CHAPTER 2 GEOLOGICAL SURVEY

2-1 Survey Method

When performing the field survey, we have enlarged topographic maps from a scale of 1:50,000 to 1:25,000 to prepare route maps. Survey routes were established by adequately examining results of the Landsat image interpretation and other related data. During the survey, we used the aerial photographs and magnetic susceptibility meters. Observations have been described on the route map as accurately as possible, and especially for important outcrops, sketches at a scale of 1:100 to 200 and colour photographs have been taken.
Survey results have been summarized in topographic maps at a scale of 1:100,000.

When obtaining and treating samples, we have collected them carefully so that they represent typical rock types and lithofacies in the survey area, and clarified the mutual relation among the rocks. In addition, when differences were recognized in rock types and lithofacies even of the same rock type, we have endeavored to clarify the mutual relationship among rocks by observing the samples using a microscope, and examined them by x-ray analysis, if necessary.

For rocks in which mineralization were recognized, examinations by microscope and chemical analyses were carried out, if necessary, by using hand specimens. For all the specimens in the examination, samples have been retained after sizing into about 6 cm x 4 cm x 2 cm leaving one fracture surface.

2-2 Survey Results

The lithology in the area consists of gneissose granite, gneissose granulite, felsic granulite, mafic granulite, iron formation and dolerite.
Charnockite and enderbite described by Odell(1975) in the adjacent area of Bangala Dam are included in felsic granulite and gneissose granulite.

Superimposed on these rocks is the shearing, which is younger than the granulite facies metamorphism. The general rock types observed, for which distinction in hand specimen is not possible without petrographic study, are given below.

Idealized geological column of Zimbabwe is shown in FIG. 2-2-1.

(1) General Geology

The geology in this survey area consists of gneissose granite, gneissose

ABSOLUTE AGE	GEOLOGIC TIME	SYSTEM/GROUP	ROCK TYPES	GEOLOGIC COLUMN	MINERALIZATION
	PLEISTOCENE /RECENT	KALAHARI	ALLUVIUM AEOLIAN SANDS		ALLUVIAL GOLD
	CRETACEOUS~ UPPER JURASSIC		ALKALINE VOLCANICS SANDSTONE ETC		
	JURASSIC TRIASSIC PERMIAN	KAROO	RHYOLITE BASALT SANDSTONES, SILTSTONES, ETC. GLACIAL BEDS, COAL MEASURES, MUDSTONES		TUNGSTEN, COPPER
	LATE PRECAMBRIAN	SIJARIRA TENGWE RIVER MAKUTI RUSHINGA	SANDSTONES, SHALES, CONGLOMERATE, ETC. LIMESTONE, DOLOMITE & ORTHOQUARZITE PARAGNEISS, METASEDIMENTS & AMPHIBOLITE		zinc, copper, lead copper
	MID PRECAMBRIAN	MALAPUTESE & KAHIRE UMKONDO LOMAGUNDI PIRIWIRI	PARAGNEISS, METASEDIMENTS & AMPHIBOLITE LIMESTONE, SHALE, QUARTZ & BASALT QUARTZ-MICA SCHISTS, ORTHOQUARTZITE, ETC. STRIPPED SLATES & MINOR QUARTZITE DOLOMITE & ORTHOQUARTZITES META-ARKOSE & BASIC METAVOLCANICS PHYLLITE & MINOR QUARTZITES		COPPER COPPER COPPER, lead COPPER, SILVER, GOLD TIN, TUNGSTEN, COPPER GOLD, TANTALUM, manganese lead, zinc
2700 -2600 Ma*		LIMPOPO MOBILE BELT	IRON FORMATION (If) MAFIC GRANULITE (Mg) FELSIC GRANULITE (Fg) GNEISSOSE GRANULITE (Gg)	DOLERITE 1700 Ma Gg Fg Gg Fg	CHROME, GOLD, TUNGSTEN zinc
3200 Ma 3300 Ma 3500 Ma	EARLY PRECAMBRIAN	BEITBRIDGE SHAMVAIAN BULAWAYAN SEBAKWIAN	PARAGNEISSES, HIGH-GRADE SEDIMENTS & ANORTHOSITIC GNEISSES METASEDIMENTS, FELSIC METAVOLCANICS METASEDIMENTS, FELSIC METAVOLCANICS ANDESTIC & DACITIC METAVOLCANICS BASALTIC METAVOLCANICS WITH METASEDIMENTS ULTRAMAFIC LAVA & INTRUSIONS		copper, magnetite GOLD, SILVER, IRON ORE COPPER, NICKEL, LEAD, ZINC, MANGANESE, TUNGSTEN PYRITE
3600 -3500 Ma		ARCHAEAN GRANITIC ROCKS	OLDER GNEISS COMPLEX		

* : METAMORPHIC AGE

MINERAL PRODUCED : GOLD
MINERAL NOT PRUDUCED: copper

FIG. 2-2-1 Idealized Geological Column

granulite, felsic granulite, mafic granulite, iron formation, and dolerite.
It is considered that these rocks have ENE-WSW foliation and show a southward dip as usual. In addition, the survey area is considered to be dominated by isoclinal folding. However, at Zaka Road, which runs through the eastern part of the survey area, the northward dipping foliation is recognized in mafic granulite and suggests that folding is likely to be somewhat opened around the above-mentioned location. In the field, foliation changes gradually and a fold structure is recognized only in limited places, but on an image, the geological structure can often be traced. The lineaments are concentrated most in the NNW-SSE direction which meets the ENE-WSW foliation at right angles. However, it is difficult to consider as a result of either image interpretation or a field survey, that such lineaments have greatly displaced the geological units, because the units in the survey area have good sideward continuity.
The major tectonic lines in the survey area are the Sazaume-Makambe tectonic line, Murerezi tectonic line and Turwi tectonic line. The area has been possibly subjected to block movement by these tectonic lines.

Description of Rocks

We have carried out microscopic observations of 125 rock samples which are typical in the survey area. Details of such rocks are as follows:

Rock name:	Gr	Gg	Fg	Mg	If	Do
Number of samples:	6	82	23	9	3	2

Gr: Gneissose granite Gg: Gneissose granulite,
Fg: Felsic granulite Mg: Mafic granulite
If : Iron formation Do: Dolerite

Results of the microscopic observation and mode analysis are listed in Appendix A-3 and A-8.

Gneissose granite has a mineral combination of quartz, potassium feldspar, plagioclase, and biotite. The result of mode analysis shows the following average composition of this rock in the survey area:

Quartz : 84.2% Plagioclase : 0.6%
Pyroxene : 0% Potassium feldspar : 12.8%
Biotite : 2.3%

The texture shown usually by this rock is entirely equigranular and the tectonic grade of the rock is considered to be low in comparison with high grade metamorphic rocks in the Limpopo Mobile Belt, which is distributed to the south of this rock.

Gneissose granulite is a mineral combination of quartz, plagioclase, potassium feldspar, clinopyroxene and orthopyroxene, biotite, and garnet. The mineral composition of this rock, which has been obtained through mode analysis, is as follows:

Quartz : 38.5%　　Plagioclase : 38.1%

Potassium feldspar : 17.5%　　Biotite : 5.1%

Pyroxene group : 4.0%　　Amphibole : 0.4%

Garnet : 0.1%　　Opaque minerals : 1.2%

Others : 3.0%

Orthopyroxene was found in 45 samples (55%) among 82 observed through a microscope. Samples containing clinopyroxene and orthopyroxene comprised 31 specimens (38%). This rock shows entirely equigranular granoblastic texture and has mostly undergone tectonic metamorphism. Among all the 82 samples, those which have undergone some tectonic metamorphism amount for 74 specimens (90%).

Felsic granulite is a mineral combination of quartz, potassium feldspar, plagioclase, biotite, and garnet and is characterized by containing no pyroxene group mafic mineral. The mineral composition of this rock, which has been obtained through mode analysis, is shown below:

Quartz : 34.0%　　Plagioclase : 29.3%

Potassium feldspar : 36.2%

The extremely small amount of pyroxene group was found in only two samples among 23 observed under a microscope. This rock contains various textures from isogranualr to ribbon quartz, and has become mylonite-type rock by undergoing tectonic metamorphism.

Mafic granulite is a mineral combination of clinopyroxene and orthopyroxene, amphibole, quartz, plagioclase and garnet, and some thin sections may not contain any minerals other than the pyroxene group. The mineral composition of this rock, which has been obtained through mode analysis, is as follows:

Quartz : 0%　　Plagioclase : 52.7%

Pyroxene group: 39.6%　　Amphibole : 2.8%

Opaque minerals : 4.0%　　Biotite : 0.1%

The texture of this rock has changed in from isogranular to polygonal and to heterogranular, and seems to have undergone comparatively weak tectonic metamorphism.

Iron formation is a special mineral combination of quartz and opaque minerals and its mineral composition obtained from mode analysis is shown below:

Quartz : 67.8% Opaque minerals : 30.8% Others : 1.4%

This rock shows ribbon quartz texture and has become a mylonite type by undergoing strong tectonic metamorphism.

Dolerite is an intrusive rock, and contains a mineral combination of quartz, clinopyroxene, and orthopyroxene. This rock can be classified into two categories based on the abundance of the clinopyroxene and orthopyroxene. The mineral composition of this rock, which has been obtained from mode analysis, is as follows:

Quartz : 0.3% Plagioclase : 42.4%

Pyroxene : 29.0% Potassium feldspar : 0.3%

Biotite : 0.6% Amphibole : 19.0%

Alteration mineral (chlorite) : 8.1%

Opaque minerals 1.5%

Note)
The classification of texture based on microscopic observation on thin sections has been performed in accordance with Bard (1986). As a result of the microscopic observation, we have found texture to range from equigranular rocks to mylonite produced through tectonic metamorphism. The survey area is located in what is called the "Limpopo Mobile Belt" and has undergone strong tectonic metamorphism. Metamorphism had developed in the area, so that we considered it possible to classify rocks by texture. In this report, therefore, we have classified rocks into the following seven types of texture, paying attention to fine and uniform granulation of minerals, which are found in thin sections.

(1) Isogranular	0
(2) Polygonal	0
(3) Heterogranular	0
(4) Framed Porphyroblastic	1
(5) Protomylonitic	2
(6) Augenmylonitic	3
(7) Ribbon Quartz	4

The isogranular, polygonal, and heterogranular types of texture are slightly different from one another and have not undergone tectonic metamorphism. Since no fine granulation of minerals has developed in such types of texture, we have designated them Tectonic Grade 0. The framed porphyroblastic texture has been designated Tectonic Grade 1 because the texture has been formed after rocks at the stage of tectonic grade 0 underwent tectonic metamorphism and after the fine granulation of minerals commenced.
For the protomylonitic texture, finely granulated minerals increase further in volume and almost no original texture is found. Therefore, this stage has been designated Tectonic Grade 2.
For the augenmylonitic texture, minerals in the original rock are finely granulated to about 0.1 mm or less in diameter and such granulated minerals are contained at larger volumes than that of potassium feldspar which has been left in an eyeball shape. This stage has been designated Tectonic Grade 3.
For the ribbon quartz texture, the augenmylonitic texture has undergone tectonic metamorphism and quartz is arranged in a ribbon shape. This stage has been designated Tectonic Grade 4.

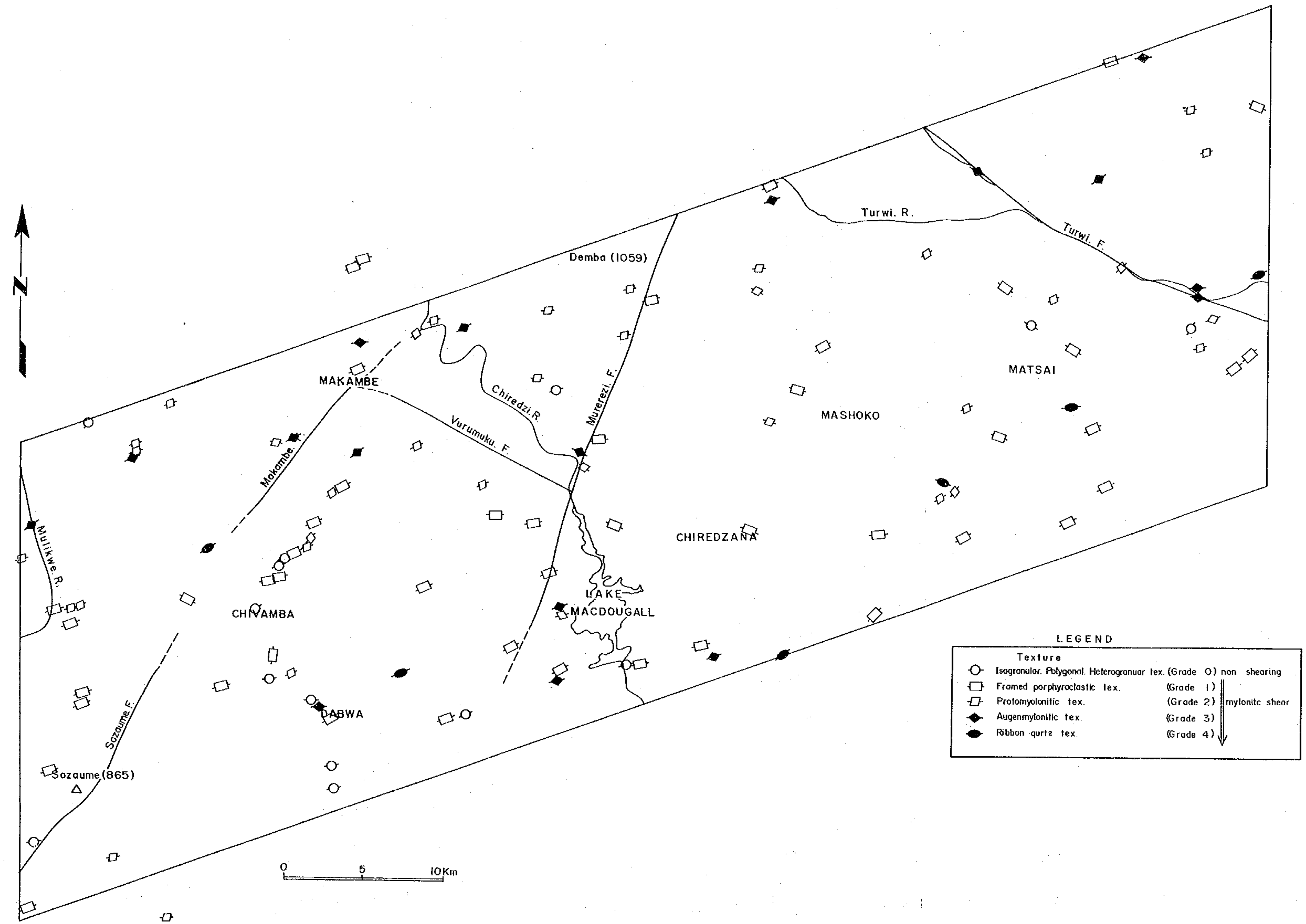


FIG. 2-2-2 Classification of Tectonite Textures

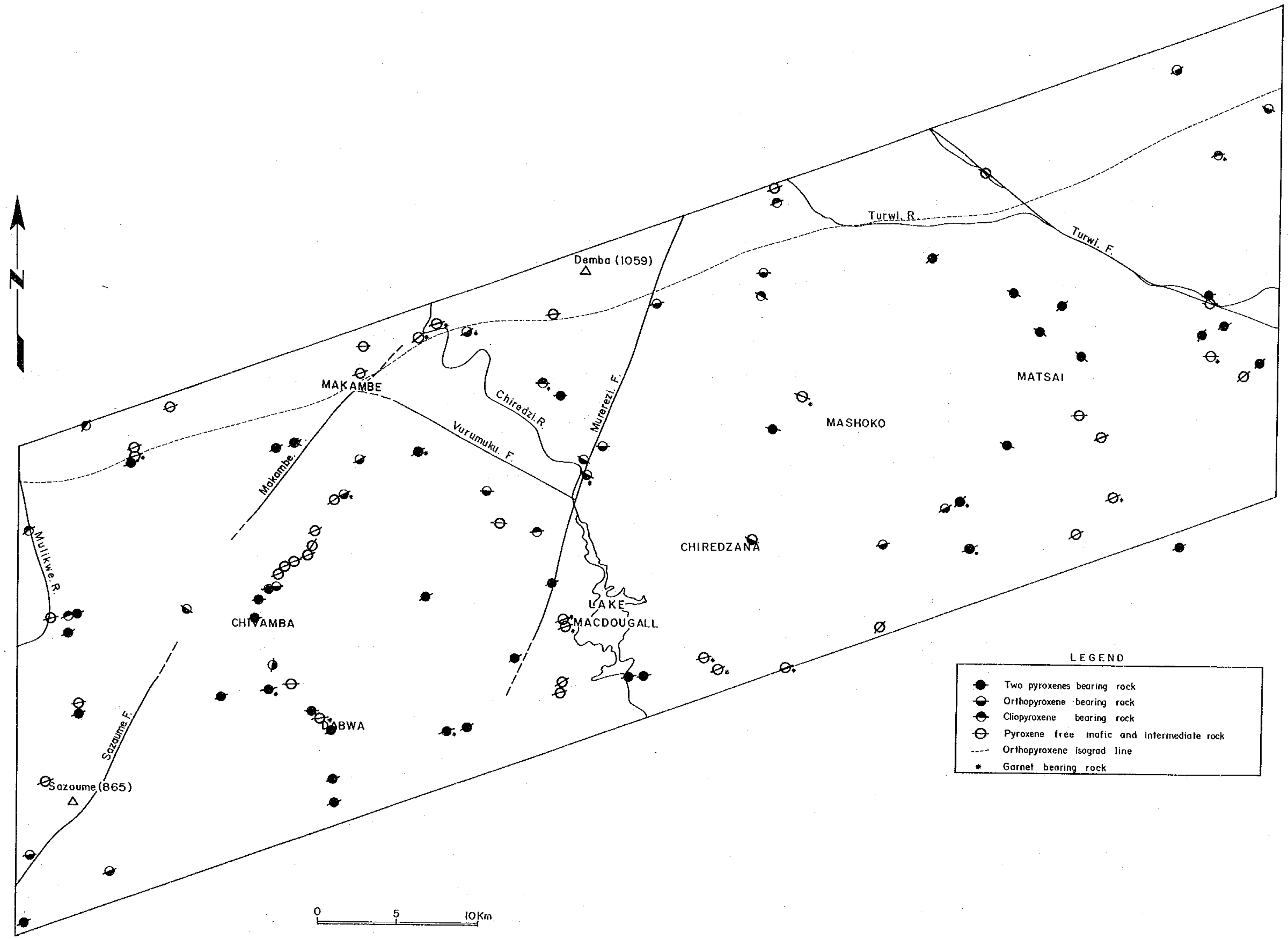


FIG. 2-2-3 Distribution of Pyroxenes and Garnet

This rock shows ophitic and intersertal texture and seems to have undergone no tectonic metamorphism.

In the survey area, most lithofacies other than dolerite have undergone mylonite-type tectonic metamorphism. As a result of microscopic tests on thin samples, 104 (85%) have shown some tectonite textures. In particular, 24 samples (20%) have shown augenmylonitic and ribbon quartz texture, and show especially strong tectonic metamorphism. Samples in which the original texture cannot be identified amount to 59 specimens (protomylonitic - augenmylonitic - ribbon quartz texture, 49%)

When metamorphism was examined and attention was paid to the appearance of important minerals, the pyroxene group was found in thin sections of 70 pieces (56%) out of the total of 125 observed with a microscope. The group is not found in felsic granulite and gneissose granite which is considered to be the Zimbabwe Craton. With regard to the pyroxene group, the gneissose granulite is rich in orthopyroxene, while the mafic granulite contains much clinopyroxene.
No garnet is found in the gneissose granite of the Zimbabwe Craton and it is the sole mafic mineral in felsic granulite. In general, garnet has a high tendency to appear in basic metamorphic rocks. The feldspar group in gneissose granulite and felsic granulite is often found as perthite and anti-perthite. In the felsic granulite, however, mesoperthite, which contains orthoclase and albite in almost the same quantity, is also found. In alteration minerals, there are some locations where epidote veins are found locally, but the alteration has been very weak as a whole. That is, weak traces of chlorite in mafic minerals and sericite in plagioclase may be found in some cases.

Classification of tectonite textures and distribution of pyroxenes and garnets are shown in FIG.2-2-2 and FIG.2-2-3.

(2) Geological Structure

Geological structure of the area is characterized by prominent ENE-WSW foliation. In general, the foliation dips south-south-east, therefore tightly folded isoclinal folding is envisaged. The dips, however, are variable in direction and amount in the northeastern area(FIG.2-2-4).
In the area west of the Murerezi structure line, which traverses the survey area, ENE-WSW foliation is predominant. On the other hand, this tendency has been dis-

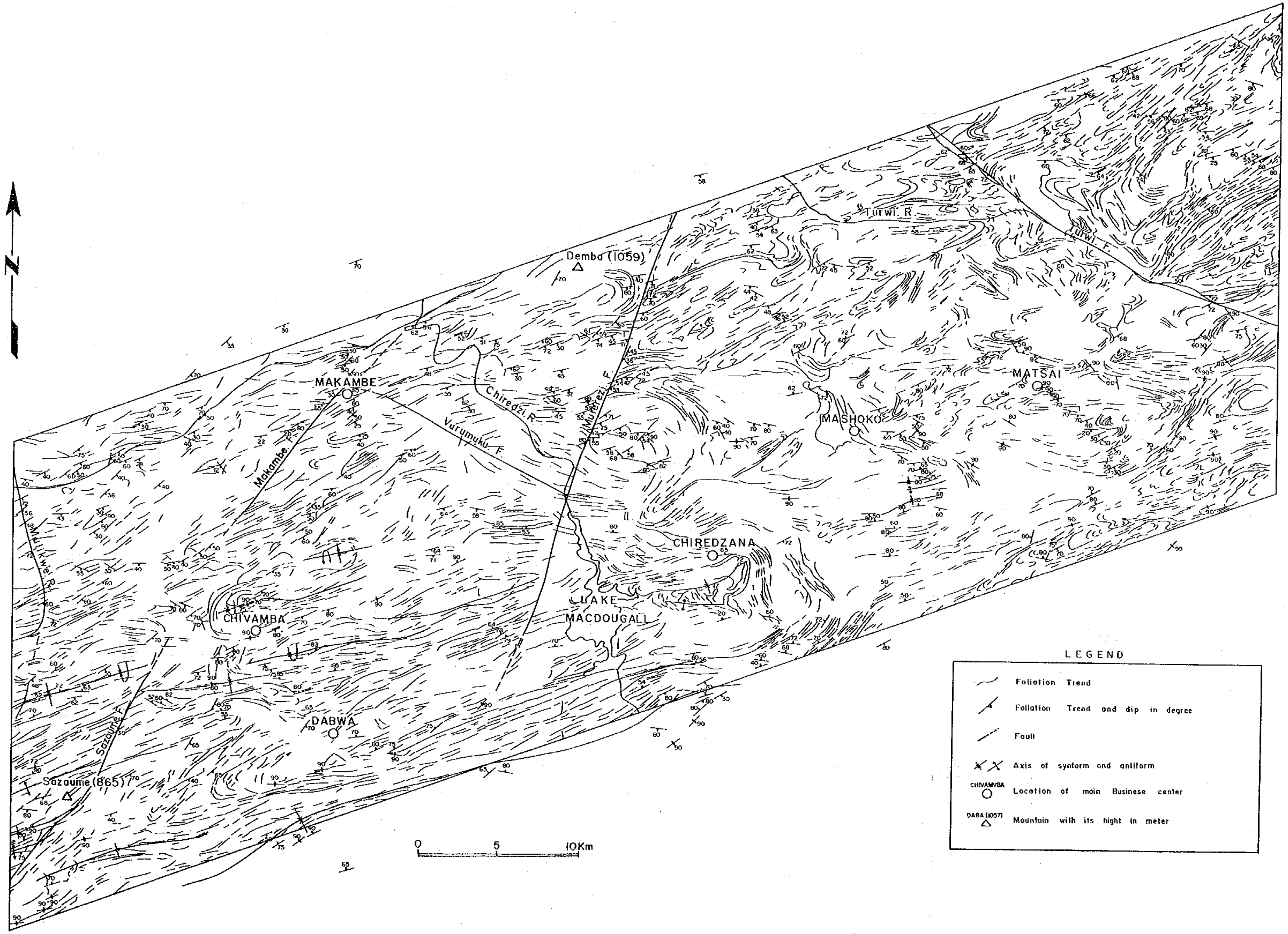


FIG. 2-2-4 Map of Geological Structure

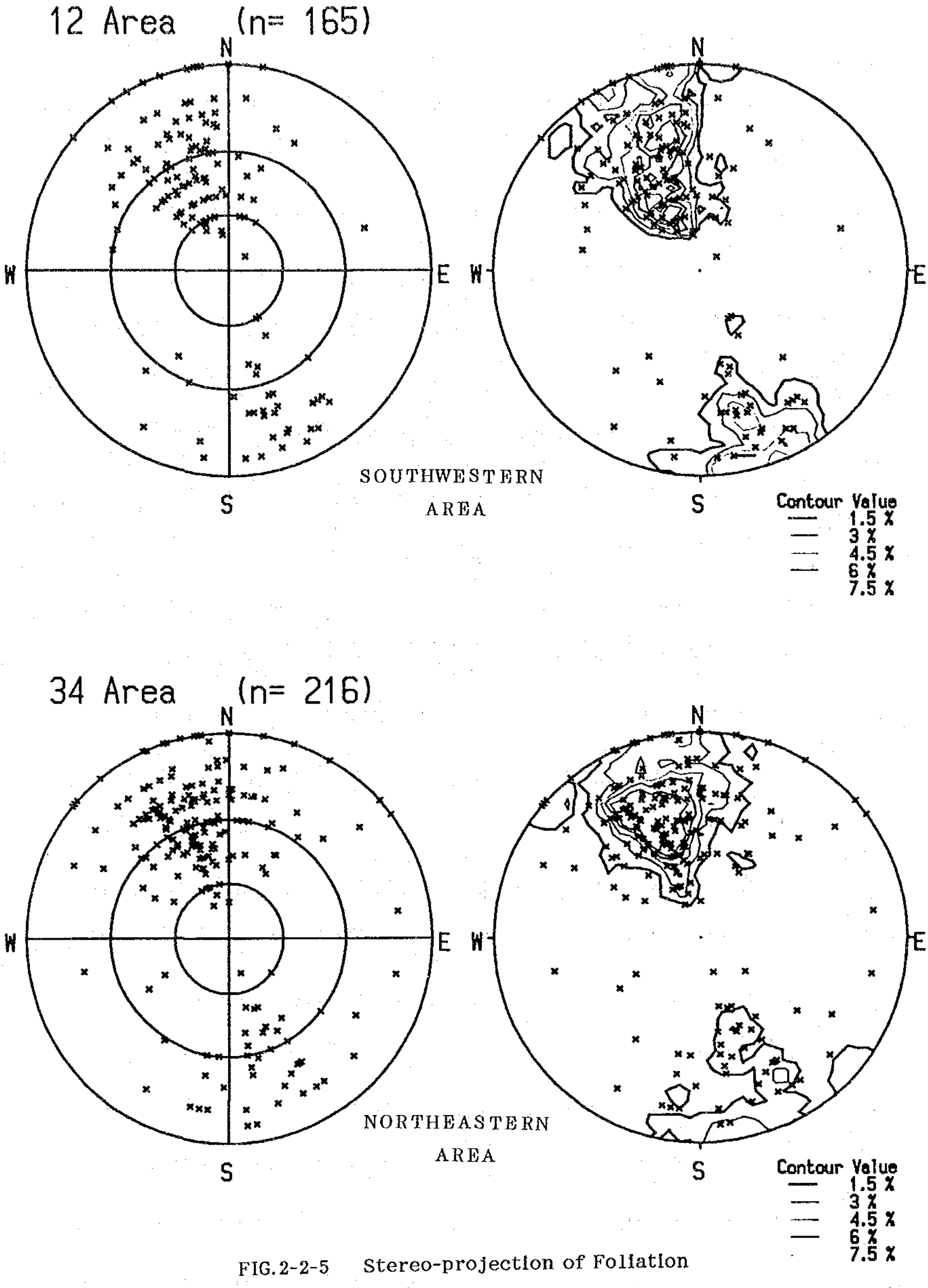


FIG. 2-2-5 Stereo-projection of Foliation

turbed considerably in the eastern area. To clarify these conditions, the foliation which has been taken from a Landsat images to understand the entire state of the survey area, is shown in FIG. 2-2-4. However, when the strikes and dips of the foliation confirmed in the field survey have been plotted, and examined on the stereo-net diagram, both areas show a similar tendency(FIG.2-2-5). This might be because the foliation crossing to the ENE-WSW direction has usually poor continuity and therefore, the measuring frequency is exceedingly lower than that for the ENE-WSW direction.

Tectonic metamorphism(deformation) in the survey area is not necessarily understood (frequency and timing) by researchers. Generally speaking, it is difficult to obtain a corresponding relationship between the time of deformation found in some areas and the time of deformation in other areas. This is because the consecutive occurrence of several deformations impairs the clarity of previous deformations. Researchers tend to recognize the deformation which has been recorded the most notably at the time of investigation as the most universal deformation in an survey area. In the survey area, deformation history can be seen twice at least as pointed out by Robertson and Du Toit(1981).

Since, in the survey area, the extension of dolerite intruding the Umkondo Formation, which is adjacent to the eastern part of the area, exists and this dolerite has undergone no mylonite-type deformation, it can be estimated that the deformation in the survey area occurred before 1,700 Ma (Stagman, 1978), the time of dolerite intrusion.

No detailed study was carried out on the deformational events that affected the area subjected, although in the Central Zone of the Limpopo Mobile Belt in Zimbabwe a complex deformational episode has been elucidated by Watkeys et al.(1983).

Geological map and sections are shown in FIG.2-2-6 and FIG.2-2-7.

(3) Geological Unit and Magnetic Susceptibility

The measurement of magnetic susceptibility was carried out at each outcrop on major routes using a magnetic susceptibility meter(Kappameter KT-5 made by the Gyofizika Brono company). The conversion from SI units to CGS units was performed in accordance with the method of Kanaya (1987). The measurement was carried out for each lithology and the total number of measurements was 602 sites. The results are shown in APPENDIX A-10, and the results can be interpreted as follows:

For gneissose granulite, the number of measurements is the largest and values for the magnetic susceptibility also vary considerably. However, they appear to concentrate in the range of 1.0 $(emu/cm^3)x10^{-3}$to 10.0$(emu/cm^3)x10^{-3}$. Although a figure of 20 $(emu/cm^3)x10^{-3}$or more is seen, such a case is rare. In this category, the rock in which quartz is tinted black and mafic minerals cannot be seen by the naked eye, is equivalent to the rock in which quartz has been finely granulated. The magnetic susceptibility of such a rock is 10 $(emu/cm^3)x10^{-3}$to 30 $(emu/cm^3)x10^{-3}$. These figures tend to be higher than that of gneissose granite.

For gneissose granulite, the number of measurements is small where gossan occurs, and figures around 0.01 $(emu/cm^3)x10^{-3}$to 2.0 $(emu/cm^3)x10^{-3}$are seen. A figure of 10 $(emu/cm^3)x10^{-3}$or more is seen rarely.

Felsic granulite shows the lowest magnetic susceptibility among rocks which are distributed in the survey area. In many cases, figures of 0.1 $(emu/cm^3)x10^{-3}$or less are seen and values around 0.5 $(emu/cm^3)x10^{-3}$are rare.

For mafic granulite, measurements overall range from 1 $(emu/cm^3)x10^{-3}$to 20 $(emu/cm^3)x10^{-3}$, with specific figures tending to concentrate at around 20 $(emu/cm^3)x10^{-3}$and 3$(emu/cm^3)x10^{-3}$.

For iron formation and dolerite, measurements fall in the range of 20 $(emu/cm^3)x10^{-3}$to 60 $(emu/cm^3)x10^{-3}$which are higher than for other rocks in the survey area. Figures of 10 $(emu/cm^3)x10^{-3}$or less are also seen, but rarely.

The above described results of magnetic susceptibility measurements suggest that general classification of the rocks can be made by Kappameter.

The results of magnetic susceptibility measurements are shown in APPENDIX A-10.

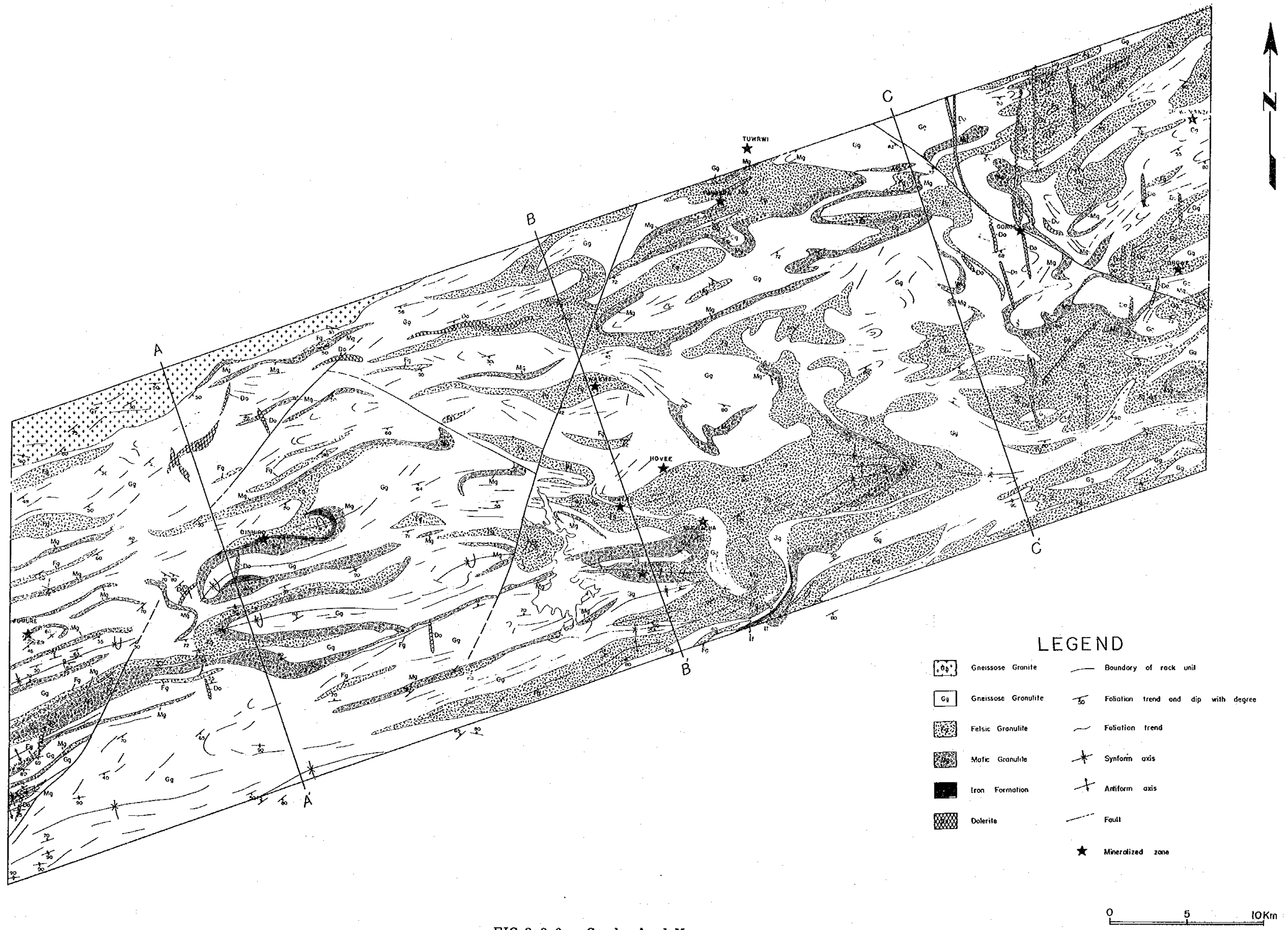


FIG.2-2-6 Geological Map

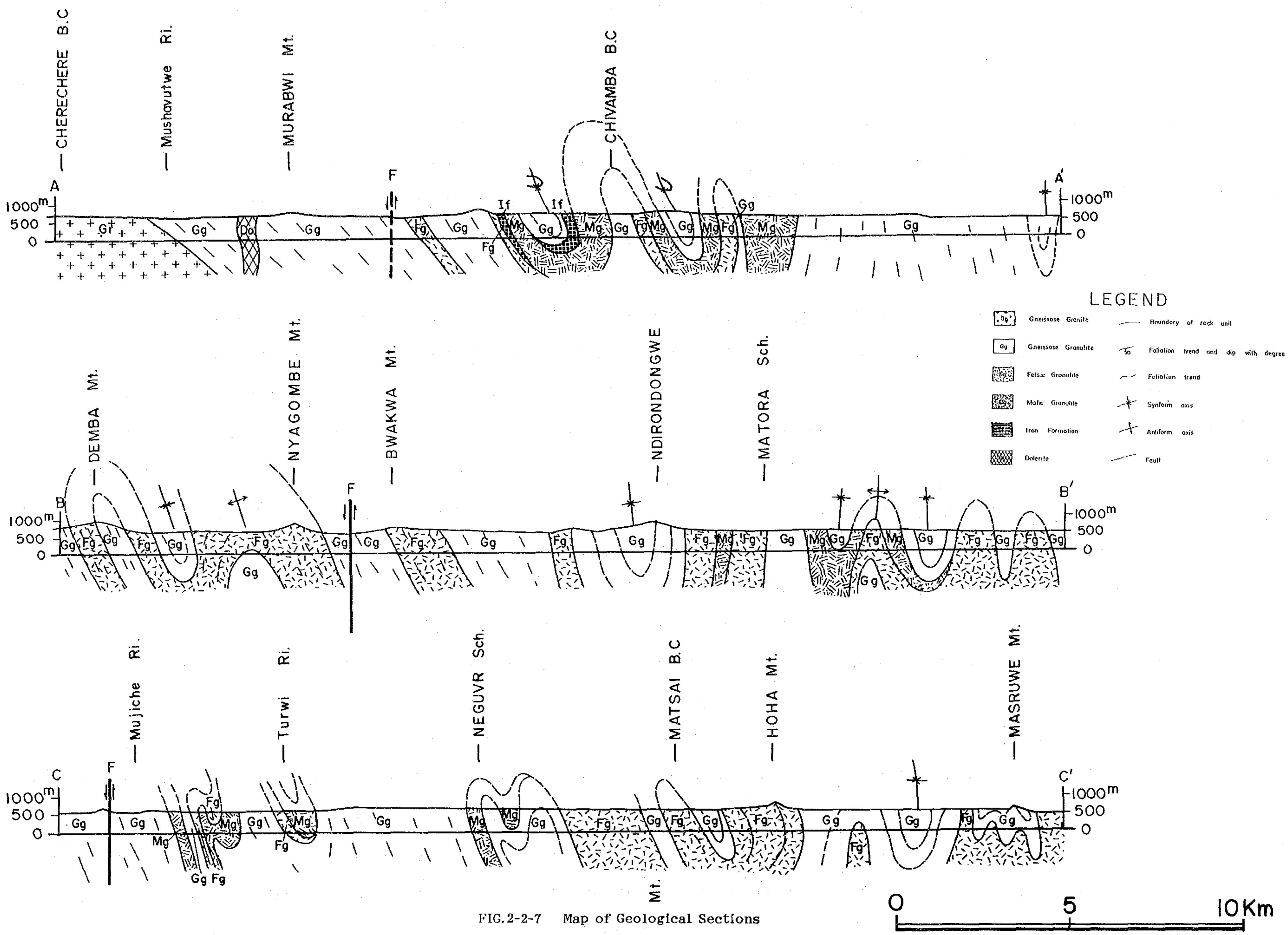


FIG.2-2-7 Map of Geological Sections

2-3 Mineralization

The genesis of the most important types of Archaean gold deposits in Zimbabwe ,namely gold-bearing iron formation, auriferous volcaniclastic sediments, and vein and shear-zone deposits, can be interpreted within the framework of the evolving Rhodesian craton.

It also is possible to classify into stratabound(iron-formations and volcaniclastic-hosted) and non-stratabound(veins and mineralized shear zones). Stratabound deposits are of only minor importance, whereas the veins and mineralized shear zones have yielded approximately 82 % of the gold in Zimbabwe.

The majority of the mineralizations in the area are of the gold-quartz veins which were generated during the metamorphism and deformation which postdated the main Limpopo high-grade metamorphism.

Although there is little doubt that the intrusion activity resulted in considerable mobilization and precipitation of enhanced concentrations of gold, it, however, is not clear what types of intrusion activity are responsible for the mineralizations in the area.

Mineralized Zone

Only a few mineralized zones were reported so far in the area. The following zones were visited by our survey members. The general description on the zones are as follows:

Jegede mineralized zone : The mineralized zone is located in the east of Lake Macdougall and 2.5 km south of Matara School. Although exposure of rock is scarce, it is supposed that mafic granulite is a country rock of the auriferous quartz vein. Width and strike/dip of the veins are approximately 1.20 m and east-west/85 s, respectively. Disseminated and veinlet-like limonite, partly representing jaspar-like, are common in veins. Fine grained pyrites still remain in the form of dissemination and veinlets against the weathering. Six pits with the dimension of 3 m(length) x 0.6 m(width) x 1.5～0.6 m(depth) distribute around the 30 m x 50m. The auriferous quartz vein systems are recognized crossing a few pits, therefore the continuation of the veins are guaranteed. Assay result in Masvingo Laboratory of a sample from the zone was Au 5.3 g/t.

The results of microscopic observation on polished sections and polished thin sections are summarized as follows:

Ore minerals from the mineralized zone consist of a small amount of pyrrhotite (

diameter : 0.8 - 0.03 mm), small to extremely small amount of pyrite (diameter : 0.25 - 0.03 mm), marcasite (diameter : 0.08 - 0.03 mm), chalcopyrite (diameter : 0.1 - 0.01 mm) and covellite. The ores sometimes accompany an association of magnetite - ilmenite. The majority of pyrrhotite is assumed to have altered into a very small aggregation of pyrite and marcasite, although fresh pyrrhotite exists in some quantity. From the textural point of view, pyrrhotite shows birds-eye texture. Pyrite appears in part as pyrite-marcasite veinlet. Chalcopyrite commonly associates with pyrrhotite and pyrite. Covellites form tiny lamellae aggregation and occupy the rim of chalcopyrite crystals. Magnetites are commonly changing into Fe-hydroxides, although single crystal and magnetite-ilmenite association exist.
It was confirmed that arsenopyrite contained 2.5 % Co by EPMA analysis (APPENDIX A-7).
For gangue minerals, vein consists of a large amount of quartz (diameter : 6 - 0.3 mm). Country rock of veins contains orthopyroxene and clino- pyroxene and orthopyroxene which are partly replaced by uralite.

The assay results of samples taken from the zone are shown as follows:

	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①	79.43	0.04	0.75	9.67	5.91	0.10	1.29	0.19	0.02	0.02	0.01	1.97
②	63.93	0.14	2.62	21.66	5.24	0.10	0.58	0.65	0.02	0.03	<0.01	4.21

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
①	12	0.80	763	0.40	367	61	256	207	44
②	6	0.60	67	0.30	228	139	216	99	24

Judging from the assay results, the zone is characterized by relatively heavy concentration of gold, silver, copper and zinc compared with other mineralized zone in the survey area.

<u>Juwere mineralized zone</u> : The mineralized zone is located in the east of Lake Macdougall and 2.0 km northwest of Matara School. Few rocks outcrop, but it is supposed that gneissose granulite is a country rock of the auriferous quartz vein. Although no definite vein systems are recognized, strike of the veins is assumed to be north-south judging from the intermittent continuation of quartz and limonite vein. Disseminated and veinlet-like limonite with quartz are common in veins. Fine grained pyrite still remain in the form of dissemination and veinlets.

Three pits with the dimension of 3 m(length) x 0.6 m(width) x 1.0～0.5 m(depth) distribute with 20 m width in the direction of north to south.

The results of microscopic observation on polished sections and polished thin sections are summarized as follows:

Ore minerals from the mineralized zone consist of extremely small amounts of pyrrhotites (diameter : 0.8 - 0.05 mm), pyrites (diameter : 0.05 - 0.02 mm), marcasites (diameter : 0.4 - 0.03 mm), chalcopyrites (diameter : 0.06 - 0.03mm) and covellites (diameter : 0.1 - 0.06mm). The majority of pyrrhotites is replaced by very small aggregation of pyrites and marcasites, although fresh pyrrhotites exist in some quantity. Some pyrrhotites have an association of pyrites and chalcopyrites. Some pyrites form an aggregation and others appear with pyrrhotites. Chalcopyrites either appear alone or are associated with pyrrhotites. Covellites form tiny lamellae aggregation and replace the rim of chalcopyrite crystals.

For gangue minerals, vein consists of a large amount of quartz (diameter : 6 - 0.4 mm), medium amount of hornblende and small amount of orthopyroxene. Flaky chlorites (diameter : 6 - 0.4 mm) fill the grain boundary of quartz.

The assay results of samples taken from the zone are shown as follows:

	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①	74.21	0.25	0.80	20.20	1.71	0.04	0.32	0.03	<0.01	<0.01	<0.01	1.78
②	62.58	0.11	1.72	22.78	6.21	0.14	1.91	0.60	0.05	0.03	0.06	2.96

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
①	1461	<0.50	1.00	15.70	324	86	88	258	31
②	97	0.05	1.00	0.20	639	49	194	7	52

Judging from the assay results, the zone is characterized by high content of Au, Bi and Cu compared with other mineralized zone in the survey area.

Turwi mineralized zone : The zone is located in the northeastern most part of the area. Mafic granulite is assumed to be a country rock. The vein system, highly silisified, is not clear. Disseminated and extremely small amounts of very fine pyrites are in the silisified material. Limonite occurs in the siliceous material as a form of dissemination and veinlets and is a lesser amount compared to the other zones. Four trenches with dimension of 10～30 m(length) x 1.0～0.6 m(width) x 1.0～0.5 m(depth) are found in a 50 m x 50m area. Trenches have varying directions of north-south, east-west and northeast-southwest.

The assay results of samples taken from the zone are shown as follows:

	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①	97.76	0.03	0.35	0.01	0.77	<0.01	0.04	0.02	0.02	0.04	<0.01	0.02
②	83.53	0.01	9.64	0.01	0.62	<0.01	0.13	2.13	2.60	0.23	<0.01	0.32

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
①	<1.00	<0.50	<1.00	<0.10	22	96	36	630	17
②	<1.00	<0.50	<1.00	<0.10	7	<10	19	326	19

Judging from the assay results, the zone is characterized by rather high content of Cr compared with other mineralized zones in the survey area.

Panganai mineralized zone : The mineralized zone is situated in the north-eastern most part of the area near Turwi. Vein system is not clear. Gossan, consisting limonite and hematite, shows a breccia structure and the original rock is unknown. The breccia structure has an appearance of "breccia dyke" often accompanied with epithermal vein deposits Japan. Druses in the breccia has small quartz(diameter:1～2mm).

The assay results of sample taken from the zone are shown as follows:

	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①	77.82	1.00	6.47	6.13	0.77	0.16	0.69	4.19	0.02	0.48	0.15	1.52

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
①	2	0.60	3.00	0.10	15	104	71	630	29

Judging from the assay results, the zone is characterized by rather high content of Cr compared with other mineralized zones in the survey area.

Gorgwe mineralized zone : The mineralized zones are located in the north-eastern part of the area, along the Turwi river and its tributary for approximately 2 km. Country rock of veins is gneissose granulite. Both width and strike of the veins are quite variable, ranging 0.1 m～1.5 m and N30W～N80E. The mode of occurrence of the zone is characterized by the veinlets and network accompanied by alkali feldspar and quartz, partly with minor amount of epidote and chlorite.

No gossan is recognized in the zone due to a lesser amount of sulphide.

The results of microscopic observation on polished sections and polished thin sections are summarized as follows:

Ore minerals from the mineralized zone consist of a small amount of ilmenite - hematite (diameter : 0.5 - 0.1 mm) and magnetite (diameter : 0.05 - 0.05 mm), extremely small amount of pyrite (diameter : 0.1 - 0.03 mm) and chalcopyrite (diameter : 0.01 - 0.001 mm). Ilmenite-hematite shows an exsolution texture. Magnetite appears as both euhedral or anhedral. Pyrite is often replaced by Fe-hydroxide. Chalcopyrite, very small, shows anhedral form. Millerite(NiS) was detected by the analysis of EPMA.

For gangue minerals, vein consists of a large volume to medium amount of quartz (diameter : 3 - 0.1 mm), plagioclase (diameter : 3 - 0.3 mm), and potassium feldspar (diameter : 3 - 0.3 mm), small to extremely small amount of orthopyroxene (diameter : 1 - 0.3 mm), clinopyroxene (diameter : 1.5 - 0.2 mm) and hornblende (diameter : 1.5 - 0.2mm). Zircon and apatite come appear as accessary minerals.

Country rock of veins is assumed to be gneissose granulite.

The assay results of samples taken from the zone are shown as follows:

	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①	71.78	0.36	14.10	1.42	1.97	0.05	1.20	1.68	4.11	1.58	0.02	1.10
②	68.49	0.41	15.39	1.22	2.17	0.04	1.26	3.13	4.33	1.35	0.12	1.33
③	60.73	0.53	16.50	2.53	3.81	0.08	3.50	4.63	4.23	1.31	0.14	1.15
④	62.31	0.18	16.31	0.61	4.53	0.12	3.33	6.72	3.68	0.45	<0.01	0.26
⑤	67.80	0.24	15.18	1.56	1.62	0.03	0.85	2.06	3.64	5.30	0.13	0.74

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
①	2	<0.50	<1.00	<0.10	18	217	102	<1.00	30
②	2	<0.50	<1.00	<0.10	25	481	68	<1.00	28
③	1	<0.50	<1.00	<0.10	59	527	142	<1.00	64

④	1	< 0.50	< 1.00	< 0.10	45	77	85	353	82
⑤	2	< 0.50	< 1.00	< 0.10	27	161	85	224	20

Judging from the assay results, the zone is characterized by rather strong concentration of Cr compared with other mineralized zones in the survey area.

Dinhiro mineralized zone : The mineralized zone is located in the western part of the area, along the hill of same name. Country rock is iron formation. Both width and strike/dip of the veins are 0.3 m～1.5 m and N50E/75° NW, respectively. The vein consists of stratiformed limonite and hematite and siliceous materials as a matrix. The vein system obliquely superimposes on the foliation of the country rock. Judging from the vein occurrence and pits distribution, the zone consists of a few paralleled vein systems.

The results of microscopic observation on polished sections and polished thin sections are summarized as follows:

Ore minerals from the mineralized zone consist of small amount of magnetite - ilmenite (diameter : 1.5 - 0.1 mm), Fe-hydroxide (width : 2.5 - 0.03 mm) and extremely small amount of ilmenite and pyrrhotite (diameter : 0.3 - 0.1 mm).

Magnetite - ilmenite shows exsolution texture in of lattice form. Pyrrhotite appears in oval form and is included in country rock.

Quartz (diameter : 1.5 - 0.1 mm), irregular in size, is only gangue mineral.

The assay results of samples taken from the zone are shown as follows:

	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①	96.58	0.04	0.27	0.96	1.07	0.02	0.04	0.02	< 0.01	< 0.01	< 0.01	0.08
②	71.70	0.16	0.59	22.86	1.07	0.03	0.03	0.02	< 0.01	< 0.01	< 0.01	2.84

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
①	< 0.01	< 0.50	1.00	0.10	25	14	51	614	23
②	5	< 0.50	1.00	0.10	234	32	38	151	16

Judging from the assay results, the zone is characterized by rather high content of Cr and Cu compared with other mineralized zones in the survey area.

Hovee mineralized zone : The mineralized zone is located in the central part of the area and upper reaches of the Mukwasini river. Although many boulders of gneiss scatter around the vein, the country rock is not known. Mafic rock, possibly dyke having strike of N40° E, exists peneconcordantly to the vein. Vein consists mainly of quartz with banded and disseminated limonite and minor amount of pyrite and chalcopyrite dissemination.

Gneiss nearby the vein possibly suffers some shearing. Twenty meters of continuation is confirmed on the field. There is a trench having a dimension of 7 m(length) x 2.0 m(width) x 1.0 m(depth).

The results of microscopic observation on polished sections and polished thin sections are summarized as follows:

Ore minerals from the mineralized zone consist of small amount of pyrrhotites (diameter:1.5-0.03 mm), extremely small amount of pyrites (diameter:0.2-0.02mm), marcasites (diameter:0.2-0.03mm), chalcopyrites (diameter:0.1-0.01mm) and covellites and medium amount of ilmenites.

The majority of pyrrhotites is replaced by a very small aggregation of pyrites and marcasites and locally shows birds-eye structure. Pyrites commonly appear as euhedral and contain very tiny marcasite crystals which may be secondary products from pyrrhotites. Chalcopyrites show anhedral form and rims are frequently replaced by covellites. Covellites form an aggregation of lamellae texture and replace the rim of chalcopyrites. Ilmenites show anhedral form and appear in aggregation as well.

For gangue minerals, vein consists of a large amount of orthopyroxenes (diameter : 2.5 - 0.3 mm), clinopyroxenes (diameter : 1.5 - 0.3 mm), and medium amount of quartz (diameter : 0.5 - 0.05 mm), and small amount of uralites (diameter : 1.5 - 0.3 mm). Mineral paragenesis is rather simple. Uralite is an alteration mineral after pyroxenes. According to microscopic observation, country rock of the zone is mafic granulite.

The assay results of sample taken from the zone are shown as follows:

	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①	60.23	1.62	1.20	6.61	20.58	0.37	8.21	0.36	0.02	<0.01	<0.01	0.25

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
①	13	0.06	<1.00	0.10	491	16	552	13	55

Judging from the assay results, the zone is characterized by high content of

Au, Cu, Zn.

Muchacha mineralized zone : The mineralized zone is located in the central area and just east of Chirezana business center. Although many boulders of garnet bearing mafic granulite scatter around the vein, the country rock is not known. Vein consists mainly of quartz with banded and disseminated limonites and minor amount of disseminated fine pyrites. The vein has a strike of N80E and a dip no-determined. There is a pit having a dimension of 1.6 m(length) x 1.0 m(width) x 1.0 m(depth). The mode of occurrence is somewhat similar to other mineralized zones except for Gorge.

The results of microscopic observation on polished sections and polished thin sections are summarized as follows:

Ore minerals from the mineralized zone consist of a medium amount of pyrrhotites (diameter : 0.3 - 0.01 mm), small to extremely small amount of pyrites (diameter : 0.35 -0.03 mm) and marcasites (diameter : 0.3-0.05 mm) and extremely small amount of chalcopyrites (diameter : 0.1-0.01 mm) and covellites. A small amount of Fe-hydroxides and and ilmenites are also included.

The majority of pyrrhotites have altered into a very small aggregation of pyrites and marcasites. From the textural point of view, pyrrhotites show birds-eye texture. Pyrites appear as euhedral crystal. Marcasite forms an aggregation of tiny euhedral crystal. Chalcopyrites commonly associate with pyrrhotites and pyrites. Chalcopyrites mainly have an association with covellites. Covellites form tiny lamellae aggregation and often occupy rims of chalcopyrite crystals. Ilmenites are anhedral and locally exhibit granular texture.

For gangue minerals, vein consists only of quartz. But country rock adjacent to vein consists of a large amount of orthopyroxenes (diameter : 2.5-0.3 mm), clino-pyroxene (diameter : 5-0.3 mm) and uralites (diameter : 2-0.2 mm) and medium amount of garnets (diameter : 5-0.3 mm). An extremely small amount of quartz fills the grain boundary of these minerals. Uralite is an alteration product of pyroxene. Country rock of the zone may be mafic granulite.

The assay results of samples taken from the zone are shown as follows:

	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①	56.09	0.39	5.81	8.76	14.72	0.29	3.90	1.04	0.04	0.10	<0.01	7.98
②	91.41	0.02	0.19	4.60	1.63	0.02	0.09	0.13	0.01	0.02	<0.01	0.93

Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
①129	0.70	46.00	1.40	345	57	270	<1	208
② 6	0.50	48.00	0.30	160	17	880	64	42

Judging from the assay results, the zone is characterized by high content of Au, As, and Zn, and rather high content of Cu.

Some samplings were carried out in Fumure, Chiwanza, and Gwakwa mineralized zones other than the above mentioned mineralized zones. The detail occurrence in the zones, however, were not clear. Only occurrence of Fe-hydroxides were reported.

The assay results of samples taken from the Fumure mineralized zone are shown as follows:

SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①86.75	0.01	0.06	8.55	3.11	0.03	0.26	0.02	<0.01	<0.01	<0.01	0.53
②84.53	<0.02	0.02	11.77	2.78	0.16	0.12	0.03	<0.01	<0.01	<0.01	0.22

Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
① 10	<0.50	4.00	<0.50	4	20	21	47	24
②<1	<0.50	5.00	<0.01	12	<10	26	332	14

Judging from the assay results, the zone is characterized by rather high content of Cr, and Au in portions as well. Samples assayed were Fe-hydroxides bearing silisified rocks.

One sample from Chiwanza mineralized zone was assayed. The results are listed below:

SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①96.98	0.05	0.20	0.66	1.16	0.01	0.03	<0.01	<0.01	0.02	<0.01	0.01

Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)

①<1	<0.50	3.00	<0.01	28	20	22	647	27

Judging from the assay results, the zone is characterized by rather high content of Cr as well as Fumure.

Two samples from <u>Gwakwa mineralized zone</u> were assayed. The results are listed below:

	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①	97.57	0.03	0.37	0.20	0.77	<0.01	0.04	0.03	0.02	<0.01	<0.01	<0.01
②	97.58	0.03	0.38	0.01	0.94	<0.01	0.04	0.02	0.05	0.13	<0.01	0.01

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
①	1	<0.50	<1.00	<0.10	25	157	37	78	17
②	1	<0.50	1.00	<0.10	13	32	17	5	21

No specific metal elements are concentrated in the zone. The samples analysed were intensely silisified ones.

Two kind of samples, high sulphide content(**) and less sulphide content(*), from <u>Renco Mine</u> were assayed. The results are shown as follows:

	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①	71.50	0.34	12.53	0.70	4.55	0.12	1.54	3.86	3.12	0.44	0.04	0.69 *
②	51.44	0.06	3.52	0.01	35.97	0.02	0.14	0.67	0.62	0.96	<0.01	5.76**

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
①	1436	1.50	<1.00	5.30	929	252	108	125	11 *
②	1497	0.70	<1.00	6.90	2133	<10	71	7	102**

Judging from the assay results, the zone is characterized by high content of Au, Bi, and Cu compared with other zones. The results also indicate that the content of sulphide mineral has little relationship with Au grade, but possibly, with that of Cu.

One sample of Umkondo deposit was assayed.

SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
①91.34	0.21	3.09	0.83	0.90	0.02	0.08	0.73	0.03	0.52	<0.01	1.49

Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Cu (ppm)	F (ppm)	Zn (ppm)	Cr (ppm)	Ni (ppm)
① 740	<0.5	2	0.1	2751	92	57	<1	19

The results show high grade of Au and Cu compared with other mineralized zones. The sample analysed was non wacke type compact sandstone with pyrite dissemination.

A compiled list of mineralized zones are shown below as TABLE 2-2-1

TABLE 2-2-1 LIST OF MINERALIZED ZONE

NAME OF MINERALIZED ZONE	MINERALIZED METAL	STRIKE/DIP, WIDTH OF VEIN	COUNTRY ROCKS	PRINCIPAL SULPHIDE MINERAL
①JEGEDE	Au?	E-W/85S, 1.2m	Mafic Granulite	Po, Py, Mc, Cp, Cv
②JUWERE	Au	N-S/?, ?	Gneissose granulite	Po, Py, Mc, Cp, Cv
③TURWI	Au?, Cr??	? /?, ?	Mafic Granulite	Po?, Py?
④PANGANAI	Au?, Cr??	? /?, ?	Gneissose granulite	Po?, Py?
⑤GORWGE	Au??	N30W～N80E/?, 0.1～1.5m	Gneissose granulite	Po, Py, Mil*
⑥DINHIRO	Au?, Cu, Cr?	N50E/75NW, 0.3～1.5m	Iron Formation	Po
⑦HOVEE	Au, Cu, Zn	N40E/?, 1.5～3.5m	Mafic Granulite	Po, Py, Mc, Cp, Cv
⑧MUCHACHA	Au, Cu, Zn	N80E/?, ?	Mafic Granulite?	Po, Py, Mc, Cp, Cv
⑨FUMURE	Au?, Cr?	? /?, ?	Mafic Granulite?	?
⑩CHIWANZA	Cr?	? /?, ?	Gneissose granulite?	?
⑪GWAKWA	Au?, Cr?	? /?, ?	Felsic Granulite?	?

* : Millerite(NiS)

All the above analytical results are listed TABLE 2-2-2.

TABLE 2-2-2 Results of Chemical Analysis of Mineralized Rock Samples

	SAMPLE NUMBER	MINERALIZED ZONE	SiO2 (%)	TiO2 (%)	Al2O3 (%)	Fe2O3 (%)	FeO (%)	MnO (%)	MgO (%)	CaO (%)	Na2O (%)	K2O (%)	P2O5 (%)	LOI (%)	Au ppb	Ag ppm	As ppm	Bi ppm	Cu ppm	F ppm	Zn ppm	Cr ppm	Ni ppm
1	M89102702	JEGEDE	79.43	0.04	0.57	9.67	5.91	0.10	1.29	0.19	0.02	0.02	0.01	1.97	12.00	0.80	763.00	0.40	367.00	61.00	256.00	207.00	44.00
2	M89102703	JEGEDE	63.93	0.14	2.62	21.66	5.24	0.10	0.58	0.65	0.02	0.03	<0.01	4.21	6.00	0.60	67.00	0.30	228.00	139.00	216.00	99.00	24.00
3	M89102704	JUWERE	74.21	0.25	0.80	20.20	1.71	0.04	0.32	0.03	<0.01	<0.01	<0.01	1.78	1,461.00	<0.50	1.00	15.70	324.00	86.00	88.00	258.00	31.00
4	M89102705	JUWERE	62.58	0.11	1.71	22.78	6.21	0.14	1.91	0.60	0.05	0.03	0.06	2.96	97.00	0.50	1.00	0.20	639.00	49.00	194.00	7.00	52.00
5	M89103101	TURWI	97.76	0.03	0.35	0.01	0.77	<0.01	0.04	0.02	0.02	0.04	<0.01	0.02	<1.00	<0.50	<1.00	<0.10	22.00	96.00	36.00	630.00	17.00
6	M89103103	TURWI	83.53	0.01	9.64	0.01	0.62	<0.01	0.13	2.13	2.60	0.23	<0.01	0.32	<1.00	<0.50	<1.00	<0.10	7.00	<10.00	19.00	326.00	19.00
7	M89103105	PANGANAI	77.82	1.00	6.46	6.13	0.77	0.16	0.69	4.19	0.02	0.48	0.15	1.52	2.00	0.60	3.00	0.10	15.00	104.00	71.00	630.00	29.00
8	M89110101	GORGWE	71.78	0.36	14.10	1.42	1.97	0.05	1.20	1.68	4.11	1.58	0.02	1.10	2.00	<0.50	<1.00	<0.10	18.00	217.00	102.00	<1.00	30.00
9	M89110102	GORGWE	68.49	0.41	15.39	1.22	2.17	0.04	1.26	3.13	4.33	1.35	0.12	1.33	2.00	<0.50	<1.00	<0.10	25.00	481.00	68.00	<1.00	28.00
10	M89110105	GORGWE	60.73	0.53	16.50	2.53	3.81	0.08	3.50	4.63	4.23	1.34	0.14	1.15	1.00	<0.50	<1.00	<0.10	59.00	527.00	142.00	<1.00	64.00
11	M89110106	GORGWE	62.31	0.18	16.31	0.61	4.53	0.12	4.33	6.72	3.68	0.45	<0.01	0.26	1.00	<0.50	<1.00	<0.10	45.00	77.00	85.00	353.00	82.00
12	M89110107	GORGWE	67.80	0.24	15.18	1.56	1.62	0.03	0.85	2.06	3.64	5.30	0.13	0.74	2.00	<0.50	<1.00	<0.10	27.00	161.00	85.00	224.00	20.00
13	M89110501	DINHIRO	96.58	0.04	0.27	0.96	1.07	0.02	0.04	0.02	<0.01	<0.01	<0.01	0.08	<0.01	<0.50	1.00	0.10	25.00	14.00	51.00	614.00	23.00
14	M89110503	DINHIRO	71.70	0.16	0.59	22.86	1.07	0.02	0.03	0.02	<0.01	<0.01	<0.01	2.84	5.00	<0.50	<1.00	0.10	234.00	32.00	38.00	151.00	16.00
15	M89110601	HOVEE	60.23	1.62	1.20	6.61	20.58	0.37	8.21	0.36	0.02	<0.01	<0.01	0.25	13.00	0.06	<1.00	0.10	491.00	16.00	552.00	13.00	55.00
16	M89110603	MUCHACHA	56.09	0.39	5.81	8.76	14.72	0.29	3.90	1.04	0.04	0.10	<0.01	7.98	129.00	0.70	46.00	1.40	345.00	57.00	270.00	<1.00	208.00
17	M89110605	MUCHACHA	91.41	0.02	0.19	4.60	1.63	0.02	0.09	0.13	0.01	0.02	<0.01	0.93	6.00	0.50	48.00	0.30	160.00	17.00	880.00	64.00	42.00
18	C89102801	FUMURE	86.75	0.01	0.06	8.55	3.11	0.03	0.26	0.02	<0.01	<0.01	<0.01	0.53	10.00	<0.50	4.00	<0.50	4.00	20.00	21.00	47.00	24.00
19	C89102802	FUMURE	84.53	<0.01	0.02	11.77	2.78	0.16	0.12	0.03	<0.01	<0.01	<0.01	0.22	<1.00	<0.50	5.00	<0.01	12.00	<10.00	26.00	332.00	14.00
20	S89102801	CHIWANZA	96.98	0.05	0.20	0.66	1.16	0.01	0.03	<0.01	<0.01	0.02	<0.01	0.01	<1.00	<0.50	3.00	<0.01	28.00	20.00	22.00	647.00	27.00
21	S89102803	GWAKWA	97.57	0.03	0.37	0.20	0.77	<0.01	0.04	0.03	0.02	<0.01	<0.01	<0.01	1.00	<0.50	<1.00	<0.10	25.00	157.00	37.00	78.00	17.00
22	S89102807	GWAKWA	97.58	0.03	0.38	0.01	0.94	<0.01	0.04	0.02	0.05	0.13	<0.01	0.01	1.00	<0.50	1.00	<0.10	13.00	32.00	17.00	5.00	21.00
23	W89110301	RENCO MINE	71.50	0.34	12.53	0.70	4.55	0.12	1.54	3.86	3.12	0.44	0.04	0.69	1,436.00	1.50	<1.00	5.30	929.00	252.00	108.00	125.00	11.00
24	W89110302	RENCO MINE	51.44	0.06	3.52	0.01	35.97	0.02	0.14	0.67	0.62	0.96	<0.01	5.76	1,497.00	0.70	<1.00	6.90	2,133.00	<10.00	71.00	7.00	102.00
25	W89102803	UMKONDO MINE	91.34	0.21	3.09	0.83	0.90	0.02	0.08	0.73	0.03	0.52	<0.01	1.49	740.00	<0.5	2.00	0.10	2,751.00	92.00	57.00	<1.00	19.00

2-4 Consideration

(1) Geological Survey

In the examination of 125 thin sections under a microscope, it was found that 91 sections were gneissose granulite or mafic granulite, and among these 91 sections, 54 sections (59%) contained orthopyroxene (Opx). It could be assumed that this orthopyroxene was formed by decomposition of biotite or amphibole as shown in the equations below:

phlogopite → orthopyroxene

$$KMg_3AlSi_3O_{10}(OH)_2 + 3SiO_2 = 3MgSiO_3 + KAlSi_3O_8 + H_2O$$

actinolite → clinopyroxene, orthopyroxene

$$Ca_2Mg_5Si_8O_{22}(OH)_2 = 2CaMgSi_2O_6 + 3MgSiO_3 + SiO_2 + H_2O$$

tschermakite → orthopyroxene, anorthite

$$Ca_2Mg_3Al_4SiO_{22}(OH)_2 + SiO_2 = 3MgSiO_3 + 2CaAl_2Si_2O_8 + H_2O$$

authophyllite → orthopyroxene

$$Mg_7Si_8O_{22}(OH)_2 = 7MgSiO_3 + SiO_2 + H_2O$$

In granite facies, neither biotite nor amphibole is stable, and each of the decomposition reactions takes place at a different temperature depending on the composition of the solid solution minerals and the excess SiO_2. When SiO_2 is not excessive, hornblende will remain even at a high temperature. Consequently, there is a tendency that more hornblende is found in basic rocks and more orthopyroxene is found in acidic rocks. Since this tendency was found in the survey area, it was thought that the above decomposition reactions were occurring. In general, this is contrary to the tendency found in igneous rocks.

FIG. 2-2-3 shows the results of metamorphic zone division made with orthopyroxene and garnet. It can be seen in this figure that an orthopyroxene isograd can be set along the north edge of the survey area. Although the number of sections, in which garnet was found, are fewer (23 sections: 19%), it can be seen that garnet is also distributed almost along the orthopyroxene isograd. This zone clearly overlaps the north edge of the Limpopo Mobile Belt which had been frequently reported(Coward et al., 1976). Although gneissose granulite and felsic granulite were widely distributed throughout the survey area, these were not suitable to be used for metamorphic zone division, because many of the constituent minerals had wide ranges of metamorphic temperature and pressure. In particular, there was little aluminosilicate which was sensitive to changes in temperature and pressure. This might be because there are few metamorphic rocks made from pelitic rock. In general, few minerals were found which were abundant in Ca. This suggests that there are few metamorphic rocks made from carbonate. Sedimentary rocks resulted from metamorphic change of only iron formations. The kinds of pyroxene found in abundance in gneissose granulite and those in mafic granulite are almost the same.

For the metamorphic conditions, Robertson and Du Toit (1981) and others clarified that a metamorphic temperature of 750°C and metamorphic pressure of 5 Kb was reached in 2,870 Ma. In addition, in this survey, mesoperthite with almost the same amount of orthoclase (Or) and albite (Ab) was found in felsic granulite and this proved that the formation temperature was higher when these two were in one phase than that of other geological units. The distribution of felsic granulite is predominate in the highest upheaval block.

It was attempted to clarify the reasons why the degree of tectonic metamorphism differs between areas from the following angles:

(1)Relationship to the faults which have been identified

(2)Differences in the physical properties of the rocks (e.g.:kinds of constituent minerals)

(3)Difference in depth (confining pressure)

(4)Chronological relationship between tectonic metamorphism and rock formation.

However, no apparent causal sequence was found. Item (4) is thought to be the reason why dolerite was not mylonitized. Since the distribution and intrusion direction of dolerite in the survey area are similar to those in Umkondo Formation, it is considered that dolerite activity took place in the survey area in 1,700 Ma. Consequently, it can be said that tectonic metamorphism occurred in the area before this age.

(2) Geological Structure

By noting the dislocation of geological units, the dislocation at one edge of a major fault seems to differ from that on the other edge of the same fault. Taking the relationship between the synform and the antiform (both of which are generally seen in the survey area) into consideration, the reason for the above-mentioned phenomenon is thought to be that the faults in the survey area are accompanied with a dip slip more frequently than with a strike slip. The survey area can be divided into four blocks which line up from west-south-west toward east-north-east, on the basis of the movement of the faults. A model can be postulated showing that the first, the second, and the third blocks rose in stages, and the forth block fell somewhat.

Very idealized relationships of block movement among the blocks are as follows:

down up down up up down

First block/Sazaume F./Second block/Murerezi F./Third block/Turwi F./Fourth block

Makambe F.

The reason why the direction and the tilt of foliation differs with areas may be found in the difference in the environment in which tectonic metamorphism took place. It is important to relate this point of view with the fact that the major faults in the survey area are accompanied more frequently with a dip slip than a strike slip. In another words, it is highly possible that the survey area was divided into blocks by Sazaume-Makambe, Murerezi and Turwi faults, and that the third block between the Murerezi and Turwi faults, in which foliation was disturbed, rose comparatively high so that tectonic metamorphism took place under high confining pressure.
Such a difference may have resulted in variation in the configuration of foliation.

(3) Mineralization

Similarities between the mineralized zones in the survey area and Renco Deposit were investigated. In the field survey of this fiscal year, however, the characteristics of the geology and mineralization in the Renco deposit could not be seen in the mineralized zones in the survey area. Assuming that deposits of the Renco type exist near the ground surface in the survey area, it is thought to be effective in exploration for deposits to examine sulfides and other constituent elements in reef which is ore horizon in Renco deposit. In the example of the Renco Deposit, a geological examination of oxide production from sulfides in the reef may help in the search for deposits of this type. In the field survey this fiscal year, phenomena based on these characteristics could not be found. The results of geochemical exploration were used to judge whether concentration of elements found in the reef of the Renco deposit was also taking place in the survey area or not, and the behavior of elements similar to that of Au-Bi-As or other elements seen in the Renco deposit was detected in Au anomalous zones, i.e. I_{Au}, IV_{Au}, V_{Au}, VI_{Au}, VII_{Au}, $VIII_{Au}$, and XI_{Au} anomalous zones. This does not necessarily mean, however, that these anomalous zones are related to the formation of the Renco-type deposits.

The intimate relationship among Au mineralization and the above mentioned elements, Au-Bi-AS, is well understood geochemically in general. From this point of view, three mineralized zones, Jegede, Juwere, and muchacha, have similar geochemical characteristics in concentration of elements to these of Renco deposit.

Mineralized zones	Elements concentrated
Jegede	Au-As-(Cu)-(Zn)
Juwere	Au-Bi-(Cu)-(Zn)
Muchacha	Au-As-Bi-(Zn)

It can be concluded from the results of macroscopic and microscopic observations and interpretation of assay results of the samples that the degree of mineralization in the mineralized zones is generally low.

For Ag mineralization, although both the background and threshold values in the survey area were high, anomalous zones were found only sporadically in the survey this year. Consequently, it cannot be concluded that these anomalous zones are promising. The fact that the Ag grade in each mineralized zone is low seems to support the results of the geochemical exploration.

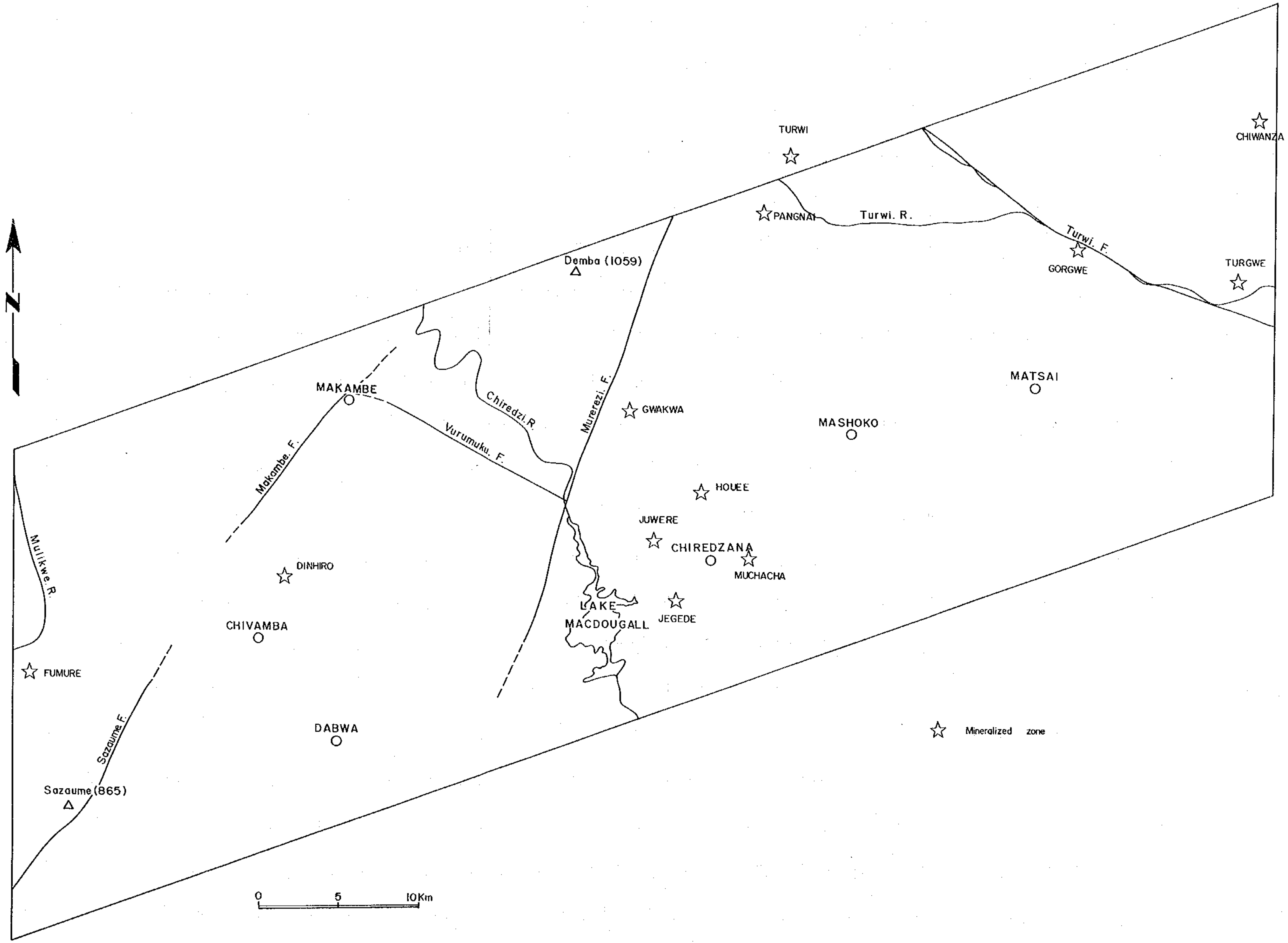


FIG. 2-2-8 Locality Map of Mineralized Zones

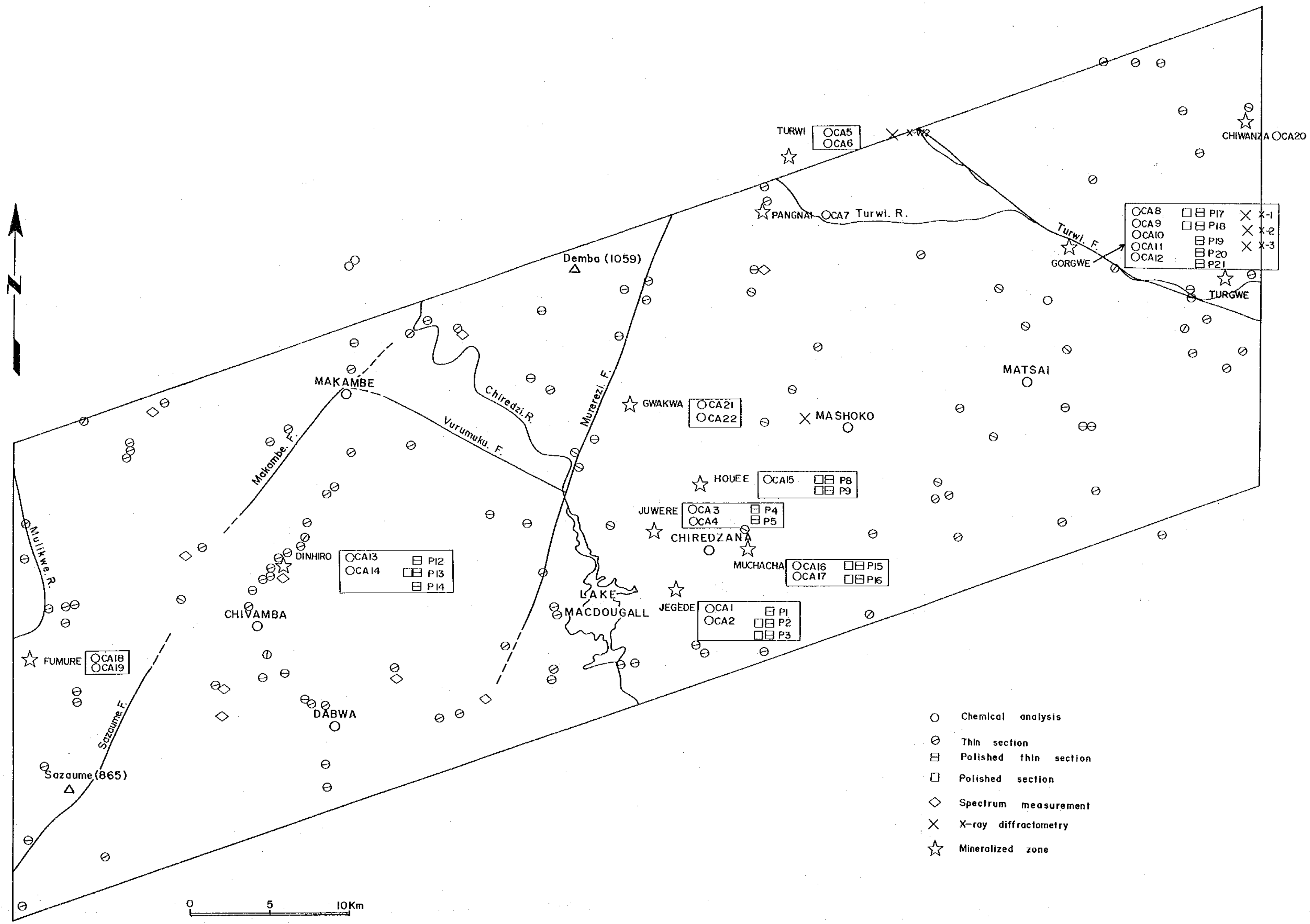


FIG. 2-2-9 Locality Map of Rock Samples

CHAPTER 3 GEOCHEMICAL SURVEY

3-1 Survey Methods

(1) Sample Collection

In the geochemical exploration using stream sediments, samples were collected checking sample collecting points, which were established previously so as to cover the entire survey area, on topographical maps. In a survey area of 2,300 km^2, 2,355 stream sediments and 150 panned stream sediments samples were collected. Sample collecting places were on the banks of streams, the sandbanks in streams or underneath rocks, etc., and a sample of about 50g of -80 mesh size was collected in each place. The analytical results of these samples are shown in APPENDIX A-1 together with the geology which was determined based on the origin of each sample, collected position, etc..

(2) Preparation of Sample and Detection Limit of Analysis

The samples were dried at the survey base. About a quantity of 20g was separated from each sample for analysis, and after preparing sample lists, samples for analysis were shipped to Iijima Laboratory, Akita, Japan.

Analytical detection limits were as follows;

Au	1 ppb
Ag	0.5 ppm
As	1 ppm
Bi	0.5 ppm
Cu	1 ppm
F	20 ppm
Zn	1 ppm
Cr	1 ppm
Fe	0.01 %

As the frequency of appearance of value below the detection limit was high for Au, As and Bi, statistical treatment was carried out by assuming the values below the detection limit as 0.5 ppb, 0.5 ppm and 0.05 ppm, respectively.

Single variate and multivariate analyses were carried out for the ten elements(Au, Ag, As, Bi, Cu, F, Zn, Cr, Fe) of 2,455 samples collected during this survey. In geochemical data analyses, it has been known empirically that the frequency distribution of the contents of minor elements contained in geochemical samples assumes log normal distribution (Lepeltier, 1969). Accordingly, it has been the general method of determining anomalous values to pay attention to the deviation (anomalous population) from the log normal distribution (background population) shown by the major part of a certain indicator. The population handled in geochemical exploration is usually the composite population of the background population and anomalous population, and it becomes important to divide these two in conformity with actual conditions. Apart from the case where the object composite population assumes log normal distribution, particular consideration is required. In the past, a method to determine background values and threshold values using a cumulative frequency distribution curve by Lepeltier (1969) and Sinclair (1976) has been used as a method to solve this problem.

Since most of indicators in this survey show log normal distribution, background and threshold values were determined on the basis of geometric mean and geometric standard deviation. The calculation was made on each geological units as possible as one can. The geological units were divided into six categories:

Dolerite : Rock code 1
Iron formation : Rock code 2
Gneissose granite : Rock code 6

Since these units have very limited distribution, collection of typical stream sediments originated from them is not expected. Statistical data of all geological units were applied to them.

Mafic granulite : Rock code 3
Felsic granulite : Rock code 4
Gneissose granulite : Rock code 5

To these units were applied their proper geostatistics.

3-2 Survey Results

(1) Background Geology and Indicator Content

The contents of indicators in the stream sediments depend upon the geological conditions and the degrees of mineralization and alteration of the background area from which the sediments came from. Accordingly, geochemical characteristics for respective geological units are shown in TABLE 2-3-1. However, as the number of samples included in rock code 2 is extremely small, data of all geological units were applied. According to this table, geochemical characteristics on each element are summarized as follows:

Au : Geometric mean(GM) of all geological units is 0.74 ppb but rock code 5 has

TABLE 2-3-1 Statistical Parameter of Indicators

ZIMB-GC1

GEOMETRIC MEAN (PPM)

ROCK NAME & CODE	NO. OF SAMPLE	Au (PPB)	Ag (PPM)	As (PPM)	Bi (PPM)	Cu (PPM)	F (PPM)	Zn (PPM)	Cr (PPM)	Ni (PPM)	Fe (%)
ALL GEOLOGICAL UNIT	2,305	0.74	0.52	0.54	0.05	11.74	54.25	51.08	30.90	30.08	3.08
DOLERITE 1	33	0.70	0.63	0.52	0.05	19.08	66.89	55.25	36.07	32.26	3.65
IRON FORMATION 2	4	0.71	1.40	0.50	0.05	14.88	35.46	94.87	87.40	47.84	4.43
MAFIC GRANULITE 3	246	0.77	0.57	0.84	0.06	16.36	58.61	52.55	48.09	42.40	3.87
FELSIC GRANULITE 4	724	0.69	0.41	0.53	0.05	10.37	56.47	50.50	30.52	28.55	2.85
GNEISSOSE GRANULITE 5	1,249	0.78	0.58	0.54	0.05	11.89	49.37	50.35	28.18	28.98	3.14
GNEISSOSE GRANITE 6	49	0.55	0.72	0.51	0.05	8.22	93.07	29.79	38.86	31.90	1.80
PANNED SAMPLES	150	0.92	0.47	1.05	0.07	10.69	64.86	145.88	11.77	38.46	9.42

THRESHOLD (PPM)

ROCK NAME & CODE	Au (PPB)	Ag (PPM)	As (PPM)	Bi (PPM)	Cu (PPM)	F (PPM)	Zn (PPM)	Cr (PPM)	Ni (PPM)	Fe (%)
ALL GEOLOGICAL	3.88	3.28	1.13	0.08	74.10	393	223	324	151	14.70
UNIT	8.90	8.24	1.63	0.11	186.10	1057	466	1047	338	32.10
DOLERITE	3.88	3.28	1.13	0.08	74.10	393	223	324	151	14.70
1	8.90	8.24	1.63	0.11	186.10	1057	466	1047	338	32.10
IRON FORMATION	3.88	3.28	1.13	0.08	74.10	393	223	324	151	14.70
2	8.90	8.24	1.63	0.11	186.10	1057	466	1047	338	32.10
MAFIC GRANULITE	4.16	4.09	2.38	0.10	97.20	419	230	549	200	17.80
3	9.80	10.93	4.80	0.13	237.00	8036	442	1857	435	38.10
FELSIC GRANULITE	2.71	1.96	1.03	0.09	70.10	411	229	294	141	14.20
4	5.36	4.29	1.42	0.11	182.20	1108	407	913	314	31.60
GNEISSOSE GRANULITE	4.57	3.95	1.03	0.09	74.00	393	223	324	151	14.70
5	11.03	10.47	1.47	0.12	184.50	1057	466	1047	338	32.10
GNEISSOSE GRANITE	4.57	3.95	1.03	0.09	74.19	393	223	324	151	14.70
6	11.03	10.47	1.47	0.12	184.10	1057	466	1047	338	32.10
PANNED SAMPLES	11.83	3.03	5.39	0.21	54.80	319	511	196	177	40.40
	41.38	7.71	12.20	0.36	124.10	708	955	796	381	83.60

MINIMUM VALUE (PPM)

ROCK NAME & CODE	Au (PPB)	Ag (PPM)	As (PPM)	Bi (PPM)	Cu (PPM)	F (PPM)	Zn (PPM)	Cr (PPM)	Ni (PPM)	Fe (%)
ALL GEOLOGICAL UNIT	0.5	0.25	0.5	0.05	0.5	8	0.5	0.5	0.5	0.16
DOLERITE 1	0.5	0.25	0.5	0.05	0.7	10	11.0	4.0	9.0	1.04
IRON FORMATION 2	0.5	1.40	0.5	0.05	6.0	10	37.0	59.0	31.0	2.29
MAFIC GRANULITE 3	0.5	0.25	0.5	0.05	0.5	8	2.0	0.5	1.0	0.33
FELSIC GRANULITE 4	0.5	0.25	0.5	0.05	0.5	10	0.5	0.5	0.5	0.21
GNEISSOSE GRANULITE 5	0.5	0.25	0.5	0.05	0.5	8	0.5	0.5	0.5	0.16
GNEISSOSE GRANITE 6	0.5	0.25	0.5	0.05	1.0	10	2.0	0.5	5.0	0.16
PANNED SAMPLES	0.5	0.25	0.5	0.05	1.0	10	19.0	0.5	4.0	0.97

MAXIMUM VALUE (PPM)

ROCK NAME & CODE	Au (PPB)	Ag (PPM)	As (PPM)	Bi (PPM)	Cu (PPM)	F (PPM)	Zn (PPM)	Cr (PPM)	Ni (PPM)	Fe (%)
ALL GEOLOGICAL UNIT	694	231.0	34.0	5.00	202	527	1060	605	1612	38.72
DOLERITE 1	4	5.8	2.0	0.10	137	469	201	130	130	17.68
IRON FORMATION 2	2	1.4	0.5	0.05	34	527	713	136	57	7.91
MAFIC GRANULITE 3	206	22.4	14.0	0.50	177	484	467	605	389	24.65
FELSIC GRANULITE 4	62	8.8	16.0	0.80	202	478	1060	489	1612	21.56
GNEISSOSE GRANULITE 5	694	231.1	34.0	5.00	177	411	390	554	426	.72
GNEISSOSE GRANITE 6	2	6.3	1.0	0.10	26	336	89	126	94	6.72
PANNED SAMPLES	1510	35.0	7.0	0.90	66	287	597	176	312	37.00

319 : MEAN(m)+2 STANDARD DEVIATION(2δ)

708 : MEAN(m)+3 STANDARD DEVIATION(3δ)

		Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe
MAFIC ROCK	AVERAGE	4.00	0.10	2.00	0.01	100	370	130	200	160	8.56
INTERMEDIATE ROCK	AVERAGE	-	0.07	2.40	0.01	35	500	72	50	55	5.85
GRANITE	AVERAGE	1.00	0.05	0.25	0.43	12	1,290	85	7	5	1.85
FELSIC ROCK	AVERAGE	4.50	0.05	1.50	0.01	20	800	5	25	8	2.70
MICA SCHIST	AVERAGE	-	0.30	-	-	30	-	70	70	50	4.90

- : NO DATA

the largest value of 0.78 ppb. On the other hand, the smallest GM is 0.55 ppb of rock code 6. A comparison on the content of indicator between the area and other area based on data by Flanagan(1976) and Vinogradov(1962) was made. Au content in the area can be pointed out to be rather low. The maximum value in the area is 1,496 ppb.

Ag : GM of all geological units is 0.52 ppm but rock code 6 has the largest value of 0.72 ppm. On the other hand, the smallest GM is 0.41 ppm of rock code 4. A comparison on content of the indicator between the area and other areas based on data by Flanagan(1976) and Vinogradov(1962) was made. Ag content in the area rather high, with a maximum value of 231.1 ppm.

As : Since approximately 95 % of data indicated content below its detection limit, it is difficult to clarify its geochemical character in the area.
GM of all geological units is 0.54 ppm but rock code 3 has the largest value of 0.51 ppm. On the other hand, the smallest GM is 0.51 ppm of rock code 6. A comparison on content of the indicator between the area and other area based on data by Flanagan(1976) and Vinogradov(1962) was made. Content in the area is fairly low, with maximum value of 34 ppm.

Bi : Since approximately 95 % of data indicated content below its detection limit, it is difficult to clarify its geochemical character in the area.
GM of all geological units is 0.05 ppm. There is no difference among the GM of elements. A comparison on content of the indicator between the area and other area based on data by Flanagan(1976) and Vinogradov(1962) was made. Content in the area is nearly the same. Maximum value in the area is 5 ppm.

Cu : GM of all geological units is 11.74 ppm but rock code 1 has the largest value of 19.68 ppm. On the other hand, the smallest GM is 8.22 ppm of rock code 6. A comparison on content of the indicator between the area and other areas based on data by Flanagan(1976) and Vinogradov(1962) was made. Cu content of rock code 6 in the area is nearly the same as granite, but a comparison of rock code 1(19.08) and mafic rock(100 ppm) shows the indicator to be fairly low in the area. The maximum value in the area is 202 ppm.

F : GM of all geological units is 54.25 ppm but rock code 6 has the largest value of 19.68 ppm. On the other hand, the smallest GM is 49.37 ppm of rock code 5. A comparison on content of the indicator between the area and other areas based on data by Flanagan(1976) and Vinogradov(1962) was made. F content in the area is fairly low, with maximum value of 527 ppm.

Zn : GM of all geological units is 51.08 ppm but rock code 3 has the largest value of 62.55 ppm. On the other hand, the smallest GM is 29.79 ppm of rock code 6. A comparison on content of the indicator between the area and other areas based on data by Flanagan(1976) and Vinogradov(1962) made clear that Zn content in the area is normal. The maximum value in the area is 1,060 ppm.

Cr : GM of all geological units is 30.90 ppm but rock code 3 has the largest value of 48.09 ppm. On the other hand, the smallest GM is 28.18 ppm of rock code 5. A comparison on content of the indicator between the area and other areas based on data by Flanagan(1976) and Vinogradov(1962) made clear that Cr content in the area is almost same for each rock type. However, the indicator's values fluctuate greatly for rock types according to Flanagan's data . The maximum value in the area is 605 ppm.

Ni : Ni has almost same characteristics with that of Cr. GM of all geological units is 30.08 ppm but rock code 3 has the largest value of 42.40 ppm. On the other hand, the smallest GM is 28.98 ppm of rock code 5. A comparison on content of the indicator between the area and other area based on data by Flanagan(1976) and Vinogradov(1962) made clear that Ni content in the area is almost the same for each rock type. However, values of Flanagan's data fluctuate greatly for various rock types. The maximum value in the area is 1,612 ppm.

Fe : GM of all geological units is 3.08 % but rock code 3 has the largest value of 3.87 %. On the other hand, the smallest GM is 1.88 % of rock code 5. A comparison on content of the indicator between the area and other areas based on data by Flanagan(1976) and Vinogradov(1962) made clear that Fe content in the area is normal. The maximum value in the area is 38.72 %.

The pattern of cumulative frequency curve is very effective in evaluating the geochemical characteristics on each indicator in the target area. Especially, it is important whether the curve shows positive skewness or negative skewness.
The positive skewness is essential for the delineation of promising mineralized area. The principal positive skewness detected in the area on all geological units is summarized as follows:

Au : Au shows a kind of positive skewness as shown in FIG.2-3-1(1).
Geochemical values consist of three populations, frequency of each population is 74 %, 25.5 % and 0.5 %. The threshold value includes the upper 2 % of the population.

Ag : Ag also shows a kind of positive skewness as shown in FIG.2-3-1(1).

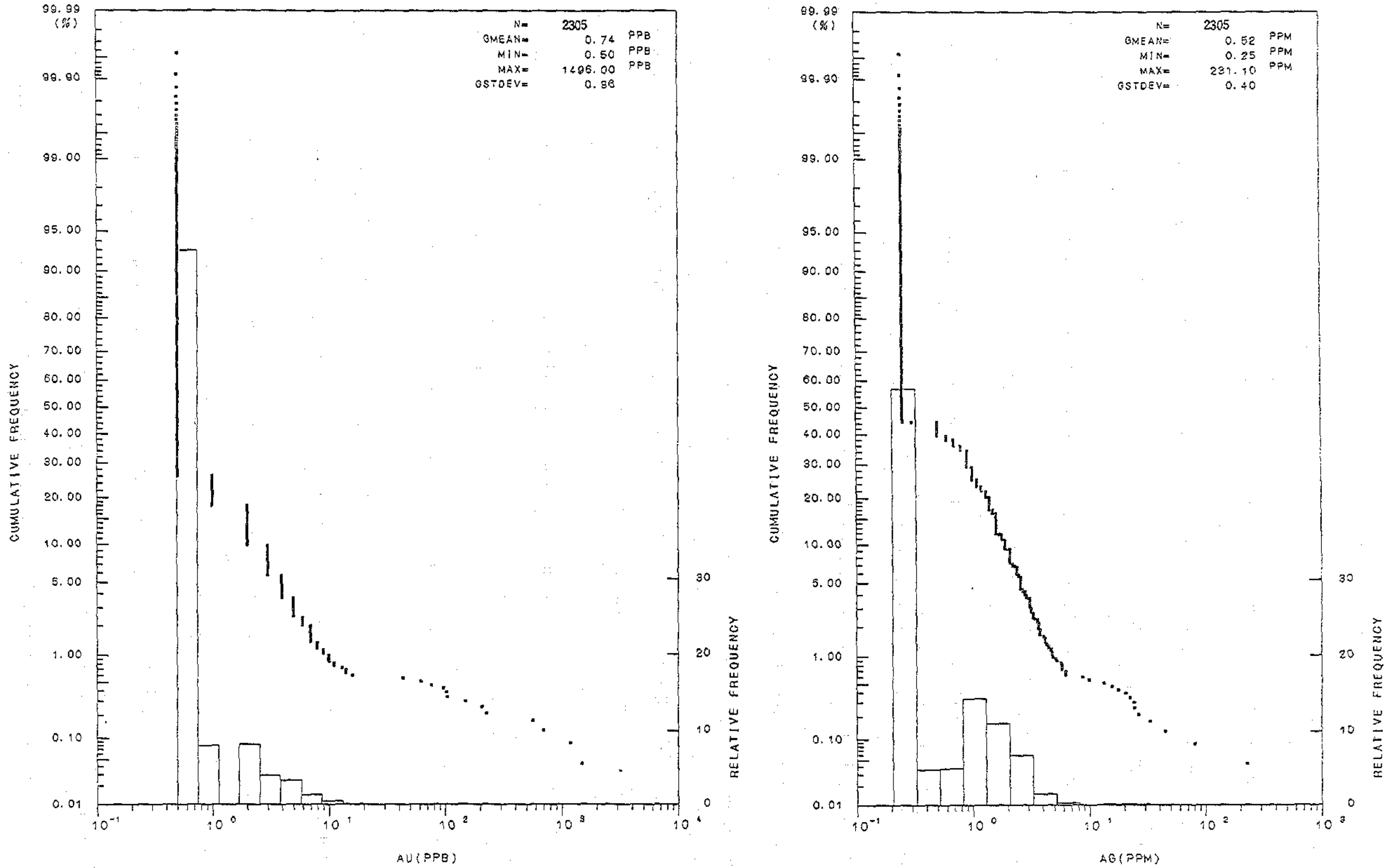


FIG.2-3-1(1) Histogram and Cumulative Frequency Curve(Au,Ag)

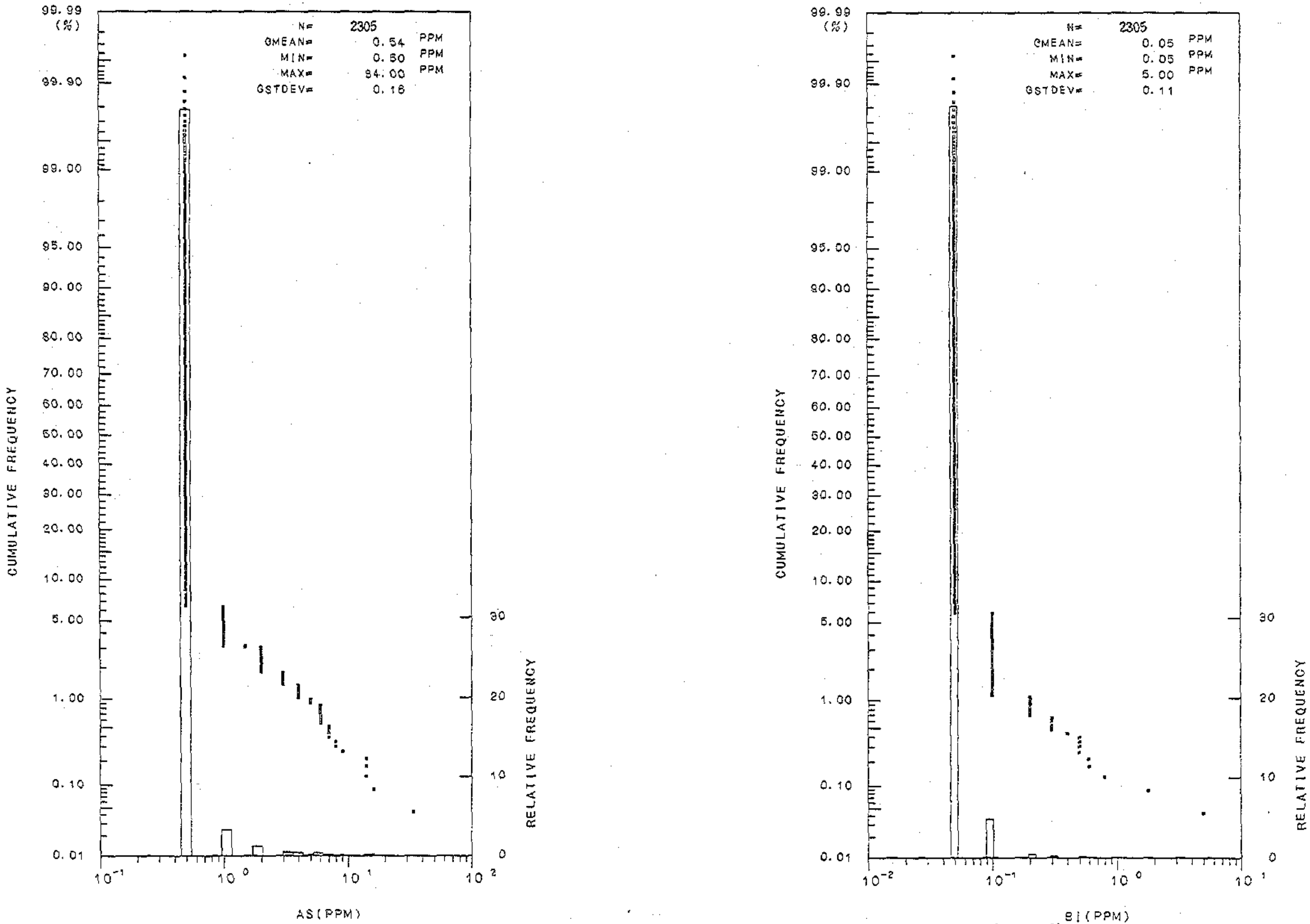


FIG.2-3-1(2) Histogram and Cumulative Frequency Curve(As,Bi)

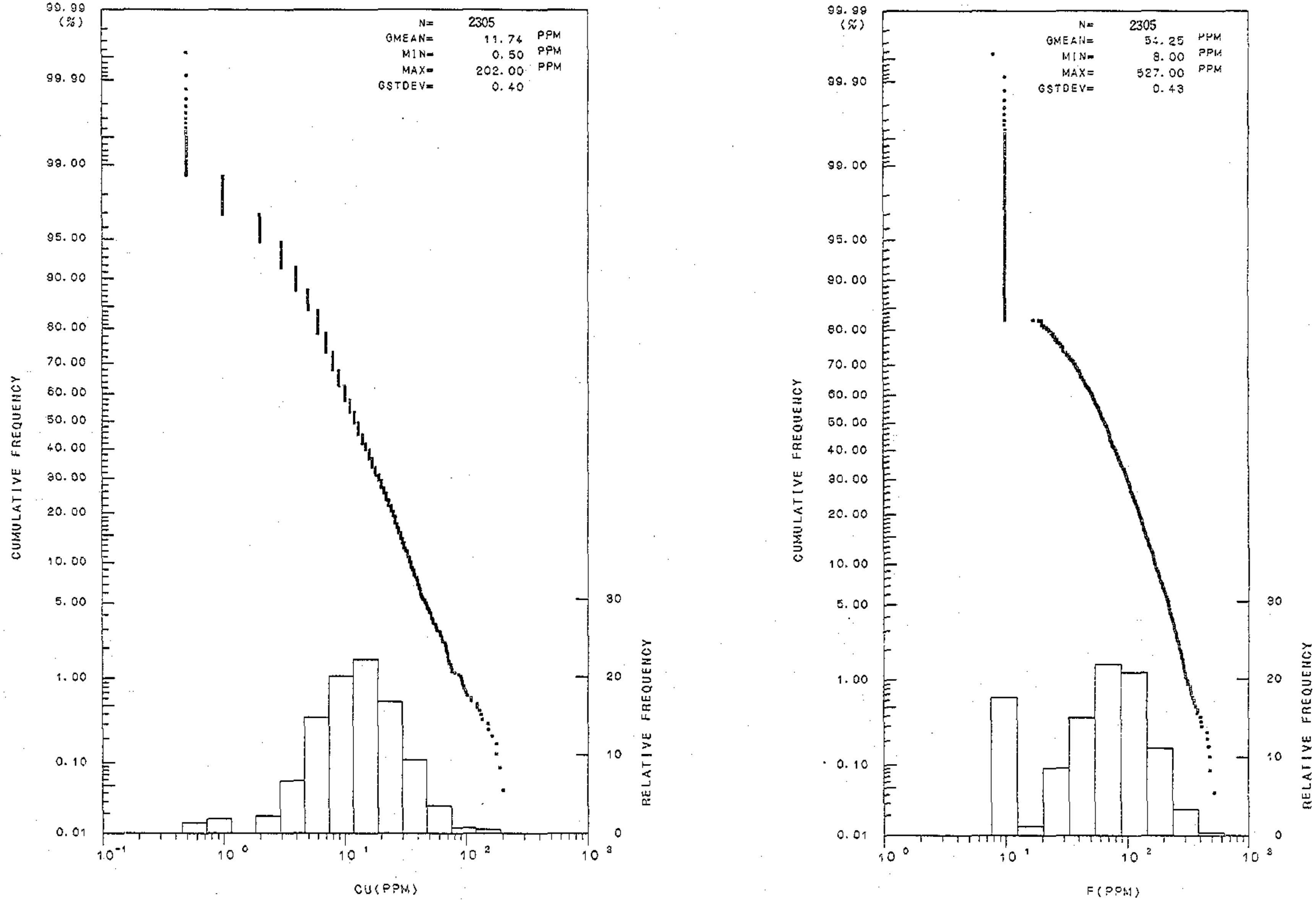


FIG.2-3-1(3) Histogram and Cumulative Frequency Curve(Cu,F)

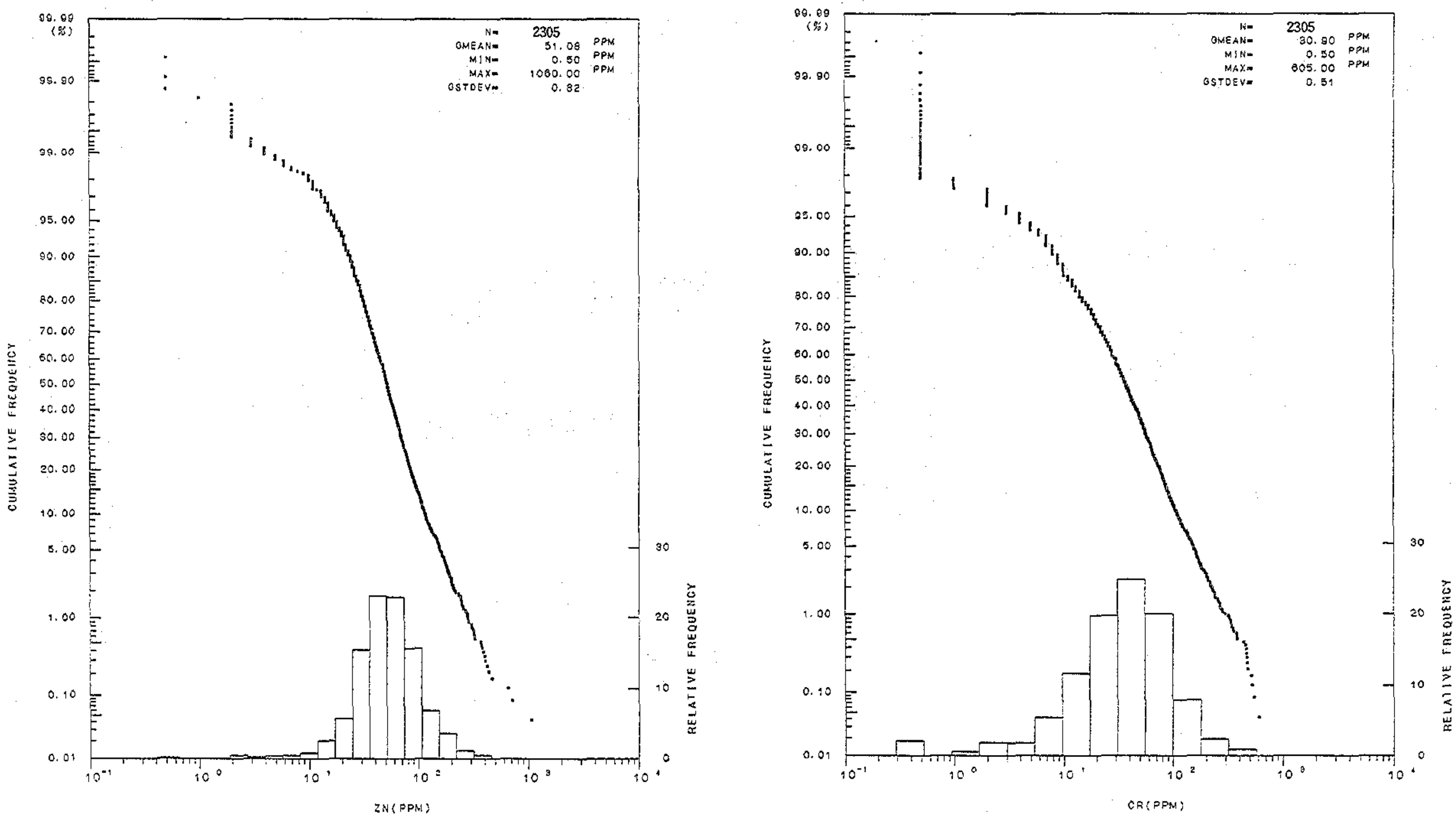


FIG.2-3-1(4) Histogram and Cumulative Frequency Curve(Zn,Cr)

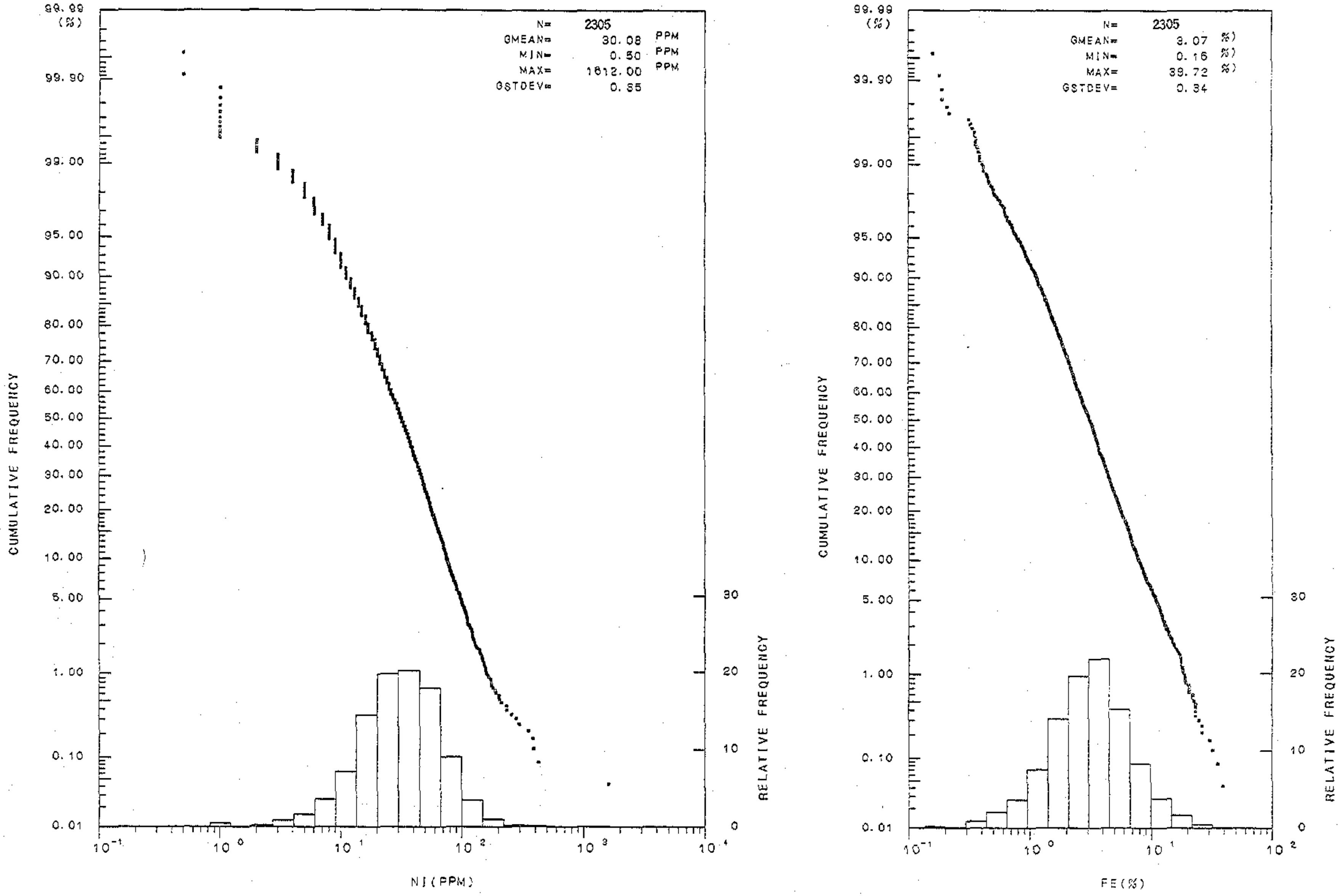


FIG.2-3-1(5) Histogram and Cumulative Frequency Curve(Ni,Fe)

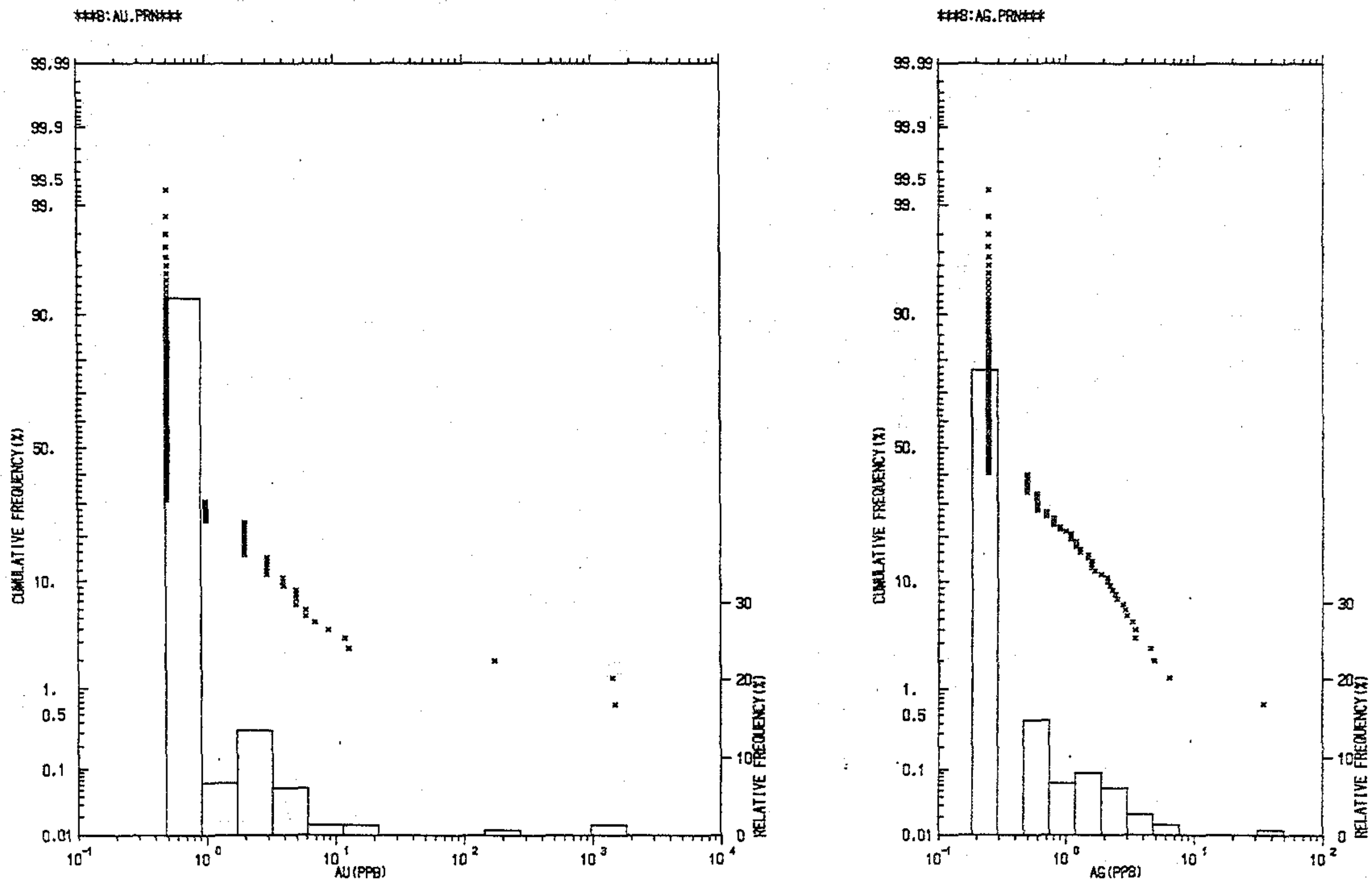


FIG.2-3-2(1) Histogram and Cumulative Frequency Curve (Panned Samples:Au,Ag)

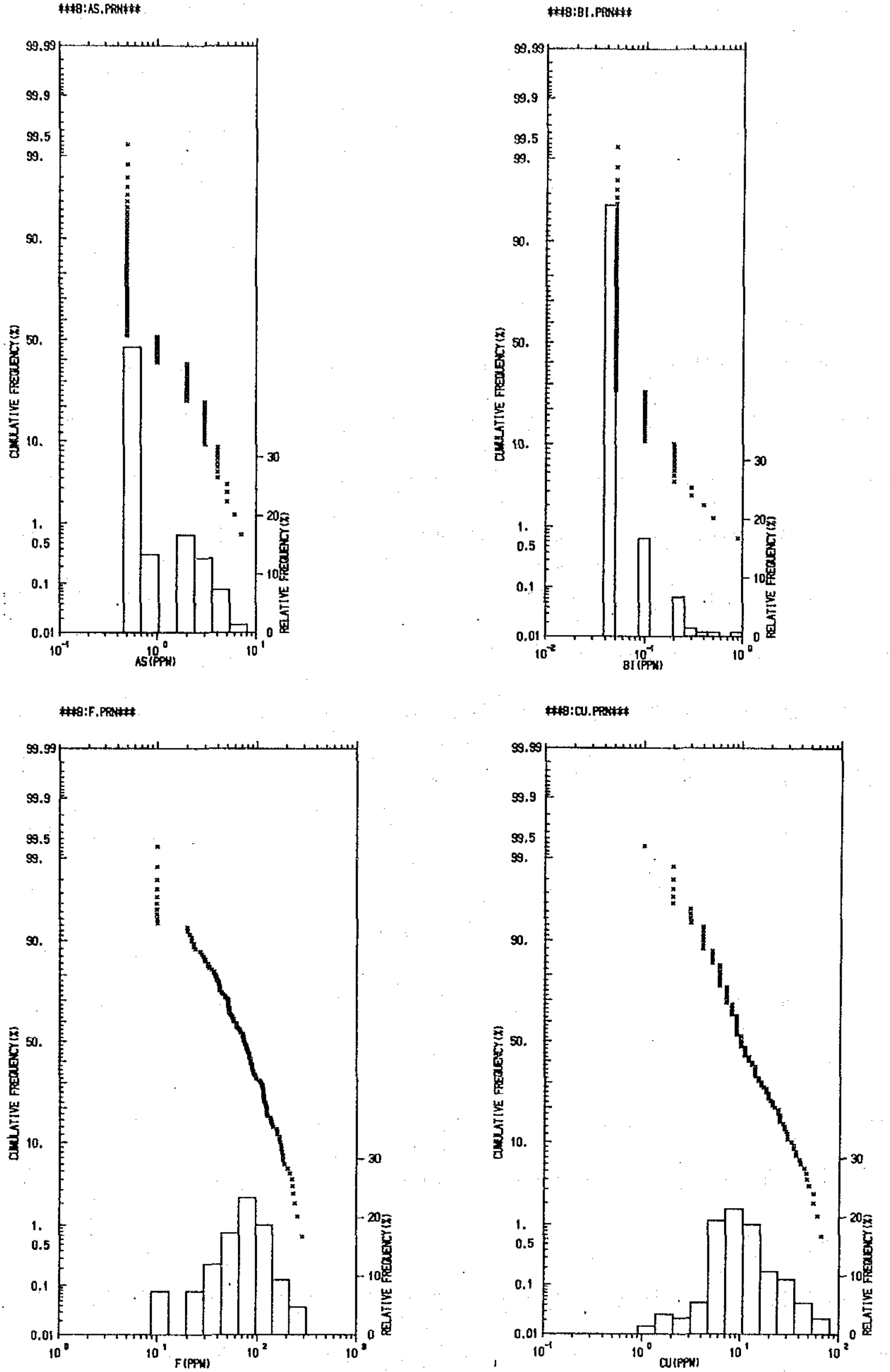


FIG.2-3-2(2) Histogram and Cumulative Frequency Curve (Panned Samples:As,Bi,Cu,F)

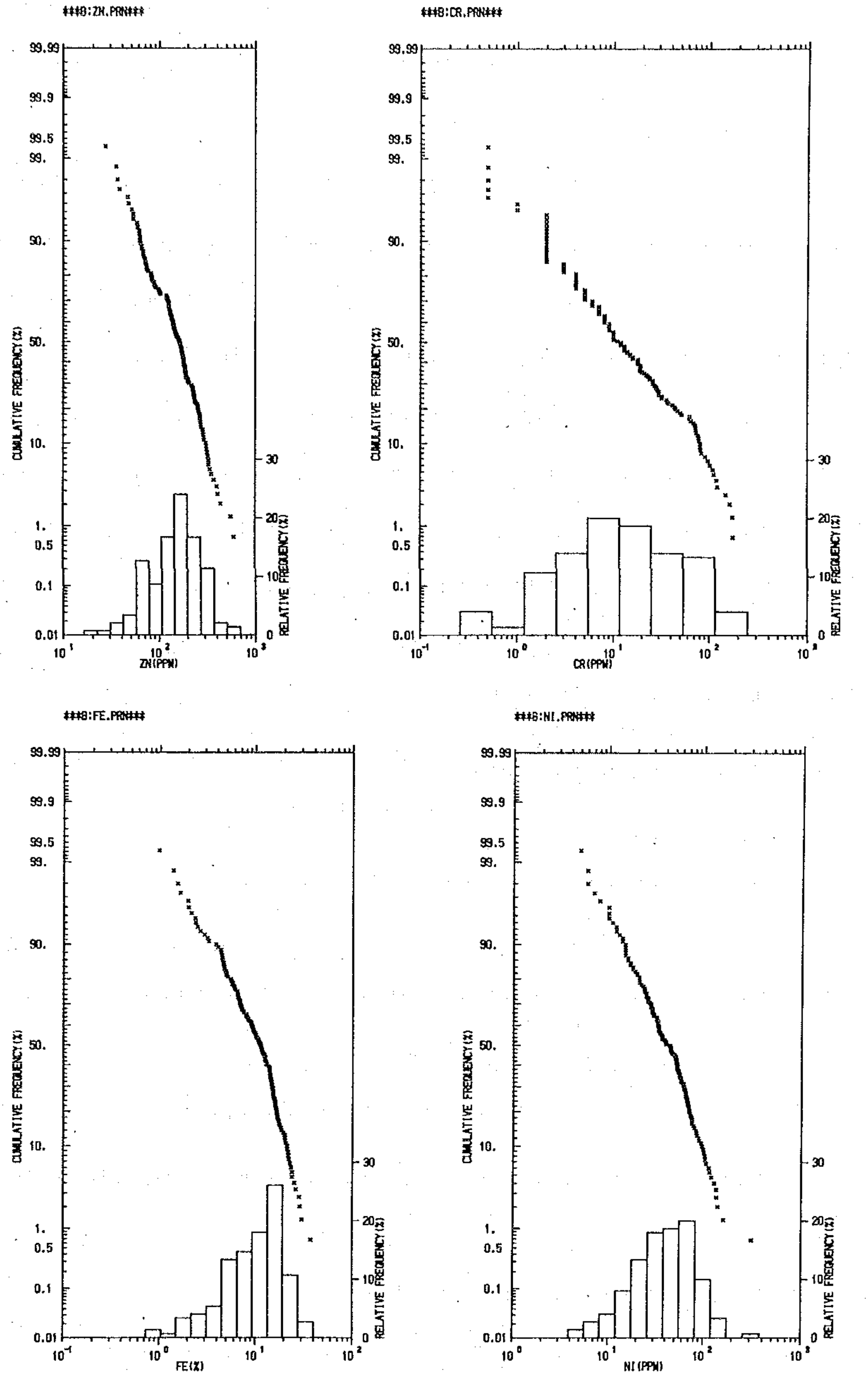


FIG.2-3-2(3) Histogram and Cumulative Frequency Curve (Panned Samples:Zn,Cr,Ni,Fe)

Geochemical values consist of three populations as well as Au, frequency of each population is 56 %, 43.4 % and 0.6 %. The threshold value includes nearly the upper 2 % of the population.

As : As also shows a kind of positive skewness as shown in FIG.2-3-1(2). Geochemical values consist of two populations, frequency of each population is 93.5 %, and 6.5 %. The threshold value includes nearly the upper 2 % of the population.

Bi : Bi also shows a kind of positive skewness as shown in FIG.2-3-1(2). Geochemical values consist of three populations, frequency of each population is 94 %, 5 %, and 1 %. The threshold value includes nearly the upper 2 % of the population.

No other indicators(Cu, F, Cr, Ni, Fe) show positive skewness, but instead show negative skewness(FIG.2-3-1(3)～(5)).

Cumulative frequency curves of panned samples(FIG.2-3-2(1)～(3)) show same configuration as stream sediments for the corresponding indicator.

(2) Determination of Threshold Values

Threshold values were determined on the basis of statistical calculation. Determination of threshold is as follows:

Threshold(1) = GM(m) + geometric standard deviation(2δ)

Threshold(2) = GM(m) + geometric standard deviation(3δ)

Attributions of geochemical indicators are shown in TABLE 2-3-1.
Threshold values are summarized for each geological unit as follows:

Au : The highest value of threshold(1)(hereinafter threshold) was obtained in rock code 5(4.57 ppb). The lowest value is in rock code 4(2.71 ppb).

Ag : The highest value of threshold was obtained in rock code 3(4.09 ppm). The lowest value is in rock code 4(1.96 ppm).

As, Bi, and Zn : No significant difference of threshold were obtained for each indicator.

Cu : The highest value of threshold was obtained in rock code 3(97.2 ppm). Other geological units show nearly the same values.

Cr : The highest value of threshold was obtained in rock code 3(549 ppm). Other geological units show nearly the same values.

Ni : The highest value of threshold was obtained in rock code 3(200 ppm). Other geological units show nearly the same values.

TABLE 2-3-2(1) Matrix of Correlation Coefficients (All Geological Units, Rock Code 1～4)

ALL GEOLOGICAL UNITS

	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe
Au	1.00									
Ag	0.01	1.00								
As	0.07	0.01	1.00							
Bi	0.06	0.01	0.12	1.00						
Cu	0.05	0.36	0.09	0.10	1.00					
F	0.00	-0.05	0.03	0.01	0.24	1.00				
Zn	0.01	-0.01	0.12	0.11	0.36	0.27	1.00			
Cr	0.02	-0.13	0.09	0.02	0.19	0.27	0.15	1.00		
Ni	0.06	0.06	0.15	0.10	0.49	0.42	0.35	0.43	1.00	
Fe	0.03	0.20	0.15	0.10	0.52	0.31	0.68	0.15	0.47	1.00

ROCK CODE 1

	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe
Au	1.00									
Ag	-0.16	1.00								
As	0.42	-0.16	1.00							
Bi	0.15	-0.28	0.56	1.00						
Cu	-0.10	0.18	0.17	0.07	1.00					
F	-0.25	-0.25	0.20	0.27	0.22	1.00				
Zn	0.03	-0.16	0.32	0.49	0.48	0.38	1.00			
Cr	-0.42	0.11	0.01	-0.03	0.14	0.45	0.02	1.00		
Ni	-0.10	-0.23	0.37	0.44	0.40	0.59	0.69	0.48	1.00	
Fe	-0.07	0.06	0.38	0.55	0.52	0.34	0.80	-0.11	0.56	1.00

ROCK CODE 3

	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe
Au	1.00									
Ag	-0.06	1.00								
As	0.16	0.07	1.00							
Bi	0.12	-0.08	0.16	1.00						
Cu	0.18	0.49	0.16	0.02	1.00					
F	0.04	0.01	0.09	0.01	0.33	1.00				
Zn	0.14	-0.04	0.10	0.15	0.32	0.23	1.00			
Cr	0.22	0.05	0.17	0.05	0.34	0.24	0.19	1.00		
Ni	0.27	0.18	0.28	0.14	0.56	0.47	0.32	0.51	1.00	
Fe	0.11	0.29	0.19	0.01	0.44	0.18	0.63	0.11	0.39	1.00

ROCK CODE 4

	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe
Au	1.00									
Ag	0.14	1.00								
As	0.05	0.04	1.00							
Bi	-0.01	0.08	0.18	1.00						
Cu	0.07	0.34	0.08	0.16	1.00					
F	-0.02	-0.08	0.06	0.04	0.26	1.00				
Zn	-0.07	-0.05	0.12	0.17	0.43	0.26	1.00			
Cr	-0.06	-0.17	0.02	0.04	0.21	0.29	0.14	1.00		
Ni	0.00	0.03	0.13	0.13	0.55	0.46	0.39	0.41	1.00	
Fe	-0.01	0.15	0.19	0.18	0.59	0.33	0.69	0.20	0.51	1.00

TABLE 2-3-2(2) Matrix of Correlation Coefficients (Rock Code 5~6, Panned Samples)

ROCK CODE 5

	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe
Au	1.00									
Ag	-0.13	1.00								
As	-0.07	-0.04	1.00							
Bi	-0.05	0.04	-0.03	1.00						
Cu	0.10	0.34	-0.15	0.02	1.00					
F	0.08	-0.16	0.03	0.18	-0.06	1.00				
Zn	0.12	-0.34	0.13	0.08	0.06	0.06	1.00			
Cr	0.08	-0.01	-0.21	-0.05	0.14	0.02	0.40	1.00		
Ni	-0.01	0.26	-0.06	0.07	0.40	0.16	0.56	0.30	1.00	
Fe	-0.02	0.29	-0.23	0.04	0.78	-0.05	0.15	0.14	0.37	1.00

ROCK CODE 6

	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe
Au	1.00									
Ag	-0.03	1.00								
As	0.04	-0.03	1.00							
Bi	0.08	0.01	0.06	1.00						
Cu	0.01	0.34	0.05	0.07	1.00					
F	0.03	-0.04	-0.04	-0.02	0.23	1.00				
Zn	0.01	0.03	0.11	0.07	0.30	0.29	1.00			
Cr	0.04	-0.17	0.09	-0.01	0.13	0.26	0.12	1.00		
Ni	0.04	0.04	0.81	0.06	0.42	0.38	0.31	0.39	1.00	
Fe	0.01	0.20	0.11	0.05	0.47	0.35	0.70	0.13	0.45	1.00

PANNED SAMPLE

	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe
Au	1.00									
Ag	0.13	1.00								
As	0.18	0.04	1.00							
Bi	-0.06	-0.07	0.14	1.00						
Cu	0.16	0.70	0.08	-0.05	1.00					
F	-0.13	0.08	-0.04	-0.28	0.14	1.00				
Zn	0.08	0.41	0.15	0.14	0.56	0.13	1.00			
Cr	-0.05	-0.15	-0.15	-0.06	-0.12	0.36	-0.12	1.00		
Ni	0.06	-0.02	0.13	-0.01	0.11	0.39	0.38	0.38	1.00	
Fe	-0.02	0.37	0.13	0.09	0.59	0.20	0.87	-0.15	0.33	1.00

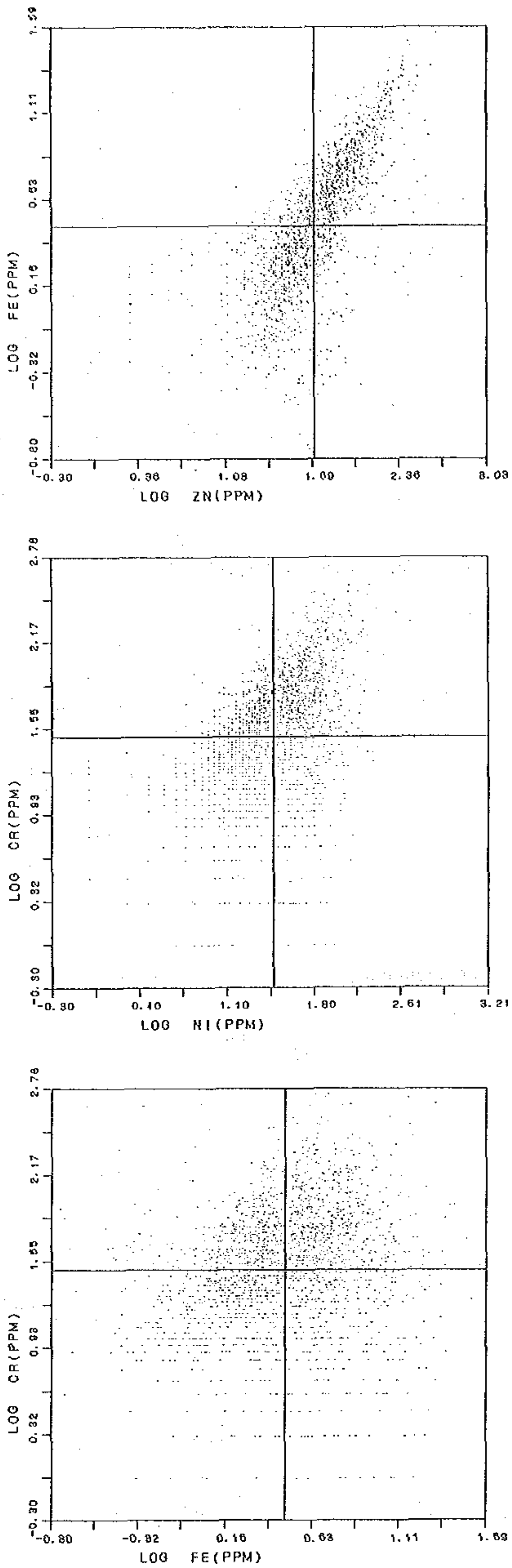


FIG.2-3-3 Scatter Diagram of All Geological Units (Zn-Fe,Ni-Cr,Fe-Cr)

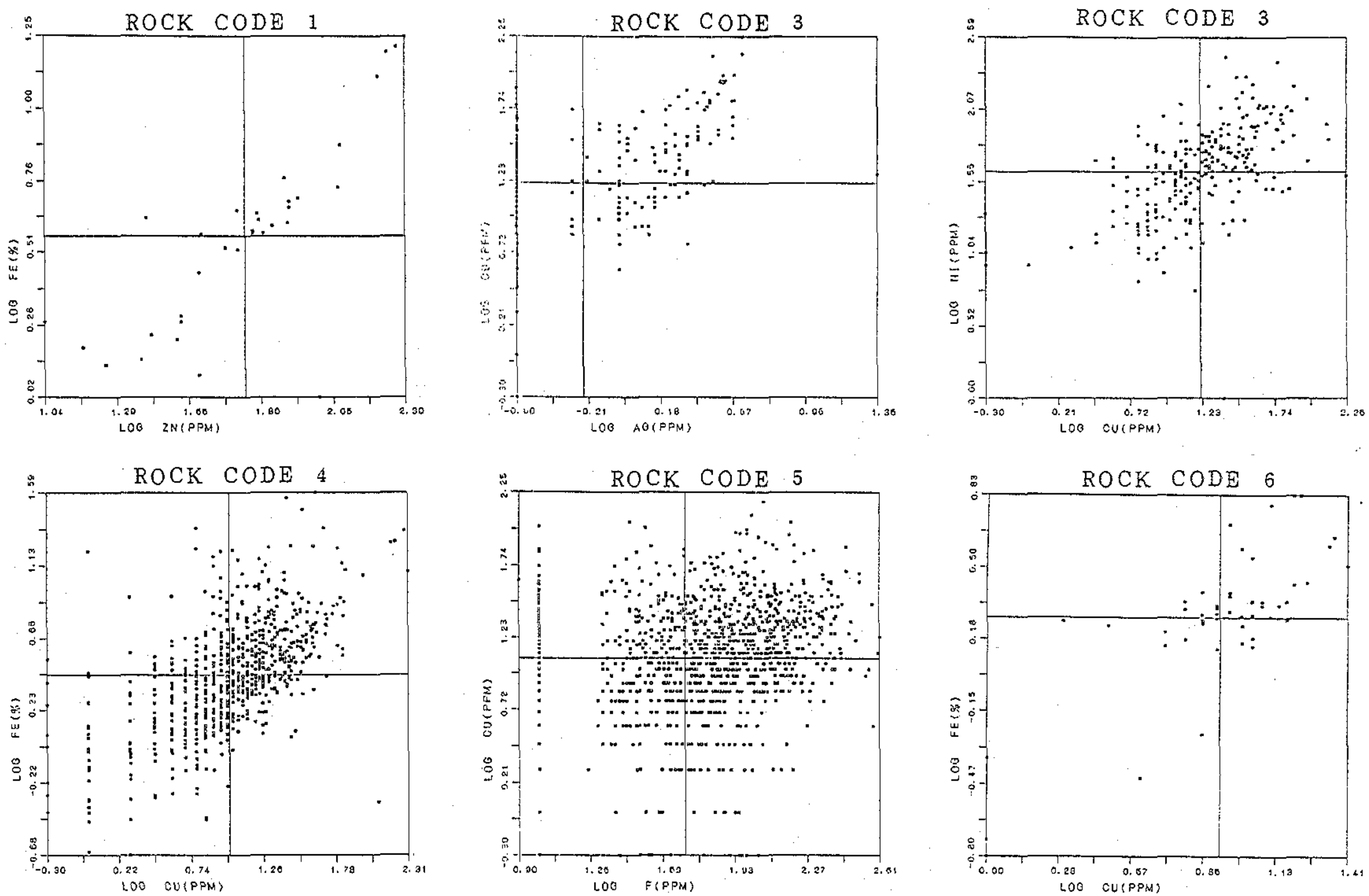


FIG.2-3-4 Scatter Diagram of Each Geological Units (Rock Code 1, 3, 4, 5, 6)

Fe : The highest value of threshold was obtained in rock code 3(17.8 %). Other geological units show nearly the same values.

We can see a general tendency where rock code 3 has more maximum threshold values.

(3) Correlation Coefficient between Indicators

The correlation coefficients between indicators on a logarithmic base were calculated for the all geological units. In the geological units, correlation coefficients between respective indicators were small, suggesting that the origins of individual indicators are different from each other.

TABLE 2-3-2(1)～(2) and FIG.2-3-3～FIG.2-3-4 show the correlation coefficients and scatter diagram on corresponding rock codes. Results of interpretation are summarized below:

All geological units : Cu-Ni, Cu-Fe, F-Ni, Cr-Ni,and Ni-F have correlation in medium degree. Only Zn-Fe has strong correlation.

Rock code 1 : The largest correlation coefficient was obtained in this rock code.

That is, Au-As, As-Bi, Bi-Zn, Bi-Ni, Bi-F, Cu-F, Cu-Ni, Cu-Fe, F-Cr, F-Ni, Zn-Ni, Zn-Fe, Cr-Ni, and Ni-Fe show more than correlation of medium degree. Zn-Ni and Zn-Fe show only strong correlation.

Rock code 3 : Indicators of Ag-Cu, Cu-Ni, Cu-Fe, F-Ni, Zn-Fe, and Ni-Cr show correlation of medium degree.

Rock code 4 : Indicators of Cu-Cr, Cu-Fe, F-Ni, Zn-Fe, Cr-Ni, and Ni-Fe show correlation of medium degree. Only Zn-Fe has strong correlation.

Rock code 5 : Indicators of Cu-Fe, Zn-Fe, Cr-Ni, and Ni-Fe show correlation of medium degree. Only Zn-Fe has strong correlation.

Rock code 6 : Indicators of Cu-Fe, Zn-Cr, and Zn-Ni show correlation of medium degree. Only Cu-Fe has strong correlation.

Panned samples : Indicators of Ag-Cu, Ag-Zn, Cu-Zn, Cu-Fe, and Zn-Fe show correlation of medium degree. Only Zn-Fe has strong correlation.

(4) Principal Component Analysis

After determining the correlation coefficients between indicators, which cannot be extracted by single variable analyses, from multi-dimensional

TABLE 2-3-3 Results of Principal Component Analysis (All Geological Units)

PRINCIPAL COMPONENT	EIGEN-VALUE	CONTRIBUTION RATIO	EIGENVECTOR										FACTOR LOADING										SCORE	
			Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	MAXIMUM	MINIMUM
Z1	2.9107	0.2911 (0.2911)	0.05	0.12	0.15	0.11	0.42	0.32	0.41	0.26	0.45	0.48	0.08	0.20	0.25	0.18	0.72	0.55	0.70	0.44	0.77	0.81	5.531	-6.161
Z2	1.3215	0.1321 (0.4232)	-0.04	-0.68	0.01	-0.10	-0.30	0.33	0.03	0.51	0.18	-0.18	-0.05	-0.78	0.01	90.12	-0.35	0.38	-0.03	0.58	0.21	-0.21	2.808	-4.461
Z3	1.1293	0.1130 (0.5362)	0.50	-0.16	0.57	0.59	-0.11	-0.20	0.01	-0.01	-0.03	-0.05	0.53	-0.17	0.60	0.63	-0.12	-0.21	0.01	-0.01	-0.04	-0.06	10.705	-1.851
Z4	0.9968	0.0996 (0.6358)	-0.61	-0.32	0.11	0.26	-0.20	-0.07	0.45	-0.31	-0.20	0.24	-0.61	-0.32	0.11	0.26	-0.20	-0.07	0.45	0.31	-0.20	0.24	4.938	-6.399
Z5	0.9077	0.0908 (0.7266)	0.60	-0.27	-0.48	-0.10	-0.11	0.09	0.37	-0.31	-0.15	0.21	0.57	-0.26	-0.46	-0.96	-0.11	0.09	0.36	-0.29	-0.14	0.20	5.537	-4.834
Z6	0.8795	0.0880 (0.8146)	-0.12	0.05	-0.60	0.74	0.08	0.12	-0.16	0.09	0.09	-0.14	-0.11	0.05	-0.56	0.69	0.08	0.11	-0.15	0.09	0.09	-0.13	12.627	-7.499

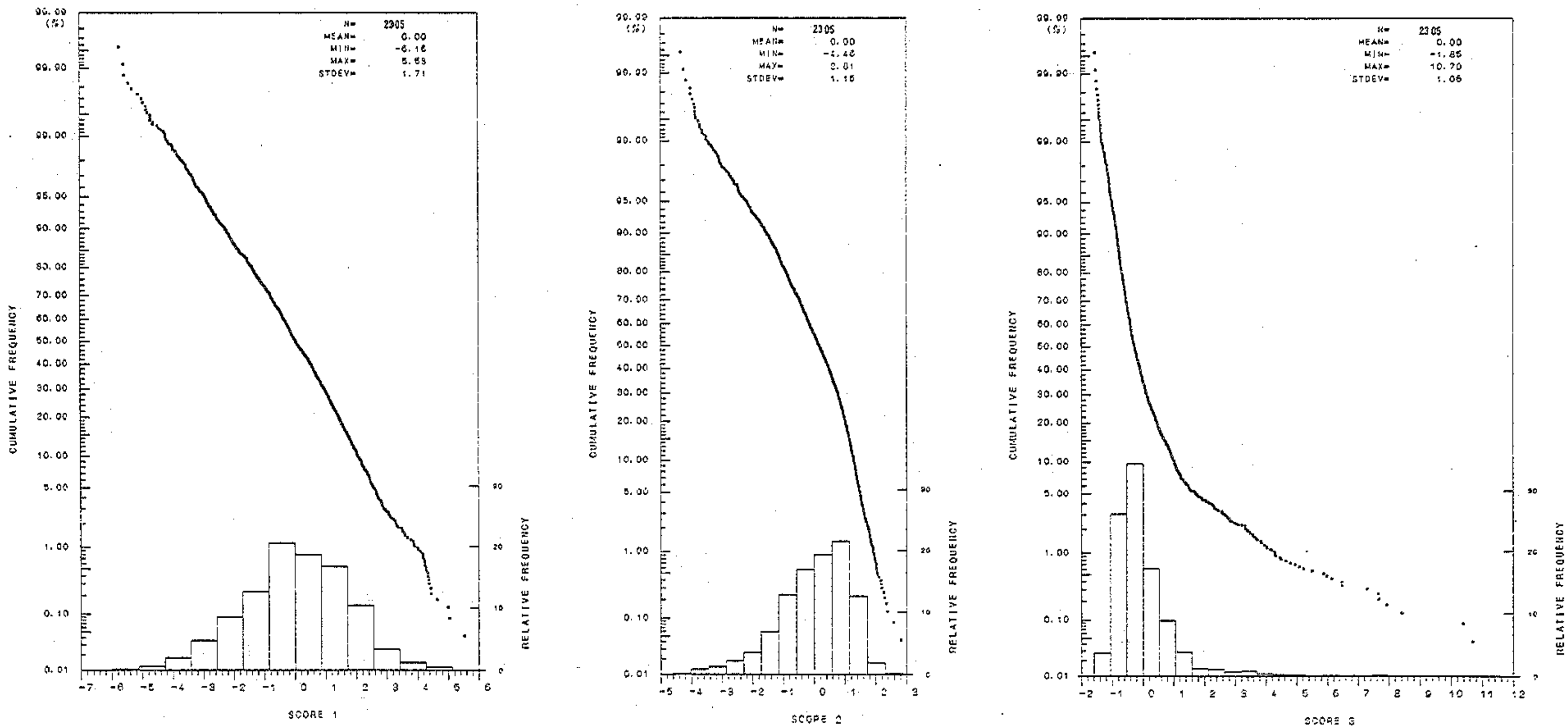


FIG.2-3-5(1) Histogram and Cumulative Frequency Curve (All Geological Units:P.C.1～3)

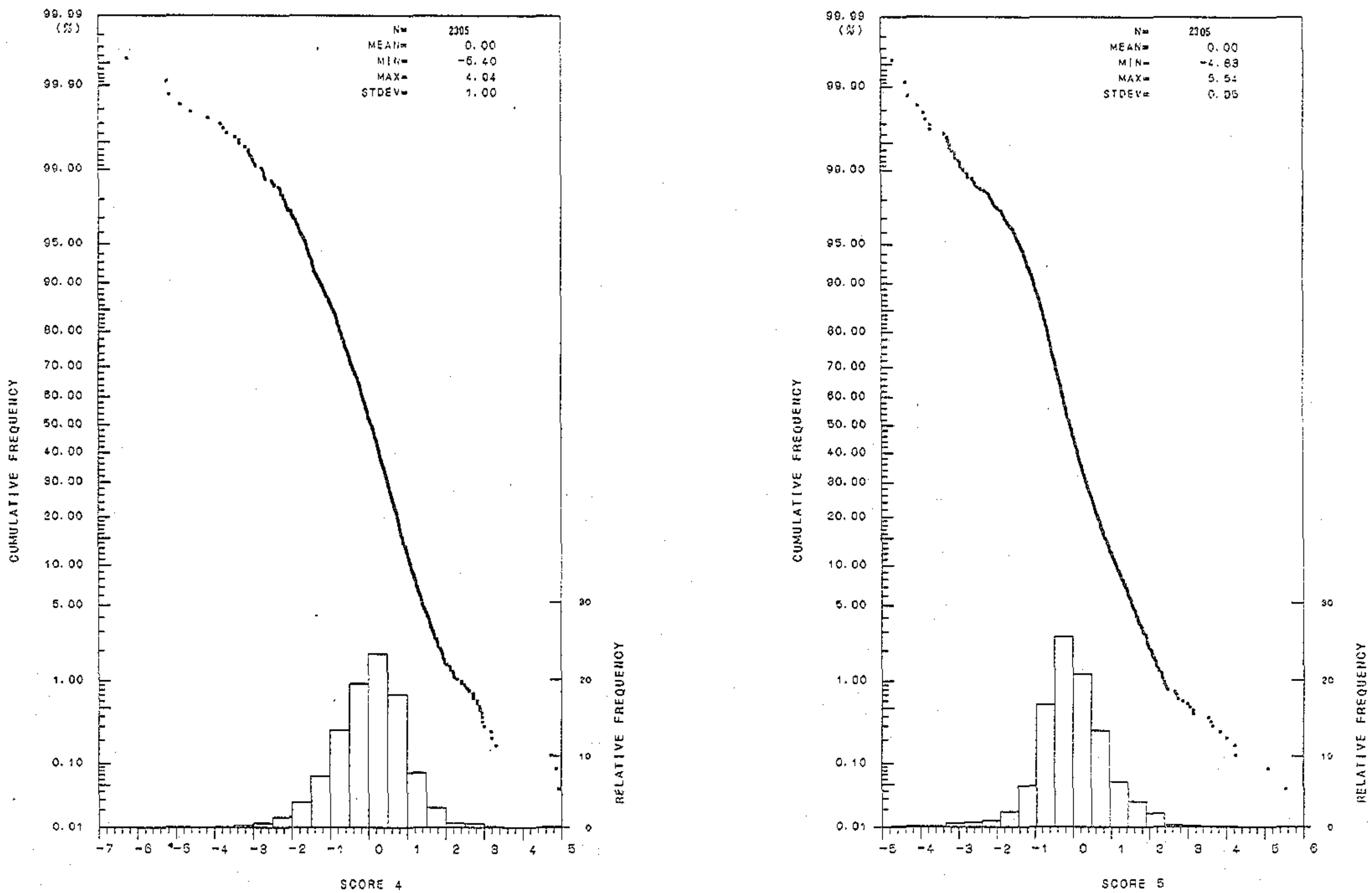


FIG.2-3-5(2) Histogram and Cumulative Frequency Curve (All Geological Units:P.C.4～5) distribution characteristics, these were applied to the determination of character and the evaluation of geochemical anomalies. Results of analysis are shown in TABLE 2-3-3 to TABLE 2-3-5.

General characteristics of each geological unit are summarized below:

All geological units : This indicates general geochemical characteristics in the area. As shown in TABLE 2-3-3, the contribution ratio for the first principal component to all the principal components is about 30%, occupying less than one third of all. The total to the ratio of the fifth principal component amounts to 73 % approximately, so that a greater part of the fluctuation of all the components can be explained by them. However, the contribution ratio of each principal is generally small and not decisive. Each component drops gradually and does not change markedly.

Factor loading is composed of correlation coefficients between principal components and variables (indicator contents). For the first principal component, Cu, Zn, Ni, and Fe show a high value of 0.70-0.81. Therefore, the first principal component is characterized by high correlation with these indicators.

The second principal component is characterized by strong negative correlation (-0.78) with Ag and correlation (0.58) with Cr.

The third principal component has the medium correlation with Au, As, and Bi.

The fourth principal component has a medium negative correlation with Au and medium correlation with Zn. However, geochemical characteristics are not so clear.

The fifth principal component has a medium correlation with Au, and negative correlation with As.

Rock code 1 : This code has a small number of samples(33 samples), therefore we cannot decide the representative geochemical character of the rock code.

As shown in TABLE 2-3-4(1), the contribution ratio for the first principal component to all the principal components is about 37%, occupying more than one third of all. The total to the ratio of the fifth principal component amounts to 85 % approximately, so that a greater part of the fluctuation of all the components can be explained by them. However, the contribution ratio of each principal is general small and not decisive. Each component drops gradually and does not change markedly, as is the case for other rock codes.

For the first principal component, As, Bi, Cu, F, Zn, Ni, and Fe show a medium to high value of 0.54-0.85. Therefore, the first principal component is characterized

TABLE 2-3-4(1) Results of Principal Component Analysis (Rock Code 1)

PRINCIPAL COMPONENT	EIGEN-VALUE	CONTRIBUTION RATIO	EIGENVECTOR										FACTOR LOADING										SCORE	
			Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	MAXIMUM	MINIMUM
Z1	3.7042	0.3704 (0.3704)	-0.01	-0.13	0.29	0.35	0.28	0.33	0.44	0.14	0.45	0.42	-0.03	-0.24	0.56	0.67	0.54	0.63	0.85	0.27	0.86	0.81	6.047	-2.994
Z2	1.9127	0.1913 (0.5617)	-0.59	0.09	-0.36	-0.28	0.12	0.31	-0.07	0.53	0.17	-0.10	-0.81	0.13	-0.50	-0.39	0.17	0.42	-0.10	0.73	0.24	-0.14	3.874	-1.828
Z3	1.4670	0.1467 (0.7084)	0.13	-0.63	0.16	0.18	-0.46	0.24	-0.18	0.30	0.11	-0.35	0.16	-0.76	0.20	0.22	-0.56	0.29	-0.22	0.37	0.13	-0.42	3.638	-2.270
Z4	0.8174	0.0862 (0.7901)	-0.38	-0.33	-0.51	0.22	-0.34	0.03	0.25	-0.42	-0.11	0.26	-0.35	-0.30	-0.46	0.20	-0.31	0.03	0.22	-0.38	-0.10	0.23	2.327	-2.819
Z5	0.6900	0.0681 (0.8591)	-0.35	0.52	0.30	0.49	-0.44	0.02	-0.25	0.10	-0.08	0.11	-0.29	0.43	0.25	0.40	-0.36	0.02	-0.20	0.08	-0.07	0.09	1.214	-1.504
Z6	0.4682	0.0469 (0.9060)	0.19	0.20	0.05	-0.28	-0.14	0.82	-0.07	-0.34	-0.15	0.06	0.13	0.14	0.04	-0.19	-0.10	0.56	-0.05	-0.23	-0.10	0.04	1.329	-1.178

by high correlation with these indicators.

The second principal component is characterized by a medium negative correlation (-0.50 - -0.81) with Au and As and strong correlation (0.73) with Cr, and medium correlation with F.

The third principal component has a medium to strong negative correlation(-0.42 - -0.72) with Au, Cu, and Fe.

The fourth principal component has a medium negative correlation with Au and medium correlation with Zn. However, geochemical characteristics are not so clear.

The fifth principal component has a medium correlation with Au, and negative correlation with As.

Rock code 3 : As shown in TABLE 2-3-4(2), the contribution ratio for the first principal component to all the principal components is about 31%, occupying less than one third of all. The total to the ratio of the fifth principal component amounts to 75 % approximately, so that a greater part of the fluctuation of all the components can be explained by them. However, the contribution ratio of each principal is general small and not decisive. Each component drops gradually and does not change markedly, as is the case with other indicators.

For the first principal component, Cu, F, Zn, Ni, and Fe show a medium to high value of 0.52-0.82. Therefore, the first principal component is characterized by high correlation with these indicators.

The second principal component is characterized by a high negative correlation (-0.73) with Ag and medium correlation (0.45-0.53) with Au, and Bi.

The third principal component has medium correlation(0.42-0.64) with Zn, Ni, and Fe.

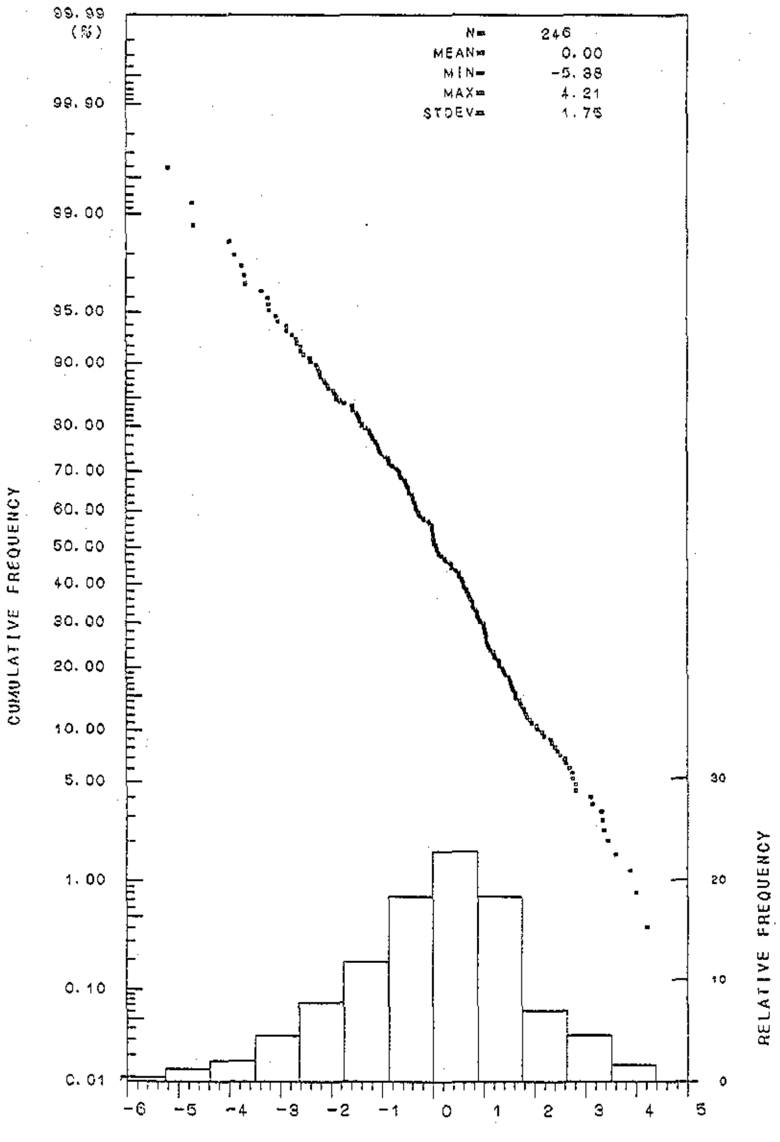
The fourth principal component dose not show any significant geochemical characteristics.

The fifth principal component is characterized by a strong negative correlation with Au.

Rock code 4 : As shown in TABLE 2-3-4(3), the contribution ratio for the first principal component to all the principal components is about 31%, occupying less than one third of all. The total to the ratio of the fifth principal component amounts to 75 % approximately, so that a greater part of the fluctuation of all the components can be explained by them. However, the contribution ratio of each principal is general small and not decisive. Each component drops gradually and

TABLE 2-3-4(2) Results of Principal Component Analysis (Rock Code 3)

PRINCIPAL COMPONENT	EIGEN-VALUE	CONTRIBUTION RATIO	EIGENVECTOR										FACTOR LOADING										SCORE	
			Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	MAXIMUM	MINIMUM
Z1	3.0826	0.3083 (0.3083)	0.20	0.20	0.21	0.09	0.44	0.30	0.35	0.32	0.47	0.39	0.34	0.35	0.37	0.16	0.77	0.52	0.61	0.56	0.82	0.68	4.214	-5.382
Z2	1.3564	0.1356 (0.4439)	0.38	-0.63	0.21	0.46	-0.29	0.07	0.09	0.22	0.11	-0.22	0.45	-0.73	0.25	0.53	-0.33	0.08	0.11	0.26	0.12	-0.26	4.794	-3.116
Z3	1.1573	0.1157 (0.5596)	-0.09	-0.16	-0.03	0.21	-0.14	-0.21	0.60	-0.44	-0.23	0.51	-0.10	-0.17	-0.03	0.23	-0.15	-0.23	0.64	-0.47	-0.24	0.55	3.472	-2.901
Z4	1.0500	0.1050 (0.6646)	0.21	-0.41	0.53	0.40	0.09	-0.52	-0.25	-0.11	-0.07	-0.00	0.21	0.42	0.54	0.41	0.09	-0.53	-0.25	-0.11	-0.08	-0.00	4.035	-6.399
Z5	0.9008	0.0901 (0.7547)	-0.73	0.01	0.33	0.40	-0.04	0.40	-0.08	-0.12	0.08	-0.10	-0.69	0.01	0.31	0.38	-0.04	0.38	-0.07	-0.11	0.07	-0.09	3.048	-5.273
Z6	0.8068	0.0807 (0.8354)	-0.06	-0.22	0.70	-0.63	-0.20	-0.01	0.02	0.01	-0.03	0.14	-0.05	-0.19	0.63	-0.57	-0.18	0.01	0.02	0.01	-0.02	0.13	3.306	-4.530



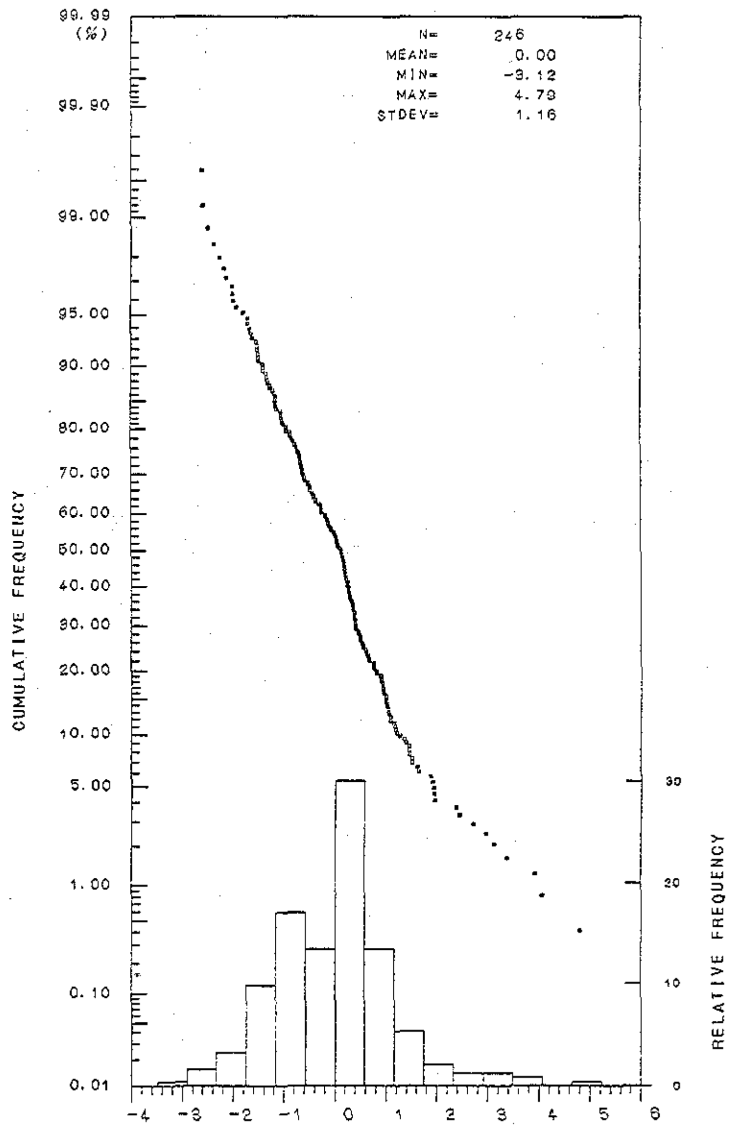


FIG.2-3-6(1) Histogram and Cumulative Frequency Curve (Rock Code 3:P.C.1～2)

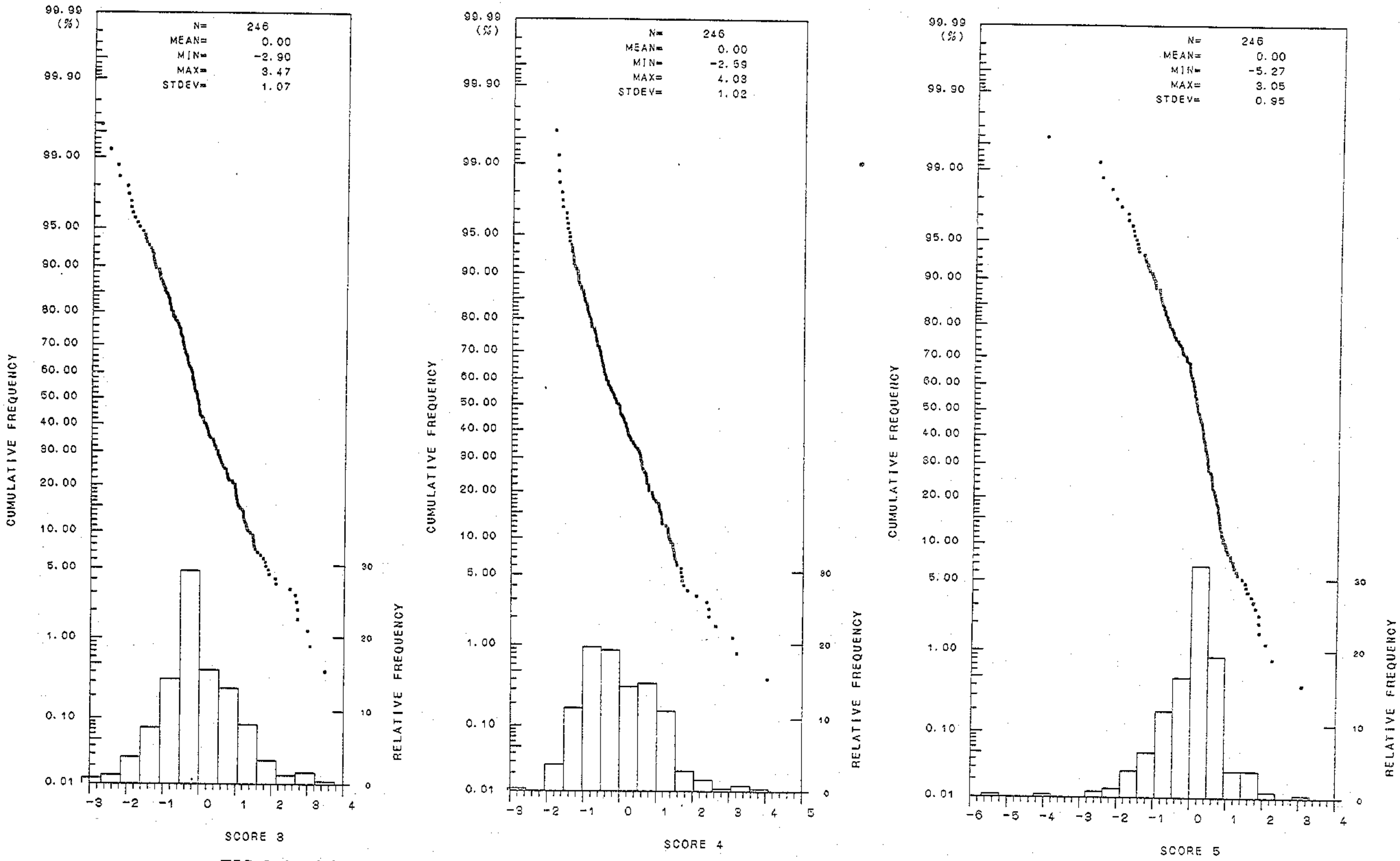


FIG.2-3-6(2) Histogram and Cumulative Frequency Curve (Rock Code 3:P.C.3~5)

TABLE 2-3-4(3) Results of Principal Component Analysis (Rock Code 4)

PRINCIPAL	EIGEN-	CONTRIBUTION	EIGENVECTOR										FACTOR LOADING										SCORE	
COMPONENT	VALUE	RATIO	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	MAXIMUM	MINIMUM
Z1	3.0790	0.3079 (0.3079)	-0.00	0.08	0.14	0.16	0.43	0.32	0.41	0.25	0.45	0.48	-0.01	0.14	0.24	0.29	0.76	0.56	0.72	0.43	0.79	0.84	5.857	-5.998
Z2	1.4165	0.1417 (0.4496)	-0.34	-0.65	-0.18	-0.20	-0.26	0.30	0.02	0.45	0.14	-0.11	-0.41	-0.77	-0.21	-0.24	-0.31	0.36	0.02	0.53	0.16	-0.14	2.085	-7.457
Z3	1.0990	0.1099 (0.5595)	0.36	0.28	-0.55	-0.56	0.23	0.16	-0.21	0.16	0.16	-0.07	0.38	0.29	-0.58	-0.58	0.24	0.17	-0.22	0.17	0.17	-0.07	8.973	-3.219
Z4	1.0061	0.1006 (0.6601)	0.64	-0.12	0.50	0.15	-0.12	0.21	-0.32	0.30	0.14	-0.21	0.64	-0.12	0.50	0.15	-0.12	0.21	-0.32	0.30	0.14	-0.21	7.366	-3.333
Z5	0.8688	0.0869 (0.7470)	0.32	-0.32	0.25	-0.57	-0.12	0.04	0.40	-0.39	-0.13	0.24	0.30	-0.30	0.24	-0.53	-0.11	0.04	0.38	-0.36	-0.12	0.22	4.726	-4.094
Z6	0.7901	0.0790 (0.8260)	0.48	-0.35	-0.56	0.49	-0.05	-0.10	0.27	-0.06	-0.09	0.05	0.42	-0.31	-0.50	0.44	-0.04	-0.09	0.24	-0.06	-0.08	0.05	5.697	-6.148

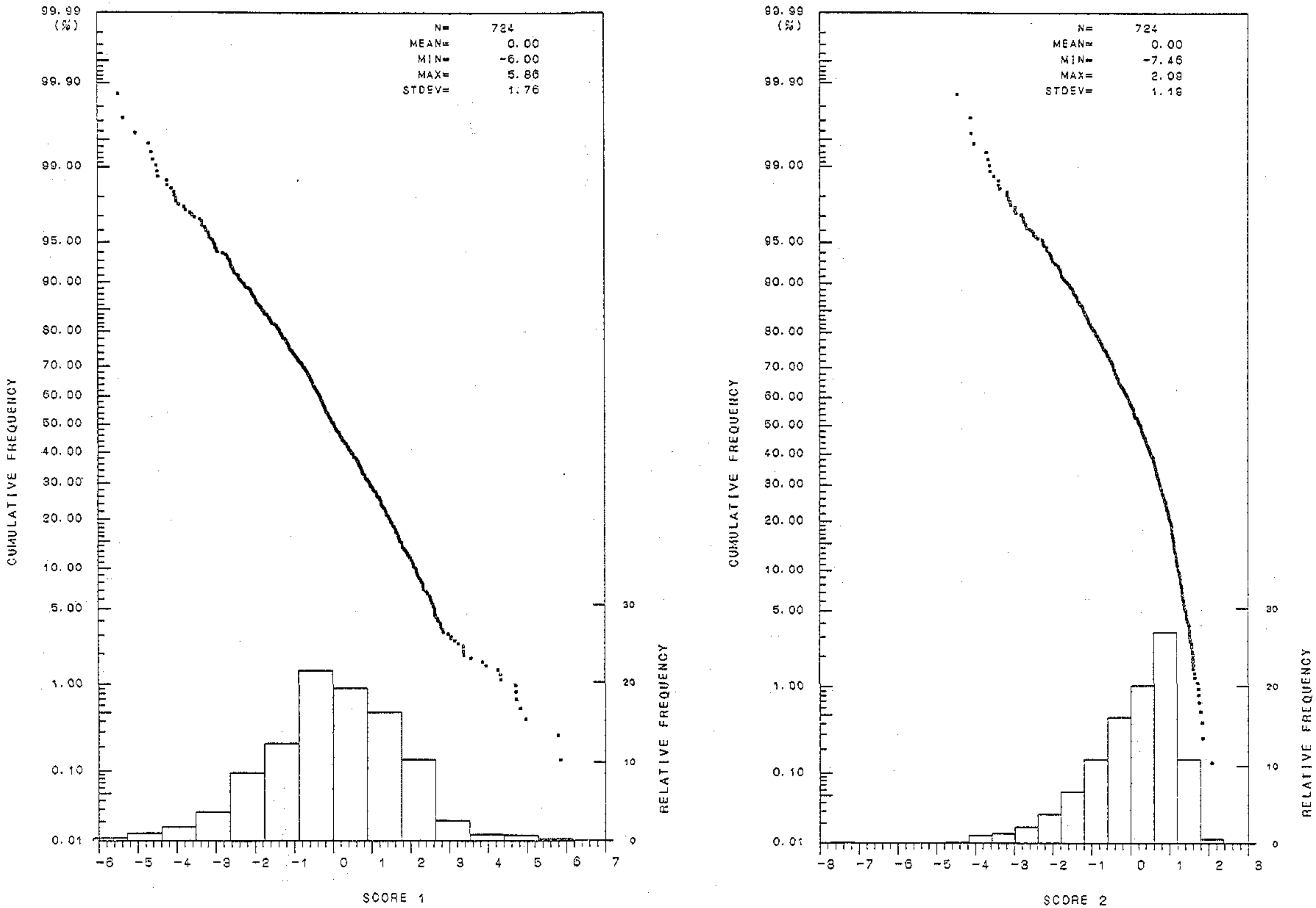


FIG.2-3-7(1) Histogram and Cumulative Frequency Curve (Rock Code 4:P.C.1～2)

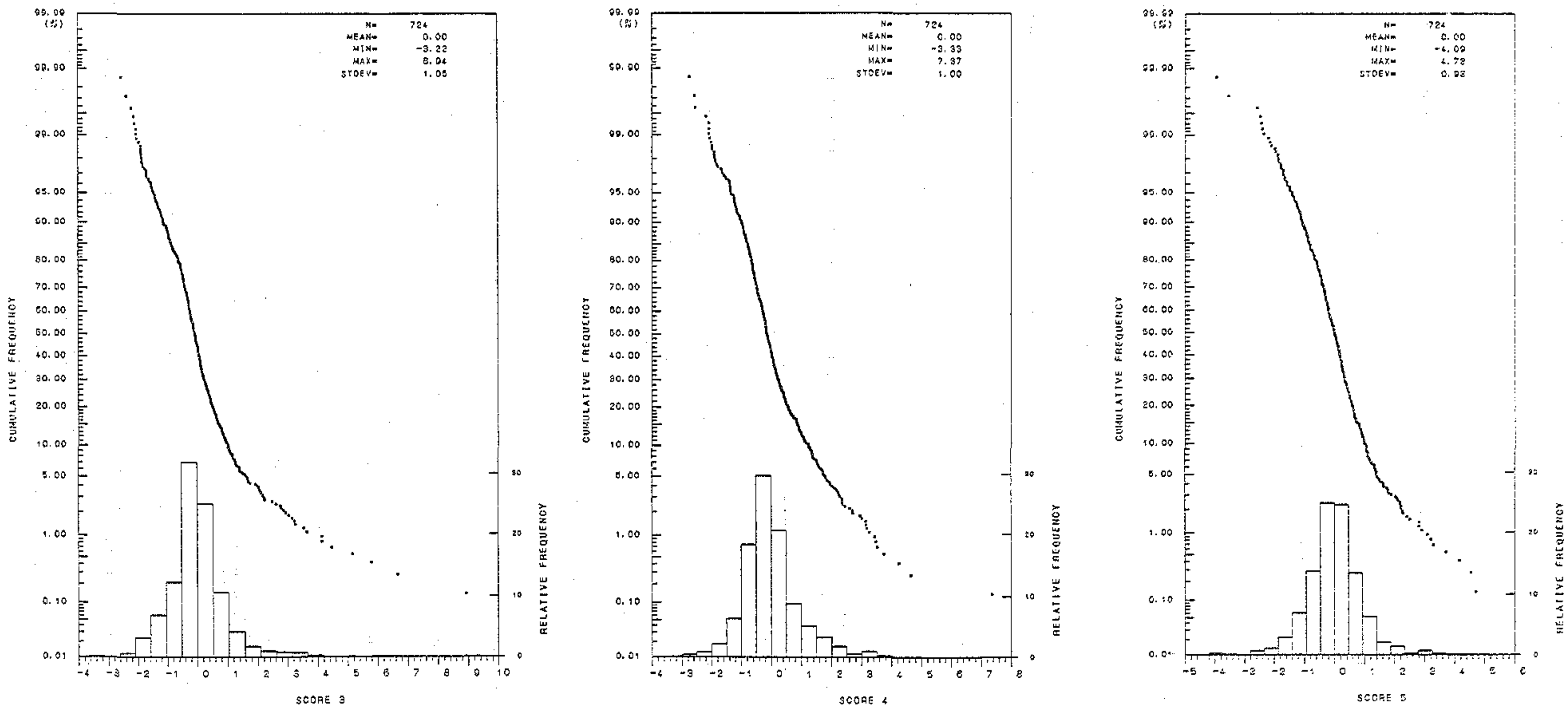


FIG.2-3-7(2) Histogram and Cumulative Frequency Curve (Rock Code 4:P.C.3~5)

does not change markedly, as is the case with other indicators.
For the first principal component, Cu, F, Zn, Cr, Ni, and Fe show a medium to high value 0.52-0.82. Therefore, the first principal component is characterized by high correlation with these indicators.
The second principal component is characterized by a medium negative correlation (-0.41) with Ag and strong negative correlation (-0.77) with Ag, and medium correlation(0.53) with Cr.
The third principal component has a medium negative correlation(-0.58) with As and Bi.
The fourth principal component is characterized by a medium correlation (0.50 - 0.64) with Au and Ag.
The fifth principal component dose not show any significant geochemical characteristics.

Rock code 5 : As shown in TABLE 2-3-4(4), the contribution ratio for the first principal component to all the principal components is about 28%, occupying less than one third of all. The total to the ratio of the fifth principal component amounts to 72 % approximately, so that a greater part of the fluctuation of all the components can be explained by them. However, the contribution ratio of each principal is generally small and not decisive. Each component drops gradually and does not change markedly, as is the case with other indicators.
For the first principal component, Cu, F, Zn, Cr, Ni, and Fe show a medium to high value(0.58-0.83). Therefore, the first principal component is characterized by a high correlation with these indicators.
The second principal component is characterized by a strong negative correlation (-0.78) with Ag and the medium correlation (0.64) with Cr.
The third principal component has a medium correlation(0.53-0.65) with Au,As, and Bi.
The fourth principal component is characterized by the medium negative correlation (0.57) with Au and medium correlation(0.58) with Ag. Contribution is about 10 %.
The fifth principal component dose not show any significant geochemical characteristics.

Rock code 6 : As shown in TABLE 2-3-4(5), the contribution ratio for the first principal component to all the principal components is about 25%, occupying one fourth of all. The total to the ratio of the fifth principal component amounts to

TABLE 2-3-4(4) Results of Principal Component Analysis (Rock Code 5)

PRINCIPAL COMPONENT	EIGEN-VALUE	CONTRIBUTION RATIO	EIGENVECTOR										FACTOR LOADING										SCORE	
			Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	Au	Ag		Bi	Cu	F	Zn	Cr	Ni	Fe	MAXIMUM	MINIMUM
Z1	2.7577	0.2758 (0.2758)	0.03	0.12	0.09	0.06	0.40	0.35	0.43	0.24	0.44	0.50	0.06	0.20	0.16	0.10	0.67	0.58	0.72	0.40	0.73	0.83	4.468	-5.640
Z2	1.3660	0.1366 (0.4124)	0.12	-0.66	0.10	-0.07	-0.31	0.26	-0.06	0.54	0.19	-0.17	0.14	-0.78	0.12	-0.09	-0.36	0.30	-0.06	0.64	0.23	-0.19	2.715	-4.147
Z3	1.1278	0.1128 (0.5252)	0.50	-0.06	0.55	0.61	-0.04	-0.25	0.08	-0.08	-0.05	0.02	0.53	-0.07	0.58	0.65	-0.04	-0.27	0.09	-0.08	-0.06	0.02	9.977	-1.361
Z4	0.9949	0.0994 (0.6246)	-0.57	-0.20	0.58	-0.23	-0.18	-0.16	0.33	-0.13	-0.17	0.19	-0.57	-0.20	0.58	-0.23	-0.18	-0.16	0.33	-0.13	-0.17	0.19	6.339	-5.337
Z5	0.9304	0.0931 (0.7177)	0.16	-0.34	-0.44	0.16	-0.30	0.21	0.46	-0.40	-0.26	0.25	0.15	-0.33	-0.43	0.15	-0.29	0.20	0.45	-0.39	-0.25	0.24	3.302	-5.569
Z6	0.9084	0.0908 (0.8085)	-0.62	-0.09	-0.21	0.73	0.03	0.01	-0.09	0.11	0.10	-0.09	-0.59	-0.08	-0.20	0.69	0.03	0.01	-0.08	0.11	0.09	-0.08	11.942	-5.241

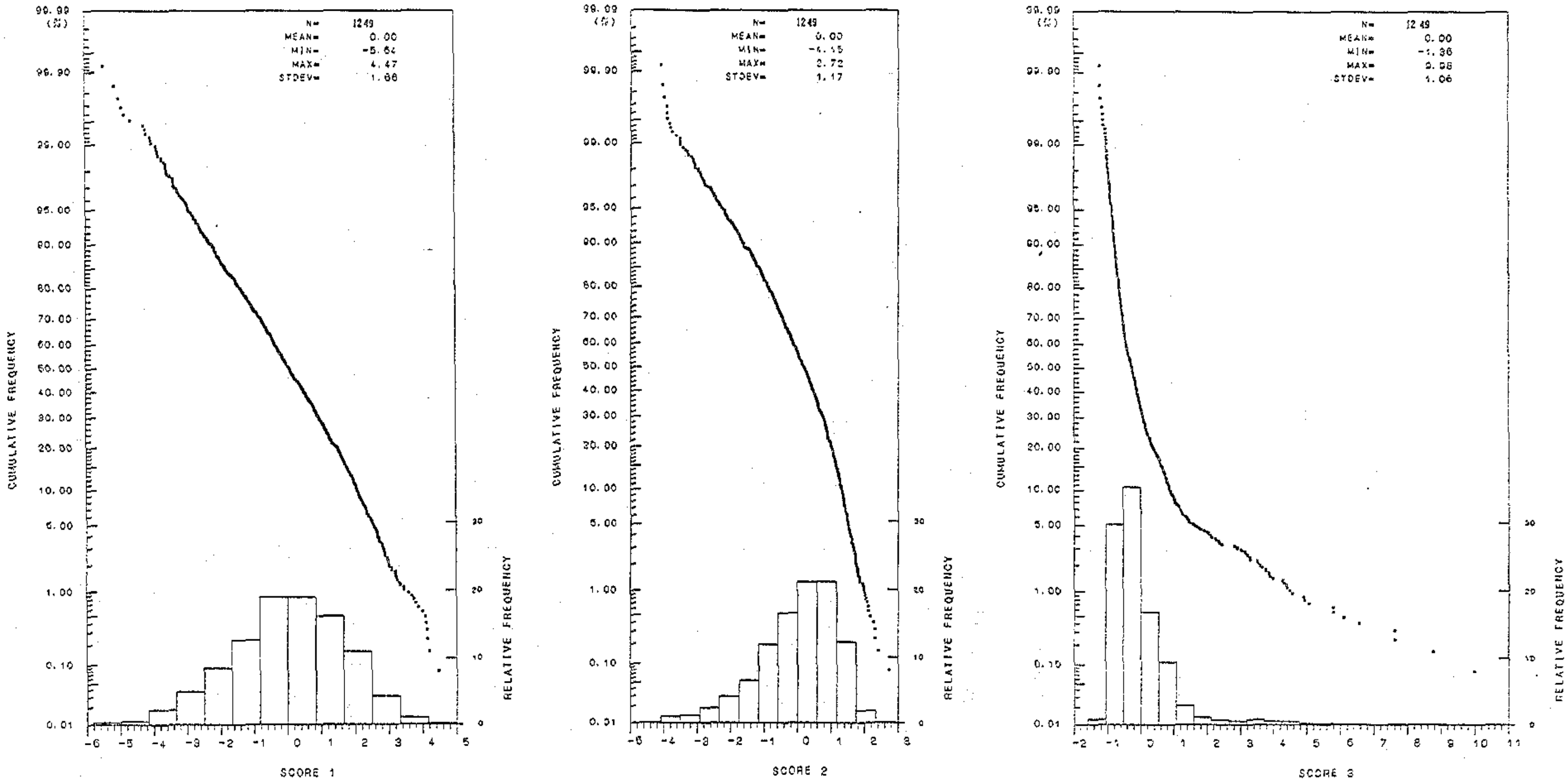


FIG.2-3-8(1) Histogram and Cumulative Frequency Curve(Rock Code 5:P.C.1～3)

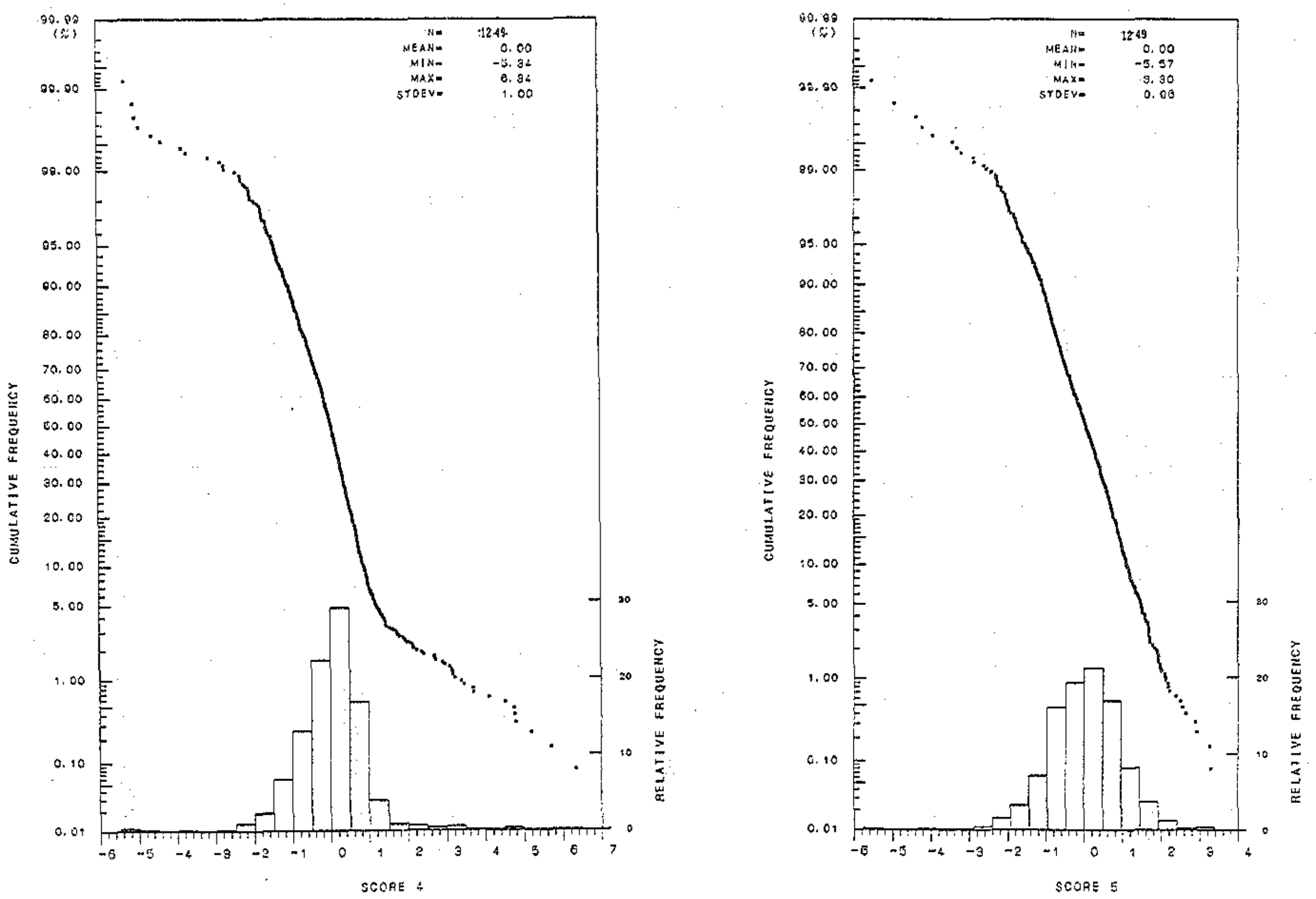


FIG.2-3-8(2) Histogram and Cumulative Frequency Curve (Rock Code 5:P.C.4~5)

TABLE 2-3-4(5) Results of Principal Component Analysis (Rock Code 6)

PRINCIPAL COMPONENT	EIGEN-VALUE	CONTRIBUTION RATIO	EIGENVECTOR										FACTOR LOADING										SCORE	
			Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	MAXIMUM	MINIMUM
Z1	2.4900	0.2490 (0.2490)	0.05	0.24	-0.18	0.06	0.51	0.01	0.27	0.29	0.48	0.51	0.08	0.37	-0.28	0.09	0.81	0.02	0.42	0.45	0.75	0.81	2.892	-5.617
Z2	1.7401	0.1740 (0.4230)	-0.20	0.49	-0.13	-0.07	0.24	-0.29	-0.59	-0.32	-0.22	0.22	-0.26	0.65	-0.17	-0.09	0.32	-0.38	-0.78	-0.43	-0.30	0.29	2.692	-3.252
Z3	1.2051	0.1205 (0.5435)	-0.35	0.18	0.32	0.63	-0.02	0.46	-0.01	-0.32	0.19	0.00	-0.38	0.19	0.35	0.69	-0.02	0.51	-0.01	-0.35	0.21	0.00	5.186	-1.885
Z4	1.1109	0.1111 (0.6546)	-0.46	0.15	0.59	-0.33	-0.06	-0.44	0.27	0.02	0.21	-0.05	-0.48	0.15	0.62	-0.35	-0.06	-0.46	0.28	0.02	0.22	-0.06	3.447	-2.832
Z5	0.9720	0.0972 (0.7518)	-0.61	0.05	-0.52	0.20	-0.29	-0.12	-0.02	0.44	0.03	-0.14	-0.61	0.052	-0.51	0.20	-0.28	0.12	-0.02	0.43	0.03	-0.21	3.363	-1.701
Z6	0.8064	0.0807 (0.8325)	0.07	-0.31	-0.01	0.58	0.10	-0.62	0.24	-0.17	-0.23	0.17	0.06	-0.28	-0.01	0.52	0.09	-0.56	0.21	-0.15	-0.21	0.15	1.444	-3.180

75 % approximately, so that a greater part of the fluctuation of all the components can be explained by them. However, the contribution ratio of each principal is generally small and not decisive. Each component drops gradually and does not change markedly, as is the case with other indicators.

For the first principal component, Cu, Ni, and Fe show a high value(0.75-0.81), and a medium correlation(0.42-0.45) with Zn and Cr.

The second principal component is characterized by a medium correlation (0.65) with Ag, a strong negative correlation (-0.78) with Zn and a medium negative correlation(-0.43) with Cr.

The third principal component has a medium correlation(0.51-0.69) with Bi, and F. But we can not understand any significant geochemical characteristics for the component.

The fourth principal component is characterized by a medium negative correlation (-0.46 - -0.48) with Au and F. On the other hand, As shows a medium correlation(0.62).

The fifth principal component dose not show any significant geochemical characteristics.

Histogram and cumulative frequency curve of the principal component score are shown in FIG.2-3-5(1)～FIG.2-3-8(2).

Panned samples : As shown in TABLE 2-3-5, the contribution ratio for the first principal component to all the principal components is about 29%, occupying less than one third of all. The total to the ratio of the fifth principal component amounts to 81 % approximately, so that a greater part of the fluctuation of all the components can be explained by them. However, the contribution ratio of each principal is generally small and not decisive. Each component drops gradually and does not change markedly, as is the case with other indicators.

For the first principal component, Ag and Ni show a medium value(0.40-0.65) and a strong correlation(0.82-0.89) with Cu, Zn, and Fe.

Therefore, the first principal component is characterized by a high correlation with these indicators.

The second principal component is characterized by a strong correlation (0.75-0.77) with F and Cr, and medium correlation (0.66) with Ni.

The third principal component has a medium correlation(0.55-0.71) with As, and Bi.

The fourth principal component is characterized by a medium correlation (0.46)

TABLE 2-3-5 Results of Principal Component Analysis (Panned Samples)

PRINCIPAL COMPONENT	EIGEN-VALUE	CONTRIBUTION RATIO	EIGENVECTOR										FACTOR LOADING										SCORE	
			Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	MAXIMUM	MINIMUM
Z1	2.954	0.295	0.09	0.38	0.13	0.02	0.48	0.13	0.52	-0.07	0.24	0.51	0.16	0.65	0.22	0.04	0.82	0.22	0.89	-0.12	0.40	0.88	4.622	-5.021
Z2	1.853	0.185	-0.15	-0.23	-0.12	-0.21	-0.10	0.57	0.01	0.55	0.49	0.03	-0.20	-0.32	-0.17	-0.29	-0.14	0.77	0.01	0.75	0.66	0.04	3.009	-3.777
Z3	1.278	0.128	0.02	-0.37	0.49	0.63	-0.28	-0.14	0.17	0.01	0.30	0.11	0.02	-0.42	0.55	0.71	-0.32	-0.16	0.19	0.02	0.34	0.13	3.409	-2.055
Z4	1.136	0.114	0.78	0.06	0.43	-0.30	0.05	0.01	-0.15	0.10	0.15	-0.23	0.83	0.06	0.46	-0.32	0.05	0.01	-0.16	0.11	0.16	-0.24	5.314	-2.614
Z5	0.861	0.086	0.31	0.24	-0.50	0.46	0.11	-0.31	-0.00	0.50	0.11	-0.13	0.29	0.22	-0.46	0.43	0.10	-0.29	-0.00	0.47	0.10	-0.12	2.257	-2.290

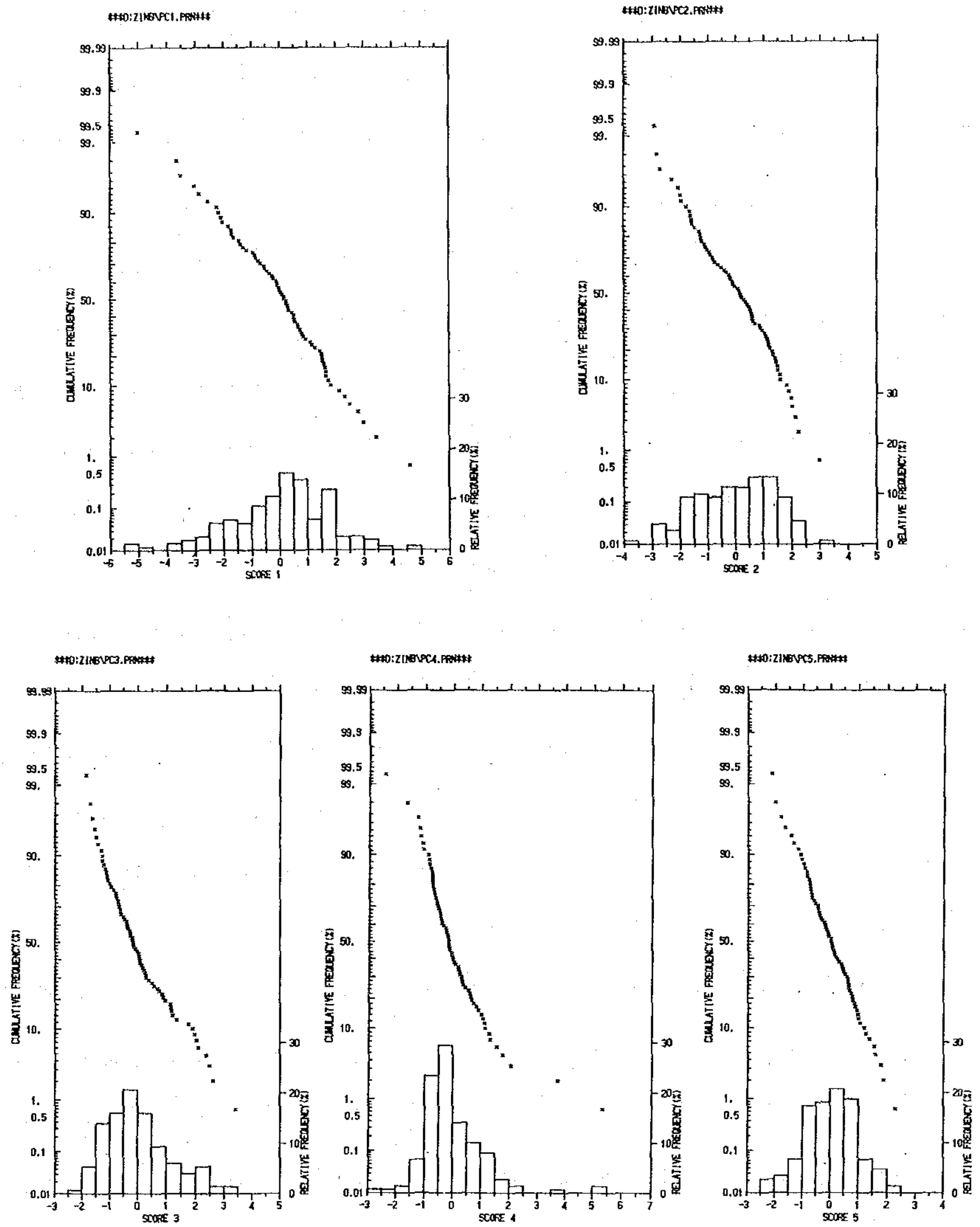


FIG.2-3-9 Histogram and Cumulative Frequency Curve (Panned Samples:P.C.1～5)

with As and strong correlation(0.83) with Au.
The fifth principal component has a medium correlation with Bi, and Cr,but dose not show any significant geochemical characteristics.

Histogram and cumulative frequency curve of the principal component score is shown in FIG.2-3-9.

(5) Evaluation of the Anomalous Zones

Besides the Au anomalous zones and Ag anomalous zones, concentrations of As anomalous values and Bi anomalous values are also found. Except for these, the anomalous zones in the survey area consist of a single element found only sporadically(FIG.2-3-10). Although Au and Ag themselves are elements requiring exploration, As and Bi are looked for in a geochemical exploration only as indirect indicators of the concentration of other elements (e.g. Au or Ag). In the survey this fiscal year, since the amount of samples whose As and Bi content was less than the detection limit turned out to be 93 to 94%, much larger than that for Au or Ag, data for the As or Bi content were used only as supplementary data to help understand the geochemical relationship with Au or Ag. For Cu, Zn, Cr, and Ni, only the relationship with Au or Ag was examined, because anomalous zones for these elements were found only sporadically and because there is little evidence that these zones were related to mineralization processes.

The general relationships between Au or Ag anomalous zones and anomalous zones of other indicators are shown below:

Au : Thirteen Au anomalous zones as follows were found, as shown in Table 2-3-6(1). The geochemical characteristics of these anomalous zones can be summarized as follows:

I_{Au} : Two Zn anomalous values and four anomalous values in the fourth principal component score in rock code 4 (highly related to Au-As, the same shall apply hereafter), and two anomalous values in the fourth principal component score for the panned samples (Au) were found in this anomalous zone. Consequently, it can be expected that mineralization of Au accompanied with As and sometimes also with Zn is occurring in this anomalous zone.

II_{Au}: Only two Zn anomalous values and one Fe anomalous value were found in this zone.

III_{Au}: Two As anomalous values, six Bi anomalous values and one Zn anomalous value were found. Also two anomalous values in the third principal component score (Zn-Fe) and one anomalous value in the fifth principal component score (Au-As-Bi) in rock code 3, one anomalous value in the fourth principal component score (Au-As) in rock code 4, and two anomalous values in the third principal component score (Au-As-Bi) and one anomalous value in the fourth principal component score (Au-As) in rock code 5 were found. It should also be noted for future reference that one anomalous value in the first principal component score (As-Bi-Cu-F-Zn-Ni-Fe) was found in rock code 1.

IV_{Au}: Two Bi anomalous values and four anomalous values in the fourth principal component score in rock code 4 (Au-As) were found. Also one anomalous value for the panned samples (As-Bi) and two anomalous values in the fourth principal component score (Au) were found in this anomalous zone.

V_{Au}: One Ag anomalous value, three Bi anomalous values, one Cu anomalous value, one Zn anomalous value and one Fe anomalous value were found. In rock code 3, one anomalous value was found in the third principal component score (Zn-Fe). Gwakwa mineralized zone is located near to this anomalous zone.

VI_{Au}: This zone is related most strongly to the results of analysis for elements and principal components. Two Ag anomalous values, two As anomalous values, two Bi anomalous values, one Cu anomalous value and two F anomalous values were found. In rock code 4, eight anomalous values in the second principal component score (Au-Ag), two anomalous values in the third principal component score (As-Bi) and five anomalous values in the fourth principal component score (Au-As) were found. In rock code 5, one anomalous value was found in the third principal component score (Au-As-Bi). For panned samples, two anomalous values for Au and Ag, one anomalous value for Cu and Zn, three anomalous values for the first principal component score (Ag-Cu-Zn-Fe) and anomalous values in the fourth principal component score were found. Juwere mineralized zone belongs to this type of anomalous zone.

VII_{Au}: Two As anomalous values and one Bi and Zn anomalous value were found in the zone. In rock code 5, two anomalous values in the third principal component score (Au-As-Bi) and one anomalous value in the fourth principal component score (Au).

$VIII_{Au}$: Two Bi anomalous values were found. In rock code 5, one anomalous value in the third principal component score (Au-As-Bi) and two anomalous values in the fourth principal component score (Au) were found.

IX_{Au}: One Ag anomalous value and one Bi anomalous value were found. In rock code 5, two anomalous values in the third principal component score (Au-As-Bi) and two anomalous values in the fourth principal component score (Au) were found. It should be noted for future reference that one anomalous value was also found in the second principal component score (Zn-Cu) in rock code 6.

X_{Au}: One Ag anomalous value was found. In rock code 5, one anomalous value in the second principal component score (Ag), one anomalous value in the third principal component score (Au-As-Bi) and two anomalous values in the fourth principal component score (Au) were found.

XI_{Au}: One Ag anomalous value, three As anomalous values and five Bi anomalous values were found. In rock code 3, two anomalous values in the first principal component score (Cu-F-Zn-Cr-Ni-Fe) and one anomalous value in the fifth principal component score (Au) were found. In rock code 4, one anomalous value in the first principal component score (Cu-F-Zn-Ni-Fe), one anomalous value in the second principal component score (Au-Ag) and one anomalous value in the fourth principal component score (Au-As) were found. In rock code 5, two anomalous values were found in the third principal component score (Au-As-Bi). For the panned samples, one Bi anomalous value was found.

XII_{Au}: One Ag anomalous value, two As anomalous values, five Bi anomalous values, one Cu anomalous value and three Ni anomalous values were found. In rock code 5, one anomalous value in the third principal component score (Au-As-Bi) and three anomalous values in the fourth principal component score (Au) were found. For the panned samples, one Bi anomalous value was found. Fumure mineralized zone belongs to this type of anomalous zone.

$XIII_{Au}$: Two Ag anomalous values, one As anomalous value and one F anomalous value were found. In rock code 5, one anomalous value was found in the third principal component score (Au-As-Bi).

Ag : Seven Ag anomalous zones of the following were found, as shown in TABLE 2-3-6(2). The relationship between these anomalous zones and indicator anomalous zones is summarized as follows:

I_{Ag}: One Cu anomalous value was found. In rock code 4, five anomalous values were found in the secondary principal component score (Ag). For the panned samples, one anomalous value was found in the first principal component score (Ag-Cu-Zn-Fe).

II_{Ag}: Three Bi anomalous values, one Zn anomalous value, one Ni anomalous value and one Fe anomalous value were found. In rock code 4, two anomalous values were found in the first principal component score (Cu-F-Zn-Ni-Fe). For the panned samples, one Au anomalous value, one Ag anomalous value and one Cu anomalous value were found. One anomalous value in the first principal component score (Ag-Cu-Zn-Fe) and one anomalous value in the fourth principal component score (Ag) were also found. Juwere mineralized zone belongs to this type of anomalous zone.

III_{Ag}: Two Bi anomalous values and two Fe anomalous values were found. In rock code 4, two anomalous values were found in the second principal component score (Au-Ag). In rock code 5, one anomalous value in the first principal component score (Cu-Zn-Ni-Fe) and one anomalous value in the second principal component score (Ag) were found.

IV_{Ag}: One Bi anomalous value, one Cr anomalous value and one Fe anomalous value were found. In rock code 3, one anomalous value was found in the second principal component score (Ag). In rock code 4, one anomalous value was found in the first principal component score (Cu-F-Zn-Ni-Fe). In rock code 5, one anomalous value was found in the second principal component score (Ag). For the panned samples, one Au anomalous value, one anomalous value in the first principal component score (Ag-Cu-Zn-Fe) and two anomalous values in the fourth principal component score (Au) were found.

V_{Ag}: In rock code 3, one anomalous value was found in the second principal component score (Ag). For the panned samples, one Au anomalous value and one As anomalous value were found. One anomalous value in the first principal component score (Ag-Cu-Zn-Fe) and one anomalous value in the fourth principal component score (Au) were also found.

VI_{Ag}: In this anomalous zone, only one Bi anomalous value was found for the panned samples.

VII_{Ag}: In this anomalous zone, only one As anomalous value was found.

Except for Au , the content of other elements was very low in the mineralized zones in the survey area, geochemical anomalous zones were found only sporadically in comparison with those for Au, and the correlation coefficients among indicators was rather weak; consequently, no promising anomalous zones were identified.

On the other hand, 13 Au anomalous zones were detected as a concentration of anomalous geochemical values.
On the basis of the following criteria, finally seven promising Au anomalous zones have been selected.

Criteria:

(1)Number(B) of Au anomalous value which is included in a anomalous zone counts 2 points as a score.

(2)Number(C) of anomalous values of elements(Ag, As, Bi) which are included in an anomalous zone counts 1 point as a score.

(3)Number(C) of anomalous values of principal component score which are geochemically correlated to Au mineralization counts 1 point as a score.

(4)Calculation of "Index of geochemical anomaly"

"Index of geochemical anomaly"= [(B)+(C)] / (A)

Where, (A) stands for dimension(k㎡) of anomalous zone.

The selected calculation results of an "index of geochemical anomaly" are listed below:

ANOMALOUS ZONE	DIMENSION OF A. Z. (A)	SCORE COUNTED BY Au ANOMALY (B)	SCORE COUNTED BY OTHER A. (C)	" INDEX OF GEOCHEMICAL ANOMALY" [(B)+(C)] ／ (A)
① I Au ANOMALY	65 k㎡	38	8	0.71
② Ⅳ Au ANOMALY	32 k㎡	12	10	0.69
③ Ⅴ Au ANOMALY	14 k㎡	12	4	1.14
④ Ⅵ Au ANOMALY	90 k㎡	44	27	0.79
⑤ Ⅶ Au ANOMALY	15 k㎡	10	6	1.07
⑥ Ⅷ Au ANOMALY	12 k㎡	14	5	1.58
⑦ X I Au ANOMALY	28 k㎡	14	15	1.04

A. Z. : ANOMALOUS ZONE   A. : ANOMALY

Seven Au anomalous zones were selected.

The results can be divided into 3 groups depend on acquired scores:

ANOMALOUS ZONE	"INDEX OF GEOCHEMICAL ANOMALY" VALUE	
GROUP 1		
Ⅷ Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	1.58
GROUP 2		
V Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	1.14
Ⅶ Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	1.07
X I Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	1.04
GROUP 3		
Ⅵ Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	0.79
I Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	0.71
Ⅳ Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	0.69

Taking all related factors, especially mineralized zones included, into consideration, the seven anomalous zones were evaluated with priority.

The results are as follows:

ANOMALOUS ZONE	"INDEX OF GEOCHEMICAL ANOMALY" VALUE		PRIORITY
Ⅷ Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	1.58	A
V Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	1.14	B
Ⅵ Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	0.79	B
Ⅶ Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	1.07	B
X I Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	1.04	B
I Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	0.71	C
Ⅳ Au ANOMALY	"INDEX OF GEOCHEMICAL ANOMALY"	0.69	C

Because of no definitive criterion for the discovery of mineralized zones, we calculated an "index of geochemical anomaly" as an expedient.

(6) Relation between Geochemical Anomalies and Mineralization

The mineralization in the area is not so promising judging from the assay results of samples from the mineralized zones(TABLE 2-2-2). Detected promising mineralized zones are all related to Au mineralization.

The characteristics of the mineralized zones are shown as follows:

N A M E M. Z.	MINERALIZATION	ANOMALOUS INDICATORS	G E O L O G Y	G. C. ANOMALOUS Z O N E(Au)
JEGEDE	Au?	Au-As-Cu-Zn?-Cr??	Mafic Granulite	
JUWERE	Au	Au-Bi-Cu-Cr??	Gneissose granulite	VI_{Au}
TURWI	Au?, Cr??	Au?-Cr??	Mafic Granulite	
PANGANAI	Au?, Cr??	Au?-Cr??	Gneissose granulite	
GORWGE	Au??	Au?-F-Cr??	Gneissose granulite	
DINHIRO	Au?, Cu, Cr?	Au-Cu-Cr	Iron Formation	
HOVEE	Au, Cu, Zn	Au-Cu-Zn	Mafic Granulite	
MUCHACHA	Au, Cu, Zn	Au-As-Bi?-Cu-Zn-Ni?	Mafic Granulite?	
FUMURE	Au?, Cr?	Cr	Mafic Granulite?	XI_{Au}
CHIWANZA	Au?, Cr?	Cr	Gneissose granulite?	
GWAKWA	Au?, Cr?	?	Felsic Granulite?	

G. C. : geochemical M. Z. : mineralized zone

Only Juwere and Fumere mineralized zone are included in the mineralized zones. Consequently, it can be concluded that rather week relationships between the mineralized zone and geochemical anomalous zones are envisaged.

On the other hand, characteristics of the geological anomalous zones are shown as follows:

NAME A.Z.	ANOMALOUS INDICATORS BY STREAM SEDIMENTS	ANOMALOUS INDICATORS BY P. C. SCORE	ANOMALOUS INDICATORS BY PANNED SAMPLES	MINERALIZED ZONE
I Au	As, Zn	Au-As		
IV Au	Bi	Au-As	As-Bi, Au	
V Au	Ag, Bi, Cu, Zn	Zn-Fe		
VI Au	Ag, As, Bi, Cu	Au-Ag, As-Bi, Au-As	Au, Ag, Cu, Zn Ag-Cu-Zn	Juwere
VII Au	As, Bi, Zn	Au-As-Bi, Au		
VIII Au	Bi	Au-As-Bi		
XI Au	Ag, As, Bi,	Au, Au-Ag, Au-As Au-As-Bi	Bi	Fumure

A. Z.: anomalous zones P. C.: principal component

We tried a comparison between the concentration of indicators(Au, Ag, As, Bi, etc.) within the mineralized zones and reef in Renco deposit.

ELEMENTS	VALUES	ELEMENTS	VALUES
Au	1,760	Pb	587
Ag	31.6	Zn	480
Cu	50,000	Co	229
Bi	1,900	As	882
Ni	469	S	38,000
Cr	167	Fe	400,000
Te	present	Wo	present

After Bohmke & Varndell(1986)

As a result of the interpretation, the following mineralized zones have similar geochemical characteristics to those of reef in Renco Deposit.

Jegede mineralized zone
Juwere mineralized zon
Muchacha mineralized zone

An investigation was carried out to delineate the relation between the mineralized zones and geochemical anomalies. Since only Juwere and Fumure mineralized zones are included within the geochemical anomalous zones, the relationship between mineralization and geochemical anomalies of stream sediments and panned samples is not so clear in general. It can be concluded that the above mentioned seven geochemical anomalous zones have rather similar geochemical characteristics to those of three mineralized zones(Jegede, Juwere, and Muchacha mineralized zones) on the basis of their analytical results, especially on the concentration of elements(such as Ag, As, Bi) which are accompanied with Au mineralization .

All the mineralized zones in the survey area may be classified as vein-type deposits. Consequently, this type of deposit is different from that of Renco deposit which is assumed to be a synsedimentary exhalative deposit.
More detailed studies on the mineralization in the survey area are warranted.

2-3 Consideration

The degree of concentration of indicators in the survey area depends not only on the geochemical characteristics of the rocks, which constitute the geological unit, but also on the overall geochemical characteristics of the area. When the content of indicators in the survey area was compared with world-wide data of Flanagan (previously mentioned) or those of Vinogradov (previously mentioned), the concentration level of indicators in the survey area may be evaluated objectively, and moreover, indirect mineralization information may be drawn from these data for the content of indicators. Taking geological units into consideration, elements can be classified into the following three groups:
(1) elements which have higher content in the survey area than in other areas, (2) indicators which have about same content compared with other areas, and (3) indicators which have lower content than in other areas.

(1) Ag: It could be seen that only the content of this element in the survey area is higher than the figures shown by Flanagan (previously mentioned) and

Vinogradov (previously mentioned). Consequently, it can be generally concluded from the results of geochemical exploration that the concentration level of this element may be fairly high. As mentioned below, however, the grade of Ag in samples collected in mineralized zones in the survey area was low, and this is not thought to be promising.

(2) Bi, Cr, Ni, Fe: For these indicators, although the content differed with geological units, the content in the survey area turned out to be about the same as in other areas.

(3) Au, As, Cu, F, Zn: For these elements, although the content differed with geological units, the content of indicators in the survey area was generally lower than in other areas. This may indicate that the concentration tendency of these indicators is weaker in the survey area than the world-wide average.

The cumulative frequency curve of indicators was taken into consideration to examine the relationship between the content of indicators and the mineralization process in the survey area. The possibility of mineralization of each indicator can be primarily judged by observing whether the curve shows positive skewness or negative skewness.

The curves for the following indicators show positive skewness:

Au, Ag, As, Bi

Since As and Bi are considered as the indicators of Au mineralization, it can be concluded that Au mineralization and Ag mineralization is possibly occurring in the survey area. As mentioned above, however, the correspondence of Ag mineralization to the actual mineralized zones is not sufficient; consequently, it is considered that the possibility of Ag mineralization is less than that of Au mineralization.

For the other indicators, i.e. Cu, F, Zn, Cr, Ni and Fe, positive skewness is not shown. In particular, the curves for Cu, F and Cr tend to show negative skewness. Consequently, the possibility of mineralization of these indicators is thought to be less than that of the indicators, the curves for which show positive skewness.

The geochemical characteristics of mineralization in the survey area can be considered when the correlation between indicators is examined. In all geological units in the survey area (rock codes 1 to 6), the following correlation can be seen:

Cu-Fe, Zn-Fe, Cr-Ni

In addition, the following weaker correlation is frequently seen:

F-Ni, Ni-Fe

In particular, the correlation factor for Zn-Fe is high (0.70 or higher).

These results suggest that, if mineralization is considered, correlation indicators may have been produced in the same mineralization process. There may be another interpretation that the correlation is caused by the basic geochemical characteristics of these indicators.

It should be noted that either Au or Ag has little or no correlation with other elements. The characteristics of indicators can be understood by analyzing the results of principal component analysis, as described in the following:

Noting the principal component structure in the major geological units in the survey area (rock codes 3 to 5), the correlation with indicators such as Cu-F-Zn-(Cr)-Ni-Fe can be seen in the first principal component with very few exceptions, while the correlation with Au-Bi, Au-As, Au-Ag-Bi and As-Bi can be seen in the other principal components. This suggests that the patterns of indicator concentration can be classified largely into two groups. It can be thought that the latter combination of indicators shows a part of the Au mineralization characteristics in the survey area. In other words, it can be considered that the concentration process of the former indicators (Cu-F-Zn-(Cr)-Ni-Fe) probably differs from that of the latter indicators, and that Au mineralization is accompanied with mineralization of Bi, As, Ag, etc..

It can be concluded from the results of the above discussion that, as shown in Table 1-4-3 in Section 4, the following anomalous zones are promising.

I_{Au} anomalous zones

IV_{Au} anomalous zones

V_{Au} anomalous zones

VI_{Au} anomalous zones

VII_{Au} anomalous zones

$VIII_{Au}$ anomalous zones

XI_{Au} anomalous zones

TABLE 2-3-6(1) Evaluation of Anomalous Zones(Au)

NAME OF ZONE ANOMALY	DIMENSION km km	NO. OF ANOMALOUS VALUE	STREAM SEDIMENTS																													MINERALIZED ZONE	PANNED SAMPLES												"INDEX OF GEOCHEMICAL ANOMALY"	ORDER OF ANOMALY"
			INDICATORS									PRINCIPAL COMPONENT ANALYSIS																					INDICATORS										P. C. A.			
												ROCK CODE 3					ROCK CODE 4					ROCK CODE 5					ALL GEOLOGICAL UNIT																			
			* Ag	* As	* Bi	Cu	F	Zn	Cr	Ni	Fe	Z1	* Z2	Z3	Z4	* Z5	Z1	* Z2	* Z3	* Z4	Z5	Z1	* Z2	* Z3	* Z4	Z5	Z1	* Z2	* Z3	Z4	Z5	ZONE	* Au	* Ag	* As	* Bi	Cu	F	Zn	Cr	Ni	Fe	Z1	* Z4		
I Au	13×5	** 19	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	1	-	-	-	-	-	-	-	—	-	-	-	-	-	-	-	-	-	-	-	2	0.71	6
II Au	5×3	** 3	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	-	-	-	-	-	-	-	-	-	-	-	-	0.40	12
III Au	11×9	** 12	-	2	6	-	-	1	-	1	2	-	-	2	-	1	-	-	-	1	-	-	-	2	1	-	1	-	1	-	-	—	-	-	-	-	-	-	-	-	-	-	-	-	0.36	13
IV Au	4×8	** 6	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	—	-	-	1	1	-	-	-	-	-	-	-	2	0.69	7
V Au	7×2	** 6	1	-	3	1	-	1	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	1.14	2
VI Au	16×5	** 22	2	2	2	1	2	-	-	-	-	-	-	-	-	-	-	8	2	5	-	-	-	1	-	-	-	-	-	-	-	JUWERE	2	2	-	-	1	-	1	-	-	-	3	1	0.79	5
VII Au	3×5	** 5	-	2	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	—	-	-	-	-	-	-	-	-	-	-	-	-	1.07	3
VIII Au	4×3	** 7	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	—	-	-	-	-	-	-	-	-	-	-	-	-	1.58	1
IX Au	8×4	** 6	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	1	-	-	-	—	-	-	-	-	-	-	-	-	-	-	-	-	0.59	8
X Au	5×4	** 4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	-	-	-	-	-	-	—	-	-	-	-	-	-	-	-	-	-	-	-	0.54	9
XI Au	7×4	** 7	1	3	5	-	-	-	-	-	-	2	-	-	-	1	1	1	-	1	-	-	-	2	-	-	-	-	-	-	-	—	-	-	-	1	-	-	-	-	-	-	-	-	1.04	4
XII Au	6×10	** 7	1	2	5	1	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-	FUMURE	-	-	-	1	-	-	-	-	-	-	-	-	0.45	11
XIII Au	5×5	** 4	2	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	—	-	-	-	-	-	-	-	-	-	-	-	-	0.48	10

**(A) : This(A) is counted as 2 point for the calculation of "INDEX OF GEOCHEMICAL ANOMALY"

* (B) : Indicator(B) and score(B) possibly indicate Au-mineralization. These are counted as 1 point for the calculation of "INDEX OF GEOCHEMICAL ANOMALY"

Calculation:

"INDEX OF GEOCHEMICAL ANOMALY"= {(sum of A) + (sum of B)} / extention of anomalous zone(km²)

Z1, Z2, ····· : PRINCIPAL COMPONENT

P. C. A. : PRINCIPAL COMPONENT ANALYSIS

1, 2, 3······ : NUMBERS OF ANOMALOUS SITES INCLUDED

TABLE 2-3-6(2) Evaluation of Anomalous Zones(Ag)

NAME OF ZONE	DIMENSION	NO. OF ANOMALOUS	STREAM SEDIMENTS																																MINERALIZED	PANNED SAMPLES											
			INDICATORS									PRINCIPAL COMPONENT ANALYSIS																								INDICATORS										P. C. A.	
												ROCK CODE 3					ROCK CODE 4					ROCK CODE 5					ALL GEOLOGICAL UNIT																	
ANOMALY	km km	VALUE	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	Z1	Z2	Z3	Z4	Z5	Z1	Z2	Z3	Z4	Z5	Z1	Z2	Z3	Z4	Z5	Z1	Z2	Z3	Z4	Z5	ZONE	Au	Ag	As	Bi	Cu	F	Zn	Cr	Ni	Fe	Z1	Z4
I Ag	3×2	4	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	—	-	-	-	-	-	-	1	-	-	-	1	-
II Ag	2×1	3	-	-	3	-	-	1	-	1	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	JUWERE	1	1	-	-	1	-	-	-	-	-	1	1
III Ag	4×4	8	-	-	2	-	-	-	-	-	2	-	-	-	-	-	-	2	-	-	-	1	1	-	-	-	-	-	-	-	-	—	-	-	-	-	-	-	-	-	-	-	-	-
IV Ag	3×6	7	-	-	1	-	-	-	1	-	1	-	1	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	—	1	-	-	-	-	-	-	-	-	-	1	2
V Ag	2×1	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	1	-	1	-	-	-	-	-	-	-	1	1
VI Ag	1×2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	-	-	-	1	-	-	-	-	-	-	-	-
VII Ag	1×2	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	-	-	-	-	-	-	-	-	-	-	-	-

Z1, Z2, ······ : PRINCIPAL COMPONENT

P. C. A. : PRINCIPAL COMPONENT ANALYSIS

1, 2, 3······ : NUMBERS OF ANOMALOUS SITES INCLUDED

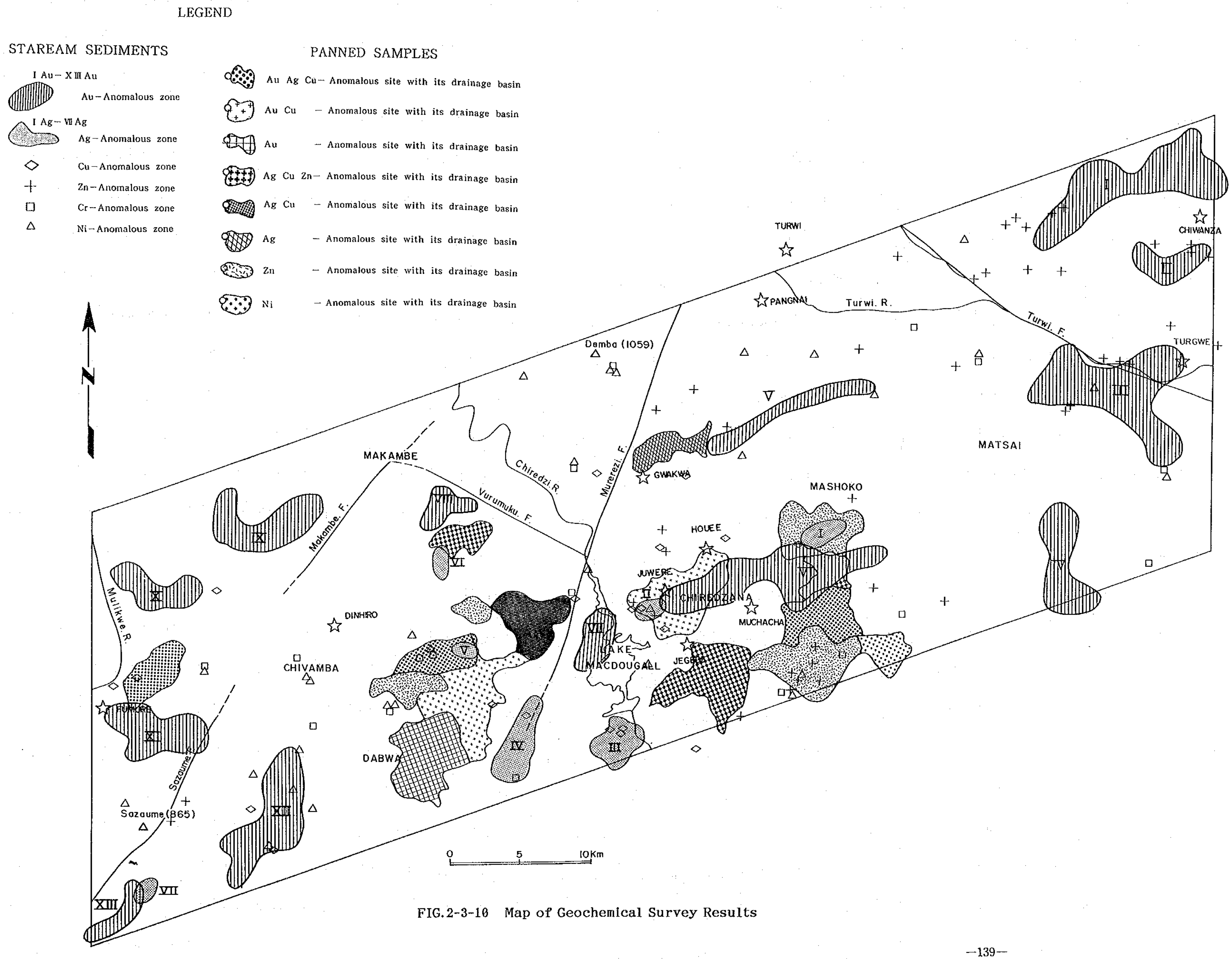


FIG.2-3-10 Map of Geochemical Survey Results