A

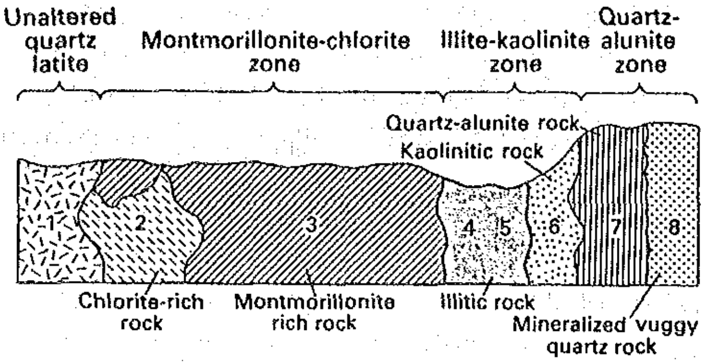
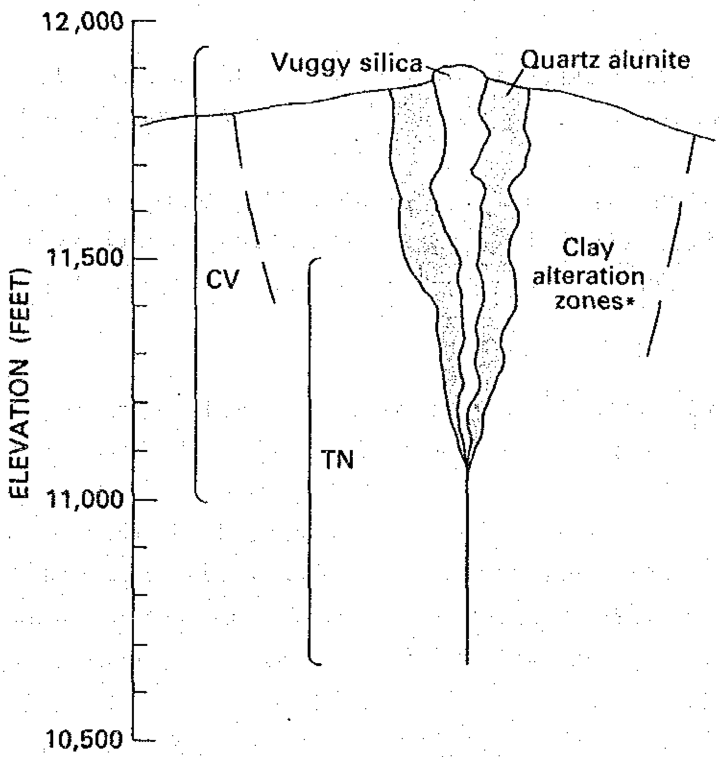


Diagram showing hydrothermal alteration pattern in the Summitville district adapted from Steven and Ratté (1960).

B



Schematic cross section of the alteration patterns and mineral zonation of the Summitville deposit. The clay alteration zones refer to zones 3-6 in the above figure. CV—covellite, luzonite, enargite, pyrite, marcasite, chalcopyrite, trace sphalerite, sulfur, and gold assemblage; TN—chalcopyrite, tennantite, pyrite, plus minor sphalerite and trace galena assemblage.

Fig. 2-2-15 Hydrothermal Alteration Pattern in the Summitville District are the major constituents of this zone with minor content of alunite and pyrophyllite, and is considered to be an acidic alteration overlapping Subzones I and II of Fig. 2-2-5. This acidic alteration is surrounded by weakly argillized zone composed of kaolinite-smectite. This latter is considered to be an overlap of acidic Subzone II over Subzone V.

2-3-3 Discussions Regarding Mineralization and Alteration

Epithermal gold deposits are classified into the adularia-sericite type formed by neutral hydrothermal solution, and the acid sulfate type formed by acidic hydrothermal solution. In recent years, the former type is often called low sulfidation type, and the latter high sulfidation type (Hedenquist, 1987). In Fiji, Emperor deposit of Viti Levu is considered to belong to the low sulfidation type and the Mt. Kasi Deposit of Vanua Levu is of the high sulfidation type.

Representative deposits of the high sulfidation type are Goldfield in Nevada USA, Summitville in Colorado USA, Chinkuashih in Taiwan, Nansatsu type in Japan and others.

Of the high sulfidation gold deposits, Summitville deposit has been most exhaustively studied regarding the time - space relation of the gold mineralization and alteration (Steven and Ratte, 1960; Stoffregen, 1987; etc.).

The Summitville is a pipe or pod-shaped Au-Ag-Cu deposit replacing quartz latite lava dome within a caldera. It continues 400 m vertically.

There is a very clear zonal arrangement of altered minerals as seen in Fig. 2-2-15 (Steven and Ratte, 1960). When considered that the illite rock of this figure corresponds to the sericite subzone (Subzone III), this arrangement agrees well with those of the Raviravi and Namosau Creek Alteration Zones.

This similarity indicates the fact that the alteration zones of the Raviravi and Namosau Creek were formed by the high sulfidation type mineralizing fluid. However, it is not clear how the deposits were developed. There are various types of deposits formed by high sulfidated fluids such as; veins (El Indio:Chile), pods (Summitville), stockwork (Nansatsu), dissemination (Temora:Australia). The shape of the deposits and the space-time relation with the acidic alteration would be strongly controlled by the development of the fissures, intensity of fracturing, existence of porous rocks and other factors related to the permeability of the host rocks.

Both Raviravi and Namosau Alteration Zones occur in the caldera structures extracted by photogeological analysis and they are controlled by the vertical fissure system formed during the caldera formation and pipe-shaped deposits similar to the Summitville deposit are believed to have been formed.

Regarding the Raviravi Alteration Zone, the correlation between the surface altered zone of Raviravi and the Summitville zones is not clear. It will be necessary to confirm the conditions of the mineralization and alteration for clarifying the total features of the mineralization in order to evaluate the mineral potential of this zone.

The alteration zones of Nalotawa-Nanuku and Yaloku are considered to be of the low sulfidation type alteration because; 1: only the weakly argillized zone consisting of sericite and mixed-layer minerals is developed in the smectite-chlorite altered subzone (propylite subzone) and acidic altered minerals are not found, 2: auriferous quartz veinlet swarm (Nasala vein swarm) is developed in the Yaloku Alteration zone.

Small acidic alteration occurs in the eastern edge of the Tavanasa Creek Alteration Zone. But it is mostly propylite consisting of smectite-chlorite and thus is considered to be of low sulfidation alteration. It is known that acidic alteration can occur near the surface by the concentration of steam even when the mineralizing fluid is chemically neutral. This process is a possible cause of the small acidic altered zone mentioned above, and also it could be the western edge of the large acidic alteration zone in the Mbalevuto Prospect adjacent to the east.

2-4 Geochemical Prospecting

2-4-1 Methods Employed

Geochemical prospecting using A soil horizon samples was carried out over an area of 206 km^2 in order to extract promising mineral prospects.
The geological and geochemical work were conducted simultaneously along the streams and ridges. The sampling interval for the geochemical prospecting ranged from 100 to 200 m. The geochemical orientation survey in the area east of the Emperor Mine, carried out during the first phase, showed that gold tend to concentrate more in the A soil horizon than in the B horizon. Since the geological environment of Mba-west has similarities to that of the above area, soil samples from A horizon were collected. The collected soil samples were dried naturally under the sun, sieved to -80 mesh, and chemically analyzed at Chemex Labs Ltd., of Canada. A total of 3,005 samples were collected and the contents of six elements, Au, Ag, As, Sb, Hg,

Te were analyzed. The analytical methods for each element and the limit of detection are as follows.

Analytical procedures (Mba-west Area)

Element	Method	Detection Limit	Upper Limit
Au	Fuse, FA-AAS	5ppb	10,000ppb
Ag	HNO_3/Aqua Regia digestion, AAS	0.2ppm	100.0ppm
As	HNO_3/Aqua Regia digestion, AAS	1ppm	10,000ppm
Sb	$HCl/KClO_3$ digestion, extraction, AAS	0.2ppm	1,000ppm
Hg	HNO_3/HCl digestion, AAS	10ppb	100,000ppb
Te	$HBr\text{-}Br_2$ digestion, extraction, AAS	0.05ppm	100.0ppm

FA :Fire Assay
AAS:Atomic Absorption Spectrometry

2-4-2 Results of Analysis

The contents of heavy metals are generally low. Of the total of 3,005 samples; Au content was below the detection limit in 2,966 samples (98.7%), Ag in 3,005 samples (100%), As in 1,924 samples (64.0%), Sb in 2,899 samples (96.5%), Te in 2,719 samples (90.5%). Only Hg content was over the limit of detection in all samples.

2-4-3 Statistical Treatment

(1) Method of statistical treatment

The statistical treatment of geochemical data usually involve multivariate analysis such as principal component analysis with the assumption that correlation exists among each component and also that each component show log-normal distribution. With the geochemical data of this area, however, correlation scarcely exists among the components and the statistical distribution is not clear. Therefore, it was concluded that multivariate analysis of these data would not produce meaningful results.

Therefore, threshold values were set for each component, and geologic structure, mineralization, alteration, relation with the results of gravity survey, and other relevant factors were examined for anomalous zones extracted from the iso-grade contour maps.

Also, anti-logarithm was used for the following analysis rather than natural logarithm used in statistical treatment of these data. The data on

Ag whose content was below the detection limit in all samples were excluded from this process. Basic statistic values are shown below.

Table 2-2-2 Basic Statistics (Mba-west Area)

	Au	Ag	As	Sb	Hg	Te
	ppb	ppm	ppm	ppm	ppb	ppm
Average (m)	2.7	-	1.0	0.1	50	0.04
Standard deviation (σ)	4.4	-	1.2	0.04	35	0.09
Maximum	180	<0.2	30	1.0	580	3.1
Minimum	<5	<0.2	<1	<0.2	10	<0.05
Detection limit	5	-	1	0.2	10	0.05
m+σ	7	-	2	0.1	85	0.13
m+2σ	12	-	3	0.2	119	0.22
Threshold	12	-	3	0.2	119	0.20

(2) Correlation of components

One half (1/2) of the detection limit values were used as the contents of the components existing in amounts less than the limit of detection. Since there are many such samples, the correlation among individual components is very low, and only some correlation can be observed between As and Te (correlation coefficient: 0.4432).

Correlation Coefficients of Soil Assay (Mba-west Area)

	Au	Ag	As	Sb	Hg	Te
Au	1.0000	0.0000	0.1122	-0.0078	-0.0013	0.0901
Ag		1.0000	0.0000	0.0000	0.0000	0.0000
As			1.0000	0.1143	0.1964	0.4432
Sb				1.0000	0.0396	0.0522
Hg					1.0000	0.0335
Te						1.0000

(3) Distribution pattern of geochemical data

The statistical distribution of homogeneous population generally approximate normal or lognormal distribution. But it is said that the distribution of the composite population, consisting of more than two constituent populations such as the "background" and "geochemical anomalies due to mineralization", often is not normal distribution (Otsu et al., 1983).

Logarithmic frequency distribution diagrams for each component were prepared in order to clarify the statistical distribution type of the geochemical data of this area. It is seen that only Hg show lognormal distribution. The statistical distribution of other components could not be determined because of the low content of the elements. The results of the soil geochemical prospecting of Tavua Caldera area (adjoining Emperor Mine to the east) conducted in 1990 by MMAJ (First Phase Survey Rpt., 1991) indicated non-normal distribution for Au, Sb, Te, and composite population type for As. The data of the present area are considered not to have a single normal type distribution, but a non-normal population, or a composite population of several normal distribution for the four components, Au, As, Sb, Te.

(4) Determination of threshold values

The cumulative frequency distribution method of Lepeltier (1969) was applied in order to determine the threshold and to extract the "anomalous" population from the composite population.

Cumulative frequency distribution diagram for each component was drawn on logarithmic probability graph paper (Fig.2-2-16). Significant breaking points or inflection points which would indicate the difference of population could not be extracted. The breaking points in very low probability parts are formed by few singular values and do not reflect the difference of population. The diagram for Hg has a breaking point near 1 % probability (Hg 150 ppm), but the change of inclination is very small and does not reflect the difference of population.

As it was not possible to determine the threshold values from the cumulative frequency distribution diagram, average + standard deviation x 2($m + 2\sigma$) was used as the threshold value. The $m + 2\sigma$ value is actually the threshold value for extracting the higher 2.5 % of lognormal distribution (Hawkes and Webb, 1962; Lepeltier, 1969). And it cannot be applied with accuracy to the data of the present area whose statistical distribution type is not clear, but it is used as a simple value for selecting the high anomalies.

2-4-4 Distribution of Geochemical Anomalies

The zones with contents higher than the threshold were extracted from the iso-grade maps for each element and were graded as geochemical anomalies (Figs.2-2-17 & 2-2-18). For elements other than Sb, $m + \sigma$ value was also graded as secondary anomalies on the maps. The following discussion on anomalous zones will include the above secondary anomalies.

Although weak, correlation is observed between As and Te and these two elements behave similarly and many of their anomalous zones overlap or are close to each other. The distribution of the anomalous zones of the three elements, Au, As, Te, coincide well with the mineralized zones mentioned earlier, and thus these elements are considered to be path finder elements for mineralization.

The Hg anomalies coincide with the mineralized and altered zones in some localities, but mostly they are off the mineralized zones and appear to occur in the peripheries of mineralization.

The Sb anomalies have no relation to mineralization whatsoever, and occurs scattered in the unmineralized parts of the central Mba-west. It is not understood what controls their distribution.

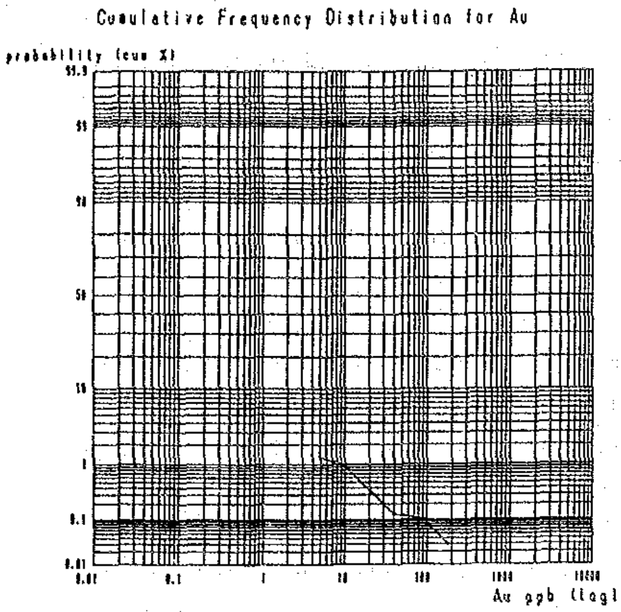
When the "geochemical anomalous zones" are defined as the zones where Au, As, Te anomalies occur in significant concentration, the following four major geochemical anomalous zones are identified in this area.

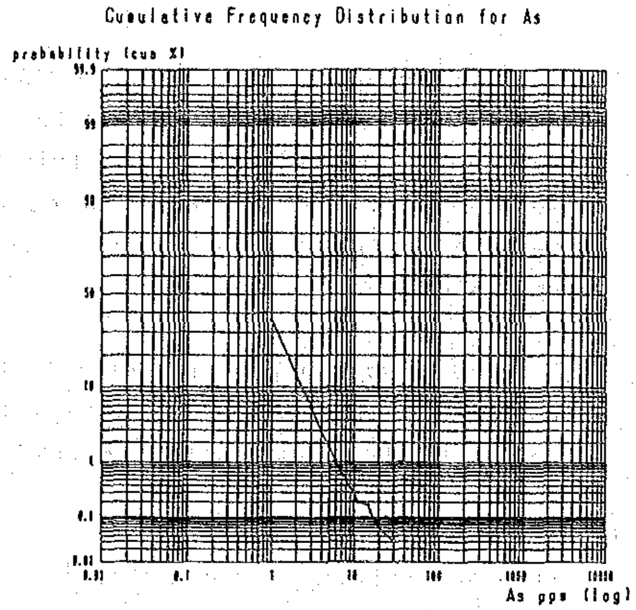
Raviravi Anomalous Area: This area coincides with the Raviravi Alteration Zone and As anomalies are widely developed in pattern similar to that of the alteration zone. Te anomalies are small and overlap the As anomalies. Au anomalies are distributed to the southwest of the altered zone overlapping the As anomalies. The Au, As, Te concentration in the anomalies appears to be unrelated to the intensity of alteration, a tendency of high concentration of these elements occurring in the weakly argillized and propylitized zones is observed.

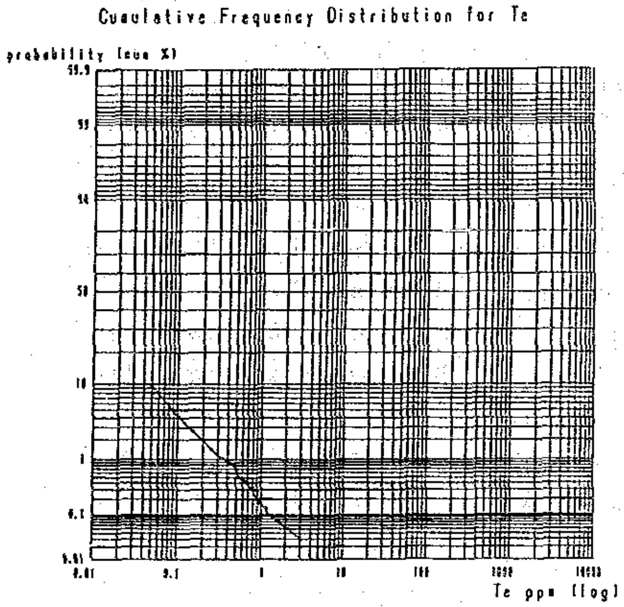
Nalotawa Anomalous Area: This area occurs in the northern half of the Nalotawa-Nanuku Alteration Zone. As and Te anomalies occur overlapping propylitization. Smaller Au anomalies occur in the central part.

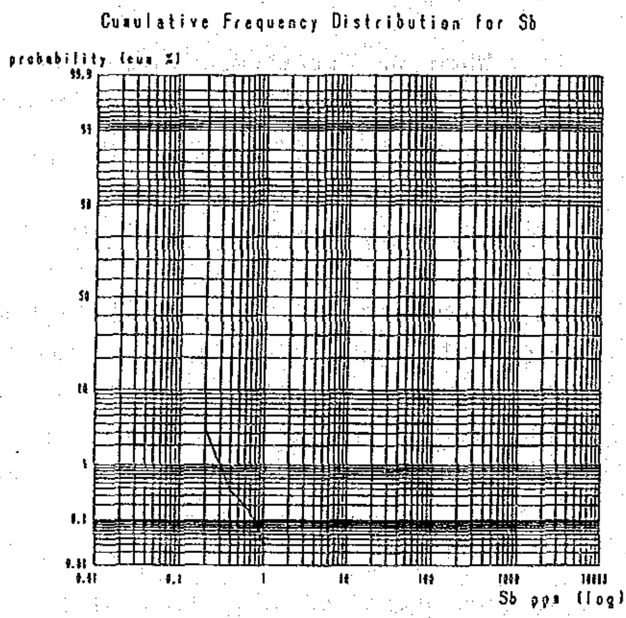
Nanuku-Yaloku Anomalous Area: This is a large anomalous area extending from the southern half of the Nalotawa-Nanuku Alteration Zone to the Yaloku Alteration Zone. Most of it consists of As anomalies and small Te anomalies overlap locally. Au anomalies are not found.

Tavanasa Creek Anomalous Area: This area coincides with the Tavanasa Creek Alteration Zone. As and Te anomalies overlap, but Au anomaly is not observed. Although not extensive enough to name anomalous areas, there are smaller but notable geochemical anomalies as follows.









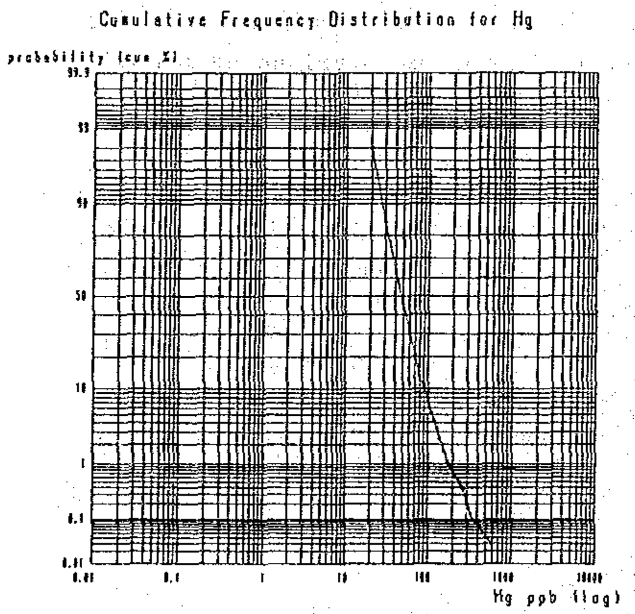


Fig. 2-2-16 Cumulative Frequency Distribution on Logarithmic Probability Paper (Mba-west Area)

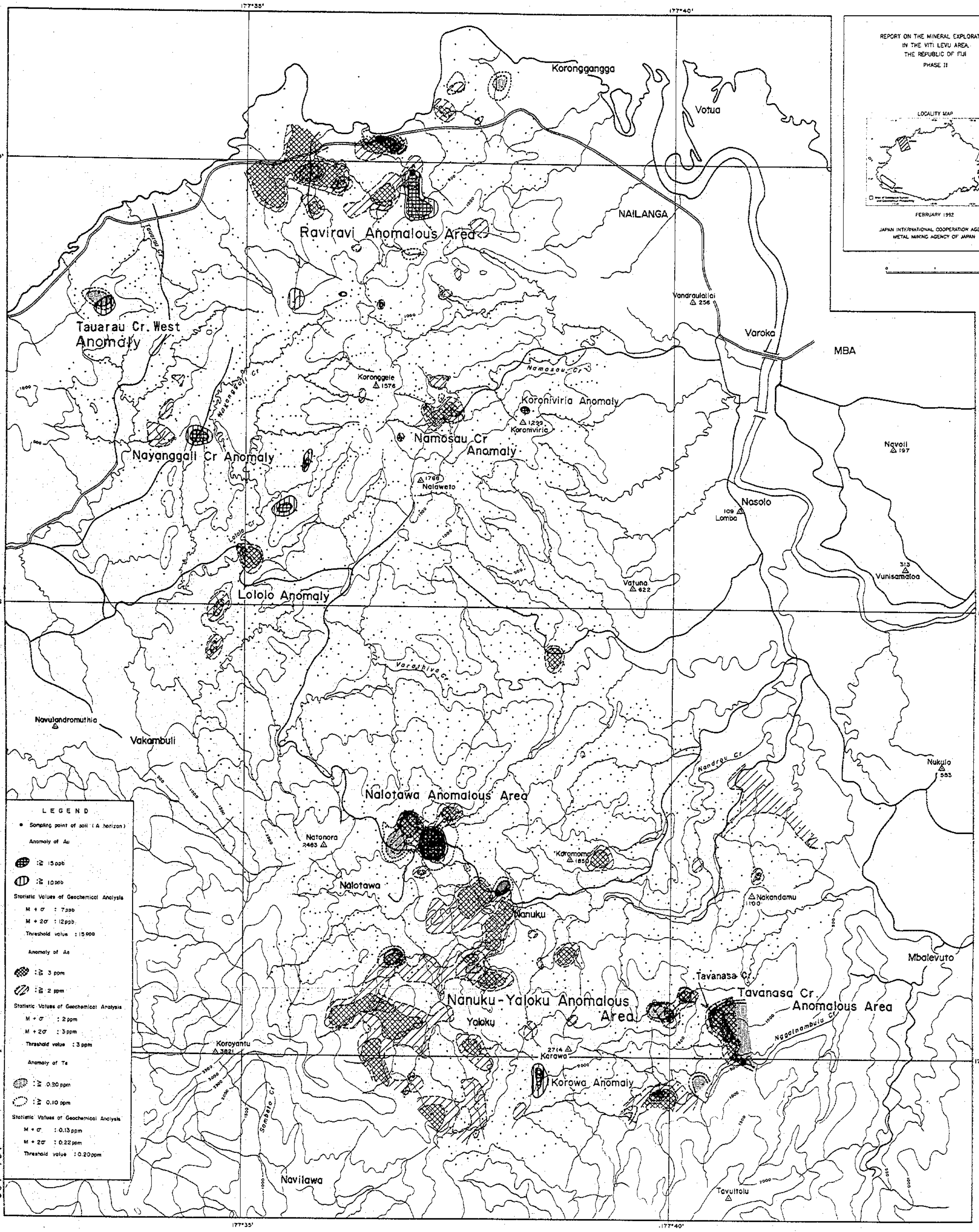


Fig. 2-2-17 Distribution of Au, As and Te Anomalies in Soils
(Mba-west Area)

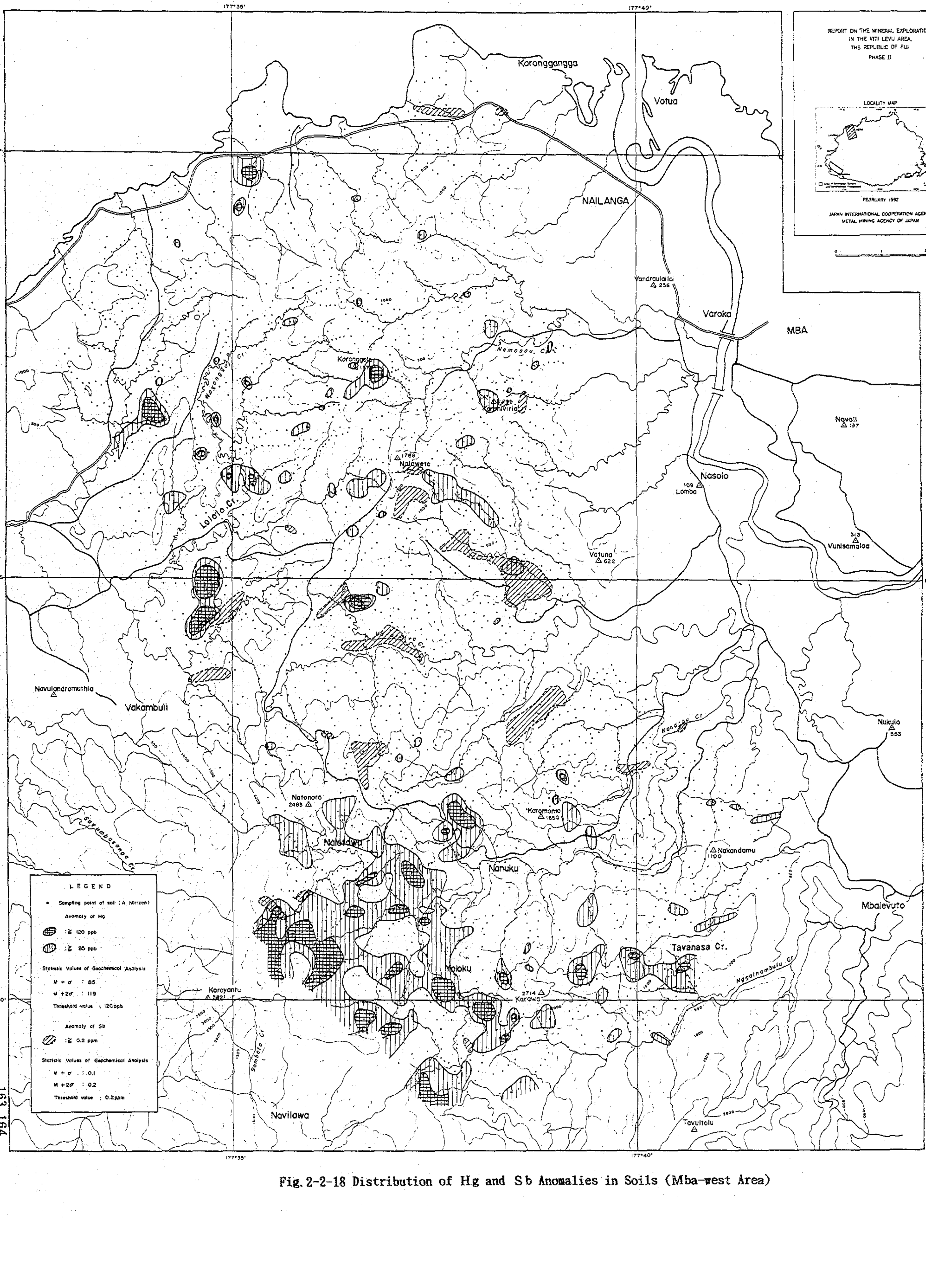


Fig. 2-2-18 Distribution of Hg and Sb Anomalies in Soils (Mba-west Area)

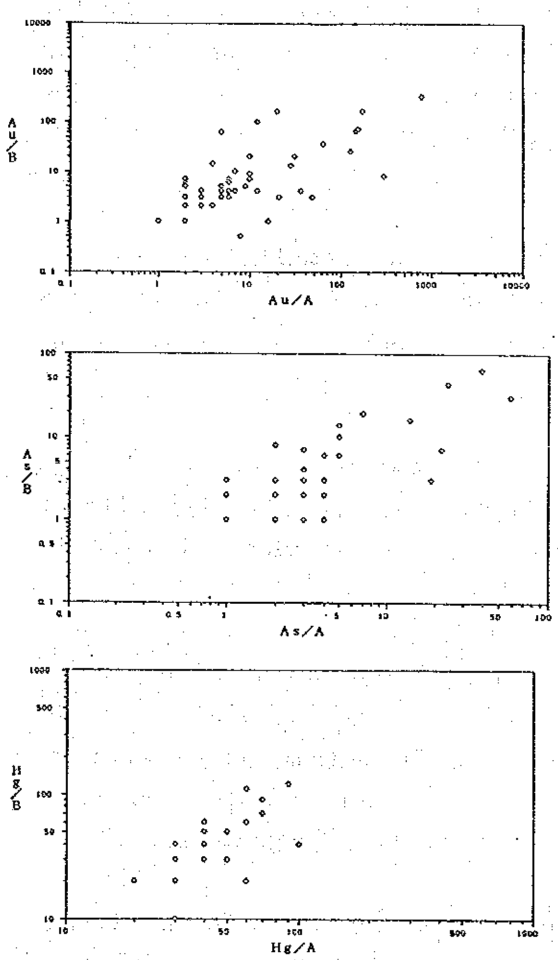


Fig 2-2-19 Correlation of Assay Values of Soil A and B Horizone (Tavua Caldera Area)

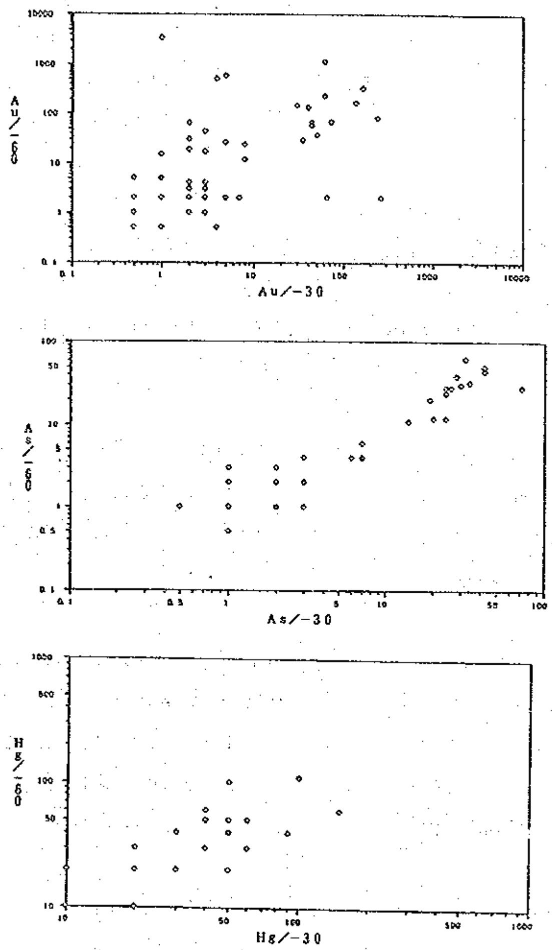


Fig. 2-2-20 Correlation of Assay Values of -60 and -30 mesh Stream Sediments (Tavua Caldera Area)

Namosau Creek Anomaly: As anomalies somewhat smaller than alteration zone are developed in the central part of the Namosau Creek Alteration Zone which was drilled during the present phase. Te anomalies overlap. The Te anomalies are smaller than those of As. Au anomaly is not found.

Lololo Creek Anomaly: There are As and Au anomalies distributed along the ridge to the west of Lololo Creek. Individual anomalies are small, but they continue with NNE-SSW trend and could be a reflection of some geologic structure. Corresponding altered zones could not be identified by geological survey.

Nayanggali Creek Anomaly: There are small As and Au anomalies distributed along the ridge to the west of Nayanggali Creek. The As and Au anomalies are independent from each other. Corresponding altered zones could not be identified on the surface.

Tavarau Creek West Anomaly: There are small As anomalies distributed along the ridge to the west of Tauarau Creek. A part of them overlap with Au anomalies. Corresponding alteration zones could not be identified on the surface.

Koroniviria Anomaly: A maximum Au content of 180 ppb was obtained from a soil sample collected near the Koroniviria Triangulation Station on the southern side. This, however, is the only one high content sample with low Au content in the samples from adjoining localities and with no other anomalous elements. This could be a singular value from "nugget effect".

Karawa Anomaly: Small Au anomalies occur independently near the Karawa Triangulation Station. These are located in the unaltered zone between the Yaloku and the Tavanasa Creek Alteration Zones. This also could be a singular point.

2-4-5 Discussions Regarding the Geochemical Prospecting

Average Au content of 47.8 ppb and maximum content of 788 ppb from A soil horizon are reported from Tavua Caldera which is the representative gold producing area of Fiji (JICA, MMAJ, 1991).

In comparison, the values obtained in Mba-west (average 2.7ppb, maximum 180 ppb) are in the order of a tenth of those in Tavua. The contents of As and Te which are considered to be related to mineralization are also low in Mba-west while those of Hg and Sb which are not related to mineralization are in the same order of magnitude.

In the above report, the values are listed in natural logarithm, this comparison was made after conversion of these figures to anti-logarithm.

The geochemical anomalies of this area are somewhat weak in their intensity, but the "anomalous zones" extracted from the Au, As, Te anomalies are in good harmony with the distribution of the alteration zones related to mineralization. Therefore, it is considered that these elements would be a useful path finder for mineral exploration.

The anomalies at Lololo Creek, Nayanggali Creek and Tauraurau Creek West are not associated with mineralized zones or altered zones at the surface. It is quite possible that these anomalies are the surface manifestations of blind altered zones in the shallow subsurface parts.

The geochemical anomalies in the northern to the central part of the Mba-west area, occur in the depression structures extracted by photogeologic studies and also in the short-wavelength high gravity anomaly zones (over 2 mgal). Thus,these anomalies are inferred to be related to mineralization, alteration, and local subsurface structures.

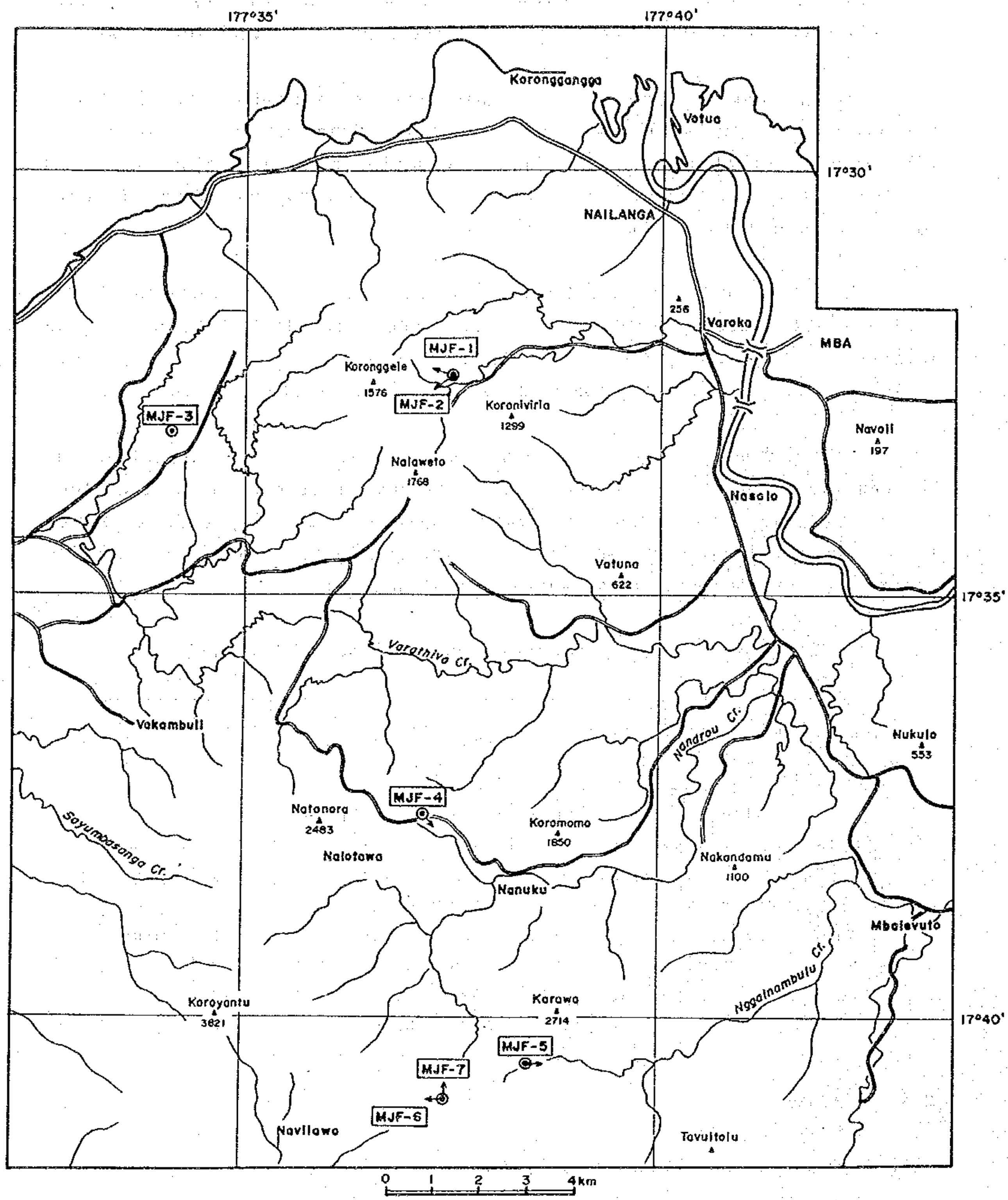
Contrast of Soil Assay between Tavua Caldera and Mba-west Area

	Number of Samples		Average		Maximum		Mini mum		unit
	Tavua	Mba	Tavua	Mba	Tavua	Mba	Tavua	Mba	
Au	62	3005	47.8	2.7	788	180	1	<5	ppb
Ag	62	3005	-	-	<0.2	<0.2	<0.2	<0.2	ppm
As	62	3005	7.8	1.0	59	30	1	<1	ppm
Sb	60	3005	0.1	0.1	0.8	1.0	<0.2	<0.2	ppm
Hg	58	3005	52	50	330	580	20	10	ppb
Te	59	3005	0.14	0.04	3.00	3.10	<0.05	<0.05	ppm

2-5 Drilling

2-5-1 Objectives, Sites, and Lengths

The objectives of the drilling were to clarify the state of subsurface gold mineralization in the Namosau Creek Alteration Zone, Nayanggali Creek Geochemical Anomaly Zone, Narotawa Alteration Zone, and Yaloku Alteration Zone. The sites and the lengths of drilling are shown below.



LEGEND

Drilling Hole

1850 Elevations in Feet

Fig. 2-2-21 Distribution Map of Drilling Holes (MJF-1~7)

Drill No.	Locality	Coordinates Latitude	Longitude	Elevation	Direction	Inclination	Drilled length
MJF-1	Namosau Cr.	S17°32.65'	E177°37.45'	91m	290°	-30°	301.00m
MJF-2	Namosau Cr.	S17°32.65'	E177°37.45'	91m	240°	-30°	301.00m
MJF-3	Nayanggali Cr.	S17°33.28'	E177°33.83'	120m	-	-90°	201.00m
MJF-4	Nalotawa	S17°37.61'	E177°37.21'	442m	135°	-40°	401.00m
MJF-5	Yaloku (Rara)	S17°40.58'	E177°38.44'	570m	90°	-50°	301.00m
MJF-6	Yaloku	S17°40.94'	E177°37.51'	686m	270°	-50°	300.90m
MJF-7	Yaloku	S17°40.94'	E177°37.51'	686m	0°	-55°	301.00m

2-5-2 Methods used

Mainly wireline method was used with a KOKEN RK-3A rig. Cores were studied by; preparation of 1/200 scale column, thin section and polished section studies, chemical analysis of mineralized parts, and X-ray diffraction studies of representative samples. At Yaloku, road construction, gravelling, repair of existing roads for a total distance of 1,600m were done in order to transport drilling equipment.

2-5-3 Geology, Mineralization and Alteration of Drill Holes

(1) Namosau Creek Alteration Zone (MJF-1 & 2)

Both holes were drilled through basalt lava and basaltic pyroclastics of the Pliocene Namosau Volcanics and confirmed the wide occurrence of argillized zone accompanied by pyrite dissemination. Ag 1.4g/t was obtained at 238.1-238.4m of MJF-1, but otherwise significant metal content was not found.

Concentric zonal arrangement of altered minerals has been clarified by surface survey near the sites. It is, from the center outward; Silicification-Alunite subzone(Subzone I) → Kaolinite subzone(Subzone II) → Sericite subzone(Subzone III) → Mixed-layer mineral subzone(Subzone IV) → Smectite-chlorite subzone (Subzone V)

The sites are at the edge of the kaolinite subzone. Drilling was done toward the part directly under the silicified-alunite subzone, and thus it was anticipated that kaolinite and silicified-alunite subzones would be encountered on a large scale.

Most of the units confirmed, however, were non-altered augite basalt and propylite (Subzone V, smectite-chlorite) with pyrite dissemination. And small clay rocks belonging to the sericite and kaolinite subzones were developed as dykes and pipes (Fig. 2-2-22).

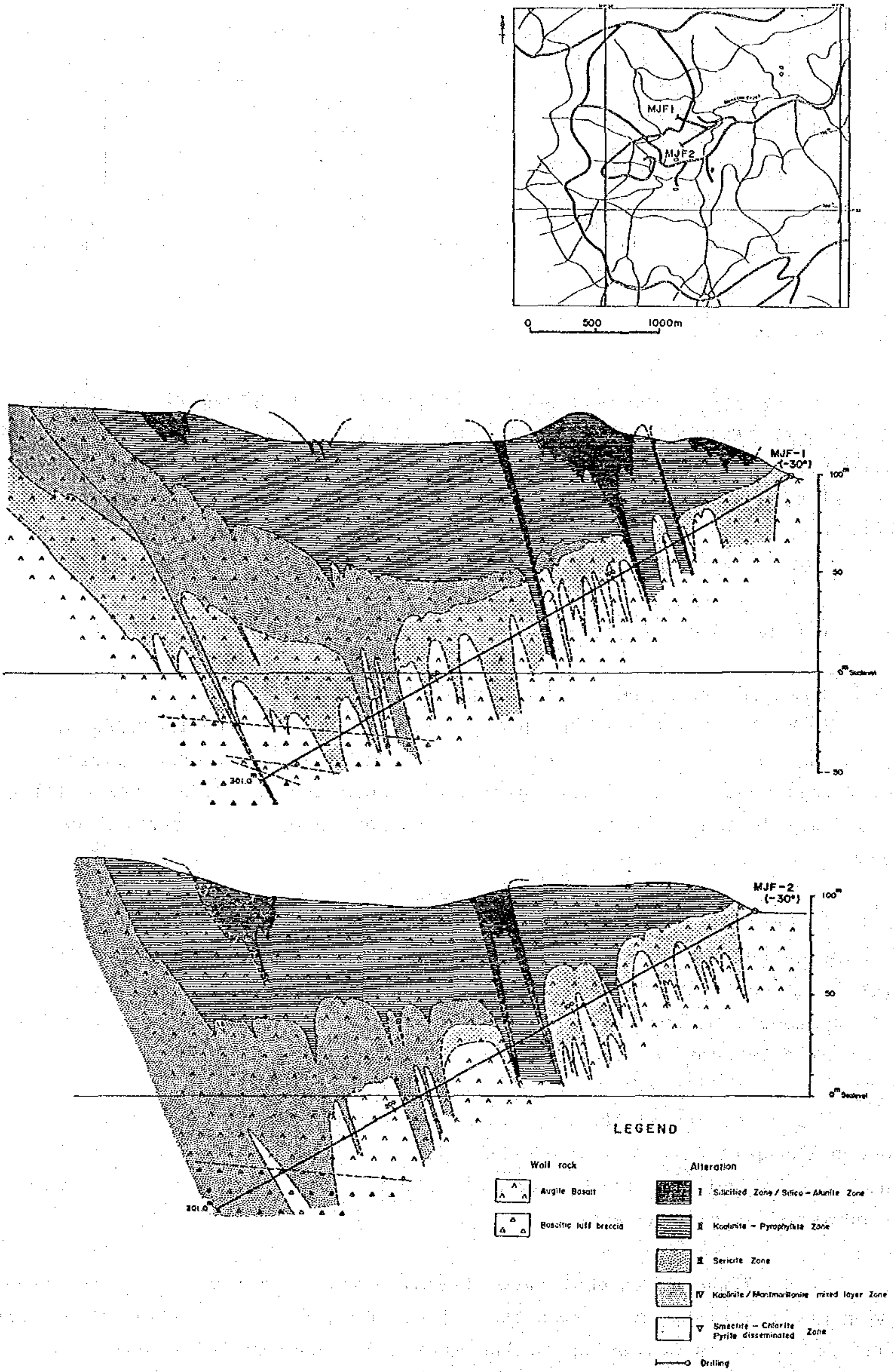


Fig. 2-2-22 Geological of Profiles of Drilling Holes (MJF-1~MJF-2)

Silicification - alunite occurs only as several veins (about 2 m wide) in this kaolinite. Mixed layer mineral subzone which is identified on the surface does not occur in the drill cores.

(2) Nayanggali Creek Geochemical Anomaly Zone (MJF-3)

The geologic units constituting this hole are: Basaltic lava (hyaloclastite), pyroclastics and sedimentary rocks alternation of Saru Formation; olivine-augite basalt and basaltic pyroclastics of Namosau Volcanics; and basalt dykes.

Neither mineralization nor vein-type hydrothermal alteration were observed in this borehole. Weak green alteration (124.2-187.8m), weak to medium propyritization (187.8-201.0m) and patches and veinlets of yellow clay and calcite occur sporadically.

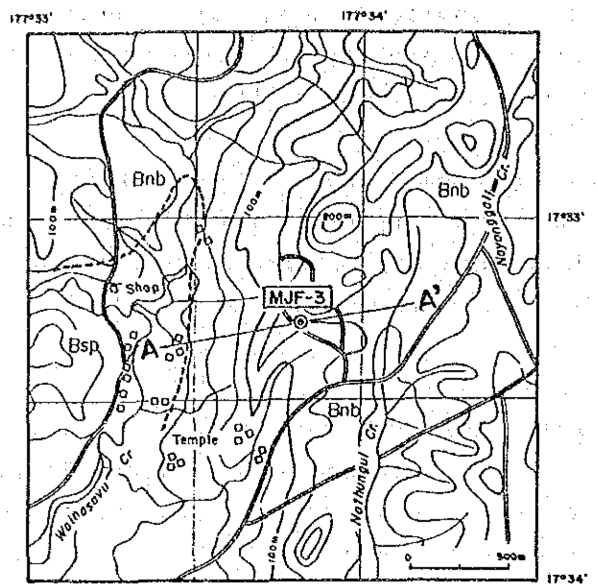
(3) Nalotawa Alteration Zone (MJF-4)

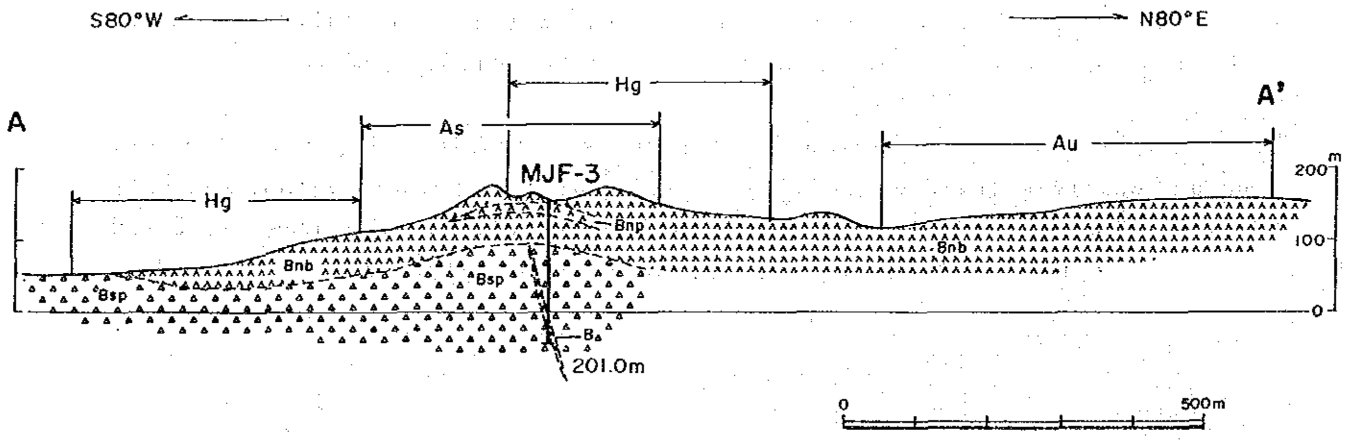
The geologic units of this borehole consists of Koronyatu Volcanic Products (basaltic lava and basaltic pyroclastics) and intrusive rocks (hornblende andesite, altered andesite, basalt) intruded therein.

Many veins were encountered in this borehole. They are; calcite veins, quartz-calcite veins, clay-pyrite-(calcite) network veins, and clay veins. Also many pyrite disseminations were observed. The ores confirmed in this borehole to have Au grade over 0.05g/t are as follows.

Depth(m)	Width(m)	Au g/t	Description
50.9- 51,4	0.5	0.116	Quartz-calcite vein
51.4- 52.4	1.0	0.082	Alteration zone along vein
100.2-103.4	3.2	0.153	Clay-pyrite veinlets
115.6-119.6	4.0	0.368	Clay-pyrite-calcite veinlets
119.6-127.6	8.0	0.152	ditto
127.6-133.7	6.1	0.083	ditto
144.8-145.0	0.2	0.091	Calcite vein
145.0-146.0	1.0	0.057	pyrite dissemination
158.1-158.11	0.01	0.052	Quartz-calcite vein

X-ray diffraction studies (XRD) of the veins showed that quartz, pyrite, and calcite are common, at times associated with smectite, sericite, dolomite and gypsum. Potash feldspar was identified in many of the veins (48.5-396.3) by sodium cobaltinitrite staining test. Polished section studies showed the common ore mineral to be pyrite associated in places with magnetite, ilmenite, goethite, chalcopyrite, sphalerite.





L E G E N D

- Namosau Volcanics
  - Bnb Basalt Lava
  - Bnp Pyroclastic Rocks
- Saru Formation — Bsp Pyroclastic Rocks
- Koroyanitu Volcanic Products
  - Bkb Basalt Lava
  - Bkp Pyroclastic Rocks
- Sabeto Volcanics
  - Ksa Andesite Lava
  - Ksp Pyroclastic Rocks
  - Ksb Basalt Lava
- Intrusive Rocks
  - A Pyroxene Andesite
  - HA Hornblende Andesite
  - B Basalt
- Au Geochemical Anomaly

cp : chalcopyrite
py : pyrite
gn : galene
q : quartz
cl : clay
ca : calcite
gyp : gypsum
lim : limonite
dol : dolomite
wd : width
v. : vein
st-w : stockwork
diss. z. : disseminated zone
sil : silicification
veins projected from attitudes measured at outcrops

Fig.2-2-23 Geological Map surround of the Drilling Hole (MJF-3)

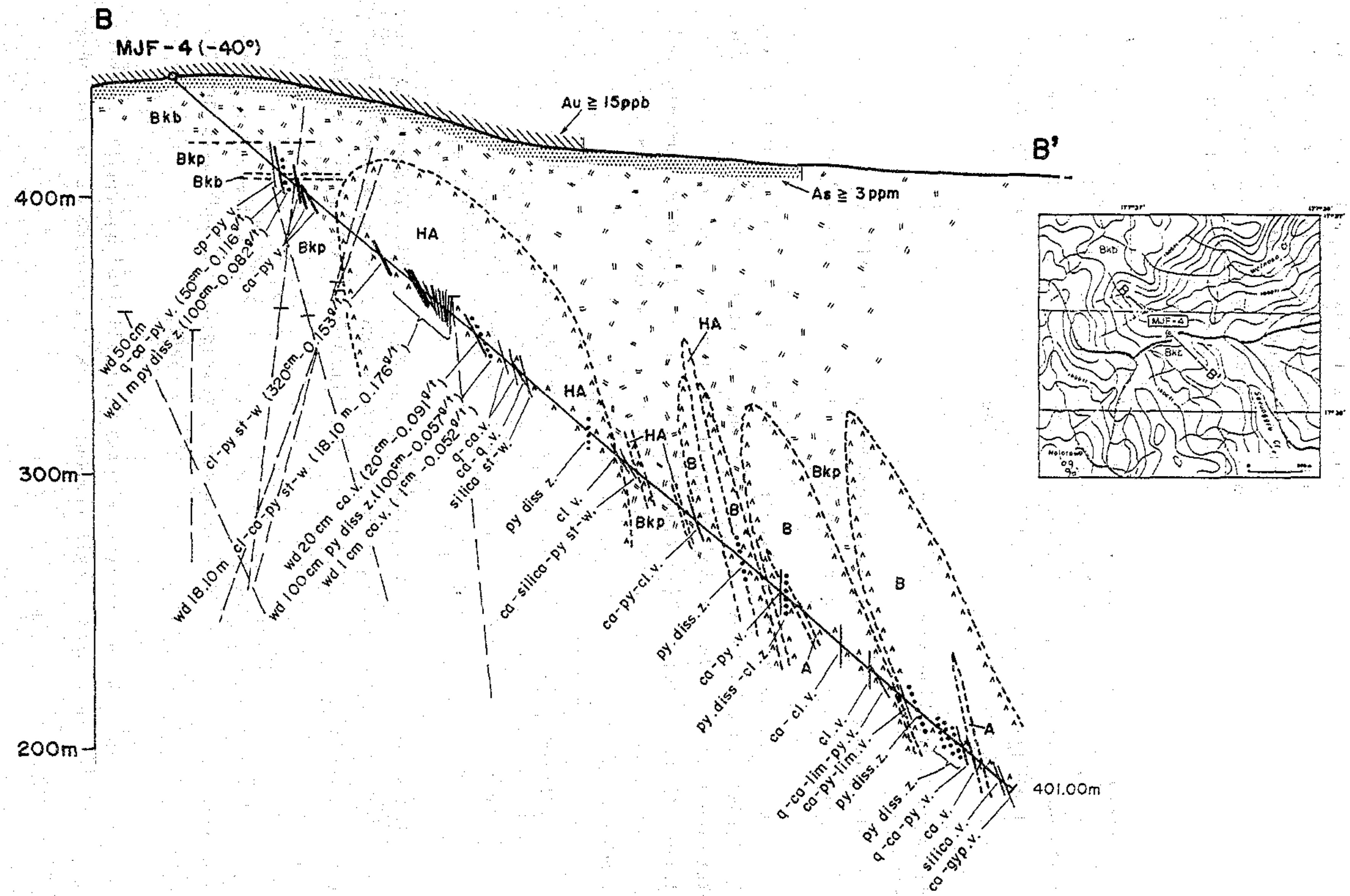


Fig.2-2-24 Geological Profile of Drilling Hole (MJF-4)

Bleached zones of several centimeters to several meters width are often observed along the margin of the veins and the constituent minerals were found to be quartz, calcite, pyrite and smectite. Similar alteration is found in the host rocks of the pyrite dissemination and network veins, and quartz, calcite, pyrite, smectite, sericite and adularia were confirmed by XRD.

Propylitization is another important host rock alteration and weak ones are confirmed at 33.0-182.6m, 234.4-270.2m, and 389.0-401.0m; medium to strong propylitization confirmed at 182.6-234.4m and 270.6-389.0m. XRD showed that quartz, calcite, pyrite, and smectite occur commonly and that chlorite and adularia are associated in places.

(4) Yaloku Alteration Zone (MJF-5, 6, 7)

[MJF-5]

The geologic units of this borehole consists of alternation of andesite lava and andesitic pyroclastics belonging to Sabeto Volcanics.

Many veins were encountered in this borehole. Many of them are 0.5-10cm wide veinlets. They are; calcite veins, quartz-calcite veins, and clay-pyrite veins. The amount of pyrite in the veins is very small. In places, there are narrow (several centimeters wide) weekly disseminated zones of pyrite adjacent to the veins. The ores confirmed in this borehole to have Au grade over 0.05g/t are as follows.

Depth(m)	Width(m)	Au g/t	Description
278.7-279.1	0.4	0.114	Calcite-quartz veinlet

XRD of the veins showed that quartz, smectite, chlorite, and calcite are common, at times associated with sericite and pyrite. A small amount of potash feldspar was identified (75.6m) by sodium cobaltinitrite staining test.

Bleached zones (several centimeters to 4.5m wide) occur often at the margin of the veins and the common constituents were found to be quartz, chlorite, sericite, calcite, and smectite by XRD.

The host rock is generally strongly propylitized and quartz, chlorite, calcite, and smectite are commonly found. Sericite occur in zones deeper than 200m.

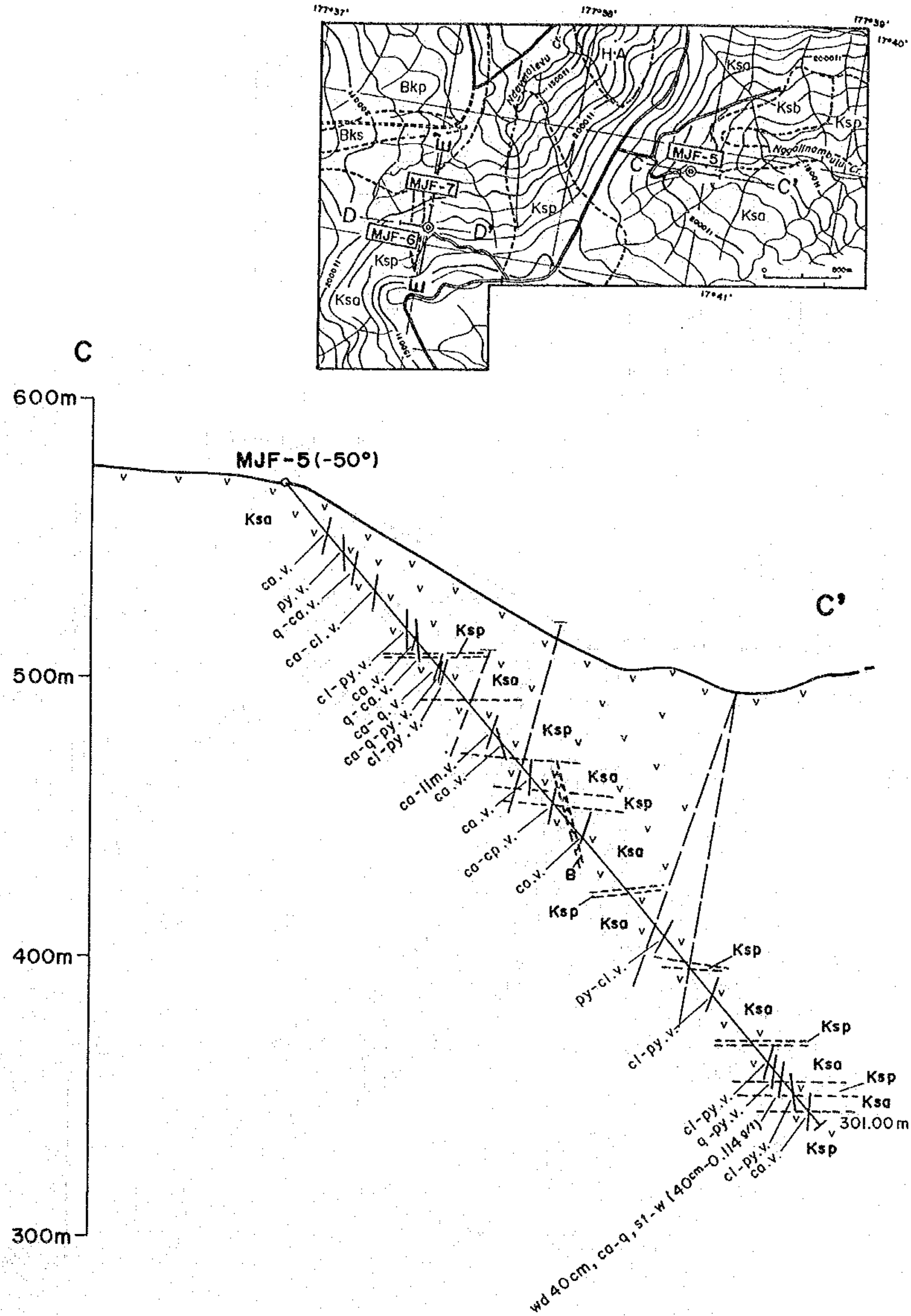


Fig.2-2-25 Geological Profile of Drilling Hole (MJF-5)

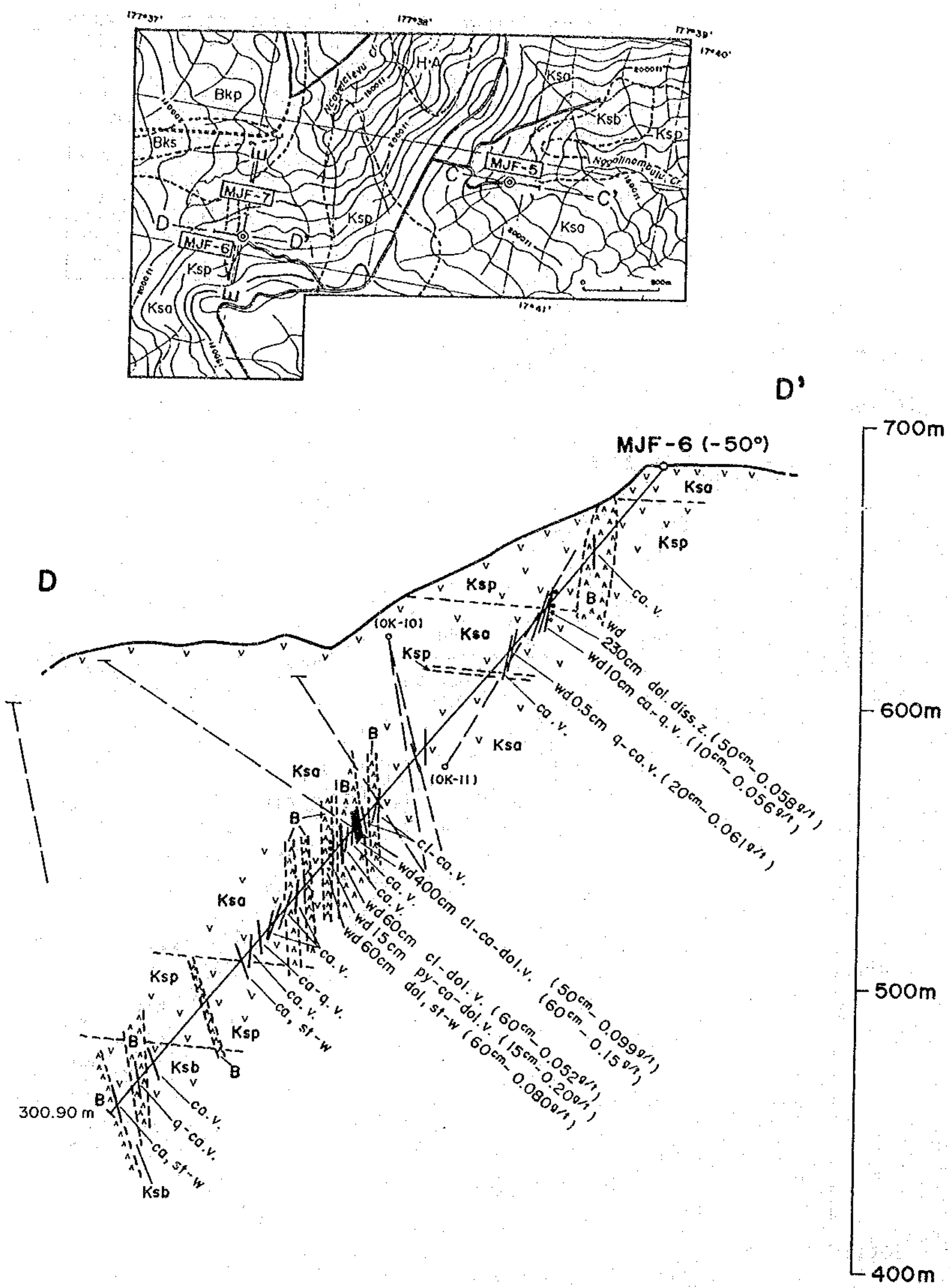


Fig.2-2-26 Geological Profile of Drilling Hole (MJF-6)

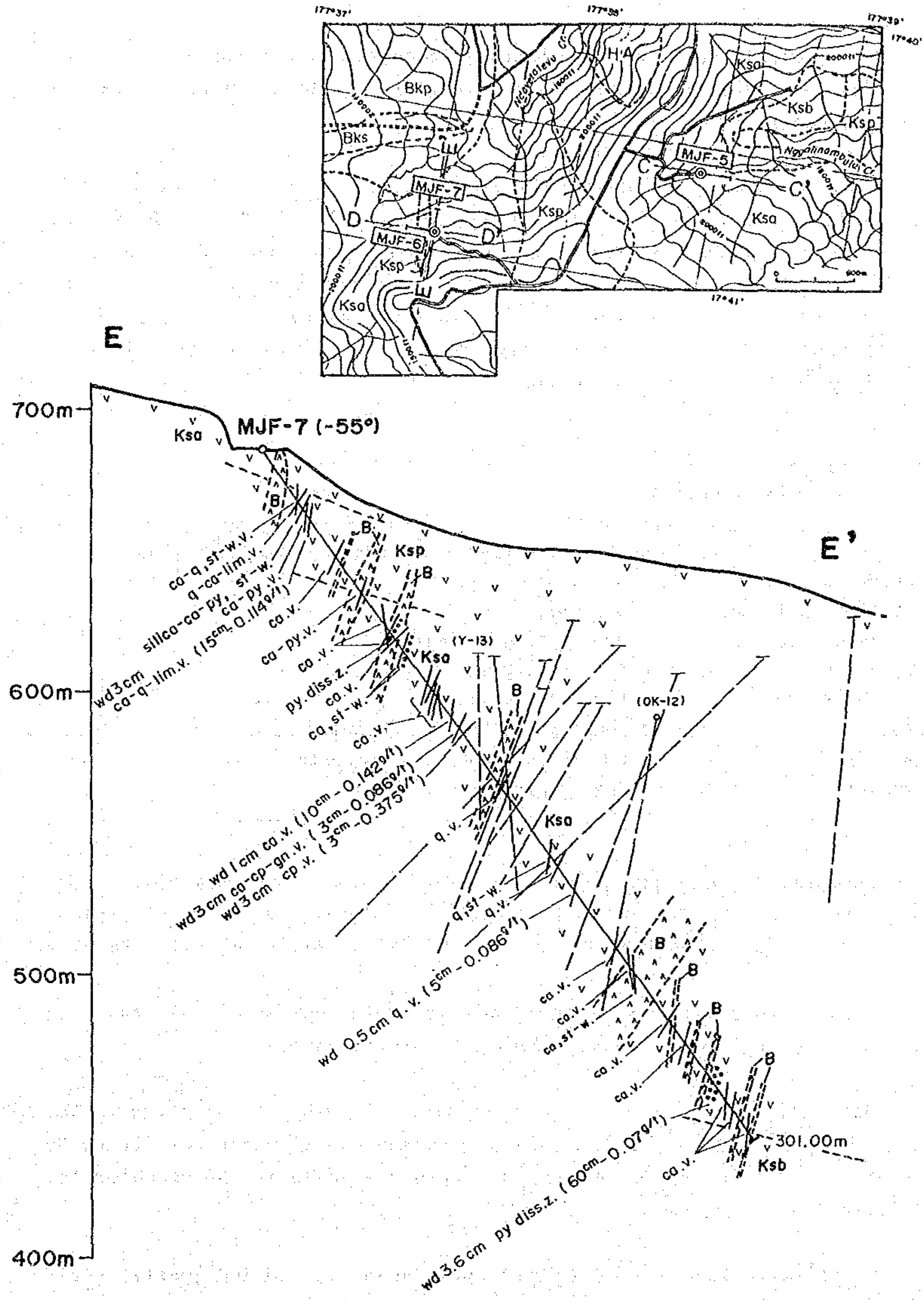


Fig.2-2-27 Geological Profile of Drilling Hole (MJF-7)

[MJF-6]

The geologic units of this borehole consists of alternation of andesite lava and andesitic pyroclastics belonging to Sabeto Volcanics, basalt lava, and basalt dykes.

Many veins were encountered in this borehole. They are 0.5-400cm wide and relatively wide veins of 15-400cm occur at 163.93-181.9m. They are; calcite veins, quartz-calcite veins, clay-calcite-dolomite veins, pyrite-calcite-dolomite veins, and dolomite-pyrite network veins. In places, there are narrow (several centimeters wide) weakly disseminated zones of pyrite adjacent to the veins. The ores confirmed in this borehole to have Au grade over 0.05g/t are as follows.

Depth(m)	Width(m)	Au g/t	Description
63.7- 64.1	0.6	0.058	Calcite-quartz vein, pyrite dissemination
86.2- 86.4	0.2	0.061	Calcite vein
154.7-155.0	0.3	0.072	ditto
156.0-157.0	1.0	0.086	calcite veinlets
165.0-169.0	4.0	0.055	Clay-calcite-dolomite vein
175.6-176.2	0.6	0.052	clay vein
180.4-180.55	0.15	0.200	Pyrite-calcite-dolomite vein
181.3-181.9	0.6	0.080	Dolomite-pyrite veinlets
195.3-195.35	0.05	0.059	Quartz-calcite vein

XRD of the veins showed that quartz and adularia are common, at times associated with chlorite, sericite, smectite, dolomite and calcite. Potash feldspar was identified (166.0m, 219.4m) by sodium cobaltinitrite staining test.

Pyrite and chalcopyrite were found to be the common ore mineral with association of magnetite and molybdenite by ore microscopy.

Bleached zones (several centimeters to 2.5m wide) occur often in the host rocks adjacent to the veins and the common constituents were found to be quartz, smectite and adularia, with occasional association of chlorite, calcite and pyrite by XRD.

The host rocks are generally strongly propylitized and quartz, sericite, adularia, calcite, and smectite are commonly found by XRD. Chlorite and pyrite occur occasionally.

[MJF-7]

The geologic units of this borehole consists of andesite lava, andesitic tuff breccia and basalt lava belonging to Sabeto Volcanics and basalt dykes.

Many veins were encountered in this borehole. They are thin veinlets of 0.5~25cm in width. They are mostly calcite veins, quartz-calcite veins, and quartz veins. Calcite-chalcopyrite-galena veins and chalcopyrite veins are rarely observed. There are a small number of weakly disseminated zones of pyrite. The ores which were confirmed in this borehole to have Au grade over 0.05g/t are as follows.

Depth(m)	Width(m)	Au g/t	Description
29.1 ~ 29.25	0.15	0.114	calcite-quartz-limonite vein
121.0 -121.1	0.1	0.142	Calcite vein
121.93-121.96	0.03	0.086	Calcite-chalcopyrite-galena vein
123.50-123.53	0.03	0.375	Chalcopyrite vein
191.4 -191.45	0.05	0.086	Quartz vein
277.0 -277.6	0.6	0.071	Pyrite dissemination zone

XRD of the veins showed that chlorite is common and in places the veins are associated with sericite, dolomite, adularia, calcite, marcasite, and pyrite. Potash feldspar was identified (26.8m, 82.35m and 275.7m) by sodium cobaltinitrite staining test in the veins. Chalcopyrite was found to be the common ore mineral with association of pyrite, bornite, galena, and stromeyerite by ore microscopy.

Bleached zones (several centimeters to 2m wide) occur often at the margin of the veins and the common constituents were found to be quartz, chlorite, adularia and calcite, with occasional association of smectite by XRD.

The host rock is generally strongly propylitized and quartz, chlorite, and calcite, are commonly found by XRD. Smectite, adularia and dolomite occur occasionally.

2-5-4 Discussions Regarding Drilling Results

(1) Namosau Creek Alteration Zone (MJF-1, 2)

It has been confirmed that below the acidic alterated zone, propylitization is widely developed in the drill cores. This is interpreted that the acidic altered zone which is widely developed on the surface has a mushroom-shaped profile and the drilling penetrated its stem. The silicification - alunite subzone is inferred to be developed in the central part of this mushroom-shaped acidic altered zone and extend in the vertical direction as veins or pipes. It is highly possible that the lowermost part of Summitville type alteration is exposed.

If Summitville type (silicified pipe) or Nansatsu type (network mineralization in strata·bound silicified rocks) deposits were to occur in the Namosau Creek area, the location of the bonanza would be higher than the present surface and most probably would have been eroded out.

(2) Nayanggali Creek Geochemical Anomaly Zone (MJF-3)

Evidences of mineralization and significant hydrothermal mineralization were not observed by drilling in this area. Thus, the occurrence of subsurface alteration zone with horizontal extent in this geochemical anomalous zone is considered to be not probable. The existence of compact volcanic rocks in the NE-SW trending topographic highs of the geochemically anomaly zone indicate that this zone is located in the center of former igneous activity. Network of iron oxides occurs in the above highs. It is not clear whether these iron oxides are secondary product from hydrothermal mineralization or weathered product from basalt, but they do indicate that fractures are developed.

From the above observation, it is believed that the geochemical anomalies are the product of vein-type hydrothermal activity subsequent to volcanism. But it is most probably very difficult to confirm because of the lack of surface manifestations and alteration.

(3) Nalotawa Alteration Zone (MJF-4)

Many of the veins confirmed in this borehole occur within the intrusive bodies (hornblende andesite, basalt, altered andesite) or along fractures formed nearby. Therefore, it is considered that factors of primary importance in the formation of the veins of this zone are the existence of fractures which control the distribution of the intrusive bodies and also the existence of compact and hard rocks in which these fractures are formed.

The veins with Au content exceeding 0.05g/t occur in zones shallower than 158.11m and although there are veins deeper than the above, the grade is low. The zone of higher gold content is directly below the surface soil Au anomaly (Au≥15ppb)(Fig.2-3-24). From the above, it is considered that the gold concentration is controlled by the depth and extends horizontally.

It is not possible to determine the type of mineralization from the ore minerals because only a few kinds of ore minerals occur in the veins. Occurrence of magnetite in epithermal veins is rare, but it is reported to occur in the deposits of the Emperor Mine.

The assemblage of the major gangue minerals (quartz, calcite, potash feldspar, smectite, sericite) and of the major alteration minerals near the veins (quartz, calcite, pyrite, smectite and adularia) is closest to that of the low sulfidation epithermal veins.

(4) Yaloku Alteration Zone (MJF-5, 6, 7)

Of the three boreholes drilled in this zone, MJF-5 is the least interesting in terms of number of veins, width of veins and the grade of ores. It was drilled through pyroclastics and fractured lava, and hard and compact dykes are not developed. On the other hand, wide veins occur concentrated between 163.93m and 181.9m depth in Borehole MJF-6 and dykes are also concentrated in this part. It is, thus, evident that development of dykes and the veins are closely related in this zone as in the case of Nalotawa Zone.

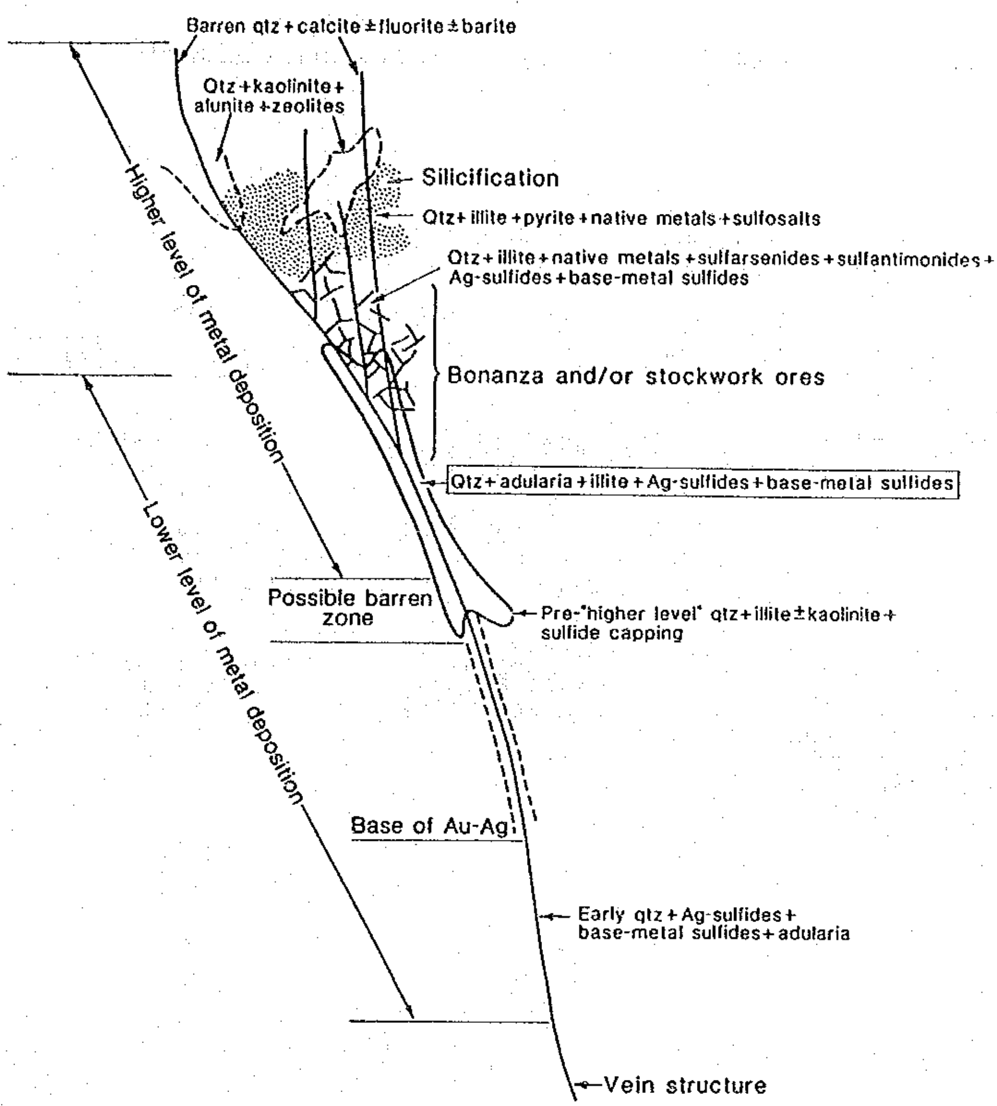
The common ore minerals of this zone are chalcopyrite and pyrite with rare occurrence of molybdenite, bornite, galena, and stromeyerite. Molybdenite usually occur in mesothermal to hypothermal deposits and not in epithermal environment. But it is reported from Cripple Creek (Colorado, USA) which is a Au-Ag-Te vein deposit and considered to be of epithermal or subvolcanic type. Stromeyerite is reported from epithermal Goldfield (Nevada, USA). It is concluded with the above examples, that the mineral assemblage of this borehole was formed under relatively deep epithermal environment.

The assemblage of major gangue minerals differ between those in the east (MJF-5) and west (MJF-6, 7). Those common to both groups are quartz, smectite, chlorite, sericite, calcite, and adularia. In the western veins, dolomite occurs in addition to the above. The major assemblage is quartz-smectite-chlorite-calcite in the eastern veins while quartz-adularia in those of the west.

The assemblage of main alteration minerals near the veins also differ in the two groups (MJF-5 and MJF-6, 7). That common for both groups is quartz-chlorite-calcite-smectite with addition of sericite in the east and adularia in the west.

The assemblage of gangue and alteration minerals indicate low sulfidation epithermal environment of formation, and the western veins were probably formed under higher temperatures.

The mode of occurrence of the veins confirmed by drilling in this zone corresponds to the " quartz + adularia + illite + Ag sulfides + base metal sulfide zone" of the low sulfidation (quartz-adularia type) epithermal model (Berger and Eimon, 1983, Fig. 2-2-28).



Schematic cross section of quartz-adularia or low sulfur bonanza deposit, Bonanza-IA model, showing alteration mineralogy and two zones of mineralization from the "closed cell convection" model of Berger and Eimon (1983).

Fig. 2-3-8 Schematic Cross Section of Low Sulfur Bonanza Deposit

Table 2-2-3 Assemblage of Ore, Gangue and Alteration Minerals

(Phase Ⅲ)

Area		Nayanggali	Nalotawa		Eastern part* of Yaloku		Western part of Yaloku		
		MJF-3	Outcrops	MJF-4	Outcrops	MJF-5	Outcrops	MJF-6	MJF-7
Host Rock	Name	Ol-Bs	Bs	Hb-Ad, Bs	Ad	Ad	Ad	Ad, Bs	Ad, Bs
Host Rock	Alteration	Sm-Tri-Cal	K/M-S/M-Ser-Sm	Qz-Sm-Py-Cal>(Chl)-(Adul)	Qz-Chl-Ser-(Sm)-Cal	Qz-Chl-Cal>(Sm)U.-(Ser)L.	Qz-Adul-Chl-Ser-(Cal)-(Sm)	Qz-Ser-Adul-Cal>Sm-(Chl)-(Py)	Qz-Chl-Cal>(Sm)-(Adul)-(Dol)
Vein	Ore Mineral	–	Py	Py-(Mg)-(Iℓ)-(Goe)-(Cp)-(Sph)	Cp-Py	(Py)	Py	Py-Cp-(Mg)-(Mo)	Cp-(Py)-(Bo)-(Gn)-(Str)
Vein	Gangue Mineral	–	Qz-Sm-Kao	Qz-Cal>Sm-Ser>(Dol)-(Gyp)-(Kf)	Qz-Chl-Ser-Cal	Qz-Sm-Chl-Cal>(Ser)>(Kf)	Qz-Adul	Qz-Adul-(Chl)-(Ser)-(Sm)-(Dol)-(Cal)	Qz>Adul-Chl-(Ser)-(Dol)-(Cal)
Adjacent to Quartz Vein (Bleached Zone)		–		Qz-Sm-Cal-Adul Py-Tc	Qz-Sm-Chl-Ser-Cal	Qz-Chl-Ser-Cal>(Sm)	Qz-Sm-Cal-Adul>Chl	Qz-Sm-Adul-(Chl)-(Cal)-(Py)	Qz-Chl-Adul-Cal>(Sm)

Abbreviations:

Ol-Bs: Olivine-Basalt, Hb-Ad: Hornblende-Andesite, Bs: Basalt
Sm: Smectite, Tri: Tridymite, Kf: Potassium feldspar, Qz: Quartz, Chl: Chlorite, Cal: Calcite, Ser: Sericite, Dol: Dolomite, Gyp: Gypsum, Adul: Adularia, Tc: Talc, Mon : Montmorillonite, K/M : Kao/Mon mixed layer minaral, S/M : Ser/Mon mixed layer mineral, Py: Pyrite, Cp: Chalcopyrite, Bo: Bornite, Gn: Galena, Str: Stromeyerite, Mg: Magnetite, Mo: Molybdenite,
Iℓ: Ilmenite, Goe: Goethite, Sph: Sphalerite
U.: upper part, L.: lower part, ( ): local, ( ): rare
*: Rara village area

Chapter 3 Sigatoka Area

In the Sigatoka area, Colo Plutonic Suite occurs widely throughout the area, and there are wide zones of alteration and mineralization (porphyry copper type, skarn type etc.,) associated with these plutonic bodies. Based on these facts, it was considered that the area should be delineated as having relatively high resource potential. And geological survey, geochemical prospecting and gravity survey were conducted during the second phase of this project.

3-1 Geology

3-1-1 Outline of Geology

The geology of this area consists of Miocene Series, Pleistocene (?) Series, and igneous bodies intruded into the Miocene Series. The Miocene Series consists of the Lower Tari and Upper Tari Formations of the Wainimala Group. The Lower Tari Formation is composed mainly of basaltic volcanic products and associated andesite lava and limestone. The Upper Tari Formation is composed of andesitic volcanic products and sedimentary rocks such as mudstone and sandstone. The Pleistocene (?) Series consists of fluviatile conglomerate.

The intrusive bodies are Colo Plutonic Suite and volcanic dykes which intrude into the Upper Tari Formation. The Colo Plutonic Suite is grouped into, age-wise, granodiorite - diorite porphyry bodies; and granodiorite, diorite, diorite porphyry, granite, quartz porphyry and aplite. The former group is older than the latter group. The volcanic dykes are composed of basalt, andesite, dacite, and rhyolite.

The Miocene Series of this area generally has a superimposed and southwestward dipping structure.

3-1-2 Geological Description

(1) Lower Tari Formation

Distribution: Throughout the area with the exception of the vicinity of Kambisi Village in the southwest side of the survey area and also west of Mt. Korokitu.

Lithology: The formation consists mainly of basalt lava and basaltic pyroclastics associated with andesite lava, silicic pyroclastics and limestone.

The basalt lava is dark green, compact, hard rock. It occurs as massive and also as brecciated lava and hyaloclastite. This rock usually contains augite phenocrysts of 1 mm in size and often is porous with amygdaloidal texture. It is also propylitized in many cases.

The basaltic pyroclastics is composed of tuff breccia, lapilli tuff, and tuff associated with tuffaceous sandstone and volcanic conglomerate consisting of granules. It is propylitized in many cases. The pyroclastics is well-sorted, the granules are propylitic basalt and the matrix is strongly compacted.

Andesite lava was identified by microscopic study of dark green brecciated lava from Tumbaivaka Creek in the north of Emuri Village and cannot be distinguished from basalt lava by unaided eyes. Thus, it was not possible to indicate the distribution of this rock in the geological map.

The silicic pyroclastics is composed of greenish white lapilli tuff and tuff distributed in the central part of the northeastern side of the area. It includes aphyric dacite to rhyolitic pebbles. In parts of this rock, it contains flat pumice and green patches, and show eutaxitic structure.

The limestone is dark gray, compact, hard, and homogeneous. It occurs as very small thin beds.

Stratigraphy: This formation is overlain conformably by Upper Tari Formation. The relation with the lower units is not clear. The pyroclastics and limestone of this formation is intercalated in the basalt-andesite lava.

(2) Upper Tari Formation

Distribution: Vicinity of Kambisi Village and to the west of Korokitu.

Lithology: It is composed of andesite lava, andesitic pyroclastics and sedimentary rocks.

The andesite lava is dark green to gray, compact, hard, and characteristically contains relatively large phenocrysts of hornblende (3-7 mm) and plagioclase (3 mm). It is propylitized in some places.

Andesitic pyroclastics is composed of volcanic breccia, tuff breccia, lapilli tuff and tuff. The volcanic breccia is intercalated locally in andesite lava as thin beds; tuff breccia, volcanic breccia, and tuff form alternation with the sedimentary rocks.

The sedimentary rocks consists of black to purple mudstone and sandstone, and thin beds of andesitic pyroclastics, basaltic tuff, and basalt are intercalated, and often form alternation. The compaction of this rock is high.

Stratigraphy: This formation overlies the Lower Tari Formation conformably and is overlain unconformably by fluviatile sediments. In this formation, pyroclastics and sedimentary rocks are intercalated in andesite lava.

(3) Fluviatile sediments

Distribution: Small scale in the northwestern part of the area.

Lithology: This unit is weathered and is reddish brown. Pebbles and subangular boulders (20-30 cm) of volcanic rocks and matrix are weakly consolidated. It is argillized and the details are not clear.

Stratigraphy: This overlies the Upper Tari Formation unconformably. This is considered to be of Pleistocene age from the degree of consolidation.

3-1-3 Intrusive Rocks

(1) Granodiorite porphyry - diorite porphyry (Colo Plutonic suite)

Distribution: Many large stocks in the northeastern side of the area.

Lithology: This rock is pale green to grayish white, compact, and contains plagioclase phenocrysts (2-4 mm) and very fine-grained mafic minerals, also phenocrysts of quartz and hornblende are often observed. It is often weathered and the color is brown to yellowish white. It is often identified as dacite or andesite by the unaided eyes, but it is porphyry microscopically. It is difficult to determine the boundary of granodiorite porphyry and diorite porphyry because of the strong weathering, thus it is treated as one unit. The rock is partly propylitized and argillized.

Time of intrusion: This porphyry intrudes into the Lower Tari Formation, and is intruded by other members of the Colo Plutonic Suite and volcanic dykes. The radiometric age of a rock in the northwest which is inferred to be this porphyry is 10.1±1.6 Ma (Fig. 2-1-18).

(2) Rhyolite

Distribution: As small dykes and stocks in the northern part of Mt.Mburua in the southeastern and northern part of Mt. Waindolo.

Lithology: White silicic rock with quartz and feldspar phenocrysts.

Time of intrusion: This intrudes into the granodiorite porphyry - diorite porphyry. The relation with other intrusive rocks is not clear. Since this rhyolite bodies occur only within the granodiorite porphyry - diorite porphyry bodies, the possibility of this rock being a segregation product from the magma which formed the Colo Plutonic Suite is considered.

(3) Diorite (Colo Plutonic Suite)

Distribution: Many large to small scale stocks distributed almost throughout the entire area.

Lithology: Many parts are weathered to sandy state and fresh parts are very rare. The rock consists of augite, hornblende, plagioclase of 1-2 mm size, and is partly micro-dioritic. Also some parts are argillized and pyritized.

Time of intrusion: This diorite intrudes into granodiorite porphyry-diorite porphyry.

(4) Diorite porphyry (Colo Plutonic Suite)

Distribution: As small stocks in the northwest, central, and southwestern part of the area.

Lithology: This porphyry is dark greenish gray, and has porphyritic texture composed of 2-3 mm size phenocrysts of hornblende and plagioclase. Parts of this rock is propylitized.

Time of intrusion: This porphyry intrudes into the Upper and Lower Tari Formations.

(5) Granodiorite (Colo Plutonic Suite)

Distribution: Many stocks of varying size occur throughout the area.

Lithology: Many parts are weathered to sandy state and fresh parts are rare. The rock consists of 2 mm size biotite, hornblende, plagioclase, quartz, and others. It is argillized and pyritized in some parts.

Time of intrusion: This granodiorite intrudes into granodiorite porphyry - diorite porphyry bodies and is intruded by aplite, basalt, and andesite dykes. The radiometric age of a rock which is inferred to be this granodiorite is 8.1 ± 0.3 Ma (Fig. 2-1-18).

(6) Granite (Colo Plutonic Suite)

Distribution: As very small stocks within the granodiorite porphyry - diorite porphyry in the southeast.

Lithology: The rock consists of 0.5-2 mm size quartz, potash feldspar, and chloritized mafic minerals. It is partly propylitized.

Time of intrusion: This intrudes into granodiorite porphyry - diorite porphyry.

(7) Quartz porphyry (Colo Plutonic Suite)

Distribution: As very small bodies within mainly granodiorite porphyry - diorite porphyry in the northwest and near granodiorite bodies in the southeast.

Lithology: This porphyry contains phenocrysts of quartz, plagioclase, hornblende, and biotite. It is often silicified and pyritized.

Time of intrusion: This rock intrudes into granodiorite porphyry - diorite porphyry bodies and the Lower Tari Formation.

(8) Aplite (Colo Plutonic Suite)

Distribution: As small bodies in the southeast.

Lithology: This is a leucocratic granitic rock forming dykes of several to 50 cm wide.

Time of intrusion: This rock intrudes into the granodiorite bodies and Lower Tari Formation.

(9) Basalt

Distribution: As dykes (often dyke swarms) within and vicinity of the plutonic bodies in the central to southeastern part of the area, only very few occurrences in the northwest.

Lithology: There are dark green, fine-grained, and compact type and doleritic type. They are both propylitized.

Time of intrusion: This basalt intrudes into the Upper and Lower Tari Formations, granodioritic bodies, and granodiorite porphyry - diorite porphyry bodies.

(10) Andesite

Distribution: As dykes in the central and southeastern part, and the distribution is to the southwestern side of the plutonic predominant zone.

Lithology: This andesite contains phenocrysts of plagioclase and hornblende, and is lithologically similar to the andesite lava in the Upper Tari Formation. It is silicified in the southeast.

Time of intrusion: This intrudes into the Upper and Lower Tari Formations, granodiorite and the granodiorite porphyry - diorite porphyry bodies.

(11) Dacite

Distribution: As dykes in the central and southeastern part of the area.

Lithology: This dacite is white to pale green and mostly aphyric and rarely with hornblende phenocrysts. Parts of this rock are silicified, argillized and pyritized.

Time of intrusion: This intrudes into the Lower Tari Formation and granodiorite porphyry - diorite porphyry bodies.

3-1-4 Geologic Structure

The Yavuna Group which forms the basement of Viti Levu occurs 8-13km north of this area. The formations of this area is generally superimposed with southwestward dip.

There is a large WNW-ESE trending fault which extends from the northwest to the southeastern part of the area. It is partly estimated, but is confirmed in the Upper and Lower Tari Formations and in the granodiorite porphyry - diorite porphyry bodies. In the southeast, a fault parallel to the above and an estimated NW-SE trending fault exist in the Lower Tari Formation and granodiorite porphyry - diorite porphyry bodies and are cut by ENE-WSW trending estimated fault. Also in the central part of the area, NNE-SSW trending fault (partly estimated) exist in the upper and Lower Tari Formations.

Regarding the fold structure of this area, a ENE-WSW trending synclinal axis is observed in the Lower Tari Formation in the northeast, but data on the strike and the dip of the axis in this formation are insufficient and the structure cannot be clarified.

The following features are observed regarding the elongation of the intrusive bodies in this area (Figs. 2-1-6 & 2-3-3).

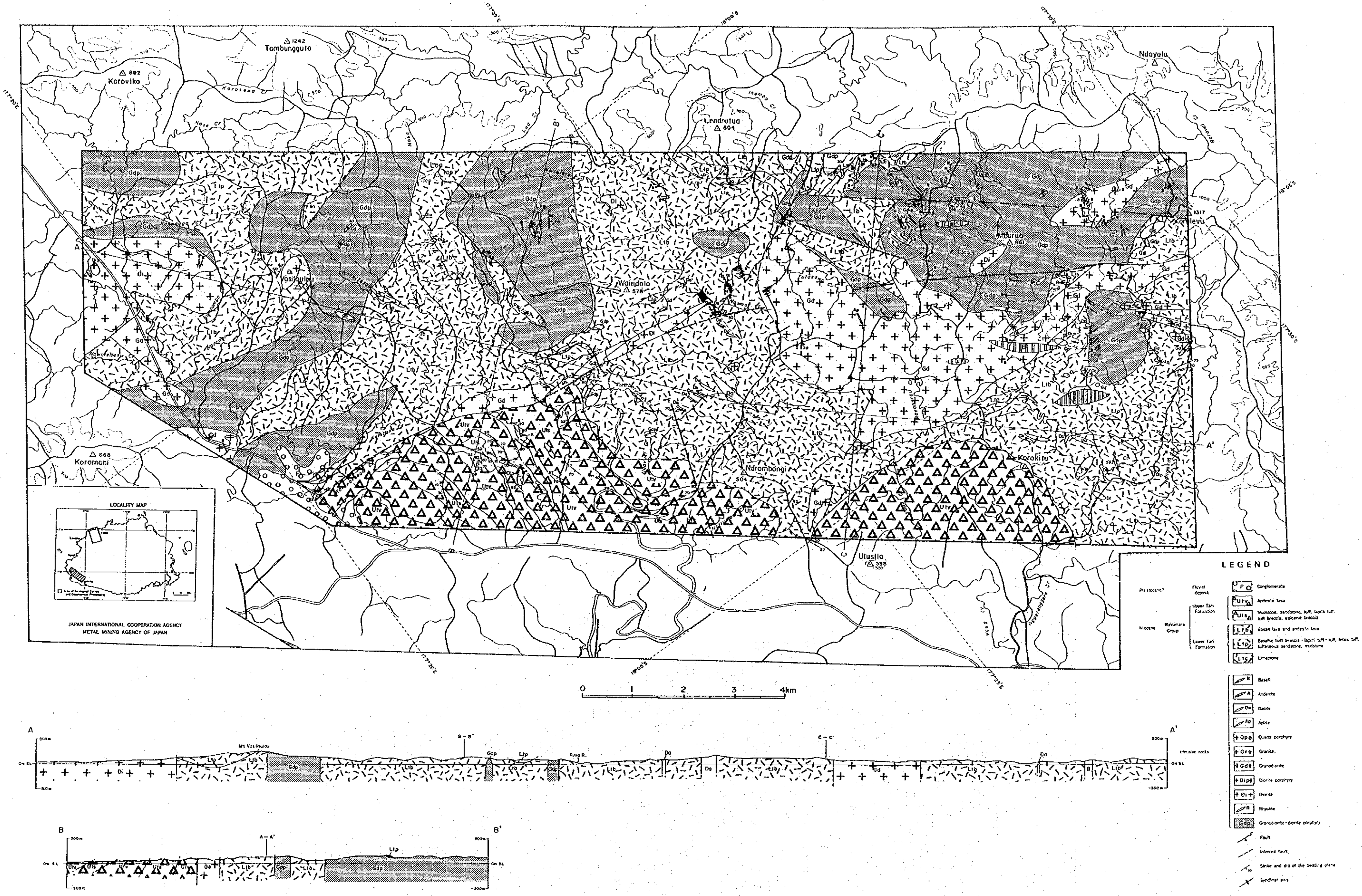
The granodiorite porphyry - diorite porphyry bodies are elongated in the WNW-ESE direction and that of many individual bodies is in the ENE-WSW direction. The granodiorite and diorite bodies extend in the WNW-ESE direction and the elongation of many individual bodies is in the E-W to WNW-ESE direction.

Regional airborne magnetic survey indicates the existence of a very large body (15km x 40km) extending in the WNW-ESE direction in subsurface zones. And it is considered that the small surface bodies are stocks or plugs branching out from this large body (Colley, 1976).

Many dacite dykes trend in the NW-SE to NNW-SSE direction and in the central part of the area, they form echelon dykes elongated in the E-W and N-S directions.

Many of the andesite dykes trend in the NW-SE to WNW-ESE direction.

The basalt dykes trend in various directions, but they have characteristic trends in each subarea. These trends are; ENE-WSW to WNW-ESE direction in the central part near the WNW-ESE fault system, NNW-SSE to NNE-SSW direction west of Mt.Mburua, and NW-SE direction southwest of Mt.Mburua. The basalt trends in many direction and is partly distributed in radial pattern in the northeast side of the southeast margin of the Sigatoka area.



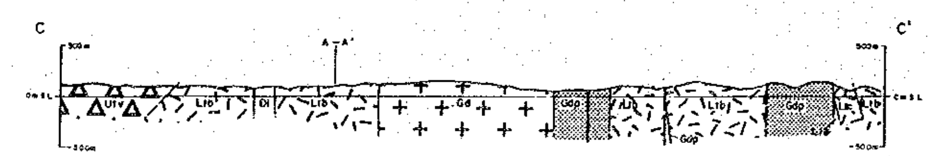


Fig. 2-3-1 Geological Map with Geological Profiles of the Sigatoka Area

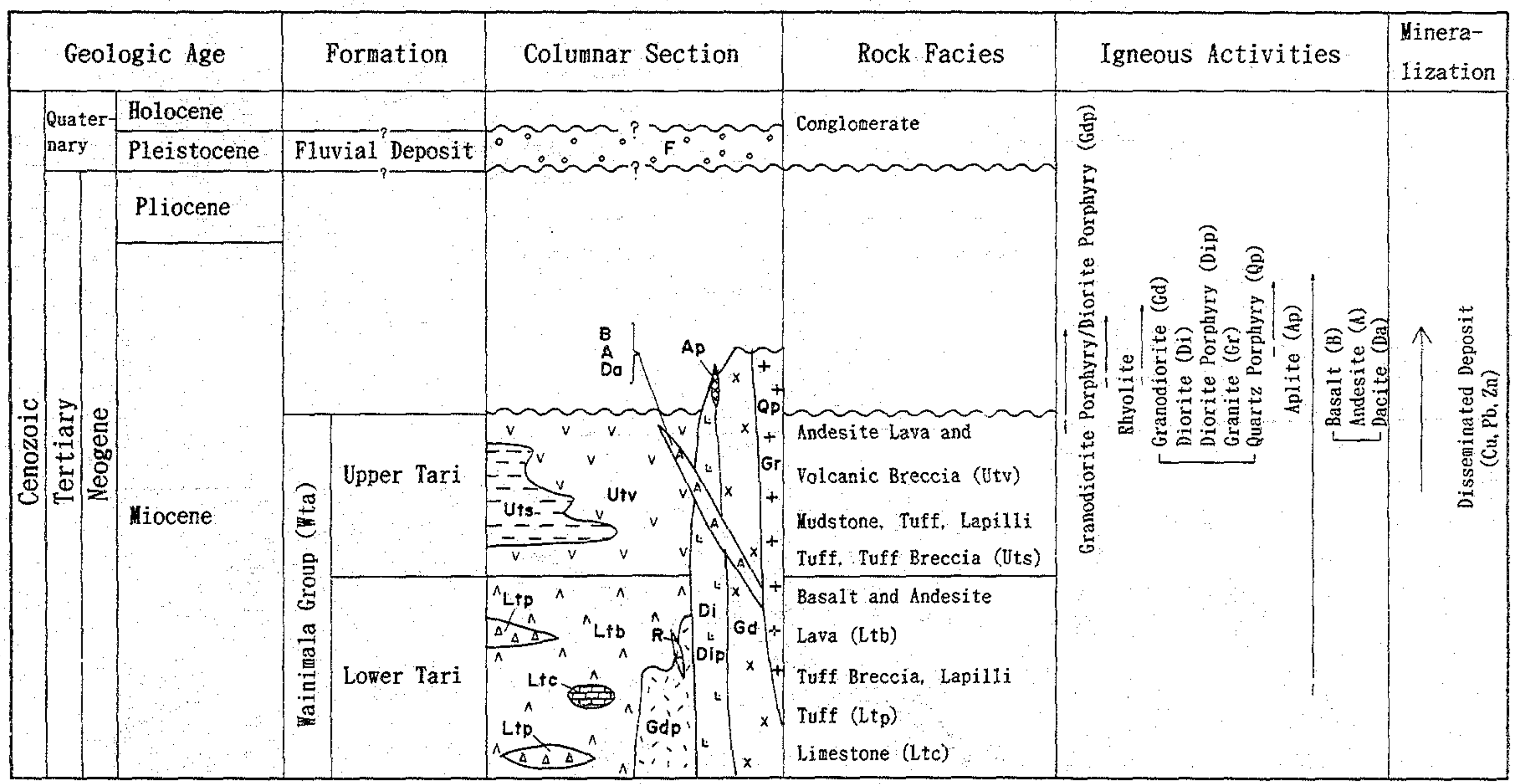


Fig. 2-3-2 Schematic Stratigraphic Columns (Sigatoka Area)

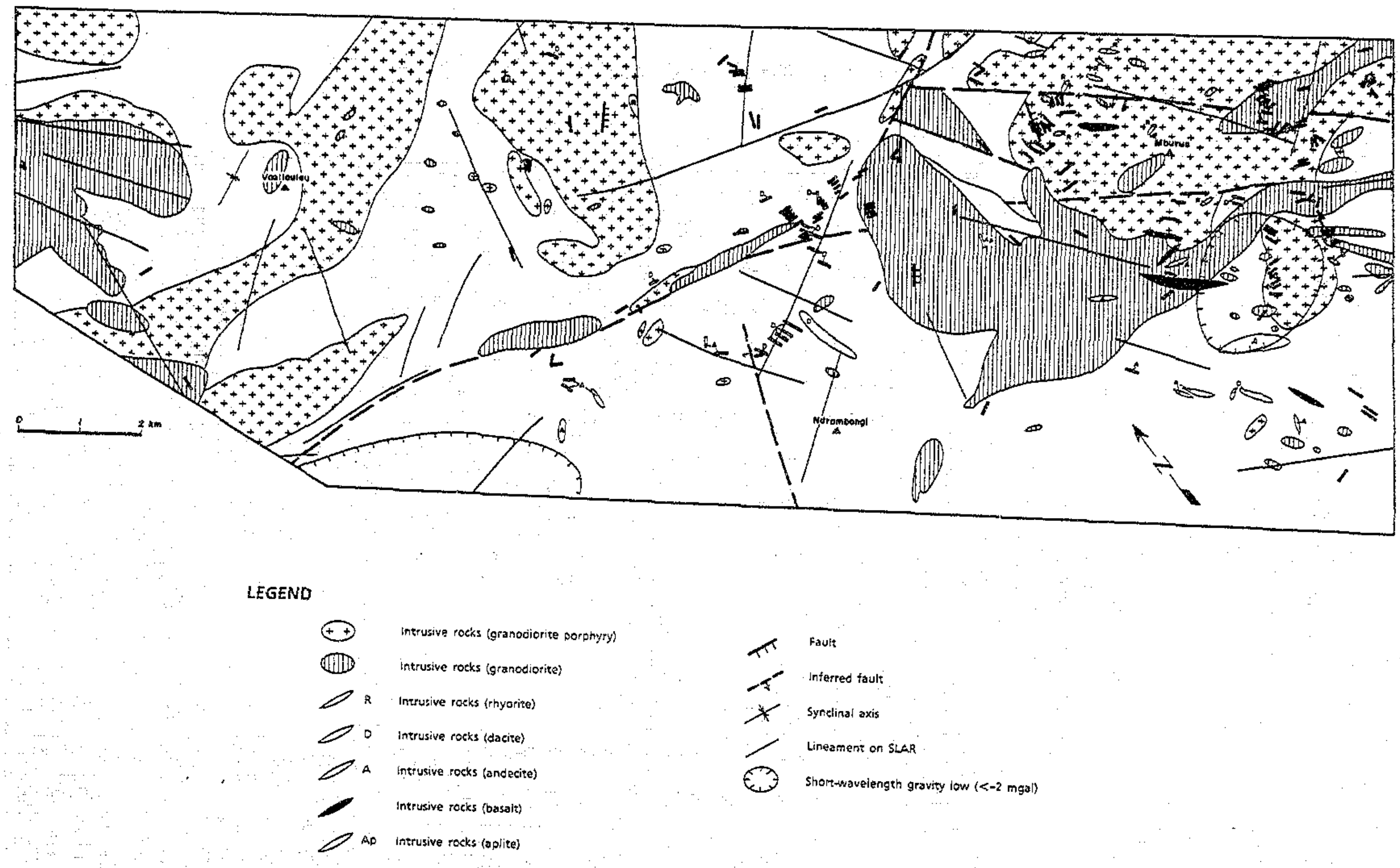


Fig. 2-3-3 Structural Map (Sigatoka Area)

The andesite, dacite, and basalt form echelon dykes elongated in the NW-SE direction.

Lineaments identified to occur in this area by SLAR image analysis during the first phase survey trend in NW-SE, WNW-ESE, and NNE-SSW to NE-SW. The latter lineaments occur widely from the northwestern part to the central part of the area.

3-2 Mineralization and Alteration

3-2-1 Known Mineral Showings and Past Mineral Exploration

A large number of small mineral showings have been known in this area (Fig. 1-8) and various exploration activities have been undertaken in the past. Many of these showings occur near the contact of Colo Plutonic Suite and Wainimala Group and the mineralization is of skarn or of porphyry copper type.

The existence of Colo Plutonics has not necessarily been confirmed near these mineral showings by the present survey, but it is believed that the plutonic body in the shallow zone is related to mineralization. Although the Colo Plutonic Suite occurs as small independent bodies on the surface, drilling results and regional airborne magnetic survey conducted by Barringer Fiji Ltd., indicates the existence of a very large body (15 km x 40 km) extending in the WNW-ESE direction in subsurface zone. And it is considered that the small surface bodies are stocks or plugs branching out from this large body. These showings are as follows.

(1) Tulasewa Prospect

It is located in the southeastern part of the survey area. The mineralization is of skarn type. Amoco Minerals Fiji Ltd., (Amoco) conducted geochemical prospecting, surface magnetic survey, IP, resistivity, PEM (Pulse electromagnetic method), and drilling (5 holes, 591.2 m) in 1976-1977. But noteworthy mineralization was not found.

(2) Korokitu Tig. Prospect

It is located in the southeastern part of the survey area. Consolidated Gold Field (Fiji) Ltd., carried out geochemical prospecting (stream sediments, rocks) in 1980-1981, but both gold and base metal occurrences were of low grade. The type of mineralization is not clear.

(3) Voua Creek Mineral Showing

It is located in the southeastern part of the survey area. This is said to be formed by Cu-Pb-Zn mineralization, but the type is not known.

(4) Tuva River Mineral Showing

It is located in the central part of the survey area. This is said to be formed by skarn type Cu mineralization.

(5) Natualevu Prospect

It is located in the central part of the survey area. Amoco conducted geochemical prospecting (soil, rocks), surface magnetics, IP, long drilling (2 holes, 479.1 m), and short percussion drilling (10 holes, 257 m). They located weak Au-Ag-Cu-Zn mineralized zone. It is said to be skarn type.

(6) Naitaki Creek Prospect

It is located in the central part of the survey area. This is said to be formed by porphyry copper type mineralization. Amoco conducted geochemical prospecting (stream sediments) and located very large Au geochemical anomaly zone (Au over 100 ppb) extending for 15 km^2 1974-1979. Further investigation by Consolidated Gold Field (Fiji) Ltd., could not confirm the anomaly and they refute the results of Amoco.

(7) Kule Prospect and Kule Creek Prospect

It is located in the northwestern part of the survey area. These are said to be formed by porphyry copper type mineralization. Amoco carried out rock geochemical prospecting, surface magnetic survey, IP, and drilling (4 holes, 610.0 m) in 1977 and located weak Cu-Zn mineralization.

(8) Nathilenga (Nacilega) Prospect

It is located in the northwestern part of the survey area. This is said to be formed by porphyry copper type mineralization. Aomco carried out soil geochemical prospecting, surface magnetic survey, IP, resistivity, and drilling (5 holes, 766.5 m) and located weak Cu-Mo mineralization in 1976. But it was concluded not to be economically feasible.

(9) Kumbuna (Kubuna) River Prospect

It is located in the northwestern part of the survey area. This is said to be formed by skarn type mineralization. Mineralization was located in siliceous limestone exposures (Cu 0.15%, Pb 1.45%, Zn 3.8%, Mo 375ppm), but it has not been drilled.

3-2-2 Mineralization and Alteration

The following mineralized and altered zones were discovered by the present survey. But many of them coincide with the above prospects (Figs.

1-8 & 2-3-5).

Surface weathering is very intense and the distinction between the altered zones and weathered zones were often difficult in this area. Thus, even those areas described as altered were treated as weathered zones unless significant alteration minerals were identified by X-ray diffraction .

(1) Tulasewa Alteration Zone

This is an argillized zone developed in the WNW-ESE direction with an areal extent of 1km x 2.5km. It is located to the east of Tulasewa Village. Silicified and pyrite dissemination occur scattered in this zone.

Zonal arrangement of altered minerals are confirmed by X-ray diffraction, but the mineral assemblage differs considerably from that of Mba-west (Fig. 2-3-4). Namely, silicified-argillized subzone (Subzone I) composed of quartz-kaolinite occurs in the center and argillized subzone (Subzone II) composed of halloysite-kaolinite/montmorillonite mixed-layer assemblage occurs on the outerside.

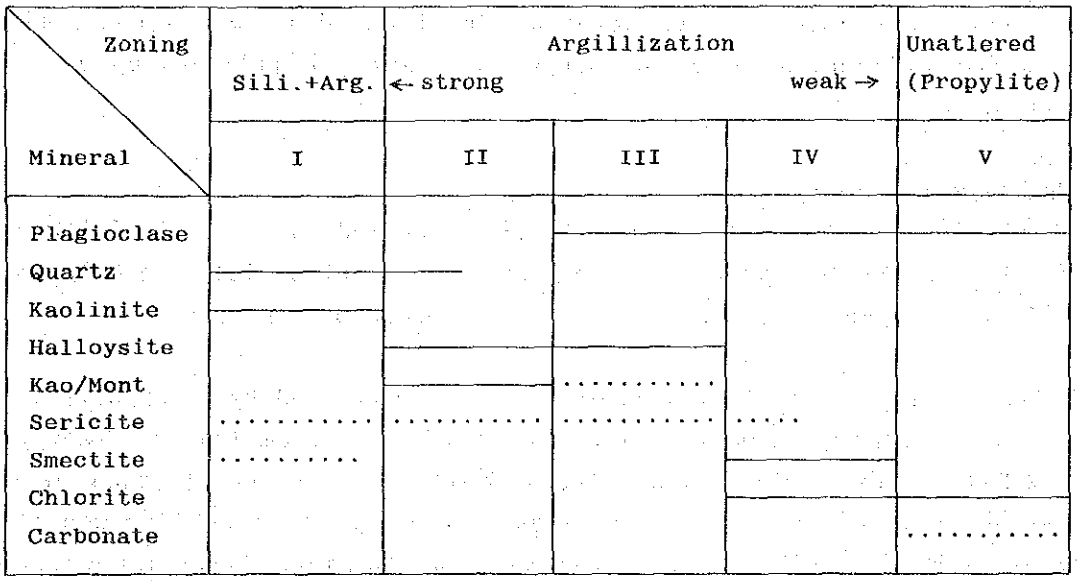
Subzone II of this zone is strongly argillized and plagioclase does not remain. But in other altered zones of this subzone, weak argillization with similar mineral assemblage but with remaining plagioclase is observed. Thus, that without remnant plagioclase is termed Subzone II-a, and that with remnant plagioclase Subzone II-b.

On the outerside of Subzone II, weak argillized subzone (Subzone III) composed of smectite-chlorite assemblage is distributed. Subzones I to III are accompanied by some sericite.

Green rocks composed of chlorite-(carbonates) are widely distributed outward from Subzone III. This is not a product of alteration associated with mineralization, but is considered to be formed by diagenesis after the burial of Wainimala Group, or by regional metamorphism by the intrusion of the Colo Plutonic suite in shallow subsurface zones. In this report, this green rock will be treated as the host rock (unaltered) of alteration.

2) Korokitu Alteration Zone

This is a silicified-argillized zone extending in the NW-SE direction and developed into 1km x 2km scale. Mineral zoning similar to Tulasewa Alteration Zone is evident. It is located on the northeast side of the Korokitu Triangulation Point. It is, namely, concentric arrangement of, center outward, quartz-kaolinite subzone (Subzone I), halloysite-kaolinite/montmorillonite mixed layer subzone (Subzone II-a), smectite-chlorite subzone (Subzone III).



Kao/Mont: Interstratified Kaolinite/Montmorillonite
Sili.:Silicification, Arg.:Argillization,

Fig. 2-3-4 Alteration Zoning by Mineral Assemblage (Sigatoka Area)

(3) Ndalandola Alteration Zone

This is a small E-W extending argillized zone distributed in the upper reaches of the Ndalandola River. The zonal arrangement of altered minerals of this zone is, Subzone II-b to Subzone III from the east westward. Pyritization is strong and some chalcopyrite dissemination is observed. Mineral prospect related to this altered zone has not been reported.

(4) Waindolo Alteration Zone

This is an altered zone extending from the southeastern side of the Lua Triangulation Point to Waindolo Triangulation Point. This zone has belt-form and its trend near Lua is N-S and bends to NW-SE near the Waindolo Point. This is the strongest altered zone confirmed in Sigatoka, but there is no record of mineralized prospect.

The zonal arrangement of altered minerals is Subzones I → II-a → II-b from the southeast northward.

(5) Kule Alteration Zone

This zone comprises Kule and Kule Creek Prospects and is 0.5-0.8km wide and 4km long in the E-W direction. The zonal arrangement of the altered minerals is, from the east westward; Subzones I → II-a → II-b → III.

(6) Oleolonga Alteration Zone

This argillized zone is developed in the E-W direction along the Oleoionga Creek and the assemblage of altered minerals is that of Subzone II-b. Related mineralization has not been reported.

(7) Vasilaulau Alteration Zone

This is a weakly argillized zone which is 1 km wide and 3 km long in the E-W direction and is located to the south of the Vasilaulau Triangulation Point. The mineral assemblage is mostly that of Subzone III, but there are locally strongly argillized Subzone II-a alteration.

(8) Nathilenga Alteration Zone

This is a weakly argillized zone in the upper reaches of the Nathilenga Creek. The assemblage of altered minerals of this zone is of Subzone III. The zone has NE-SW trend and coincides with the Nathilenga Prospect.

(9) Tokatoka Creek Alteration Zone

This is a weakly argillized zone developed in the NE-SW direction along the Tokatoka Creek. The assemblage of altered minerals are of Subzones II-b and III.

There are further, in Sigatoka area, the following small altered zones; Tuva River (ENE-WSW, Subzone III), Kumbuna Creek (E-W, Subzone II-b), Watawatakala (E-W, Subzone II-b) and others. Related mineralization have been reported in former two altered zones but have not in the last one.

Regarding Voua Creek, Natualevu, and Naitaki Creek Prospects, local pyrite-silicified parts were found, but corresponding altered zones could not be confirmed.

Ten (10) samples (including accidentals) collected from quartz veins, silicified rocks, and pyrite disseminated parts were analyzed at the Chemex Labs Ltd., in Canada. Total of six elements, namely Au, Ag, Cu, Pb, Zn, and Mo were analyzed.

The analytical results are laid out in Appendix Table 8. It is seen that minor amounts of Ag and Cu were detected in the gossan of Natualevu Prospect, but otherwise noteworthy grades were not found (OK204, Ag 7g/t, Cu 0.09 %).

3-2-3 Discussions Regarding Mineralization and Alteration

Although many prospects and mineral showings occur in this area, the associated alteration is relatively weak and some are without notable altered zones.

The host rocks of porphyry copper type deposits generally have the following zonal arrangement of altered rock assemblages; potash zone (quartz-potash feldspar-biotite) → phyllic zone(quartz-sericite-pyrite)→ argillized zone (quartz-kaolin-chlorite) → propylite zone (chlorite /epidote-calcite-adularia albite).

Although there are local strongly altered zones with quartz-kaolinite assemblage, the altered zones of Sigatoka mostly consist of weakly acidic alteration with halloysite-kaolinite/montmorillonite mixed layered mineral assemblage and neutral alteration with smectite-chlorite mineral assemblage and are quite different from those of the typical porphyry type mineralization.

It appears reasonable to consider that alteration characteristic of porphyry copper type mineralization is not developed in Sigatoka. Although there are examples of bona fide porphyry copper deposits such as the Namosi of Fiji which do not show typical porphyry alteration zoning. The prospects, which were considered to be porphyry type mineralization in Sigatoka, are treated here as small dissemination type mineralization associated with the intrusion of Colo Plutonic Suite.

Concerning mineralization classified as the skarn type, it was not possible to confirm the mineralized body itself, but judging from the very thin limestone lenses intercalated in the Wainimala Group, and also from the fact that skarn minerals were not detected in the associated altered zones, the possibility of locating large skarn deposits in the area is very low.

3-3 Geochemical Prospecting

3-3-1 Methods Employed

Geochemical prospecting using B horizon soil samples was carried out over an area of 160 km^2 in order to extract promising mineral prospects. The geological survey and geochemical prospecting were conducted simultaneously along the creeks and on the ridges, geochemical samples were usually collected at 400m intervals.

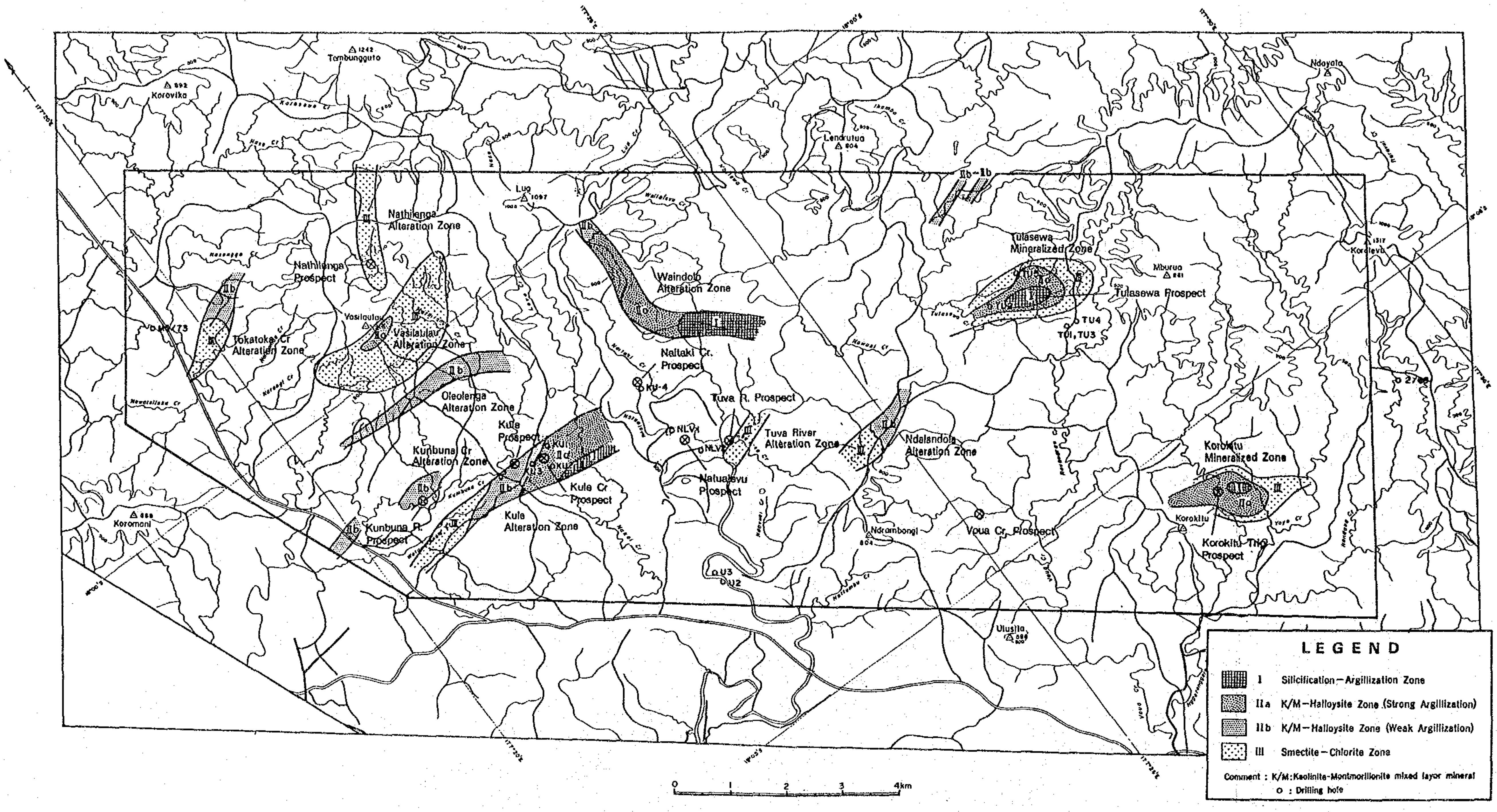


Fig. 2-3-5 Distribution Map of Alteration Zones (Sigatoka Area)

The collected soil samples were dried naturally under the sun, sieved to -80 mesh, and chemically analyzed at Chemex Labs Ltd., of Canada.

A total of 660 samples were collected and the contents of nine elements, Au, Ag, Cu, Pb, Zn, As, Sb, Hg, Mo were analyzed. The analytical methods for each element and the limit of detection are as follows.

Analytical Procedures (Sigatoka Area)

Element	Method	Detection Limit	Upper Limit
Au	Fuse, FA-AAS	5ppb	10,000ppb
Ag	HNO_3/Aqua Regia digestion, AAS	0.2ppm	100.0ppm
Cu	HNO_3/Aqua Regia digestion, AAS	1ppm	10,000ppm
Pb	HNO_3/Aqua Regia digestion, AAS	1ppm	10,000ppm
Zn	HNO_3/Aqua Regia digestion, AAS	1ppm	10,000ppm
As	HNO_3/Aqua Regia digestion, AAS	1ppm	10,000ppm
Sb	$HCl/KClO_3$ digestion, extraction, AAS	0.2ppm	1,000ppm
Hg	HNO_3/HCl digestion, AAS	10ppb	100,000ppb
Mo	HNO_3/Aqua Regia digestion, AAS	0.05ppm	100.0ppm

FA :Fire Assay
AAS:Atomic Absorption Spectrometry

3-3-2 Results of Analysis

The contents of heavy metals are generally low. Of the total of 660 samples; Au content was below the limit of detection in 656 samples (99.4%), Ag in 656 samples (99.4%), Pb in 502 samples (76.1%), As in 606 samples (91.8%), Sb in 653 samples (98.9%), and Mo in 640 samples (97.0%). The contents of Cu, Zn, Hg were above the detection limit in all samples.

3-3-3 Statistical Treatment

With the samples of this area, there are many containing elements below the detection limit and the correlation among the components is very weak. Thus, it was concluded that multivariate analysis of these data would not produce meaningful results.

Therefore, anomalous zones were extracted by threshold values for each component in the same process as for the Mba west samples.

Anti-logarithm was used rather than the natural logarithm for the following analysis and 1/2 of the detection limit was used as the content for elements under the detection limit. Basic statistic values are shown below (Table 2-3-1).

Table 2-3-1 Basic Statistics (Sigatoka Area)

	Au	Ag	Cu	Pb	Zn	As	Sb	Hg	Mo
Average	ppb	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppb
(m)	2.6	0.1	36	2	81	0.6	0.4	28	0.6
Standard deviation									
(σ)	0.8	0.0	38	11	74	0.8	0.7	16	0.4
Maximum	20	0.3	500	250	800	10	4.0	140	5
Minimum	<5	<0.2	2	< 1	1	< 1	<0.2	10	<1
Detection limit	5	0.2	1	1	1	1	0.2	10	1
m+σ	3.4	0.1	74	13	155	1.4	1.1	44	1.0
m+2σ	4.2	0.1	112	34	229	2.2	1.7	60	1.3
Threshold	5	0.2	120	30	230	1	0.2	60	1

(2) Correlation of components

One half (1/2) of the detection limit values were used as the contents of the components existing in amounts less than the limit of detection. Since there are many such samples, the correlation among the individual components is very low. Only some correlation can be observed between Pb and Zn (correlation coefficient 0.4299).

Correlation Coefficients of Soil Assay (Sigatoka Area)

	Au	Ag	Cu	Pb	Zn	As	Sb	Hg	Mo
Au	1.0000	-0.0052	0.1581	-0.0078	-0.0396	-0.0103	-0.0038	0.0110	-0.0096
Ag		1.0000	0.1211	0.2033	0.2212	0.1122	-0.0045	0.0963	0.1617
Cu			1.0000	0.1709	0.1869	0.1240	-0.0413	0.0891	0.0877
Pb				1.0000	0.4299	0.1856	-0.0016	0.0532	0.0402
Zn					1.0000	0.0795	-0.0257	0.0783	0.0436
As						1.0000	0.0175	0.0785	0.1576
Sb							1.0000	-0.0033	-0.0027
Hg								1.0000	0.0237
Mo									1.0000

(3) Distribution pattern of geochemical data

Logarithmic frequency distribution diagrams for each component were prepared in order to clarify the statistical distribution types of the geochemical data of this area. From the results, it is inferred that Hg show lognormal distribution and Zn normal distribution. Cu clearly show non-normal distribution and the types of other components cannot be determined.

(4) Determination of threshold values

Cumulative frequency distribution diagram for each component was drawn on logarithmic probability graph paper (Fig. 2-3-6).

The Pb diagram shows a clear breaking point at 5 ppm (probability 4%) and this was determined as the threshold value.

The Zn diagram shows a gentle breaking point near 160 ppm (prob. 7%) and as this is close to m+σ (160 ppm), m+σ was used as the threshold.

The Cu diagram shows breaking point only in the very low probability parts and it was not possible to determine the threshold. Thus m+σ (74 ppm) was used as the threshold.

The Hg diagram shows only an insignificant break near 60 ppb (prob. 5 %), but this coincides with m+2σ (60 ppb) and thus was used.

Breaking points reflecting the population do not occur in the diagrams for Au, Ag, As, Sb, Mo. When m+σ was used as the threshold, anomalies would appear in a very small number of samples, namely four samples for Au, four for Ag, 23 for As, two for Sb, and 20 for Mo. Thus, all values exceeding the detection limit were treated as anomalies for the above five elements.

3-3-4 Distribution of Geochemical Anomalies

Zones with contents higher than the threshold were extracted from the iso-grade maps for each element and were graded as geochemical anomalies (from Figs. 2-3-7 to Fig. 2-3-9).

This area has been prospected in the past for Cu, Pb, Zn base metals, and weak correlation is observed between Pb and Zn. Therefore, the zones with significant density of anomalies of these two elements were re-extracted as "geochemical anomaly areas" (Fig. 2-3-8). During this work, parts with only one anomaly was excluded as a singular point.

For the five elements, Au, Ag, As, Sb, Mo, all points with contents exceeding the detection limit were treated as anomalies and thus these are of small significance, but those which overlap with Cu, Pb, Zn, anomalies were considered.

The following four zones were extracted as geochemically anomalous (Fig. 1-8).

Tulasewa Anomaly Area: This is distributed surrounding the Tulasewa Alteration Zone. It partly overlaps with the altered zone, but most is in the unaltered parts. The anomalies are of Cu, Zn and Pb anomalies are not found.

Waindolo Anomaly Area: This zone extends to the southeast of the Waindolo Alteration Zone and partly overlaps with the most strongly altered part (Subzone I). Not only Cu, Pb, Zn, but also Ag and As anomalies overlap the Subzone I, therefore this is considered to be a noteworthy mineral showing.

Vasilaulau Anomaly Area: This zone extends from the Vasilaulau Alteration Zone to the north. It consists mainly of Pb and Zn anomalies and small Cu anomalies overlap in the eastern edge. Also there are overlapping As and Mo anomalies.

Kule-Tuva Anomaly Area: This zone extends from the Kule Alteration Zone to the Tuva Alteration Zone in the NW-SE direction. It consists of Cu, Pb, Zn anomalies.

Aside from the above, there are small independent anomalous zones at Navutu, Emuri, Lovo Creek, Ndrambongi and other localities. At Lovo Creek, Mo anomaly overlaps and scattered silicified, pyritized exposures are confirmed. But in other localities, mineralization-alteration is not confirmed.

3-3-5 Results of Geochemical Prospecting

Many of the geochemical anomalies of this area are developed in close relation to the altered zones confirmed on the surface. At Tulasewa, geochemical anomalies are distributed not directly over the altered zone, but in the periphery. It is not clear whether this is caused by subsurface alteration or false anomaly by secondary dispersion. Notable geochemical anomaly was not detected associated with the Korokitu Altered Zone.

Many of the anomaly zones have been drilled by Amoco, but the unexplored zones with poly-component anomalies, namely the Vasilaulau and Waidolo Zones are selected for future prospecting.

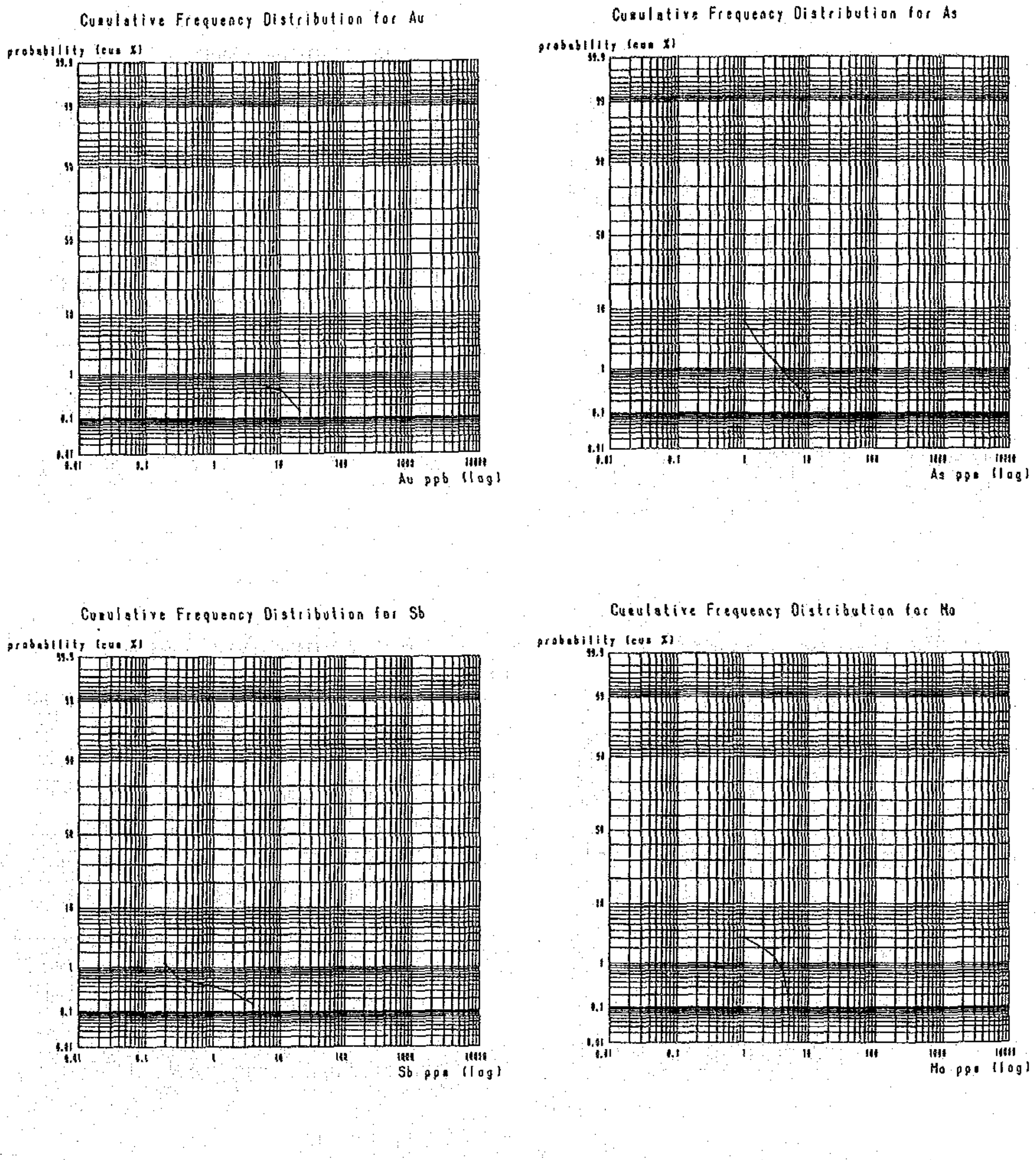
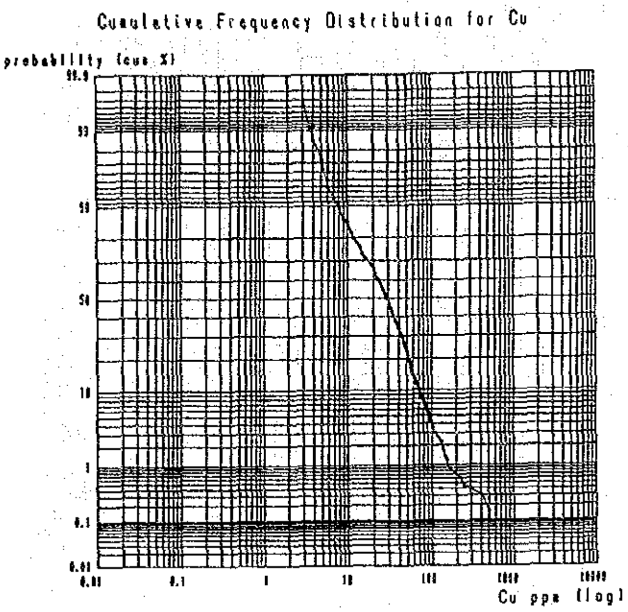
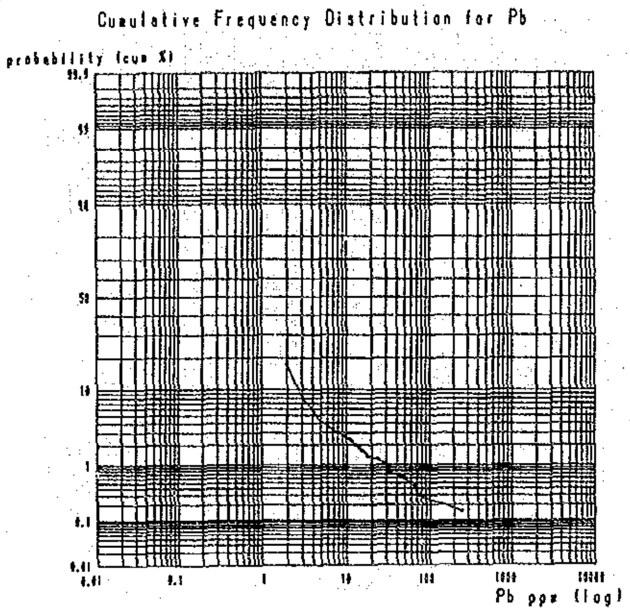
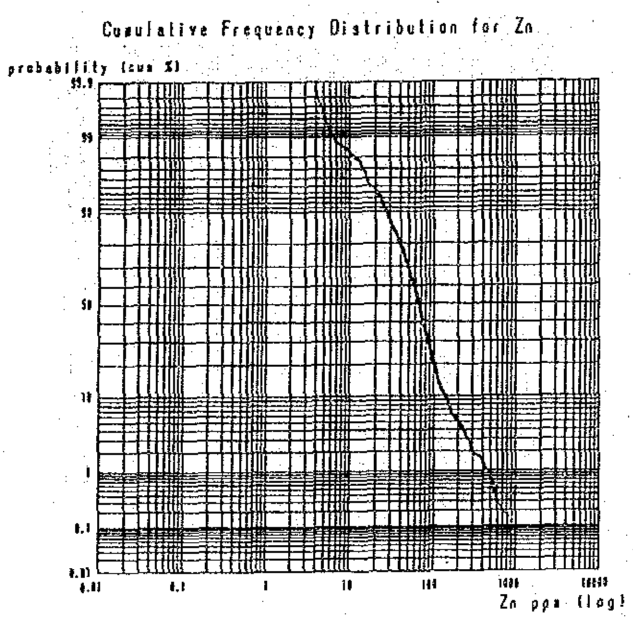


Fig. 2-3-6 Cumulative Frequency Distribution on Logarithmic Probability Paper (Sigatoka Area-1)







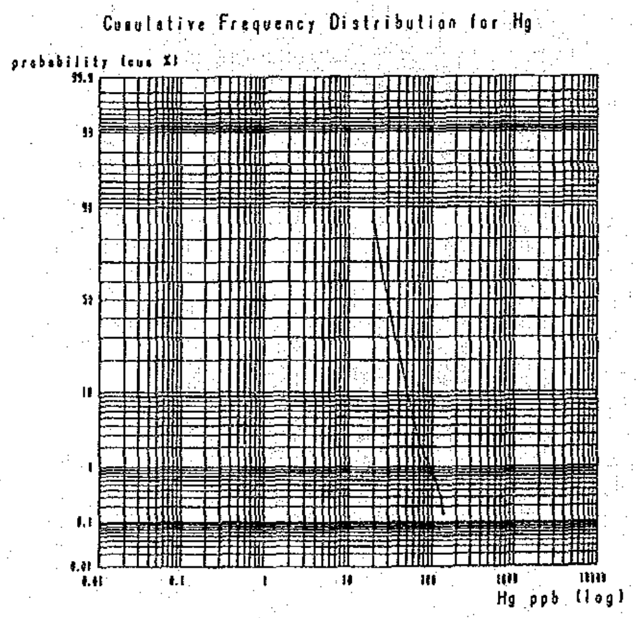


Fig. 2-3-6 Cumulative Frequency Distribution on Logarithmic Probability Paper (Sigatoka Area-2)

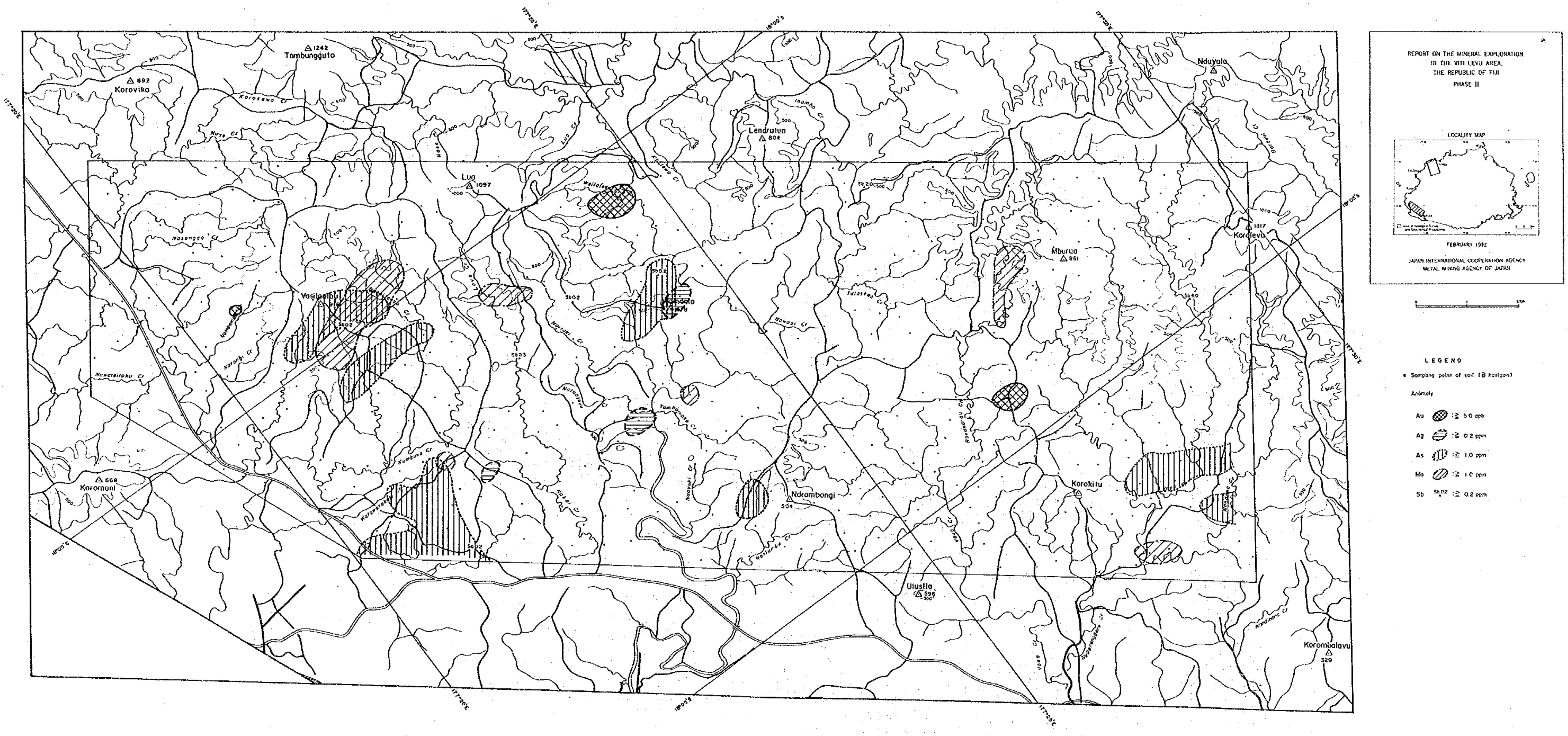


Fig. 2-3-7 Distribution of Au, As, Sb and Mo Anomalies in Soils (Sigatoka Area)

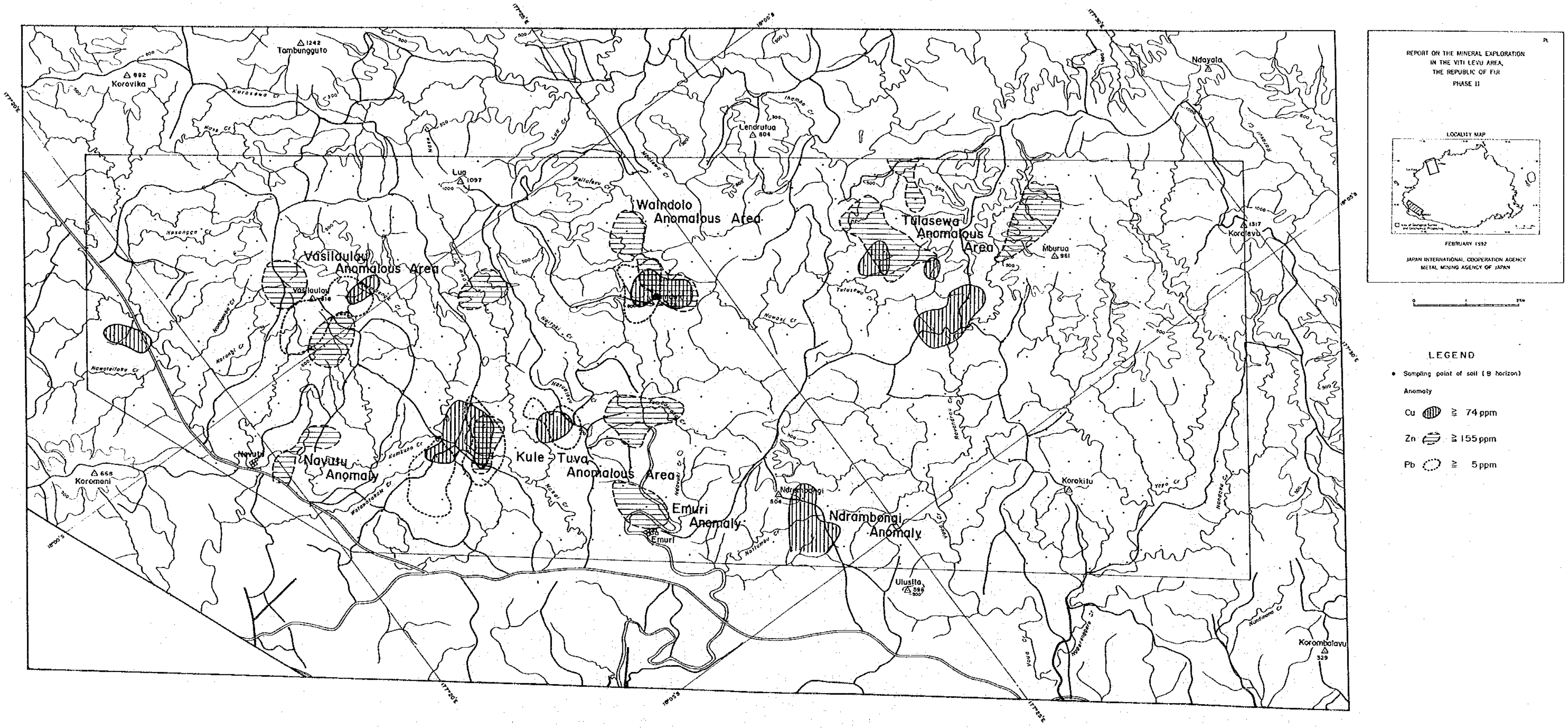


Fig. 2-3-8 Distribution of Cu, Pb, and Zn Anomalies in Soils (Sigatoka Area)

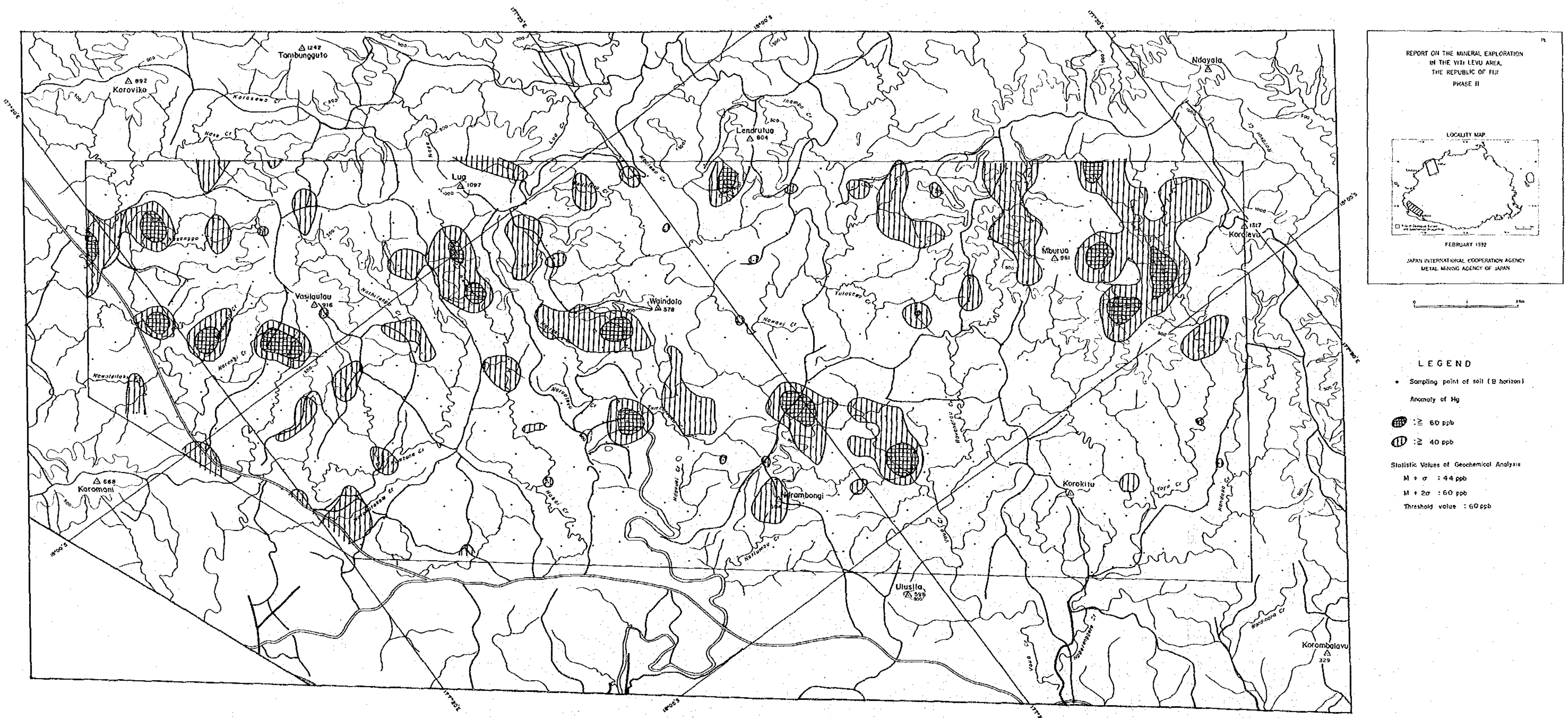


Fig. 2-3-9 Distribution of Hg, Anomalies in Soils (Sigatoka Area)