(12) Gandini Area

(A) Location, Access and Topography

(i) Location and access

The Gandini area is located 20 km west of Mombasa and 13 km southwest of Mazeras.

The area is accessible from Mombasa by driving to Mazeras, westward for 8 km on the all-weather road Nairobi-Mombasa and from Mazeras southwestward to Gandini Village for 23 km on Mazeras-Gandini-Kwale road, which is available only in dry season. The ore showings are accessible on foot 1 km south-southwesterly from the village.

(ii) Topography

The Gandini area is situated in the "Coastal Range" explicated by Gregory, J.W. (1896) and Caswell, P.V. (1953). General topography in the area is relatively undulated frequently. Altitude in the area is highest in the vicinity of Mazeras-Gandini-Kwale road at approx. 700 ft (approx. 210 m) above sea-level and tends to gradually lower toward the southern, southeastern and northwestern parts of the area to the lowest at approx. 400 ft (approx. 120 m) above sea-level in the southern part, where the ore showings are located. The general altitude difference in the area reaches to some 300 ft (90 m).

(B) Existing Geological Studies

Existing geological information in Gandini area publicly available are; Geological Sheet: Mombasa-Kwale Area, 1 to 125,000 scale by Caswell, P.V. (1953), Geological Sheet: Kwale, 1 to 50,000 scale, by Geological Survey of Kenya (1982) and Geological Maps, 1 to 25,000 and 50,000 scales, by Kenya-Austria Mineral Exploration Project (1977~1978).

Geochemical research works by the Kenya-Austria Mineral Exploration Project were implemented to examine geochemical anomalous values of stream sediments for lead, zinc, copper, barium, nickel and chromium.

No geological and mineralogical research works on the ore showings in the area have never been implemented.

(C) General Geology and Mineralization

A geological map and geological cross section in Gandini area are shown in Figure II-2-3-12 (1), geological sketch map is in Figure II-2-3-12 (2) and geological sketches of ore showings in Figure II-2-3-12 (3).

(i) General geology

General geology in Gandini area mainly consists of the lower, middle and the upper members of the Mariakani Formation and is correlated to Middle Triassic age.

The lower member of the Mariakani Formation mainly consists of medium-grained sandstone beds, mottled and well-cross-laminated.

The middle member of the Mariakani Formation mainly consists of medium-grained flaggy sandstone beds, underlain by a shale bed at its bottom.

The upper member of the Mariakani Formation mainly consists of homogeneous medium to coarse grained sandstone beds, and is underlain by thin beds of siltstone and shale at its bottom.

Each member of the Formation shows northeasterly strikes and dips gently toward the southeast. No significant lineaments and faults are recognized on airphotographs.

(ii) Mineralization

Mineralization in the Gandini area occurs as barite-quartz veins in sandstone-siltstone-shale beds.

Veins, 2-3 cm wide in average, show strikes of NE 80° to 85° and dips 85° southward to vertical. Four veins are located during this year's campaign. These veins show the maximum lateral extension of 20 m in with widths of about 2 cm and are of extremely small scale.

Wall rock alteration is weak silicification and weak argillization. No sulfide minerals are found in association with the veins.

Igneous activity related to the mineralization in the area has also never been specified.

(D) Examination

Geochemical anomalous zones shown by the previous geochemical research works are considered to be caused by the barite veins in the area.

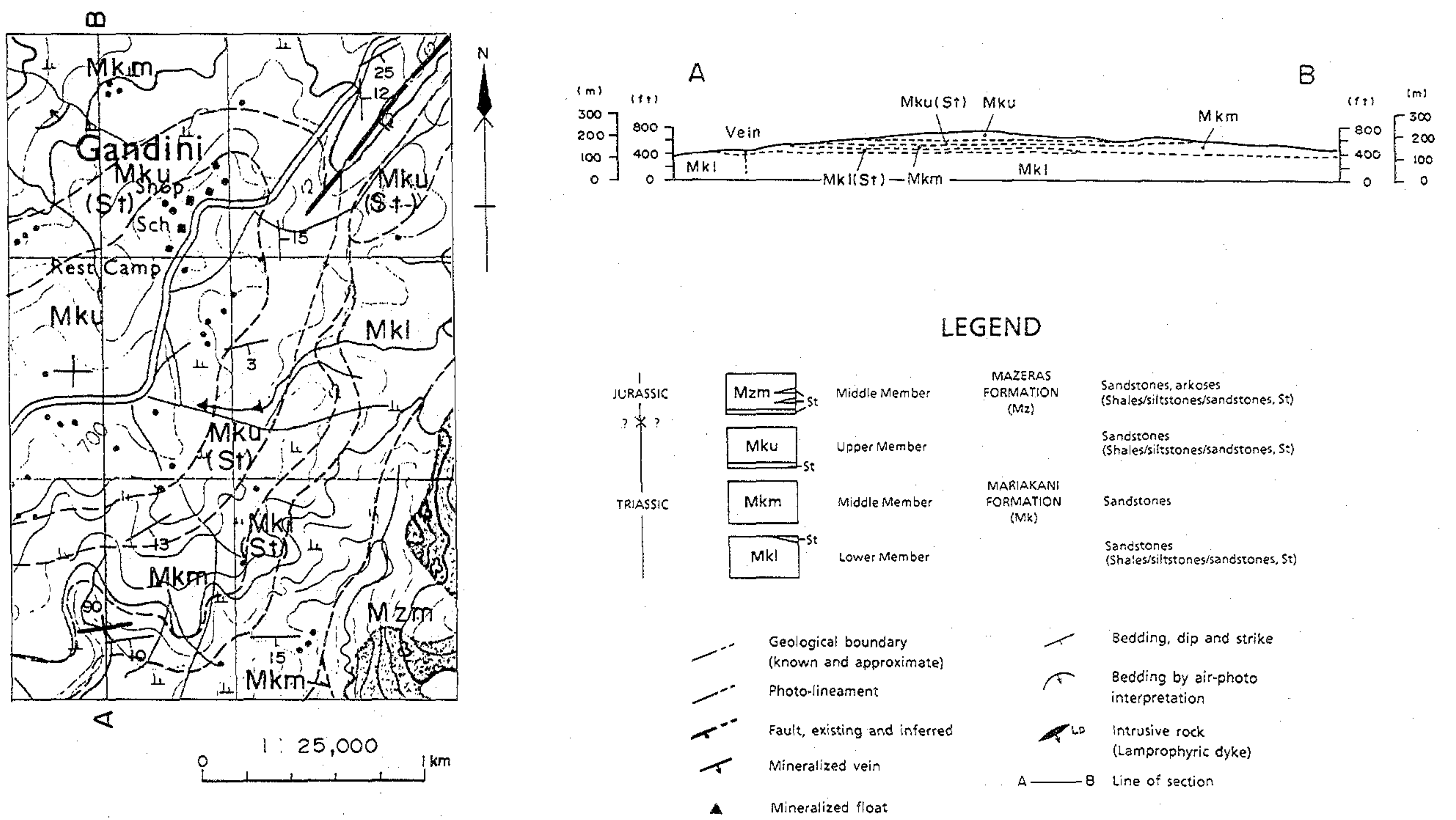


Figure II-2-3-12 (1) Geological Map of the Gandini Area

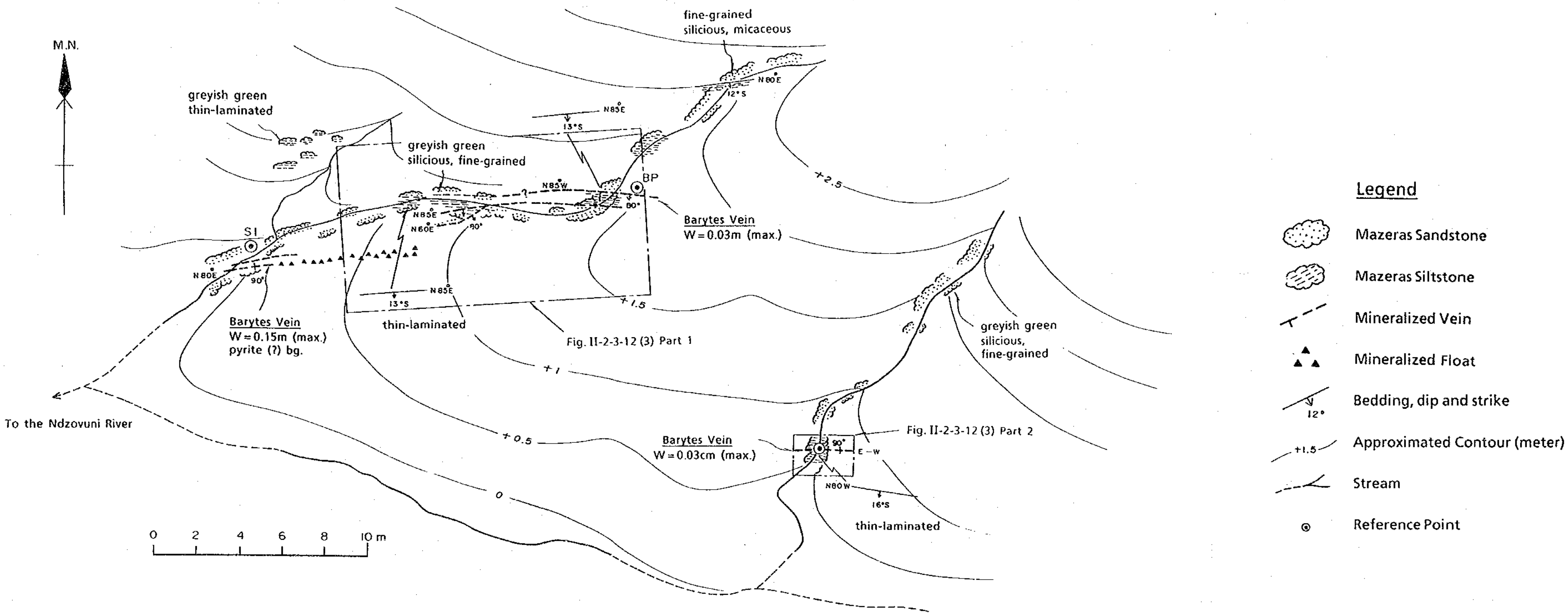


Figure II-2-3-12 (2) Geological Sketch Map of the Gandini Area

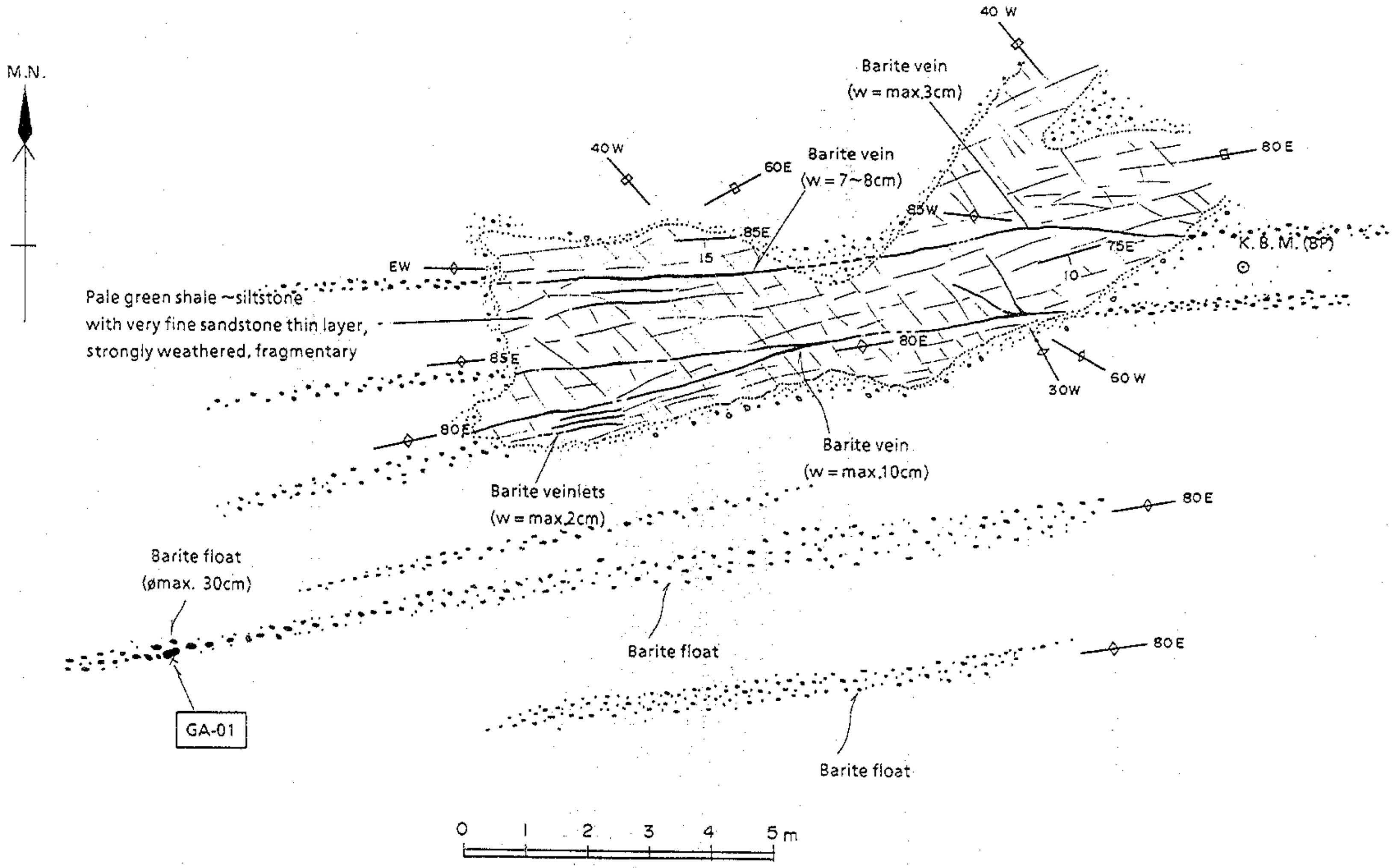


Figure II-2-3-12 (3) Geological Sketches of Barytes Veins in the Gandini Area (Part 1)

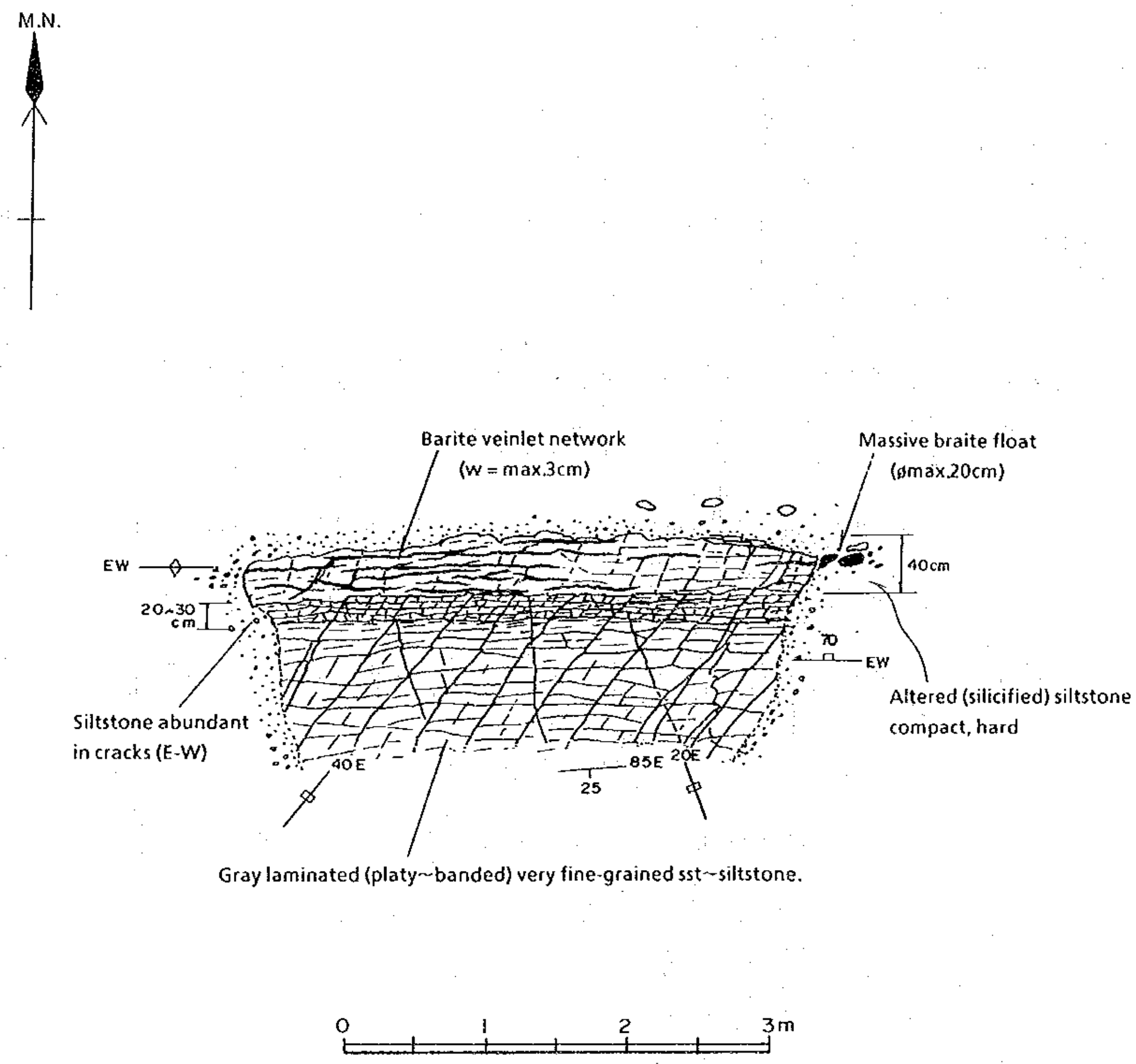


Figure II-2-3-12 (3) Geological Sketches of Barytes Veins in the Gandini Area (Part 2)

(13) Mwereni Area

(A) Location, Access and Topography

(i) Location and Access

The Mwereni area is situated approx. 40 km west-southwest of Mombasa and 17 km southwest of Kinango. Mwerei Village is accessible from Mombasa by driving on the all weather road connecting Mombasa=Lunga Lunga to Maburuni 2 km north of Lunga Lunga and then further northward to Ndavaya Village on all weather road connecting Lunga Lunga=Kinango. Mwereni Village is located 8 km south-southwest of Ndavaya Village. The ore showings are accessible from the village by walks for 1 km.

(ii) Topography

The Mwereni area is located in the "Nyika" explicated by Gregory, J.W. (1896) and Caswell, P.V. (1953). Low lands are developed along the main stream of the Ramisi River in the eastern part of the area and also along its tributaries in the south to southwestern parts. A hilly land, being 400 to 450 ft (120 to 135 m) high above sea-level, is formed in the northern to central parts of the area. The ore showings, characterized by distributions of ore floats, are observed on the southern hill-slope in the central part of the area. The area has an altitude difference of approx. 150 ft (45 m).

(B) Existing Geological Studies

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

Geochemical research work, composed of stream sediments and soil samplings and examinations of geochemical anomalies for lead, zinc, copper, barium, silver, mercury, chromium, nickel and etc., was implemented in the area by Kenya-Austria Mineral Exploration Project (1973-1977), the above.

Clarke, M.C.G. (1969) has been involved in geological research work, in which geological occurrences of galena and barite with unspecified sampling location notes are reported.

(C) General Geology and Mineralization

A geological map and a cross-section in the area are shown in Figure II-2-3-13 (1).

(i) General geology

General geology in the area mainly consists of an alternation of sandstone, siltstone and shale of the upper member of the Maji ya Chumvi Formation which is correlated to the Lower Triassic age.

The Formation shows a monoclinal structure, having a strike of NE 10° and 5° to 10° dips toward east. Faults and lineaments in the northwest-southeast and northeast-southwest directions are observed on airphotographs in the central to eastern parts of the area. The faults are estimated to be of normal type and easterly dipping, and indicate only minimal down-throws of approx. 10 m.

(ii) Mineralization

No outcrops of notable mineralization are located during this year's campain. However, mineralized floats of barite crystals, galena crystals and calcareous sandstones carrying networks of quartz veinlets may suggest that the mineralization expected in the area be quartz-barite veins or veinlets carrying lead and/or other sulphides, if any (Mwangi, M.N. (1990)).

The lead age dating value of galena by one specimen in the area shows 1.609 Ma, approximately equal to that in Mkundi area, 1.701 Ma, which are to be estimatedly correlated to Middle Jurassic age (Appendix-VI).

No igneous rocks, which may be related to any mineralization, have been recognized in the area.

(D) Examination

Geochemical anomalous zones of barium have been located by the previous geochemical research works, and may be suggested by the occurrences of barite mineralization in the area or in the vicinity.

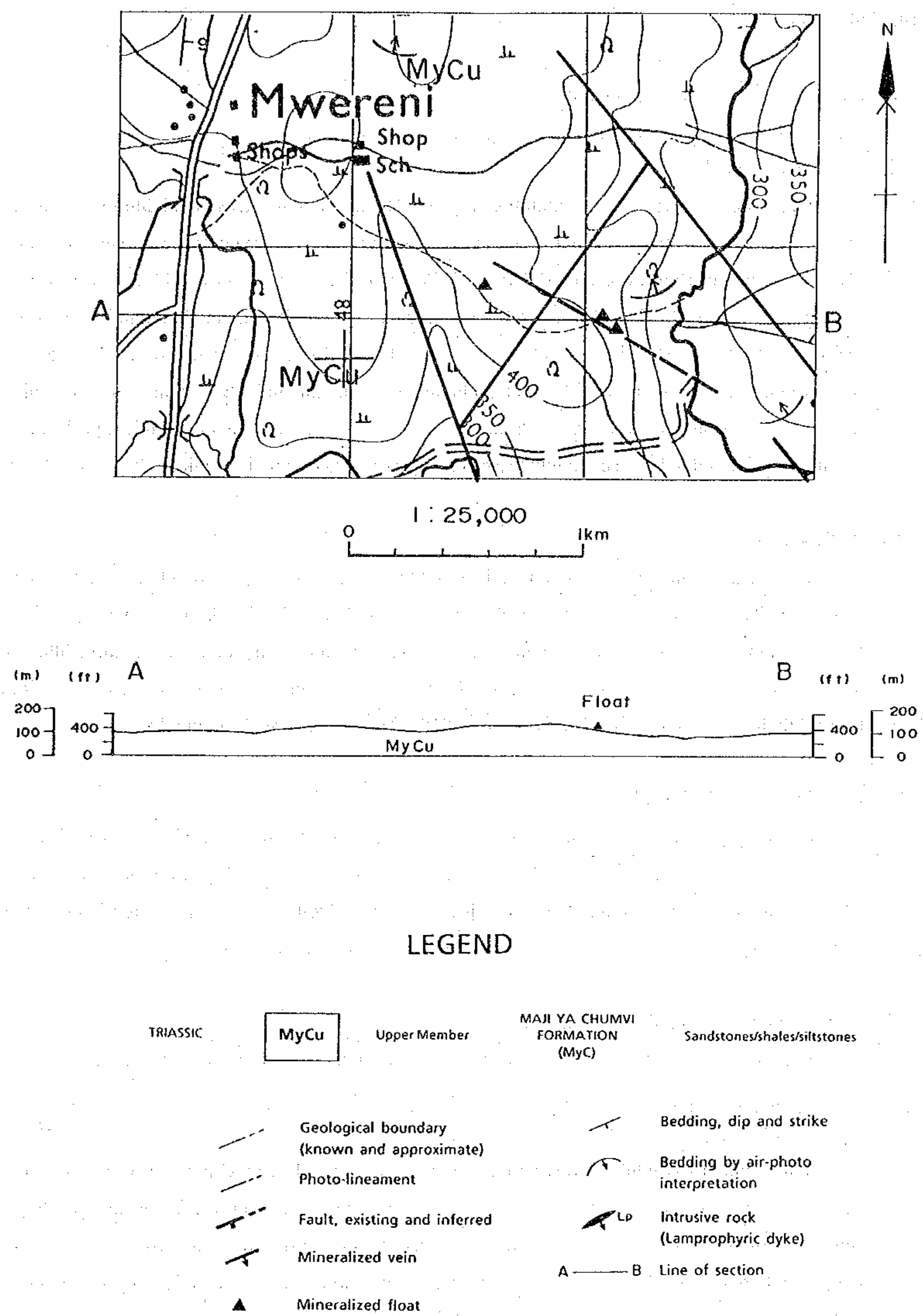


Figure II-2-3-13 (1) Geological Map of the Mwereni Area

(14) Mkang'ombe Area

(A) Location, Access and Topography

(i) Location and Access

The Mkang'ombe area is situated approx. 58 km west-southwest of Mombasa, and approx. 12 km southwest of Kinango. Ore showings are observed in two areas in the Mkang'ombe area, namely, the Kumbi (Mkang'ombe North) and the Mkang'ombe (Mkang'ombe South). The Mkang'ombe North area is accessible from Kinango by driving to Glanze Village on the all weather road Kwale=Lunga Lunga and from Glanze Village to the ore showing area on a gravel road for about 6 km. Mkang'ombe South area is accessible from Glanze Village to Kakundani Primary School by driving on a leading to Lunga Lunga for about 6 km and to the ore showing area on a gravel road for further 6 km.

(ii) Topography

The Mkang'ombe area is situated in the "Nyike" by Gregory, J.W. (1896). The area has an altitude difference of approx. 350 ft (approx. 100 m). The Ungond River, which streams down in the central and southwestern parts of the area, forms a low-land 500 to 550 ft (150 to 165 m) high above sea-level. General topography in the area is mostly gentle, having an altitude of approx. 700 ft (approx. 210 m) above sea-level in average.

(B) Existing Geological Studies

Existing geological informations, available are; the Geological Sheet: Mombasa-Kwale Area, 1 to 125,000 scale, by Caswell, P.V. (1953) and the Geological Sheet: Gulanze, 1 to 50,000 scale, by Geological Survey of Kenya (1982). Neither geology, economic geology nor geochemistry studies in the area have ever been implemented to date.

(C) General Geology and Mineralization

A geological map and a cross-section in the area are shown in Figure II-2-3-14 (1).

(i) General geology

The lower, the middle and the upper members of the Maji ya Chumvi Formation, are distributed in the area and are correlated to Upper Permian to Lower Triassic age. The lower member of the Formation mainly consists of sandstone and siltstone, and is correlated to Upper Permian age. The middle member mainly consists of shale and siltstone, characterized by carrying a nodule-bearing horizon containing nodules which yield ichthyo-fossils, and is correlated to Lower Triassic age. The overlying upper member mainly consists of an alternation of sandstone, siltstone and shale, and is correlated to Lower Triassic age.

The Formation as a whole generally strikes in NW-SE to NE-SW directions with gentle dips of around 5° to NE or to SE. No notable faults or lineaments have been recognized on airphotographs in the area by the current work.

(ii) Mineralization

Mineralization in the area has been observed in two areas, the Kumbi (Mkang'ombe North) in the northeastern part and Mkang'ombe (Mkang'ombe South) in the southwestern part.

Mineralization in Mkang'ombe North consists of milky white to khaki-yellow quartz veins accompanying malachite and azurite, 1 to 1.5 m wide, striking NE 30° to 35° and dipping almost vertically in siltstone, which is remarkably brecciated and silicified. Vein quartz is of chalcedonic character with abundant cavities filled with iron oxide minerals, possible weathered products of sulfide minerals. Networks of quartz veinlets are developed for widths of 2 to 2.5 m in the wall rocks along the both side of the quartz veins. An assay result of representative specimen of the ore showing gives 7 g/t Ag, 0.19% Pb in total (0.07% in non-sulfide form), 0.55% Zn in total zinc (0.49% in non-sulfide form), and 0.2% S. The mineralization in the area is of quartz vein type accompanying gold, silver, copper, lead and zinc.

In the Mkang'ombe South, no mineralized outcrops are located to date. Some floats of shales and siltstones contain networks quartz veinlets upto 1 cm wide and mineralization insitu, if any, may be of the same type as in the Mkang'ombe.

No igneous activity, possibly related to the mineralization has been not in both the areas to date.

(D) Examination

The ore showings, examined during this year's campaign, are located approximately 30 km west of Kwale, and is situated in the southern-most end of the general alignment of the lead-silver mineral occurrences. There may be a possibility that mineralized zones unknown to date be exist to the south of the Mkang'ombe area, in such areas as the Mwereni and the Mwena. It is worthwhile to study the possibility.

mainly consists of an alternation of sandstone, siltstone and shale, and is correlated to Lower Triassic age.

The Formation as a whole generally strikes in NW-SE to NE-SW directions with gentle dips of around 5° to NE or to SE. No notable faults or lineaments have been recognized on airphotographs in the area by the current work.

(ii) Mineralization

Mineralization in the area has been observed in two areas, the Kumbi (Mkang'ombe North) in the northeastern part and Mkang'ombe (Mkang'ombe South) in the southwestern part.

Mineralization in Mkang'ombe North consists of milky white to khaki-yellow quartz veins accompanying malachite and azurite, 1 to 1.5 m wide, striking NE 30° to 35° and dipping almost vertically in siltstone, which is remarkably brecciated and silicified. Vein quartz is of chalcedonic character with abundant cavities filled with iron oxide minerals, possible weathered products of sulfide minerals. Networks of quartz veinlets are developed for widths of 2 to 2.5 m in the wall rocks along the both side of the quartz veins. An assay result of representative specimen of the ore showing gives 7 g/t Ag, 0.19% Pb in total (0.07% in non-sulfide form), 0.55% Zn in total zinc (0.49% in non-sulfide form), and 0.2% S. The mineralization in the area is of quartz vein type accompanying gold, silver, copper, lead and zinc.

In the Mkang'ombe South, no mineralized outcrops are located to date. Some floats of shales and siltstones contain networks quartz veinlets upto 1 cm wide and mineralization insitu, if any, may be of the same type as in the Mkang'ombe.

No igneous activity, possibly related to the mineralization has been not in both the areas to date.

(D) Examination

The ore showings, examined during this year's campaign, are located approximately 30 km west of Kwale, and is situated in the southern-most end of the general alignment of the lead-silver mineral occurrences. There may be a possibility that mineralized zones unknown to date be exist to the south of the Mkang'ombe area, in such areas as the Mwereni and the Mwena. It is worthwhile to study the possibility.

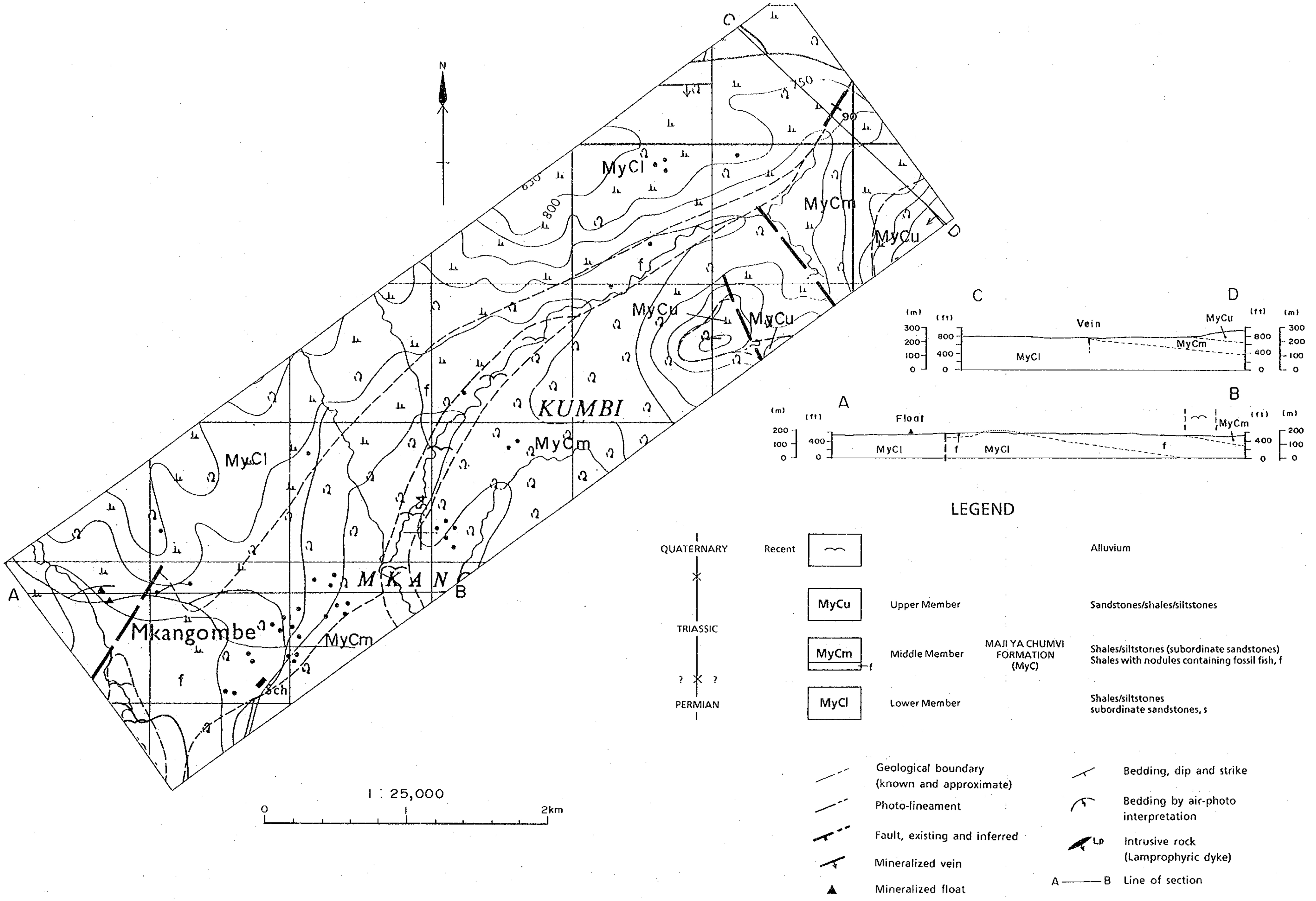


Figure II-2-3-14 (1) Geological Map of the Mkang'ombe Area

(15) Mangea-Kwa Dadu Area

(A) Location, Access and Topography

(i) Location and Access

The Mangea-Kwa Dadu area is situated approx. 86 km north-northeast of Mombasa and 48 km west of Malindi. The area is accessible by driving from Mombasa northwestward on the Kilifi-Dida-Vitengeni all weather road via Kilifi, and further on the Vitengeni-Kanoneni road northward via Vitengeni for 10 km to the Mwahera Crest, where the ore showings in the area are observed on northern hill slope.

(ii) Topography

The Mangea-Kwa Dadu area is situated in the "Coastal Range" explicated by Gregory, J.W. (1896) and Caswell, P.V. (1953). General topography in the area is widely undulated, having an altitude difference of approx. 800 ft (approx. 240 m). The Mwahera Range, 850 ft high above sea-level at the crest, runs northeast-southwesterly to form a mountainous land, approx. 1,200 ft (approx. 360 m) high above sea-level, the highest. On the hand, lands of gentle relief are formed in the southern to southwestern parts of the area. The ore showings in are located at a hill crest near the Mwahera Crest and on the gentle northern slope of the Crest.

(B) Existing Geological Studies

Existing geological informations in the area available are; the Geological Sheet: Malindi Area, 1 to 125,000 scale, by Thompson, A.O. (1956) and the Geological Sheet: Vitengeni, 1 to 50,000 scale, by British Technical Cooperation Project (1981).

Stream sediments geochemical research on copper, zinc, lead, barium, manganese and vanadium, delineated on 1 to 50,000 Sheet, was implemented by British Technical Cooperation Project (1979-1982). No geologic, and economic-geology studies, concerning to the ore showings in the area, have ever been implemented to date. It is verbally reported that a brecciated silicified zone, accompanying quartz veinlets are located at on a slope, 1 km northwest of the Mwahera Crest, and was prospected by trenching in 1980s.

(C) General Geology and Mineralization

A geological map and a cross-section in the area are shown in Figure II-2-3-15 (1).

(i) General geology

General geology in the area mainy consists of sandstone beds of the lower member of the Mazeras Formation, which is correlated to Upper Triassic to Lower Jurassic age. The sandstone is very coarse-grained, less consolidated and highly porous, and abundant in quartz and feldspar grains 0.5 to 1 mm in sizes intergranularly cemented by clay minerals. The beds generally show an undisturbed structure, striking in N-S to NW-SE and dipping 2° to 3° NE or E. A notable fault, striking northwest and dipping northeast ward, is observed in the northern part of the area.

Two sets of lineaments, striking NNW-SSE and NE-SW, are predominated on airphotographs along the both sides of the road near the Mwahera Crest.

(ii) Mineralization

Following 2 types of mineralization are observed along the road from the Mwahera Crest toward the Mwahera Village in the north.

- Type 1 is hosted by sandstone slightly to moderately silicified and composed of networks of milky-white chalcedonic quartz,veinlets upto 0.7 cm wide, accompanying a minor amount of barite, observed. A representative sample of the showing gives 0.8% of Ba.
- Type 2 is characterized by an occurrence of intergranular quartz and limonite as matrices in brecciated and silicified sandstone.

  A very fine, single galena grain, 0.5 millimetre long, is discernible in a quartz veinlet. Limonite is considered to be originated from metallic sulfide minerals.

No igneous activities, related to the mineralization, have been recognized to date.

(D) Examination

A sample of brecciated rocks, matrices of which are cemented by limonite, were collected from gossanous outcrops widely distributed in the area and yielded 0.1 g/t Ag, 0.06% Pb in total (0.05% Pb in non-sulphide form) and 0.80% Ba.

According to the results of the work to date, mineralization of Pb-Ag-Ba may be expected in the area. Further examination of the area may be warranted.

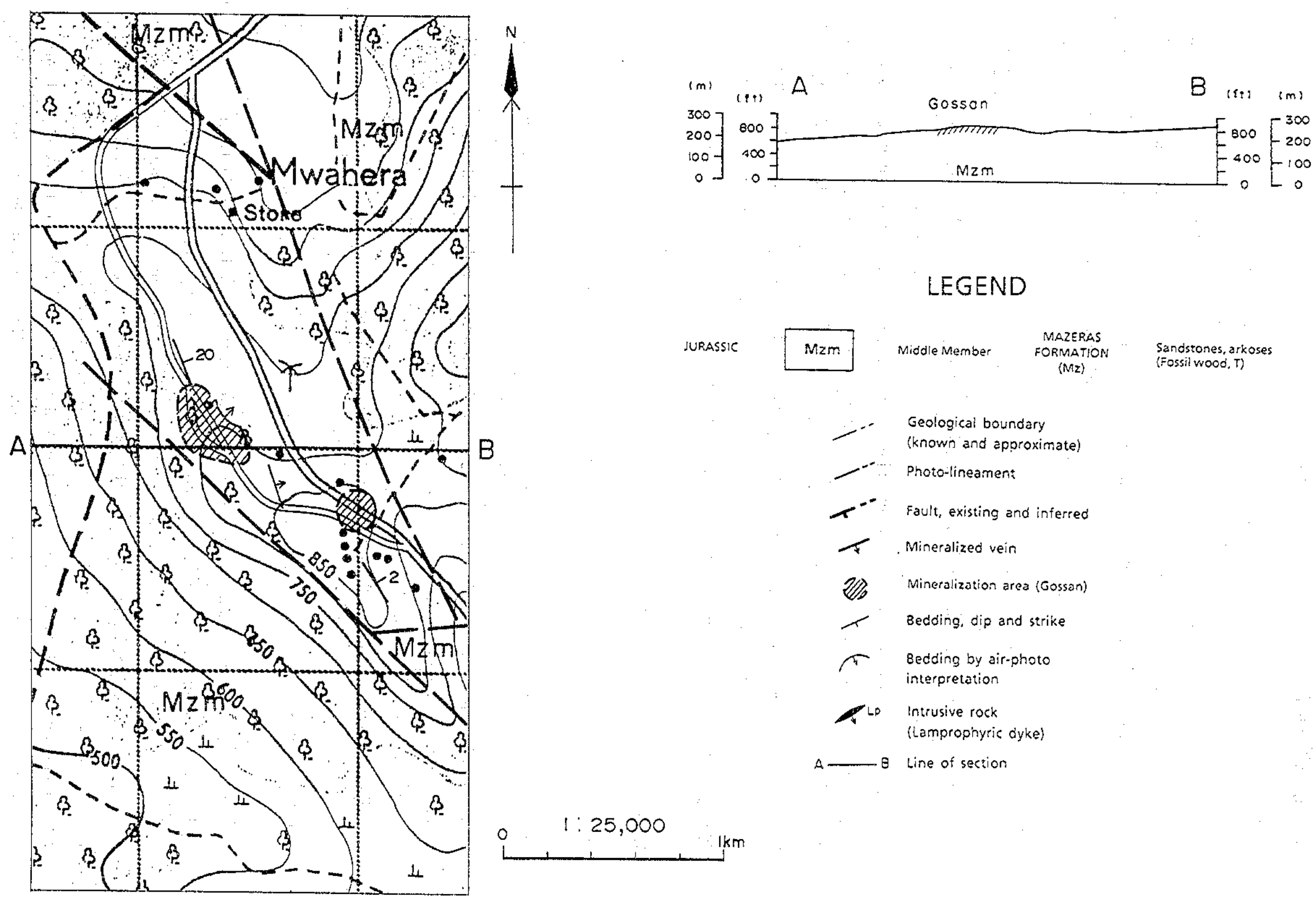


Figure II-2-3-15 (1) Geological Map of the Mangea-Kwa Dadu Area

2-4 Geochemical Surveys

(1) Pan-concentrate Geochemical Survey

The survey was carried out because of the necessity for determining some aspects of the gross regional mineral potential in the Mombasa area.

In the survey, the 100 samples were collected within an area of about 9,000 km^2.

Field procedure

Before beginning the fieldwork, suitable stream sand sampling locations were selected and plotted on a map with scales 1:250,000 of the Mombasa area. All major streams were sampled, and their tributaries were sampled near the confluence with the major streams. The sand chosen from a suitable locality in the stream-bed was panned down by the standard gold-panning method to a semiconcentrate having a volume of a 20 milliliter test tube. Samples were collected in small plastic bags, and preliminarily dried in the sun. With adverse accessibility the sampling rate was less than four concentrates per team per day.

Laboratory

Mineral identification

For the identification of the minerals under the microscope, all optical properties such as color, pleochroism, form, optical orientation, refractive index, birefringence, and interference figure were used. X-ray diffractometry was also used for the mineral identification of the 11 samples.

The mineral content of the samples was listed on Appendix X.

Chemical analysis

Samples collected from the area were sent for chemical analysis in the Chemex Labs Ltd., Canada; where the samples were dried and pulverized to approximately -150 mesh.

The pan-concentrate samples were analyzed for trace elements include Au, Ag, Cu, Pb, Zn, Ba, Mn, Fe, S, U, Th, Pt, P and Hg. Trace elements, Cu, Pb, Zn, Ba, Mn, Fe, U, P and Hg were determined by ICP-AES, Inductively Coupled Plasma - Atomic Emission Spectrometry. Au and Pt were determined by FA-ICP-AFS, Fire Assay-Atomic Fluorescence Spectrometry after nitric-aqua regia digestion. Ag was determined by AAS, Atomic Absorption Spectrometry after nitric-aqua regia digestion. Thorium was determined by NAA, Neutron Activation Analysis after encapsulation and irradiation. And sulfur was analyzed by using Leco Induction Furnance-IR Detector.

Results and discussion

The pan-concentrated stream sediment samples were analysed for 14 elements Au, Ag, Pb, Zn, Ba, Mn, Fe, S, U, Th, Pt, P, and Hg. Of the 14 elements, U was assayed at a single value 1 ppm, for all the samples and it is, therefore, meaningless to treat U values statistically. The analytical results for other elements are briefly discussed below.

Au: Majority of the samples (approx. 70%) indicated less than 1 ppb (detection limit) in Au. According to the cumulative frequency distribution of the Au values, 6 ppb is chosen for the threshold to differentiate anomalous Au values. Samples from 4 localities yielded anomalous Au values as shown in Figure GC-2.

Ag: Nearly 98% of the samples indicated less than 0.2 ppm (detection limit) in Ag. Therefore it is almost meaning less to treat Ag values statistically. Only two samples which yielded Ag values above the detection limit are located in the proximity to the Vitengeni lead (barite) mine as shown in Figure GC-2.

Cu: Cu values range from less than 1 ppm upto 50 ppm, and indicate few distinct peaks in the frequency distribution. Therefore, the Cu value population apparently comprises more than 2 subpopulations. In this study, the Cu values above 20 ppm are regarded as distinctively anomalous and those between 7 and 20 ppm as possibly anomalous. Geographical distribution of anomalous values in Cu is shown in Figure GC-2.

Pb: Most of the samples (more than 90%) range from 2 ppm (detection limit) to 10,000 ppm analytical capper limit and the population appears to consist of more than 2 subpopulations. Of the 100 samples in total 3 samples indicated outstandingly high values, 400, 3,000 and 10,000 ppm and were collected from streams in the proximity of the Vitengeni and Kinangoni mine (Figure GC-2).

Zn: Zn values range from less than 2 ppm (detection limit) to 234 ppm. The population apears to consist of several subpopulations in the frequency distribution but may be regarded as a single population in the cumulative frequency distribution which indicates a nearly streight line. However, 2 threshold values, 35 and 150 ppm are chosen at 2 inflection points of slight change in slopes of the cumulatives frequency curve to differentiate possible anomalous and anomalous values. Geographical distribution of anomalous values in Zn are shown in Figure GC-2.

Ba: The population of Ba values appears to be distinctly separated into 3 major subpopulations in the frequency distribution. The subpopulation less than 500 ppm Ba may represent a regional background in the area. Values between 500 ppm and 3,000 ppm, forming another subpopulation may be anomalous in a regional sense but their geographical distribution is too wide to specify terget areas for further prospecting. Only the subpopulation above 3,000 ppm Ba values is regarded as anomalous in this study. The distribution of anomalous barium values appears to be specially related to known mineral occurrences such as the Kinangoni, the Vitengeni and other minor mineral showings.

Mn: The population of Mn values may also be a combination of some different subpopulations but distribution of these subpopulations is not so distinct as in the case of Ba values. Only 1 sample yielded a Mn value exceeding 5,000 ppm and was collected in a stream located near the Kinangoni prospect to the north (Figure GC-2).

Fe: Fe content in the pan-concentrated samples ranges widely between 0.36 and more than 15% analytical apper limit. The frequency distribution pattern suggest that the Fe value population may consist of some different subpopulations. However, it is very difficult to distinguish each subpopulation. The threshold value of 9% Fe is chosen at an inflection point with a slight change in slopes of the cumulative frequency curve in this study. Only 3 anomalous values in Fe are found in the samples collected from streams in the western part of the area (Figure GC-2).

S: S content in the samples ranges between 0.004 and 5.450% but most samples (approx. 95%) are less than 0.2% in S. The frequency distribution of the S values indicates a log-normal pattern with positive skewness. The second inflection point at around 0.08% may be regarded as a threshold value to differentiate anomalous S values. In this study, 3 threshold values, 2, 0.3 and 0.08 ppm S are chosen to differentiate the 1st class anomalous, 2nd class anomalous and 3ed class anomalous and the background populations. Geographical distribution of the anomalous values is between Mangea-Kwadadu and Kinangoni (Figure GC-2).

Th: Th content in the pan-concentrated samples in the area ranges between 2 and 1,308 ppm, and seems to be generally high with nearly 40% of the samples having yielded 100 ppm or more Th. The frequency distribution pattern suggest that the population of Th values consists of many different subpopulations. In this study, 3 threshold values, 750, 150 and 50 ppm Th, are chosen to differentiate the 1st class anomalous, the 2nd class anomalous the 3rd class anomalous, and the background populations respectively. Geographical distribution of the anomalous values is widely dispersed in the area (Figure GC-2).

Pt: Pt content in the samples ranges between 2.5 and 10 ppb. The population of Pt values appears to be separated into 3 subpopulations with threshold values of 3 and 7 ppb. The subpopulation less 3 ppb in Pt is regarded as the background population. Only 5 samples indicated anomalous values in Pt and were collected in streams in the southern half of the area (Figure GC-2).

P: The population of P values appears to consist of a number of subpopulation which are difficult to differentiate from each other except one isolated populations. Values exceeding 1,100 ppm are located in the southern part of the area to the north of the Mrima Hill (Figure GC-2).

Hg: Most of Hg values (approx. 70%) are less than 1 ppm (detection limit). Threshold values of 30 and 6 ppm are chosen to differentiate the anomalous, the possibly anomalous and the background populations. The anomalous values exceeding 6 ppm in Hg are only 2 and located in the northern part of the area (Figure GC-2).

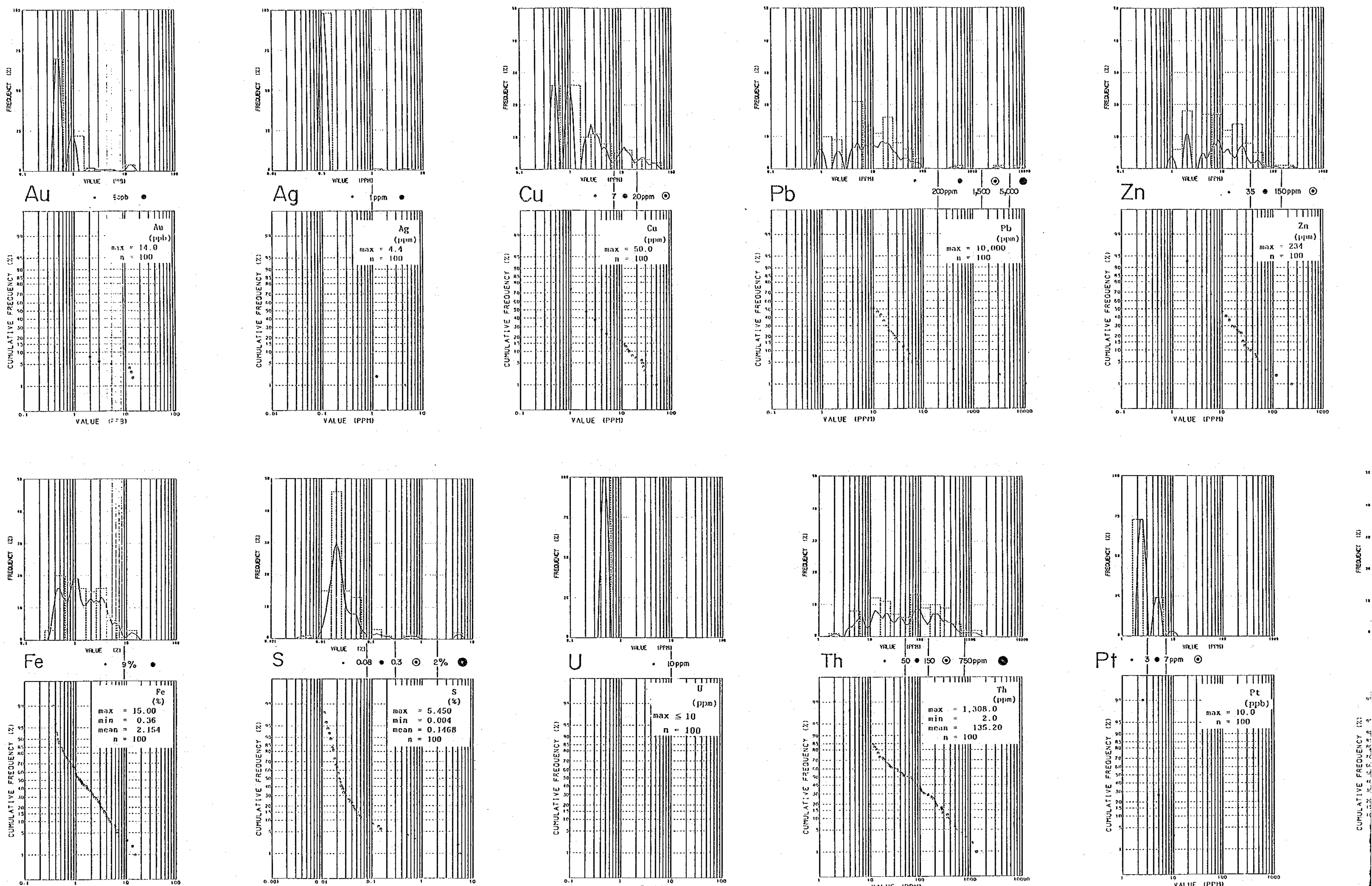
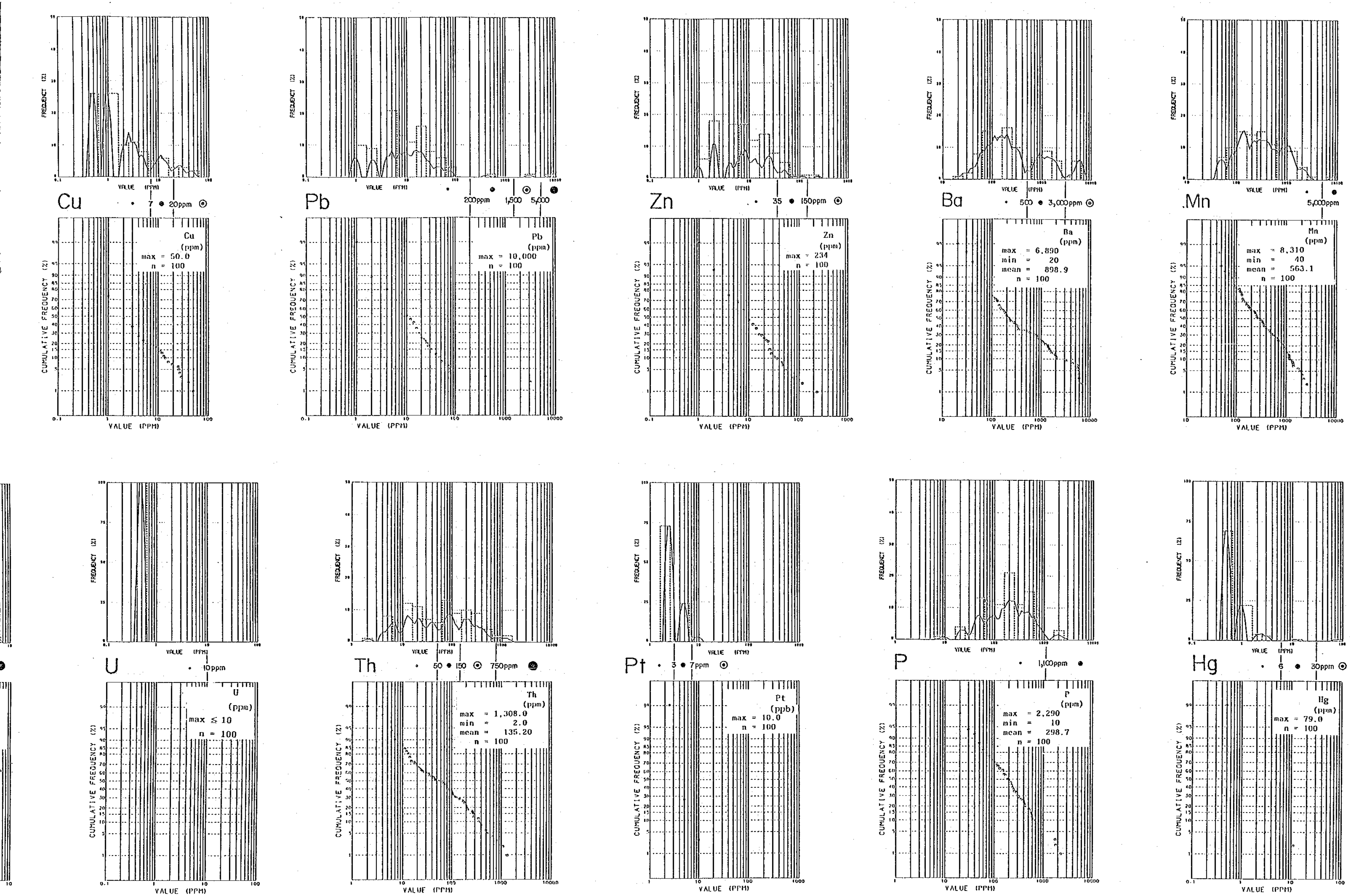
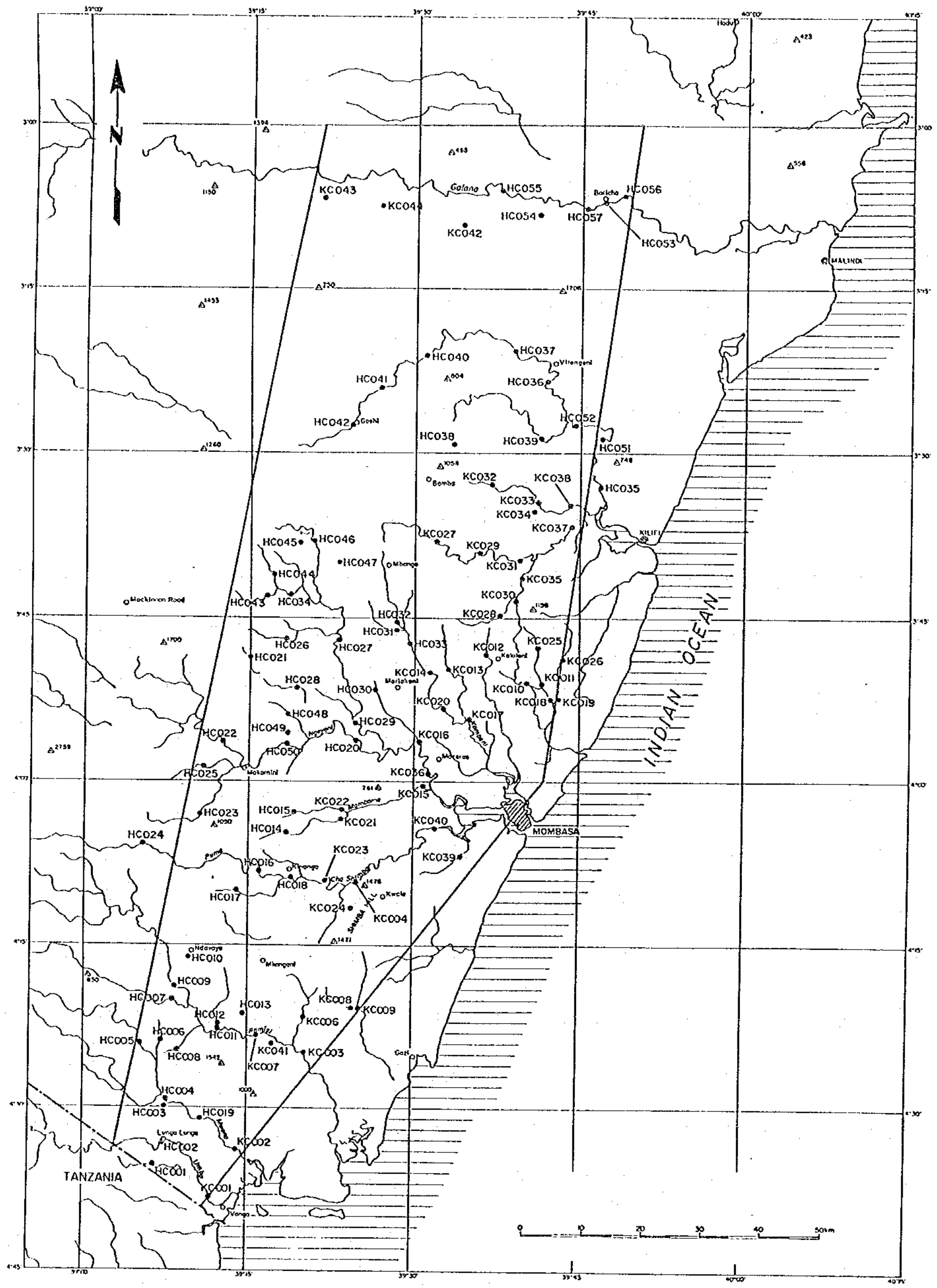


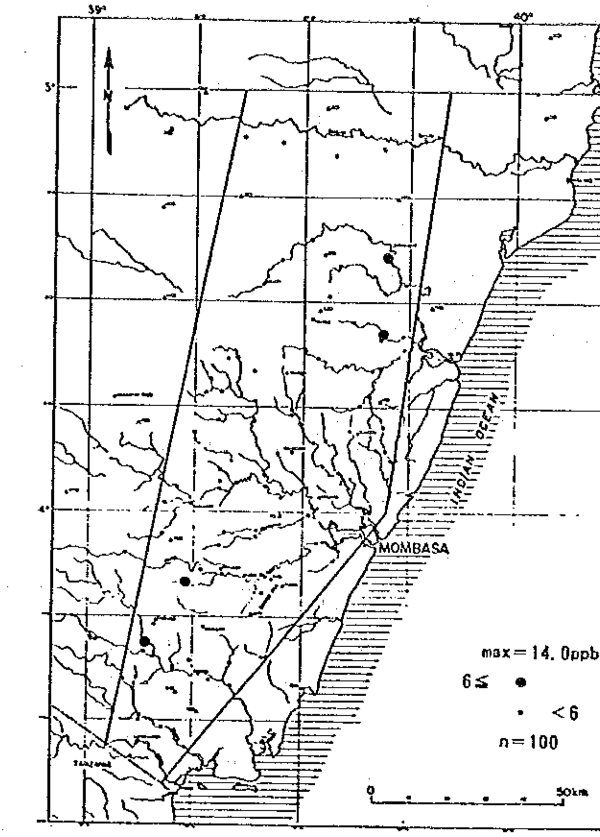
Figure GC-1 Frequency distribution and cumulative frequency distribution of 14 selected elements in pan-concentrated stream



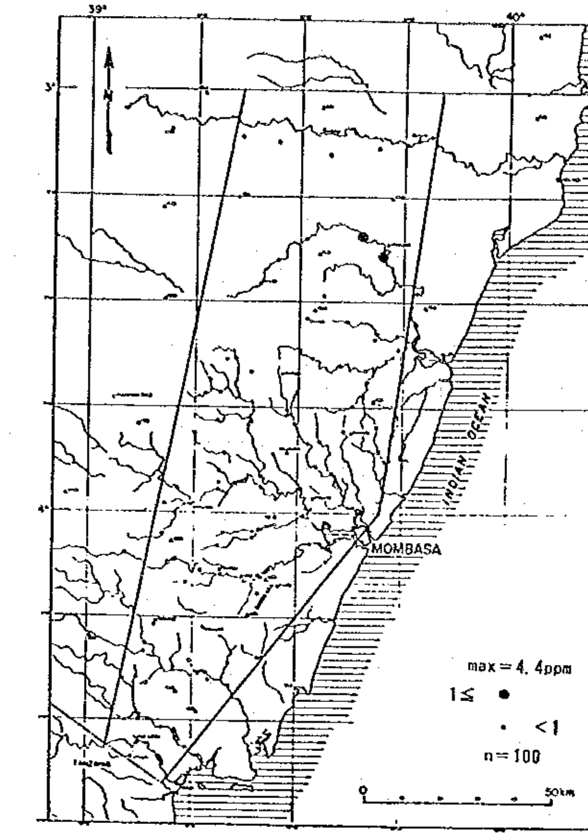
ibution and cumulative frequency distribution of 14 selected elements in pan-concentrated stream sediments from the Mombasa area



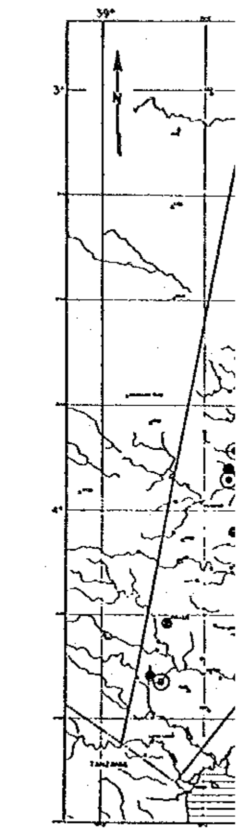
Au



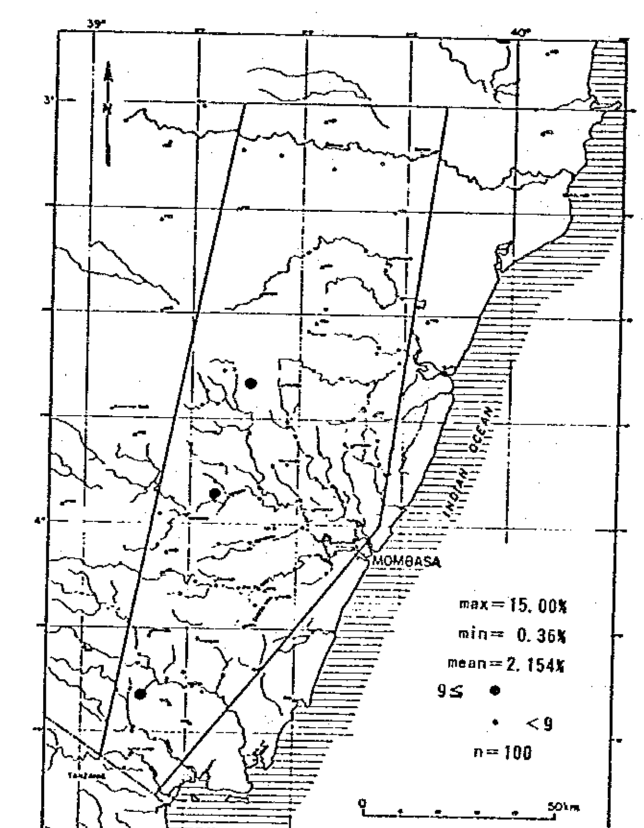
Ag



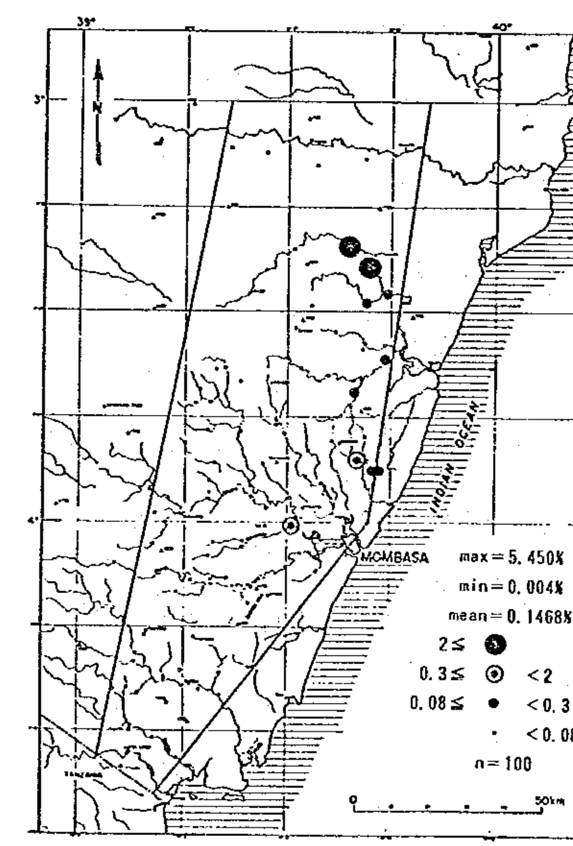
Cu



Fe



S



U

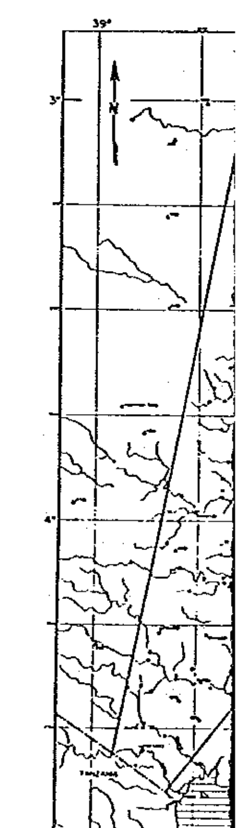


Figure GC-

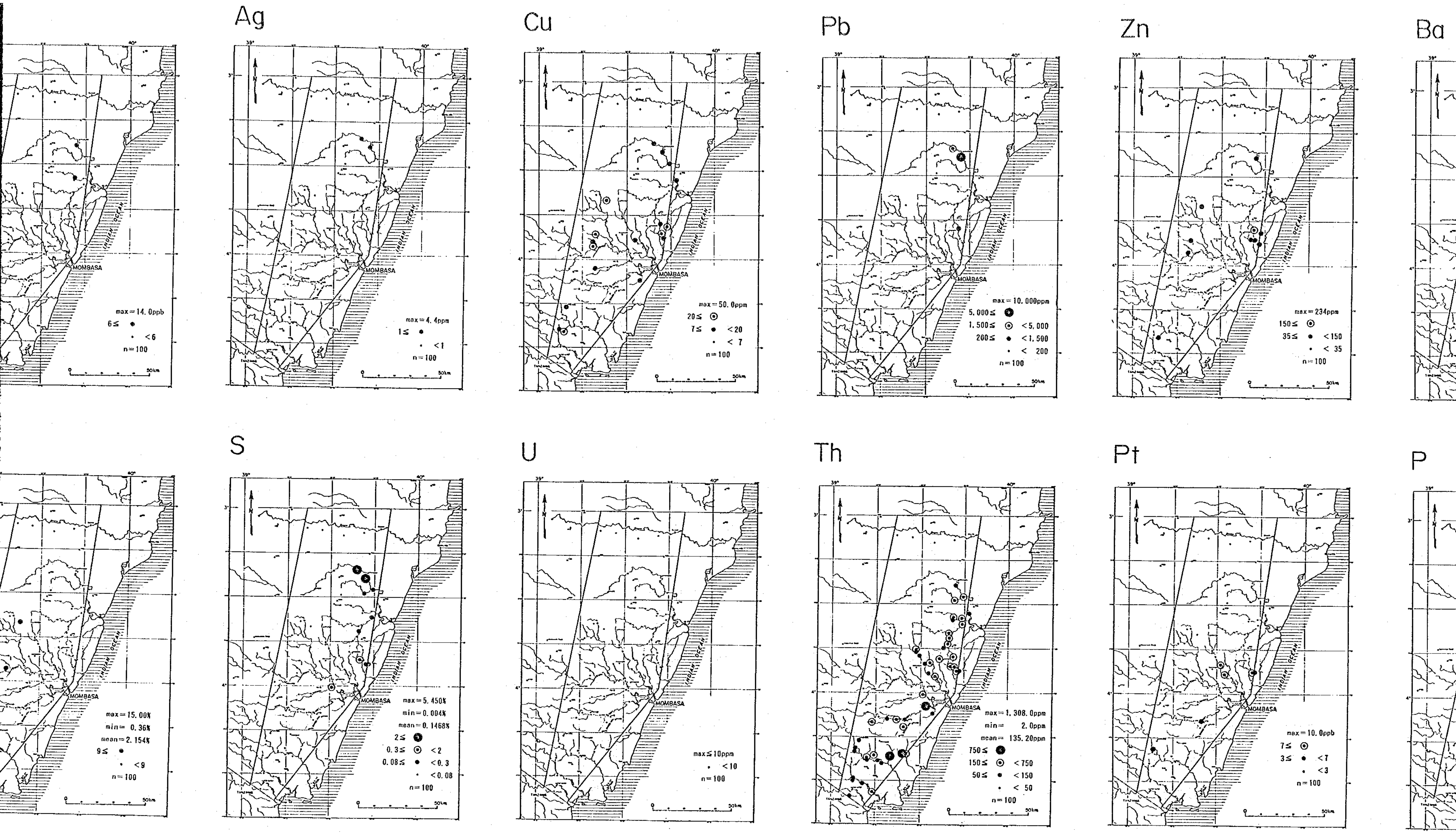
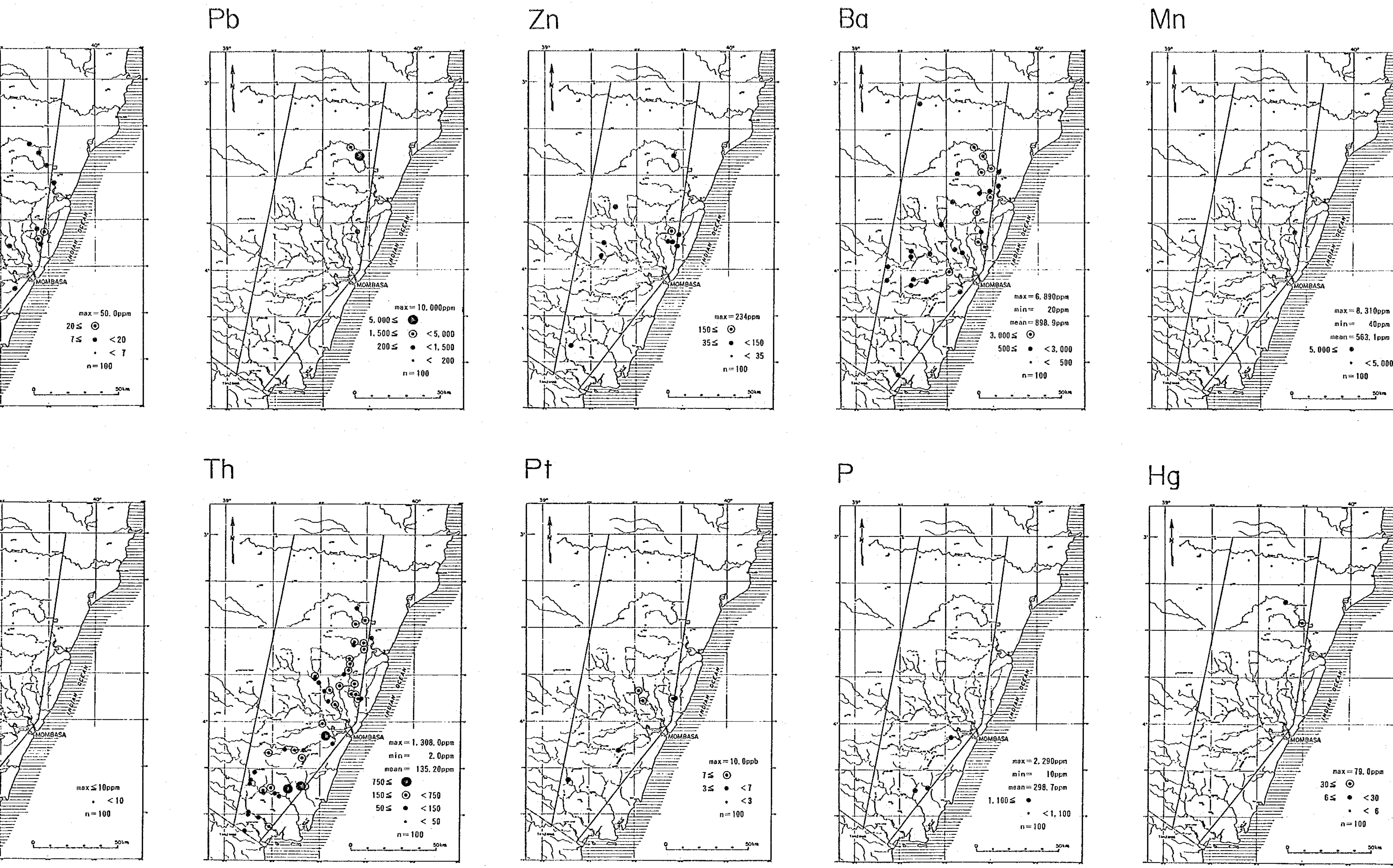


Figure GC-2 Distribution of 14 selected elements in pan-concentrated stream sediments from the Mombasa area



istribution of 14 selected elements in pan-concentrated stream sediments from the Mombasa area

(2) Soil geochemical survey

Field procedure

The soil samples were collected from a depth of about 20 cm, which is below the humus zone where present. The samples were collected at an interval of about 50 to 100 m, depending on the size and intensity of mineralization judging from surface evidences. At Mukundi, a rectilinear grid was adopted for the sampling. Samples were collected from each point and preliminarily dried under the sun, and were then sieved through 80 mesh. About 200 grams of sample were collected. The samples were then sent to the laboratory.

Laboratory

Geochemical analysis of the samples was carried out in the Chemex Labs Ltd., Canada.

The samples were prepared by nitric-aqua-regia digestion method for the analysis of 8 trace elements and neutron activation encapsulation and irradiation for thorium.

The soil samples were analyzed for 9 trace elements including Au, Ag, Cu, Pb, Zn, Ba, Mn, Fe and S. The elements Cu, Pb, Zn, Ba, Mn and Fe were determined by ICP-AES (Inductively Coupled Plasma-Atomic Emission Spectroscopy). Au was determined by FA-NAA (Fire Assay-Neutron Activation Analysis. Ag was determined by AAS (Atomic Absorption Spectroscopy). Sulfur was analyzed by using Leco induction furnace-IR detector.

Results and discussion

The soil samples were analyzed for 9 elements; Au, Ag, Cu, Pb, Zn, Ba, Mn, Fe, and S. The analytical results for the elements are briefly discussed below.

For statistical analysis, the assay results were divided into 3 groups, namely those for the Mrima Hill-Jombo Hill area; the Kinangoni, Mkang'ombe, and Mangea-Kwa Dadu areas; and the Mkundi area, according to types of mineralization associated. Frequency and cumulative frequency distribution are shown in Figures GC-3, 6 and 10 for Mrima Hill-Jombo Hill area; the Kinangoni, Mkang'ombe, and Mangea-Kwa Dadu areas; and the Mkundi area, respectively. Geographical distribution of values in the elements of the 5 areas are shown in Figures GC-4, 5, 7, 8, 9 and 11.

(A) Mrima Hill-Jombo Hill area.

Au: Au values range from 2 ppb to 64 ppb, and indicate few distinct peaks in the frequency distribution. Therefore, the Au value population apparently comprises more than 2 subpopulations. In this study, 3 threshold values, 45, 13 and 6 ppb Au, are chosen to differentiate the 1st class anomalous, the 2nd class anomalous, the 3rd class anomalous, and the background populations respectively. Geographical distribution of the anomalous values is shown in Figures GC-4 and 5.

Ag: 95% of the samples indicated less than 0.2 ppm (detection limit) in Ag. The Ag value population apparently comprises more than 2 subpopulations. In this study, 2 threshold values 0.2 ppm (detection limit) and 0.8 ppm Ag are chosen to differentiate possible anomalous and anomalous values. Geographical distribution of anomalous values in Ag are shown in Figures GC-2 and 3.

Cu: Cu values range from less than 1 ppm (detection limit) upto 169 ppm. The population of Cu values appears to be ditinctly separated into 2 independent subpopulations in the frequency distribution. The subpopulation, in this study, the Cu values above 70 ppm are regarded as anomalous. The anomalous values exceeding 70 ppm in Cu are only in the Jombo Hill area (Figure GC-3).

Pb: Pb values range from less than 2 ppm (detection limit) upto 626 ppm, and the population appears to consist of more than 2 subpopulations. In this study, 2 threshold values, 500 and 30 ppm are chosen to differentiate the 1st class anomalous, the 2nd class anomalous, and the background populations respectively. Geographical distribution of the anomalous values is shown in Figures GC-2 and 3.

Zn: Zn values range from less than 2 ppm (detection limit) upto 1,955 ppm. The population of Ba values appears to be distinctly separated in to 2 major subpopulations in the frequency distribution. In this study, 2 threshold values, 1,600 ppm and 400 ppm are chosen to differentiate the 1st class anmalous, the 2nd class anomalous, and the background populations respectively. Geographical distribution of the anomalous values is shown in Figures GC-2 and 3.

Ba: More than 15% of the samples exceeded 10,000 ppm (analytical upper limit). The subpopulation above 1,100 ppm Ba values is regarded as anomalous in this study. Geographical distribution of anomalous values in Ba is shown in Figures GC-2 and 3.

Mn: More than 40% of the samples exceeded 10,000 ppm (analytical upper limit). The subpopulation above 2,400 ppm Mn values is regarded as anomalous in this study. Geographical distribution of anomalous values in Mn is shown in Figures GC-2 and 3.

Fe: More than 50% of the samples exceeded 15% (analytical upper limit). The subpopulation above 6% Fe values is regarded as anomalous in this study. Geographical distribution of anomalous values in Ba is shown in Figures GC-2 and 3.

S: S content in the samples ranges between 0.005 and 1.890%. The population of S values appears to be distinctly separated into 3 major subpopulations in the frequency distribution. In this study, 2 threshold values, 0.5 and 0.02 are chosen in the frequency distribution of the S values. Geographical distribution of anomalous values in S is shown in Figures GC-2 and 3.

(B) Kinangoni, Mkang'ombe and Mangea-Kwa Dadu areas

Au: Nearly 30% of the samples indicated less than 1 ppb (detection limit). According to the frequency distribution of the Au values, 100, 20 and 4 ppb are chosen for the threshold to differenctiate anomalous Au values. In this study, the Au values above 20 ppb are regarded as distintively anomalous and those between 4 and 20 ppb as possibly anomalous. Of the 120 samples in total 2 samples indicated outstandingly high values, 30 and 407 ppb and were collected from the Kinangoni and Mkang'ombe areas respectively.

Ag: More than 80% of the samples indicated less than 0.2 ppm (detection limit) in Ag. The Ag values above 0.6 ppm are regarded as anomalous and those between 0.2 and 0.6 ppm as possively anomalous. The samples which yielded Ag values above the detection limit are located only in the Kinangoni area.

Cu: Cu values range from less than 1 ppm (detection limit) upto 81 ppm, and indicate few distinct peaks in the frequency distribution. Therefore, the Cu value population apparently comprises more than 2 subpopulations. In this study, the Cu values above 60 ppm are regarded as anomalous. Only 1 sample indicated anomalous value, 81 ppm and was collected from the Mkang'ombe area.

Pb: Pb values range from less than 2 ppm (detection limit) upto 5,220 ppm and the population appears to consist of more than 2 subpopulations. In this tudy, 2 threshold values, 100 and 300 ppm Pb are chosen to differentiate the 1st class anomalous and 2nd class anomalous, and the background populations respectively. Anomalous values in Pb are found only in the samples collected from the Kinangoni area.

Zn: Zn values range from less than 2 ppm (detection limit) to 1,410 ppm. In this study, the Zn values above 400 ppm are regarded as ditinctively anomalous. Anomalous values in Zn are found in the samples collected from the Mkang'ombe area.

Ba: Ba values range from 55 ppm to 6,570 ppm. The population appears to consist of several subpopulation in the frequency distribution. In this study, two threshold values, 1,500 and 600 ppm Ba are chosen to differentiate the 1st class anomalous, 2nd class anomalous and the background populations respectively. Geographical distribution of anomalous values in Ba is shown in Figures GC-7, 8 and 9.

Mn: Mn values range from less than 5 ppm (detection limit) to 2,310 ppm. The threshold value of 1,100 ppm Mn is chosen at an inflection point with a slight change in slopes of the cumulative frequency curve in this study. Anomalous values in Mn are found only in the samples collected from the Mangea-Kwa Dadu.

Fe: Fe content in the samples ranges widely between 0.62 and 11.15%. The frequency distribution of the Fe values indicates a log-normal pattern with positive skewness. The second inflection point at around 5% may be regarded as a threshold value to differentiate anomalous Fe values. Anomalous values in Fe are found in the samples collected from the Kinangoni and Mangea-Kwa Dadu areas except the Mkang'ombe area.

S: S content in the samples ranges between 0.009 to 2.470%. The frequency distribution of the S values indicates a log-normal pattern with positive skewness. The second inflection point at around 0.1% may be regarded as a threshold value to differentiate anomalous S values. In this study, 2 threshold values, 0.5 and 0.1% are chosen to differentiate the 1st class anomalous, 2nd class anomalous and the background populations. Anomalous values in S are found in the samples collected from the Kinangoni and Mkang'ombe areas except Mangea-Kwa Dadu area.

(C) Mkundi area

Au: Majority of the samples (approx. 90%) indicated less than 1 ppb (detection limit) in Au. According to the cumulative frequency distribution of the Au values, 7 ppb is chosen for the threshold to differentiate anomalous Au values. Only one sample from the area yielded anomalous Au values as shown in Figure GC-11.

Ag: Nearly 95% of the samples indicated less than 0.2 ppm (detection limit) in Ag. In this study, the Ag values above 1.2 ppm are regarded as anomalous. Only one sample yielded anomalous Ag values as shown in Figure GC-11.

Cu: All of the samples indicated less than 15 ppm.

Pb: More than 99% of the samples indicated less than 60 ppm Pb.

Zn: More than 99% of the samples indicated less than 50 ppm Zn.

Ba: Ba content in the samples ranges from less than 10 ppm (detection limit) to 1,540 ppm. In this study, the threshold value of 1,000, and 300 ppm Ba, are chosen at an inflection point with a slight change in slopes of the cumulative frequency curve in this study. Geographical distribution of anomalous values in Ba is shown in Figure GC-11.

Mn: Mn content in the samples ranges from less than 5 ppm (detection limit) to 1,525 ppm. The threshold value of 1,100 ppm Mn is chosen at an inflection point with a slight change in slopes of the cumulative frequency curve in this study. Only two anomalous values in Mn are found in the samples collected from the area.

Fe: All of the samples indicated less than 2.81%. The population is regarded as a single population in the cumulative frequency distribution which indicates a nearly straight line.

S: Almost all of the samples indicated less than 0.07%. Only 1 sample yielded a S value exceeding 0.07%.

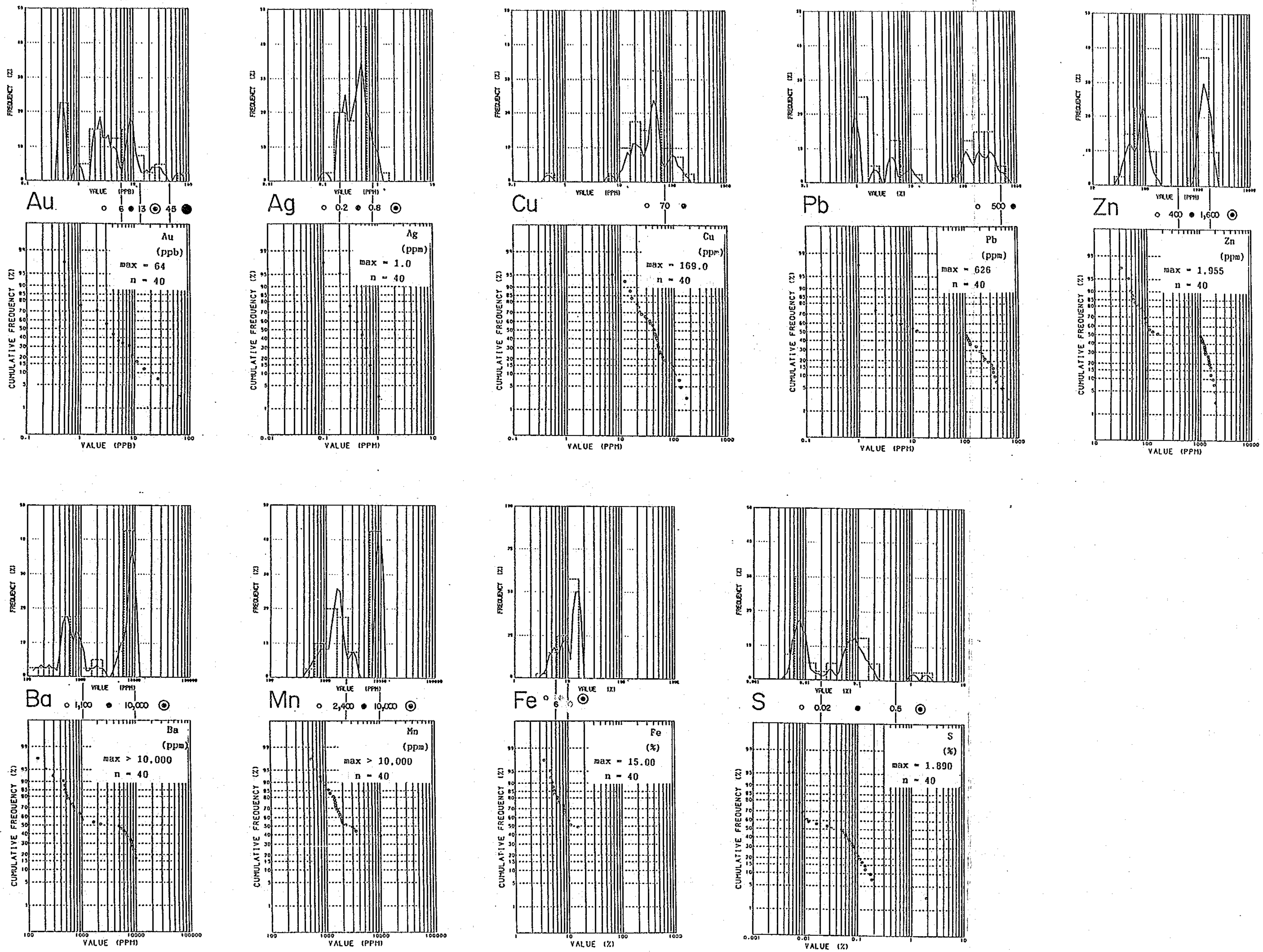


Figure GC-3 Frequency distribution and cumulative frequency distribution of 9 selected elements in soil from the Mrima Hill-Jombo Hill area

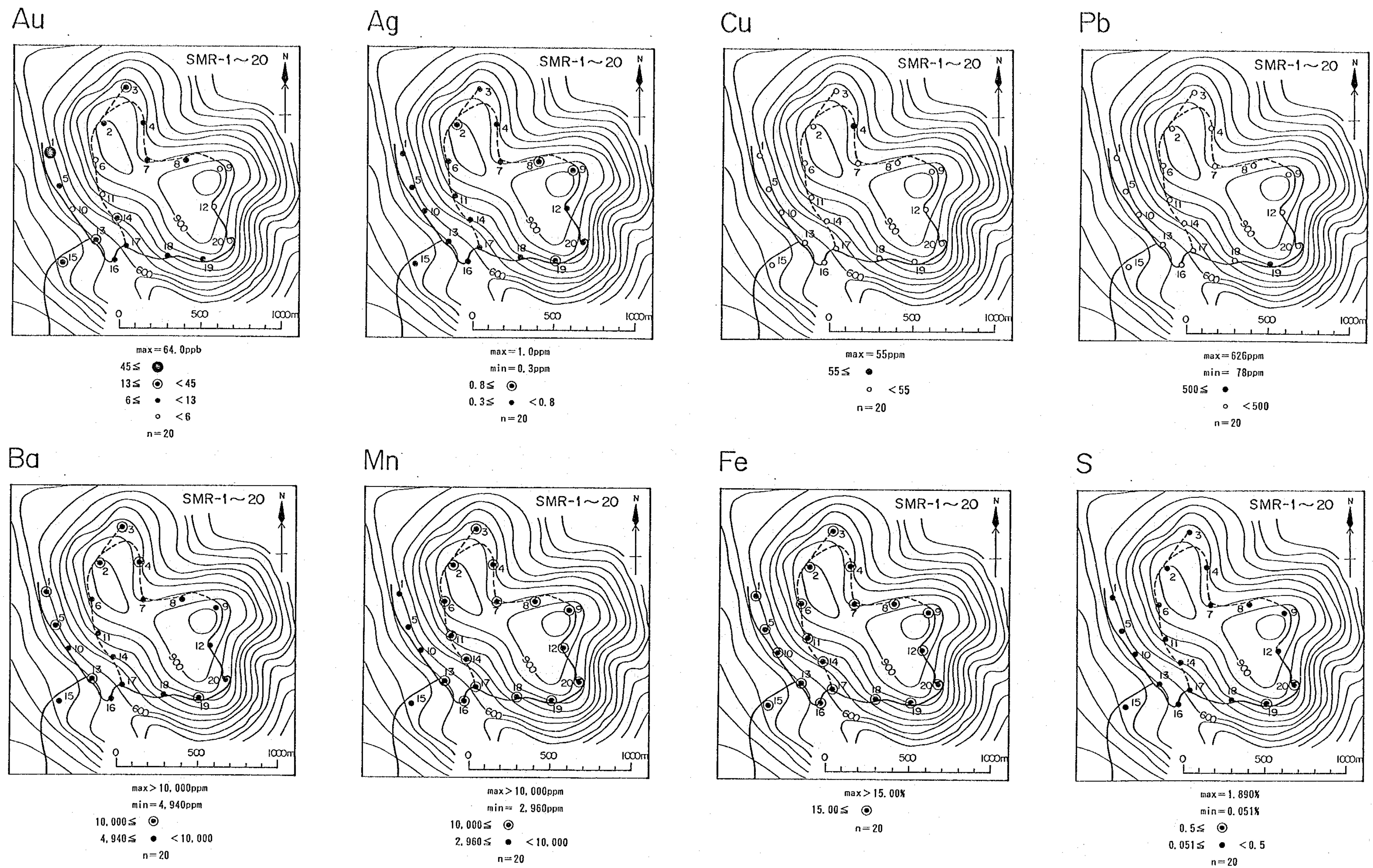
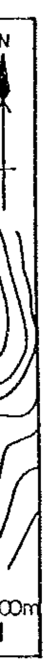
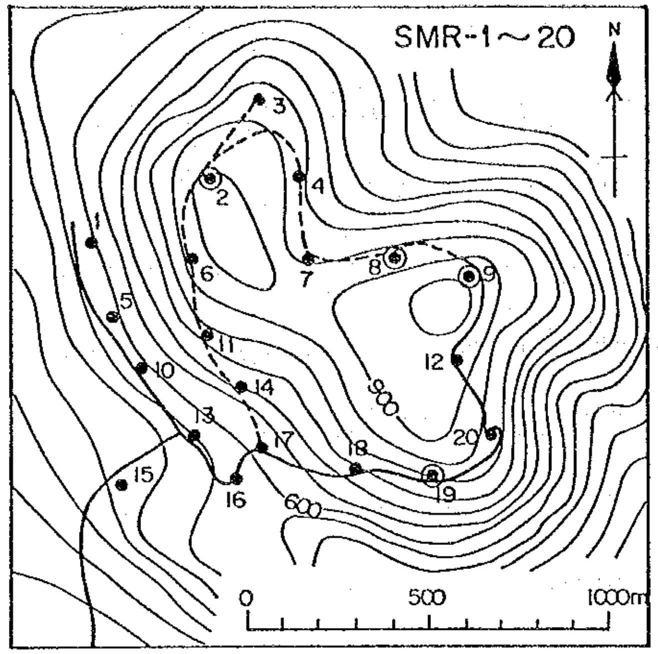


Figure GC-4 Distribution of 9 selected elements in soil from the Mrima Hill area

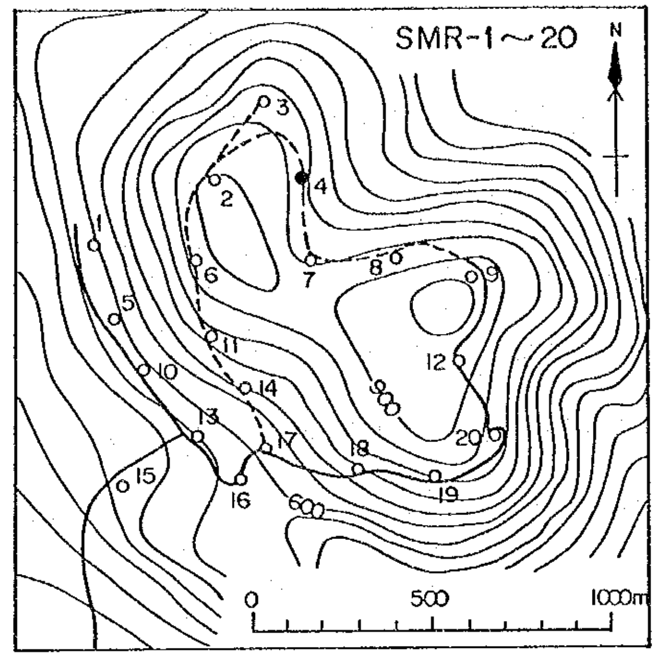


Ag



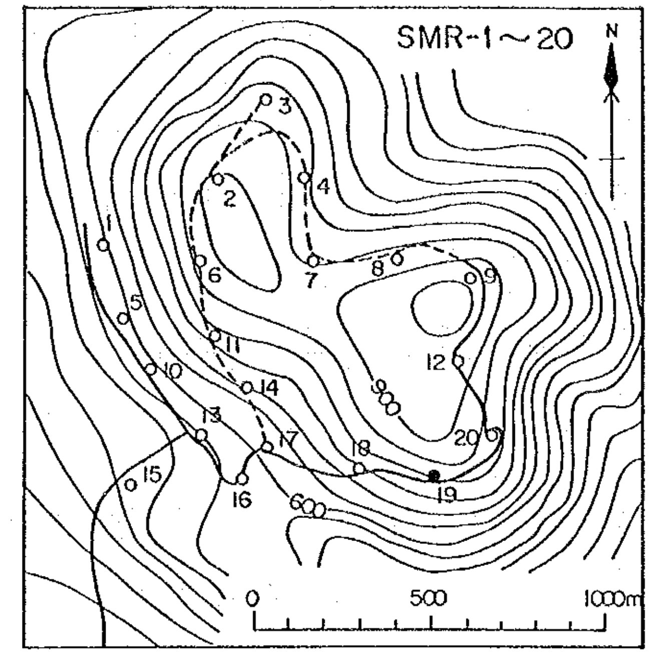
max = 1.0ppm
min = 0.3ppm
0.8≦ ◉
0.3≦ ● <0.8
n = 20

Cu



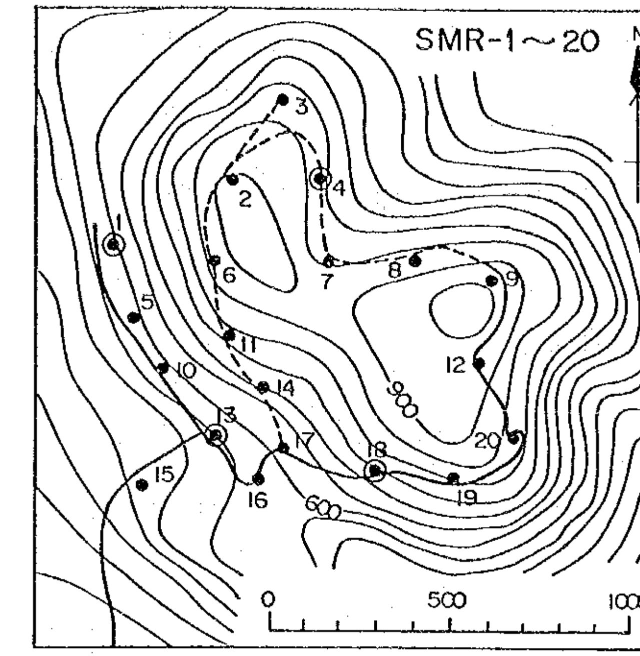
max = 55ppm
55≦ ●
○ <55
n = 20

Pb



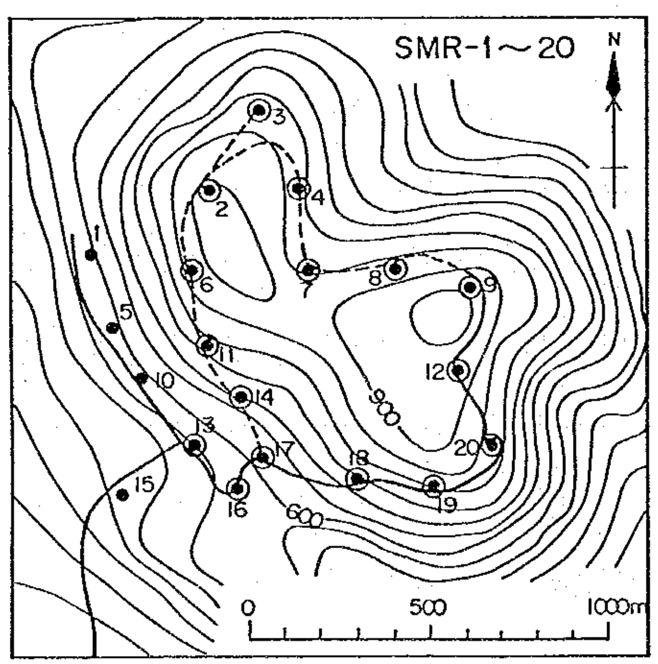
max = 626ppm
min = 78ppm
500≦ ●
○ <500
n = 20

Zn



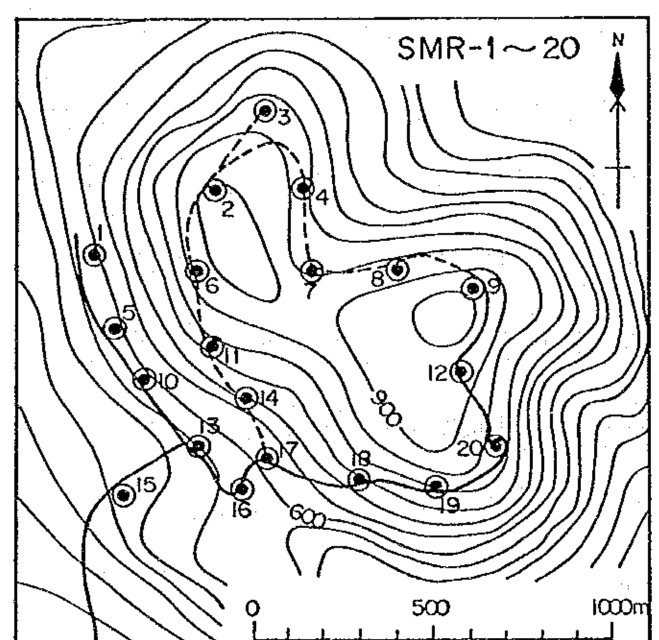
max = 1,955ppm
min = 1,000ppm
1,600≦ ◉
1,000≦ ● <1,600
n = 20

Mn



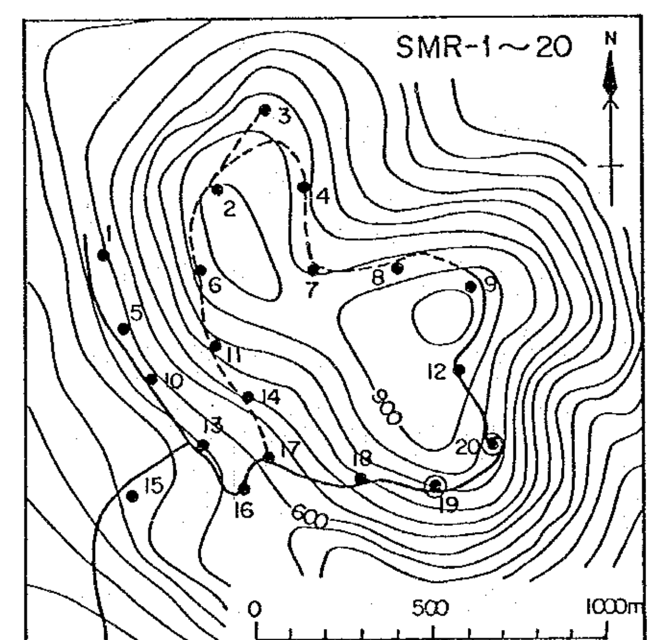
max > 10,000ppm
min = 2,960ppm
10,000≦ ◉
2,960≦ ● <10,000
n = 20

Fe



max > 15.00%
15.00≦ ◉
n = 20

S



max = 1.890%
min = 0.051%
0.5≦ ◉
0.051≦ ● <0.5
n = 20

Figure GC-4 Distribution of 9 selected elements in soil from the Mrima Hill area

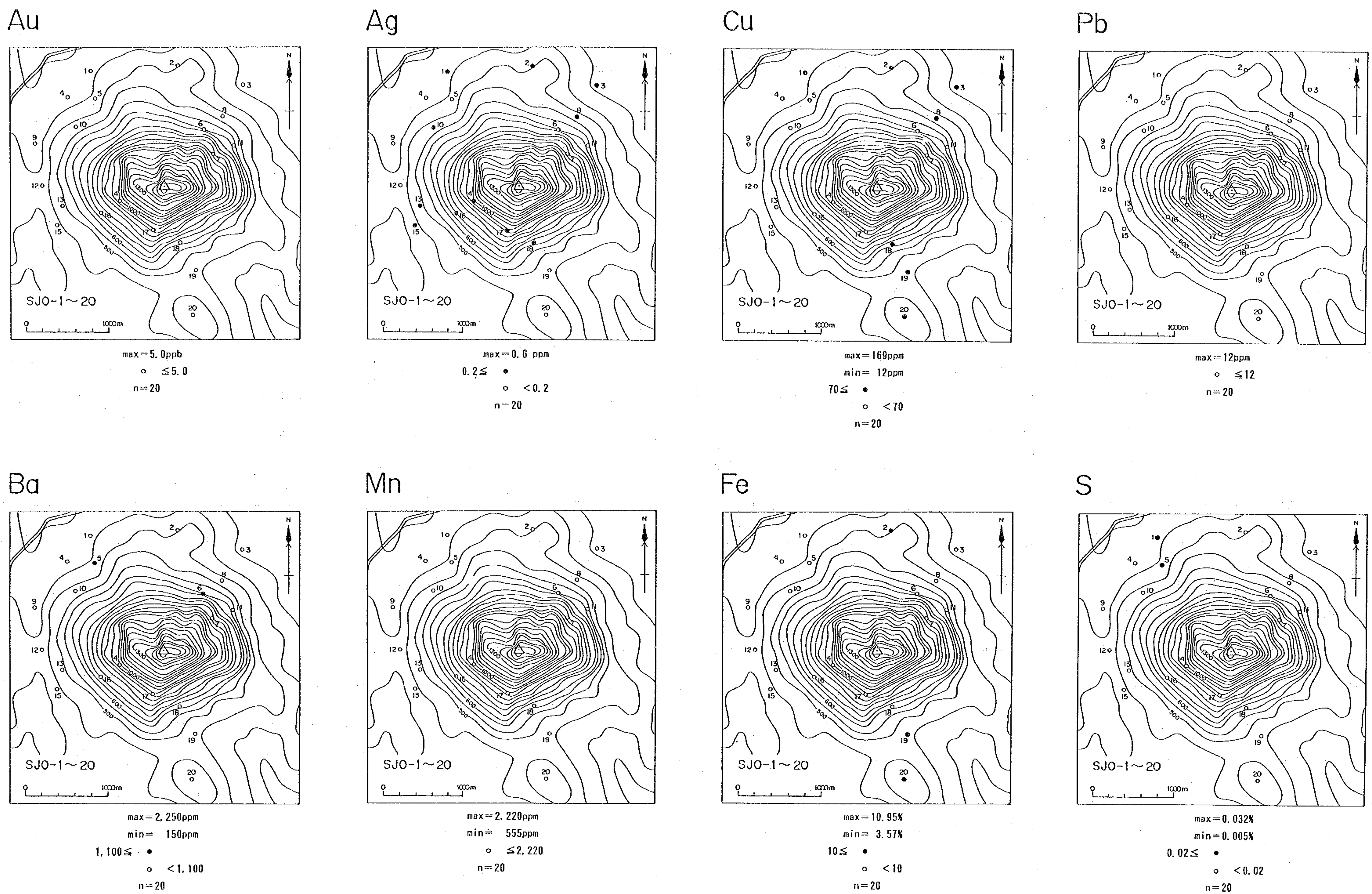
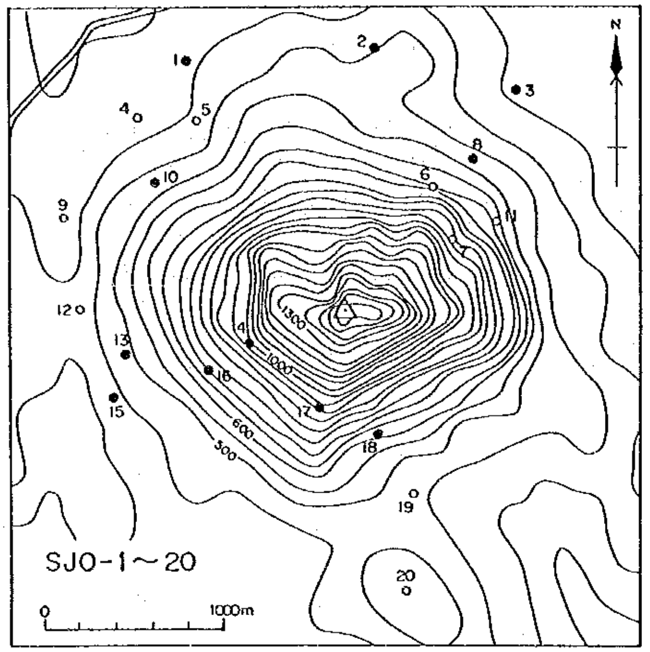


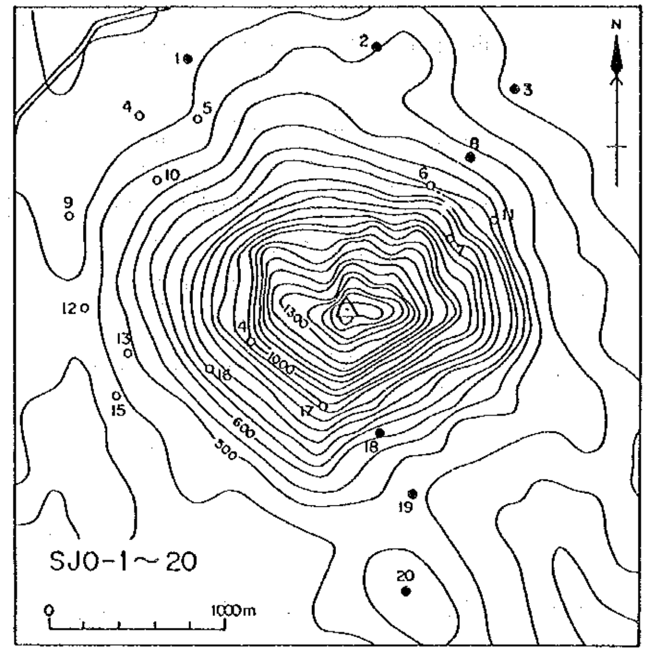
Figure GC-5 Distribution of 9 selected elements in soil from the Jombo Hill area

Ag



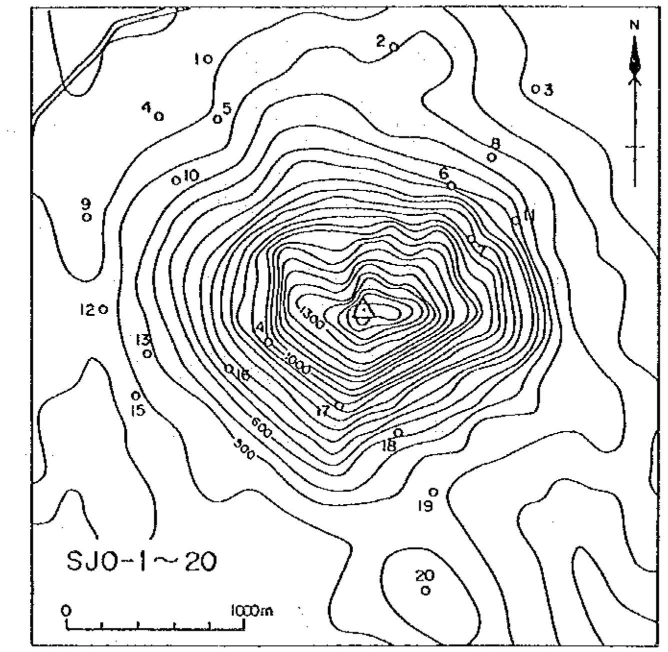
max=0.6 ppm
0.2≦ ●
○ <0.2
n=20

Cu



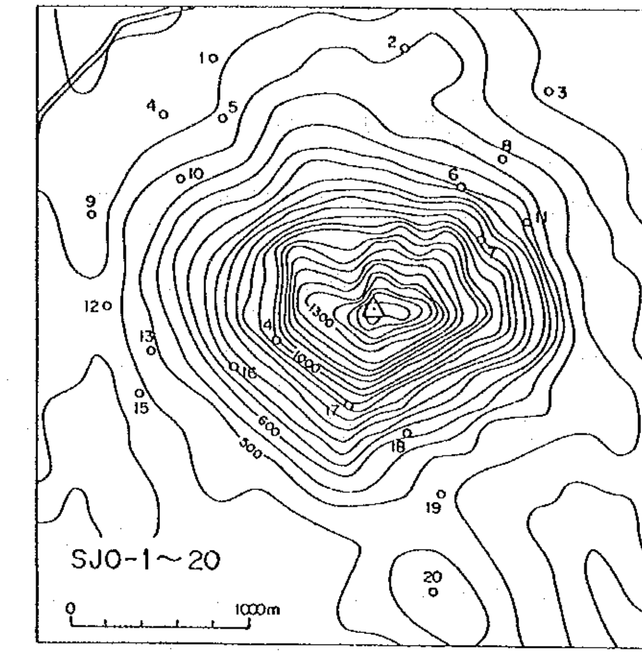
max=169ppm
min= 12ppm
70≦ ●
○ <70
n=20

Pb



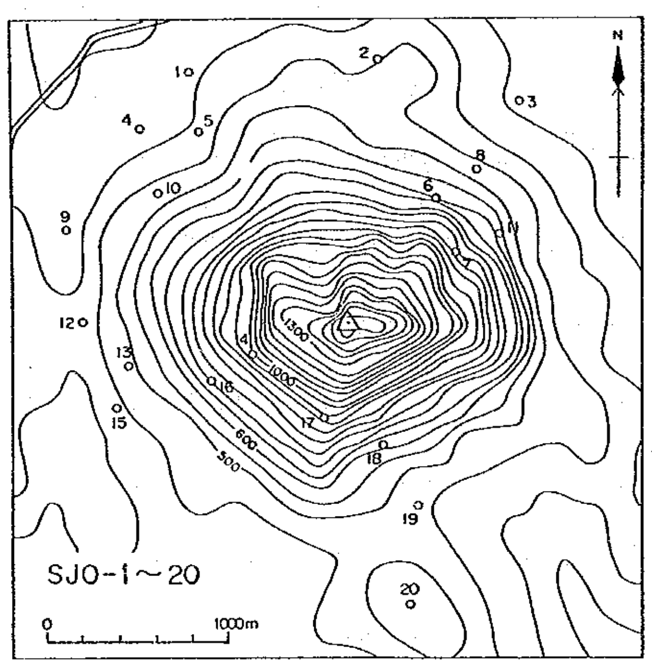
max=12ppm
○ ≦12
n=20

Zn



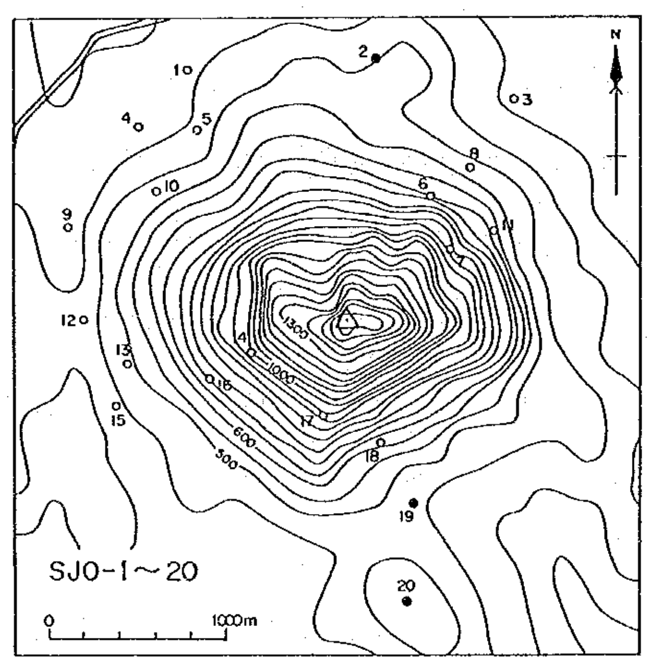
max=154ppm
min= 32ppm
○ ≦154
n=20

Mn



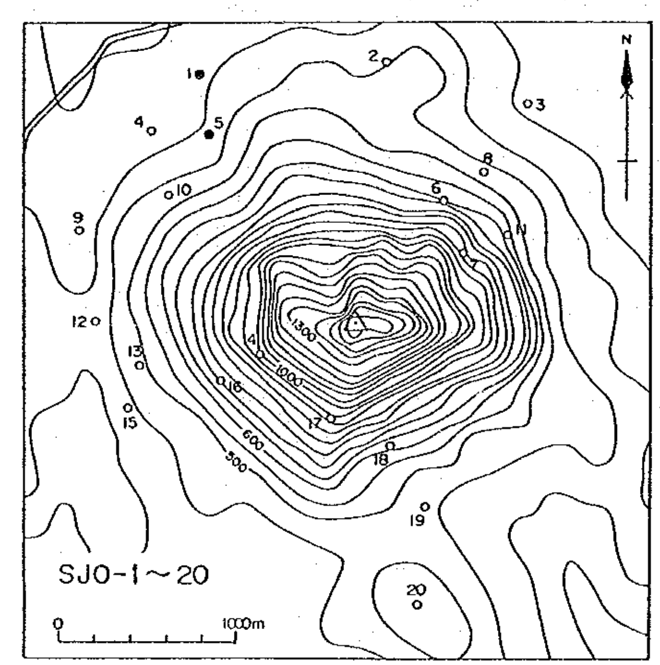
max=2,220ppm
min= 555ppm
○ ≦2,220
n=20

Fe



max=10.95%
min= 3.57%
10≦ ●
○ <10
n=20

S



max=0.032%
min=0.005%
0.02≦ ●
○ <0.02
n=20

Figure GC-5 Distribution of 9 selected elements in soil from the Jombo Hill area

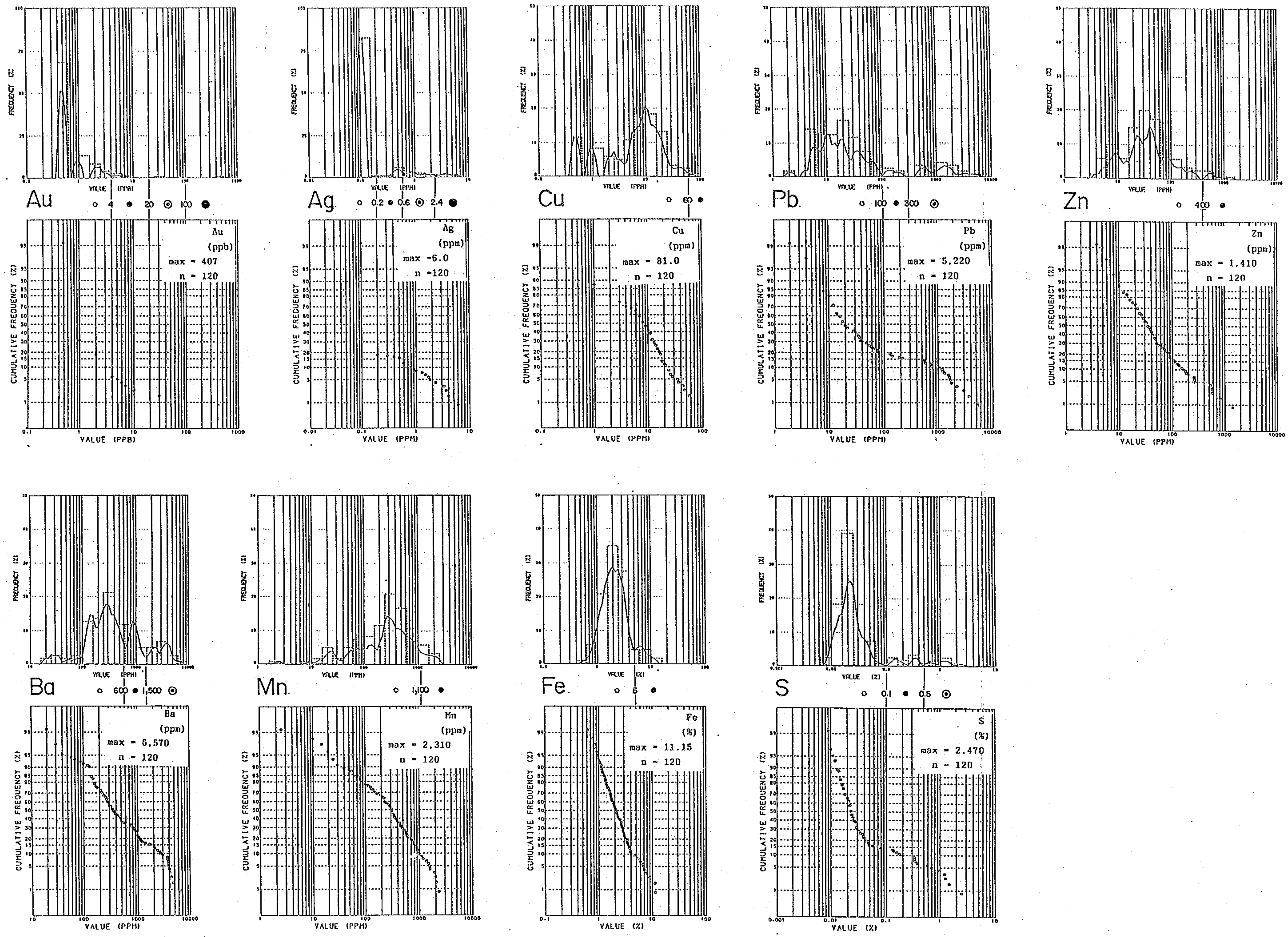


Figure GC-6 Frequency distribution and cumulative frequency distribution of 9 selected elements in soil from the Kinangoni,Mkang'ombe and Mangea-Kwa Dadu areas

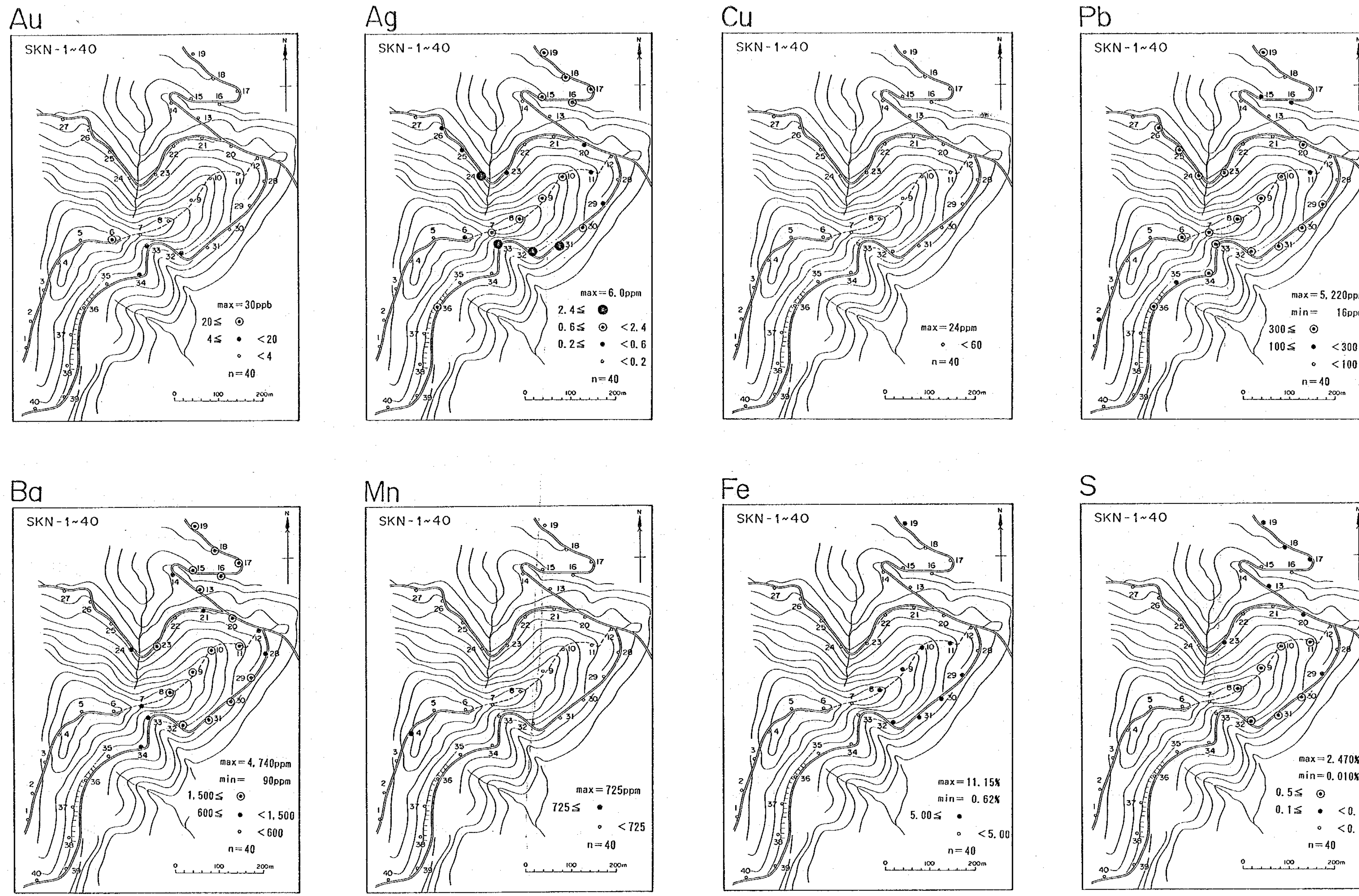


Figure GC-7 Distribution of 9 selected elements in soil from the Kinangoni area

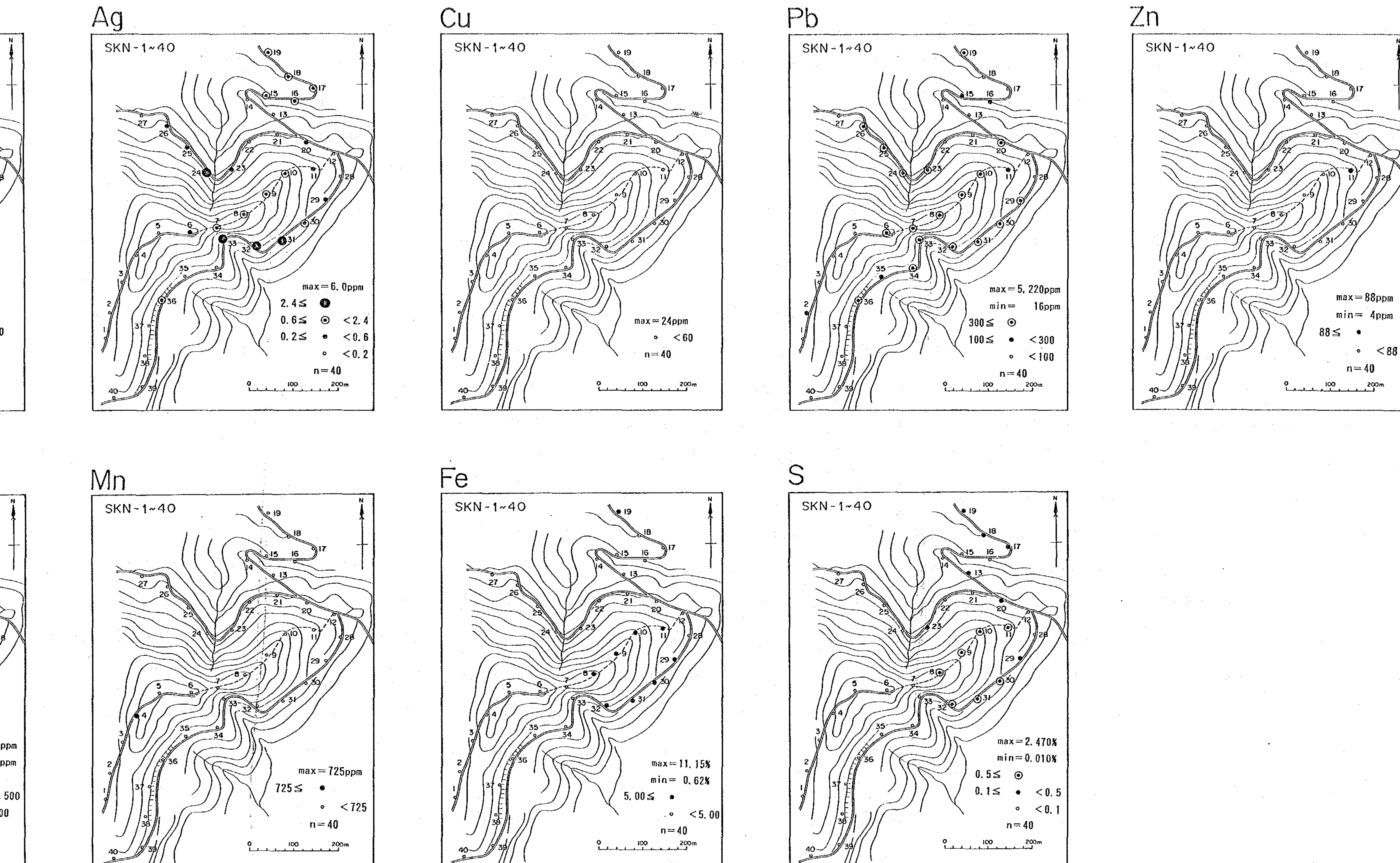


Figure GC-7 Distribution of 9 selected elements in soil from the Kinangoni area

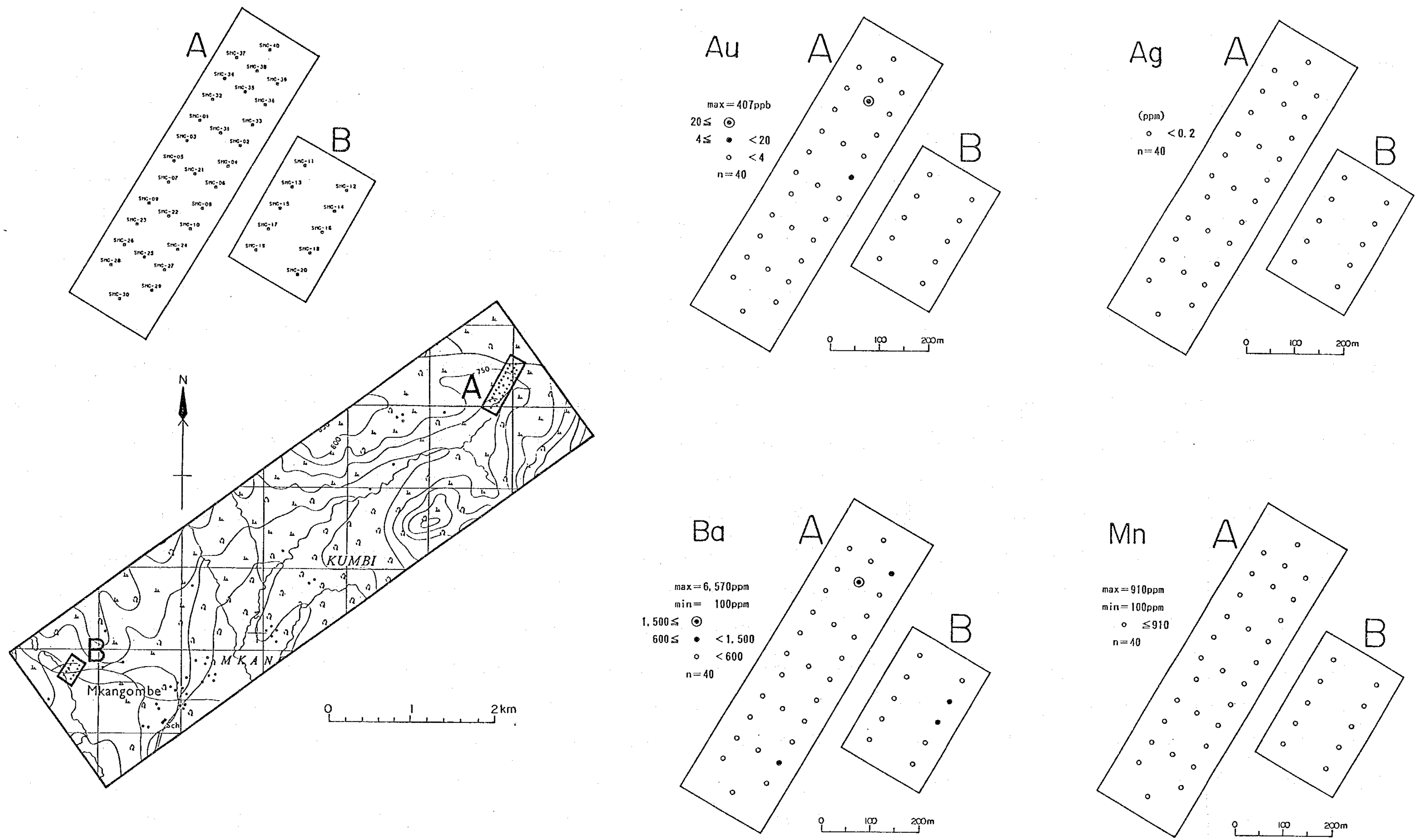


Figure GC-8 Distribution of 9 selecte

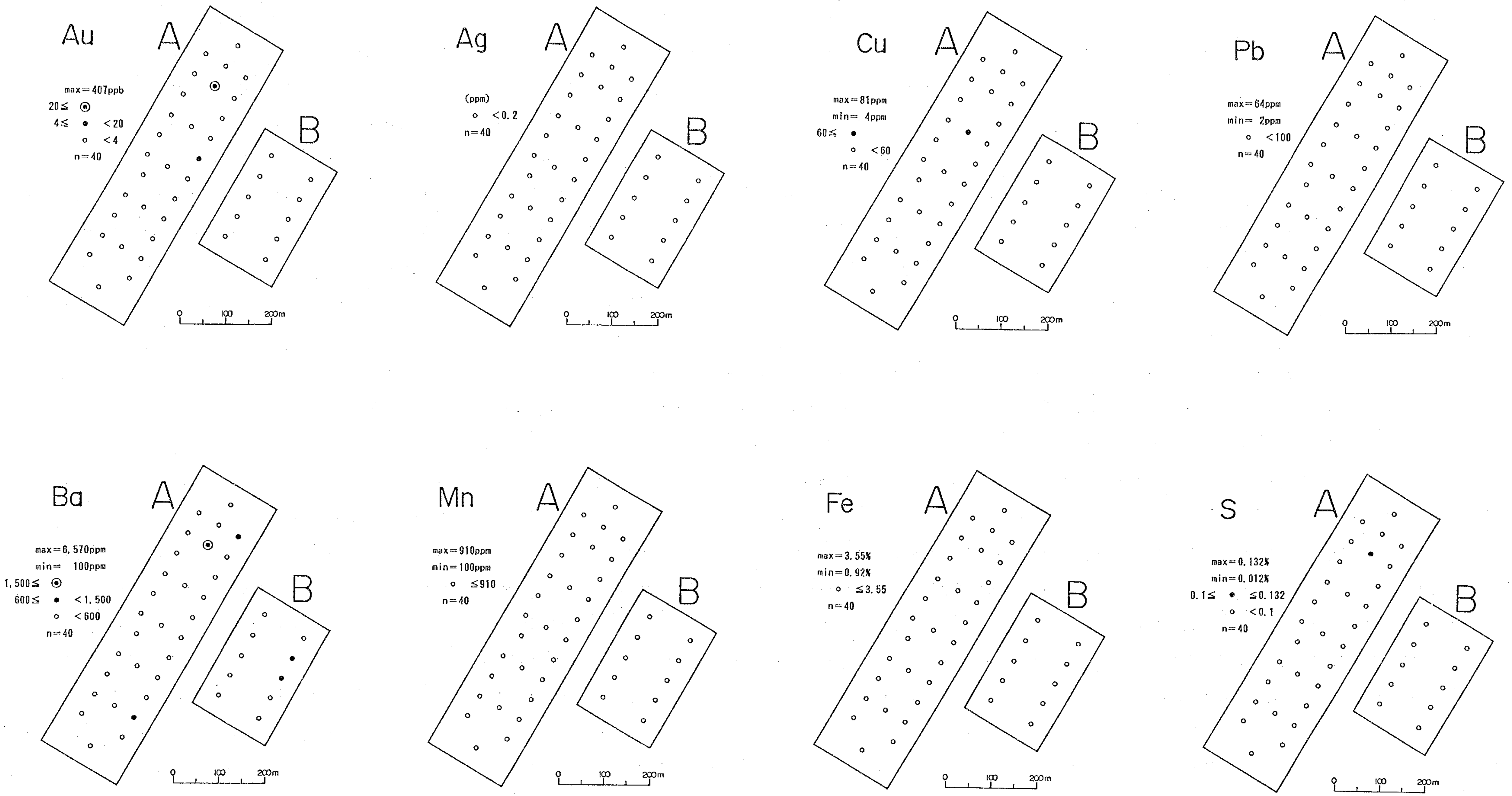
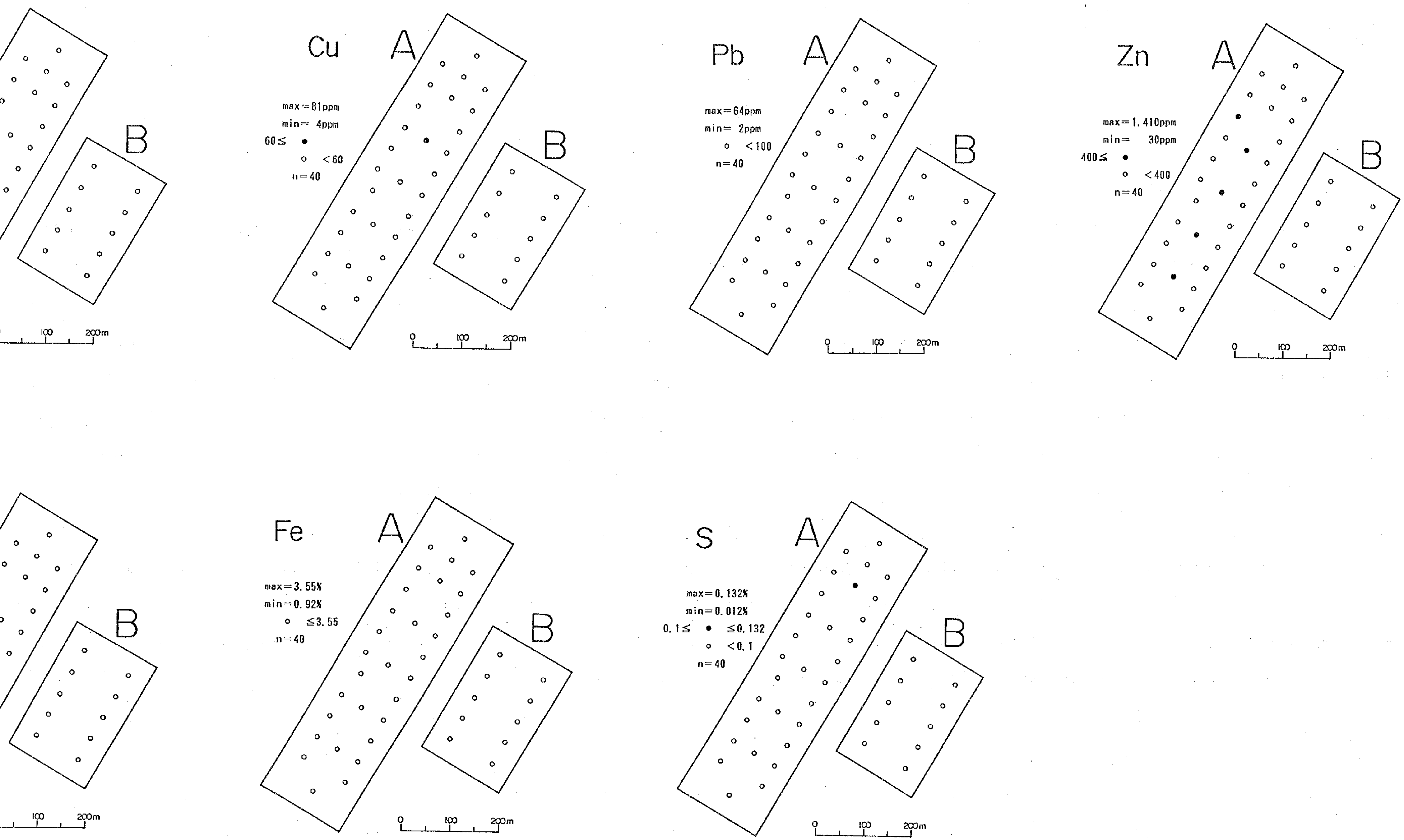


Figure GC-8 Distribution of 9 selected elements in soil from the Mkang'ombe area



ibution of 9 selected elements in soil from the Mkang'ombe area

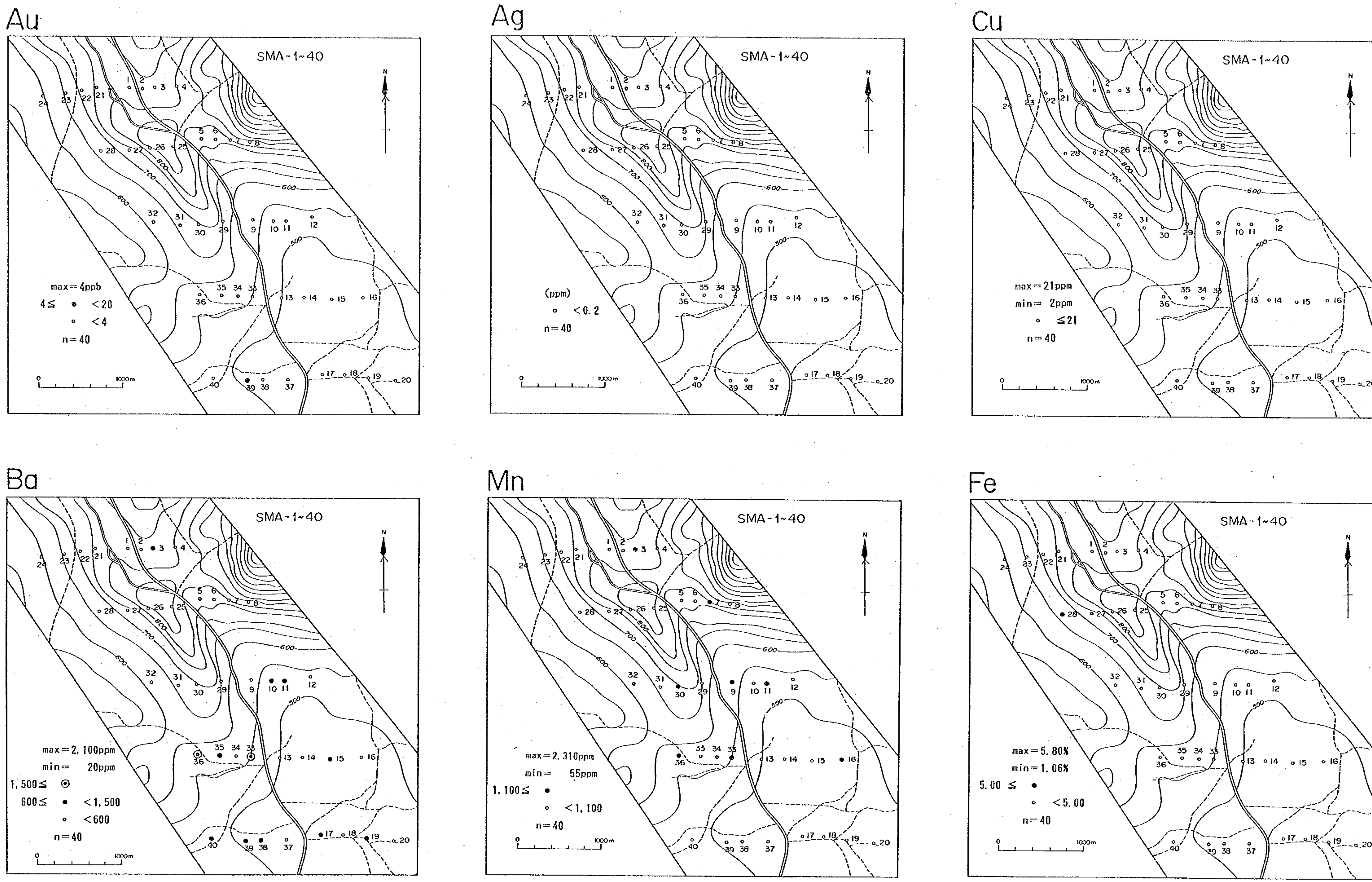
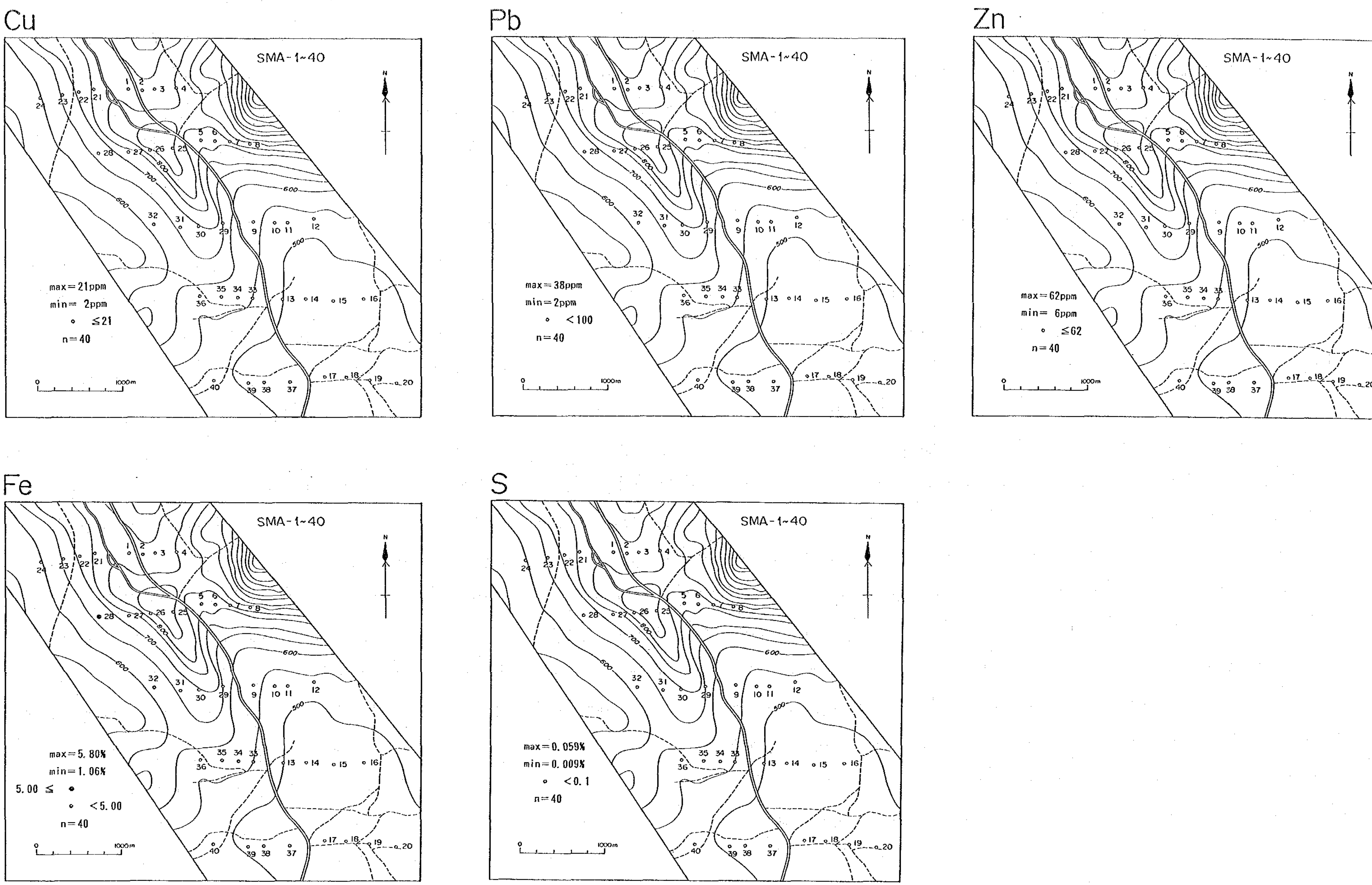


Figure GC-9 Distribution of 9 selected elements in soil from the Mangea-Kwa Dadu area



in soil from the Mangea-Kwa Dadu area

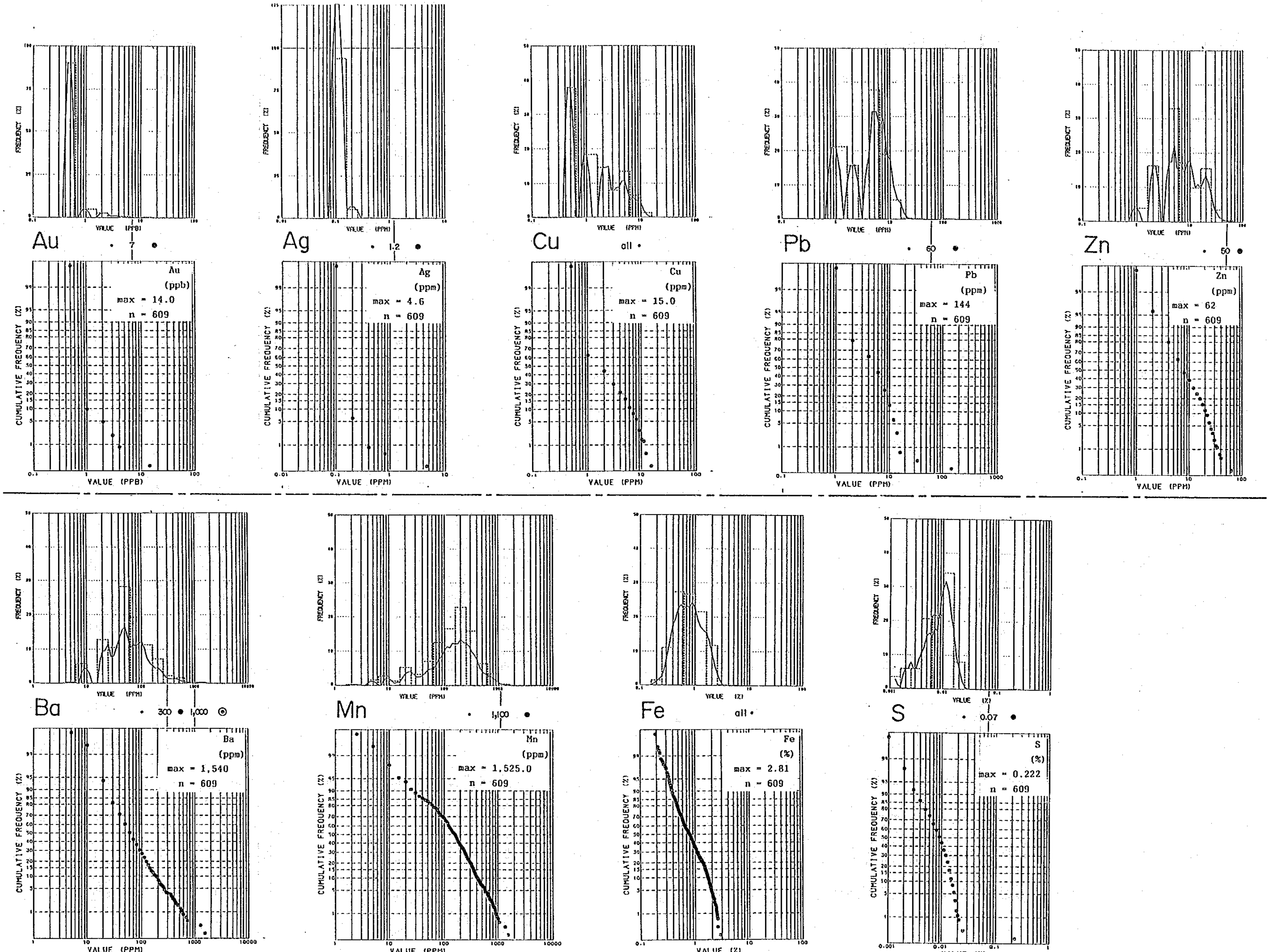


Figure GC-10 Frequency distribution and cumulative frequency distribution of 9 selected elements in soil from the Mkundi area

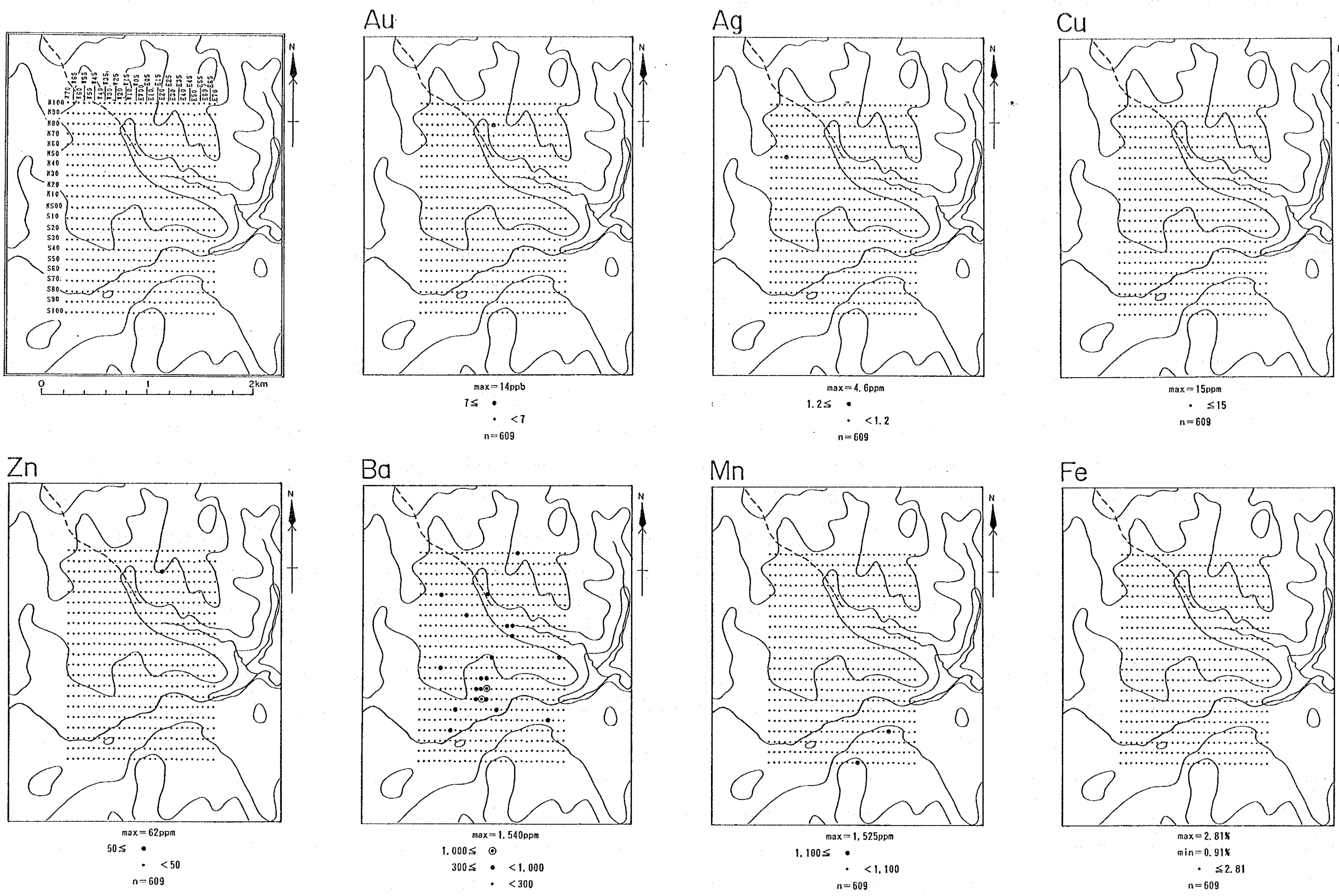


Figure GC-11 Distribution of 9 selected elements in soil from the Mkundi area

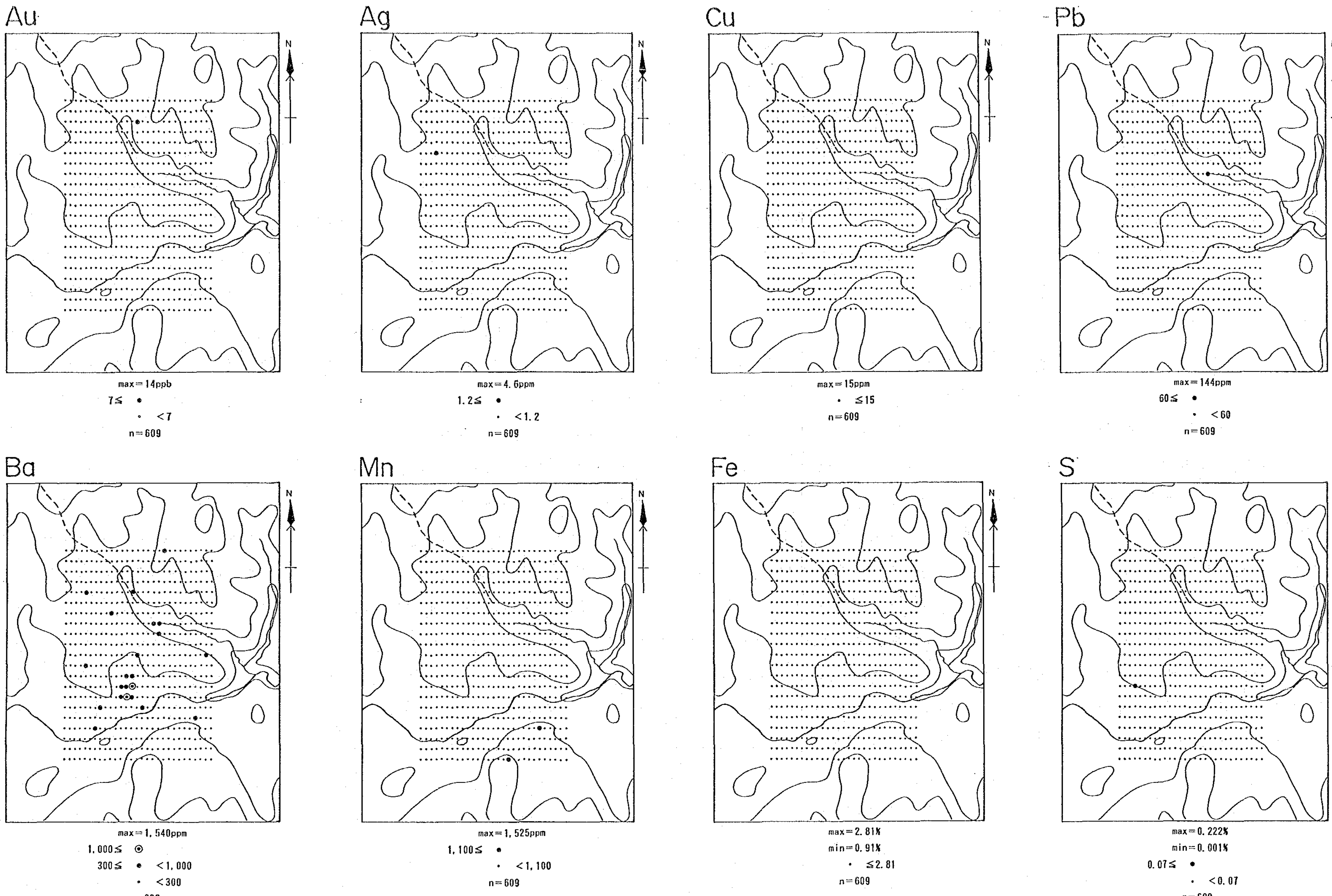


Figure GC-11 Distribution of 9 selected elements in soil from the Mkundi area

2-5 Laboratory Work and Results

Microscopic observation of rocks in thin sections	Appendix II
Microscopic observation of ore minerals in polished section	Appendix III
EPMA analaysis	Appendix IV
X-ray diffraction analysis	Appendix V
Pb-Pb age determination	Appendix VI
Whole rock analysis of samples from the Mombasa area	Appendix VII
Trend in AFM diagram, relation between FeO/MgO ratio and SiO_2 content, and relation between FeO content and FeO/MgO ratio in the igneous rocks from the Mombasa area.	Appendix VIII
Chemical analysis ore samples from the mineral showings	Appendix IX
Minerals identified in pan-concentrated stream sediment samples from the Mombasa area	Appendix X
Geochemical analysis of pan-concentrated samples from the Mombasa are	Appendix XI
Geochemical analysis of soil sampes from the Mrima Hill-Jombo Hill, Kinangoni, Mkang'ombe and Mangea-Kwa Dadu areas	Appendix XII

PART III

CONCLUSIONS AND RECOMMENDATIONS

<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).

<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.