

Chapter 2 Geography of the survey area

2 - 1 Location and accessibility

The Viti Levu South area is within longitude 177°25' - 178°30' E and latitude 17°45' - 18°15' S, and within 1858250 - 1987650 mE and 3874000 - 3910000 mN in FMG coordinate system. The area covers about 4,000 km² and occupies approximately the southern 2/5 of the Viti Levu Island, the main island of the Republic of Fiji Islands. The area extends over Rewa Province, Tailevu Province, Naitasiri Province, Namosi Province, Serua Province and Nadroga & Navosa Province. The distance from east to west is approximately 71 - 129 km and the distance from north to south is approximately 32 - 36 km. The area includes capital Suva City in the eastern side and other small towns such as Navua, Korolevu and Sigatoka etc along the southern coastal line.

The total population of the Suva City is approximately 70,000. The capital is equipped with an airport at Nausori and some hotels, shops, department stores for daily necessities and hospitals. In addition, market and the government facility and simple hospital etc exist even in each town.

Concerning the traffic, the Queens Road that runs the coastal line of southern side is paved, but most of roads into inland area have not yet been paved. There is an international airport in the Nadi town along the west coast outside the area. It takes 4 hours between Nadi - Suva City by car and it takes 1.5 hours between Suva City and Sigatoka by car. During the survey of Naitasiri Province, a government dormitory at Vunidawa of approximately 50 km north from Suva was available. However during the survey of Nadroga & Navosa Province, a small community hall at Keiyasi village was available, which is located approximately 50 km northeast from Sigatoka. While the survey of northern Namosi Province, Waisoi exploration camp was available as a base camp for the entire team.

2 - 2 Topography and drainage system

The topographic profile of the survey area is composed of flat coastal land and rugged terrain inland peculiar to volcanic island with the altitude ranges from 0m to 1,000m from mean sea level. Nadrau Plateau (over 1,000m) is distributed in the northern part of the area and Korobasabasaga Range (1,147m), Medrausucu Range (738m) and Mt. Naitaradamu (1,152m) are located in the central part of the area. These plateau and major ridges extend from northeast to southwest forming steep mountain ranges, which compose central watershed of the Viti Levu Island. The northwest - west side of the watershed consists of plains of the Sigatoka River drainage basin and relatively well-dissected gentle hills. The southeast side of the watershed consists of the small plains and deltas along the Rewa River and the Coastal Rivers.

The drainage system of the survey area consists of 3 major drainage systems. The Rewa River extends on the eastern side of the central watershed, which flows from northwest to southeast, and the Navua River extends on the south side of the watershed. While, the Sigatoka River extends on northwest to west side of the watershed. The tributaries of the Rewa River or the Navua River in the central ravine area flow from west to east, then change the courses toward the south and empty in the Pacific Ocean. Besides these drainage systems, a lot of small-scale rivers, which flow from north to south, are distributed along the southern coast in the survey area. Refer to Fig.I-2-1.

2 - 3 Climate and vegetation

The climate of the survey area is tropical marine and under the influence of southeast trade

wind. The dry season falls between May and October and the rainy season is between November and April. The southeast side of the central watershed is located in the upwind side of the southeast trade wind. Therefore, the precipitation is expected much in all year round and especially in the rainy season, the daily squall peculiar to the tropical zone can be seen. It is the season of cyclone from November to April and the precipitation is very much. The precipitation at Suva is 3,000mm/year and that of mountainous region reaches to 6,000mm/year. The monthly average precipitation around Suva is 100mm in the dry season, while 400mm in the rainy season. In Suva, the monthly average of Mean Daily Minimum Temperature is approximately 21 - 24o centigrade and the monthly average of Mean Daily Maximum Temperature is approximately 26 - 32o centigrade. The annual average of Mean Daily Temperature is approximately 26o centigrade and the annual average of Mean Relative Humidity reaches 80%. Refer to Table.I-2-1.

On one side, the plants of the tropical rain forest grow thick from the central to the southeast part of survey area owing to the much precipitation through all year. While on the other side, the northwest to west part of the survey area is located in the downwind side of the southeast trade wind. So much of the grassland lies on the relatively reclaimed hill and the trees and shrubs are growing up by the rivers. The major croplands are located in the Sigatoka River and The Rewa River drainage basin. The central part of the tropical rain forest consists of a primeval forest of endemic species.

Table I-2-1 Summary of the meteorological statistics in Suva, 2001

Items	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR Total/ave.
Precipitation (mm)	354	248	363	443	94	111	96	229	79	304	317	296	2935(mm)
Mean Daily Temperature ()	27.8	28.3	27.6	27.9	26.7	24.6	24.0	24.6	25.3	25.3	27.0	27.9	26.4()
Mean Daily Maximum Temperature ()	31.8	32.3	31.2	31.5	30.2	27.6	26.9	28.1	28.6	28.8	30.7	31.3	29.9()
Mean Daily Minimum Temperature ()	23.8	24.2	24.0	24.2	23.2	21.6	21.0	21.1	22.0	21.7	23.3	24.4	22.9()
Mean Relative Humidity (%)	82	80	82	83	79	80	80	79	78	77	77	78	79.6(%)

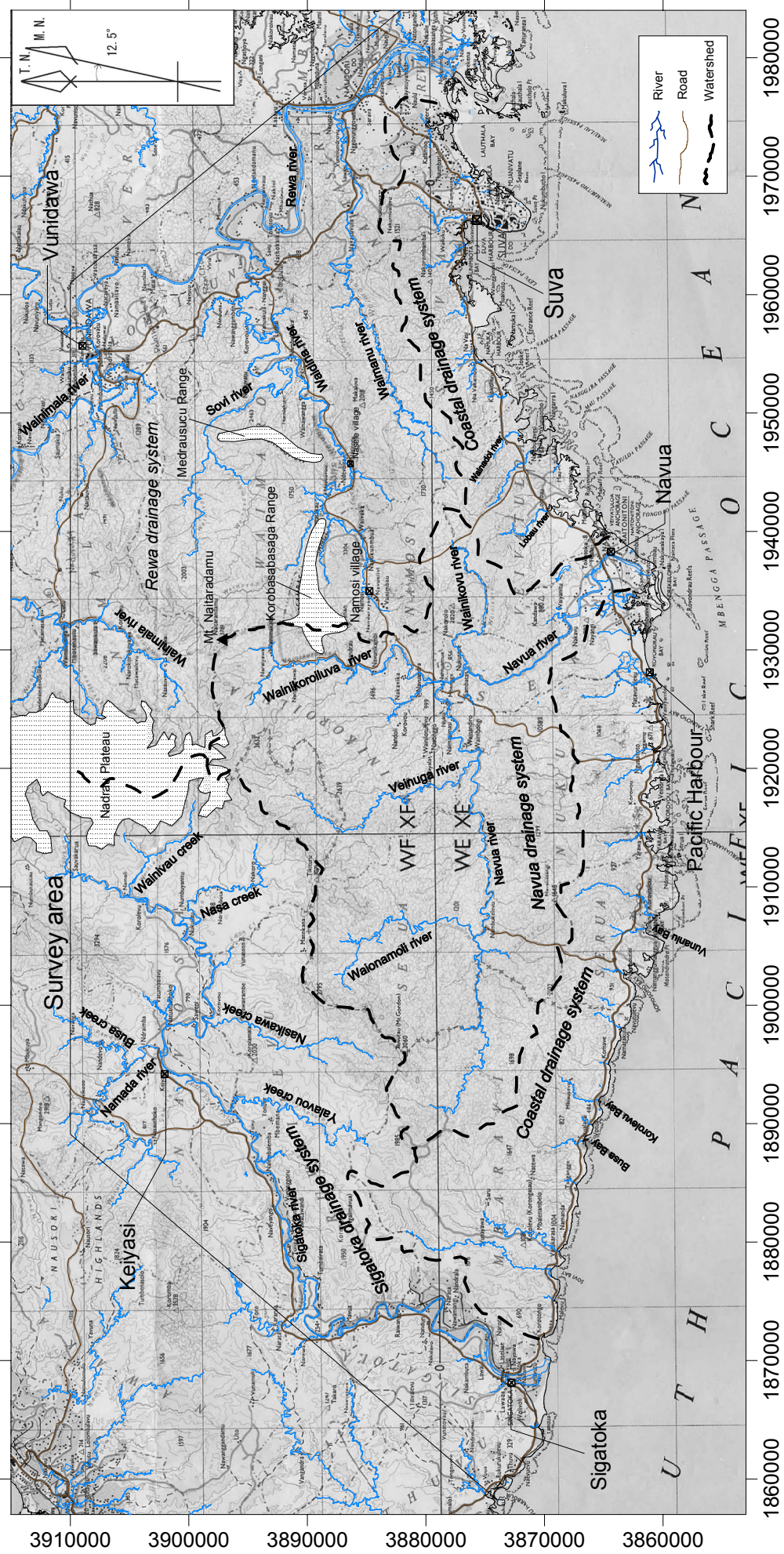


Fig.I-2-1 Topographic map of the Viti Levu South Area (1:500,000)

Chapter 3 General geology

The Republic of Fiji Islands is located in the junction between Pacific Ocean Plate and India-Australia Plate that continues from New Guinea through Solomon and Vanuatu to Fiji Island. The basement of Fiji Islands is composed of volcanic arcs after 65Ma and marine sedimentary basins developing nearby the arcs. The currently known Fiji Islands forms a portion of so-called Circum-Pacific Volcanic Zone or "Rim of Fire" the coupled plate boundary between Pacific and Indo-Australian plates.

The geology of the survey area consists entirely of Cenozoic Groups after 40Ma. The basement is the Yavuna Group, which is distributed in the western part of the survey area. The Wainimala Group overlies the Yavuna Group, while the Medrausucu Group overlies the Wainimala Group. The Colo plutonic rocks intrude these strata. The geological map of the survey area is shown in Fig.I-3-1.

The Yavuna Group forms the basement of the area accompanied with pillow lava, gabbro and reef limestone of Tertiary stage, 40 - 36.5Ma.

The rocks of Wainimala Group are composed of Late Oligocene - Middle Miocene sedimentary rocks. While the lower part of Wainimala Group consists of volcanic breccia and volcanic conglomerate and the upper part consists of lutite, sandstone, reef limestone and volcanoclastic rocks. Hence the rocks of Wainimala Group were altered to various extents and covered unconformably by the Medrausucu Group. The Savura volcanic rock that consists of andesite around Suva and the Sigatoka Group that consists dominantly of sedimentary rocks in the northwest area, are the equivalent strata of the Wainimala Group. The Sigatoka Group outcrops characteristically as limestone around the middle stream of the Sigatoka River.

The rocks of Middle Miocene - Pliocene Medrausucu Group consists of the Namosi andesites in the lower part, the Korobasabasaga Pyroclastic Rocks in the upper part. The amphibole andesite in the Namosi andesites indicates the age of 5.9Ma. The equivalent strata, which consist mainly of sedimentary rocks, are distributed in the east and the west of the survey area. The Verata sedimentary rocks are distributed in the east and the Tuva Group and the Navosa Group are distributed in the west of the survey area. The Pliocene Ba volcanic rocks are widely distributed in the north of the survey area.

The Colo plutonic rocks, in which oldest accurate age is $12.46 \pm 0.51\text{Ma}$, consist mainly of gabbro to tonalite, in the margin of which diorites and amphibole andesites are distributed. Quartz diorite porphyry and amphibole porphyry outcrop in the Namosi - Waisoi mineral occurrences of the central part of the survey area. These porphyries underwent potassic alteration and silicification.

More than 15 independent porphyry copper mineral occurrences were located around Namosi area in the centre of the area, such as Waisoi, Waivaka and Wainabama. The mineralization is recognized at the contact between the Namosi andesites of the Medrausucu Group and the Colo plutonic rocks. To the east of Namosi area, some placer gold deposits are known in the Waimanu River basin, and the Wainadoi-Au mineral occurrence was recognized at the contact between the Wainimala Group and the Colo plutonic rocks. At Colo - I - Suva, a mineral occurrence (Zn - Cu - Au - Ag), which consists of small massive sulfide ore in dacites, is distributed at the north side of Suva.

In addition, the Wainaleka mineral occurrence (Cu-Zn), which resembles a Kuroko type deposit and the Rama Creek mineral occurrence (Cu-Au porphyry type) are distributed in the Navua River drainage system. The Nakoro mineral occurrence (Zn-Cu-Pb-Ag-Au), which consists of volcanogenic massive sulfide deposit, is hosted by the Wainimala Group in the Sigatoka River drainage system. Besides, small-scale Sulua creek and the Korotoga mineral occurrences (Cu-Zn) are hosted by the Wainimala Group distributed in the lower reach of the Sigatoka River.

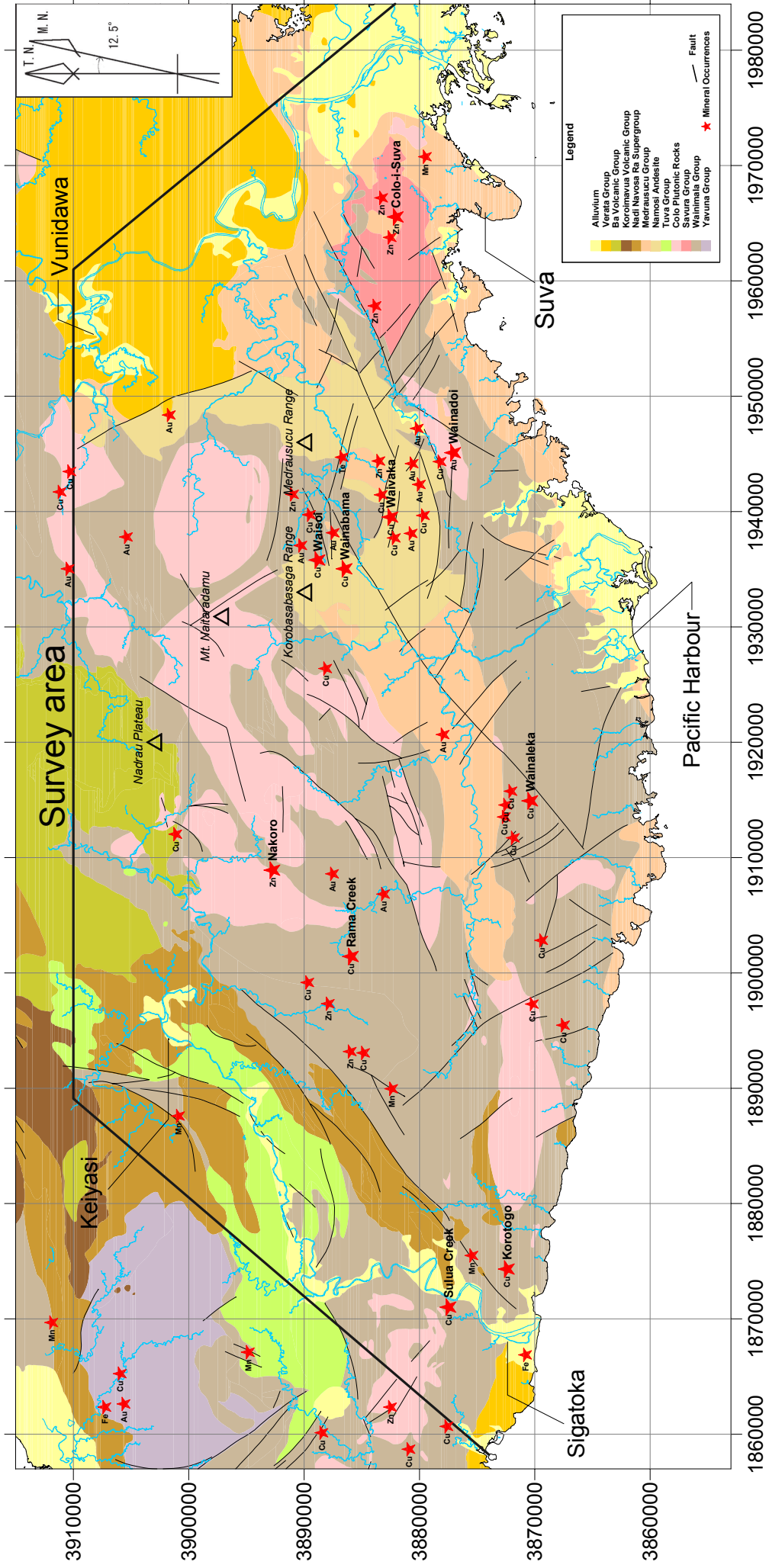


Fig.I-3-1 Geological map and mineral occurrences of the Viti Levu South area (1:500,000)

Chapter 4 Summary of the survey results

4 - 1 Stream sediment survey

The stream sediment survey was executed in order to confirm the geochemical characteristics of stream sediments in the survey area. A total of 1845 stream sediment samples (within which 128 samples are duplicates) were collected from 1717 points in rivers or creeks within the survey area. For laboratory and sample preparation, these samples were sieved under 80 mesh (180 μ m) in the field. The samples were analysed for 29 chemical elements by ICP-AES or AAS in laboratory. The analysis results were compiled and examined for comprehensible regional geochemical characteristics of the survey area. Furthermore, these data were multivariate - statistically handled for principal component analysis.

The drainage system of the survey area is composed of the Rewa river, the Navua river and the Sigatoka river and exceptive the Coastal Rivers. The geochemical characteristic of stream sediment in the survey area is summarized as follows.

The Ca, Mg and Na indicate high values in the northwest part of the area within the main rock forming elements such as Al, Ca, K, Na, Mg and P. Among them, Ca and Mg show specifically high values in the middle stream of the Sigatoka River, which is due to surrounding carbonate rocks such as limestone. While Ba, Cr and V reflect the background geology. The Cr shows specifically high value in distribution range of the Verata group on the eastern part of the area. In general, Ag, As, Au, Cd, Cu, Hg, Mo, Pb, S, Sb and Zn are associated with hydrothermal mineralization. Among them, high ranges of Ag, As and Hg are scattered in the area. The Au anomalies are concentrated on a large-scale mineralized zone in Namosi area, some Au mineral occurrences of the upper Waimanu River and Wainadoi River, and also small sized Au anomalies are scattered in throughout the area. The Cu values are specifically high around the large-scale mineralized zone in Namosi area, which is currently undergoing with exploration activities. The anomalies of Mo, Pb and Zn are surrounding the Cu anomalies. A small anomaly of Mo was detected at the eastern side of Wainaleka mineral occurrence that is known as a porphyry type deposit (Echo Creek).

In the principal component analysis, the first to the third principal components were examined. In the first principal component, elements forming coloured minerals or opaque minerals contribute to positive score and elements forming colourless minerals contribute to negative score. In the second principal component, sedimentary rocks, volcanoclastic rocks and volcanic rocks have a weak relation to positive scored area while intrusive rocks have a weak relation to negative scored area. In the third principal component, hydrothermal Cu-Au deposits affect positive score and high scored range are in harmony with the location of Cu-Au mineral occurrences.

4 - 2 Hydrological survey

The hydrological survey was carried out for analysis of river water at 10 points for supplementary survey. In addition, one weather station was installed inside the survey area to acquire the meteorological data.

As for the results of the water quality measurements, the average of the river flow was 13.3 m^3/sec in during dry season / 25.5 m^3/sec in during rainy season. The average of the river flow in rainy season was twice of that in dry season. The turbidity showed the lowest value of 0mg/l and the highest value of 28mg/l / 333mg/l. The turbidity in rainy season was higher compared with

the turbidity in dry season. Electric conductivity of the river water showed the lowest value of 3.5 mS/m / 3.4 mS/m , the highest value of 40.7 mS/m / 22.4 mS/m , the mean of 13.1mS/m / 9.18mS/m. There was such a tendency that electric conductivity differs depending on water system. For example, the average of the electric conductivity was 25.6 mS/m / 15.44 mS/m in Sigatoka River System, and electric conductivity in the Sigatoka River System was higher in comparison with other 3 river system including the Rewa river, the Navua River and the Coastal rivers. pH showed the minimum of 6.39 / 6.10 , the maximum of 8.44 / 8.12 and the mean was 7.72 / 7.38. These river waters indicate variation from weak acidity, neutrality to weak alkaline. There was a tendency where pH differs depending on water system, for example, pH 8.11 / 7.73 in the Sigatoka River system and pH 7.5 / 7.16 in the Rewa River system. Indicating the tendency of high pH in the rainy season was found.

Stiff diagram shows, as for anions, the shapes of the stiff diagrams for 4 river systems (the Rewa River, the Navua River, the Sigatoka River and the Coastal rivers) are spear type and show that the HCO_3 is abundant. As for cations, the shapes of the stiff diagrams for the Sigatoka River are spear type and show that the Ca is abundant. The difference in the cation quantities is not seen in the Rewa River, the Navua River and the Coastal rivers. Grasping the total concentration of the major components from the shape of the diagrams, the total concentration of the Sigatoka River is higher than the other 3 rivers. Both the results of the dry season and the rainy season, that mentioned above have the same tendency.

Piper plot shows, as for the anion of river water in this survey area, the HCO_3 is higher than ($\text{Cl}+\text{SO}_4$) at almost all points. As for the cation, ($\text{Ca}+\text{Mg}$) is higher than ($\text{Na}+\text{K}$). Generally, all the 4-river systems in the survey area belong to II Carbonate Hardness territory, and are a circulating characteristic supply a type of surface water of the unconfined groundwater. The chemical component and concentration of the river water of the survey area showed the almost similar quality to the average river water of the world.

The trace elements have been compared with the regulation value of Australian Drinking Water Guidelines (ADWG). As the result, points of Fe, Al, As, Cr Ni, Pb and Se showed higher values in comparison with ADWG, showed along the Rewa River drainage system and middle stream of The Navua river. These concentrations in rainy season were higher compared with those in dry season.

Chapter 5 Conclusion and proposal

5 - 1 Conclusion

5-1-1 Stream sediment survey

During the stream sediment survey, a total of 1845 samples were collected from 1717 points in rivers or creeks within the survey area. The samples were analysed for 29 chemical elements. The analysis results were compiled and examined for comprehensible regional geochemical characteristics of the survey area. The geochemical characteristic is summarized as follows.

The Ca, Mg and Na indicate high values in the northwest part of the area within the main rock forming elements such as Al, Ca, K, Na, Mg and P. Among them, Ca and Mg show specifically high values in the middle stream of the Sigatoka River, which is due to surrounding carbonate rocks such as limestone. While Ba, Cr and V reflected the background geology. The Cr shows specifically high value in distribution range of the Verata group on the eastern part of the area. In general, Ag, As, Au, Cd, Cu, Hg, Mo, Pb, S, Sb and Zn are associated with hydrothermal mineralization. Among them, high ranges of Ag, As and Hg are scattered in the area. The Au anomalies are concentrated on a large-scale mineralized zone in Namosi area, some Au mineral occurrences of the upper Waimanu River and Wainadoi River, and also small sized Au anomalies are scattered in throughout the survey area. The Cu values are specifically high around the large-scale mineralized zone in Namosi area. The anomalies of Mo, Pb and Zn are surrounding the Cu anomalies.

5-1-2 Hydrological survey

Field measurement including water flow, water quality and water quality analysis were executed at the 80 points (186 samples) from 4 drainage systems in the Rewa River, the Navua River, the Sigatoka River and the Coastal Rivers in dry and rainy seasons.

As results of these, we could grasp the background data. The general feature of the river water in this survey area shows neutral pH, indicating Ca as a principal cation and HCO_3 as principal anion. Such water as rich in alkaline-earth carbonate is thought to be circulating through free groundwater. The chemical component and concentration of the river water of the survey area showed as almost similar quality to the average river water of the world. The Sigatoka River system shows higher total concentration of the major cations and anions in comparison with the other 3 river systems. This may be a primary factor that raises electric conductivity and pH. Furthermore, the cause why the presence of the Ca and HCO_3 are high in the Sigatoka River system is thought to be influence of sedimentary rocks such as limestones outcropping along the Sigatoka River system. Accordingly to compare with the data of the dry season and rainy season survey, the value of electric conductivity and major dissolved compositions (TDS, Na, Mg, HCO_3 and Cl) in rainy season showed lower value compared with those in dry season. This means that major dissolved compositions were diluted by river water derived from high precipitation in rainy season. While, river flow rate, turbidity and results of trace elements of Al, As, Cr and Zn in rainy season showed higher value compared with those in dry season. These trace elements were not diluted by river water and their concentration was controlled by some reasons. Analysis of Fe, Al, As, Cr Ni, Pb and Se showed some higher values in the Rewa River drainage system and middle stream of the Navua river in comparison with ADWG. These concentrations in rainy season were higher compared with those in dry season.

One weather station was set up inside the Namosi Secondary elementary school to establish

the weather observation system. In addition, meteorological data of the past 5 years, which had been observed at 6 points inside the survey area, were acquired from Fiji Meteorological Service in Nadi. This data are used as a database for the future hydrological survey.

It is important to collect and confirm the environmental basic database because the new regulation concerning the natural environmental policy of the Republic of the Fiji Islands is due to be endorsed by Fiji Parliament soon. The second phase survey of this environmental baseline study includes stream sediment survey and hydrological survey with meteorological data collection. In addition, the first phase survey included fauna survey, flora survey, soil bacteria survey and archaeological survey. A large number of data, which were acquired from this survey, are concluded to be useful for the environmental assessment of future industrial developments.

5 - 2 Proposal for the future

Through this two years survey program, a large number of data regarding hydrology, meteorology, stream sediment geochemistry, flora and fauna, soil bacteria and archaeology were collected from the Viti Levu South area. The objective of this survey is to acquire background database regarding natural environmental field and to integrate these basic data for environmental assessment of future industrial developments. It is necessary to continue acquiring new data in the future in order to protect natural environment from the damage costed by human activities and to keep alert on the effect of industrial developments.

The following two proposals are recommended based from the results of Phase I & II of this survey.

(1) Hydrological survey

The background data as to flow rates and qualities of the river water were acquired twice in dry season and rainy season. The relation between flow rate and trace elements especially heavy metals has been examined. In order to clarify the mechanisms as to the effect of precipitation and flow rate on these elements, it is recommended to acquire these background data in 4 times par year in the future.

(2) Fishes and benthos

In viewpoint of acquisition and arrangement of background data, it is desired to investigate fishes and benthos with more species and more specimens.