Chapter 2 Geological Survey

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.

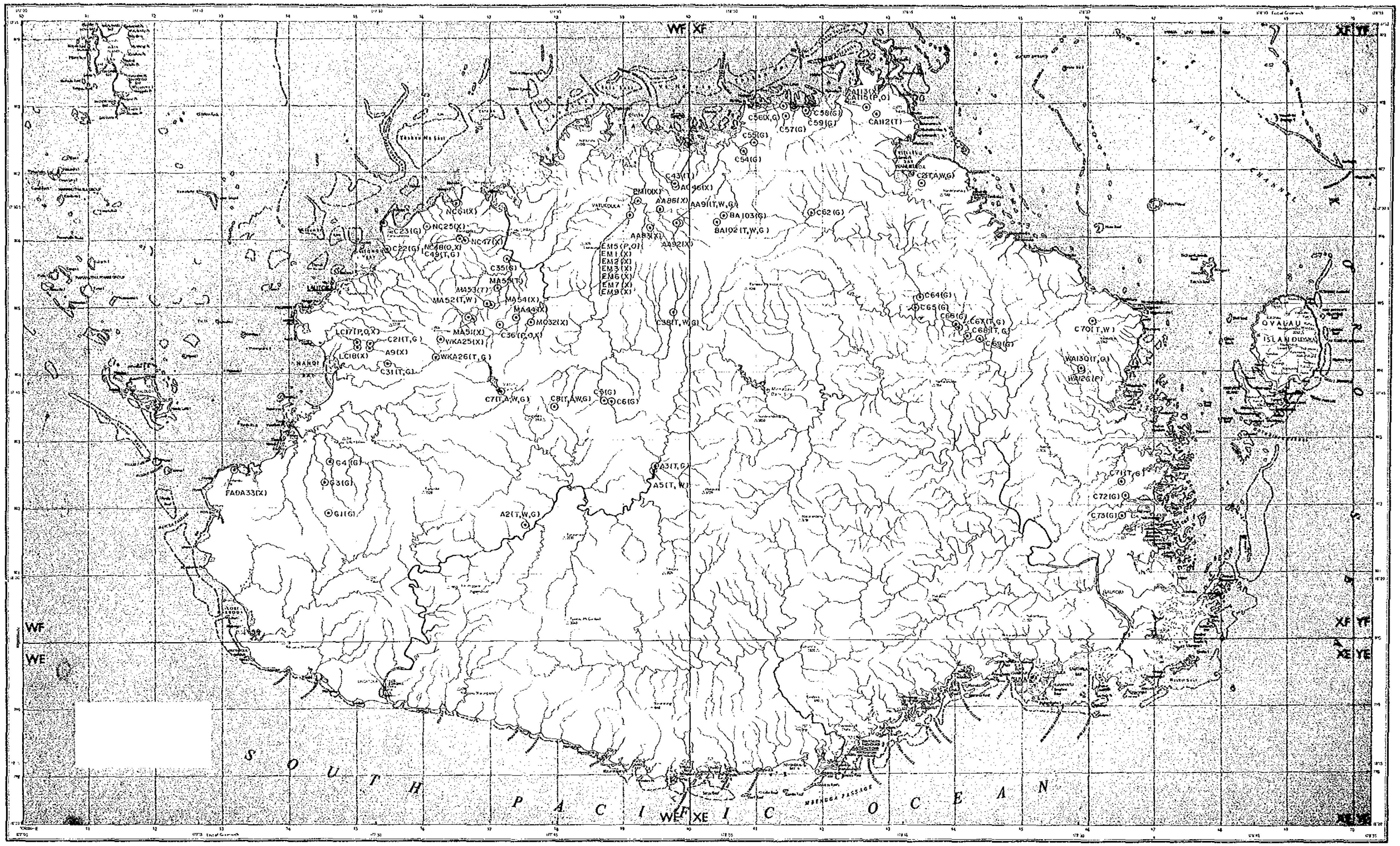
2-2 Outline of Geology

2-2-1 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. 2-2-3).

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



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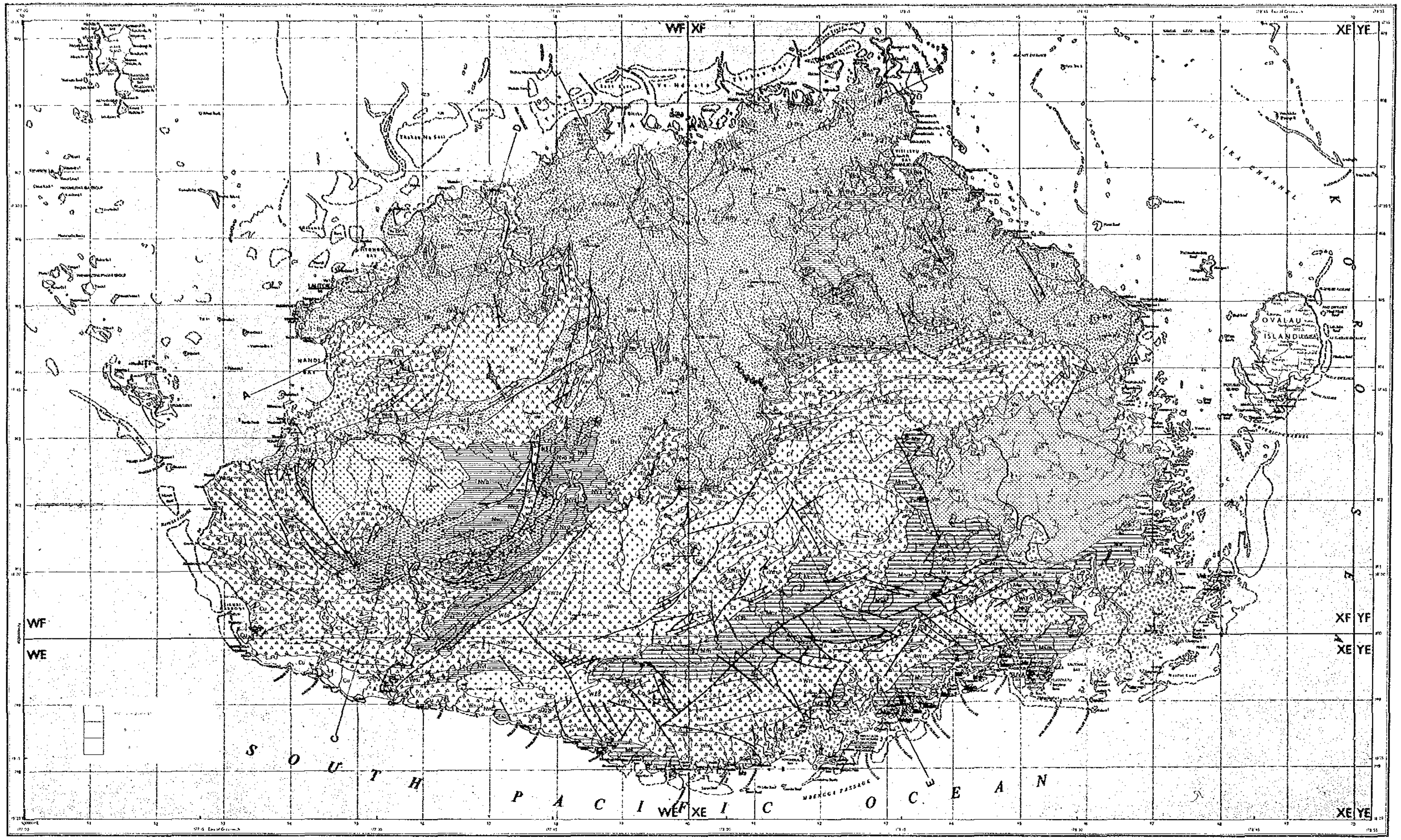
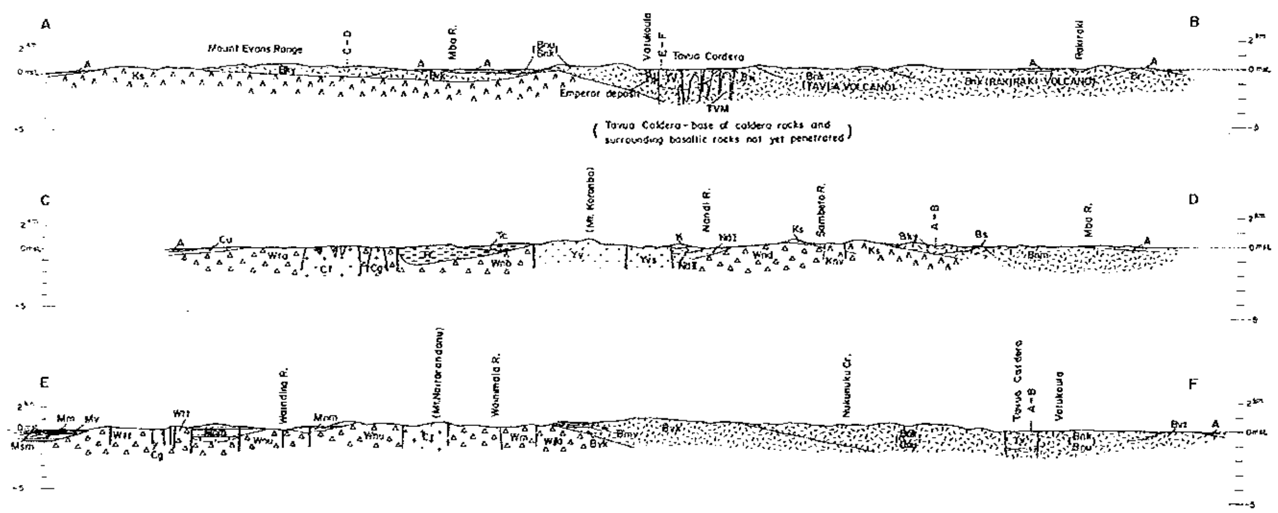
⊙ Rock samples
A9 (T,A,W,G)

T : Thin section
P : Polished section
A : K/Ar radiometric age determination
W : Whole rock analysis
O : Ore assay
X : X-ray diffractive analysis
G : Density measurement for gravity survey

Fig. 2-2-1 Sample Location Map of the Survey Area





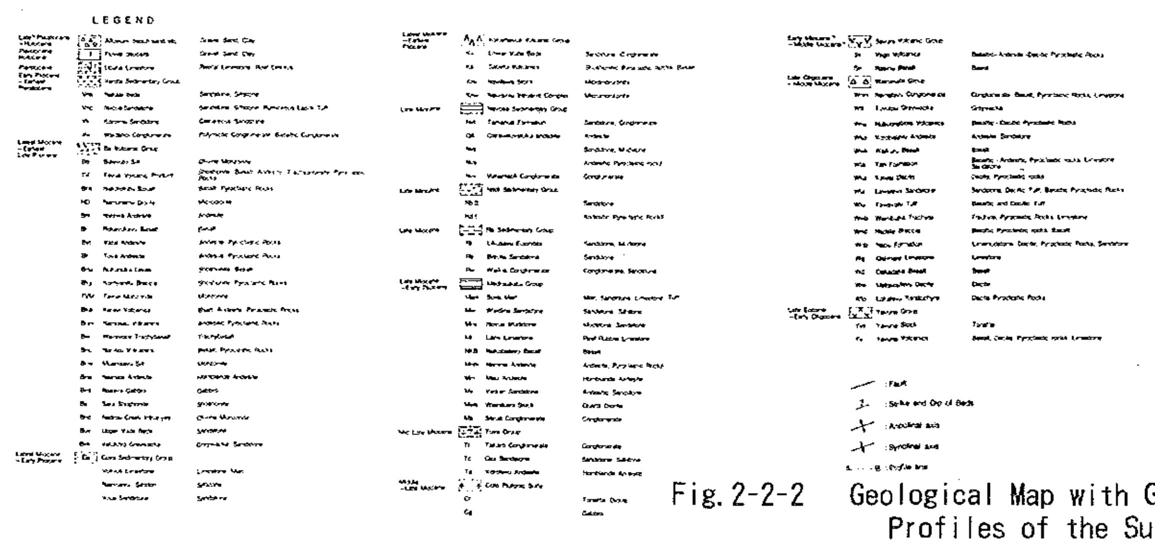


Fig. 2-2-2 Geological Map with Geological Profiles of the Survey Area

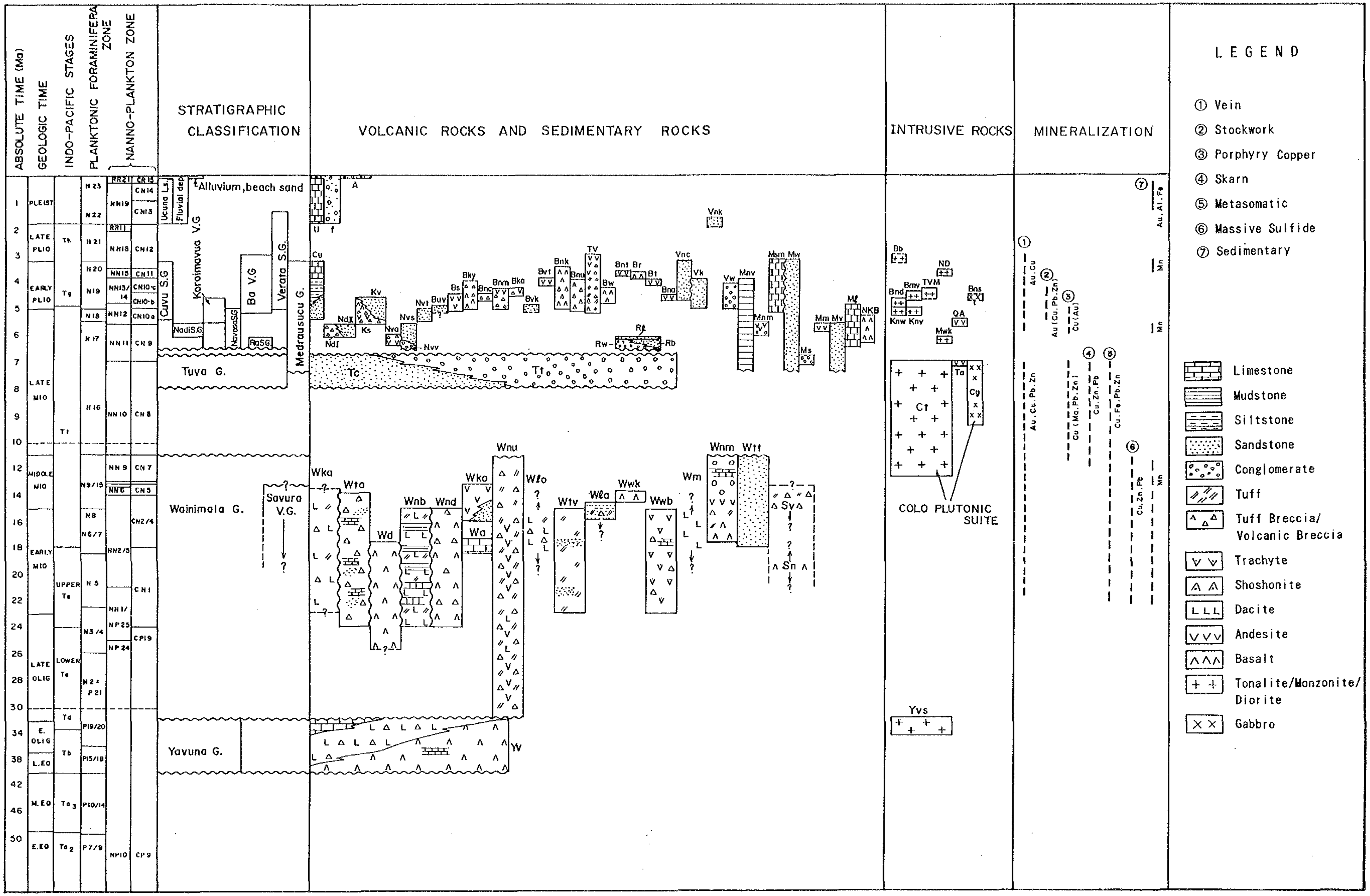
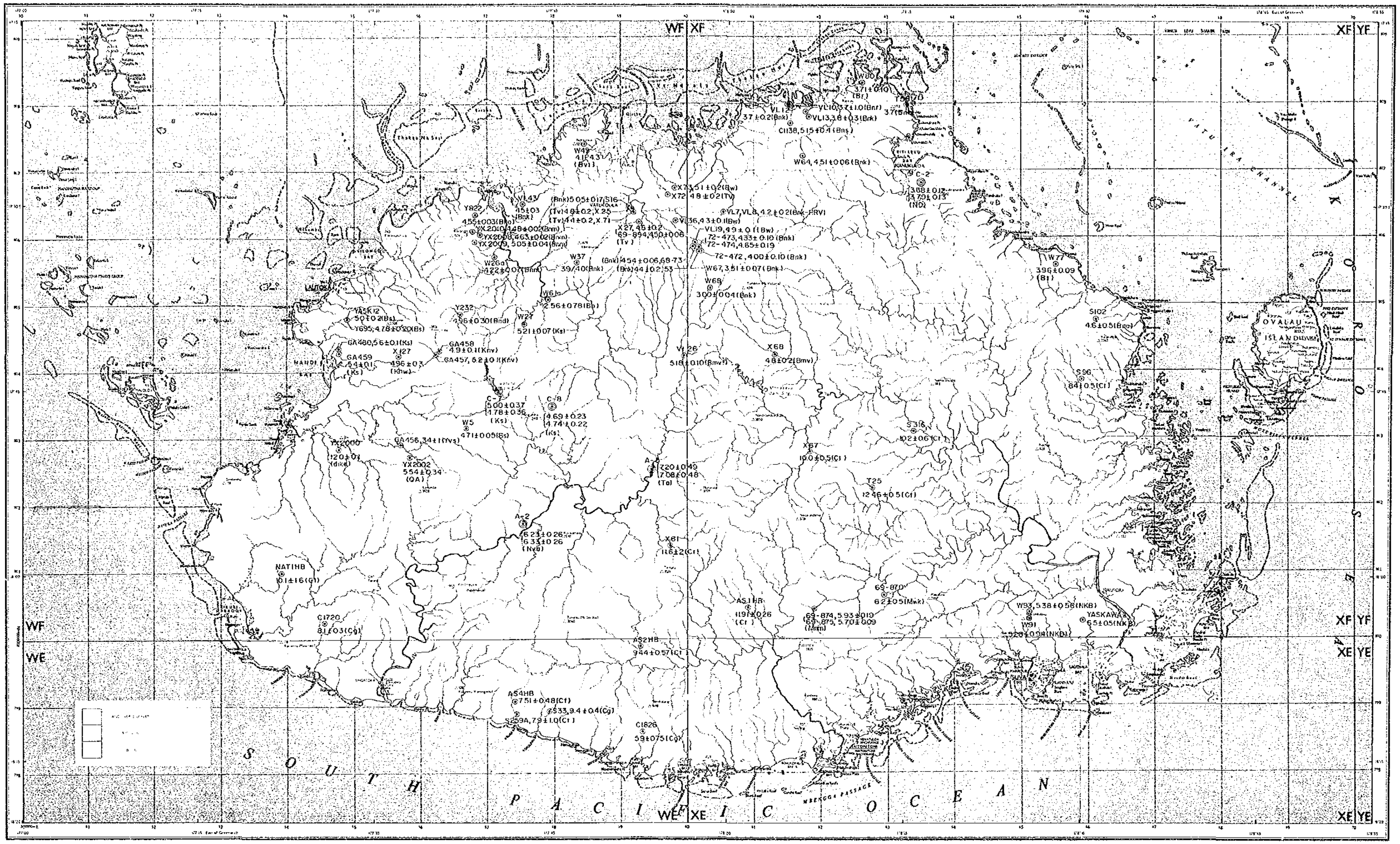


Fig. 2-2-3 Schematic Stratigraphic Columns of the Survey Area



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

Fig. 2-2-4 Map Showing the Results of Radiometric Age Determination

Table 2-2-1 The Results of Radiometric Age Determination
(K－Ar DATING)

Sample No.	Locality	Rock Name Formation	Sample Type	Potassium (K wt%)	Rad. ^{40}Ar (10^{-6}cc/g)	K-Ar Age (Ma)	Air Cont. (%)
A-2	NE of Singatoka N of Tuvu	Hb-Ad (Nva)	Whole rock	1.00±0.03	24.2±0.7	6.23±0.26	46.7
					24.6±0.7	6.33±0.26	46.9
A-5	NE of Singatoka Korolevu	Hb-Ad (Ta)	Whole rock	0.94±0.05	26.3±0.8	7.20±0.49	48.7
					25.9±0.8	7.08±0.48	48.3
C-2	W of Nanukuloa	Micro-Dio (ND)	Whole rock	3.97±0.08	56.8±1.4	3.68±0.12	45.7
					58.5±1.7	3.79±0.13	47.5
C-7	Vaturu Dam Site	Ad (Ks)	Whole rock	0.86±0.05	16.7±0.7	5.00±0.37	61.1
					16.0±0.7	4.78±0.36	61.7
C-8	E of Vaturu Dam Mbukuya	Ol-Bs (Ks)	Whole rock	1.87±0.06	33.9±1.4	4.69±0.23	56.1
					34.3±1.2	4.74±0.22	52.7

Abbreviations: Hb-Ad; Hornblende Andesite, Ol-Bs; Olivine Basalt, Dio; Diorite

Table 2-2-2 The Results of Microscopic Observation of Thin Sections

Sample No.	Locality	Rock Name	Formation	Texture	Phenocryst/ Crystal Fragment										Groundmass/ Matrix									Altered Mineral	Rock Fragment
					Qz	Kf	Pl	Bi	Hb	Au	Hy	Ol	Op	Ap	Si	Kf	Pl	Bi	Hb	Au	Op	Gl	Ca		
A-2	NE of Singatoka	Hb-Ad.	Nva	Porph.			◎		○				•		△	△	○			•	•	◎		Ac(Gl, Pl-p)	
A-3	NE of Singatoka	Hb-Ad.	Wnm	Porph.			○		○	△			•				○		△		•	◎		Ca(Au, Hb-p), Chl(Au)	
A-5	NE of Singatoka	Hb-Ad.	Ta	Porph.			○		○	△			△			○	○					◎		Mont(Au, hole Gl)	
C-2	W of Nanukuloa	Micro-Dio.	ND	Suboph.			◎	△	•	○			△	•		•	•	•				○		Zeo(Gl), Ca(Gl-p)	
C-7	Vaturu Dan	Alkali Bs	Ks	Porph.			○	△		○			○				△	•		•		◎			
C-8	E of Vaturu Dan	Ol-Bs.	Ks	Porph.			○			△		•	•				•			•		◎		Ca(Ol)	
C-21	S of Lautoka	Alt-Ad.	Ks	Porph.			○	△	○	○			•			○	○					◎		Se(Pl-p), Chl(Bi, Hb, Au), Ep(Hb), Ca(Au), Mont(Gl)	
C-31	NE of Nandi Sambeto R.	Volc. Ss.	NdII	Granul.	△	○	◎			•			•											Chl・Se・Ep(Volc. Rocks), Ca(grain boundary)	Ad・Ls(○), Tr・Ss・Ms(•)
C-38	SE of Vatukoula	Sho.	Bnk, Bnu	Porph.			△			○		△	•				△			△		◎			
C-43	EN of Vatukoula	Dio. Po	Bnk	Porph.			◎	•	•	◎			△	•								○		Ca(Au, Gl), Chl(Gl)	
C-49	W of Mba	Lap. Tuff	Bnm	—	△		○						•										•	Mont・Chl(•), Hal(△) Il(○), Chab(◎)	?(strongly altered)
C-67	NW of Korovou	Fossil. Ls.	Wla	—	•		•						•										◎	Calcite(veins)	Calcite
C-68	NW of Korovou	Tuff	Wla	Porph. (Breccia)	○			○	○				•									◎		Chl・Ca(Gl)	Dc, Ls & Volc. rock
C-70	N of Korovou	Hb-Ad.	Bna	Porph.			○		○	○			△									◎		Chl(druse), Ac(Gl, Pl)	
C-71	S of Korovou	Tfc. St	Vnc	—		•	•		△	○			•											Ac(◎), Sm(○), Chl・Hal(△)	
AA-91	E of Vatukoula	Ol-Monz.	TVM	Holocr.		◎	○	△		○		△	△	•											
BA-102	E of Vatukoula	Sho.	Bnk	Porph.			△			○		•	•				•			•		◎			
CA-112	SW of Rakiraki	Ol-Bs.	Bnk	Porph.			△			○		○	•				•			•	•	◎			
MA-52	S of Mba	Hb-Ad.	Ks	Porph.			◎		△	○			•				•					◎		Ca(Au)	
MA-53	S of Mba	Ol-Bs.	Bky	Porph.			◎			△		•	•				•			•		◎			
MA-55	S of Mba	Tuff	Bvk	—			△		•	△			•	•										Mont(○), Chab(○), Chl(•), Il(•), Cr(○)	Au bearing rock(?)
WA-130	N of Korovan	Hb-Dio.	Ct	Suboph.	○		◎		◎	△			•												
WKA-26	NE of Nandi	Micro-Dio.	Knv	Holocr.		◎	○	○		○			○	•										Se(Kf・Pl, p)	

Abundance of minerals: ◎ ; abundant, ○ ; common, △ ; a few, • ; trace

Abbreviations Texture: Granul; Granular, Holocr; Holocrystalline, Porph; Porphyritic, Suboph; Subophitic.
Mineral: Qz;Quartz, Kf;Alkali feldspar, Pl;Plagioclase, Bi;Biotite, Hb;Hornblende, Au;Augite, Hy;Hypersthene, Ol;Olivine, Op;Opaque mineral, Ap;Apatite, Si;Silica mineral, Gl;Glass, Ca;Carbonate, Ac;Analcime, Chab;Chabazite, Chl;Chlorite, Cr;Cristobalite, Ep;Epidote, Hal;Halloysite, Il;Illite, Mont;Montmorillonite, Sm;Smectites, Se;Sericite, Zeo;Zeolite, p;partly
Rock : Ad;Andesite, Alt;Altered, Bs;Basalt, Dc;Dacite, Dio;Diorite, Fossil;Fossiliferous, Ls;Limestone, Lap;Lapilli, Monz;Monzonite, Ms;Mudstone, Po;Porphyrite, St;Siltostone, Ss;Sandstone, Tfc;Tuffaceous, Tr;Trachyte, Volc;Volcanic Sho;Shoshonite

Table 2-2-3 Result of Whole Rock Analysis

Sample No.	C038	BA102	C070	AA091	C002	C007	C008	MA052	A002	A005
SiO_2	47.850	47.870	51.270	50.110	47.840	45.480	49.460	52.760	57.280	57.840
TiO_2	0.600	0.620	0.860	0.740	0.750	0.620	0.770	0.800	0.560	0.580
Al_2O_3	12.640	12.730	17.060	17.090	18.040	17.960	18.540	19.170	19.100	16.470
Fe_2O_3	4.807	5.701	4.569	5.251	3.482	6.383	4.745	4.619	4.005	3.355
FeO	5.060	4.660	4.140	4.480	4.110	2.220	3.730	3.510	1.570	2.830
MnO	0.170	0.190	0.170	0.220	0.160	0.190	0.180	0.200	0.090	0.150
MgO	9.580	8.520	4.760	4.180	3.070	4.400	3.600	2.980	2.670	2.680
CaO	11.470	12.110	7.780	9.060	7.020	9.030	9.310	9.890	7.360	5.920
Na_2O	1.650	1.580	3.280	3.120	3.200	5.130	3.040	2.870	4.110	3.200
K_2O	2.420	3.150	2.860	4.470	5.450	1.420	2.400	1.910	1.370	1.450
P_2O_5	0.410	0.470	0.450	0.730	0.870	0.560	0.360	0.390	0.220	0.160
BaO	0.060	0.060	0.060	0.070	0.100	0.050	0.040	0.030	0.100	0.060
LOI	1.840	0.015	1.870	1.230	5.020	4.850	1.250	1.820	1.510	2.660
Total	98.557	97.676	99.129	100.751	99.112	98.293	97.425	100.949	99.945	97.355
FeO*	9.386	9.791	8.252	9.206	7.244	7.965	8.000	7.667	5.175	5.849
Fe/Mg	0.980	1.149	1.734	2.202	2.360	1.810	2.222	2.573	1.938	2.183
S.I	40.745	42.494	43.087	43.888	38.199	42.108	46.949	49.699	38.835	44.383
Q	0.000	0.000	0.175	0.000	0.000	0.000	0.419	6.221	10.198	17.108
or	14.302	18.617	16.903	26.418	32.210	8.392	14.184	11.288	8.097	8.570
ab	13.954	11.426	27.738	17.506	13.455	24.318	25.709	24.271	34.757	27.062
an	19.938	18.341	23.386	19.430	18.768	21.795	29.859	33.789	29.630	26.300
ne	0.000	1.049	0.000	4.811	7.372	10.329	0.000	0.000	0.000	0.000
di-wo	14.320	16.150	5.132	8.679	4.353	8.087	5.839	5.319	2.275	0.846
di-en	10.779	12.530	3.775	6.123	2.743	6.990	4.316	3.921	1.966	0.609
di-fs	2.100	1.877	0.868	1.810	1.339	0.000	0.960	0.889	0.000	0.160
hy-en	3.162	0.000	8.075	0.000	0.000	0.000	4.646	3.498	4.680	6.062
hy-fs	0.616	0.000	1.857	0.000	0.000	0.000	1.034	0.793	0.000	1.587
ol-fo	6.944	6.083	0.000	3.002	3.434	2.778	0.000	0.000	0.000	0.000
ol-fa	1.491	1.004	0.000	0.978	1.847	0.000	0.000	0.000	0.000	0.000
mt	6.966	8.263	6.622	7.611	5.047	5.978	6.877	6.695	3.730	4.862
hm	0.000	0.000	0.000	0.000	0.000	2.257	0.000	0.000	1.431	0.000
il	1.140	1.178	1.634	1.406	1.425	1.178	1.463	1.520	1.064	1.102
ap	0.971	1.113	1.065	1.728	2.060	1.326	0.852	0.923	0.521	0.379
TOTAL	96.680	97.630	97.200	99.490	94.040	93.430	96.150	99.120	98.350	94.640
Femic Total	48.489	48.199	29.027	31.336	22.247	28.594	25.987	23.557	15.668	15.607

FeO*: Total iron

S.I : Solidification index (Kuno et al. 1957)

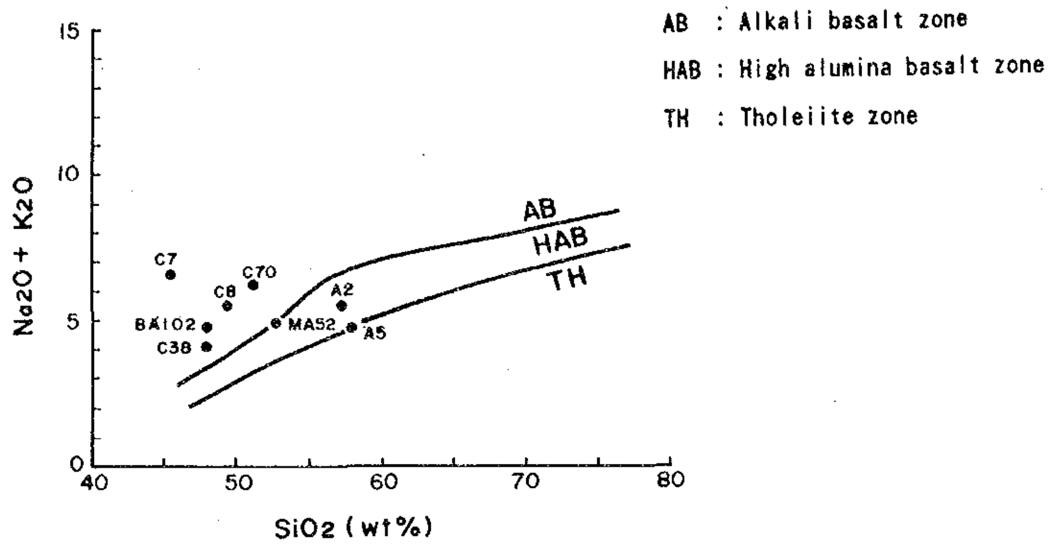


Fig. 2-2-5 $Na_2O+K_2O-SiO_2$ Diagram

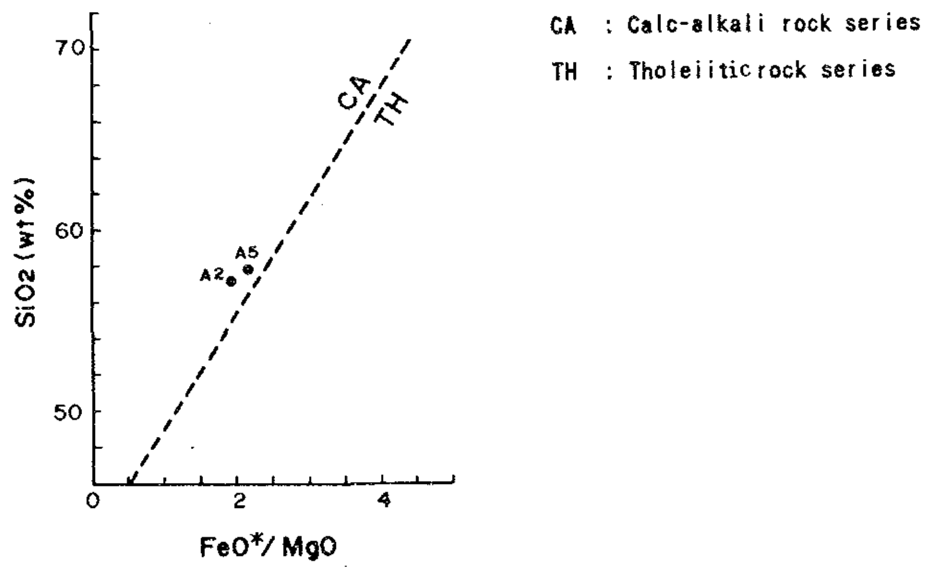
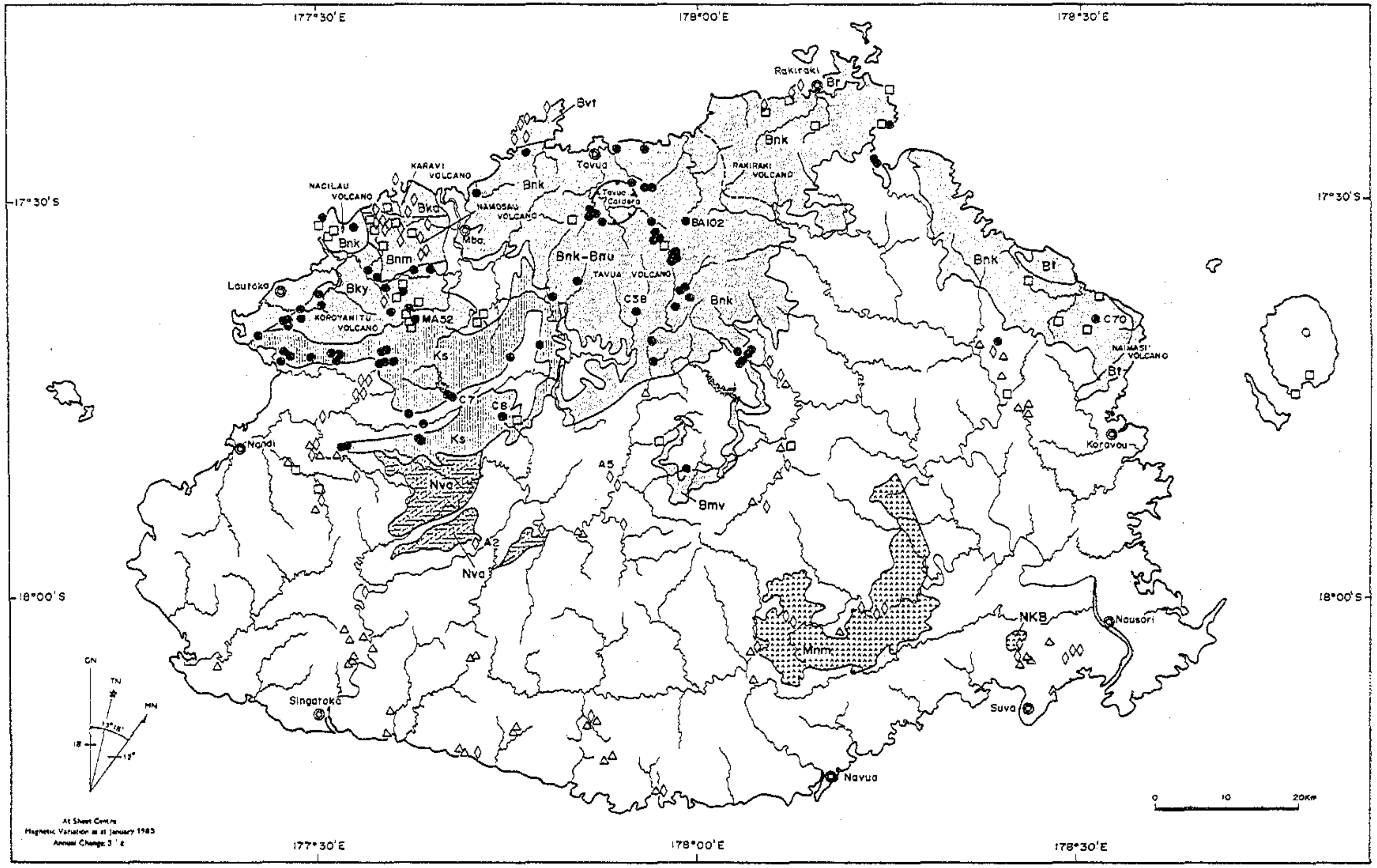


Fig. 2-2-6 FeO*/MgO$-SiO_2$ Diagram



(LEGEND) ●: Shoshonitic rocks / Alkali rocks. □: High-K Calc-alkaline rocks. ◊: Calc-alkaline rocks. △: Low-K Tholeiitic rocks.

Fig. 2-2-7 Classification Map of Rock Series of the Survey Area 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.

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 Singatoka 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, Singatoka, Mba Rivers and in the down stream areas of the Nadi and Navua Rivers. They are distributed in the coastal zones in small bodies.

2-2-2 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. 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.

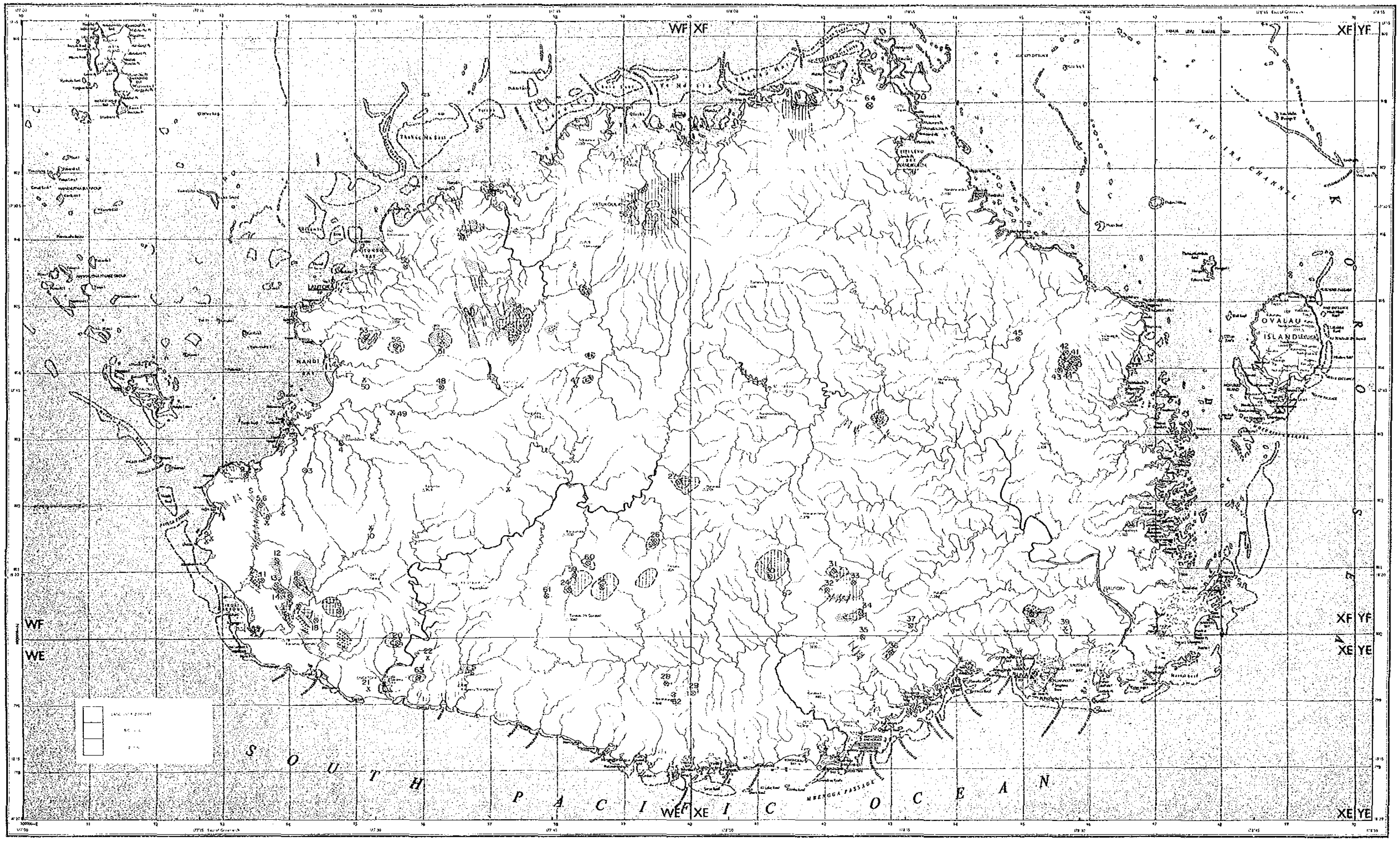
Synclinal and anticlinal axes are seen to develop parallel to the extension of the plutonic rocks (ENE to ESE, NNE), in the Wainimala and Tuva Groups near the Colo Plutonic Suite in the central part of the island.

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.

2-3 Outline of Mineralization

Veins, network-dissemination, porphyry copper, replacement, contact metasomatic, and sedimentary mineralization are the known in Viti Levu. The major mines and mineral prospects are listed in Appendix 1.



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. Tuvenki 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. Waitololu [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. Tavaravi Creek [Cu(Au)]
53. Vuda [Au(Cu-Ag)]
54. Bafevuto [Pb-Zn,Cu-Au-Ag]
55. Drasa [Al]
56. Emperor Mines Vatukoula [Au-Ag-Te(Cu-Zn)]
57. Waikate-kala [Au]
58. Ba delta [Fe]
59. Naruku-levu [Cu,Zn(Au,Ag)]
60. Tubatolu [Cu]
61. Matalo [Cu]
62. Nancy-Kelia [Cu(Zn)]
63. Korologo [Cu-Zn(Pb-Au-Ag)]
64. **Rokiroki [Au]**

L E G E N D

- 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

Fig. 2-2-8 Distribution Map of Mines, Prospects and Alteration Zones of the Survey Area

Table 2-2-4 Results of X-ray Diffractive Analysis

Sample No.	Altered Rock	Rock unit	Location	Clay Mineral									Silica m.			Sulfate m.			Carbonate			Feld.		Miscellaneous m.				
				Mo	Ch	Se	Ka	Pr	Ha	Da	※Ch-Mo	※Ka-Mo	Tr	Cr	Qz	Al	Gy	Ja	Ca	Do	Si	Pl	Kf	He	Mg	Lm	Py	Ho
A-9	Wt. str. -clay/sil. Lm-films	Ks	SW of Naivuivui			●		○							◎	∘						●					●	
AA-83	White clay Lm. in cracks	Tv	SE of Vatukoula												◎	◎							∘			●	●*	
AA-86	White, str. altered, Ridges	Tv	E of Vatukoula									∘			○	∘							○				●	
AA-92★	White clayey, Lm	T_{VM}	E of Vatukoula									∘			○							●?	∘			∘	●	
AC-46	White, Sil. /Argil.	B_W	ENE of Vatukoula				∘								◎	●							●?		●?			
C-36	Dark gray, Py-diss, Sil.	Ks	E of Koroyanitu												◎	●											∘	
C-56	Chloritized, Ca vein	Bnk	W of Narewa		∘		●							●	∘				○			○		●?				∘
CA-113	Weathered white clay	Bnk	SE of Rakiraki	∘								●			○				●				○					
EM-1★	White weak argil. tuff	Tv	Vatukoula			∘		∘							●	∘							○‡				∘	
EM-2★	Green andesite	Tv	Vatukoula		∘	○								∘?	●								○‡				●?	
EM-3	Trachybasalt	Tv	Vatukoula			∘									∘				∘?	∘?			○				∘?	
EM-6★	Ash	Tv	Vatukoula			∘									○												∘	
EM-7	White argil. And. dike	Tv	Vatukoula			●	●							∘?	○	∘						○	○				∘?	
EM-9	Wt. argil. And. dike Lm net	Tv	Vatukoula	∘		∘	∘								○							∘	∘					
EM-10	Wt~gray, sandy tuff, sil.	Tv	Vatukoula												○	∘							○				●	
FADA-33	Yell~white, str-clay, Lm	Wta	Senilambui				○							∘?	◎												●?*	
LC-17	Argil. Py-Qz vein	Ks	SW of Naivuivui				●								◎	◎											∘	
LC-18	Yell~light brown, Lm	Ks	SW of Naivuivui												◎	○										●		
MC-32	Light brownish white	Bky	ENE of Koroyanitu				●								◎	○										●?	●?	
MA-44★	Wt-clayey, Lm-diss	Bky	ENE of Koroyanitu									∘			○								●		●?		●?*	
MA-51★	Weak argil.	Ks	NE of Koroyanitu									∘			○								●	●				
MA-54	White~green, porphy-And.	Bky	ENE of Koroyanitu					∘			∘			○		∘							∘					
NC-25★★	Wt~brown, weak argil-Bas.	Bnm	W of Koronggele									∘			●								●?		●?		●?*	
NC-47	Al-Qz network, And-vol-bre	Bnm	Koronggele				∘		∘						◎	○											●?*	
NC-48	Sil. Py-diss, And-tuff-bre	Bnm	Koronggele			∘	●							●?	◎	∘						○					∘	
NC-51	Reddish~brown, Al-Qz net	Bka	E of Koronggangga					●		●?					◎	○							●?			∘		
WKA-25	White hard clay, Lm-net	Ks	N of Navilawa				●								◎	○										∘?		

Abbreviations:

◎:Abundant ○:Common ∘:Few ●:Rare

★: a little irregular crystallinity

★★:irregular crystallinity

Mo:Montmorillonite, Ch:Chlorite, Se:Sericite, Ka:Kaoline, Pr:Pyrophyllite, Ha:Halloysite, Da:Diaspore, ※:Mixed layer mineral,
Tr:Tridymite, Cr: α-Cristobalite, Qz:Quartz, Al:Alunite, Gy:Gypsum, Ja:Jarosite, Ca:Calcite, Do:Dolomite, Si:Siderite,
Pl:Plagioclase, Kf:Potassium feldspar, He:Hematite, Mg:Magnetite, Lm:Limonite, Py:Pyrite, Ho:Hornblende,
Wt:white, Yell:yellow, Str:strong, Sil:silicification, Argil:argillization, And:andesite, Bas:basalt
*:Pyrite or marcasite ‡:Sanidine ?

Table 2-2-5 The Results of Ore Assaying

Sample No.	Locations No.	Mines/Prospects	Material	Assay Results Au(g/t)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)	Mo(%)
C-36	54	Balebuto	Py vein	<0.07	<0.3	0.01	<0.01	<0.01	<0.001
CA-115	—	Rakiraki	Qz vein	0.41	<0.3	0.01	<0.01	<0.01	<0.001
EM-5	56	Emperor	Qz vein	0.14	<0.3	0.10	<0.01	<0.01	<0.001
LC-17	53	Vuda	Qz-Alu Vein	0.07	<0.3	0.06	<0.01	<0.01	<0.001
NC-48	—	West of Mba	Py diss.	<0.07	<0.3	<0.01	<0.01	<0.01	<0.001

Location No. denoted as the number in the list and map of the prospects and mines

Abbreviations: Py; Pyrite, Qz; Quartz, diss; dissemination Alu;Alunite

Table 2-2-6 The Results of Microscopic Observation of Polished Specimens

Sample No.	Locations No.	Mines/Prospects	Material	Minerals Py	Cpy	Sph	Cov	Goe	Hem	Ba	Qz	Note
C-36	54	Balebuto	Py vein	○	•	•		•		•		
CA-115	—	Rakiraki	Qz vein					△	△		◎	* 1
EM-5	56	Emperor	Qz vein	△	•	•	•				◎	* 2
LC-17	53	Vuda	Qz-Alu vein	○								
WA-126	41	Wailotu	Powdery sulfide	○	○	○						

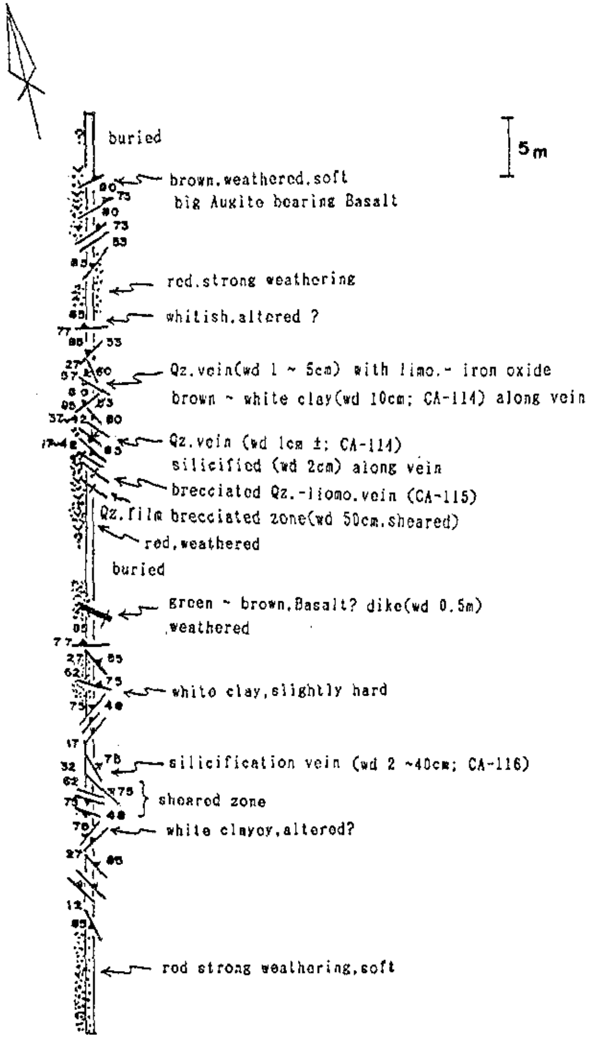
Location No. denoted as the number in the list and map of the prospects and mines

Abundance of Minerals: ◎; abundant, ○; common, △; a few, •; trace

Abbreviations: Py; Pyrite, Cpy; Chalcopyrite, Sph; Sphalerite, Cov; Covelline,
Goe; Goethite, Hem; Hematite, Ba; Barite, Qz; Quartz, Alu; Alunite

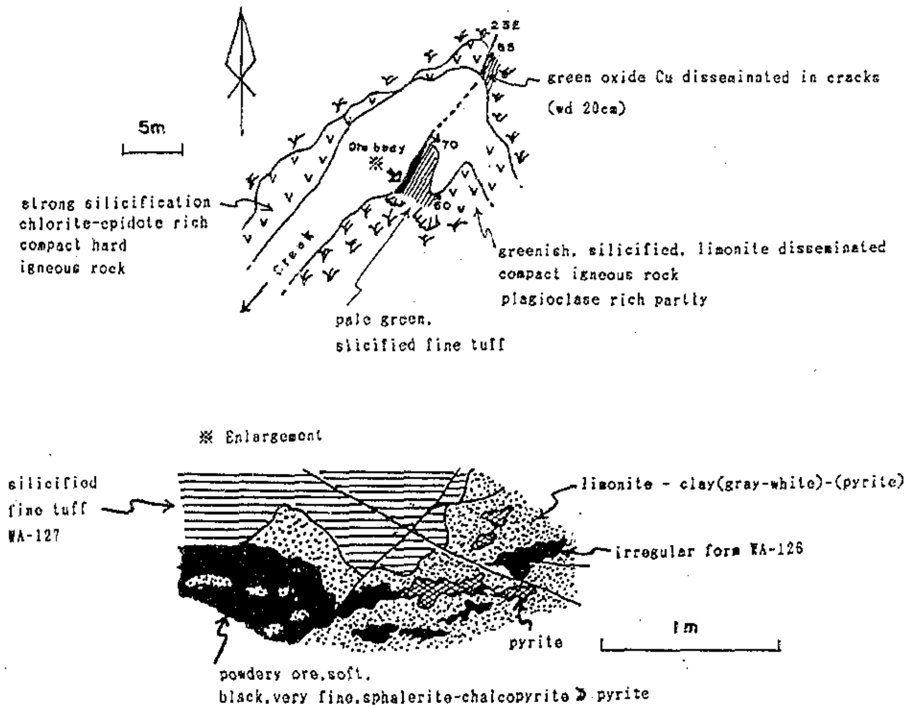
* 1: Goethite or lepidochrocite.
Hematite denote the pseudomorph of pyrite.

* 2: Covelline are paragenetic with pyrite and are denoted as the pseudomorph of nukundamite.



Symbols: vein, joint, v v v basalt, clay

Sketch of Trench (Rakiraki, Northeast of Viti Levu)



Sketch of Outcrop (Wailotu, East of Viti Levu)

Fig. 2-2-9 Sketches of Prospects

(1) Veins and network-dissemination

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

① 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, Balevuto, 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 Balevuto; Koroimavua Volcanic Group for Vunda 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 (Fig. 2-2-9).

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 activity (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 750 m, maximum dipward extension 360 m; the gently dipping veins are less than 1 m wide, maximum strikewise extension 2,300 m, maximum dipward extension 2,300 m. 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 Balevuto 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 Vunda 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.

② 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.

① 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).

② Volcanic type porphyry mineralization

This type of mineralization is known to occur at Waisoi, Wainambama and Waivaka in the southern part of Viti Levu, and at Kingston Mine and Tawaravi Creek in the Sambeto 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, Tulaseua, 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

① 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. Coloform texture and graded texture of sulfide are sometime observed in the ore. The host rocks in the vicinity underwent sericitization and chloritization.

② 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 Kalambo Mine in the southeast.

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 mineralied 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.

③ Residual type metal concentration

Mineral prosepct 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.

④ Mechanical mineral concentration

Mechanical accumulation of metallic minerals occurs at Waimanu in the south, at Singatoka 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 Singatoca 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.

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 Table 2-2-7 . 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.

The result of the survey of the 15 areas are reported below.

(1) Area A

Relatively clear annular basin topography exists in this area and it is called Tavua Caldera. But clear caldera scarps could not be observed.

Within the SLAR annular structure in the central part of the area,

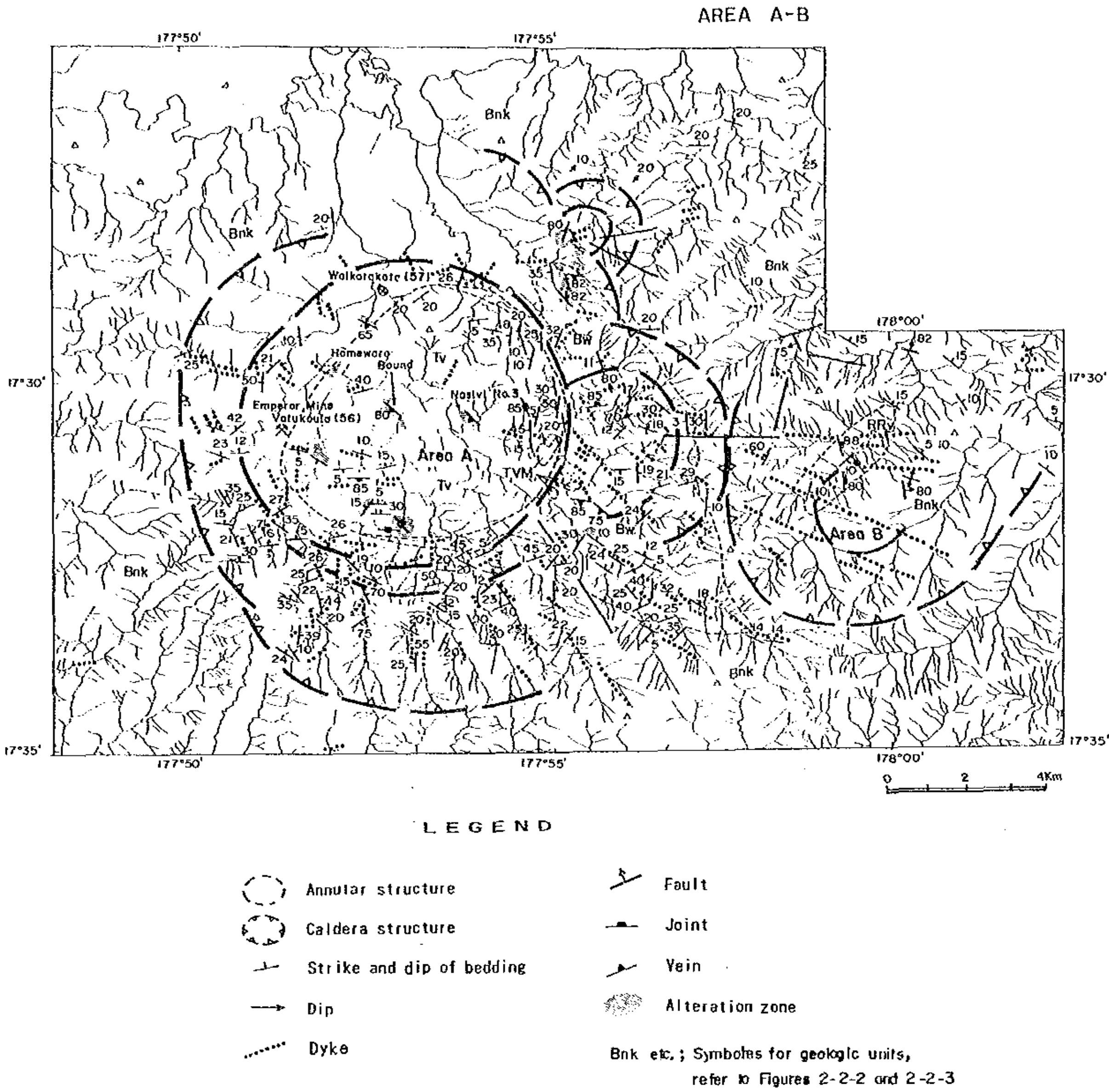


Fig. 2-2-10 Field Geological Data Map of Areas A and B

trachyandesitic effusive material of the Tavua Volcano is distributed in an oval shape. This effusive material(Tv) which belong to the Ba Volcanic Group is somewhat younger than the basaltic effusives(Bnk, Bw) in the vicinity. This basaltic material is distributed widely in the island with the centre of distribution in this area.

Breccia is distributed along parts of the periphery of the oval Tavua Volcano Effusives(Tv). At the southern part of this oval border, there are basalt and andesite dykes parallel to the border and similar dykes occur in a radial pattern further inside the effusives and also farther outside.

Also there are cone sheets of andesitic rocks and fractured andesitic stocks within the oval. Monzonite bodies have intruded into the southeastern part of the border.

Regarding the attitudes of the formations, they are; NW to E-W strike and N to NE dip at the southern part of the central SLAR annular structure, NNW to NNE strike and W dip in the northwestern and northeastern part of the structure, and ENE-WSW strike and S-N dip at the eastern part of the Emperor Mine. Also the beds within the structure dip toward the centre.

The deposits of the Emperor Mine are located at the western margin of the oval border of the Tavua Volcano Effusives. It was observed from the survey of the open pit at Koroere Hill that the alteration of the host rocks near the N-S veins is mainly sericitization, but alunite and kaolin occur in the bleached white andesite dykes intruding into the western side of the veins and pyrophyllite and alunite were found in the bleached white tuff distributed on the eastern side of the veins.

Zones of intense acidic alteration consisting mainly of alunite occur sporadically in the E-W to WNW direction within the oval border. NW to WNW trending veins and ridges of silicified rocks are distributed in the central alteration zone and auriferous quartz vein network occurs in the alteration zone in the northwest.

Small semi-annular and semi-caldera structures were identified by aerial photographs to the northeast of the central SLAR annular structure, and SLAR semi-annular and SLAR semi-caldera structures occur in the southern part of the above. However, caldera scarps were not observed in both cases.

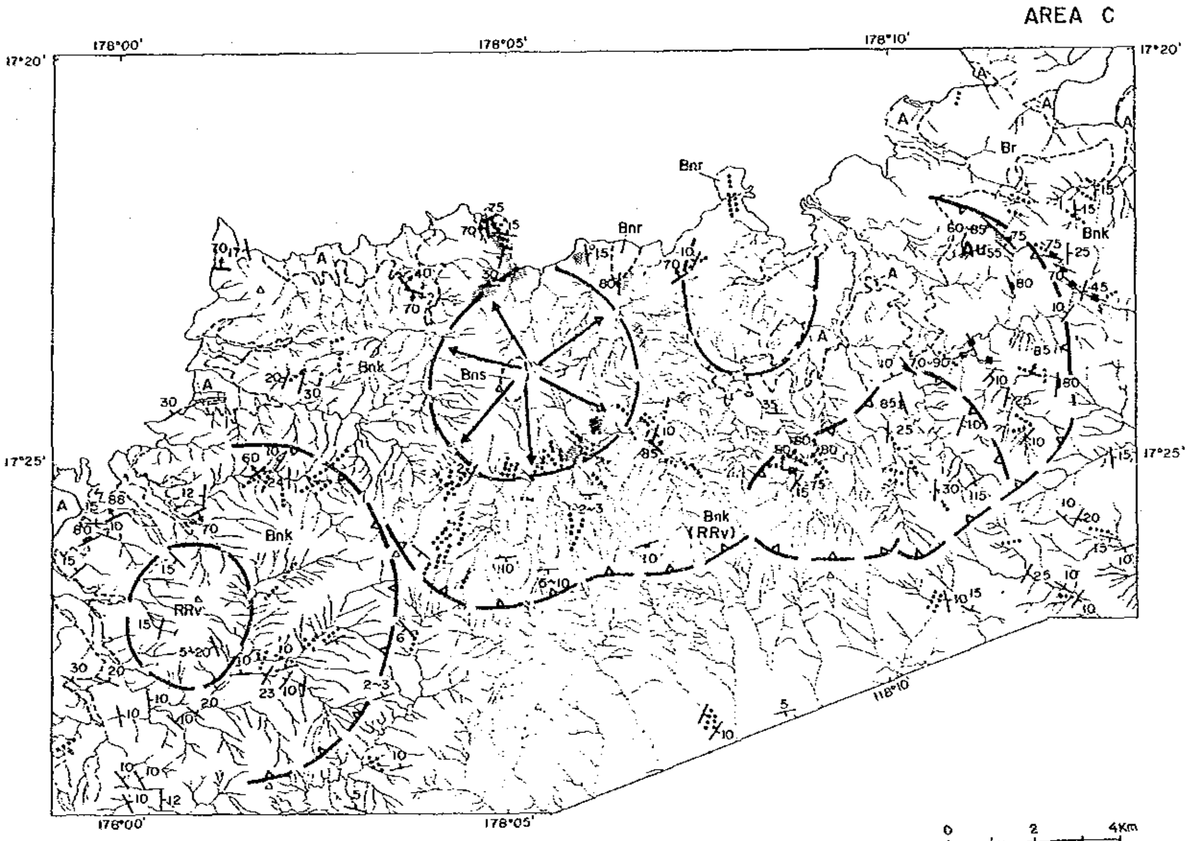
In the semi-annular structure area in the northeastern part, intense alteration zones consisting of kaolin and alunite occur with basaltic lava and volcanic breccia in the vicinity. E-W and NE trending quartz veinlets and small outcrops of diorite porphyrite occur in the alteration zones. The dykes and faults occur with more or less radial pattern.

In the southeastern part of the semi-annular structure, trachybasalt is the major unit with an intense weathered zone in the central part. The alteration conditions are not clear. The attitudes of the beds are irregular. NW trend is predominant for dykes with some E-W trending dykes in the northeast.

(2) Area B

SLAR semi-annular and SLAR semi-caldera structures were extracted in this area (Fig. 2-2-10), but caldera scarps were not found in the field.

The geology of this area consists of basaltic lava and pyroclastics of the Ba Volcanic Group. The strike of the beds near the SLAR semi-annular structure in the central part is NE to NNE and it is harmonious with the semi-annular structure. The dykes trend in the WNW to E-W direction, the joints in the NNW and the faults in the NNW to NNE and E-W direction. Alteration zones and altered boulders are not observed in the area.



LEGEND

Annular structure
Caldera structure
Dome structure
Strike and dip of bedding
Dip
Dyke
Fault
Joint
Vein
Anticlinal axis
Synclinal axis
Alteration zone

Bnk etc.; Symboles for geologic units, refer to Figures 2-2-2 and 2-2-3

Fig. 2-2-11 Field Geological Data Map of Area C

(3) Area C

A SLAR annular structure, SLAR semi-caldera structures and a SLAR dome structure were extracted in this area (Fig. 2-2-11), but caldera scarps were not observed in the field.

The geology of the area consists mainly of basaltic lava and pyroclastics of the Ba Volcanic Group. The geologic formations generally form dome structure near the SLAR dome and inside the SLAR annular structure in the centre of the area and it has semi-dome structure near the SLAR semi-caldera to the east. But the geologic structure is irregular in the SLAR annular zone in the west and SLAR caldera structures in the southeast.

Gabbro intrusive bodies occur inside the central SLAR dome and andesite plug occurs to the north. The basalt and andesite dykes intruding near the central SALR dome and SLAR annular structures occur more or less in radial pattern.

Propylitic alteration is developed near the central SLAR dome and pyrite veinlets are observed. Also NW trending auriferous quartz veins are found near the eastern SLAR semi-caldera.

(4) Area D

SLAR dome structures were extracted at four localities in this area (Fig. 2-2-12). A large SLAR semi-caldera structure surrounding the above SLAR structures from the south and the east was also extracted. However, caldera scarps were not observed in the field.

The geology of this area consists of sandstone and conglomerates of the Ra Sedimentary Group and basaltic lava and pyroclastics of the Ba Volcanic Group. Semi-dome structure is observed near the two SLAR domes in the east and to the northwest of the small westernmost SLAR dome. However, the two SLAR domes in the east were not observed in the field, but fold axes with NNW to NNE trend were confirmed. Also the two SLAR domes in the west are located in both limbs of the anticline with NE to NNE trend.

The volcanic rocks are distributed in the eastern and western part of the area, but not within the SLAR dome in the north. There is a small micro diorite body in the northeast.

NW to WNW trending faults and joints are developed where the two eastern

SLAR domes were extracted. Alteration zones and altered rocks are not found in this area.

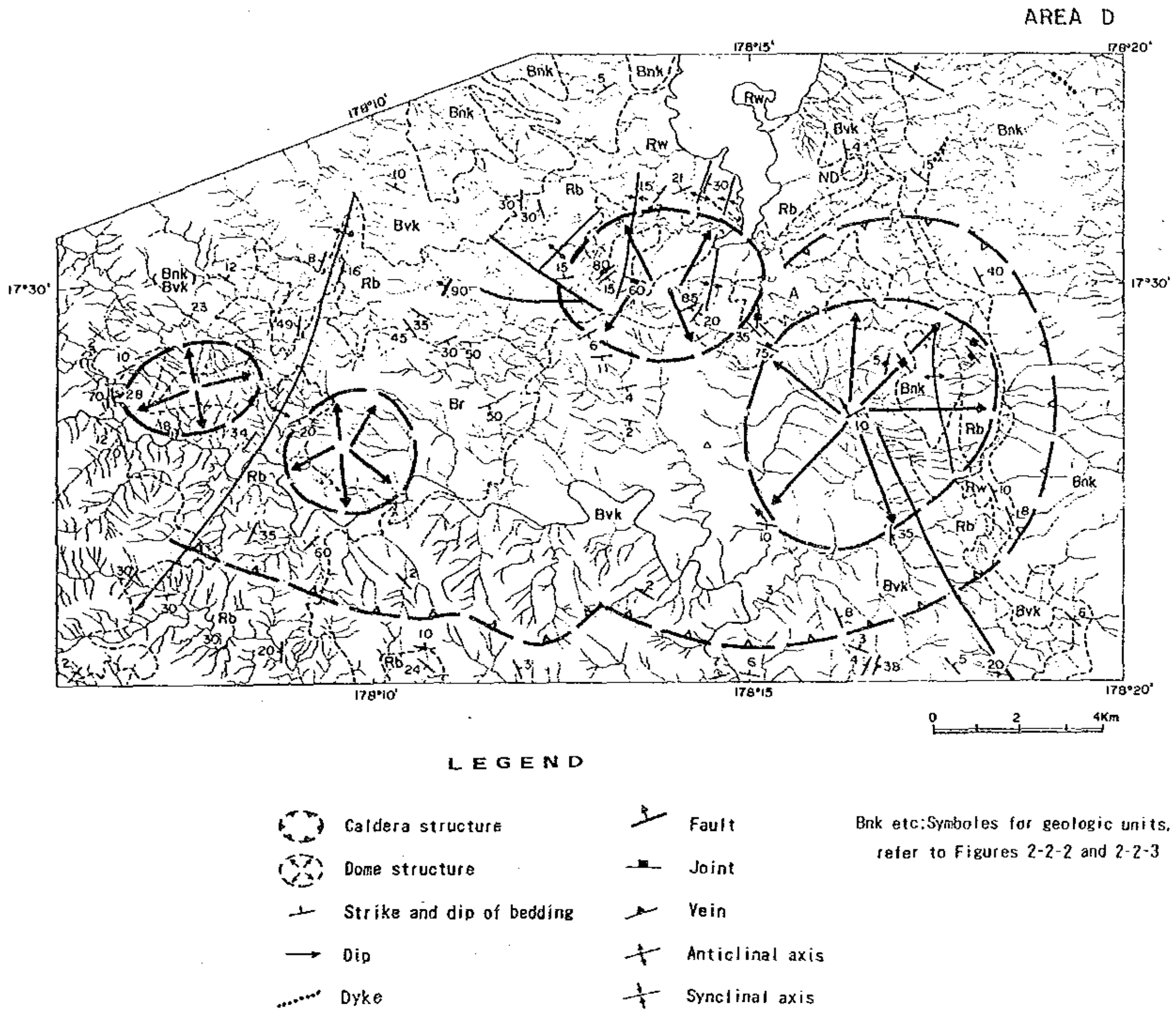


Fig. 2-2-12 Field Geological Data Map of Area D

(5) Area E

A SLAR semi-caldera structure was extracted (Fig. 2-2-13), but caldera scarps were not found in the field. Andesite lava and pyroclastics of the Ba Volcanic Group are distributed in the central part of the SALR semi-caldera zone. Ba lava and pyroclastics of the Ba Volcanic Group overlies them near the periphery of the SLAR structure. The data concerning the attitudes of the geologic formations are scarce and thus the geologic structure of the area is not clearly known, but the andesite lava and pyroclastic is gently raised. Network of joints are developed in the andesite lava. The dykes (basalt, andesite) have NE and WNW trend.

Films of pyrite occur locally in the andesite lavas of this area, but there are no other manifestations of hydrothermal alteration.

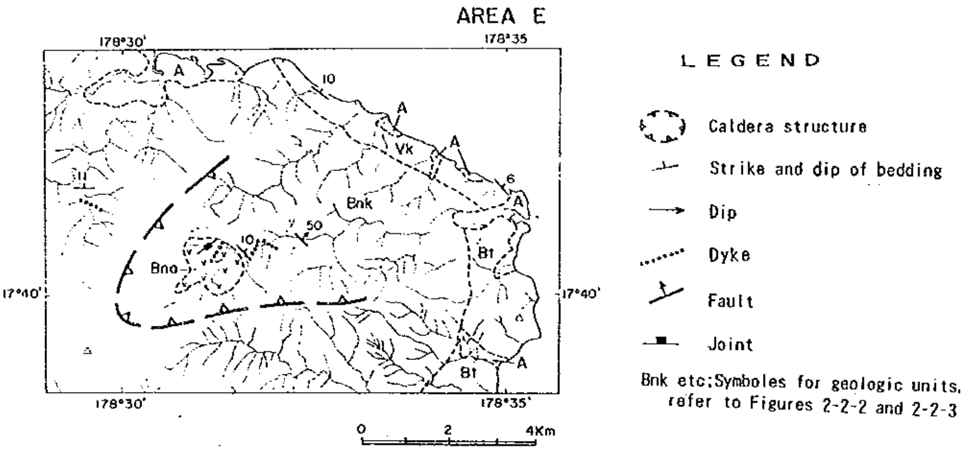


Fig. 2-2-13 Field Geological Data Map of Area E

(6) Area F

A SLAR annular structure and a SLAR caldera structure were extracted in this area (Fig. 2-2-14), but caldera scarps were not observed in the field.

Tonalite of the Colo Plutonic Suite extend in the ENE direction and pyroclastics and volcanics of the Wainimala Group are distributed around the plutonic body. The Wainimala Group in the northern part of the SLAR annular structure is monoclinic with southward dip. Many of the fissures in this area intersect each other perpendicularly. For example, the faults are of

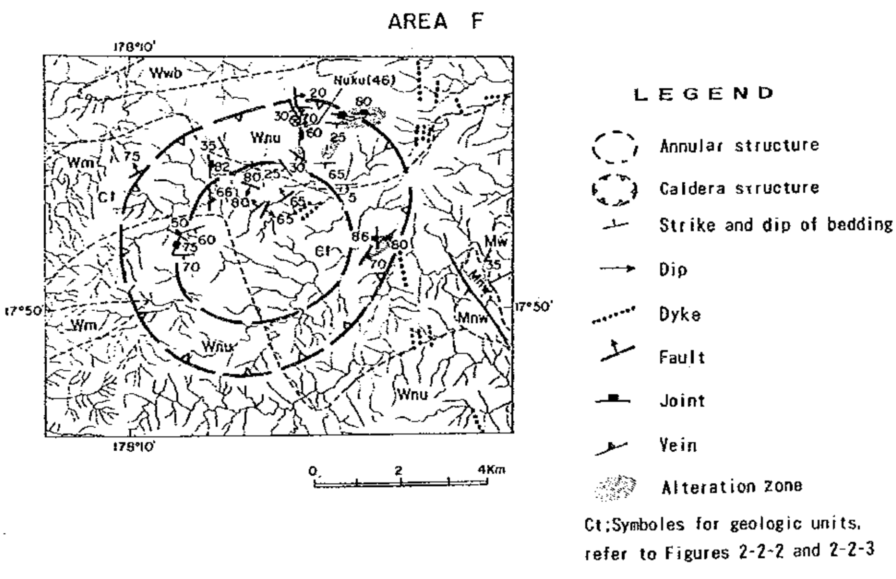


Fig. 2-2-14 Field Geological Data Map of Area F

NNW and ENE systems, the joints strike in the N-S and E-W directions, the veins in the N-S, E-W and NE directions and dykes have NNW to N-S and ENE strike.

Strong to medium alteration zones composed of silicified, pyritized and white argillized material occur in the Wainimala Group in the north. Also quartz-pyrite veinlets occur in the tonalite and Wainimala Group.

(7) Area G

A SLAR annular structure, a SLAR semi-caldera structure and SLAR dome structures were extracted in this area (Fig. 2-2-15), but caldera scarps could not be observed in the field.

Pyroclastics and sedimentary rocks of the Wainimala Group are distributed in the north and east while andesite, pyroclastics, quartz porphyry, quartz diorite porphyry, and sediments of the Medrausucu Group occur in the western and southern parts of this area. The attitude of the geologic formations is monoclinic with W to SW dip in the SLAR annular structure zone, but it is irregular where the SLAR domes are distributed. ENE to ESE system is predominant among faults. Near the SLAR annular and dome structures, joints paralle to the outline of these structures are developed. The direction of the veins and dykes vary widely.

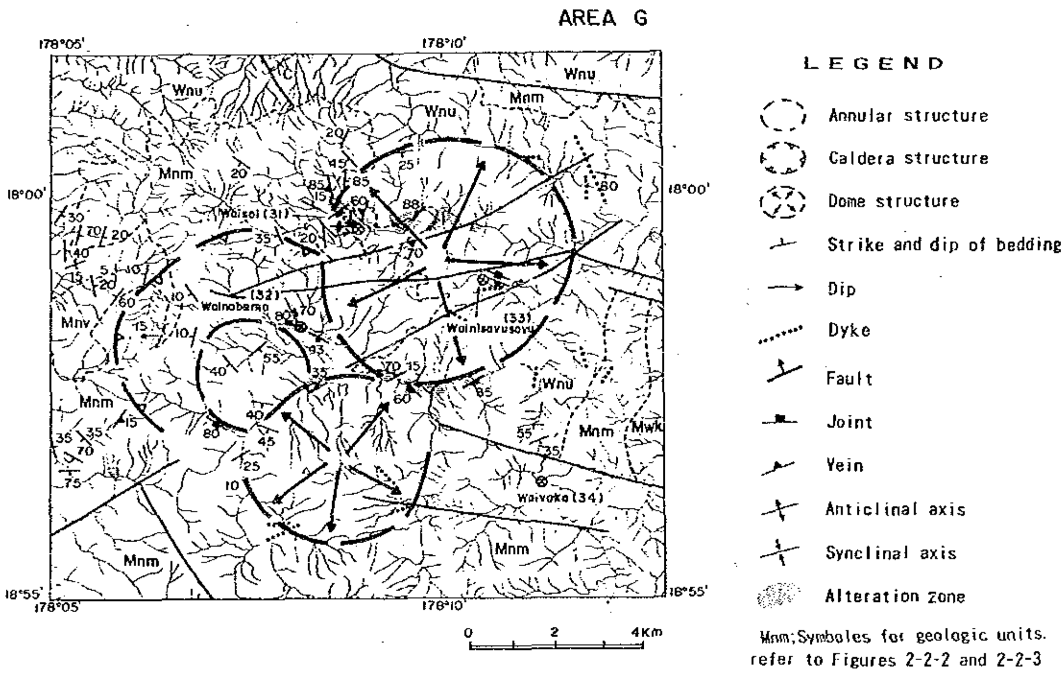


Fig. 2-2-15 Field Geological Data Map of Area G

Strongly argillized zone extends in the E-W direction to the north of the northern SLAR dome structure. This alteration zone is associated with quartz network veins accompanied by base metal dissemination (Waisoi Prospect). Porphyry copper deposit occurs below this alteration zone. Strong to weak argillization and propyritization occur at the intersection of the SLAR annular and dome structures. These alteration zones extend in the E-W direction including the Wainabama Prosepect.

(8) Area H

A SLAR annular structure was extracted in this area (Fig. 2-2-16).

The geology of this area is composed of sandstone, basaltic lava and pyroclastics of the Ba Volcanic Group. The geologic formations of this area are almost horizontal and a gentle syncline is found in the southwest. There are no evidence of alteration in this area.

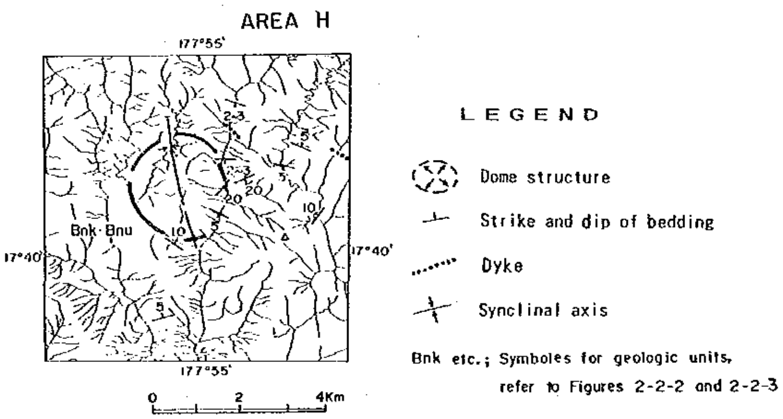


Fig. 2-2-16 Field Geological Data Map of Area H

(9) Area I

A SLAR semi-annular structure was extracted in this area (Fig. 2-2-17).

The vicinity of semi-annular structure consists mostly of sandstone, basaltic lava and pyroclastics of the Ba Volcanic Group, but in the west, shoshonitic pyroclastics of the Koroimavua Volcanic Group are the major geologic units. Synclines with N-S to NNE axes occur near the SLAR semi-annular structures but the attitudes of the formations in the south are irregular. The faults developed to the southeast of the SLAR structure trend harmoniously with the outline of the above structure in the NE to ENE direction. The joints near the synclinal axes also trend in the direction (NNE to NE) harmonious to the axes and some joints are perpendicular (E-W) to the axes.

There are no evidences regarding alteration of the host rocks in this area.

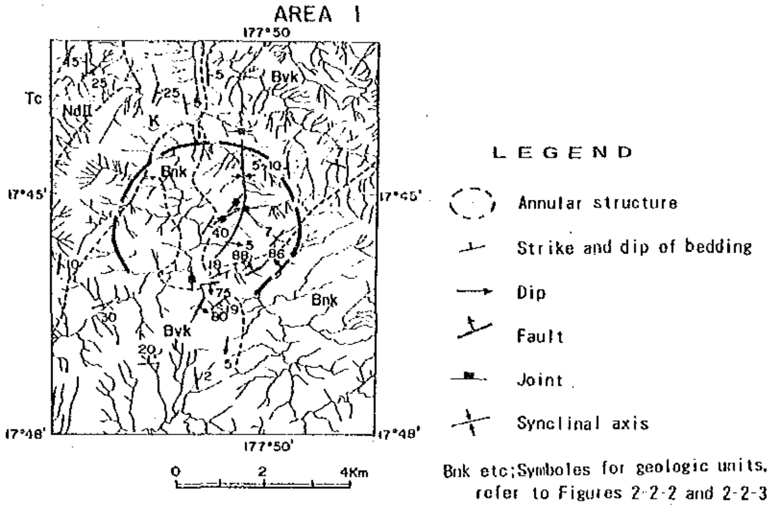


Fig.2-2-17 Field Geological Data Map of Area I

(10) Area J

A SLAR caldera and a SLAR dome structure were extracted from this area (Fig. 2-2-18).

The geology of this area is composed of basaltic propyrite, pyroclastics, sandstone and limestone of the Wainimala Group; tonalite of the Colo Plutonic Suite; sandstone and mudstone of the Navosa Sedimentary Group; and sandstone and monzonite sills of the Ba Volcanic Group. The attitude of the geologic formations is northwestward dipping monoclinic in the north to the west and is irregular from the southern to the southeastern part of the area. Andesite stocks of the Tuva Group occur in the Wainimala Group near the western SLAR caldera and SLAR dome structures. There the majority of the joints trend in WNW direction, while in the vicinity of the SLAR structure in the southeast, there are joints and faults suggesting the existence of annular joints and fissures. The dykes and faults in the southern part of the SLAR dome in the east trend in the WNW direction.

Although evidences of alteration were not found near the western SLAR caldera and SLAR dome, plutonic-type porphyry copper mineralization (Wainivau Prospect) occur at the western margin of the SLAR dome structure in the east.

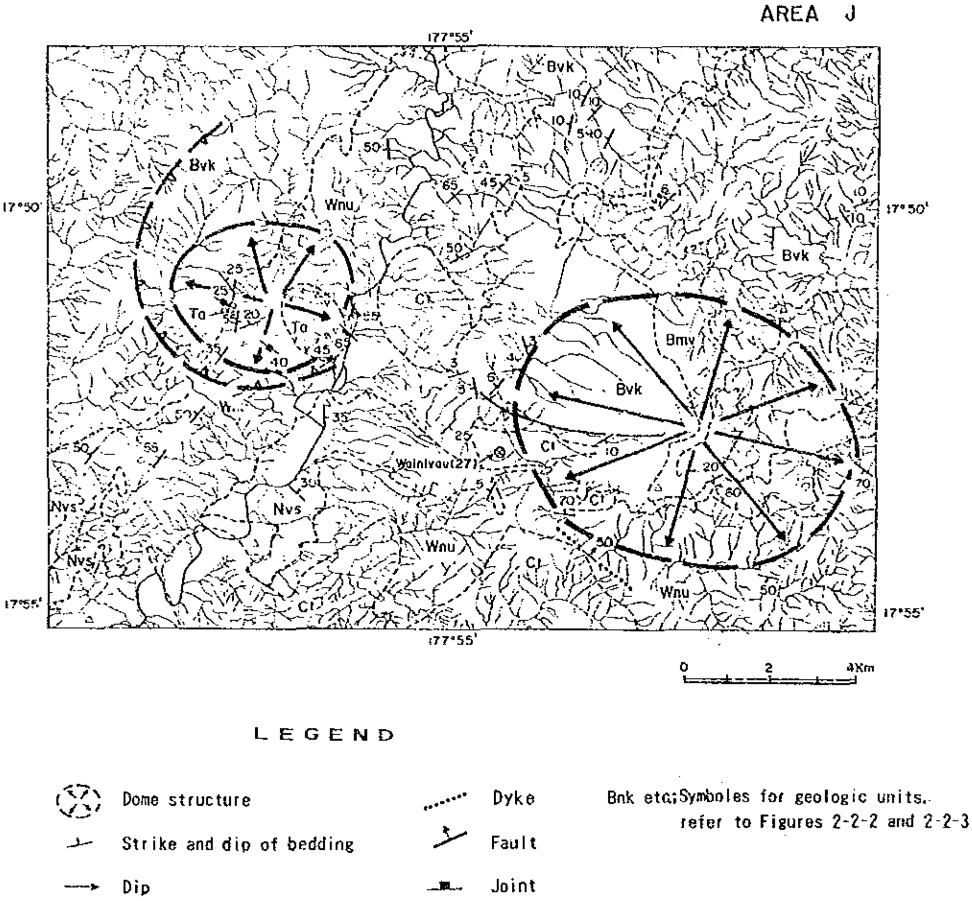


Fig. 2-2-18 Field Geological Data Map of Area J

(11) Area K

SLAR domes and caldera structures and photogeologic caldera were extracted in this area (Fig. 2-2-19), but caldera scarps were not observed in the field.

The geology of this area is composed mainly of shoshonitic lava and pyroclastics of the Koroimavua Volcanc Group and micro monzonite - latite complex. Data regarding the attitude of the geologic formations are scarce and the geologic structure is not clearly known. In parts of the vicinity of the SLAR domes, the border between the mudstone and pyroclastics controls the drainage. The strike of the faults in this area are NNE, E-W, that of the joints NNW, E-W, and of the veins is NNW and NNE.

Evidences of alteration are not observed near the SLAR domes, but inside of the aerial photographic semi-caldera structure, there is a porphyry copper network dissemination (Kingston Prospect) within a pyrite-propyrite-sericitized zone and there is an acidic altered zone consisting of quartz-alunite-kaolin to the north with a NNE trending silicified ridge.

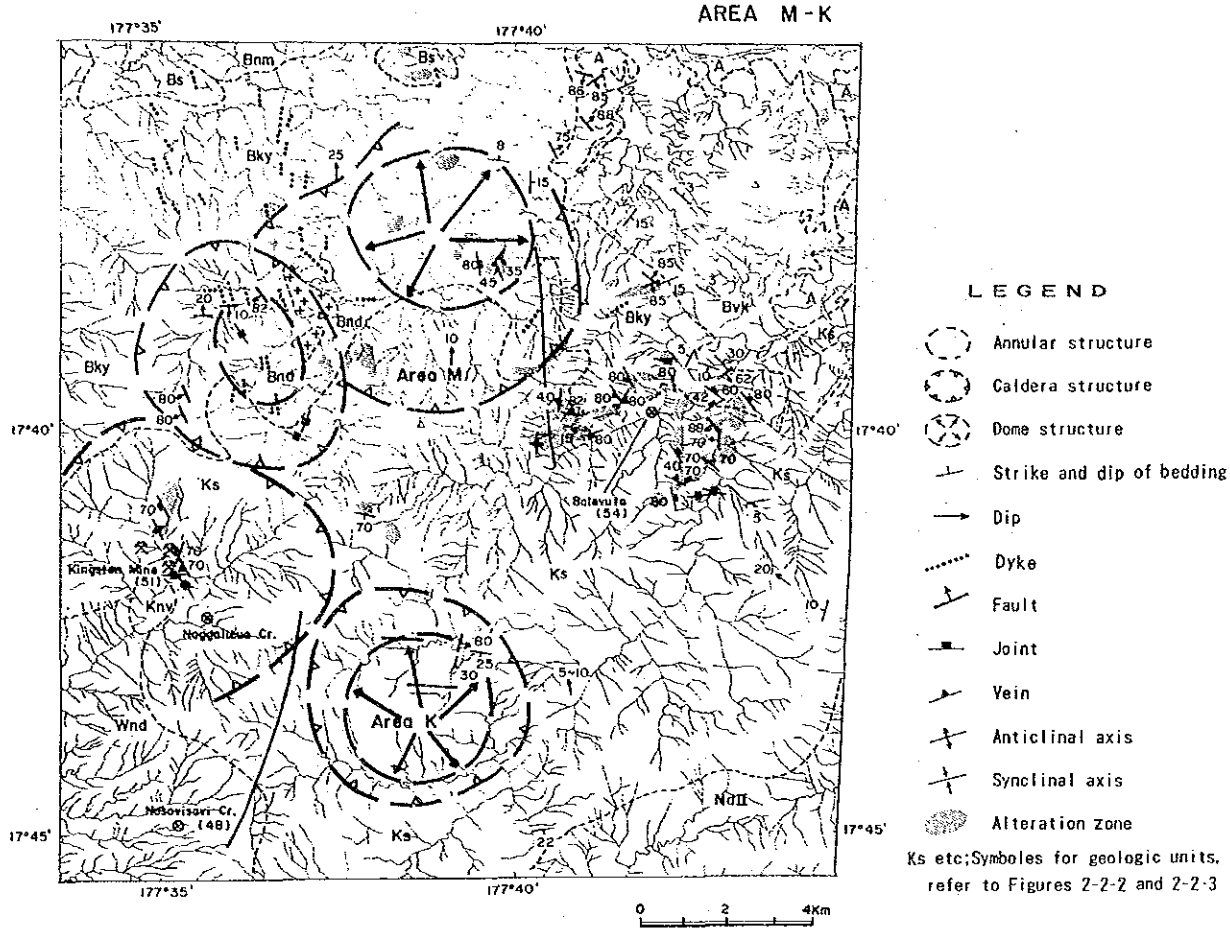


Fig. 2-2-19 Field Geological Data Map of Areas K and M

(12) Area M

SLAR annular, caldera and dome structures were extracted in this area (Fig. 2-2-19), but caldera scarps were not observed in the field.

The geology of this area is composed mainly of shoshonitic lava, pyroclastics of Koroimavua Volcanic Group and shoshonitic lava, pyroclastics, sandstone, monzonite and other units of the Ba Volcanic Group. In the northeastern part of the SLAR dome structure, the geologic formations dip north to east and is harmonious with the SLAR dome structure, but otherwise data are lacking and the details of the geologic structure are not known. Shoshonite dykes occur in a radial pattern in the central to the northern part of the western SLAR dome structure with monzonite intrusion to the east. To the southeast of the SLAR dome structure, andesite dykes occur with varying trends. The faults within the western SLAR annular structure trend NNW and E-W, the joints NW to WNW and NNE. To the southeast of the SLAR dome structure, the faults and joints trend in various directions and the veins in the NW, N-S and WNW directions.

Alteration is observed within and around the SLAR dome structure and the altered zones occur scattered in the NW direction. At the Balevuto Prospect in the southeast, strongly altered zones consisting of alunite, kaolin and pyrite are widely distributed and quartz-limonite vein network is developed. Within the SLAR dome structure, pyrophyllite and alunite are found in the southeastern alteration zone while kaolin is found in the eastern alteration zone within the annular structure.

(13) Area L

A SLAR semi-annular and SLAR semi-caldera structures were extracted in the western part of this area, and SLAR semi-calderas in the eastern part (Fig. 2-2-20). Caldera scarps were not observed in the field.

The geology of this area consists of shoshonitic lava, pyroclastics, sandstone, and micromonzonite of the Koroimavua Volcanic Group and shoshonitic lava and pyroclastics of the Ba Volcanic Group. The dip of the geologic formations is NW at the northwest and southeastern parts of the SLAR semi-annular structure, but the geologic structure of the central part of the structure is not clear because of alteration zones.

Steep faults of NE, WNW to NW trend are developed in the northern part of the SLAR semi-annular structure while E-W trending veins, joints and dykes occur in the central part. Alunite, kaolin and pyrite are found from the intensive alteration zone (Vuda Prospect) within the semi-annular structure and pyrophyllite, alunite and pyrite from the NE trending silicified zone in

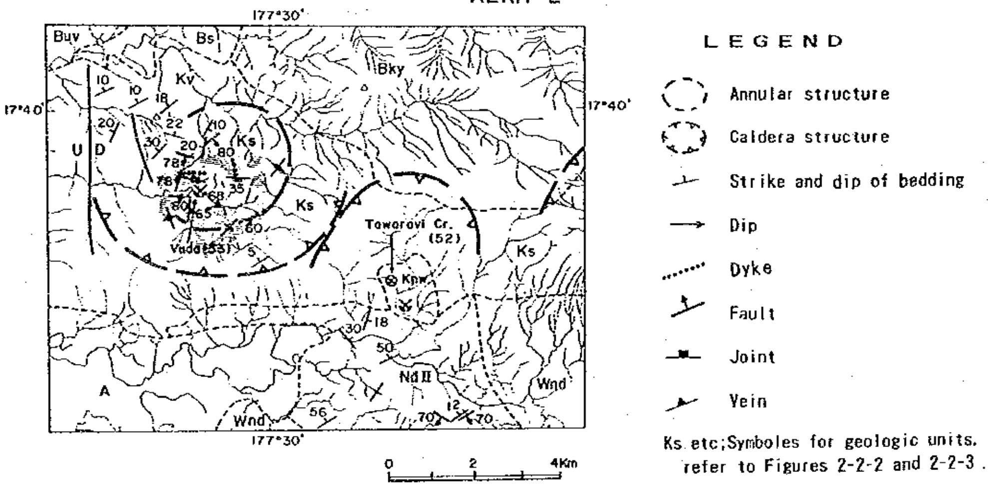


Fig. 2-2-20 Field Geological Data Map of Area L

in the southeast. Also analysis of the pyrite-quartz-alunite veinlets showed gold content of Au 0.07 g/t. Micromonzonite is distributed in the SLAR semi-caldera. Weak pyritization and propyritization (Tawaravi Creek Prospect) are observed near the micromonzonite.

(14) Area N

SLAR semi-annular and SLAR semi-caldera structures were extracted from the western part and SLAR caldera and semi-caldera structures in two localities in the eastern part of this area. Caldera scarps were found in the southeastern SLAR caldera, but not in other structures.

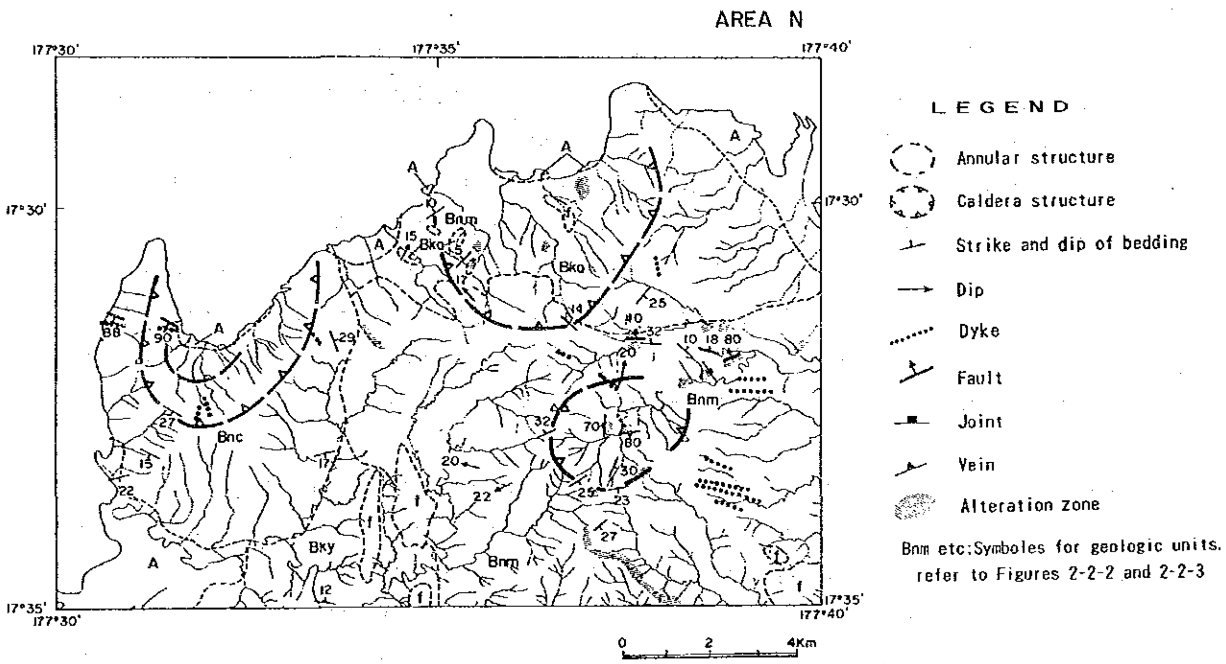


Fig. 2-2-21 Field Geological Data Map of Area N

Ba Volcanic Group is widely distributed throughout this area and they are basaltic lava and pyroclastics in the west, basalt and andesite lava and pyroclastics in the northeast, and andesite pyroclastics in the southeast. Although not very clear, dome occurs in the vicinity of the southeastern SLAR caldera and the western SLAR semi-annular structure. The andesitic pyroclastics in the southeast covers the southern part of the northeastern SLAR semi-caldera with southward dip. Faults with ENE to ESE strike are distributed in east-west direction in the eastern and western parts of the area. Basalt and andesite dykes occur in radial pattern near the SLAR calderas in the west and southeast.

Alteration zones of varying intensity occur scattered in the NW direction near the SLAR caldera and SLAR semi-caldera in the east. Pyrophyllite and alunite occur in the alteration zones within the SLAR semi-caldera structure in the northeast, and alunite, kaoline, sericite and pyrite in the alteration zones within the southeastern SLAR caldera structure.

(15) Area O

A SLAR dome structure was extracted from this area. The geology of this area is composed mainly of pyroxene andesitic lava, pyroclastics and siltstone. The geologic formations have northward dip in the northern and southern parts of the SLAR dome. There are hornblende andesite plugs to the west and northeast of the dome. There is a small white alteration zone immediately to the south of the dome structure.

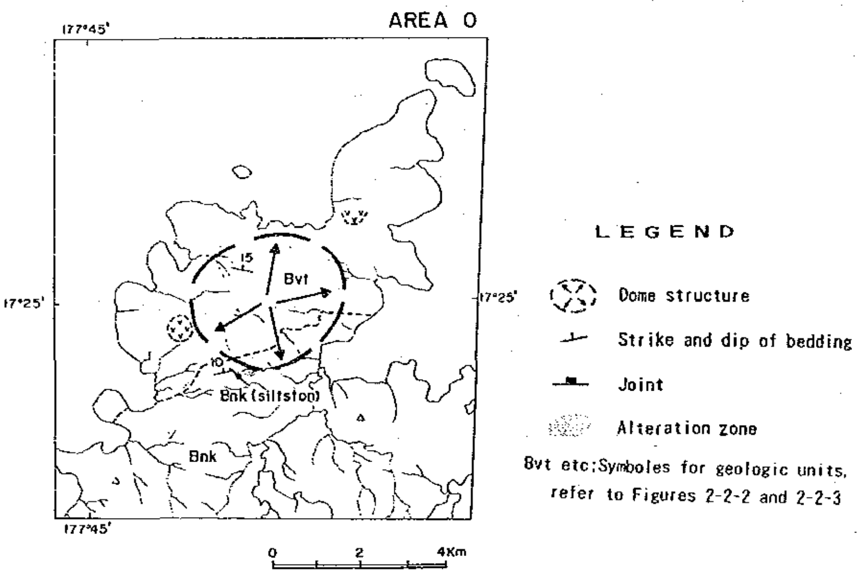


Fig. 2-2-22 Field Geological Data Map of Area O

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.

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 northeast 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 exists, 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.

Abbreviations

(Table 2-2-7)

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 2-2-7 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, ⑤ 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 2-2-7 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 } basin str.	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 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	S: 2×1(?)km	3×2.5km
Mineralized Zone	classification	non	Cu(-Au) vein, porphyry copper type	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	−