main minerals with minor amount of sulfides, such as galena, shalerite. Dimension of each vein is 20~60 meters along strike and 40~120m along dip. Sulfide mineral contents are increased with the depth.	Open cast mining was suspended by in late 1980s. Barytes powder is being produced from old stockpiles.
4.	Jaribuni	Bamba	5_{81} ~ 5_{83}	96_{01} ~ 95_{95}	Kilifi District	Fe	Limestone of Kambe Formation	Residual	Hematite, (Limonite)	—	Weathered, Enriched	Residual iron ore deposit, which fills up depressions associated with karst topography, formed in surficial part of limestone of Kambe Formation In shallower depth, general granularity of iron ore shows fine. But in deeper depth, ore nodules are lighly glomerated and clustered.	Mine is being operated Production: 180~220 ton/day Ore grade: More than 25% Fe Workers: 400~500
5.	Kiwara Hill	Bamba	5_{76} ~ 5_{78}	95_{95} ~ 95_{91}	Kaloleni Division, Kilifi District	Mn	Sandstone of Mazeras Formation	Residual	Pyrolusite, Cryptomelane, Hollandite	—	Weathered, Replaced, Enriched	Manganese oxide ores which replace sandstone of Mazeras formation are enriched by weathering. Ore is classified into three types, such as dissemination type, replacement types, massive type or nodule type.	Drilling and ore reserve culculation were carried out during 1960s.
6.	Goshi	Mapotea	5_{42} ~ 5_{46}	96_{17} ~ 96_{14}	Kilifi District	Ba	Sandstone of Maji ya Chumvi Formation	Vein, Eluvial	Barite,	Quartz	Argillization, Silicification & Weathered	Massive baryts vein deposit are pursuable 700 metres long as an echelon form. Barytes ore body is of an eluvial type formed by weathering. Barytes ore vein is currently being mined by open pit mining by man-powered hand digging.	Open cast mining had been carried out. Consecutive mining by man power has just started.
7.	Changómbe	Mazeras	5_{66} ~ 5_{68}	95_{69} ~ 95_{65}	Kaloleni Division, Kilifi District	Zn, Pb, Ag	Sandstone of Mazeras Formation	Vein & Stratiform	Sphalerite, Galena, Chalcopyrite	Quartz, Calcite, Barite	Silicification, Argillization	Float is sole traces of mineralization, which seemed to occur as quartz vein and network in sandstone of the Mazeras Formation. Limonitic floats are common in the north. Meanwhile, lateritic soil can be observed in the south.	Drilling had been made in 1960s.
8.	Mwachi River (Tributary)	Mazeras	5_{58} ~ 5_{62}	95_{62} ~ 95_{58}	Kwale District	Zn, Pb, Ag	Sandstone of Mazeras Formation	Vein & Stratiform	Sphalerite, Galena, Chalcopyrite	Calcite, Quartz	Silicification	Mineralization occurs as calcite vein and network with sphalerite and minor amount of galena. Four mineralized zones are specified along the tributary.	
9.	Mkundi	Msambweni & Ndavaya	5_{27} ~ 5_{32}	95_{17} ~ 95_{13}	Kwale District	Cu, Pb, Zn	Sandstone of Mariakani Formation	Vein	Galena, Sphalerite, Chalcopyrite, (Malachite)	Quartz, Barite	Silicification, Argillization	Mineralized quartz vein and network with intensely silicified envelops trunkate and displace lamprophyric dykes. Galena, chalcopyrite, malachite and pyrite occur in quartz veins in Mkundi North. In Mkundi South, silicified zones with quartz fineveins are observed. Hotsprings are active in these areas.	
10.	Lunga-Lunga	Vanga	$5_{09.5}$ ~ $5_{11.5}$	94_{96} ~ 94_{93}	Kwale District	Ba, (Pb)	Sandstone and Siltstone of Maji ya Chumvi Formation	Vein	Barite, Witherite, Galena, Sphalerite	Quartz	Argillization, Silicification	Massive barytes veins with minor amount of galena and sphalertie are distributed as echelon veins. Brecciated barytes vein with fragments, such as barytes, shale, sandstone, occur in veins and in hanging and foot wall rocks. Witherite and barytocalcite are firstly discernible.	Open cast mining had been done in 1980s. Several trenches are observed in Metreni area and near the Tanzanian Border.
11.	Mwena	Kwale	5_{13} ~ 5_{16}	95_{06} ~ 95_{03}	Kwale District	Ba	Sandstone of Maji ya Chumvi Formation	Vein	Barite	Quartz	Silicification, Argillization	Several thin barytes veins are observed. Each vein forms an echelon pattern with maximum length of 40 meters.	
12.	Gandini	Kwale	5_{51} ~ 5_{53}	95_{54} ~ 95_{51}	Kwale District	Ba	Sandstone of Mariakani Formation	Vein	Barite	Quartz	Silicification, Argillization	Several thin barytes veins are observed. Veins show a parallel distribution. But length of each vein is less than 10 meters.	
13.	Mwereni *estimated by floats	Ndavaya	5_{15} ~ 5_{18}	95_{22} ~ 95_{20}	Kwale District	Ba*, Pb*	Sandstone of Maji ya Chumvi Formation	Vein*	Barite*, Galena*	Quartz*	Unspecified	Floats of barytes and galena fragments have been collected. But mineral showing has not yet been specified. Mineralization observed in ore floats are of baryte veins with minor amount of galena.	
14.	Mkangómbe North (Kumbi) South ** estimated by floats	Glanze	5_{14} ~ 5_{21}	95_{41} ~ 95_{35}	Kwale District ditto	ditto**	Siltstone of Maji ya Chumvi Formation ditto**	Vein ditto**	Malachite, Azurite	Quartz ditto**	Silicification ditto**	North (Kumbi) : Quartz vein and network specimen with green-Cu and blue-Cu have been collected from the showings. South : No mineralized showing is observed. Several floats suggest that the same type of mineralization to that in the Kumbi area occurs in this area.	
15.	Mangea-Kwa Dadu	Vitengeni	$5_{75.5}$ ~ $5_{77.5}$	96_{40} ~ 96_{38}	Kilifi District	Pb, Zn, Ag, Ba	Sandstone of Mazeras Formation	Vein	Galena	Quartz Barite	Silicification	Quartz vein network and limonitic gossan are distributed. One pin-hole grain of galena in a milky thin quartz vein, is observed. In southern area, barytes vein network specimen were collected.	Several trenches for exploration are observed in gossan area.

enriched deposit of niobium, rare earths and thorium which are contained in primary minerals or in secondary minerals formed by weathering.

The vein type mineralization consists of zinc-lead-silver quartz veins in the Kinangoni-Chang'ombe areas, of zinc-lead-silver calcite veins in the Mwachi River (Tributary) area and of barite-lead veins in the Vitengeni, the Mwena, the Gandini, the Mwereni and the Goshi areas.

iii) The residual type mineralization observerd consists of concentration of iron oxide minerals in soils, overling limestone bed rock and filling depressions of karst topography forms in the Jaribuni area, and of concentration of manganese oxide minerals in surface soils in the Kiwara Hill area.

The eluvial type mineralization, being mined in the Goshi area occurs directly on the top of the primary barite vein mineralization.

iv) There are 3 operating mines in the Project area, namely, i.e., the Kinangoni lead-zinc, the Jaribuni iron and the Goshi barite mines. Powdered barite ores are currently produced from old ore stockpiles in the Vitengeni as well. Barite-lead ores were ever mined in the Vitengeni and barite (witherite) ores in the Lunga Lunga area.

v) Ore mineralization to the north of the Gandini area continues northeaterly along the Karroo-Jurassic Boundary Fault to the Vitengeni area via the Mwachi River (Tributary), the Chang'ombe and the Kinangoni areas. The southward continuation of the boundary fault beyond the Gandini seems to terminate at around 7 km NE of Kwale but to be discontinuously traceable to the Mkundi. A mineralized zone, extending north-northeasterly from the Mwena area, the Mwereni area toward the Mkang'ombe may form an other mineralized zone and possibly continue to as far as the Goshi. This possibility is supported by the results of the previous geochemical work.

vi) The results of the lead isotope dating on the galena samples from the 6 mineral occurrence areas indicated that the mineralization ages of galena in the Vitengeni, the Kinangoni and the Mwachi River were 227.5 Ma (average of 3 samples), 237.4 Ma (average of 3 samples) and 222.0 Ma (average of 2 samples) respectively and were correlated to middle to upper Triassic age, and that those in the Mkundi, the Mwereni and the Lunga-Lunga were 170.1 Ma, 160.9 Ma and 96.4 Ma (1 sample each) respectively and the former two were correlated to middle Jurassic age and the last was to Albian stage of middle Cretaceous age.

According to these results, the ages of mineralization tend to become younger south southwestward along the Karroo-Jurassic boundary fault in the project area.

vii) It will be necessary for finding new mineralization or verifying mineral potential of the project area to carry out further exploration along the Karroo-Jurassic Boundary Fault and also along the other inferred ore zone located in further inland side. The exploration work of next stage should include studies of regional geology based on remote sensing techniques and re-examination of the existing data, as well as geological and geophysical, electrical in particular, surveys for targets selected on the basis of established geological models for the mineralization.

The following is the description of the 15 mineral occurrences investigated during this year's campaign including location, access, outlines of the existing geological information, general geology and mineralization for each mineral occurrence. Comparative studies of the this year's results to those of the previous works, new geological findings and recommendations for future significance to the exploration targets areas are also included.

(1) Mrima Hill - Jombo Hill Area

(A) Location, Access and Topography

(i) Location and Access

The Mrima Hill-Jombo Hill area is located approximately 65 km southwest of Mombasa, and approximately 25 km northwest of Simoni. Mrima Hill is accessible by motor driving 80 km on the all weather road, Mombasa = Lunga Lunga road from Mombasa via Ramsi to the junction with a road which lead to the south end of Mrima Hill by 500 m.

Jombo Hill is accessible by motor driving 12 km on the gravel road Route E 944 from Mrima Village, northwest of Mrima Hill, to reach to the southern end of Jombo Hill.

(ii) Topography

The Mrima Hill-Jombo Hill area is located in the "Nyika" explicated by Gregory, J.W. (1896). The general topography in the area is represented by a plateau-like flat land pertaining to "Nyika", 150 to 350 ft (35 to 105 m) above sea level, and by a hilly land where Mrima Hill and Jombo Hill are located.

The altitude of the former flat land varies 100 to 350 ft (30 to 95 m) above sea level, while, it is higher in northern part of the area than in southern. The hilly land includes Mrima Hill (approx. 982 ft or 295 m above sea level) and Jombo Hill (approx. 1,543 ft or 463 m above sea-level), which are relatively conspicuous ones in the land. The former extends northwesterly-southeasterly, while, the latter east-westerly. Both of the Hills have the areas of 2.5 km by 2 km at the base of the hills and show a dome-like shape, having relative heights of approx. 700 ft (approx. 210 m) and approx. 1,000 ft (approx. 300 m) above the base of the hills.

The Kiruku, the Nguluku, the Kikonde, which are small hills or hilly land in the area and have the areas of 0.3 km to 1.2 km at the base of the hills, with having relative heights of approx. 150 to 250 ft (approx. 45 to 75 m) above the base of the hills.

(B) Existing Geological Studies

General geology in the area consists of alkaline igneous rocks and associated carbonatite bodies, and sediments of the Maji ya Chumvi Formation. Great geological interests have been drawn in the carbonatite bodies since former days.

General geological informations are publishedly available by Geological Sheet: Mombasa-Kwale Area, 1 to 125,000 scale of Caswell, P.V. (1953), by Geological Sheet: Msambweni and Ndavaya, 1 to 50,000 scale respectively, of Geological Survey of Kenya (1985) and by Geological Map, 1 to 50,000 and 1 to 25,000 scales, of Kenya-Austria Mineral Exploration Project (1977~1978).

Mobley, C.W. initially reported an occurrence of igneous rocks in 1895, particularly alkaline rocks in the area. The geological research in the area was followed in details by Caswell, P.V. (1953) and Baker, R.H. (1953). Recently, Dodhia, S. and Pandit, S. (1977), Winani, P. (1977), Nyambok, I.O. and Lindqvist, B. (1978), Dindi, E.W. (1978) and Ndola, T.N. (1990) have also implemented the geological studies.

Geochemical exploration work of stream sediment sampling for lead, zinc, copper, barium, silver, mercury, chromium, nickel and etc. was implemented by the Kenya-Austria Mineral Exploration Project (1973-1977). Soil geochemistry at various locations in the area have been carried out since then. The summary of the previous geochemical work is tabulated in Table II-2-3-1 (1).

Wide occurrence of iron and manganese oxide minerals concentration in surface soil associated with carbonatite intrusions, has been drawn a keen interest in the mineral potential in the area. Brief historical particulars concerning to research works and ore showings are shown below:

Some 1919	: Soil occurrence with manganese minerals was discovered.
Murray and Hughes (1934)	: Investigated an occurrence of iron and manganese oxide minerals.
Norston, E. (1934)	: Disseminated pyrite and chalcopyrite in dolomitic limestone were studied. Chemical assay shows 1~2 g/t Au, 19 g/t Ag and 1 g/t Pt.
Lathbury, F.H. (1934)	: Collected disseminated pyrite-marcasite-chalcopyrite ore in siliceous rock.

Table II-2-3-1 (1) Statistics of Geochemical Survey on Mrima Hill-Jombo Hill Area

Code No.	Area Name		Mrima Hill	Jombo Hill-Dzihirini		Survey on Anomaly 'N'	Mrima-Jombo	Mrima-Jombo (Follow up)
1-1	Surveyed by		Mines and Geological Department	Mines and Geological Department		Mines and Geological Department	Austromineral GmbH.	Austromineral GmbH.
1-2	Year surveyed		1976	1977		1980	Jan. 1977-Oct '77	Nov. 1977-Nov '78
1-3	Reported by		S. Dodhia & S. Pandi (1977) Investigation Note 1976/3	P. Winani (1977) Investigation note 1977/4		I. K. Githinji (Apr. 1980) South Coast Project	Austromineral GmbH (Oct. 1978) Mineral Exploration Project Report	Austromineral GmbH (Oct. 1978) Follow up works on anomaly D, H & J and seven volcanic vents, Lunga-Lunga barytes deposit.
1-4	Surveyed area (km²)		3.25 km2			12km²	225km²	?
2	Sampling	Numbers of sample	1,382 samples	320 samples (203 samples/169 station: Dzihirini; 117 samples: Jombo)		1,856 samples	1,245 samples	1,841 samples
		Stream sediment or soil	Soil	Soil		Soil	Soil	Soil
		Sampling method	Grid (line spacing 100m)	One traverse lines (Jombo) Two traverse lines (Dzihirini)		Grid (20 lines, 100m line spacing)	Grid (22 lines, 1,000m line spacing)	Grid (11 lines, 180m-200m line spacing)
		Sampling interval	25m	50m		50m	200m	30-40m
		Horizon sampled	B	B		0.2~0.2m below surface	0.3m below horizon A	0.4~0.5m below horizon A
3	Sample preparation	Mesh size analysed	−80 mesh	−80 mesh		−80 mesh	−80 mesh	−80 mesh
		Weight of sample	?	0.75gr/sample		0.75gr/sample	?	?
		Drying hours	?	?		? at 100°C	?	?
		Extracted	?	by 1: 1 HCl and diluted to 15ml		by 1: 1 HCl and diluted to 15ml	by N HCl	by N HCl
4	Assay	Elements analysed	Pb, Zn, Cu	Pb, Zn, Cu, Ba, Mn & Ag		Pb, Zn, Cu, Ba, Cd & Mg	Pb, Zn, Cu, Ba, La, Mg & As	Pb, Zn, Ba, Cu, Mn & Mg
		Equipment	Atomic Absorption Spectometry (AAS)	Atomic Absorption Spectrometry (AAS)		Atomic Absorption Spectometry (AAS)	Atomic Absorption Spectometry (AAS)	Atomic Absorption Spectometry (AAS)
5	Data statistics			(Jombo Hill)	(Dzihirini)			
		Numbers of data	1,382	117 (1 traverse line)	203 (2 traverse lines)	1,856	1,245	1,841
		Statistics	Pb Zn Cu	Mn Ba Cu Zn Pb	Mn Ba Cu Zn Pb	Pb Zn Ba Cu	Pb Ba Cu Zn La	Pb Zn Ba Cu Mn & Mg
		· Mean (ppm)	236 ? 34			17 60 280 20		
		· Standard deviation (ppm)	150 ? 14			16.4 40.3 208.3 15.2		
		· Range (ppm)	35 80 4 ~ ~ ~ 1,284 4,720 118	490 70 10 26 8 ~ ~ ~ ~ ~ 2,010 1,370 144 158 32	180 30 1 6 3 ~ ~ ~ ~ ~ 2,730 460 180 226 32			
6	Anomaly & Interpretation	Anomaly (threshhold)	x + 2.5σ (ppm)	?	?	x + 2σ (ppm)	Graphic Method	Graphic Method
			Pb Zn Cu	Mn Ba Cu Zn Pb	Mn Ba Cu Zn Pb	Pb Zn Ba Cu	Pb Ba Cu Zn La	Pb Zn Ba Cu Mn Mg
		Above (ppm)	611 3,000 69	2,603 1,094 102 123 27	1,867 235 70 101 33	50 140 700 50	180* 2000* 110* 400* 7,000* 50* 500* 40* 100* 3,500*	
		numbers of anomaly	5 6 4				No sample has been taken on the Mrima-Jombo hills and slopes.	2 2 2 – – –
7	Follow up survey					Four follow up Diamond Drill Holes		

* high and medium anomaly

	Chemical assay shows 0.5 g/t Au and 2~6 g/t Ag.
Yates, H.W. (1942)	: Barite-associated manganese oxide ore and limonite were reported. Ore reserves indicate 624,000 tons, which are limited to the surficial part properly, 0.6 m thick.
Pulfrey, W. (1948)	: Reviewed the existing geological informations. Concluded a geological potential of lead mineralization in the area and recommended an execution of systematic research and drill.
Thompson, A.O. (1952)	: Delineated spontaneous potential anomalies, extending NE 30° directionally, by electrical investigation. Estimated an occurrence of lead vein mineralization. Delineated radioactive anomalies in the area to conduct a monazite occurrence, however, was really found to be of a pyrochlore occurrence.

In accordance with the examinations of the previous research results, occurrences of base metal mineral resources, such as manganese, iron and also gold, silver, lead, niobium, rare earths, phosphate have been expected to be potential and promising in Mrima Hill area. Mines and Geological Department, followed by the Anglo-American Corporation of South Africa Limited, has initially started the research works on niobium resources properly. Pechiney-Saint-Gobain have further followed the exploration work on rare earths resources, particularly on europium. Exploration work results are tabulated in Table II-2-3-1 (2).

Caswell, P.V. (1953) reported a gold occurrence in Jombo Hill area. Caswell has refered geological informations obtained in 1930s, which are inevitably obscure as the backup reference for the current work.

Mineral occurrences, other than gold, have never been reported in Jombo Hill.

(C) General Geology and Mineralizaiton

Geological map and geological cross sections in the area, 1 to 25,000 scale, are shown in Figure II-2-3-1 (1) and geological sketches in Figure II-2-3-1 (2).

(i) General geology

General geology in the area consists of upper member of the Maji ya Chumvi Formation, lower member of the Mariakani Formation and middle member of the Mazeras Formation in ascending order, which are intruded by alkaline igneous rocks, those are

Table II-2-3-1 (2) Statistics of Exploration Activities on Mrima Hill Ore Deposits

			Mines and Geological Department	Anglo American Corporation of South Africa Ltd.		Mines and Geological Department		Pechiney-Saint-Gobain
1	Year Surveyed		1953~1955	Dec. 1955~1957 (Final Report; August 1957)		1959~1962 (F. D. Bingo & P. Joubelt, 1966)		1968~1971
2	Pit	Numbers of pit Digging meters	162 2,916ft	More than 400 More than 12,000ft	400ft along lines, 200 ft line interval Minimum distance between pits: 280ft			539 NA
3	Trench	Numbers of trench volume removed						59 12,192m³
4	Drilling	Numbers of drill Total length	2 NA	10 3,669ft				177 2,975m
5	Schaft	Numbers of schaft Total length	3 NA					
6	Wintz	Numbers of wintz Total length		9 NA				
7	Adit	Numbers of adit Total length		1 1,000ft				
8	Sample	Numbers of sample		Total : 4,795 spls (for Nb content) pit sample : 385 core sample : 1,049 wintz sample : outcrop sample : 3,325 miscelaneous :				Total : 5,152 spls for Eu assay : 2,000 for La, Ce, Nb assay : 920 for Eu, REE, Nb assay : 949 for Nd assay : 500 others : 783 mineralogical chemical physical beneficiation (200 tests by Nb, Eu, La, Ce & Nd)
9	Ore for Various Tests			Bulk samples for various test : 14 tons represented carbonatite : 4 tons weathered ore : 10 tons				Handpicked : 60 tons (Eu rich ore) For various studies : 43 (mineralogical, physical and beneficiation studies) For Eu processing test : 100 For Nb processing test : 20 For Nb beneficiation labo-test : 7 To Msambweni pilot plant : 900
10	Ore Reserve	Year calculated	calculated in 1955	calculated in 1957		calculated in 1960		Ore reserve calculation is not available.
		Depth	top 20ft of soil	30ft below surface	30 to 100ft below surface	30ft below surface	same as left (high grade ore)	
		Reserve	30million tons	55mil. tons	50mil. tons	41.8 mil. tons	4.93 mil. tons	
		Grade	0.72% Nb_2O_5	0.67% Nb_2O_5	0.70% Nb_2O_5	0.67% Nb_2O_5	1.15% Nb_2O_5	

NA: not available

further overlain by upper member of the Magarini Formation and upper-most sediments, composed of talus, soil, sand and mud.

Upper member of the Maji ya Chumvi Formation consists of silty sandstone with flaggy texture and is correlated to the lower Triassic age. Lower member of the Mariakani Formation is composed of medium- to coarse-grained sandstone, massive, greenish gray and consolidated. Middle member of the Mazeras Formation is composed of massive arkose sandstone with well-developed cross-bedding feature and is correlated to the middle Jurassic age.

Occurrences of alkaline intrusive igneous bodies observed in the above formations are enumerated being alkaline complex, intruded by carbonatitic rocks in Mrima Hill, alkaline complex in Jombo Hill, as well as agglomerate, presumably formed in the old vent in Nguluku Hill. Fenites in Kikonde and syenite 1.5 km west of Henzamwenye are observed in the forms of small hills or hilly land.

Mrima Hill Body

Mrima Hill Body is geologically composed of carbonatite, agglomeratic carbonatite, fenitized rock and talus sediment of the above rocks and weathered carbonatite soil (Figures II-2-3-1 (1) and II-2-3-1 (2)).

· Carbonatite

Calcite occupies more than 90 percent of the whole mineral components. Carbonatite bodies are marginally associated with sövite having sparse plagioclase and opaque minerals, as well as biotite carbonatite and dolomitic carbonatite. Agglomeratic carbonatite body is observed in northern slope of the hill, being allocated in central part of the carbonatite body at the hill crest.

Mineral components of carbonatite are shown below:

carbonate minerals (calcite, dolomite), hornblende, pyroxene, olivine, feidspar, mica (biotite, phlogopite), chlorite, epidote, magnetite, quartz, barite, sulfide minerals (pyrite, pyrrhotite, galena, sphalerite, marcasite), pyrochlore, monazite, apatite, ilmenite, rutile, zircon and etc.

· Fenitized sediments

Fenitized sandstone and siltstone, formed by a carbonatite intrusion in marginal vicinity of Mrima Hill Body is observed in south-western and south-eastern parts of the body.

· Talus sediment

Talus sediment, formed by the weathered products of hill-forming carbonatite and agglomerate, is observed in marginal part of the Mrima Hill Body.

· Soil by weathering of carbonatite

There are 2 kinds of soils; one is pisolitic, reddish brown and limonitic, the other, kaolinitic and grayish white. Pyrochlore, barite and manganese montmorillonite are associated with the former. The latter is characterized by carrying hematite. The soils are observed in small basins formed at the crest of Mrima Hill or in depressions related to the karst topography formed at the top of the carbonatite body. The soils pose a significant factor concerning to the genesis of carbonatite mineralization and enrichment as shown hereinafter.

Secondary minerals formed by rock weathering are shown below:

limonite, manganese oxide minerals (cryptomelane, pyrolusite and etc.), kaolinite, montmorillonite, gorceixite, florencite and etc.

<u>Jombo Hill Body</u>

Jombo Hill Body is of alkaline complex, with which micro-foyaite having a ring-wise marginal facies, and foyaite-melteigite having a hybrid facies inside of the above are associated. Nepheline syenite is also observed in central part of the body.

General rock facies of alkaline complex forming components are shown below:

· Micro-foyaite

Fine-grained, relatively homogeneous in general. Anhedral orthoclase and nepheline are frequent. Forms a outer-most marginal facies of the body and small hills topographically in general cases.

· Foyaite

Shows a horse-shoe-like distribution circumscribing northern and northeastern to eastern slope of the hill body. Shows a frequent rock facies variation, medium- to coarse-grained associated with reddish-brown nepheline and orthoclase, 5 to 20 mm long, and or microperthite.

· Melteigite

Occupies an area of southern part of Jombo Hill. Medium- to coarse-grained, dark gray to black, associated with euhedral hornblende, nepheline and pyroxene, 0.5 to 5 mm long. Shows a frequent rock facies variation, as same as foyaite.

· Nepheline syenite

Observed in two locations at the crest of the body. Considered to be an intrusion at the later stage of the igneous activity. Discriminated by having a peculiar rock colour due to pale brown nepheline and greenish gray feldspar. Hard, homogeneous and medium- to coarse-grained, majorly composed of euhedral nepheline, alkali feldspar (clinoperthite) and pyroxene (monoclinic pyroxene). Quantitative ratio of these minerals shows 50 to 55 percent, 35 to 40 percent and 3 to 7 percent, respectively.

· Associated intrusive rocks

Kiruku Body in eastern end of the area and Nguluku Body in northern end are considered to be of vents by igneous activities of alkaline rock and are composed of so-called "agglomerate". Kiruku Body consists of lithic fragments of silicified sandstone and limonite. Fine- to medium-grained chalcedonic silica minerals, alkali feldspar and limonite with approximately equivalent quantity ratio are observed under a microscope. Ngukulu Body is associated with an intrusive rock, monzonite and syenite, at the location 1.5 kilometres northwest of Henzamwenye Village. The intrusive rock is gray, medium-grained and homogeneous, and is microscopically composed of plagioclase, alkali feldspar, hornblende, having a ratio of 40 to 60 percent, 35 to 50 percent and 2 to 8 percent, respectively. The groundmass is cemented by quartz, feldspar and calcite. Rock fragments of sedimentary rocks are several millimetres to ten centimetre long.

A hilly land, extended northwesterly-southeasterly and located 2.5 km north of Mrima Hill, is composed of fenitized sandstone by abundant small dykes of syenite (Caswell, P.V. (1953)).

Numerous alkaline intrusive bodies, observed in the area, are enumerated to be of lamprophyric dykes, such as sannite, camptonite, monchiquite, and syenite.

(ii) Mineralization

Alkaline igneous rocks are widely observed in the area in various forms. Carbonatite body in Mrima Hill is solely noticeable for an attention to the evaluation of mineral resources in the area. The carbonatite body has been remarked since former days, as shown before, for a potential of manganese resources initially, consecutively been followed to be of gold, silver and lead resources, and also thorium, niobium and rare earths resources recently.

The remarkable mineralization in the area is represented by an occurrence of pyrochlore, gorceixite and minor amount of monazite by an enrichment of primary components after a weathering of carbonatite body. The characters of the mineralization in the area are summarized as follows:

· Distribution form of mineralization

Mineralization occurs in the form to filling up depressions of karst topography formed by weathering on the surface of carbonatite body. The average thickness of mineralized zone varies several feet to several hundreds feet. It shows two types of mineralization, i.e., kaolinitic and limonitic-manganiferous.

· Ore minerals

Ore minerals associated with the carbonatite body in the area are summerized below:

niobium: pyrochlore

rare earths : gorceixite, pyrochlore, monazite, florencite

thorium : pyrochlore, gorceixite, apatite

· Ore reserves and ore grade

Ore reserves and ore grade of mineralized carbonatite body in the area are shown in Table II-2-3-1 (2).

Ore reserves of rare earths and thorium minerals are estimated by Kenya Department of Mines (1955), to be of 31 million tons of soil ore and 3.1 percent REO and thorium.

During this years campaign, 4 sampling points, old pits and trenches, were selected to verify the existing assay results. Samples were collected from the walls of the pits and trenches, and were assayed for REEs, U, Th, Y, Sr and other elements Niobium contents, ranging from 650 to 8,530 ppm, were arithmetically averaged at 5,262, 1,634 and 5,840 ppm respectively at the 3 sampling points, No. 1, No. 2 and No. 3.

Total REE contents, ranging from 3.14% to 14.58%, were arithmetically averaged at 4.19, 6.10 and 7.59% respectively at the 3 sampling points, No. 1, No. 2 and No. 3.

The contents, ranging from 625 to 3,425 ppm, were arithmetically averaged at 1,521, 1,139 and 2,200 ppm respectively at the 3 sampling points.

These assay results fluctuate in very wide ranges but the average for each sampling point are nearly equivalent to the one obtained in the past work.

(D) Examination

30 rock samples were collected from the walls of the old trenches and pits in the Mrima Hill carbonatite ore deposit and analized for total of 23 elements which include 8 REEs, Y, U, Th, Sr and Nb.

All the results are shown in Appendix- . The assay results of the samples taken at 4 localities were nearly equivalent to those of the samples collected in the past work for the elements such as Nb, REEs and Th. Contents of Ba, P and Pb in the rock samples were much higher than those in the soil samples but to insignificant extent for commercial consideration.

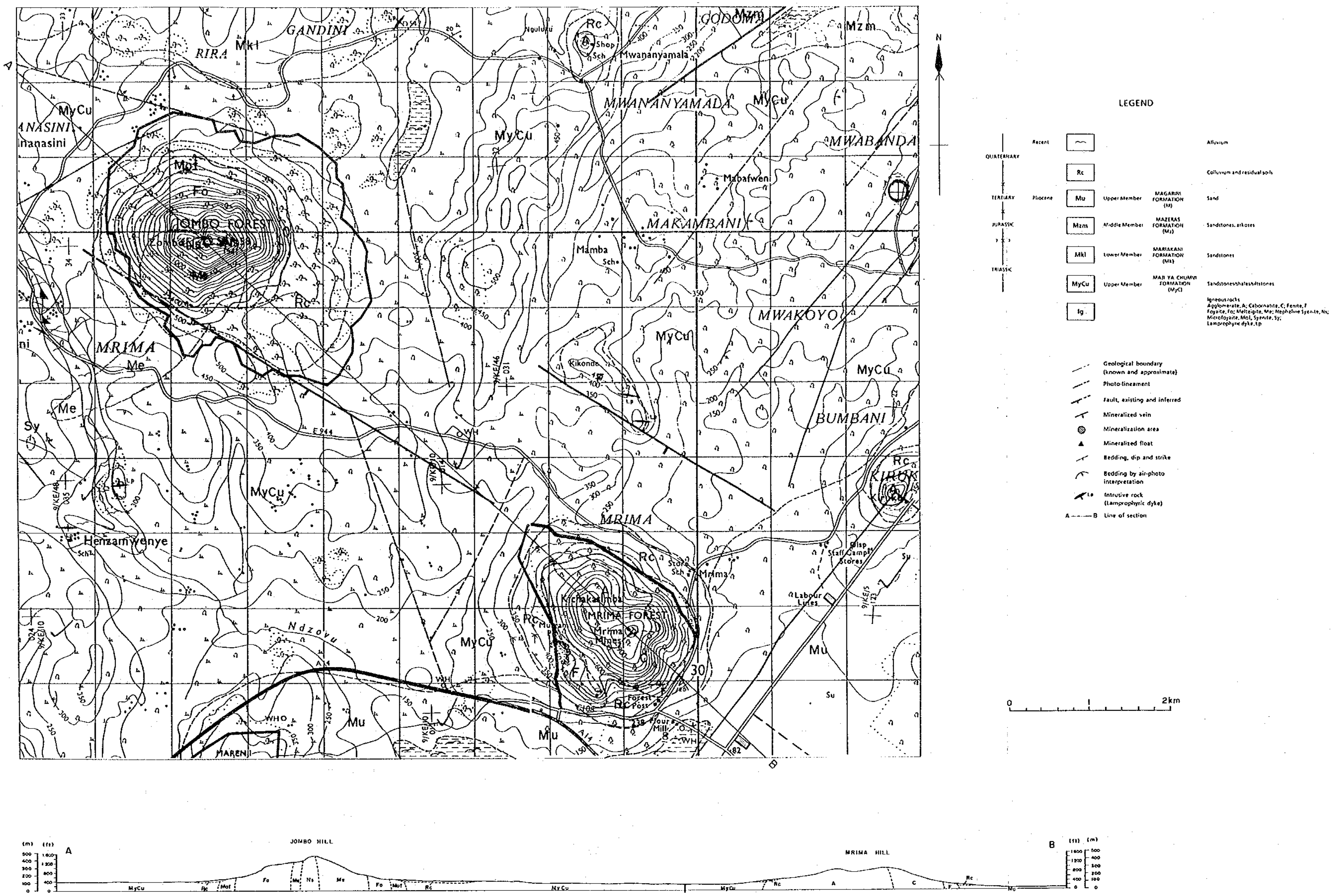


Figure II -2-3-1 (1) Geological Map of the Mrima Hill - Jombo Hill Area

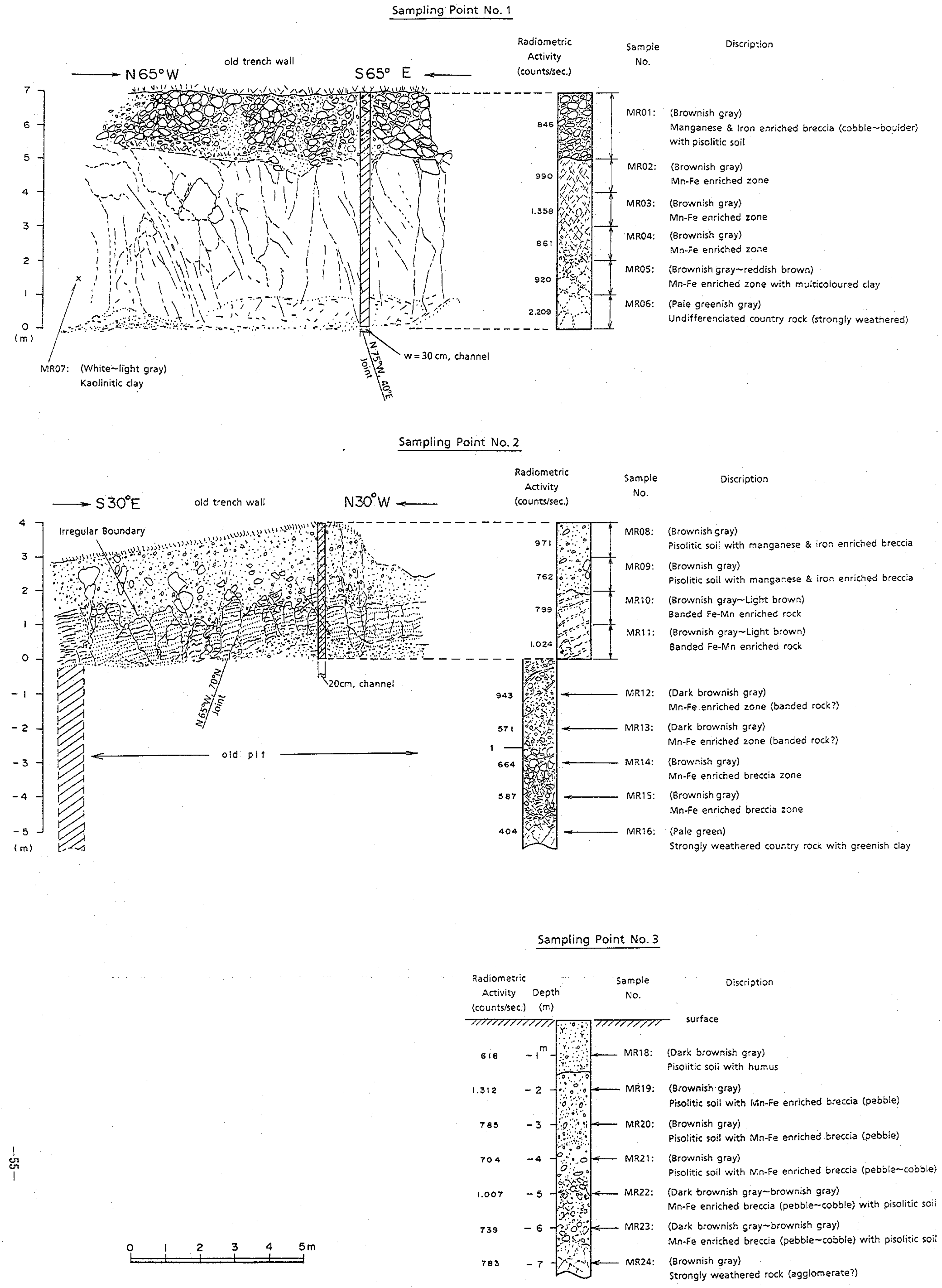


Figure II-2-3-1 (2) Geological Sketches of Sampling Points (No. 1, No.2 and No. 3)