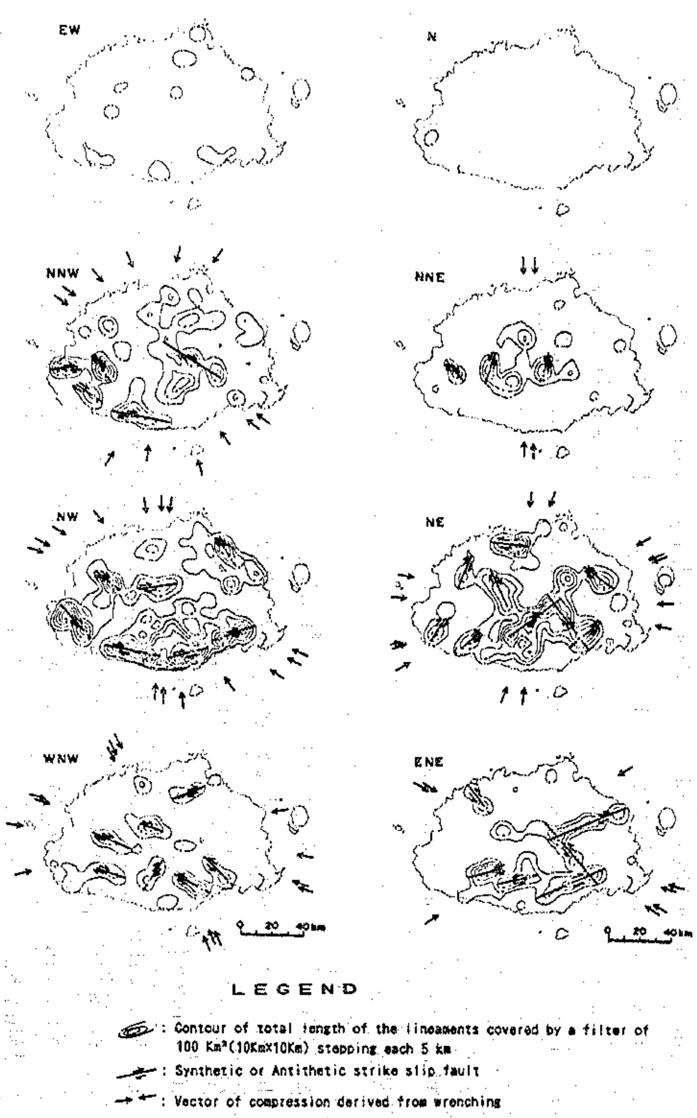


Fig. 2-1-3 Tectonic Interpretation Map on SLAR Lineament by Systems

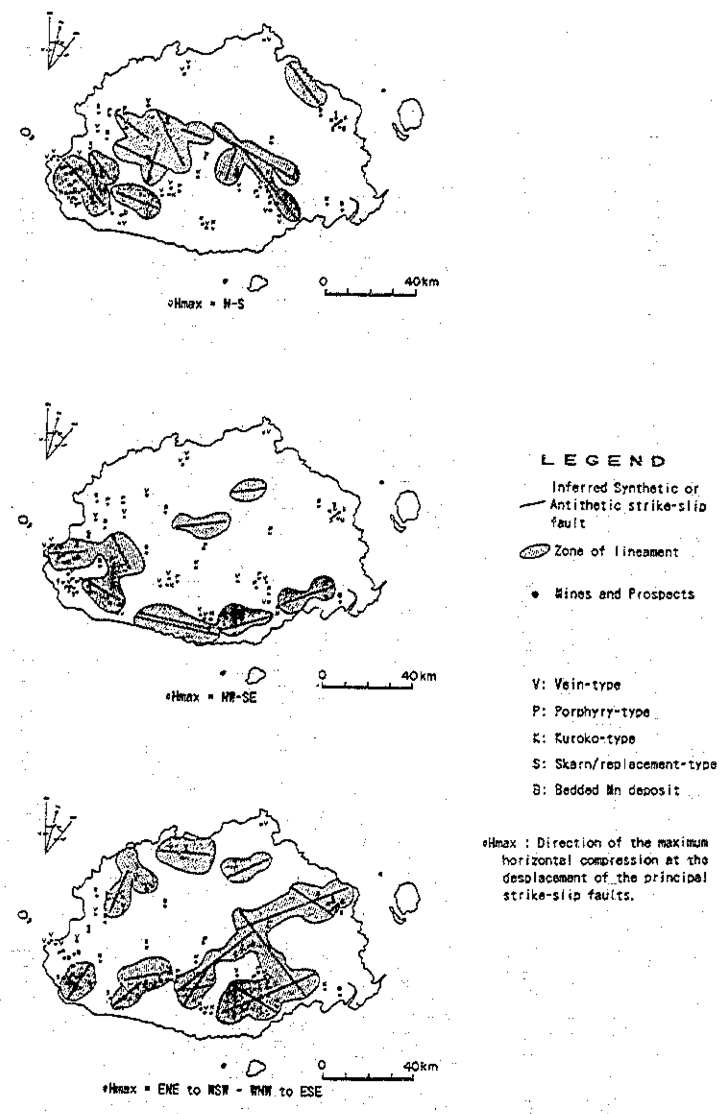


Fig. 2-1-4 Map showing Relationship between Mines-Prospects and Distribution Area of SLAR Lineament

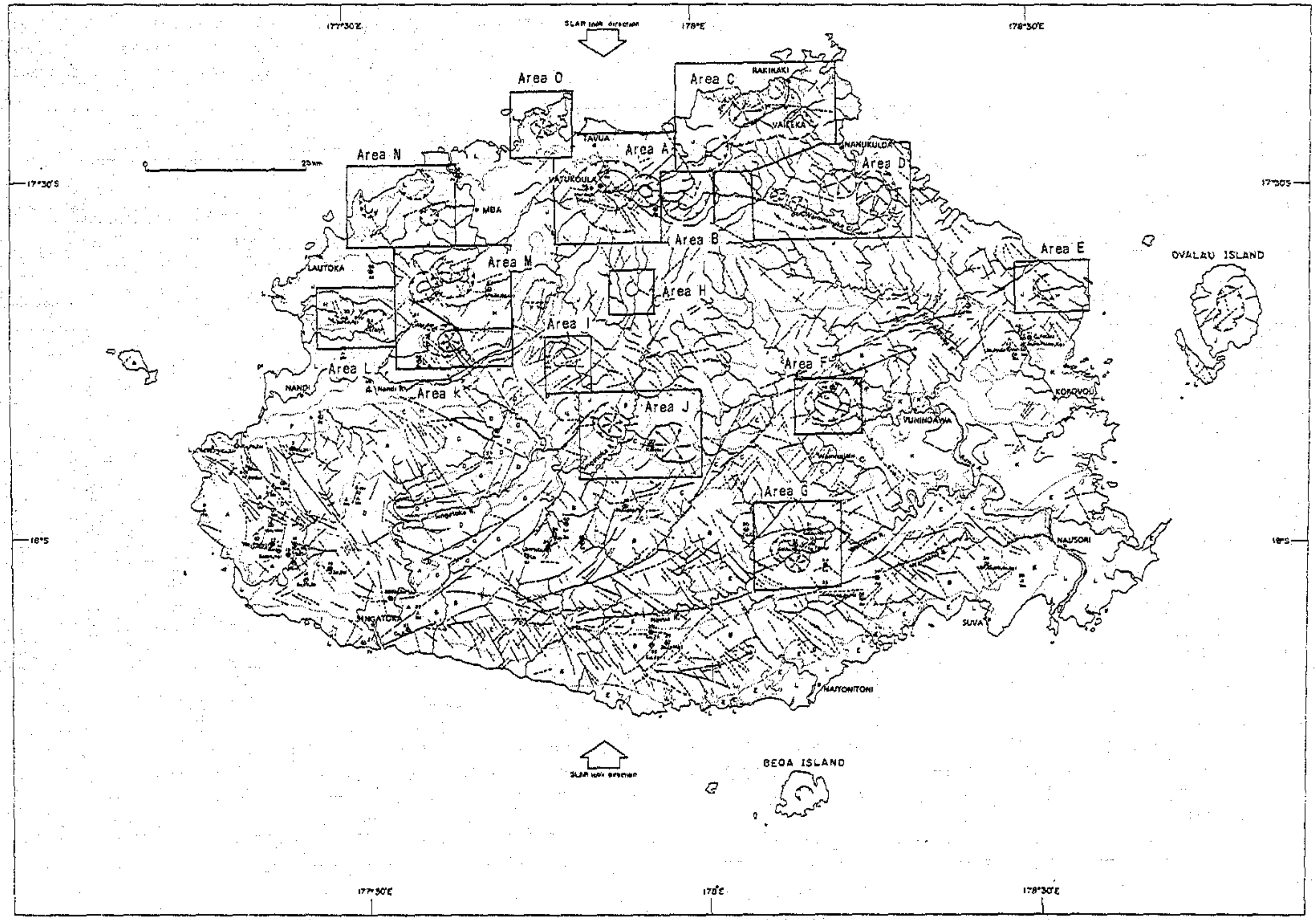


Fig. 2-1-5 Location Map of the Morphological Anomalous Areas Extracted by Photogeological Interpretation of SLAR Imageries

Table 2-1-2 Characteristics of Promising Area Extracted from Photogeological Interpretation of SLAR Imageries

(Phase I)

Interpretation / Factor / Area		Photogeological Characteristics: Morphological Anomalies on SLAR Imageries			High-Density Zone of Lineament	Lineament of NE-SW Direction	Gold Mineralization found within or in the vicinity of SA or SC	Gold Mineralization located on Lineament or Intersection of Plural Lineaments	Geological Characteristics: Ba Volcanic Group	Granitc Rocks intruded into Ba Volcanics	Mineralization of Cu-Pb-Zn -Mo etc.	Complex of Late Miocene to Early Pliocene	Comparison with Model Areas A and G (Number of Coincident Factor): Area A			Area G		
		SA	SC	SD									○	△	Total	○	△	Total
A	Emperor Mine	○	○	–	○	○	○	○	○	○	–	–	8	–	⑧	2	–	2
B	E-Vatukoula	●	○	–	△	–	○	–	○	–	–	–	4	1	⑤	2	–	2
C	Rakiraki	●	○	●	△	△	–	–	○	○	–	–	4	2	⑥	3	–	3
D	S-Nanukuloa	–	●	●	△	–	–	–	○	○	–	–	3	1	4	2	–	2
E	N-Korovou	–	○	–	○	–	–	–	○	–	△	–	3	–	3	1	1	2
F	W-Vunindawa	●	●	–	△	△	–	–	–	–	○	–	2	2	4	3	–	3
G	U-Waindina River	●	○	●	–	–	–	–	–	–	○	○	2	1	3	5	–	⑤
H	S-Vatukoula	●	–	–	–	–	–	–	○	△	–	–	2	1	3	1	–	1
I	U-Mba River	●	–	–	○	○	–	–	○	△	–	–	4	1	⑤	1	–	1
J	U-Singatoka River	–	●	●	–	–	–	–	○	○	○	–	3	–	3	3	–	3
K	E-Nandi	–	●	●	○	–	–	–	○	△	△	–	3	1	4	2	1	3
L	NE-Nandi	●	○	–	–	–	○	–	○	△	△	○	4	1	⑤	3	1	④
M	S-Mba	○	○	●	△	–	–	–	○	○	△	–	4	2	⑥	3	1	④
N	W-Mba	●	○	–	–	–	–	–	○	–	–	–	3	–	3	2	–	2
O	W-Tavua	–	–	○	–	–	–	–	○	–	–	–	1	–	1	1	–	1
Symbols	●	present (newly extracted)			–	–	–	–	–	–	–	–			–			–
Symbols	○	present (known)			large	dense	present	present	present	present (in the vicinity)	present (in the vicinity)	presnt (in the vicinity)			high			high
Symbols	△	–			small	scarce	–	–	–	present (periphery)	present (periphery)	present (periphery)			–			–
Symbols	–	non			non	non	non	non	non	non	non	non			–			–

Abbreviations

N: to the north of
S: to the south of
E: to the east of
W : to the west of
NE: to the northeast of
U : upstream part of
SA: SLAR Annular structure
SC: SLAR Caldera structure
SD: SLAR Dome structure

[box] Model Areas

The characteristics of the Area G are the following five points.

a. Existence of SLAR annular structure.
b. Existence of SLAR caldera structure.
c. Existence of SLAR dome structures.
d. Existence of Cu, Pb, Zn, Mo mineralization.
e. Existence of the volcanic-plutonic complex of Late Miocene to Early Pliocene.

Of the selected 15 areas, the following five have geologic characteristics similar to those of the vicinity of the deposits of the Emperor Mine.

Area B: East of Vatukoula.
Area C: Rakiraki (Vaileka)
Area I: Upper reaches of the Mba River.
Area L: Northeast of Nadi.
Area M: South of Mba.

The following two areas have geologic similarity to the vicinity of the porphyry copper deposits.

Area L: Northeast of Nadi.
Area M: South of Mba.

1-2 Geological Survey

1-2-1 Survey Methods

One of the major activities of the first year of this project was to understand the relationship between the geologic structure and mineralization through geological and geophysical reconnaissance of the survey area. The field work was planned and implemented on the basis of the results of the SLAR imagery and SPOT image interpretation and study of previous geoscientific results.

Regarding mineral resources and satellite images, Kouda et al., (1989) pointed out as follows. The existence of three factors, namely heat from magma, subsurface fractures and circulating water, are the environment necessary for the formation of epithermal metallic deposits. The probability of these conditions being met is highest at the concentrated fracture zones formed in association with the intrusion of magma. Of the structures formed by the magmatic intrusion, the volcanic collapse structure is best identified by satellite image interpretation. Resurgent calderas are the environment very closely related to gold and silver vein mineralization."

The most important known mineralization in Viti Levu is the gold veins of the Emperor Mine and the porphyry copper deposit of Namosi. The former occurs in the fissures at the periphery of a caldera and the latter is associated with an intrusive body. In the SLAR imageries, annular and caldera structures were identified in the area of the above two mineralized zones and dome structures were observed in the area of the Namosi deposit.

It was considered highly possible that the photogeologic annular, caldera and dome structures reflected the intrusion of magma in the survey area because these structures were identified in zones where large epi-mesothermal metallic deposits were emplaced. Thus, the geological survey was planned to start from those areas where these photogeologic structures were identified. Also the zones with structural and geologic features photogeologically similar to those of the above two mineralized zones were given high priority. Aside from the above, major mines, mineral prospects and areas of important geologic units were also surveyed.

Published topographic maps of 1:50,000 scale were used in the field as well as satellite images and aerial photographs.

The intensity of argillization and silicification was divided into the following groups in the field.

Strong: alteration covers a large area and the texture of the original rocks is not clear.

Medium: alteration localized and the original texture discernible.

Weak : alteration zone very minor.

1-2-2 Outline of Geology

(1) Stratigraphy

The geology of Viti Levu is composed of Upper Eocene-Lower Oligocene Series, Upper Oligocene-Middle Miocene Series, Middle-Upper Miocene plutonic rocks, Upper Miocene Series, Upper Miocene-Lower Pliocene Series, uppermost Miocene-Upper Pliocene Series, Lower Pliocene-lowermost Pleistocene Series, Pleistocene Series and Pleistocene-Holocene Series (Fig. 2-1-7).

The Upper Eocene-Lower Oligocene Series are the Yavuna Group which forms the basement of the survey area. This group is distributed in the western part of Viti Levu and it is composed of hard, compact Yavuna Volcanics and tonalite (34 Ma; Rodda, 1982) which intrudes the volcanics. The Yavuna Volcanics consists of basalt, basaltic pyroclastics, dacite, dacitic pyroclastics and neritic limestone. Also Late Eocene planktonic foraminifers occur in the host rocks of the Wainaleka sulfide deposit in the south central part of the island (McGowran in Rugless, 1983). Parts of the Yavuna Volcanics underwent burial metamorphism of zeolite - green schist facies. During Oligocene, Wainimala Orogeny characterized by tonalite intrusion occurred and sedimentation was practically non-existent.

The Upper Oligocene-Middle Miocene Series is composed of the Wainimala Group and the Savura Volcanic Group. The Wainimala Group occurs widely in southern Viti Levu and overlies the Yavuna Group unconformably in the southwest. The group consists of various hemipelagic to neritic formations and the lithology varies from basalt, andesite, dacite and various pyroclastics to sandstone, mudstone, limestone, conglomerate and others. These strata interfinger with each other in many cases and the fossils indicate the latest Oligocene to Middle Miocene time of deposition. Propylitization is generally observed in the volcanics and pyroclastics in the southwest. The volcanic rocks of this group belong mainly to the tholeiite series. The Savura Volcanic Group is distributed in the southeastern Viti Levu and consists of basalt, andesite and dacitic pyroclastics. The age is inferred to be Early-Late Miocene, but it has not been confirmed.

The Middle-Upper Miocene plutonic rocks are the Colo Plutonic Suite. These rocks are distributed in a belt extending from the southwest through the south central to the eastern part of Viti Levu. The radiometric ages of the rocks range between 12.5 and 7 Ma. The lithology of these rocks is bimodal, tonalitic (rarely dioritic) and gabbroic. Contact metamorphism is observed along the marginal parts of the rock body.

The Upper Miocene Series is composed of Tuva Group, Ra Sedimentary Group, Nadi Sedimentary Group and Navosa Sedimentary Group. The Ra Sedimentary Group and the lower part of the Navosa Sedimentary Group as well as the middle part of the Navosa Sedimentary Group and the Nadi Sedimentary Group have contemporaneous heterotopic relationship.

The Tuva Group is distributed on the southwestern side and the east-central part of Viti Levu and overlies the Wainimala Group unconformably. The border between these two groups in the northeast is unconfirmed with the exception of a limited part. This group is composed mostly of sandstone and conglomerate and the time of deposition is considered to be middle Late Miocene. Quartz and large amount of feldspars are found in parts of the sandstone and it is possible that parts of tonalite was eroded in the latter part of the deposition of this group (Rodda, 1989). Andesite which probably constitutes volcanic plug occurs in the sandstone and fresh andesitic pebbles occur in the conglomerate. Thus it is inferred that volcanic activities continued during the deposition of this group (Rodda, 1989). The age determination carried out during the present work showed the age of the hornblende andesite (Ta) of Korolevu in the upper reaches of the Singatoka River to be 7.20+0.49 and 7.08±0.48 Ma and they are correlated to this group. The Ra Sedimentary Group is distributed in the northeastern part of Viti Levu, overlies the Tuva Group unconformably and is, in turn, overlain unconformably by Ba Volcanic Group. The lithology of this group is sandstone, mudstone and conglomerate and the age of deposition is believed to be late-Late Miocene.

The Nadi Sedimentary Group is distributed along the Nadi River in western Viti Levu, overlies the Tuva Group unconformably and is overlain unconformably by the Koroimavua Volcanic Group. This group is composed mainly of andesitic pyroclastics and sandstone%marl with conglomerate at the base. Paleontological data indicate deep sea deposition for a part of the group in late-Late Miocene.

The Navosa Sedimentary Group is distributed along the Singatoka River in the western side of the island and overlies the Tuva Group unconformably. The northern part of this group is overlain by Ba Volcanic Group. This group is composed of conglomerate, sandstone, mudstone, andesitic pyroclastics and andesite plug. The age is late-Late Miocene.

The Upper Miocene-Lower Pliocene Series is composed of Medrausucu Group, Koroimavua Volcanic Group and Cuvu Sedimentary Group. The Koroimavua Volcanic Group is a heterotopic facies of the middle part of the Medrausucu Group, the upper part of the Navosa Sedimentary Group and the lower part of the Cuvu Sedimentary Group.

The Medrausucu Group is distributed from the central to the southeastern part of the island and overlies the Wainimala Group, Savura Volcanic Group and Colo Plutonic Suite unconformably. This group is composed of conglomerates, sandstone, andesite, andesitic pyroclastics, basalt, limestone, mudstone, marl and tuff. Their age is from Late Miocene to Early Pliocene. The andesitic rocks in the Namosi district is associated with many small intrusive bodies of hornblende andesite, quartz porphyry and quartz diorite porphyry and it is considered to be a part of an igneous complex and the age is determined to be 5.7 to 6.0 Ma -Gill and McDougall, 1973).

The Koroimavua Volcanic Group is distributed in the northwestern part of the island and overlies the Tuva Group unconformably. This group is considered to overlie the Nadi Sedimentary Group conformably and the time of deposition is latest Miocene-Early Pliocene. The Group is composed of shoshonitic pyroclastics, basalt and sandstone-conglomerate. It is associated with small bodies of micromonzonite-microdiorite. Two types of augite phenocrysts with different grain size occur in the shoshonite.

The Cuvu Sedimentary Group is distributed along the western coast of Viti Levu and overlies the Wainimala Group unconformably. It consists of sandstone, siltstone, limestone and marl and the age is latest Miocene-Early Pliocene.

The uppermost Miocene-Upper Pliocene Series consists of Ba Volcanic Group. This group occurs widely in the northern Viti Levu and is composed of various neritic to continental strata. The age of deposition is latest Miocene-early Late Pleistocene and the lower part of this group is a heterotopic facies of the upper part of the Koroimavua Volcanic Group, and also most of this Ba Volcanic Group is a heterotopic facies of the Cuvu Sedimentary Group. The lithology is greywacke, siltstone, sandstone, shoshonite, shoshonitic pyroclastics, basalt, basaltic pyroclastics, trachybasalt, andesite, andesitic pyroclastics, and trachyandesite. These rocks are associated with small bodies of micromonzonite, gabbro and microdiorite.

The volcanic rocks of this group effused in the northwestern, north central, northeastern and eastern Viti Levu. Shoshonite and calc-alkalic rocks effused in the northwest, mostly shoshonite in the north central, calc-alkalic rocks and small amount of shoshonite in the northeast and calc-alkalic rocks effused in the eastern Viti Levu (Fig. 2-1-9)

The shoshonitic rocks of the north central Viti Levu have notable zonal structure and contain two types of augite phenocrysts with different grain size. The Tavua Volcano which is the source of these rocks is the largest volcano of the island and its center of volcanism is called the Tavua Caldera.

The Lower Pliocene-lowest Pleistocene strata consists of Verata Sedimentary Group. It is distributed in the east central part of Viti Levu and most of the strata is Early Pliocene in age and is a heterotopic facies of the upper Medrausucu Group, Ba Volcanic Group and Cuvu Sedimentary Group. The constituent rocks are of continental origin, such as conglomerate, sandstone, siltstone, and pumiceous tuff.

The Pleistocene Series consists of Ucuna Limestone. This is distributed in small bodies along the coast in northern Nadi Bay, southern Sigatoka and other areas and its rocks are reef limestone and reef detritus.

The Pleistocene-Holocene Series are fluvial deposit, alluvium and beach sands. The fluvial material is Pleistocene-early Holocene while the others are Late Pleistocene-Holocene in age. The fluvial deposits consist of pebbles, sand and clay and they occur in relatively large size along the lower reaches of the Rewa River and also in small bodies in the northwest and southwestern Viti Levu. The alluvium also consists of pebbles, sand and clay and occur widely along the Rewa, Sigatoka, Mba Rivers and in the down stream areas of the Nadi and Navua Rivers. They are distributed in the coastal zones in small bodies.

(2) Geologic Structure

The Yavuna Group (Upper Eocene - Lower Oligocene) which constitutes the basement of the survey area is distributed in the western part of Viti Levu Island.

The Upper Miocene Tuva Group and the lower strata are distributed in the southern half of the island. The Colo Plutonic Suite is distributed from the northeast to the southwestern part of the island. They are most widely distributed in the south central part and here, the erosion of the rocks is deeper compared to the northeastern and southwestern parts indicating the greater uplift of this part. To the north and south of the Colo Plutonic Suite, the volcanics and sediments of the Wainimala Group lie symmetrically with ENE strike. The Tuva Group, in the eastern part, also strikes ENE and dips northward with gentle folding. But in the western part, it is distributed from the south northeastward in a semi-annular pattern around the Yavuna Group.

The distribution of the Upper Miocene - Lower Pliocene sedimentary rocks is not clear in the northern Viti Levu because of the occurrence of younger volcanics in the area. The exception is to the north and south of the Colo Plutonic Suite where they occur with ENE strike.

The Upper Miocene - lowermost Pliocene volcanic rocks occur predominantly in the northwest Viti Levu (Koroimavua Volcanic Group) and in the southeast (Namosi Andesite, Mau Andesite and Nakoblevu Basalt in the Medrausucu Group) and they are partly accompanied by plutonic rocks.

The Lower Pliocene volcanics are distributed in northwest, north central, northeast and east Viti Levu. Their centres of volcanism are arranged in the ENE direction in the northern part, and in the NW direction in the eastern part. They are partly accompanied by plutonic rocks.

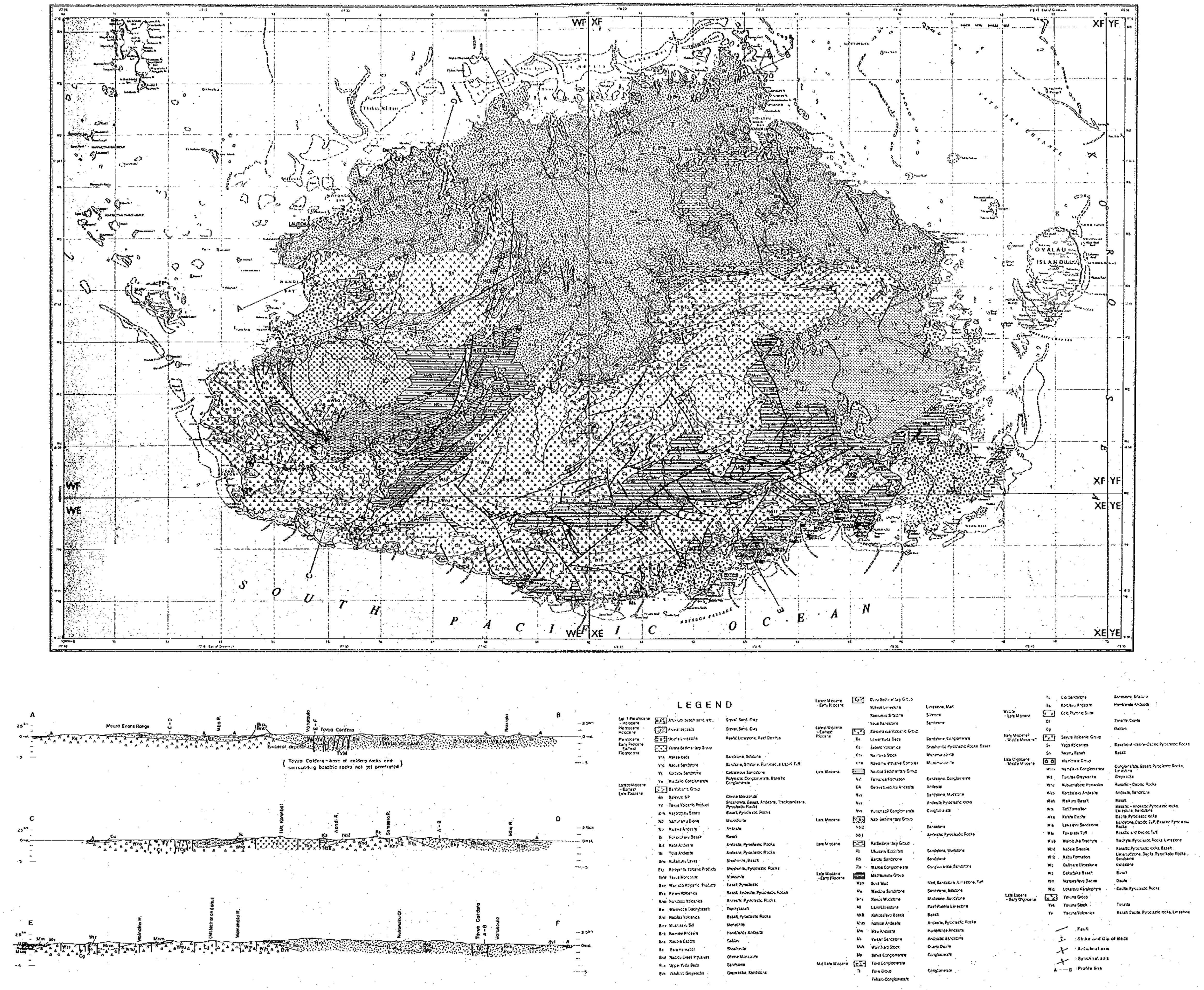


Fig.2-1-6 Geological Map with Geological Profiles of Viti Levu Island

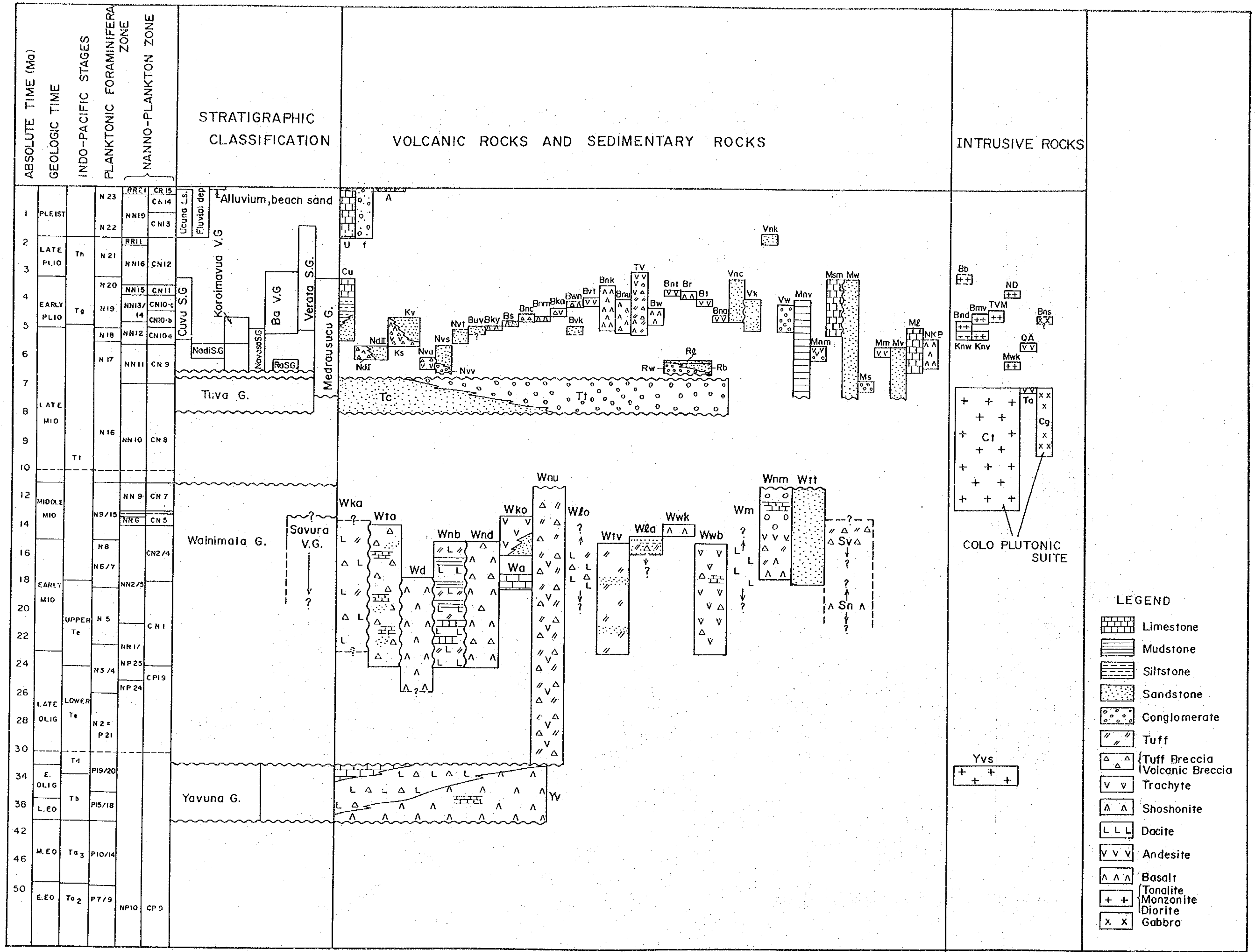
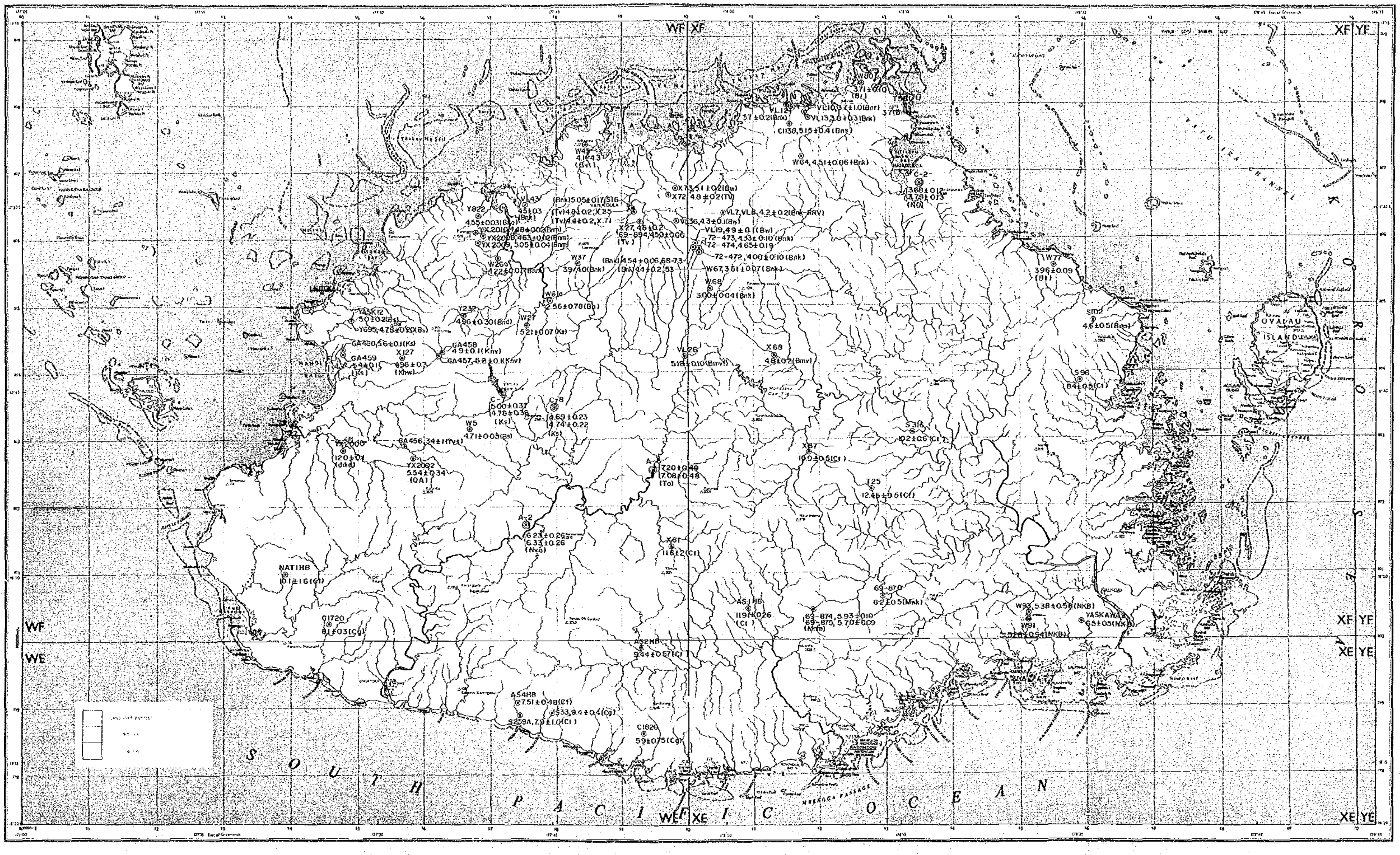


Fig. 1-6 Schematic Stratigraphic Columns of Viti Levu Island



LEGEND

A−2 : Sample number
6.23 ±0.26 : K-Ar radiometric age (Ma)
(Nva) : Symbol of formation
◎ : MMAJ-JICA (1990) data
⊙ : Data compiled by M.R.D.

Fig. 2-1-8 Map Showing the Results of Radiometric Age Determination

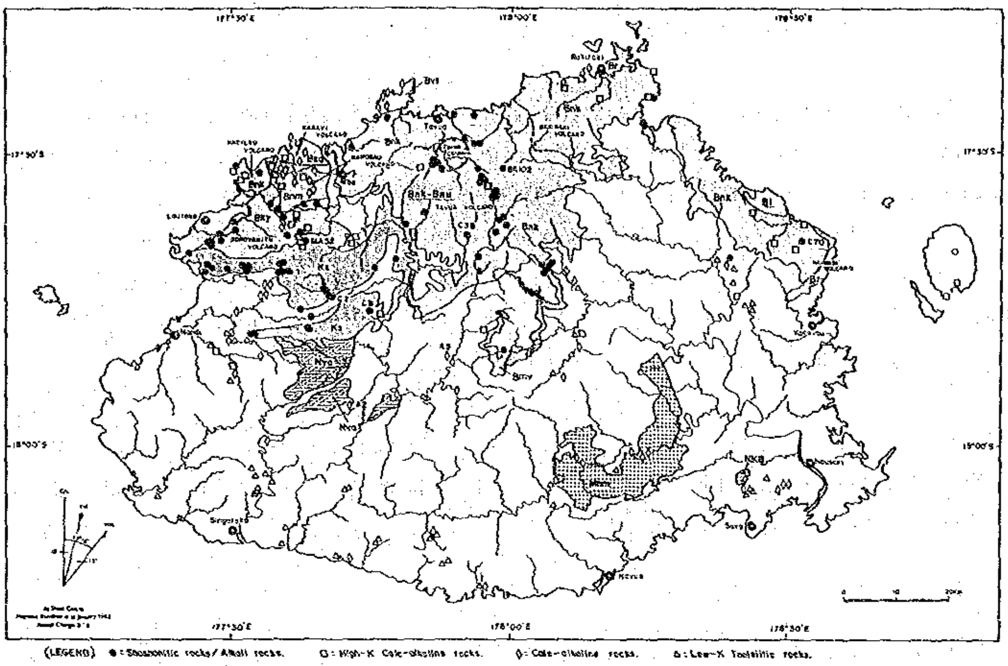


Fig. 2-1-9 Classification Map of Rock Series of the Survey Area

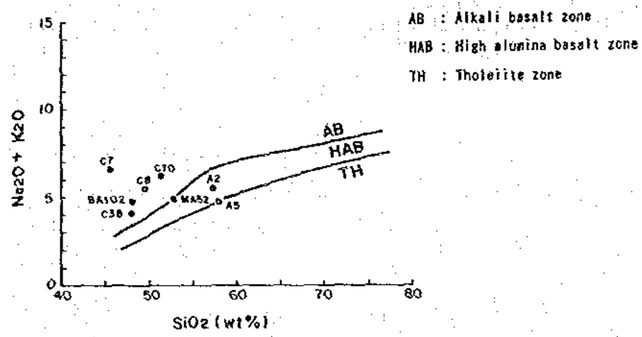


Fig. 2-1-10 Na_2O+K_2O-SiO_2 Diagram

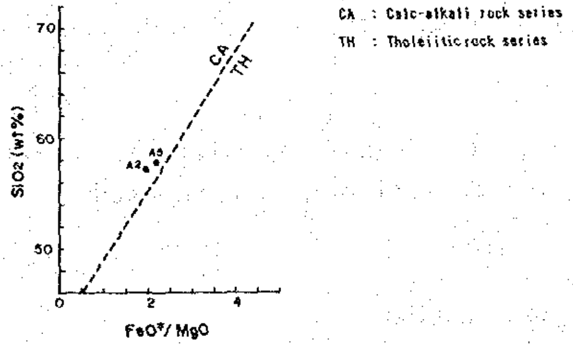


Fig. 2-1-10 FeO^*/MgO-SiO_2 Diagram

Intrusive bodies are aligned in the NW direction in the Lower Pliocene Series from the central Viti Levu to southeastern Mba.

A number of faults occur to the south of the Colo Plutonic Suite in the central part and around the Yavuna Group in the southwestern part. In the central part of the island, faults with ENE, EW, NE and NW strike with predominant strike in the ENE and NW direction are developed in the Wainimala Group and the Medrausucu Group to the south of the Colo Plutonic Suite. On the other hand, faults with ENE to NNE and NNW strike are developed within the Colo Plutonic Suite area.

In the southwestern part near the Yavuna Group, faults with NNW to NW, ENE to ESE, NE to NNE strike are developed in the Wainimala Group and Tuva Group while those with NE to NNE strike occur in the Navosa Sedimentary Group.

Other than the above, NNW and WNW striking faults are developed in the Ba Volcanic Group and Ra Sedimentary Group area in the northeast Viti Levu. In the western to the central part, N-S to NNW trending faults are developed in the Ba Volcanic Group and the Koroimavua Volcanic Group.

The folds are most abundant in the areas where faults are observed to occur frequently.

Synclinal and anticlinal axes are seen to develop parallel to the extension of the plutonic rocks (ENE to ESE, NNE), in the Wainimala and Tuva Groups near the Colo Plutonic Suite in the central part of the island.

In the southwestern part of the island, many fold structures occur in the area with the Yavuna Group at the centre. They are: NNW to WNW trending synclines and anticlines in the Wainimala and Tuva Groups in the southwest; ENE to NNE trending synclines and anticlines in the Tuva Group in the southeast; ENE trending synclines and anticlines in the Wainimala Group and the Nadi Sedimentary Group in the north, NNE synclines and anticlines in the Nadi Sedimentary Group and the Koroimavua Volcanic Group in the northeast.

In the southern part of Nanukuloa in the northeastern Viti Levu, NNE trending synclines and anticlines are developed in the Ra Sedimentary Group.

1-2-3 Outline of Mineralization

Veins, network-dissemination, porphyry copper, replacement, contact metasomatic, and sedimentary mineralization occur in Viti Levu.

(1) Veins and network-dissemination

Mines and mineral prospects formed through this process occur in the northeast, west and southern part of Viti Levu.

a. Northeast-Western Viti Levu

There are the following mineralized zones in this area - from northeast westward -: Rakiraki, Waikatakata, Homeward Bound, Nasivi No.3, Emperor Mine, Mbalevuto, Vuda, Nasavisavi Creek, Malakua Creek, Uthiwai Road, Faddy's and Mistry Mine.

The host rocks of the above mineralization are; Ba Volcanic Group for Rakiraki, Waikatakata, Homeward Bound, Nasivi No.3 and Emperor Mine; Koroimavua Volcanic Group and Ba Volcanic Group at their border zone for Mbalevuto; Koroimavua Volcanic Group for Vuda and Nasavisavi Creek; Yavuna Group for Malakua Creek; Wainimala Group for Uthiwai Road, Faddy's and Mistry Mine.

There are relatively large amount of data regarding the following mines and mineral prospects. They will be described briefly.

At the Rakiraki Prospect, auriferous quartz veins (0.5 to 40 cm wide) with NW trend were discovered in weathered basalt by geochemical prospecting and trenching. Gold content is said to locally reach several tens of grams per ton. White clay zones (50 m wide) with kaolin-montmorillonite mixed-layer minerals occur near the veins.

The deposits of the Emperor Mine are located at the western margin of the largest caldera (6 km across) of the eruptive centers of the Ba Volcanic Group activity. The Waikatakata Prospect is at the northern margin and the Homeward Bound - Nasivi No.3 Prospects are located at the central part of this caldera.

The past volcanic activities near this caldera are (Ibbotson, 1967; Ahmad, 1987; Anderson and Eaton, 1990; Rodda, 1989): Effusion of olivine basalt, shoshonite, trachybasalt (5.1±0.2 to 4.8±0.2 Ma: radiometric determination at margin of the caldera) → formation of cauldrons → augite trachy andesite activity (pyroclastics: 4.4±0.2 Ma, cone sheets) → formation of inner caldera and lacustrine sedimentation → biotite trachyandesite activty (lava: 4.5±0.06 Ma, pyroclastics, intrusives) and lacustrine sedimentation → monzonite intrusion (4.3±0.1 Ma) and trachyte intrusion → basalt activity (lava and pyroclastics: 3.9±0.1 Ma).

Gold mineralization occurred in the faults and dikes within the olivine basalt and augite trachyandesite pyroclastics at Emperor; in the fractures within trachybasalt at Waikatakata; in the fractures of the augite trachyandesitic pyroclastics and cone sheets, and of the biotite trachyandesitic pyroclastics and lavas at Homeward Bound - Nasivi No.3.

The deposits of the Emperor Mine consists of about 20 fissure filling veins. There are largely three types of fissures, namely those associated with steep N to NW trending dikes, low dip (less than 45°) faults, and steep faults trending WNW.

The ores occur from the surface to a depth of approximately 700 m and bonanzas occur at the intersections of the fissures. The dimensions of the individual veins are: the steep veins are several to several tens of centimeters wide, maximum strikewise extension 750m, maximum dipward extension 360m; the gently dipping veins are less than 1 m wide, maximum strikewise extension 2,300m, maximum dipward extension 2,300m.

The grade is Au 50 g/t at the bonanza but the average is calculated to be 7.5 g/t. Au-Ag ratio is 1:1. The ore minerals are petzite, native gold and auriferous pyrite accompanied by arsenopyrite, marcasite, sphalerite native tellurium, tetrahedrite-tennantite, chalcopyrite, galena, stibnite and native silver.

The gangue minerals are mainly quartz, accompanied by calcite, dolomite, ankerite, adularia and muscovite. The veins are often brecciated and the high grades zones are developed particularly in the gentle dip veins and at the intersections of the veins. The fluid inclusion temperature of quartz is 300 to 160°C (Ahmad et al., 1987; Kwak, 1990).

The alteration of the host rocks occurs in a relatively narrow zone (less than 2 m wide) adjacent to the veins and it consists of sericite, silica minerals, carbonate minerals, adularia, pyrite and smectite. Alteration is thus limited in scope and high grade gold ores also occur in the unaltered zones. There are irregularly developed alteration zones which are not related to mineralization and they consist of chlorite, carbonate minerals, sericite and pyrite.

Waikatakata Prospect is a gold mineralized zone formed in NW to WNW trending fractures. Between the Emperor Mine and Waikatakata Prospect, auriferous quartz veinlets which are several millimeters to several centimeters wide with Au 3 to 25 g/t, occur in silicified zone and in weathered basalt and andesite dikes.

Homeward Bound - Nasivi No.3 Prospect consists of auriferous silicified veins-ridges (about 50 cm to 15 m wide) in white altered zones along WNW to NW trending fractures. The constituents of the veins are quartz and alunite. Drilling revealed that gold mineralization is not developed in the lower parts of the silicified rocks and in some parts, monzonite was confirmed.

At Mbalevuto Prospect, quartz, limonite and quartz-alunite veinlets (about 5mm to 1 m wide, Au 0.ng/t) are developed into network in white alteration zones consisting of alunite, kaolin and pyrite.

At the Vuda Prospect, white alteration zone consisting of alunite and kaolin are developed near an abandoned adit in which pyrite-quartz and limonite-alunite-quartz veinlets (1 to 15 cm wide, Au several g/t) are developed. The host rock near the old adit is unaltered shoshonite. An alunite-quartz silicified zone forms a ridge extending about 700 m in the NE direction in the southern part of the altered zone, but gold mineralization is not developed in this silicified zone.

At the Faddy's Prospect, quartz-limonite veinlet network is developed in a white argillized zone composed mainly of kaolin. Drilling confirmed the bulk minable reserves of 920,000 t (Au 4.9 g/t).

The deposits of the Mistry Mine consist of quartz-limonite veins developed in the faults trending NNE and the highest grade of chip samples of the vein is; Au 11.9 ppm, Ag 15.9 ppm and Pb 28.2 %. Au content is higher near the surface and decreases downward. Drilling revealed weak dissemination of chalcopyrite and sphalerite in the lower parts. Also hornblende andesite to fine-grained diorite which is considered to be the peripheral facies of the Colo Plutonic Suite was confirmed by this drilling. Silicification, white argillization and pyritization are observed near the deposit. Also weak pyritization and propylitization are observed in the peripheral zones.

b. Southern Viti Levu

The vein type mineralized zones in this part of the island are; Waitotolu, Wainisavusavu, Matalo, Nancy Kalia and Korotogo in the Wainimala Group; Wainikovu in Namosi Andesite of the Medrausucu Group and Wainadoi in quartz diorite of the Colo Plutonic Suite.

The commodities are Au-Ag-Cu at Wainadoi, Cu at Matalo and Cu-Zn at the other prospects. Most of the associated alteration is sericite - chlorite type. Since the Colo Plutonic Suite occurs in the vicinity of the above mineralized zones, these could be porphyry copper type metal concentration, but the details are yet to be clarified.

(2) Porphyry copper

The porphyry type mineralization in Viti Levu is classified into two groups, namely the "plutonic type" which occurs in the Colo Plutonic Suite and in the Wainimala Group near the plutonic suite in the central east to southwest Viti Levu, and the "volcanic type" which is found in the Medrausucu Group in the south and in the Koroimavua Volcanic Group in the northwest.

a. Plutonic type porphyry mineralization

This type of mineralization is known to occur at Nuku, Wainivau, Rama Creek, Naitaki Creek, Kule, Nathilenga and Koroisa.

The mineralization occurs at both the periphery of intensely weathered tonalitic bodies of the Colo Plutonic Suite and near the top of these bodies where weathering has not been intense. Thus it is considered that mineralization occurred in relatively deep zones related to the plutonic activity (7 to 12 Ma). The surface manifestation of the mineralization is strong dissemination of pyrite and weaker chalcopyrite, bornite, chalcocite, sphalerite, molybdenite dissemination is often observed. Secondary minerals such as malachite and covelline are common. Quartz veins are not well developed. Alteration is mainly sericite-chloritization or propyritization with local association of potassium alteration (biotite, potash feldspars).

b. Volcanic type porphyry mineralization

This type of mineralization is known to occur at Waisoi, Wainabama and Waivaka in the southern part of Viti Levu, and at Kingston Mine and Tawaravi Creek in the Sabeto Range in the northwest.

The southern prospects is located mainly in the Namosi Andesite (5.5 to 6.0 Ma) of the Medrausucu Group with some extending into the adjacent Wainimala Group. The mineralization is associated with the quartz porphyry, quartz diorite porphyry, hornblende andesite and other rocks intruded into the Namosi Andesite and the plutonic bodies are not observed at the surface. The alteration is mainly sericite-chloritization or pyrite-propyritization accompanied by potassium alteration (biotite) in the central part. Quartz veins are well developed, mineralization is dissemination of mainly pyrite, chalcopyrite and bornite associated in part with chalcocite, sphalerite, molybdenite and tetrahedrite. Secondary minerals such as malachite and covelline are observed. Gold is associated with copper mineralization and the content is higher in the shallower parts. There are no oxidized or secondary enrichment zones. The following reserves were confirmed at two localities by drilling at Waisoi.

Waisoi East: 230 million tons Au 0.16 g/t, Cu 0.47 %, Mo 143 ppm
Waisoi West: 360 million tons Au 0.14 g/t, Cu 0.47 %

The mineralization in the northwest Viti Levu occurs in the Sabeto Volcanics (4.6 to 5.6 Ma) of the Koroimavua Volcanic Group and in the Navilawa Stock (4.9 to 5.2 Ma) which intruded into the above volcanics and also in the Nawainiu Intrusive Complex (5 Ma).

The major mineralization of the Kingston Mine is the network dissemination of chalcopyrite in the periphery of the micromonzonite-latite volcano plutonic complex plug (Navilawa Stock) and quartz veins are not well developed. Bornite, malachite and azurite are observed in some of the fissures. There are no oxidized or secondary enrichment zones. High grade gold-silver-bearing veins (maximum grade: Cu 20.3 %, Au 97 ppm, Ag 434 ppm) were mined from the old mine. The alteration is pyrite-propyritization and sericitization in the vicinity of the old mine, and there is also a white alteration zone to the north composed of quartz-alunite-kaolin which forms a ridge extending in the NNE direction.

The Nawainiu Complex consists of heterogeneous micromonzonite body and its texture is often porphyritic. It underwent quartz-calcite-sericite alteration and pyrite-propyritization, but copper sulfide minerals are not observed and fissures and veins are not developed.

(3) Replacement, skarn mineralization

Replacement mineralization occur at Wailotu, Wainavola and Wainiviti in the eastern part of Viti Levu and at Taci, Tuveriki Mine in the west.

The mineralized zone in east Viti Levu occur in Wainimala Group and it consists of base-metal sulfide dissemination, veins and magnetite veins. It is accompanied by silicified limestone lenses. Small bodies of Colo Plutonic Suite occur in the vicinity. Silicified, chloritized and sericitized zones which also contain pyrite dissemination are widely developed near the mineralized zone.

The western mineralized zones occur in the Yavuna Group and the

Wainimala Group. They are massive iron deposits accompanied by limestone lenses. There are gabbro and tonalite bodies in the vicinity.

The contact metasomatic mineralization is known at Kubuna River, Natualevu, Tuva River, Tulasewa, Sulua Creek and other localities in the southwest.

These mineralized zones occur at the contact of the limestone of the Wainimala Group and the Colo Plutonic Suite. In this contact zone, skarn minerals are developed. The mineralization occur in this skarn zone as base metal sulfide dissemination and lenses and also as sulfide veins transecting the carbonate rocks. Alteration zone consisting of quartz and sericite is distributed widely around the mineralized zone extending northwestward and porphyry type prospects occur to the northwest.

(4) Sedimentary mineralization

a. Massive sulfide

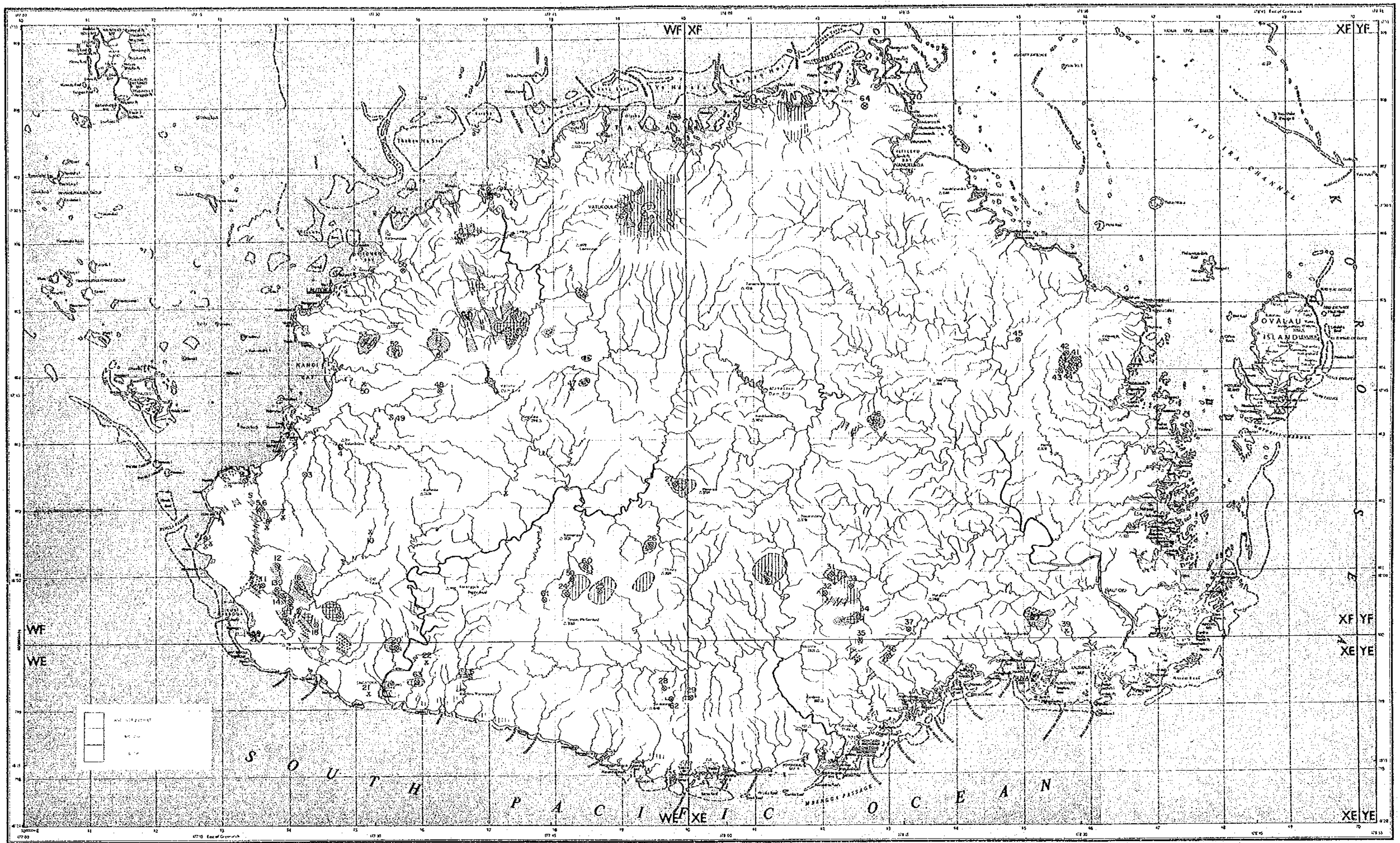
This type of mineralization occurs at Kavika-Lo, Nakoro, Kula, Wainaleka in southern Viti Levu, at Wainivesi in the east and at Tholo-i-Suva in the southeastern part.

The Tholo-i-Suva mineralized zone occurs in the Savura Volcanic Group and the other mineralized zones in the Wainimala Group.

These are stratabound mineralized zones which occur in pyroclastics formed by submarine volcanic activities. Base-metal - mainly Cu and Zn - sulfides are concentrated in massive or lenticular form. Network veins of pyrite and silica are sometimes associated. The host rocks are often mafic to intermediate, but in some cases are felsic in nature. Zoning of the mineralized zones containing higher Zn in the upper parts and higher Cu in the lowest parts are observed in some prospects such as Tholo-i-Suva and Wainaleka. The major gangue minerals are quartz and barite accompanied variously by gypsum, magnetite, Mn minerals and jasper, but bedded sulfate bodies do not occur. Colloform texture and graded texture of sulfide are sometime observed in the ore. The host rocks in the vicinity underwent sericitization and chloritization.

b. Bedded manganese type mineralization

The mines and prospects of this type in the survey area are as follows. The Nambu, Vunamoli, Nasauthoko, Koroviko, Votualevu, Sivia Creek, Tambungguto and Mbaravi Mines in the western side of the island; the Wainivesi and Waivisa Prospects in the east; and the Kalabo Mine in the southeast.



LEGEND

- Strongly argillized alteration
- Medium argillized alteration
- Weakly argillized alteration
- Propylitic alteration
- S Silicification
- Working mine
- Closed mine
- Prospect
- 1~63 Location Nos. denoted as the numbers in the list of the prospects and mines

MINES AND PROSPECTS

1.. Mistry Mine [Au-Ag-Pb(Cu,Zn)]
1A. Faddy's [Au]
2. Uciwai Road [Cu-Pb-Zn]
3. Malakua Creek [Cu-Zn]
4. Taci [Fe]
5. Koroisa [Mn,Au-Cu-Pb-Ag]
6. Koroisa [Au-Cu-Pb-Ag & Ba]
7. Nabu Mine [Mn]
8. Koroviko Mine [Mn,Fe-Ba]
9. Tuveriki Mine [Fe]
10. Vunamoli Mine [Mn]
11. Kubuna River [Zn-Pb-Cu]
12. Nacilega [Cu-Mo]
13. Kule or Kule Creek [Cu]
14. Kule Creek [Cu]
15. Natualevu [Zn(Cu-Ag)]
16. Naitaki Creek [Cu-Pb-Zn]
17. Tuva River [Cu]
18. Voua Creek [Cu-Pb-Zn]
19. Tulasewa [Zn-Cu]
20. Sulua Creek [Cu-Zn]
21. Sigatoka Dunes [Fe,Ti]
22. Baravi Mine [Mn]
23. Nasaucoko Mine [Mn]
24. Kavika-Lo [Zn-Cu(Pb,Ag,Au)]
25. Rama Creek [Cu(Au)]
26. Nakoro [Zn-Cu,Ag-Au]
27. Wainivau [Cu(Au)]
28. Kula [Cu-Zn]
29. Wainaleka [Zn-Cu(Ag)]
30. Waitotolu [Cu-Zn]
31. Waisoi [Cu(Au-Mo]
32. Wainabama [Cu(Au-Mo)]
33. Wainisavu savu [Cu-Zn(Au)]
34. Waivaka [Cu]
35. Wainikovu [Cu(Au-Ag,Zn-Pb)]
36. Wainadoi [Au(Ag,Te,Cu)]
37. Waimanu [Au]
38. Colo-i-Suva [Zn-Cu(Au)]
39. Kalabo Mine [Mn]
40. Wainivesi Mine [Zn-Cu-Pb(Au-Ag)]
41. Wailotu [Cu-Fe(Zn)]
42. Wainavola [Fe]
43. Wainiviti [Zn-Pb-Cu]
44. Wainivesi [Mn]
45. Waivisa [Mn]
46. Nuku [Cu]
47. Tabuquto Mine [Mn]
48. Nasavisavi Creek [Fe]
49. Sivia Creek [Mn]
50. Votualevu Mine [Mn]
51. Kingston Mine [Cu,Au-Ag]
52. Tawaravi Creek [Cu(Au)]
53. Vuda [Au(Cu-Ag)]
54. Balevuto [Pb-Zn,Cu-Au-Ag]
55. Drasa [Al]
56. Emperor Mines Vatukoula [Au-Ag-Te(Cu-Zn)]
57. Waikata-kata [Au]
58. Ba delta [Fe]
59. Naruku-levu [Cu,Zn(Au,Ag)]
60. Tubatolu [Cu]
61. Matalo [Cu]
62. Nancy-Kalia [Cu(Zn)]
63. Korotogo [Cu-Zn(Pb-Au-Ag)]
64. Rokiroki [Au]

Fig. 2-1-11 Distribution Map of Mines, Prospects and Alteration Zones of the Survey Area

The mineralized zones of the Tambungguto Mine and the Sivia Creek Mine in the northern part of the western side of Viti Levu occur in the Nadi Sedimentary Group while those of other prospects of the western Viti Levu occur in the Wainimala Group. In the eastern side, the mineralized zones occur in the Wainimala Group and those in the southeast, in the Medrausucu Group.

These mineralized zones, with the exception of those in the southeast, form bedded or irregular manganese oxide deposits in well stratified volcano-sedimentary formations and are accompanied by iron oxide bearing siliceous rocks. The deposits are often cut by faults and are brecciated. In some cases the manganese oxides occur as veins or replacing limestone. The host rocks in the vicinity are strongly chloritized.

The mineralized zones in the southeast are manganese oxide deposit which occur in the sandstone and marl alternation near the border of the Suva Marl and Nakobalevu Basalt.

c. Residual type metal concentration

Mineral prospect of this type occurs at Ndrasa in the northwest Viti Levu. This consists of small bauxite bodies formed by the lateritic weathering of basaltic pyroclastics of the Ba Volcanic Group.

d. Mechanical mineral concentration

Mechanical accumulation of metallic minerals occurs at Waimanu in the south, at Sigatoka Dunes in the southwest and at Mba Delta in the northern Viti Levu.

The deposit at Waimanu is a placer gold concentration within the alluvium overlying the Wainimala Group in the upper reaches of the Waimanu River. The Wainandoi gold veins in the gabbroic bodies of the Colo Plutonic Suite occur in the upper stream zone of this deposit.

The accumulations at Sigatoca Dunes and at Mba Delta consist of placer iron concentration. The Singatoca Dunes contain magnetite and other heavy sands derived from Wainimala Group, Ba Volcanic Group and Colo Plutonic Suite in the inland areas. The Mba Delta consists of deltaic sediments consisting of alluvium sand and silt which contain heavy minerals derived from the Ba Volcanic Group in the inland areas.

1-2-4 Survey Results

The primary emphasis of the geological field survey of this phase was on ascertaining, in the field, the following points in the 15 areas delineated by SLAR imagery analysis. Whether the annular and caldera structures extracted from SLAR imageries and aerial photographs are collapse structures or not; whether the SLAR dome structures are volcanic or not; the detailed nature of the mineralized zones and the alteration zones. The results of the survey and the study of previous work were carefully considered and are shown in Fig. 2-1-12 to 2-1-15 and Table 2-2-3. The intensity of alteration was assessed in the field and the alteration zones were classified accordingly. They are shown on the 1:250,000 scale mine and prospect locality map (Fig. 2-1-11).

1-2-5 Discussions

The significance of the annular, caldera and dome structures which were extracted photogeologically will be discussed in this section for each area.

(1) Area A

There is a circular enclosed depression in this area and its size is similar to the SLAR annular structure. Within this depression volcanic effusive material which is younger than those of the vicinity is distributed and it suggest the possibility of the volcanic nature of the depression. The breccia and dykes along the outline of this younger effusives indicate the existence of annular fissures. Also there are enormous amount of basaltic effusive near this area. These circumstantial evidences indicate that this depression first formed as a Kilauea-type caldera and that the outline of the volcanic effusives within the depression is the edge of the caldera.

The development of ring dykes, cone sheets and radial dykes around the above inferred caldera indicate that the fissures formed by the rise and fall of the subvolcanic magma were subsequently filled by the magma. Also from the nature of the volcanic material, namely the distribution of andesitic rocks within the inferred caldera and the intrusion of monzonite in the southeastern part of this caldera, it is inferred that differentiation proceeded and mixing occurred in the magma chamber during that period. Two types of augite phenocrysts occur in the basalt lava near the caldera. This fact also suggest that mixing of magma occurred in the chamber. Also the marked zonal structure of these augite phenocrysts indicate that magma effusion occurred repeatedly and the composition of the magma chamber changed with each eruption.

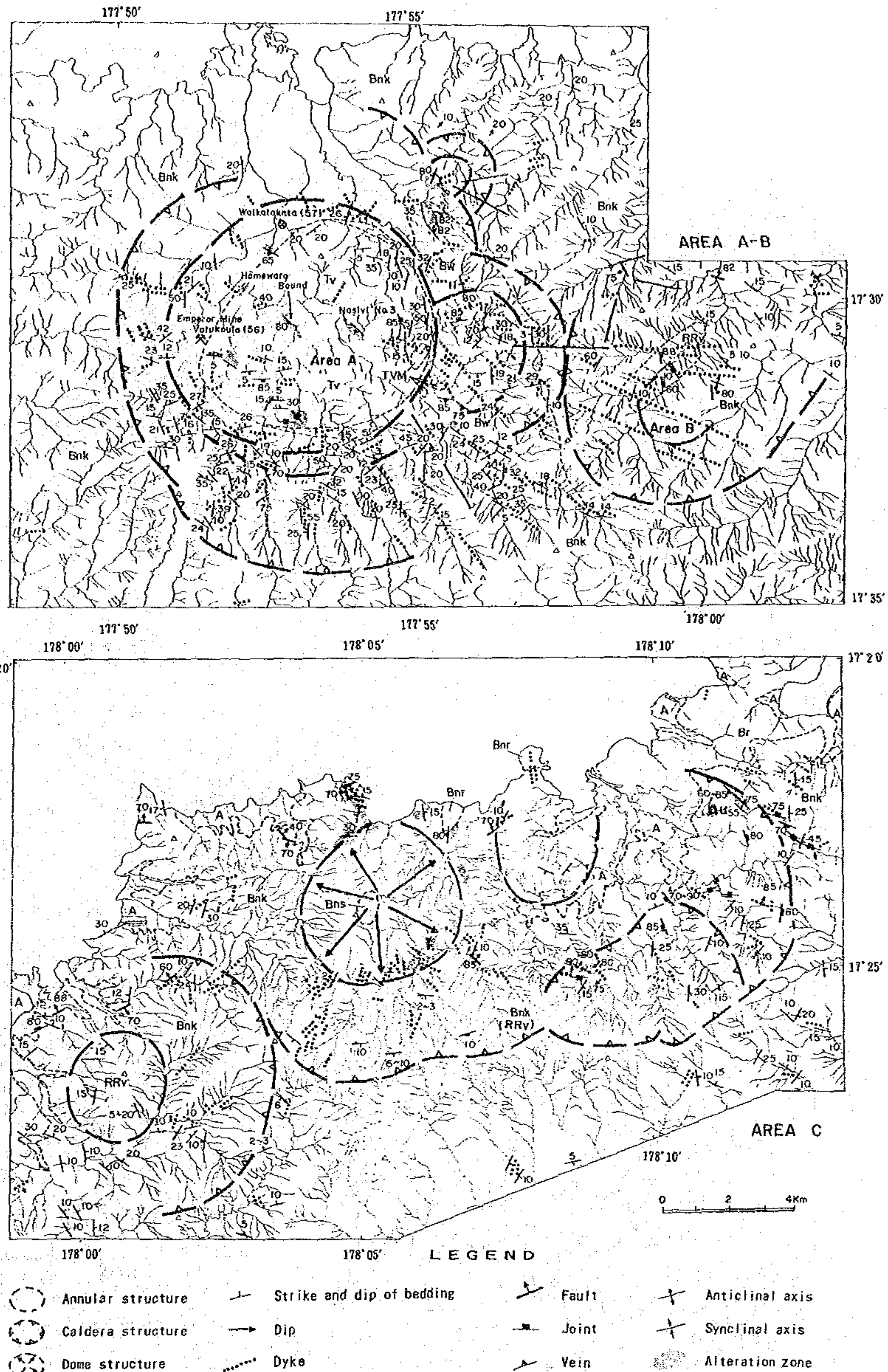


Fig. 2-1-12 Field Geological Data Map of Areas A, B and C

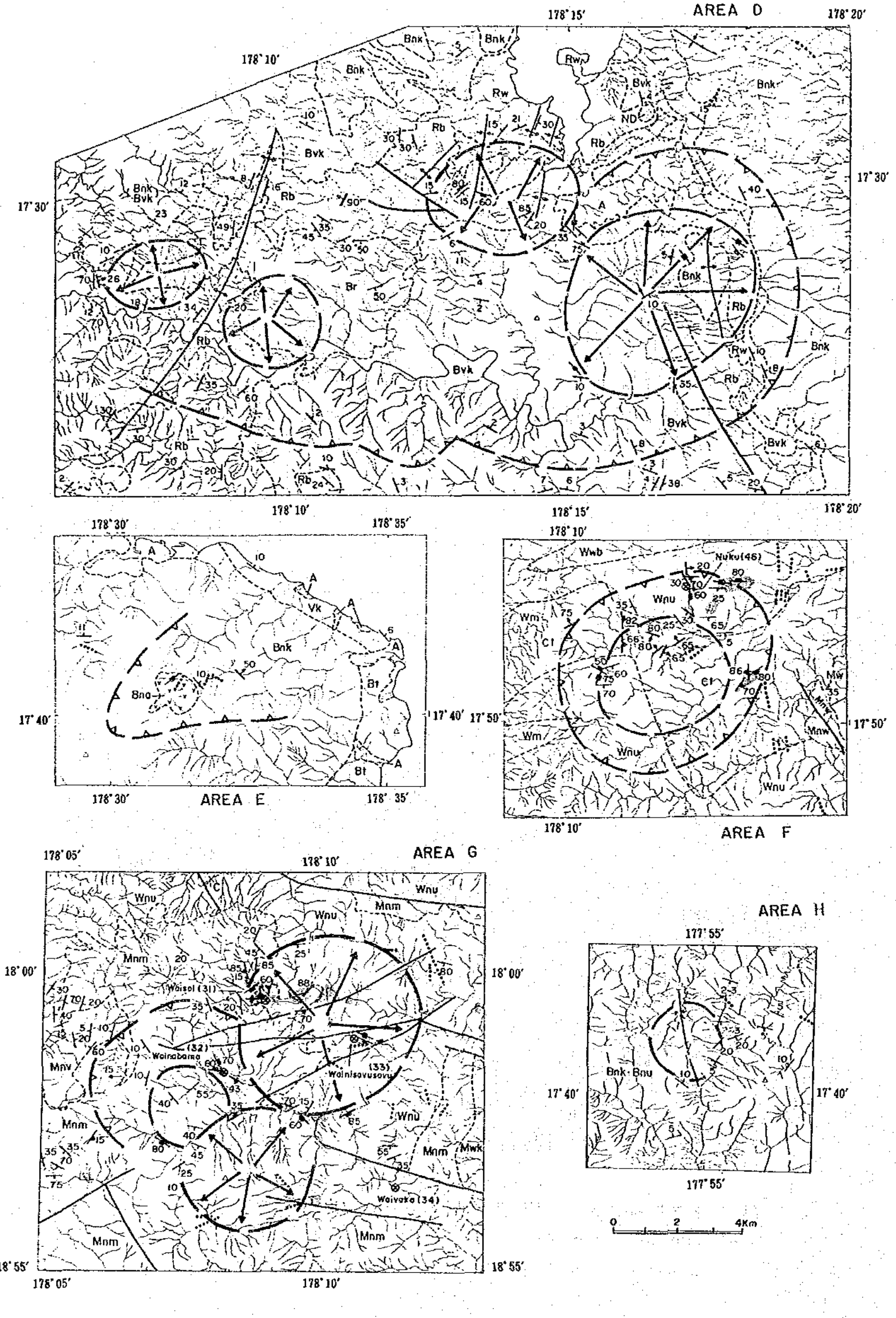


Fig. 2-1-13 Field Geological Data Map of Areas D, E, F, G and H

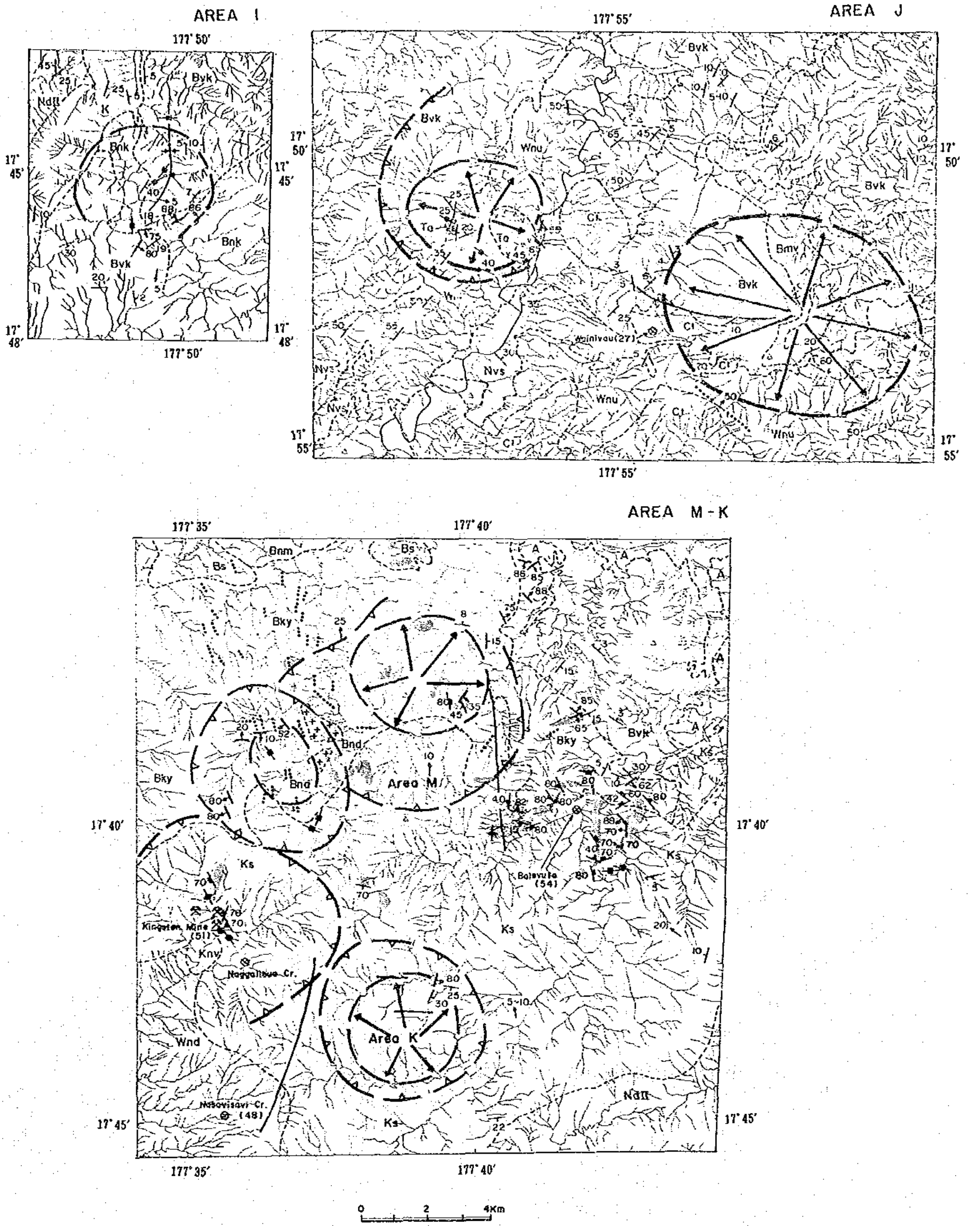


Fig. 2-1-14 Field Geological Data Map of Areas I, J and M-K

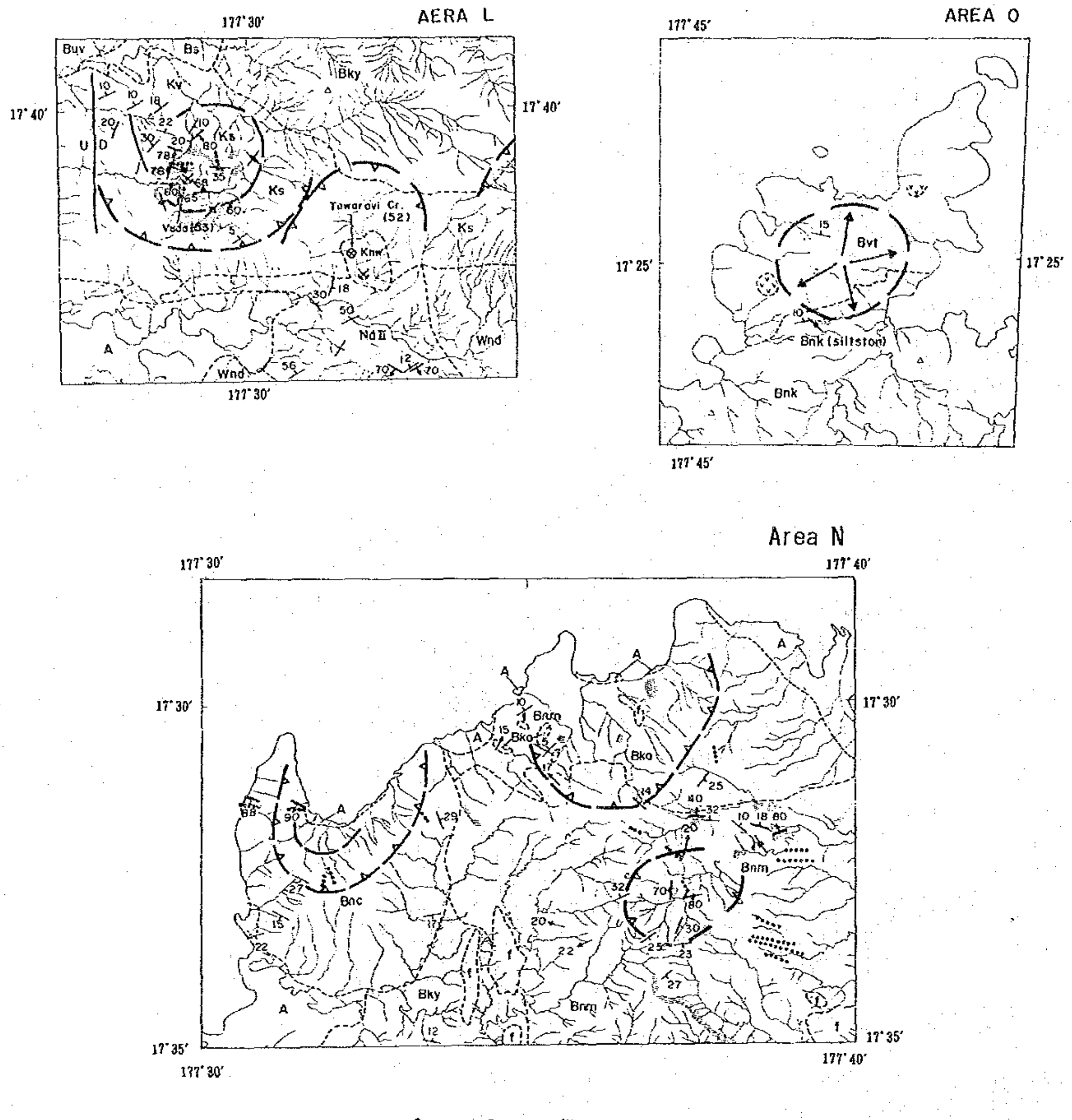


Fig. 2-1-15 Field Geological Data Map of Areas L, O and N

Abbreviations

(Table 2-1-3)

Morphological Anomalies on SLAR Imageries

N : northern part
S : southern part
E : eastern part
W : western part
C : central part
NE : northeastern part
SE : southeastern part
AP : extracted from Aerial Photograph
str. : structure

Others

na. : not available
Alu : alunite
Ser : sericite
Kao : kaoline
Qz : quartz
Py : pyrite
Pyrophy : pyrophyllite
Sil : silicification

Table 2-1-3 Summary of Results of Geological Survey with Emphasis on Areas of Morphological Anomaly (1)

Area		A	B	C	D
Morphological Anomalies on SLAR Imageries		① Annular str. (C) ② Caldera str. (C) ③ Semi-Annular str. (NE・AP) ④ Semi-Caldera str. (NE・AP) ⑤ Semi-Annular str. (SE) ⑥ Semi-Caldera str. (SE)	① Semi-Annular str. ② Semi-Caldera str.	① Annular str. (W) ② Semi-Caldera str. (W) ③ Dome str. (C) ④ Semi-Caldera str. (C) ⑤ Semi-Annular str. (E) ⑥ Semi-Caldera str. (E)	① Dome str. (extremely W) ② Dome str. (W) ③ Dome str. (C~E) ④ Dome str. (E) ⑤ Semi-Caldera str. (S~E)
Geologic Structure	dip and strike	① basin str. ② southern part:N・dip western part:NE・dip ⑤ irregular	① strike:parallel to semi-annular str. (NS~NW・strike E~NE・dip)	①,⑥ irregular ③,⑤ domal str. ⑥ semi-domal str.	①,③,④ semi-domal str.
	folding	not conspicuous	not conspicuous	not conspicuous	①~④ NNE~N-S
	intrusives	① Monzonite stock, Andesite stock and dike ①~⑥ Basalt and Andesite	①,② Andesite and Basalt dikes	③,⑤ Gabbro, Andesite plug, Basalt and Andesite dikes	northeastern part of the area:Microdiorite (small body)
	volcanics	dominant	dominant	dominant	distributed in eastern and western parts of the area
Fracture	fault system	② southeastern part:NW ⑤,⑥ EW	①,② NNW~NNE, E-W	② WNW~ENE	③,④ NW~WNW
	joint system	① parallel to annular str.	①,② NNW	⑥ WNW, NNW	③,④ NW~WNW
	vein system	Emperor Mine:NW, E-W, N-S ① NW	na.	③ Py veinlet:NNE ⑥ Qz-Au vein:NW	na.
	dike system	① parallel to annular str. inside and outside:radial ② southeastern part:NW~EW southern part:N-S, ③ NE	①,② WNW~E-W	③~⑥:radial	irregular (few dikes)
	abrupt change of bedding	exist in a part from Emperor Mine to Waikumbukumbu	exist in the vicinity of boundary between areas A and B (N-S direction)	exist between ② and ④ ENE→NNW	southwestern part of ⑤: WNW, ③:N-S
	SLAR lineament	NE system:large high-density zone Au-mineralization near contact of high-density zones	NE system	NE system 〉 NW system	NW~WNW system along ⑥:small high-density zone
Alteration Zone	nature of alteration	Emperor Mine:mainly Ser ① Alu, Sil ③ Kao-Alu	na.	eastern part of ③: propylitic eastern margin of ⑥: white clay (narrow)	na.
	trend	① NNE~N, WNW	–	propylitic:NNW white clay:NW?	–
	dimension	① 4×2km, 4×1km propylitic zone:10×10km	–	propylitic:(7+α)×3km white clay:0.1×0.05km(?)	–
Mineralized Zone	classification	Au-Ag-Te vein	non	propylitic:Py veinlet white clay:Qz-Au vein	na.
	trend	① WNW ③ E-W, NE	–	Py veinlet:? Qz-Au vein:NW	–
	dimension	7×(2.5~0.7)km	–	?	–
Gravity Anomaly		① low, ②,③,④ high	–	③,④ high, ⑥ low ⑥ partly low	–
Aeromagnetic Anomaly		①~⑥ not high	①~② not high	①~⑥ not high	①~⑤ not high
Mechanism and genesis of geologic structures		① volcanic collapse caldera ② erosion caldera ③,⑤ active intrusion of magma ④,⑥ ?	Geologic structure has been formed closely associated with volcanism of area A.	① center of eruption ②,④,⑥ erosion caldera ③ volcanic dome by active intrusion of magma or resurgent caldera ⑤ volcanic dome by active intrusion of magma	①,② ? ③,④ volcanic dome ⑤ erosion caldera

Table 2-1-3 Summary of Results of Geological Survey with Emphasis on Areas of Morphological Anomaly (2)

Area		E	F	G	H
Morphological Anomalies on SLAR Imageries		① Semi-caldera str.	① Annular str. ② Caldera str.	① Annular str. ② Semi-Caldera str. ③ Dome str. (N) ④ Dome str. (S)	① Annular str.
Geologic Structure	dip and strike	northern part:NW-E-W·strike NE-N·dip southern part:?	northern part: E-W·strike, S·dip	①, ② W-SW·dip (monoclinic) ③, ④ irregular	horizontal to very gentle dip
	folding	not conspicuous	not conspicuous	not conspicuous	Syncline(NNW)
	intrusives	Basalt and Andesite dike	Tonalite	Quartz porphyry, Quartz-diorite porphyry, Andesite dikes	Basalt(very few)
	volcanics	whole area	exist in Wainimala Group	dominant	dominant
Fracture	fault system	NW(one observed)	NNW, ENE	ENE-WNW dominant	na.
	joint system	irregular in Hornblende Andesite	N-S, E-W	parallel to margin of ① and ③	na.
	vein system	irregular (very few)	N-S, E-W, NE	irregular (ENE, NNW-NNE, NW)	na.
	dike system	NW, NE(few dikes)	NNW-N-S, ENE	irregular (ENE, NW, NNW-NNE)	NW-WNW(few dikes)
	abrupt change of bedding	na.	na.	exist in western marginal part of ③	na.
	SLAR lineament	high-density zone: NW-NNW, ENE systems	② high-density zone	no high-density zone	no high-density zone
Alteration Zone	nature of alteration	na.	northern part of ② white clay-sil:(a) white clay:(b)	northern part of ③ propylitic, white clay	na.
	trend	–	NNE(?)	E-W	–
	dimension	–	(a) 2×2km (b) 2×0.2km	3.5×1.5km 1×1km	–
Mineralized Zone	classification	Py film	Qz-Cu-Py veinlet	Porphyry Copper Cu(-Au-Mo), Cu-Zn(-Au)	na.
	trend	–	?	?	–
	dimension	–	?	ore reserves:230Mt :360Mt	–
Gravity Anomaly		–	–	–	–
Aeromagnetic Anomaly		not high	①, ② high	③, ④ partly high	high
Mechanism and genesis of geologic structures		erosion caldera (Crater might have been eroded.)	① active intrusion of magma ② erosion caldera	① initial caldera ② erosion caldera derived from collapse caldera ③, ④ volcanic dome related to complex of volcanics and intrusives	strike control expressed by syncline

Table 2-2-7 Summary of Results of Geological Survey with Emphasis on Areas of Morphological Anomaly (3)

Area		I	J	K	L
Morphological Anomalies on SLAR Imageries		① Semi-Annular	① Dome str. (W) ② Semi-Caldera str. (W) ③ Dome str. (E)	① Dome str. (E) ② Caldera str. (E) ③ Semi-Caldera str. (W·AP)	① Semi-Annular str. (W) ② Semi-Caldera str. (W) ③ Semi-Caldera str. (E)
Geologic Structure	dip and strike	NE·strike } basin str. NW or SE·dip southern part: irregular	①, ② NW·dip (monoclinic) ③ irregular	na.	① northern part: NW·dip ②, ③ na.
	folding	Syncline(N-S~NNE)	not conspicuous	–	not conspicuous
	intrusives	na.	① Hornblende Andesite ③ Tonalite, Monzonite	③ Micromonzonite-Latite	Micromonzonite Andesite
	volcanics	dominant	dominant	dominant	dominant
Fracture	fault system	NE~ENE(few faults)	③ WNW	① E-W, NNE(few faults)	① NE, WNW~NW
	joint system	NNE~NE, E-W	①, ③ WNW	③ NNW, E-W	① E-W
	vein system	na.	na.	③ NNW, NNE	① NNW~NNE, E-W, NE
	dike system	na.	③ WNW(few dikes)	na.	① NNW, E-W(few dikes)
	abrupt change of bedding	southern part E-W→N-S	western margin of ③ near fault	na.	na.
	SLAR lineament	NE~ENE system high-density zone :E-W system	no high-density zone	high density zone :NW system	NNW~NW system no high-density zone
Alteration Zone	nature of alteration	non	western margin of ③: propylitic	③ S:propylitic and Py-Ser N:{ Qz-Alu-Kao, Silicified zone(ridge)	① Qz-Alu-Kao-Py, Qz-Pyrophy-Alu-Py, propylitic
	trend	–	E-W(?)	NNE	NNE~NE
	dimension	–	4×2.5km	2×1(?)km	3×2.5km
Mineralized Zone	classification	non	Cu(-Au) vein, porphyry copper type	S:{ Cu-Au network veinlets porphyry copper type N:acid sulfate type(Au vein)	acide sulfate type Au(-Cu-Ag-Py) vein
	trend	–	na.	na.	na.
	dimension	–	na.	na.	na.
Gravity Anomaly		–	–	③ high	①, ② high
Aeromagnetic Anomaly		not high	eastern part of ③:high	①, ② partly high ③ high	①~③ high
Mechanism and genesis of geologic structures		volcanic collapse, structure or strike control expressed by syncline	local volcanic uplifting probably related to intrusion of Andesite and Monzonite	① volcanic dome ②, ③ erosion caldera derived from collapse caldera	① caldera ② erosion caldera ③ erosion caldera (originally center of eruption)

Table 2-2-7 Summary of Results of Geological Survey with Emphasis on Areas of Morphological Anomaly (4)

	Area	M	N	O	Area to the west of Singatoka
Morphological Anomalies on SLAR Imageries		① Annular str. (W) ② Caldera str. (W) ③ Dome str. (E) ④ Caldera str. (E)	① Semi-Annular str. (W) ② Semi-Caldera str. (W) ③ Semi-Caldera str. (E) ④ Caldera str. (E)	① Dome str.	not extracted
Geologic Structure	dip and strike	③ domal str. ①, ②, ④ na.	①, ②, ④ domal str.	N·dip(northern and southern parts)	WNW, N, S·dip
	folding	non	non	non	Anticline(WNW) Syncline(WNW)
	intrusives	①, ② Shoshonite dike ④ Monzonite, Andesite plug	④ Hornblende Andesite dike ② Pyroxene Andesite dike	Hornblende Andesite	Tonalite, Gabbro, Andesite
	volcanics	dominant	dominant	dominant	present in Wainimala Group
Fracture	fault system	①, ② NNW, E-W ③, ④ (outside)irregular	WNW~ENE(few faults)	na.	WNW, N-S~NNW
	joint system	①, ② NW~WNW, NNE ③, ④ (outside) irregular	NW(few joints)	NW(few joints)	WNW~ENE (NW, NE)
	vein system	③, ④ (outside) NW, N-S, WNW	na.	na.	NNE~NE ?
	dike system	①, ② NNW~NNE(radial) ③, ④ and outside:irregular	①, ② radial ②, ④ (outside) WNW~E-W	na.	NW, NE, ENE
	abrupt change of bedding	na.	na.	na.	na.
	SLAR lineament	NNW system small high-density zone	ENE and NNW systems no high-density zone	non	NW, N-S, NE systems
Alteration Zone	nature of alteration	③ Pyrophy-Alu ④ Kao Balevuto:Qz-Alu-Kao-Py	③ Pyrophy-Alu ④ Alu-Kao-Ser-Py	white clay (very narrow)	white clay silicification propylitic, sericite
	trend	NW~NNW	NW	na.	WNW
	dimension	25×10km (extends toward north)	43×4km (extends toward Area M)	na.	75×15km
Mineralized Zone	classification	Qz-Limonite network veinlet (Balevuto)	④ Py vein	na.	Au-Ag-Pb vein: (a) Cu-Pb-Zn porphyry type: (b) Bedded Mn (c)
	trend	na.	na.	na.	(a) NNE, (b) na. (c) WNW
	dimension	na.	na.	na.	(a) 45×12m, (b) na. (c) 100×200m
Gravity Anomaly		① high	①~④ high	high	—
Aeromagnetic Anomaly		①~④ high	①~④ not high	not high	not high
Mechanism and genesis of geologic structures		① collapse caldera ~resurgent caldera ② erosion caldera ③, ④ resurgent caldera	① initially crater or collapse caldera ② erosion caldera ③ collapse caldera, erosion caldera older than ①, ② & ④ ④ initially crater or collapse caldera	movement of block uplifting related to volcanic activities	—

The fact that the western border of the SLAR annular structure is located outside of the inferred caldera edge shows that the depression expanded by erosion after the formation of this caldera. Also the SLAR semi-annular and SLAR semi-caldera structures to the south, east and north-east of the above enclosed depression are interpreted to be the erosional fronts by which the depression was enlarged.

The existence of a line of geologic structural discontinuity extending in the WNW direction through the south of the Emperor Mine is inferred from the changes of the attitude of the geologic formations near the caldera. The dip of the geologic units within the caldera shows that the collapse occurred even after the deposition of the Tavua Volcanic products within the caldera. If the volcanic activity which caused this collapse occurred within the caldera, the effused material cannot be found at present and they must have been eroded and transported away. On the other hand, in the case of Kilauea, the crater within the caldera does not emit large quantities of lava and thus it is possible that steam eruption may have taken place to cause the above collapse. The Tavua Effusives are andesitic in nature and thus this eruption probably was not of the Kilauea type.

Small semi-annular and SLAR semi-caldera structures were extracted at two localities east of the above caldera from SLAR and aerial photographs. These, however, are strongly eroded and evidences linking them to collapse formation cannot be observed. Koide (1982) showed that when a magma with conical shape rose to a shallow depth, the pressure increased on the sides and the zone directly above the magma subsided, resulting in annular structures without accompanying effusive material. Within the semi-annular structure extracted from aerial photographs, in the northeast, small bodies of diorite porphyrite are observed and dykes and faults are arranged in semi-radial pattern in the vicinity. Thus, this semi-annular structure could be related to magmatic intrusion. Similar possibility exists for the SLAR semi-annular structure in the southeast. Both of these small structures are cut by the central caldera and thus the smaller ones are older than the central structure.

(2) Area B

SLAR semi-annular and SLAR semi-caldera structures were extracted in this area and basaltic volcanics occur within them, but direct evidences for the collapse origin cannot be found for these structures. The dykes in this area is believed to be a part of the radial dykes related to the formation of the Tavua Caldera of Area A and there are no evidences for the intrusion of magma into this area.

(3) Area C

The geology within the SLAR annular structure and near the SLAR dome in the central part of this area forms a semi-dome. Also there are intrusions of andesite plugs, gabbro and radial dykes. It is, therefore, inferred that these SLAR annular and SLAR dome structures are volcanic domes formed associated with the intrusion of magma.

The SLAR annular structure in the west agrees fairly well with the outline of the tuff distribution. There is a knob composed of volcanic breccia in the central part of the structure and it is inferred that a centre of eruption exists within the structure. The attitude of the geologic formations is disordered and probably irregular flexure occurred in relation to volcanic activities.

The SLAR caldera developed in the vicinity of the SLAR dome and SLAR annular structures could be an erosion caldera and the primary depression could have existed within the zone of the SLAR dome and SLAR annular structures. In this case the SLAR dome is considered to be a dome uplift after the formation of the caldera and the dome within the SLAR annular structure could be a resurgent caldera.

(4) Area D

The SLAR dome structure in the northern part of this area and it occurs in the sandstone zone. Field survey revealed that there is a fairly large dome-like structure in the area and that the SLAR dome is a part of this larger dome. There is a crater-like depression at the summit of the SLAR dome and microdiorite intruded into the sandstone in the northeast. From the above, it is considered that there is a high possibility of the formation of volcanic domes and of steam eruption in this area.

Within the SLAR dome in the east, there are volcanic breccias containing pebbles of Wainimala Group and basalt lava distributed in the northeast and it is inferred that the centre of volcanism existed in the vicinity. And since the geology around the structure forms a dome-like structure, it is probably a volcanic dome.

The SLAR domes extracted at two localities in the west are in basalt lava and pyroclastics zone and the possibility of volcanic domes exist, but the details of the geology is not clear.

(5) Area E

A SLAR caldera was extracted within a volcanic rock zone and gently raised structure is observed in the centre, but collapse structure was not identified. SLAR caldera could be an erosion caldera formed by the erosion of a crater.

(6) Area F

In this area, SLAR annular and SLAR caldera structures were extracted in the Wainimala Group and the Colo Plutonic Suite. Direct evidences of collapse were not identified. Southward dipping structure was observed in the north, but the structure in the south is not clear. Therefore, the existence of basin structures is not clear. These SLAR structures have almost perfect circular shape and are relatively clearly defined and thus these are probably relatively young structures. Also it could have been formed by the intrusion of magma as indicated by Koide (1982) and/or by erosion.

(7) Area G

SLAR annular, SLAR semi-caldera and SLAR dome structures were extracted in this area, but collapse nor dome could be identified structurally. However, a volcanic centre is inferred to exist within these structures, because andesite and porphyry complex belonging to the Medrausucu Group is distributed in the area. And the possibility of SLAR annular structure being a caldera, SLAR semi-caldera being an erosional caldera enlarged from a collapsed caldera and of SLAR dome being a volcanic dome formed after the formation of the volcanic caldera, is considered to be high.

(8) Area H

A small SLAR annular structure was extracted within sandstone and basalt lava and pyroclastics in this area. The locality coincides with that of a gentle syncline. This SLAR structure is considered to topographically reflect the difference of resistance of the rocks to erosion and not to be of volcanic origin.

(9) Area I

A SLAR semi-annular structure was extracted in volcanics and sandstone zone of this area. This forms a topographic depression and synclinal structure is observed. Also a group of faults inferred to be a part of circular fissures is observed in the south. Thus there is a possibility of this being a volcanic collapse structure.

(10) Area J

SLAR caldera % dome and SLAR dome structures were extracted in this area. But dome is not observed structurally. However, andesite stocks have intruded into the SLAR dome in the west, monzonite into the SLAR dome in the east and the attitude of the geologic formations is disordered and fissures are developed near these structures and there is a possibility of these being an uplift of volcanic nature.

(11) Area K

Structural data on the SLAR dome and SLAR caldera of this area are scarce and their origin is not clearly known. Both SLAR structures are relatively well preserved and as they occur in volcanic zones, it is considered likely that the SLAR caldera is an erosional caldera developed from volcanic collapsed structure and that SLAR dome is a volcanic dome formed after the formation of the caldera.

Micromonzonite volcanic complex plugs are distributed in the central part of the aerial photographic semi-caldera and it probably indicates old volcanic centre. Thus this structure is considered to be an erosional caldera formed from a volcanic crator or collapsed caldera.

(12) Area M

The SLAR caldera which exists around the SLAR annular structure in this area is considered likely to have been formed by the erosion of a collapsed caldera around the volcanic centre in the SLAR annular structure.

Volcanic rocks occur in the SLAR annular structure zone, but collapsed structure cannot be found. The possibility, however, of a volcanic centre located within the structure is considered to be high, because of the occurrence of radial dykes and monzonite plugs near the annular structure. The collapsed structure could have been eroded due to the uplift related to the rise of magma.

Data regarding the geologic structure of the SLAR dome zone are generally scarce and the geologic structure is not clear, although what seems to be a dome is found in the northeast. It is possible that resurgent caldera type structure such as the SLAR annular - SLAR caldera structure in the west also existed in this area because the SLAR caldera surrounds this structure.

(13) Area L

Volcanic rocks are distributed in the SLAR semi-annular structure zone of this area, but collapsed structure cannot be found. Since there is a SLAR semi-caldera which is probably a part of an erosion caldera around the SLAR semi-annular structure, it is possible that caldera existed near the SLAR semi-annular structure.

Nawainiu Intrusive Complex occurs in the southern part of the SLAR semi-caldera in the east and this is considered to have been the volcanic centre. Thus this SLAR semi-caldera is considered to have been the old volcanic crater or a part of the erosional caldera formed from a collapsed caldera.

(14) Area N

Volcanic rocks are distributed in the western SLAR semi-annular and SLAR semi-caldera structure zone and the semi-annular structure is a topographic depression, but evidences of collapse cannot be identified from the geologic structure. The semi-dome and the radial dykes found near the SLAR semi-caldera indicate the existence of a volcanic dome. At the SLAR semi-annular structure in the centre of the dome, probably volcanic vent or collapsed caldera existed in the past and the erosional caldera which formed subsequently was extracted as SLAR semi-caldera during the present study.

Dome and radial dykes are found near the SLAR caldera in the southeast and processes similar to the western structures are considered to be applicable here.

Also similar mechanism of formation can be considered for the SLAR semi-caldera in the north, but this zone is intensely eroded and the southern part is covered by pyroclastics derived from the southeastern volcanoes. Therefore, this structure is considered to be older than that of the above two areas.

(15) Area O

SLAR dome was extracted in this area, but dome structure could not be found geologically in the field. Andesite plugs occur to the west and northeast of this structure and the centre of this dome is located on the line joining these plugs and it could be possible that this indicates the volcanic block uplift.

1-3 Gravity Survey

Gravity survey was carried out in northern Viti Levu during the first phase and in the southern part during the second phase.

1-3-1 Survey Methods

The methods applied in the gravity survey is shown in Fig. 2-1-16.

(1) Field Survey

a. Gravity measurements

Stations: Gravity measurement were made at a total of 1,355 stations during the two years, namely 517 stations covering an area of 2,000km^2 in the northern Viti Levu in the first phase and 838 stations spread over 8,400km^2 in the southern part of the island in the second phase (Fig. 2-1-17). Because of its importance, the gravity of the Sigatoka area in the southwest was measured more densely than other areas.

Instrumentation: Two sets of LaCoste G gravimeters were used for field measurements. The specifications of the gravimeters used are as follows.

Gravity meter No.	G-178	G-204
Year of manufacture	Feb.,1968	May,1969
Operating range	0-7,344.88 mgal	0-7,261.53 mgal
Accuracy	0.02 mgal	
Size	14 x 15x 20 cm	
Weight	8.6 kg	
Power source	12 V battery	
Manufacturer	LaCoste & Romberg(USA)	

Gravity base stations and reference stations: The following three reference stations were used for deter-mining the gravity values of the base stations. Jezek(1976) was used for the gravity values of the reference stations.

St.No.	Elev.	Latitude	Longitude	Gravity value	Location
189-63	17.8m	18°07.00'S	178°27.5'E	978,599.56mgal	MRD,Suva
189-69	5.0m	17°45.50'S	177°25.0'E	978,532.11mgal	Nadi Airport
189-70	5.0m	17°45.70'S	177°25.0'E	978,532.11mgal	Nadi Airport

MRD:Mineral Resources Department

b. Leveling

The elevation of the stations was mainly determined by GPS (Global Positioning System) static survey and was augmented by conventional leveling using auto-level and altimeter.

Instrumentation: Three sets of 4000ST GPS surveyers (Trimble Navigation Ltd.), one WILD NA20 automatic level and two Paulin precision altimeters were used for leveling.

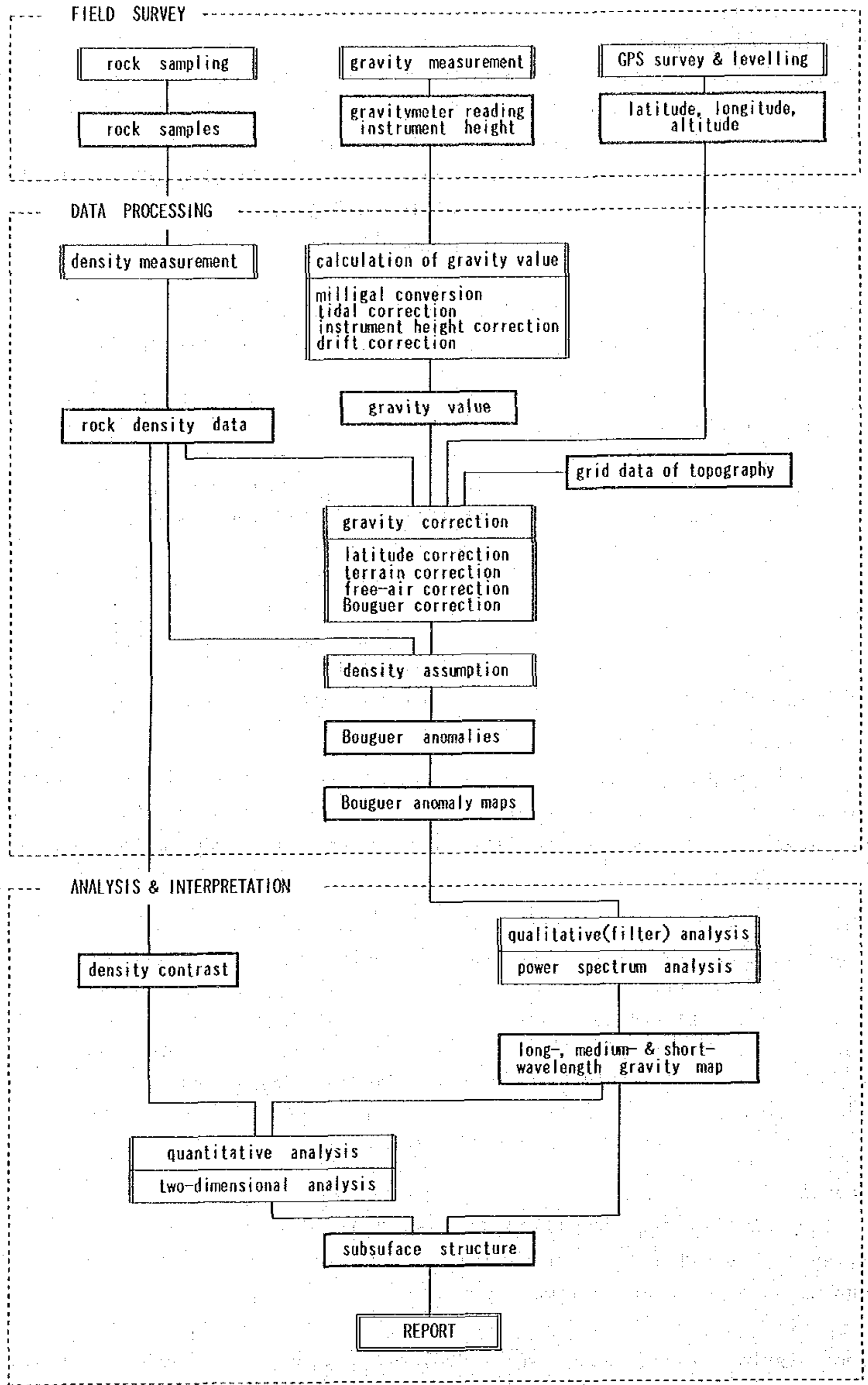


Fig.2-1-16 Gravity Survey Procedures

GPS survey: GPS relative positioning was employed. In this method, the position of the station is determined by receiving the satellite signals simultaneously at the base and the measurement stations and then calculating the position of the station relative to that of the base.

St.name	Elevation	Latitude	Longitude
Nacovu Tri.	68.572 m	18°08'35.28"S	178°26'24.43"E
Nandai Tri.	45.928 m	18°09'06.85"S	177°30'53.19"E
Loa Tri.	33.802 m	17°39'04.43"S	177°23'37.39"E
Loa GPS	28.364 m	17°39'03.10"S	177°23'35.60"E

From GPS survey, latitudes and longitudes based on "WGS (World Geodetic System)-84" ellipsoid are obtained and these were converted to coordinates based on "International" ellipsoid during data processing. Of the 1,355 stations established, 1,223 were positioned by GPS method.

Leveling: The 121 stations were positioned by conventional leveling by the automatic level. The stations were plotted in the topographic map and their latitudes and longitudes were read.

Altimeter measurements: Precision altimeters were used for the determination of elevation at 11 localities where use of GPS and levels was hindered by topography, vegetation and other factors. The stations whose elevation was measured by altimeter are plotted in black circles (●) in Fig. 2-1-17.

c. Sampling

Rock samples for density measurements were collected throughout the survey area with due consideration to the stratigraphy, lithology and other relevant factors. The number of collected samples amounted to 146, 38 in Phase I Survey and 108 in Phase II Survey.

(2) Data Processing

The following data processing were made.

a. Calculation of gravity values

In order to calculate the gravity values from the dial readings, the following calculation were carried out.

Milligal conversion,
tidal correction,
instrument height correction,
drift correction.

b. Gravity reduction

The following corrections were carried out in the process of calculating the Bouguer anomaly values from the gravity value.

Latitude correction,
terrain correction,
atmospheric correction,
free air correction,
Bouguer correction.

c. Preparation of gravity maps

Three types of Bouguer anomaly maps were prepared with correction densities of 2.40, 2.50 and 2.67 g/cm^3.

(3) Analytical methods

a. Density measurement of rock samples

The natural dry and wet densities of the collected samples were measured.

b. Gravity analysis

Power spectral analysis: This method is used with the objective of separating the long- and medium-wavelength anomalies caused by deep-seated structures and the short-wavelength anomalies caused by shallow structures.

Profile analysis: The two-layered model profile analysis was carried out for the short-wavelength and medium-wavelength gravity anomalies using the Talwani's equation (Talwani et al,1959).

1-3-2 Survey Results

(1) Density measurements

Regarding the rock density of the area, the following characteristics are clarified from the studies of 38 samples (average density 2.50 /cm^3 collected during the first phase, 108 samples (2.53 /cm^3) of the second phase, and existing data (Rodda and Deberal, 1966) on 266 samples (2.64 /cm^3).

① The lithology affects the density more than the formations. With the exception of limestone, the sedimentary rocks generally have lower density, while the volcanic and intrusive rocks have high density.

② Sedimentary rocks in older formations tend to have higher density.

③ With the exception of gabbro of the Colo Plutonic Suite, the oldest Yavuna Group has the highest density.

④ In the Wainimala Group, the density of the sedimentary rocks (18 samples, 2.49 $/cm^3$) is lower than that of the volcanic rocks (25 samples, 2.61 $/cm^3$).

⑤ In the Ba Volcanic Group, the difference between the density of the sedimentary rocks (7 samples, 2.12 $/cm^3$) and volcanic rocks (9 samples, 2.65 $/cm^3$) is very large.

(2) Bouguer anomaly maps

Three types of Bouguer anomaly maps were prepared, namely ρ=2.40, 2.50 and 2.67 $/cm^3$ and the map with ρ=2.50 $/cm^3$ (Fig.2-1-18) was selected for the present interpretation from the density measurements.

According to Fig. 2-1-18, in the area from northeastern coast to the western part of the island, gravity highs exceeding 60 mgal considered to be almost independent are aligned from the east westward; vicinity of Rakiraki, Tavua-Vatukoula, northwest of Mba, southwest of Mba, and south-east of Nadi. On the other hand, in the area from the southeast to south-western part of the island, the gravity anomalies occur as belts extending in the NE-SW to ENE-WSW direction. The two areas have contrasting gravity features. Low gravity zone is developed in the central part of the island.

(3) Filter analysis maps

a. Results of spectral analysis

The following average depths of the density boundary were calculated from the results of the power spectral analysis of the Bouguer anomaly map with density of 2.50 $/cm^3$.

A Group	average depth	D_A = 24.1 km
B Group	" "	D_B = 4.9 km
C Group	" "	D_C = 2.7 km

From these results, the Bouguer anomalies were separated by the three frequency bands corresponding to the Groups A, B and C. Then long-wavelength gravity map (Fig. 2-1-19), medium-wavelength gravity map (Fig. 2-1-20) and short-wavelength gravity map (Fig. 2-1-21) were prepared.

b. Long-wavelength gravity map

There is a center of gravity low in the central part of the island and the Bouguer anomaly increases outward in a radial manner. The gradi-