the anomalous values by the component are considereded to be possibly caused by a concentrations of heavy metallic elements in weathered soils of the lower and middle members of Maji-ya-Chumvi Formation.

The second and the third principal components are estimated to show the behaviours of arsenic and sulphur with weak relations to other elements.

Lead and barium provide slightly high contribution ratios for the fourth principal component. Lead shows a positive correlation, while barium shows a negative one. The scores of the fourth principal component on each sample were examined to judge a presence of a relation to mineralization, however, the result is negative by showing a scattered mode of appearance of samples of high scores.

The principal component, which is estimated to be properly influenced by the mineralization in the Area, has not yet been pointed out. The cumulative contribution ratio by the first through the fourth principal components reaches to be of some 90 percent.

4-3-4 Interpretations of geochemical anomalies

The localities of geochemical anomalies in the Area are shown in PL.9, PL.10 and PL.14.

The general geochemical characteristics of the respective pathfinders examined by the current works are stated below:

<u>Gold</u> : Gold is estimated to be irrelative to the mineralization in the Area by general showing of low content in three specimens of more than 2 ppb, while, 7 ppb is the highest.

<u>Silver</u> : The whole samples show a content of less than 0.2 ppm of silver, that is below the detection limit.

<u>Copper</u> : Eight samples show anomalous values of copper, 73 ppm is the highest. Low anomalous values are scatteredly observed to unlikely represent an anomalous zone. Anomalous values are chiefly observed in the areas covered by the middle and lower members of Maji-ya-Chumvi Formation. Two sample values, numberd as MD 016 and MC 021, shown nearby the occurrence of quartz ore veins, are inferred to be possibly influenced by the mineralization by showing a content of 73 ppm and 33 ppm, respectively.

<u>Lead</u> : Eight samples show anomalous values of lead, 108 ppm is the highest. Low anomalous values are scatteredly observed to unlikely represent an anomalous zone. Anomalous values are chiefly observed in the areas, covered by the middle and lower members of Maji-ya-Chumvi Formation in overlapping mode of appearance with copper anomalies by three specimens. A geochemical relation to the mineralization in the area is estimated to be negligible.

<u>Zinc</u> : Four samples show anomalous values of zinc, 464 ppm is the highest. The samples of anomalous values are randomly observed to unlikely represent an

anomalous zone. Two sample values, numbered as MD 016 and MB 116, shown nearby the occurrence of quartz ore veins, are inferred to be possibly influenced by the mineralization by showing a content of 464 ppm and 224 ppm, respectively.

Barium : One sample of low anomalous value of barium of 900 ppm is observed. A geochemical possibility of an influence by the mineralization in the area is unlikely estimated.

Manganese : Three samples show anomalous values of manganese, 4,310 ppm is the highest. The samples with anomalous values were collected in separate locations, some one kilometer apart, in southern part of Mkangombe Village. Each anomalous value is observed in overlapping modes of appearance with that of iron to lead to a suggestive concept of genesis by the geological occurrence of ferruginous concretions nearby the sample locations that a concentration of manganese might be caused by a formation of ferruginous concretions in soils.

Iron : Twelve samples show anomalous values of iron, 12.65 percent is the highest. The iron-anomalous values are scatteredly observed in the modes of grouping of one or two samples in the places, where the middle and lower members of Maji-ya-Chumvi Formation cover, to unlikely represent anomalous zones. The occurrence of ferruginous concretions is observed nearby the locations, where samples with iron-anomalous values were collected to lead to a suggestive concept of genesis that iron and manganese, copper, lead, zinc, barium, and etc., which are estimated to be closely related to iron geochemically, might be concentrated in soils in accordance with the formation of ferruginous concretions.

Arsenic : Nine samples show anomalous values of arsenic, 30 ppm is the highest. Low anomalous values are scatteredly observed to unlikely represent anomalous zones. Geochemical relations to geology and geological structure are also estimated to be negligible.

Mercury : Three samples show anomalous values of mercury, 4 ppm is the highest. Anomalous values are scatteredly observed to unlikely represent anomalous zone, while, geochemical relations to geology and geological structure are also estimated to be obscure.

Sulphur : Two samples show anomalous values of sulphur, 0.031 percent is the highest. The samples with sulphur-anomalous values were collected in the locations in and closely nearby the occurrence of quartz vein ore mineralization.

4-4 Interpretation

4-4-1 Mineral potential

The turget ore deposit in the Area is base metals quartz vein associated with gold and silver. A couple of important information of this mineralization have been obtained through the current survey for the first time. Two of major things revealed through the survey are as follows.

1 Mode of mineralization on the ground surface in Mkangombe North Ore Showing.

2 Existence of a zone characterized by the development of quartz veins including Mkangombe South Ore Showings.

The quartz veining mineralized zone is considered to be the most potential zone of mineralization in the Area.

4-4-2 Results of geochemical research works and mineralized zone

The geochemically anomalous values shown in Mkangombe Area are scatteredly observed overall to unlikely represent geochemical anomalous zones of significance.

A couple of anomalous value of copper and zinc, to likely be under a possibly geochemical influence of mineralization, is observed nearby the occurrences of quartz ore veins and quartz ore floats.

The geochemical anomalous zones of significance in the Area, which are estimated to be represented under a geochemical influence by the significant mineralization, have not yet been pointed out by the current works, however, further geochemical works, carried out on reconnaissance routes of short-ranged intervals in detailed scale in the mineralized zones of quartz ore veining, are envisaged to effectively reveal a potential possibility to represent geochemical anomalous zones of significance in the Area.

Four elements, such as gold, copper, lead and zinc, are estimated to be preferentially employed as the pathfinders for further works by the following bases:

Gold : A geochemical anomalous zone of 407 ppb value by soil geochemistry has been represented in Mkangombe North by first-year programme work.

Copper and zinc : Quartz veins occurrences, associated with copper and zinc minerals, are observed in the Area. The samples with anomalous values of copper and zinc by possible mineralization influences were collected by the current work.

Lead : Quartz veins occurrences, associated with lead minerals, are observed in the Area by the current work.

A part of copper-lead anomalous zones, to be necessarily examined separately, is considered to be represented by those, which could be overlappedly shown by the occurrences of ferruginous concretions.

4-4-3 Future work programme

Implementations of diamond drill operations for deeper portions of Mkangombe North Mineral Showing, in which a most distinct mode of mineralization in the quartz veining mineralized zone has been specified by ground surface mapping, are deserved to be warranted in Mkangombe Area.

CHAPTER 5 MRIMA-JOMBO AREA

5-1 Measures of Survey Works

Geological mapping and geochemical exploration works, covering an area of 100 sq. km, route-mapping of a 88.9 km extension in total and collecting 262 soil samples in total, were carried out in the field during the course of the current work programme. Measures of the survey works are identical with that in Ganze Area.

5-2 Results of Geological Research

5-2-1 General geology

Geological map and geological cross-sections in Mrima-Jombo Area are shown in Figure II-5-1, representative geological profile is in Figure II-5-2, respectively.

General geology in the Area majorly consists of the sediments of Triassic to Jurassic ages, volcanic rocks of Cretaceous age and the unconsolidated sediments of Tertiary to Quaternary ages. Triassic to Jurassic sediments are mainly of sandstone beds. Volcanic rocks, which show the largest coverage of occurrence in the Area of the current programme, are observed in the form of intrusives of varied type of alkaline volcanic rocks. Unconsolidated sediments are observed to be of Tertiary sediments and of colluvial, residual and alluvial sediments of Quaternary age.

(1) Maji-ya-Chumvi Formation (MyCu)

Maji-ya-Chumvi Formation is widely observed from south-western to north-eastern parts in the Area and is mainly composed of sandstone beds, correlated to be of Lower Triassic age. A small occurrence of shale beds is observed in one location in the Area, however, the extension is still obscure. Sandstone beds show grey to dark grey and fine-grained with local developments of thin-bedded flaggy texture.

(2) Mariakani Formation (Mkl)

Distributions of the Lower Member of Mariakani Formation (Mkl) are estimated by floats pursuits in north-western margin of the Area. They are mainly composed of sandstone, brownish grey, very-fine-grained to fine-grained, compact and massive with locally developed weak lamina textures.

(3) Mazeras Formation (Mzm)

The Middle Member of Mazeras Formation (Mzm) is reported to cover north-eastern corner of the Area, being composed of arkose massive sandstone beds with a development of cross-limina textures and of Middle Jurassic age.

(4) Magarini Formation (Mu)

The Upper Member of Magarini Formation (Mu) is reported to cover south-eastern part of the Area, overlying Maji-ya Chumvi and Mazeras Formations, being mainly composed of unconsolidated sand beds, less-graded, creamy white, dominated by quartz and of Pleiocene-Neogene age.

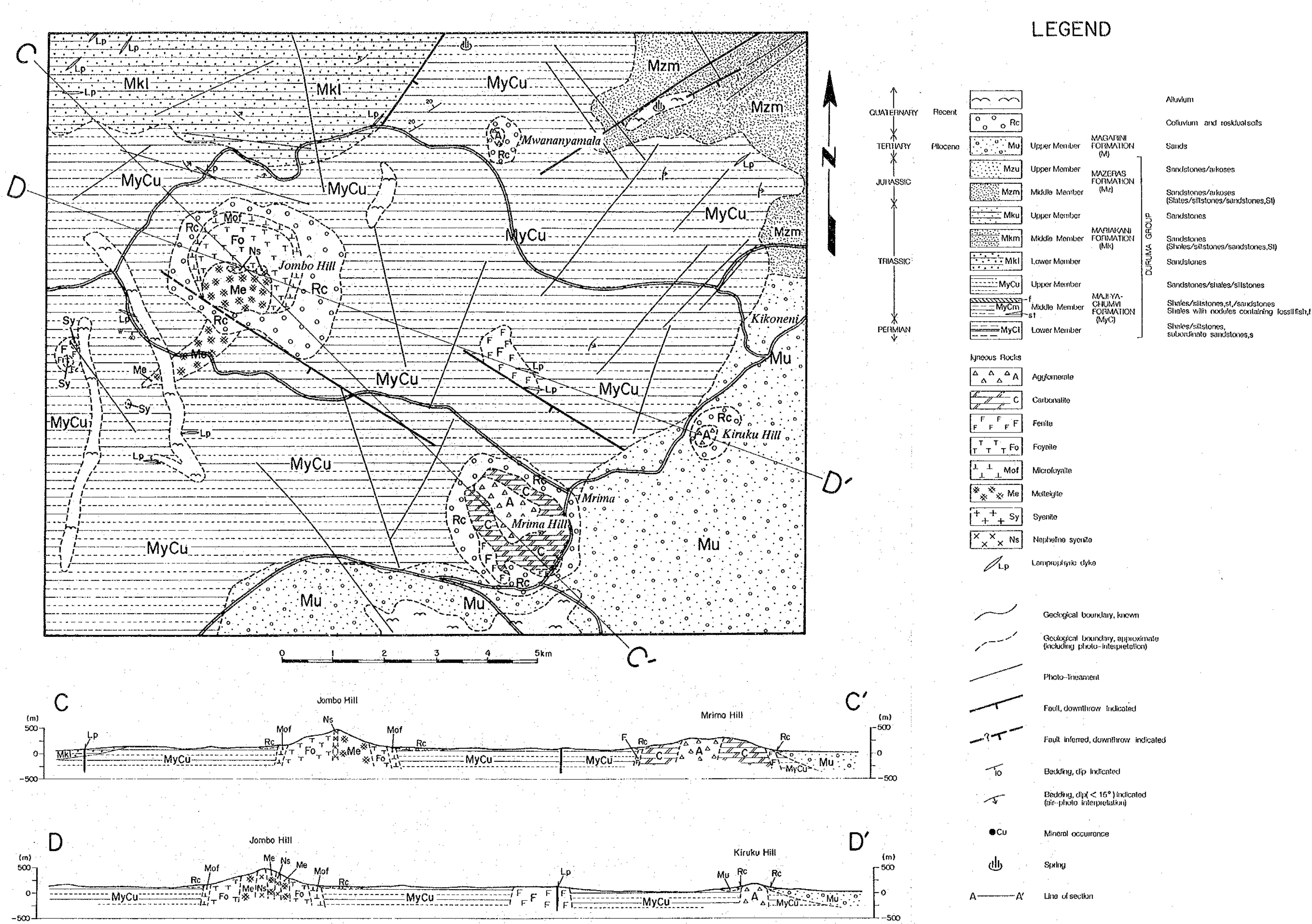

Figure II–5–1 Geological Map of the Mrima-Jombo Area

Geologic age	Geologic unit		Symbol	Column	Rock facies	Event
Quaternary	Alluvium				Sands, gravels	
	Colluvium & residual soils		Rc		Breccias, soils	
Tertiary (Pliocene)	Magarini f.	Upper m.	Mu		Sands	Mukundi Pb-Zn Cu Mineralization
Tertiary or Cretaceous	Alkaline intrusive rocks		A, C, F, Fo, Me, Ns, Mof, Sy, Lp		Aggromerate: A, Carbonatite: C, Fenite: F, Foyaite: Fo, Melteigite: Me, Nepheline syenite: Ns, Microfoyaite: Mof, Syenite: Sy, Lamprophyric dyke: Lp	Alkaline igneous activity + Nb, REE Mineralization Faulting
Jurassic	Mazeras f.	Middle m.	Mzm		Sandstones	Down-warping
Triassic	Mariakani f.	Lower m.	Mkl		Sandstones	
	Maji-ya-Chumvi f.	Upper m.	MyCu		Sandstones, shales, siltstones	

f. : formation   m. : member

Figure II-5-2 Generalized Geological Columnar Section of the Mrima-Jombo Area

(5) Igneous rocks

Varied occurrences of alkaline igneous rock bodies, which are in the form of intrusives into the sediments of Mesozoic age, are observed in the Area, such as alkaline rock complex, intruded by carbonatite in Mrima Hill, alkaline rock complex in Jombo Hill, agglomerate, estimated to be formed close to the former craters in Kiruku Hill and Nguluku Hill, fenites in Kikonde, and syenites forming small hills or hilly region 1.5 km north-westward from Henzamwenye.

a) 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.

· Carbonatite (C)

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, feldspar, mica (biotite, phlogopite), chlorite, epidote, magnetite, quartz, barite, sulfide minerals (pyrite, pyrrhotite, galena, sphalerite, marcasite), pyrochlore, monazite, apatite, ilmenite, rutile, zircon, etc.

· Fenitized sediments (F)

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 (Rc)

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.

Secondary minerals formed by rock weathering are shown below:

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

b) Jombo Hill Body

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 (Mof)

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 (Fo)

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 (Me)

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 (Ns)

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.

c) Associated intrusive rock bodies

Kiruku Body in eastern part of the area and Nguluku Body in northern central 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. Nguluku body consists of lithic fragments of sedimentary rocks such as sandstone and shale. The size of lithic fragments varies from several millimeters to ten centimeter long. The groundmass is cemented by quartz, feldspar and calcite.

Several syenite intrusive bodies, being accompanied by fenitized sandstone, occur in a area of 3.5 km to 4 km southwest of Jombo Hill. The syenite 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.

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.

5-2-2 Geological structure

The general geological structure in the Area is interpreted to show ESE-WNW to ENE-WSW trending with gentle dipping toward north in north-western part of the Area, while, NNE to SSW trending with gentle dipping toward east in eastern part. Magarini Formation is estimated to be of generally flat sediments.

Two types of fault, ESE to WNW and ENE to WSW directional which show an accordant representation with the lineaments on air photographs, are developed in the Area. Lamprophyric dykes show the trends, such as N60°W, N75°W, N40°E and etc, which are also directionally accordant mostly with faults and the lineaments shown on air photographs.

5-2-3 Ore showing and mineralized zone

The localities of mineral occurrencies of the Area are shown in PL.6.

Mineral occurrence and ore showing, ever known in the Area, are stated below:

(1) Carbonatite ore body in Mrima Hill

Carbonatite ore body in Mrima Hill has been noticed as the resources of iron and/or gold, silver, lead, further of noobium, rare earths elements and thorium in recent years. Carbonatite ore bodies in Mrima Hill are estimated to be formed by the geological enrichment after weathering of primary pyrochlore, monazite, secondarily formed gorceixite and etc.. Geological generals of ore bodies, elucidated by the previous research works, are summarized below:

- Occurrence of ore bodies

  Ore bodies in Mrima Hill occur on superficial depressions of carbonatite body, formed by weathering, as the filling materials of karstic lay. General thickness of the bodies varies in the range of several feet to several hundres feet. Ore bodies, themselves, are kaolinitic and/or limonitic-manganiferous.

- Ore minerals

  Niobium : pyrochlore
  REE : gorceixite, pyrochlore, monazite, florencite
  Thorium : pyrochlore, gorceixite, apatite

- Ore reserves and ore grade by existing reports

  Refer to Table II-5-1.

Table II-5-1 Ore reserves of carbonatite ore body, Mrima Hill

		by Mines and Geological Department	by Anglo-American Corporation of South Africa Ltd.		by Mines and Geological Department	
Ore Reserves	Year calculated	1955	1957		1960	
	Depth	Top 20 ft. of soil	30 ft. below surface	30 to 100 ft. below surface	30 ft. below surface	same as left (high grade ore)
	Reserves	30 million tons	55 million tons	50 million tons	41.8 million tons	4.93 million 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

(2) Ore showing of iron and manganese

Concretions of iron-manganese oxide minerals, five millimetres to some ten centimetres diameter, are observed in lateritic soils on the hill slopes of Mrima Hill. Geological and economical investigations and research works on the above concretions have been implemented by various private sectors or public organizations. The major mineral compositions of the concretions are of pyrolusite, psilomelane, hematite, limonite, barite and etc., while, a concentration of gold, silver, copper, lead, zinc and etc. is also reported. Chemical assay values of major metals by Carswell, 1953 are shown below:

MnO_2	:	30.51 – 60.80	%	by 4 specimens
MnO	:	4.38 – 6.60	%	by 3 specimens
Fe_2O_3	:	8.20 – 45.20	%	by 4 specimens
Cu	:	0.02	%	by 1 specimen
Pb	:	0.04	%	by 1 specimen
Zn	:	0.21	%	by 1 specimen
Au	:	0.8	g/T	by average of 3 specimens
Ag	:	5.6	g/T	by average of 4 specimens

g/T : gramme per ton
% : percent

Field reconnaissance of the concretions occurrence and chemical assay of two speciments were carried out by the current works. The chemical assay values are shown in Table II-5-2.

Table II-5-2 Results of chemical analysis of iron-manganese concretions

	Gold g/T	Silver g/T	Iron %	Manganese %	Copper %	Lead %	Zinc %
F009	< 0.07	76	30.0	> 3.00	0.006	0.014	1.015
H010	< 0.07	< 2	35.9	0.098	0.005	0.004	0.007

g/T : gramme per ton
% : percent

A concentration of iron and manganese, and of silver and zinc is observed by the current works. The concentration of iron and manganese is estimated to be formed by the weathering of carbonatite body. Sedimentary rocks and/or subsurface lead-zinc-barite ore body are presumed to be one of the materials of consideration that estimates a source of gold, silver or base metals.

(3) Other ore showing

Gold : An extraordinary instance of occurrence of electrums in nepheline syenite in Jombo Hill has been reported by Carswell 1953, however, is to be estimated to be less promising economically for future considerations.

Lead : An occurrence of sparse galena-disseminated mineralization in Maji-ya-Chumvi Formation in western Mrima has been reported by Carswell 1953, however, is estimated to be of less economical.

5-3 Results of Geochemical Exploration Research

5-3-1 Chemical analysis and interpretation

The general procedures of geochemical analysis and detection limit values of rare earths elements and etc. are shown in Table II-5-3. Those for gold, copper, lead, zinc, iron, manganese and barium are identical to as shown in Table II-1-1.

The general procedures of interpretations are also identical to those in Ganze Area. Statistical analysis works were implemented on the basis of the population of geochemical specimens properly collected in the Area.

Table II-5-3 Analytical Procedures

Element	Unit	Description	Method	Detection Limit	Upper Limit
Strontium	ppm	Nitric aqua regia digest	ICP-AES	1	10,000
Phosphorus	ppm	Nitric aqua regia digest	ICP-AES	10	10,000
Niobium	ppm	–	Fusion Plasma Array	5	10,000
Yttrium	ppm	–	Fusion Plasma Array	5	10,000
Uranium	ppm	–	NAA	1	10,000
Thorium	ppm	–	NAA	0.1	10,000
Lanthanum	ppm	–	NAA	1	10,000
Cerium	ppm	–	NAA	2	10,000
Neodymium	ppm	–	NAA	5	1,000
Samarium	ppm	–	NAA	0.1	500
Europium	ppm	–	NAA	0.5	100
Terbium	ppm	–	NAA	0.1	100
Ytterbium	ppm	–	NAA	0.1	1,000
Lutetium	ppm	–	NAA	0.1	500

ICP-AES : Inductively Coupled Plasma - Atomic Emission Spectrometry
NAA : Neutron Activation Analysis
– : Not Specified

5-3-2 Univariate analysis

(1) Standard statistic values

Standard statistic values in Mrima-Jombo Area are shown in Table II-5-4.

(2) Determination of cumulative frequency distribution and threshold values

Cumulative frequency distribution and interpretations in Mrima-Jombo Area are shown in Figure II-5-3.

Table II-5-4 Statistics of Geochemical Data, Mrima-Jombo Area

Element	Unit	Number of Samples	※	Max.	Min.	Mean (m)	Standard Deviation (σ)	m+2σ
Au	ppb	262	177	94	< 1	—	—	—
Ba	ppm	〃	0	>10,000	10	290.5	0.499	289.7
Sr	〃	〃	0	3,390	1	50.5	0.577	719.2
Nb	〃	〃	0	2,600	10	71.4	0.505	730.6
Y	〃	〃	0	880	18	53.7	0.332	247.4
U	〃	〃	0	16	1	4.1	0.179	9.4
Th	〃	〃	0	413	6	22.1	0.343	107.2
La	〃	〃	0	6,512	9	91.6	0.516	985.1
Ce	〃	〃	0	7,450	22	168.5	0.432	1,229.2
Nd	〃	〃	0	1,865	5	62.8	0.464	532.1
Sm	〃	〃	0	433	1	12.3	0.445	95.6
Eu	〃	〃	10	94	< 1	2.6	0.511	26.9
Tb	〃	〃	2	23	< 0.05	1.3	0.420	8.9
Yb	〃	〃	0	40	2	5.4	0.229	15.4
Lu	〃	〃	0	5	0.30	0.8	0.210	2.2
Cu	〃	〃	1	174	< 1	11.6	0.438	86.9
Pb	〃	〃	3	216	2	12.8	0.378	73.1
Zn	〃	〃	2	2,940	2	30.5	0.561	404.3
Fe	%	〃	0	14.00	0.12	2.527	0.369	13.837
Mn	ppm	〃	0	1800	10	599.4	0.554	7,697.4
P	〃	〃	0	>10,000	30	314.0	0.525	3,515.3

※ Number of Samples Under Detection Limit

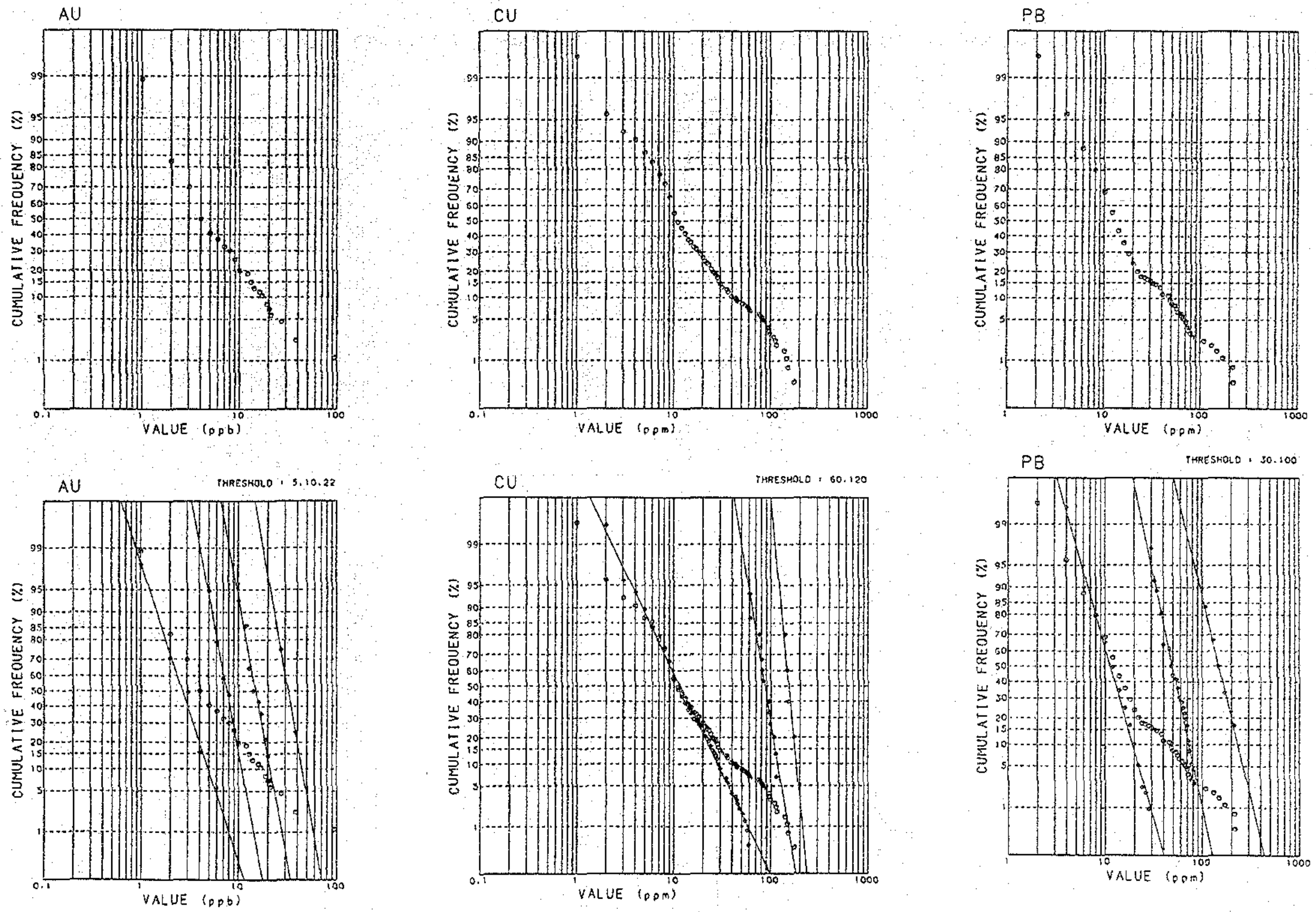

Figure II–5–3 (1) Cumulative Frequency Curves and Partition of Populations, Mrima-Jombo Area

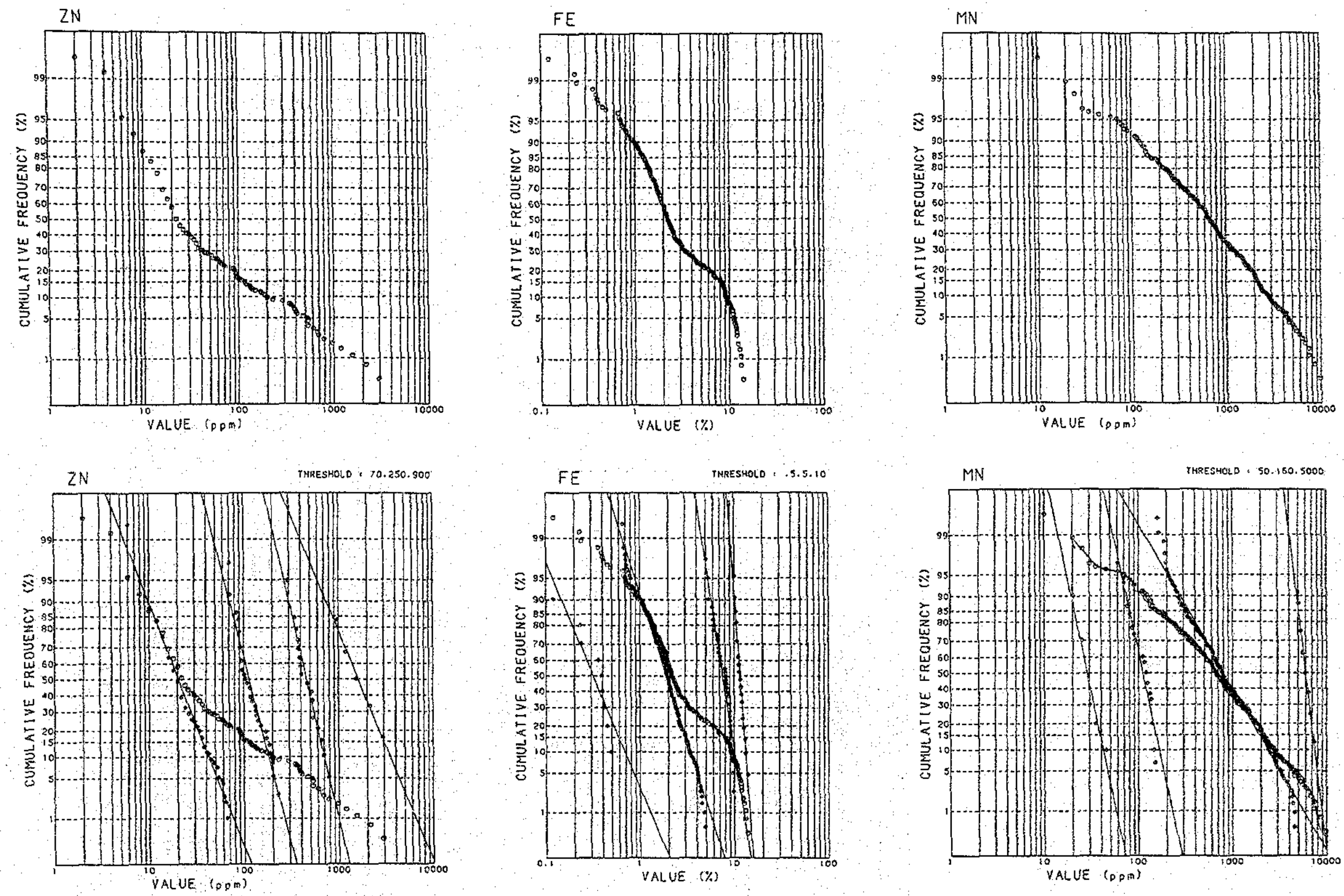

Figure II–5–3 (2) Cumulative Frequency Curves and Partition of Populations, Mrima-Jombo Area

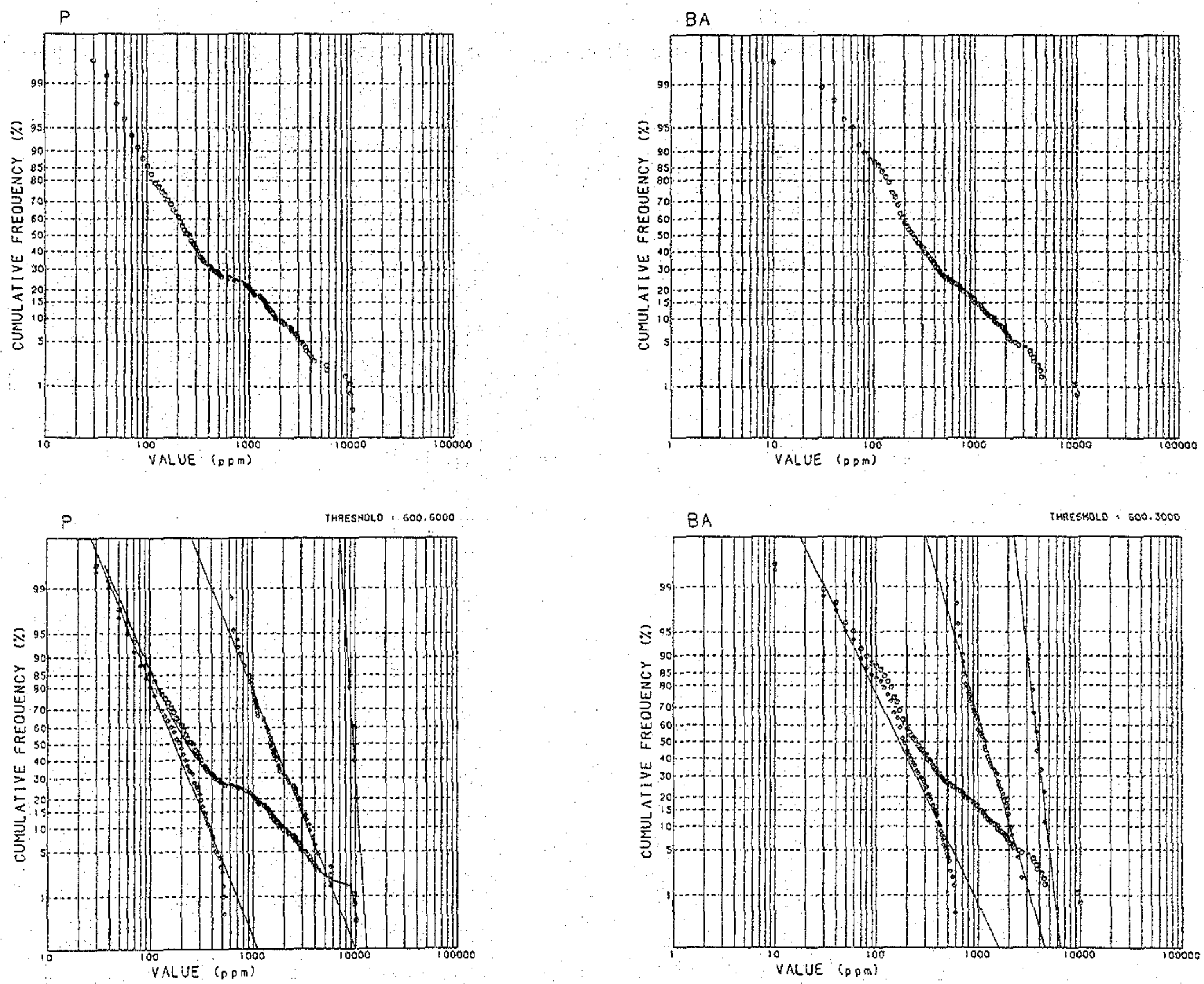

Figure II–5–3 (3) Cumulative Frequency Curves and Partition of Populations, Mrima-Jombo Area

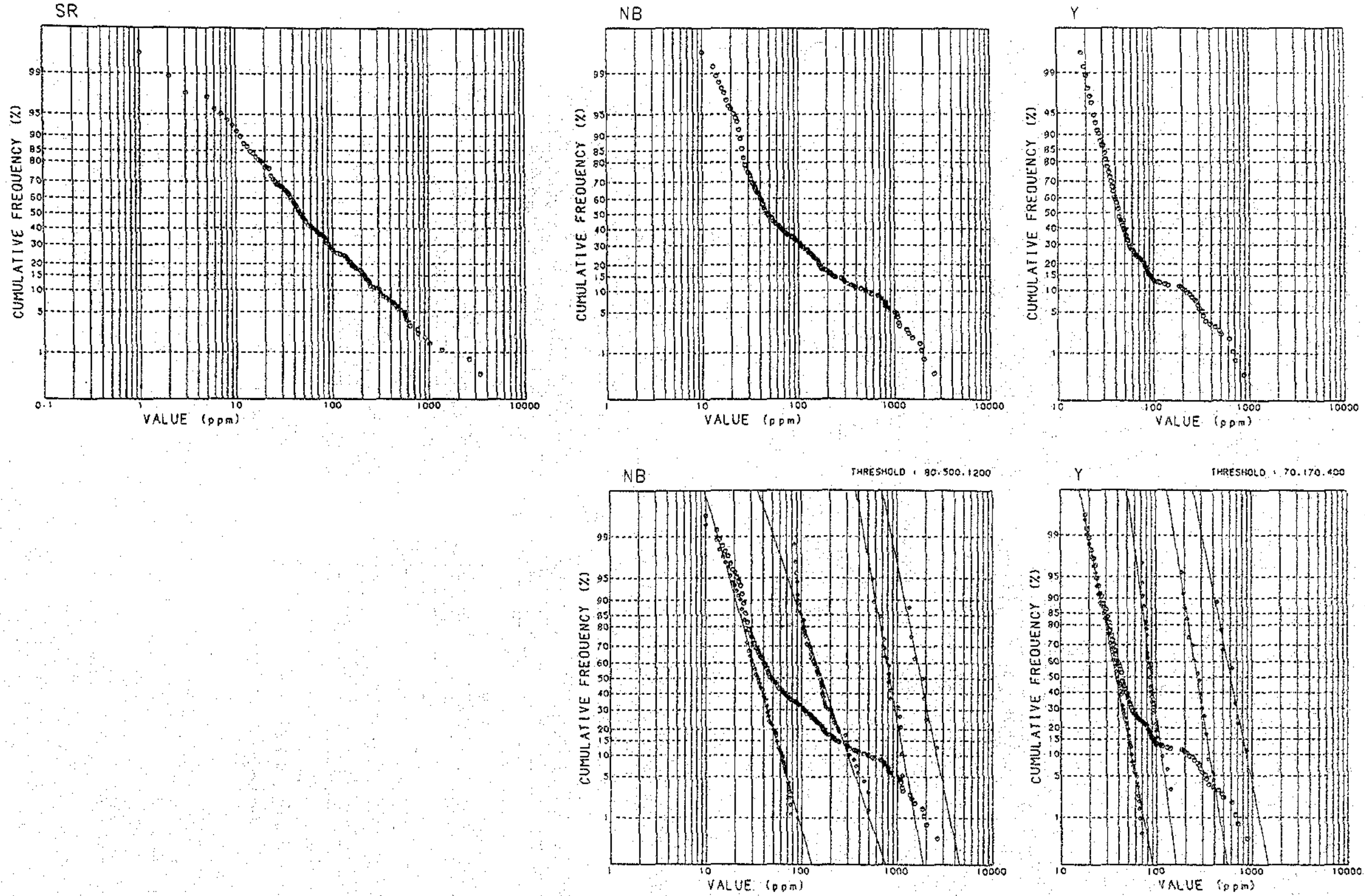

Figure II–5–3 (4) Cumulative Frequency Curves and Partition of Populations, Mrima-Jombo Area

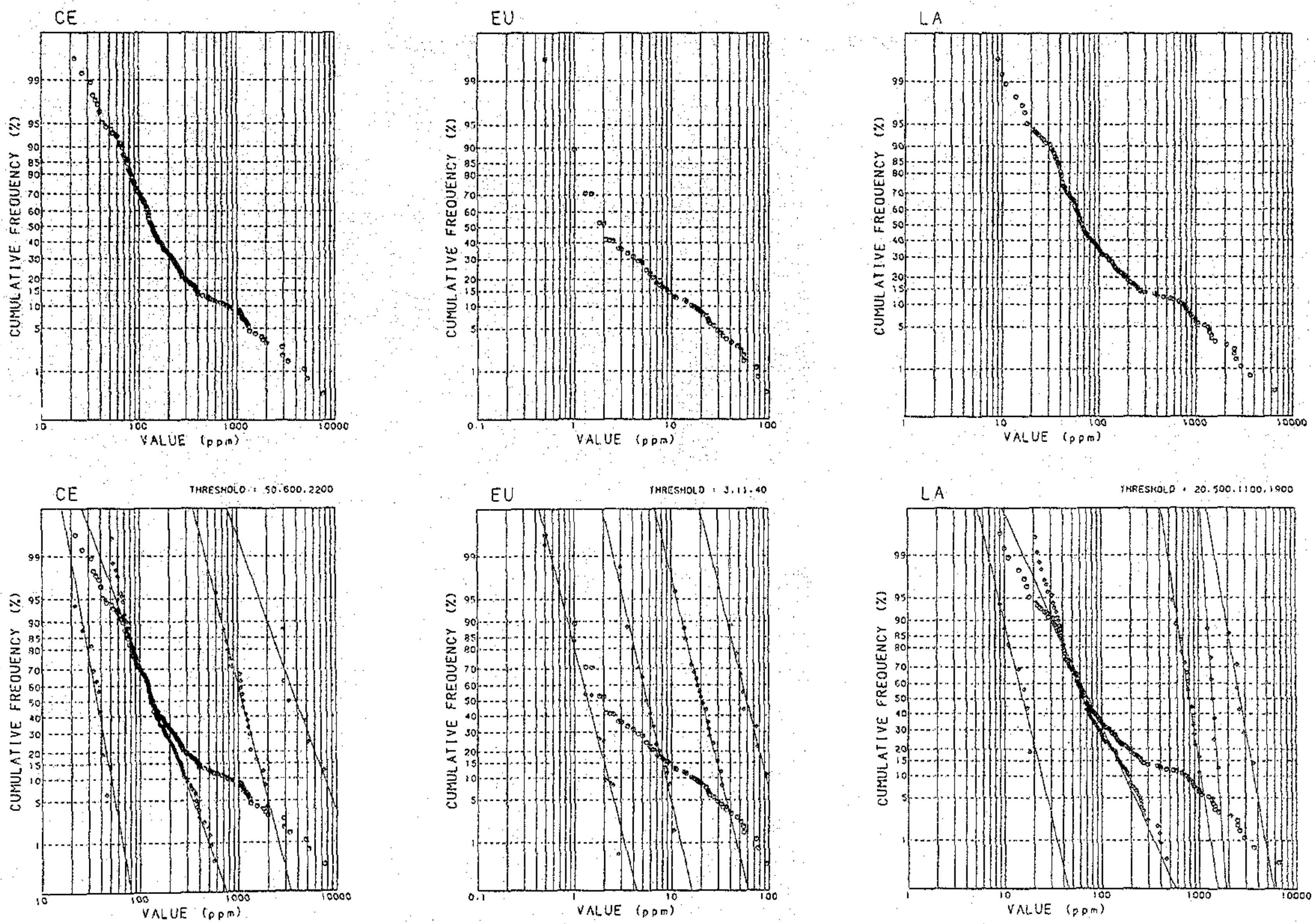

Figure II–5–3 (5) Cumulative Frequency Curves and Partition of Populations, Mrima-Jombo Area

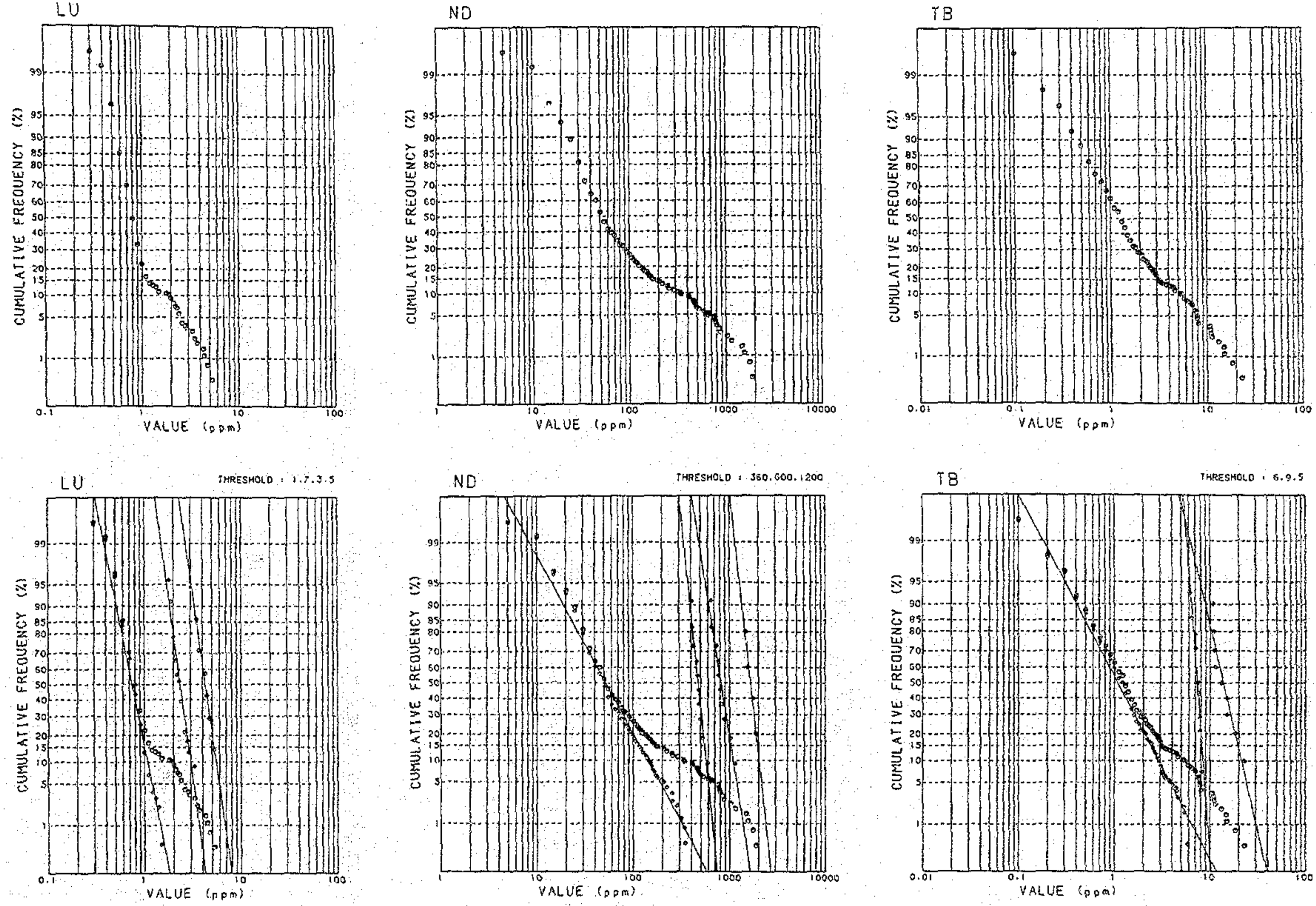

Figure II–5–3 (6) Cumulative Frequency Curves and Partition of Populations, Mrima-Jombo Area

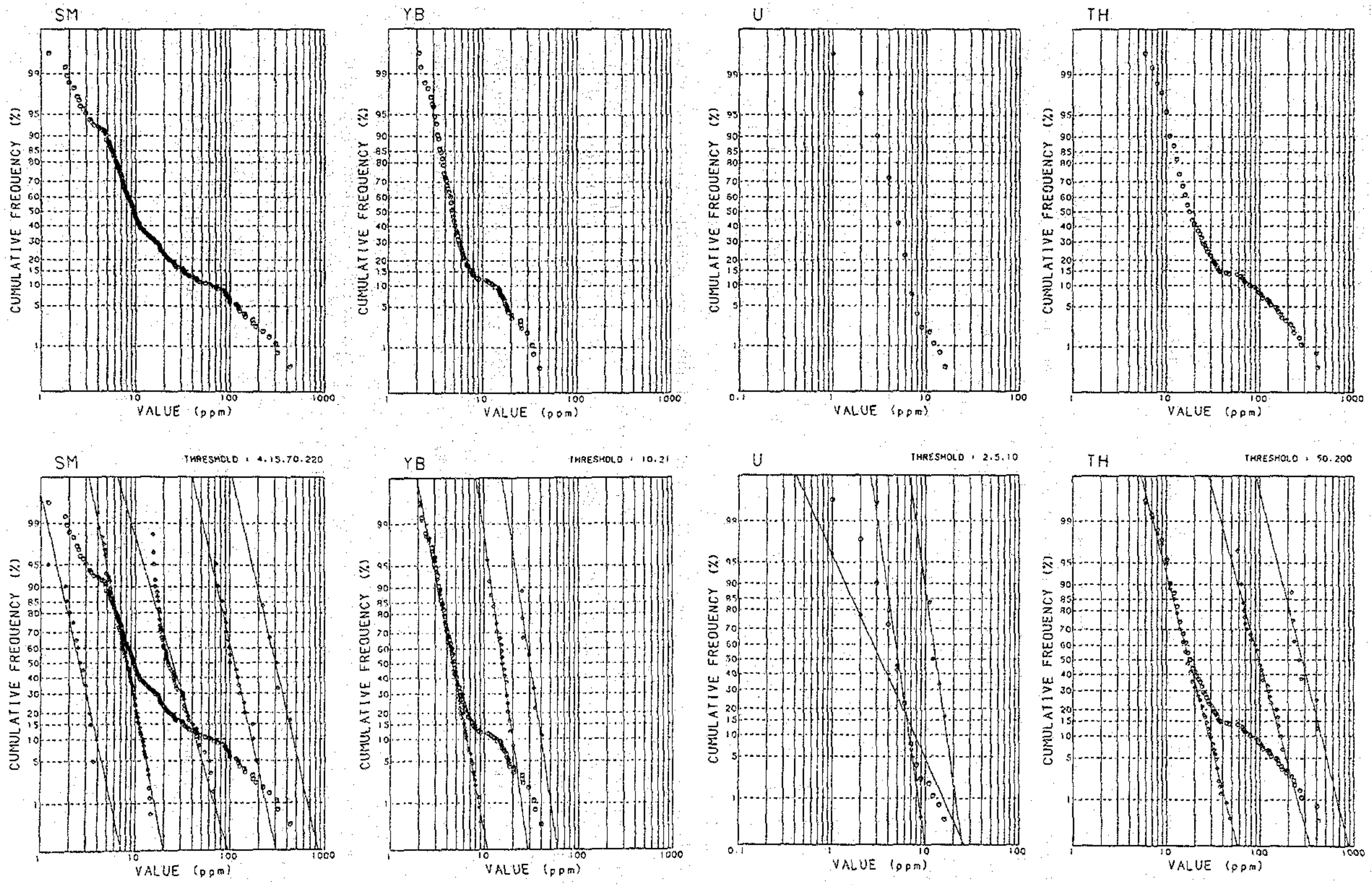

Figure II–5–3 (7) Cumulative Frequency Curves and Partition of Populations, Mrima-Jombo Area

Threshold values in Mrima-Jombo Area, determined by the identical criteria to those in Ganze Area, are shown in Table II-5-5.

5-3-3 Principal component analysis

(1) Correlation of pathfinders

Correlation coefficients between the respective pathfinders in the Area are summarizedly shown in Table II-5-6. Correlation coefficient values, other than uranium-copper and uranium-iron, are collectively positive-correlated.

Correlations between the elements, other than uranium, are generally high, more than the value of 0.5 with the exceptions of gold-copper-lead correlations. Positive correlation coefficient values between niobium, rare earths elements, thorium and zinc are very high, such as 0.776 to 0.986, while, those elements also provide high values of more than 0.6 with gold, barium, copper, iron, manganese, phosphorus, lead and strotium. Uranium exceptionally shows a weak correlation to the other elements, for instance, with the coefficient value of 0.492, which is the highest in case of uranium-lutetium.

(2) Principal component analysis

The results of principal component analysis are shown in Table II-5-7.

The first principal component provides the value of the contribution ratio of 0.767, i.e., some 77 percent out of the total geochemical figures are included in the category of the first principal component. Positive correlations between most elements, other than uranium, are remarkably shown, while, the geochemical behaviours of niobium, rare earths elements and zinc are particularly well-represented. The first principal component is geologically estimated to chiefly represent a concentration of the elements in soils of carbonatite and agglomerate bodies.

The second principal component provides the value of the contribution ratio of 0.109, which is estimated to cover approximately a half of the geochemical behaviours of copper and uranium, while, copper is positive-correlated and uranium is negative-correlated. The second principal component is estimated to be represented in connection with the high copper concentration irrelatively distributed to carbonatite body occurrences, while, the possible geochemical relations of that to copper-lead-quartz vein mineralization, observed in Mukundi Ore Showing for instance, are still obscure.

The third principal component provides the value of the contribution ratio of 0.034, which is estimated to cover approximately a half of the geochemical behaviours of uranium.

The cumulative contribution ratio by the first through the third principal components reaches to be of some 91 percent.

5-3-4 Interpretations of geochemical anomalies

The localities of geochemical anomalies in the Area are shown in PL.9, PL.10, PL.11, PL.12 and PL.14.

The general geochemical characteristics of the respective pathfinders examined by the current works are stated below:

Table II-5-5 Threshold and Number of Anomalous Samples
—— Mrima-Jombo Area ——

Element	Threshold	Number of Samples	Ratio %	Applied Criterion
Au	10 ppb	17	3.8	1
Ba	3,000 ppm	11	4.2	1
Sr	719 ppm	7	2.7	2
Nb	1,200 ppm	7	2.7	1
Y	400 ppm	8	3.1	1
U	10 ppm	5	1.9	1
Th	200 ppm	7	2.7	1
La	1,900 ppm	7	2.7	1
Ce	2,200 ppm	7	2.7	1
Nd	1,200 ppm	4	1.5	1
Sm	220 ppm	5	1.9	1
Eu	40 ppm	8	3.1	1
Tb	9.5 ppm	9	3.4	1
Yb	21 ppm	8	3.1	1
Lu	3.5 ppm	6	2.3	1
Cu	120 ppm	4	1.5	1
Pb	100 ppm	6	2.3	1
Zn	900 ppm	5	1.9	1
Fe	10 %	20	7.6	1
Mn	6,320 ppm	6	2.3	3
P	6,000 ppm	4	1.5	1

Table II-5-6 Correlation Coeficients — Mrima-Jombo Area

	Au	Ba	Cu	Fe	Mn	P	Pb	Sr	Zn	Nb	Y	Ce	Eu	La	Lu	Nd	Sm	Tb	Th	U	Yb
Au	---	85	85	85	85	85	83	85	84	85	85	85	85	85	85	85	85	85	85	85	85
Ba	0.670	---	261	262	262	262	259	262	260	262	262	262	252	262	262	262	262	260	262	262	262
Cu	0.052	0.712	---	261	261	261	259	261	260	261	261	261	251	261	261	261	261	259	261	261	261
Fe	0.384	0.788	0.910	---	262	262	259	262	260	262	262	262	252	262	262	262	262	260	262	262	262
Mn	0.614	0.805	0.716	0.793	---	262	259	262	260	262	262	262	252	262	262	262	262	260	262	262	262
P	0.356	0.799	0.817	0.856	0.831	---	259	262	260	262	262	262	252	262	262	262	262	260	262	262	262
Pb	0.727	0.664	0.258	0.429	0.582	0.435	---	259	258	259	259	259	249	259	259	259	259	257	259	259	259
Sr	0.513	0.910	0.791	0.823	0.839	0.848	0.577	---	260	262	262	262	252	262	262	262	262	260	262	262	262
Zn	0.725	0.905	0.728	0.845	0.839	0.857	0.689	0.884	---	260	260	260	250	260	260	260	260	258	260	260	260
Nb	0.750	0.838	0.634	0.761	0.808	0.814	0.657	0.854	0.912	---	262	262	252	262	262	262	262	260	262	262	262
Y	0.814	0.835	0.557	0.737	0.800	0.759	0.742	0.793	0.918	0.946	---	262	252	262	262	262	262	260	262	262	262
Ce	0.743	0.842	0.643	0.795	0.832	0.809	0.702	0.836	0.919	0.942	0.958	---	252	262	262	262	262	260	262	262	262
Eu	0.746	0.832	0.666	0.807	0.844	0.825	0.641	0.857	0.915	0.947	0.936	0.946	---	252	252	252	252	252	252	252	252
La	0.790	0.849	0.628	0.775	0.826	0.786	0.721	0.843	0.922	0.966	0.974	0.977	0.958	---	262	262	262	260	262	262	262
Lu	0.801	0.685	0.353	0.528	0.676	0.585	0.733	0.627	0.776	0.838	0.921	0.867	0.793	0.887	---	262	262	260	262	262	262
Nd	0.698	0.811	0.636	0.775	0.808	0.786	0.656	0.816	0.894	0.944	0.942	0.956	0.949	0.967	0.851	---	262	260	262	262	262
Sm	0.743	0.851	0.678	0.819	0.816	0.809	0.676	0.852	0.928	0.956	0.964	0.976	0.966	0.986	0.853	0.970	---	260	262	262	262
Tb	0.754	0.755	0.647	0.772	0.792	0.764	0.599	0.785	0.846	0.867	0.876	0.905	0.902	0.899	0.789	0.895	0.907	---	260	260	260
Th	0.846	0.707	0.377	0.579	0.699	0.580	0.759	0.644	0.781	0.848	0.917	0.886	0.817	0.910	0.922	0.875	0.870	0.798	---	262	262
U	0.376	0.162	-0.143	-0.059	0.177	0.067	0.385	0.117	0.168	0.237	0.316	0.260	0.128	0.267	0.492	0.205	0.210	0.170	0.423	---	262
Yb	0.821	0.722	0.398	0.576	0.709	0.629	0.755	0.689	0.818	0.876	0.952	0.907	0.843	0.921	0.983	0.886	0.893	0.821	0.943	0.465	---

Right upper : Number of Samples Calculated
Left bottom : Correlation Coeficients

Table II-5-7 Summary of Principal Component Analysis — Mrima-Jombo Area

PRIN COMP	EIGEN VALUE	CONTRIB	CUM CONTRIB		Au	Ba	Cu	Fe	Mn	P	Pb	Sr	Zn	Nb	Y	Ce	Eu	La	Lu	Nd	Sm	Tb	Th	U	Yb
P 1	16.113	0.767	0.767	EIGENVECTOR	.191	.222	.168	.204	.217	.208	.182	.219	.238	.240	.243	.244	.240	.246	.218	.239	.245	.228	.222	.066	.227
				FACTOR LOADING	.767	.892	.674	.819	.873	.834	.730	.880	.956	.964	.975	.979	.963	.987	.875	.961	.982	.917	.889	.265	.911
				CONTRIBUTION	.588	.796	.455	.671	.762	.695	.533	.774	.914	.928	.951	.959	.927	.975	.765	.924	.965	.841	.791	.070	.829
P 2	2.285	0.109	0.876	EIGENVECTOR	-.334	.104	.451	.319	.121	.269	-.244	.196	.080	.000	-.091	-.013	.053	-.037	-.257	.003	.016	.024	-.232	-.442	-.230
				FACTOR LOADING	-.505	.157	.681	.482	.183	.406	-.369	.297	.121	.000	-.137	-.019	.081	-.056	-.388	.005	.025	.036	-.351	-.668	-.347
				CONTRIBUTION	.255	.025	.464	.232	.034	.165	.136	.088	.015	.000	.019	.000	.007	.003	.151	.000	.001	.001	.123	.446	.120
P 3	0.704	0.034	0.910	EIGENVECTOR	-.347	.072	.247	.056	.131	.223	-.003	.154	-.007	-.048	-.053	-.026	-.162	-.063	.041	-.090	-.078	-.145	-.066	.801	.014
				FACTOR LOADING	-.291	.060	.207	.047	.110	.187	-.003	.129	-.006	-.041	-.044	-.022	-.136	-.053	.034	-.076	-.066	-.122	-.055	.673	.011
				CONTRIBUTION	.085	.004	.043	.002	.012	.035	.000	.017	.000	.002	.002	.000	.018	.003	.001	.006	.004	.015	.003	.452	.000
P 4	0.498	0.024	0.933	EIGENVECTOR	.205	.433	-.061	-.031	.143	-.085	.639	.263	.170	-.097	-.071	-.106	-.078	-.079	-.211	-.206	-.123	-.194	-.119	-.078	-.183
				FACTOR LOADING	.145	.306	-.043	-.022	.101	-.060	.451	.186	.120	-.068	-.050	-.075	-.055	-.056	-.149	-.145	-.087	-.137	-.084	-.055	-.129
				CONTRIBUTION	.021	.094	.002	.000	.010	.004	.204	.034	.014	.005	.003	.006	.003	.003	.022	.021	.008	.019	.007	.003	.017
P 5	0.316	0.015	0.948	EIGENVECTOR	.475	.153	-.251	-.110	.377	.085	-.540	.149	.041	.072	-.067	-.068	.117	-.049	-.180	-.120	-.069	.190	-.168	.190	-.168
				FACTOR LOADING	.267	.086	-.141	-.062	.212	.048	-.304	.084	.023	.040	-.038	-.038	.066	-.028	-.101	-.068	-.039	.107	-.095	.107	-.094
				CONTRIBUTION	.071	.007	.020	.004	.045	.002	.092	.007	.001	.002	.001	.001	.004	.001	.010	.005	.002	.011	.009	.011	.009
P 6	0.230	0.011	0.959	EIGENVECTOR	.055	-.370	.115	.240	.604	-.057	.266	-.296	-.124	-.285	-.092	.001	-.038	-.079	-.020	-.072	-.109	.345	.113	-.004	-.029
				FACTOR LOADING	.026	-.177	.055	.115	.290	-.027	.127	-.142	-.059	-.136	-.044	.001	-.018	-.038	-.010	-.034	-.052	.165	.054	-.002	-.014
				CONTRIBUTION	.001	.031	.003	.013	.084	.001	.016	.020	.004	.019	.002	.000	.000	.001	.000	.001	.003	.027	.003	.000	.000

Gold : Seven samples show anomalous values of gold, 94 ppb is the highest. The values are relatively high in comparison with the other four Areas by the current works. Anomalous values are collectively observed nearby Mrima Hill and in Kiruku Hill.

Copper : Four samples show anomalous values of copper, 174 ppm is the highest. High-graded and anomalous values are collectively observed in the area, southward from Jombo Hill, where Maji-ya-Chumvi Formation covers.

Lead : Six samples show anomalous values of lead, 216 ppm is the highest. Anomalous values are collectively observed nearby Mrima Hill and in Kiruku Hill. The anomalous values are estimated to be shown in association with zinc in the following section in geological connection with primary metallic minerals occurrences associated with carbonatite mineralization, since small quantities of galena and sphalerite occurrences in carbonatite bodies have been reported.

Zinc : Five samples show anomalous values of zinc, 2940 ppm is the highest. Anomalous values are collectively observed nearby Mrima Hill.

Iron : Twenty samples show anomalous values of iron, 14 percent is the highest. Anomalous values are collectively observed nearby Mrima Hill, in Kiruku Hill and south of Jombo Hill. The anomalous zone southward from Jombo Hill is nearly overlapped with high-copper-graded zone.

Manganese : Six samples show anomalous values of manganese, 9,800 ppm is the highest. Anomalous values are collectively observed nearby Mrima Hill and in Kiruku Hill.

Phosphorus: Four samples show anomalous values of phosphorus, more than 10,000 ppm is the highest. Anomalous values are collectively observed nearby Mrima Hill.

Barium : Eleven samples show anomalous values of barium, more than 10,000 ppm is the highest. Anomalous values are collectively observed nearby Mrima Hill and in Kiruku Hill.

Strontium : Seven samples show anomalous values of strontium, 3,390 ppm is the highest. Anomalous values are collectively observed nearby Mrima Hill.

Niobium : Seven samples show anomalous values of niobium, 2,600 ppm is the highest. Anomalous values are collectively observed nearby Mrima Hill.

Rare Earths Elements (Yttrium, Europium, Lanthanum, Lutetium, Neodymium, Samarium, Terbium, Ytterbium)

: Four to nine samples show anomalous values of rare earths elements. Anomalous values of the elements, other than neodymium and samarium, are collectively observed nearby Mrima Hill and in Kiruku Hill, while, neodymium and samarium are collectively nearby Mrima Hill properly.

Uranium : Five samples show anomalous values of uranium, 16 ppm is the highest. Anomalous values are collectively observed nearby Mrima Hill.

Thorium : Seven samples show anomalous values of throium, 413 ppm is the highest. Anomalous values are collectively observed in south-eastern hillfoot of Mrima Hill and in Kiruku Hill.

Areal representations of the anomalous values of the elements, chemically analysed by the current works in the Area, provide a particularly characteristic features that most of anomalous values of the elements, other than copper, are collectively observed in the vicinity of Mrima Hill and/or in Kiruku Hill. Anomalous values of some elements are collectively observed in the vicinity of Mrima Hill properly, while, high-graded values of the respective elements, approximate to anomalous values, are eventually observed collectively in both of nearby Mrima Hill and in Kiruku Hill. This may show an apparent disparity of the appearance of anomalous zones caused by the determinative disparity of threshold values of the respective elements.

The distribution of the anomalous values of the elements, other than copper, are estimated to be eventually influenced under an unique geological situation in Mrima and Kiruku Hills, i.e., primary accumulation of the elements in carbonatite and agglomerate bodies or secondary concentration in weathered overburden soils.

As shown in the previous section 5-2-3, the occurrences of iron and manganese oxide concretions, in which an accumulation of precious and base metallic elements have been reported, are abundantly observed. The accumulation of the elements in accordance with the progress of the formation of those concretions may play a role to enhance a new opportunity to reveal geochemical anomalies.

Copper-anomalous zones, separately observed from those of other elements, are observed in southern part of Jombo Hill. Areal relations of those to geology and mineralization are still obscure, however, possibly be inferred that 1) to be influenced by the occurrence of copper-lead-quartz veins mineralization, such as Mukundi Ore Showing for instance and 2) to be accumulated in accordance with the forming of ferruginous concretions. The item of 2), above-mentioned, is considered to be possible, since being that lead concentration in the Area is not normally associated with copper concentration, iron-anomalous zones in the Area are partly overlapped by copper-anomalous ones, ferruginous concretions, in which heavy metallic elements are generally accumulated, are frequently observed in the areas of copper-anomalous values and etc..

5-4 Interpretation

5-4-1 Mineral potential

The major mineral showings in the Area are specified to be of the following three types of occurrences.

1) Niobium and rare earths elements mineralization associated with carbonatite
2) Mineral showings of iron and manganese
3) Mineral showings of precious and base metallic elements

The current research works of the second-year programme have been implemented for the objectives of the on-site collations and elucidation of an areal extension of mineralized zones concerning to the item 1), the above, and clarification of modes of mineralization concerning to the item 3), the above.

Based on the results of geochemical research works by the current programme, the geochemical anomalies of rare earths elements of significance are represented not only in the vicinity of the carbonatite bodies of Mrima Hill, as ever been reported, but also significant geochemical anomalies of niobium and rare earths elements of small scale are collectively represented in the vicinity of agglomerate body in Kiruku Hill. These results may pose a geological possibility of the occurrences of niobium and rare earths elements in association with agglomerate bodies in Nguluku in central-northern part of the current project area.

The occurrence of fenifized body, situated three kilometres northward from Mrima Hill, is also considered to may pose a geological possibility of an occurrence of underlying subsurface carbonatite bodies.

The occurrence of electrum and galena in connection with precious and base metallic mineralization has ever been reported by Carswell, 1953, however, the prospect has been regarded to be of less promising. The accumulation of precious and base metallic elements in the Area is also estimated by the current geochemical research to be causedly formed by a primary concentration in carbonatite and agglomerate bodies themselves or a secondary concentration in manganiferous concretions to lead to an evaluation that the geological showing of precious and base metallic mineralization to be deserved for further works in the Area might not be warranted.

5-4-2 Results of geochemical research works and mineralization

Geochemical anomalies of gold, lead and zinc, which are collectively observed in the vicinity of Mrima Hill and Kiruku Hill, are estimated to be causedly formed by a primary accumulation of the elements in carbonatite and agglomerate bodies and a secondary concentration in iron-manganiferous concretions in weathered soils. Copper anomalies in the Area, which are estimated to be shown in possible connection with a forming of ferruginous concretions, are separately represented from those of the other base metallic elements. It is, therefore, conclusively estimated that the geochemical anomalies of precious and base metallic elements, represented in the Area, are estimated to be unlikely responsible for the ground surface showing of the mineralized zones of precious and base metals.

Geochemical anomalies of most of the elements, other than copper, by the current works are collectively observed in the vicinity of Mrima Hill and Kiruku Hill to be causedly shown in connection with the occurrences of carbonatite and agglomerate bodies. Mineralized zones of niobium and rare earths elements in association with carbonatite bodies in Mrima

Hill have ever been noticeable, while the mineralization of similar type to the above is also recognizable in agglomerate body in Kiruku Hill by the current works.

5-4-3 Future work programme

Mineral showings of significance of precious and base metallic resources in the Area have not yet been observed by the current work to lead to an evaluation that the mineral potential of those commodities are estimated to be unlikely possible to be deserved to warrant a consecutive future exploration programme in the Area.

Further implementations of detailed geological and geochemical research works (including trench work) are considered 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, is also considered to be deserved to warrant a further fostering geoscientific works to elucidate modes of mineralizations in the site.

The scale of the mineralized zones in Kiruku Hill is possibly smaller than those in Mrima Hill, however, further future detailed exploration works in Kiruku Hill, to elucidate a detail of mineralization, are considered to be required in provisions for a possible future mining development progress of Mrima Hill Ore Bodies, to possibly be concurrently operated with that of Kiruku Hill Ore Bodies.

PART Ⅲ CONCLUSION AND RECOMMENDATION

CHAPTER 1. CONCLUSIONS

The general conclusions concerning to the Mombasa Project evaluations by the second-year 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 current 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 in 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 are specified by the current 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 currently 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 current 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 through leaching of economic materials on ground surface by weathering to cause a showing of the current geological situation is still be interested.

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

(4) Mkangombe Area

Mkangombe North Ore Showing has been specified by the current works to be composed of copper-lead-zinc-quartz veins ore bodies, 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. 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 bodies of economic significance are evaluated to be unlikely promosing, since ground surface showing of precious and base metallic mineralizations have not yet been specified and geochemical anomalies, represented in the Area, are estimated to be genetically shown in relations to the occurrences of carbonatite and agglomerate bodies.

Mineralizations of niobium and rare earths elements have been specified by the representations of geochemical anomalies in Mrima Hill and also in Kiruku Hill to occur in both of carbonatite and agglomerate bodies. These type of mineralizations are inferred to be potential in agglomerate bodies in Nguluku. Fenitized bodies in northern Mrima Hill is estimated to be potential to be underlain by subsurface carbonatite bodies.

CHAPTER 2. RECOMMENDATIONS

The general recommendations of the consecutive research work programmes to be implemented on an upcoming level, concerning to the Mombasa Project evaluations, are stated below on the bases of the above conclusions:

(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. In the zone, diamond drill operations investigating the mineralization at deeper portions are recommended in Ribe and Chiume Hill mineralized zone, where no diamond drill has been carried out by past exploration programme though significant showings of mineralization are present. Detailed geological survey works preceding the drill operations may be desired to locate the drill sites in both the mineralized zones.

In one view, a possible new discovery of ore bodies in the zone is expected to provide remarkable contibutions further toward a local economical development to be sustained for a long period of time and also toward a considerable extension possibility of the Kinagoni mine life on the bases of exsisting mine facilities, man power capability 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 of Mkangombe North Mineral Showing, in which a most distinct mode of mineralization in the quartz veining mineralized zone has been specified by ground surface mapping are deserved to be warranted in Mkangombe Area.

(3) Further implementations of detailed geological and geochemical research works (including trench work) are considered to be deserved to warrant in Kiruku Hill, Mrima-Jombo Area, to produce a thorough evaluation 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, is also considered to warrant a further fostering geoscientific works to elucidate modes of mineralizations in the site.

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APPENDIXES

APPENDIX 1

MICROSCOPIC OBSERVATION OF ROCKS IN THIN SECTION

1. Igneous Rocks
2. Sedimentary Rocks

Summary of Microscopic Observation (Igneous Rocks)

Sample No.	Rock Name	Phenocrysts						Groundmass & Texture										Secondary Minerals						Note
		Kf	Ne	Cpx	Am	Ol	Sph	Pl	Kf	Ne	Cpx	Am	Opq	Sd	Ap	Ca	Texture	Qz	Chl	Cly	Lim	Se	Bi	
B035	Monchiquite		○	○	△		△		◎			◎	△		△	△	Porphyritic					△		
B036	Soda-Minett	◎		◎	○				◎		○	○	△		△		Porphyritic					△		
B038	Carbonatite												△			◎	Granular				○			Epidote < 5% Barite rare
B039	Carbonatite														△	◎	Granular Banded				○			Quartz ≒ 20% Barite rare
B040	Carbonaceous Rock							○					△		△	◎								
B041	Nepheline Syenite								◎	◎		○	—	△	—		Granular Porphyritic							Sphene ≒ 5%
B042	Nepheline Syenite								◎	◎		○		○			Granular						—	Sphene < 5%
C015	Camptonite			△		◎		○			◎				△		Porphyritic						—	
C022	Tuff breccia												△		△					◎	◎			Quartz
C030	Silicified Rock												△		○		Mosaic	◎			△			
C033	Silicified Rock												△		○		Mosaic	◎	△		△			
C034	Altered Tuff (?)														△			◎			◎			
F010	Carbonatite												—			◎	Granular				△			Dolomite < 5% Barite < 5%

Pl : Plagioclase　Kf : Pottasium feldspar　Ne : Nepheline　Cpx : Clinopyroxene　Am : Amphibole

Sph : Sphene　Ca : Calcite　Lim : Limonite　Ap : Apatite　Chl : Chlorite

Sd : Sodalite　Se : Sericite　Cly : Clay minerals　Opq : Opaque minerals　Bi : Biotite

Ol : Olivine

◎ : abundant　○ : common　△ : minor　— : rare

Microscopic Observation of Rocks in Thin Section (Igneous Rocks) (1)

Sample Number	Rock Name	Macroscopical features and microscopical texture and structure	Minerals
B035	MONCHI-QUITE	• Olive gray with white spots • Compact and hard • Porphyritic	◇ PHENOCRYSTS • Nepheline ≒ 10%, 0.5〜2mm, large euhedral grain, partly replaced by sericite along rim • Clinopyroxene ≒ 10%, 0.2〜0.5mm euhedral prism • Amphibole ≒ 5%, < 0.2mm, euhedral prism • Sphene ≒ 2〜3%, < 0.2mm, prism wedge shape ◇ GROUNDMASS (> 70%) • Sanidine, long lath-prism, altered to sericite • Amphibole, needle shape • Apatite • Opaque • Carbonate, secondary
B036	SODAMINETT	• Gray with white spots and black prismatic crystals • Compact and hard • Porphyritic	◇ PHENOCRYSTS • Clinopyroxene ≒ 20%, 0.3〜1.5mm, euhedral〜subhedral prism • Amphibole ≒ 20%, < 1mm, lath, including clynopyroxene, amphibole, apatite, sphene and opaque mineral ◇ GROUNDMASS (≒ 50%) • Sanidine, tabular lath, altered • Clinopyroxene • Amphibole • Sphene • Apatite, needle shape • Opaque
B038	CARBONA-TITE	• Brown and white banded • Granular • Pyrite (< 1mm) bearing	• Calcite ≒ 70%, 0.5〜3mm showing polygonal texture • Pyrite < 5%, cubic opaque, altered to limonite • Limonite like fine mineral aggregate < 20% • Epidote < 5%, < 0.05mm, needle〜prism • Zircon • Apatite • Pyrochlore like cubic grain < 1mm • Barite

Microscopic Observation of Rocks in Thin Section (Igneous Rocks) (2)

Sample Number	Rock Name	Macroscopical features and microscopical texture and structure	Minerals
B039	CARBONA-TITE	• Light brown • Banded • Layered texture, parallel alignment of opaque aggregate • Calcite vein < 1mm wide	• Calcite ≒ 70%, < 0.2mm (unhedral) polygonal texture • Opaque, limonite < 20% • Quartz < 20% • Zircon • Monazite or zenotime • Apatite • Pyrochlore (?), cubic, rare • Barite
B040	CARBONA-CEOUS IGNEOUS ROCK	• Pale olive green • Very fine-grained • Massive compact hard • Pyritized ——— • Heterogeneous rock consisting of ① Carbonaceous rock ② Rock fragments ③ Calcite vein ≒ 1mm thick	◇ Carbonaceous rock part • Calcite • Plagioclase ◇ Rock fragments ≒ 20%, < 5mm • Calcite < 0.1mm • Plagioclase • Epidote needle • Apatite • Opaque
B041	NEPHELINE SYENITE	• Light brownish gray • Compact and hard • Porphyritic • Holocrystalline	• Alkalifeldspar (perthite) ≒ 50%, 2~40mm euhedral prism, including nepheline and amphibole, altered • Nepheline ≒ 30%, < 10mm, euhedral prism • Amphibole ≒ 10%, < 10mm tarbular prism, twin, zoning • Sphene ≒ 5%, < 0.5mm, twin • Sodalite < 5%, irregular shape interstitial • Apatite, rare, < 0.2mm, prism • Opaque
B042	NEPHELINE SYENITE	• Light brownish gray • Compact and hard • Coarse-grained • Granular	• Alkalifeldspar (perthite) ≒ 40%, 0.5~60mm euhedral prism, carlsbad twin, some show zoning • Nepheline ≒ 30%, 10~30mm, zoning euhedral grain • Amphibole ≒ 20%, 0.5~2mm zoning euhedral tabular~prism, • Sphene < 5%, 0.1~2mm, twin • Sodalite ≒ 10%, inter-

Microscopic Observation of Rocks in Thin Section (Igneous Rocks) (3)

Sample Number	Rock Name	Macroscopical features and microscopical texture and structure	Minerals
(CONT.)			stitial • Biotite (secondary)
B015	CAMPTONITE	• Dark gray with brown spots • Compact and hard • Porphyritic	◇ PHENOCRYST • Olivine ≒ 25%, 0.5〜2mm euhedral〜subhedral grains • Clinopyroxene < 5%, < 1mm euhedral prism, zoning ◇ GROUNDMASS (≒ 70%) • Clinopyroxe ≒ 40%, 0.1〜0.2mm euhedral〜subhedral prism • Plagioclase ≒ 10%, 10〜30mm, poilkilitic, including clinopyroxene, olivine, apatite and opaque mineral • Apatite < 1%, prism • Vetrified glassy groundmass, now replaced by very fine grained crystal aggregate • Biotite, secondary
C022	TUFF BRECCIA	• Light brown • Lithic fragments ≒ 20%	• Extensively altered to limonite and clay minerals aggregate ≒ 90% • Quartz and apatite are well preserved • Calcedony filling cavities • Opaque, partly or completely altered to limonite • Monazite, < 0.05mm, rarely occur
C030	SILICEFIED ROCK	• Light brown • Strongly silicified rock • Quartz vein < 2mm wide small droozy • Mosaic	◇ FINE GRAINED PORTION (≒ 90%) • Quartz ≒ 70%, < 0.01mm • Apatite = 10〜20%, < 0.05mm irregular〜prism • Opaque < 10%, mostly limonite ◇ COARSE GRAINED PORTION probably cavity filling • Quartz < 0.01mm • Limonite • Calcedony

Microscopic Observation of Rocks in Thin Section (Igneous Rocks) (4)

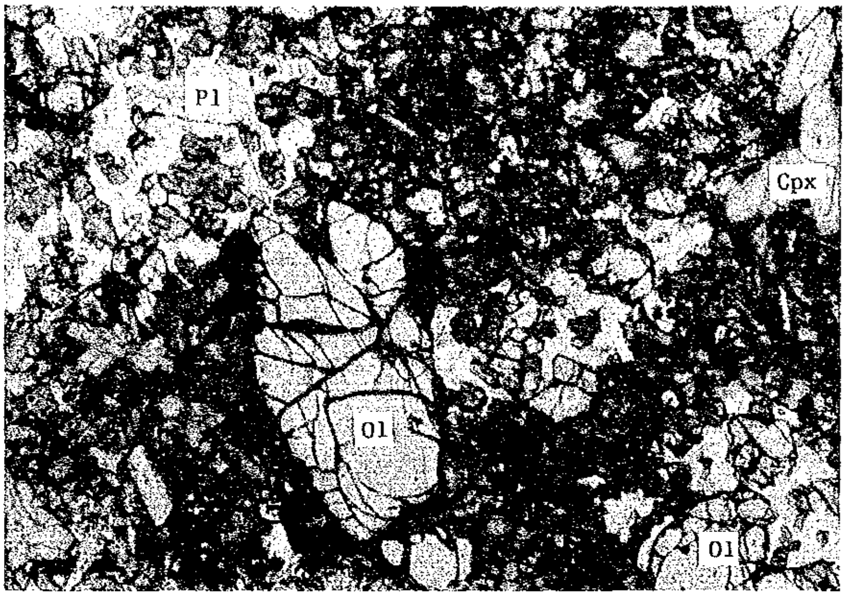
Sample Number	Rock Name	Macroscopical features and microscopical texture and structure	Minerals
C033	SILICIFIED ROCK	• Light brownish gray • Strongly silicified rock (similar to C030) • Tiny Quartz crystals in small cavities • Mosaic	• Quartz ≒ 80%, < 0.05mm irregular shape, polygonal • Apatite ≒ 20%, < 0.05mm irregular to prism • Opaque < 5%, < 0.05mm, atoll texture, partly altered to limonite • Very fine grained opaque scattered • Chlorite, secondary
C034	ALTERED TUFF (?)	• Dark brown with white spots • Liomonite stained • Quartz vein, 1mm wide	• Extremely altered rock • Limonite and quartz are predominant • Quartz ≒ 50%, < 0.05mm • Limonite ≒ 50% • Apatite < 10%
F10	CARBONA-TITE	• Light brownish gray • Very fine grained • Granular	• Calcite ≒ 90%, < 1mm • Dolomite < 5%, 0.1mm • Barite < 5% • Limonite • Opaque

Photomicrographs of Rocks in Thin Section
(Igneous Rocks)

Abbreviations

Minerals

Qtz	: quartz	Kf	: potassium feldspar
Pl	: plagioclase	Bi	: biotite
Am	: amphibole	Cpx	: clinopyroxene
Ne	: nepheline	Ol	: olivine
		Sd	: sodalite
		Sph	: sphene



one polar

crossed polars

0.1mm

Sample No. : C015
Location : West of Gulanze
Rock name : Camptonite

Photomicrographs (thin section)