No. 8

REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION ENVIRONMENTAL BASELINE STUDY
IN
THE VITI LEVU SOUTH AREA,
THE REPUBLIC OF FIJI ISLANDS

PHASE I

MARCH 2003

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION ENVIRONMENTAL BASELINE STUDY
IN
THE VITI LEVU SOUTH AREA,
THE REPUBLIC OF FIJI ISLANDS

PHASE I

MARCH 2003

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

Preface

In response to the request of the Government of the Republic of Fiji Islands, the Japanese Government decided to conduct a Mineral Exploreation Project (Environmental Baseline Study) in the Viti Levu South Area and entrusted to survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Republic of Fiji Islands a survey team headed by Mr. Osamu Takahashi from September 9th to December 14th, 2002 and another team headed by Mr. Akira Shimizu from January 16th to February 8th, 2003.

The team exchanged views with the officials concerned of the Government of the Republic of Fiji Islands and conducted twice field surveys in the Viti Levu South Area. After the team returned to Japan, further studies were made and the present report has been prepared.

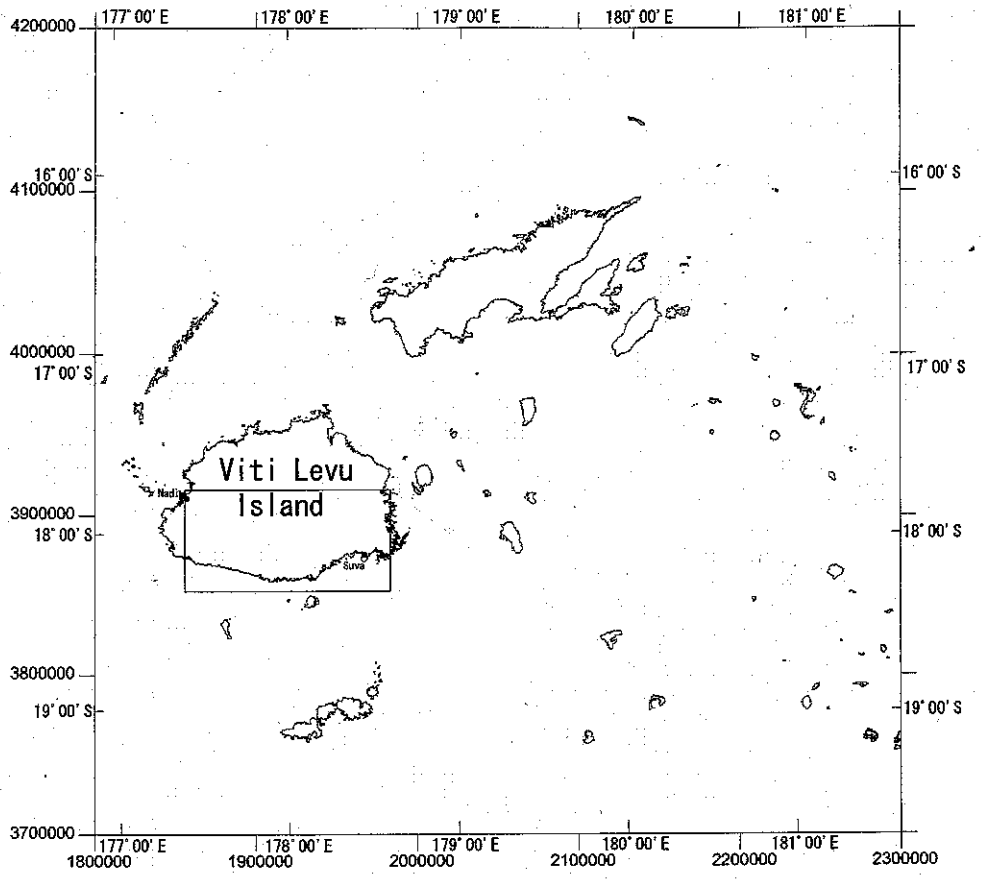
We hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of the Republic of Fiji Islands for their close cooperation extended to the team.

March 2003

Takao KAWAKAMI
President
Japan International Cooperation Agency

Norikazu MATSUDA
President
Metal Mining Agency of Japan



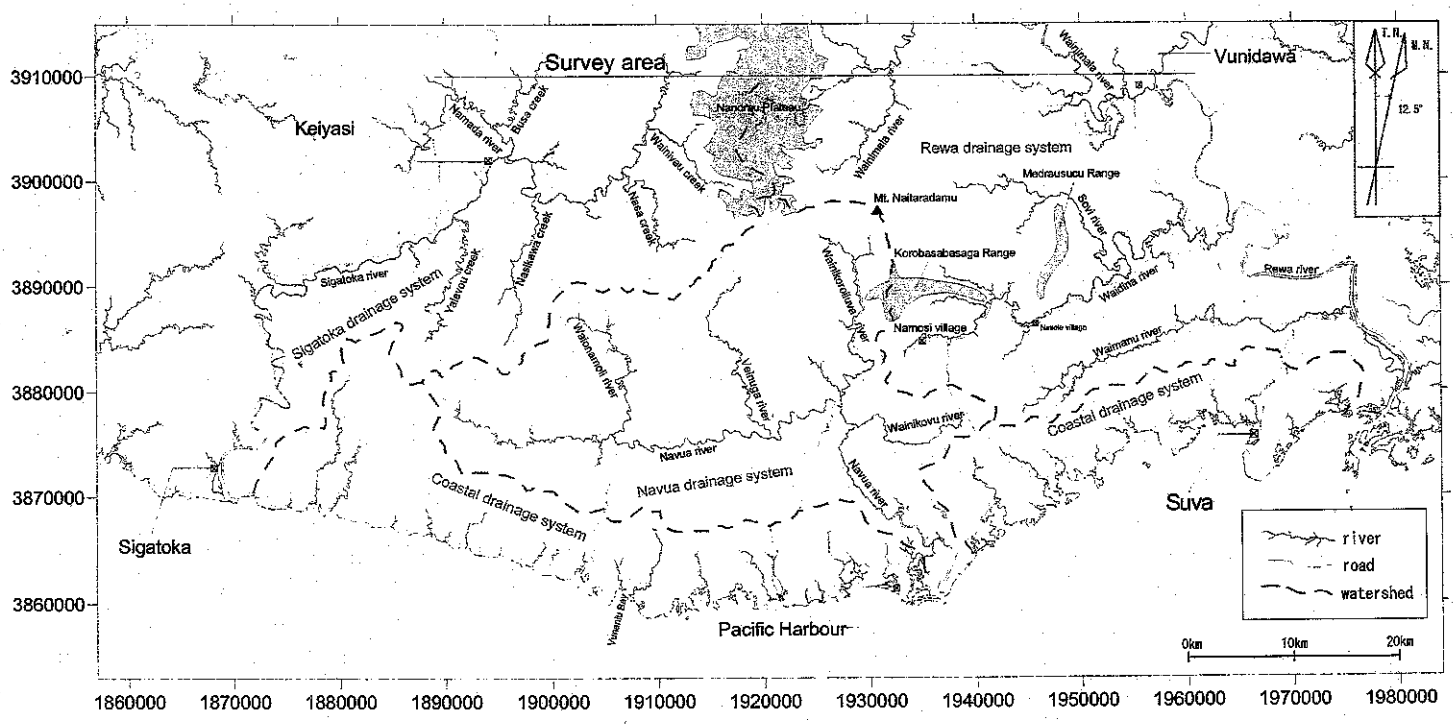


Fig. I-1-1 Location map of the survey area

Summary

This survey corresponds to the 1st phase program (fiscal year 2002) of the Cooperative Mineral Exploration (Environmental Baseline Study) in the Viti Levu South Area, of the Republic of Fiji Islands. The objective of this survey is to acquire the background data regarding the natural environmental field that conform to domestic environmental law of Fiji. The dispatches of the survey team were executed in the dry season from September 9th to December 14th, 2002 and in the rainy season from January 16th to February 8th, 2003.

The survey area covers the southern 1/3 side of Viti Levu Island, the main island of the Republic of Fiji Islands. The area occupies approximately 4,000km^2 and the range of east to west is approximately 71-129 km and north to south is approximately 32 - 36 km. The elevation is 0 m to 1,000 m from mean sea level and the topographic profile is hilly up and down peculiar to volcanic island. From the center to southeast side of the area, thick tropical rain forest is well developing and the biological diversity is abundant, such as Birds. Croplands and pastures are distributed along the Queens Road, the plain along Rewa River between Suva - Nausori - Vunidawa and relatively cultivated hill and plain along Sigatoka to Keiyasi. Village and urban district are developing in these areas.

There is no active mine of metallic minerals in the survey area, however porphyry type copper deposits are distributed in the center of the area. In addition, the small-scale Wainadoi-Au mineral occurence is situated in the eastern part of the area, which is thought as the epithermal Au deposit.

Items of survey are hydrological survey, stream sediment survey, fauna and flora survey, soil bacteria survey and archaeological survey were executed,in this phase.

As for hydrological survey, field measurement of water flow, field measurement of water quality and water quality analysis were executed at the 80 points (88 samples) from 4 drainage systems: Rewa River, Navua River, Sigatoka River and the Coastal Rivers. These 4 drainage systems have a litte different characteristic respectively about component concentration and component ratio. Especially the water of Sigatoka River drainage system shows higher Ca and HCO_3 concentration in comparison with the water of Rewa River drainage system. This is due to influence of sedimentary rocks such as limestones, which exist inside this drainage system arera. Although some component concentration and component ratio are various, the general character of the river water of the survey area show the tendency as seen rivers in general. neutral pH, Ca as principal cation, HCO_3 as principal anion. Because Fiji Islands belongs to the climate of tropical rain forest, the air temperature is high and the precipitation is much, the peculiar characteristic condition had been expected. However 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. As for trace elements in the river water, Cd and Se show somewhat high values.

One weather station was set up inside the Namosi village elementary school, which observes air temperature, wind direction, wind velocity, relative humidity, insolation and precipitation. In addition, meteorological data of the past 4 years, which had been observed at 6 points inside the survey area, were acquired from Fiji Meteorological Service, Nadi.

In the stream sediment survey, total 905 samples (822 points) were chemically analyzed. As for geochemical characteristic of the stream sediments of each drainage system, Rewa River

drainage system is the most strongly influenced by hydrothermal deposits and Cu, Zn, As, Cd, Sb and Au show anomalies. Navua River drainage system is also influenced by hydrothermal deposits after Rewa River drainage system and Zn, Cd, Sb and Au show anomallies. Sigatoka River drainage system is influenced by sedimentary rocks such as limestones and Ca and Mg show higher values than those of other drainage systems, though they are the crustal average levels. In Sigatoka River drainage system, Cd and Sb also show high values similarly to other drainage systems. As for Coastal rivers system, Mg, P, K, Ni, Sr and Ba show lower values than those of other drainage systems. In all drainage systems, Cd, Sb and Au show especially high value in comparison with the crustal average. The anomalies of Cd and Sb are scattered in all the survey area, therefore it is suggested that the background value itself is high and also the content of these elements in igneous rocks nearby is high. On the other hand, Au shows more limited distribution of anomalies, such as Namosi region - upper stream of Waimanu river in Rewa River drainage system and Wainikovu River in Navua River drainage system, where exist influence of hydrothermal deposits. As (arsenic) anomly distribution is similar to that of Au. In all drainage systems, Be, Na, Al, P, K, Ni, Sr, Ba, Hg and Pb show lower values than the crustal average, especially P, K, Ni, Sr and Ba are low.

Fauna and flora survey consists of fauna survey, sampling and chemical analysis of fishes & benthos, flora survey and vegetation distribution survey. Fauna of the survey area consists of total 84 species of animals, which are mainly composed of Birds. In the field survey in Namosi region (tropical rain forest), 34 species of birds including Pink-billed parrotfinch were recognized, which is worldwide rare species. As for Reptile, *Emoia mokosariniveikau* that is a family of Skink, which had been detected only in Vanua Levu Island, was recognized. Flora of the survey area is divided characteristically into 8 ecosystems according to the topography & the climate. The most widely distributed ecosystem is Lowland rain forest (tropical rain forest). Upland rain forest and Cloud forest are distributed in the inland ravine area. The Coastal vegetation is widely distributed along the coast and the Grassland vegetation is widely distributed in Sigatoka area. Total 81 of rare and endangered species of vascular bundle plant are distributed in the Viti Levu South Area that hosts the tropical rain forest which represents the survey area. In the field survey of the tropical rain forest, almost 100% (173 species) of the plants are indigenous species and 60% among them (104 species) are endemic species. The ratio of endemic species is high and 9 rare and endangered species such as *Agathis macrophylla* - dakua or epiphytic orchid are distributed in the area.

The vegetation distribution, which is based on the pseudo color image of the ASTER optical sensor, is well concordant with the vegetation distribution which is verified in the ground truth survey. From interpretation of the ASTER images, it has been clarified that the vegetation distribution in the survey area is divided largely to 5 territories.

As for the survey regarding fishes & benthos, 26 samples of the typical eel and shellfishes (corbicula) were sampled and chemically analysed. Among the trace elements, As (arsenic) value of the fishes, As and Cd (cadmium) values of the shellfish are relatively high.

In the soil bacteria survey, 5 soil samples were collected from Namosi region. These samples were screened primarily for the detection of useful microbes. Microbes, which may possess the function similar to sulphur oxidative bacteria, iron oxidative bacteria, heavy-metal tolerant filamentous fungi and yeast, were detected in the sample of this suvey. This suggests the

potential of microbes applicable to bacteria leaching and mine wastewater treatment.

As a result of archaeological survey, it has been clarified that 213 cases of historical relics or cultural assets are distributed in the survey area. These are the settlement ruins that are so-called early Lapita (earlist human settlement ruins before approximately 3000 years), the late prehistorical sites (before approximately 1000 years) and the late historical sites. The principal ruins are ring structure and fortress ruins that are called Ring dintch and Hill fort and village and settlement ruins that are called Koromakawa, Naga and Yavu. Many of the ruins are distributed in the plains, the valleys and the adjacent hills such as Sigatoka, Keiyasi, Suva and Nausori.

As a result of 1st phase survey, necessity of chemical analysis of the stream sediment samples in remained area, such as Sovi basin or northern Navua River, is proposed. In addition, it is recommended as synthesis analysis that river water samples, stream sediment samples, soil samples, stone & rock samples, animal samples from the same place are sampled and analyzed for mutual comparison and examination and verification of reproducibility. Besides, synthetical analysis of the river water that considers seasonal variation is desired in addition to the annual meteorological data.

Contents

List of Diagrams

Figures

Tables

Appendix

Photograph

Plate

Part I General Remarks

Part I General Remarks

Chapter 1 Introduction

1 - 1 Background of the survey

In the Republic of Fiji Islands, since the gold had been discovered in Navua River drainage basin of Viti Levu Island in 1868, numerous the gold & copper mineral occurences have been discovered. Especially in regard to the gold, the gold produced at the Mt.Kasi mine of Yanawai area, Vanua Levu Island was exported for the first time from Fiji in 1932. Gold has occupied large proportion in all the export items, 81,500,000 F$, 9.9% of all the export amounts in 1996 and has become an important export item of the country comparable with sugar and clothing. The Mt.Kasi mine was closed in July 1998 due to the downturn of the gold price and the depletion of the ore reserve. At present, gold is produced 3.5 t/year at the Emperor mine (Northern Viti Levu: 10.2 g/tAu, ore reserves 2,270,000 t, gold quantity approximately 23 t), which is a largest gold mine in the country.

1,830,000 US$ was invested to Fiji for the prospecting metal mineral resource in 1999, and the number of prospecting licenses has risen to 35. Main explorations have been intermittently executed for the copper in the Viti Levu Island by the Joint Venture (JV) of Australian enterprise (Western Mining) and Canadian enterprise (Placerdome) and Fiji government from the 1970'S. In addition, Tuvatu gold deposit is promoted as a gold prospecting project.This gold deposit is located in the same geological structure as the Emperor mine.

Moreover, there is a porphyry type copper deposit at Namosi region inside the survey area. The ore reserve is 950,000,000 t, the grade 0.43% Cu, with 0.14 g/tAu (cutoff grade 0.3%Cu), and Japanese enterprise (Nittetsu Mining Co. Ltd.) is possesing the mining concession and presently executes a prospecting project.

The Government of the Republic of Fiji Islands has attached importance to the Environmental Impact Appraisal (EIA) with a view to the environmental preservation for mine development although they have promoted mine development positively. Thay aim at an acquisition of the background data of natural environment in keeping with future sustainable development. Then the Fiji Government requested the Japanese Government a cooperative survey (September 4th, 2001, communication F 644). On July 4th of 2002, the Scope of Work (S/W) and the Minites of Meeting (M/M) were sealed between Japanese International Cooperative Agency (JICA) and Metal Mining Agency of Japan (MMAJ) and Ministry of Land & ALTA & Mineral Resource of the Republic of Fiji Islands.

1 - 2 Outline of the 1st phase survey

1 - 2 - 1 Objective of the survey

The objective of this survey is to collect and to integrate the background data implemented in relation to the scheduling natural environmental law, concerning the natural environment in the Viti Levu South area, the Republic of Fiji Islands, where is expected to develop a new mine. In the survey area, the survey team has excuted Environmental Beseline Study to make this report to compile preliminary data for the mining exploitations in furture. In addition, another

objective is to transfer the survey technology to the counterpart through in this survey period.

1 - 2 - 2 Survey area

The survey area covers 1/3 of the southern side of Viti Levu Island, the main island of the Republic of Fiji Islands. The area involves over Rewa Province, Namosi Province, Serua Province and Tailevu Province, Naitasiri Province and Nandronga & Navosa Province.That area is approximately 4,000km^2. The range of east to west is approximately 71-129 km and north to south is approximately 32 - 36 km. The area includes the capital Suva City in the eastern area and some small towns such as Navua, Kolorevu and Sigatoka along the southern coastal line.

Nandrau Plateau (altitude more than 1,000m), Korobasabasaga Range (1,147m) and Medrausucu Range (738m), Mt.Naitaradamu (1,152m) are located in the centeral part of the survey area. Most of the mountain ranges extend from northeast to southwest and form watershed. Rewa River and Navua River flow in the southeastern side of the watershed, while Sigatoka River flows in the northwestern side of the watershed.

1 - 2 - 3 Suvey methods

Maps in this report are made with the Transverse Mercator Projection of orthogonal coordinate system (Datum: FMG).

(1) Hydrological survey

The hydrological survey is to investigate the distribution of water system, the amount of flow and the water quality and also to measure the change of the amount of flow of surface water in the area. Then, the collected data are to be used to clarify the relationship between topography, geology and behaviors of surface and ground water. In addition, one weather station was set up at one point inside the area to acquire the meteorological data.

(2) Stream sediment survey

The stream sediment survey is to collect samples from the rivers in the area and to analyze these samples on chemical composition in order to confirm the regional geochemical background in the area.

(3) Fauna and flora survey

The fauna and flora survey is to collect and to compile existing literature and to execute a field survey at one region in the area in order to understand the habitat of animals and the actual condition of plants and to acquire the data of the rare species in the survey area. In regard to fishes and benthos, eels and shellfishes were catched as representative samples and analyzed to heavymetal element. In addition, the vegetation distibution was predicted based on the Satellite Image Analysis and Grountruth suvey was executed in the field.

(4) Soil bacteria survey

The bacteria survey is to pick up soil samples around Namosi deposit and to cultivate microbes and to confirm items of bacteria and to examine applicability of bacteria leaching and biological wastewater treatment.

(5) Archaeological survey

The archaeological survey is performed in order to confirm the status of ruins to be protected within the whole survey area using the existing data mainly. If necessary, specialists or scholars will be consulted.

1 - 2 - 4 Quantity of the survey

Table I-1-1 shows the survey contents and laboratory examination items and the respective quantity of this survey.

Table I-1-1 Contents of the survey

(1) Contents and quantity of the survey

Contents	Quantity
Hydrological survey	
Whole area	Area 4,000 km² Dry season (water quality, flow, sampling): 80 points(88 samples) Rainy season (water quality, flow, sampling): 80points (88 samples) Setting Weather station and measurement: 1 point
Stream ssediment survey	
Whole area	Area 4,000 km² 822 ponts (905 samples)
Fauna and flora survey	
Whole area	Area 4,000 km² Fauna samples, Fish: 5 points, Shell fish: 21points Fauna and flora field survey: 1 point Vegitation distribution survey (satellite image ground truth): 10 points
Soil bacteria survey	
Whole area	Soil samples: 5 points
Archaeological survey	
Whole area	Area 4,000 km²

(2) Laboratory examination and quantity

Laboratory examination	Quantity
Hydrological survey Water quality analysis (Total dissolved solid, hardness, COD, Cl, SO_4, HCO_3, CO_3, CN, Au, Al, Sb, As, B, Ba, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Ni, K, Ag, Na, Zn, F, Se, N(NH_3), N(NO_3), N(NO_3), T-P Sulphide)	196
Stream sediment survey Stream sediments chemical analysis (Au, Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sr, Ti, V, W, Zn)	905

Fauna and flora survey Fauna samples chemical analysis (fishes and shell fishes) (Au, Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Sr, Ti, V, W, Zn) Soil bacteria survey Sulfate-reducing bacteria, Sulphur oxidative bacteria, Iron oxidative bacteria, heavy-metal tolerant filamentous fungi and heavy-metal tolerant yeasts	26 5

1-2-5 Perssonel of the survey mission

Japan side

(Planning and Coordination)

Tetsuo Suzuki (MMAJ)
Norikazu Kuni (MITI)
Kiyoto Kurokawa (JICA)
Masao Okumura (MMAJ)
Kazuhiro Miyake (MMAJ)

(Field Survey Team)

Osamu Takahashi (Nittetsu Mining Consultants)
Akira Shimizu (Nittetsu Mining Consultants)
Ryuta Okubo (Nittetsu Mining Consultants)
Filipe Drutai (MRD)
Apeti Soro (MRD)

(Supervision of Operation)

Masao Okumura (MMAJ)

Fiji side

Niumaia Tabunakawai
(Ministry of Land-ALTA-Mineral Resourse)
Bhaskar Rao (MRD,President)
Vijendora Prasado (MRD)

Isereli Nagata (MRD)
Moape Navia (MRD)
Rudra Deo (MRD)

1-2-6 Periods of the survey

1st phase survey was excuted as following schedule.

(Field survey)

Environmental Baseline Study September 9th, 2002 ~ December 14th,2002 (97 days)
January 16th, 2003 ~ February 8th, 2003 (24 days)

(Supervision of Operation)

Masao Okumura (MMAJ) September 23th, 2002 ~ October 17th,2002 (22 days)

Chapter 2 Geography of the survey area

2 - 1 Location and accessibility

The survey area is within east longitude 177°25 ' - 178°30 ' and south latitude 17°05' - 18°15', and within 1858250 mE - 1987650 mE and 3874000 mN - 3910000 mN in FMG cordinate system. The area ranges about 4,000 Km^2 and occupies approximately southern 1/3 of the Viti Levu Island, the main island of the Republic of Fiji Islands, and extends over the Rewa Province, Namosi Province, Serua Province, Tailevu Province, Naitasiri Province and Nandronga & Navosa Province. The east to west range is approximately 71 - 129 km and north to south approximately 32 - 36 km. The area includes capital Suva City in easternside, and small towns such as Navua, Kolorevu and Sigatoka etc along the southern coastal line.

As for Suva City, the population is approximately 70,000 people, and an airport, hotels, shops for daily necessaries, department store and hospitals etc has been completed. In addition market and the government facility and simple hospital etc exist even in each town.

Concerning traffic, the Queens Road which 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. Distance between Suva City and Sigatoka is 93km and it takes 1.5 hours by car. Survey designated the Suva and Pacific harbor as base and executed. The bases of the survey were basically fixed at Suba and Pcific Harbour. In the survey of Naitasiri Province, the government dormitory in Vunidawa village of approximately 50 km north (approximately 1 hour) from Suva was available. In the survey of Nandronga & Navosa Province, a small house in Keiyasi village of approximately 50 km north (approximately 1 hour) from Sigatoka was used. In the survey of northern Namosi Province, Wainikatama camp was availabale as a base.

2 - 2 Topography and drainage system (Fig.I-2-1)

The altitude of the survey area ranges from 0m to 1,000m from mean sea level and the topographic profile is hilly up and down peculiar to volcanic island. Nandrau Plateau (over 1,000m) is distributed in the northern part of the survey area and Korobasabasaga Range (1,147m), Medrausucu Range (738m) and Mt. Naitaradamu (1,152m) are located in the central part of the survey area. These plateau and major ridges extend from northeast to southwest forming steep mountain ranges. These plateau and the ranges also form 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 Rewa River and the Coastal Rivers.

The drainage system of the survey area consists of 3 main drainage systems. Rewa River flows on the southeastern side of the central watershed which extends from northeast to southwest. Navua River flows on the south side of the watershed. Sigatoka River flows in the northwest - west side of the watershed. Tributaries of Rewa River or 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. A lot of small-scale rivers, which flow from north to south, are distributed along the southern coast in the survey area.

2 - 3 Climate and vegetation

The climate of the survey area is tropical marine and under the influence of southeast trade wind. It is the dry season from May to October and the rainy season from November to April. The southeast side of the central watershed is located in the upwind side of the southeast trade wind, therefore the precipitation is much in all year. 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 - 24°centigrade and the monthly average of Mean Daily Maximum Temperature is approximately 26 - 32°centigrade. The annual average of Mean Daily Temperature is approximately 26°centigrade and the annual average of Mean Relative Humidity reaches 80% (Table I-2-1).

On one hand, 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. The other hand, the northwest to west part of the survey area is located in the downwind side of the southeast trade wind. 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 Sigatoka River and 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(%)

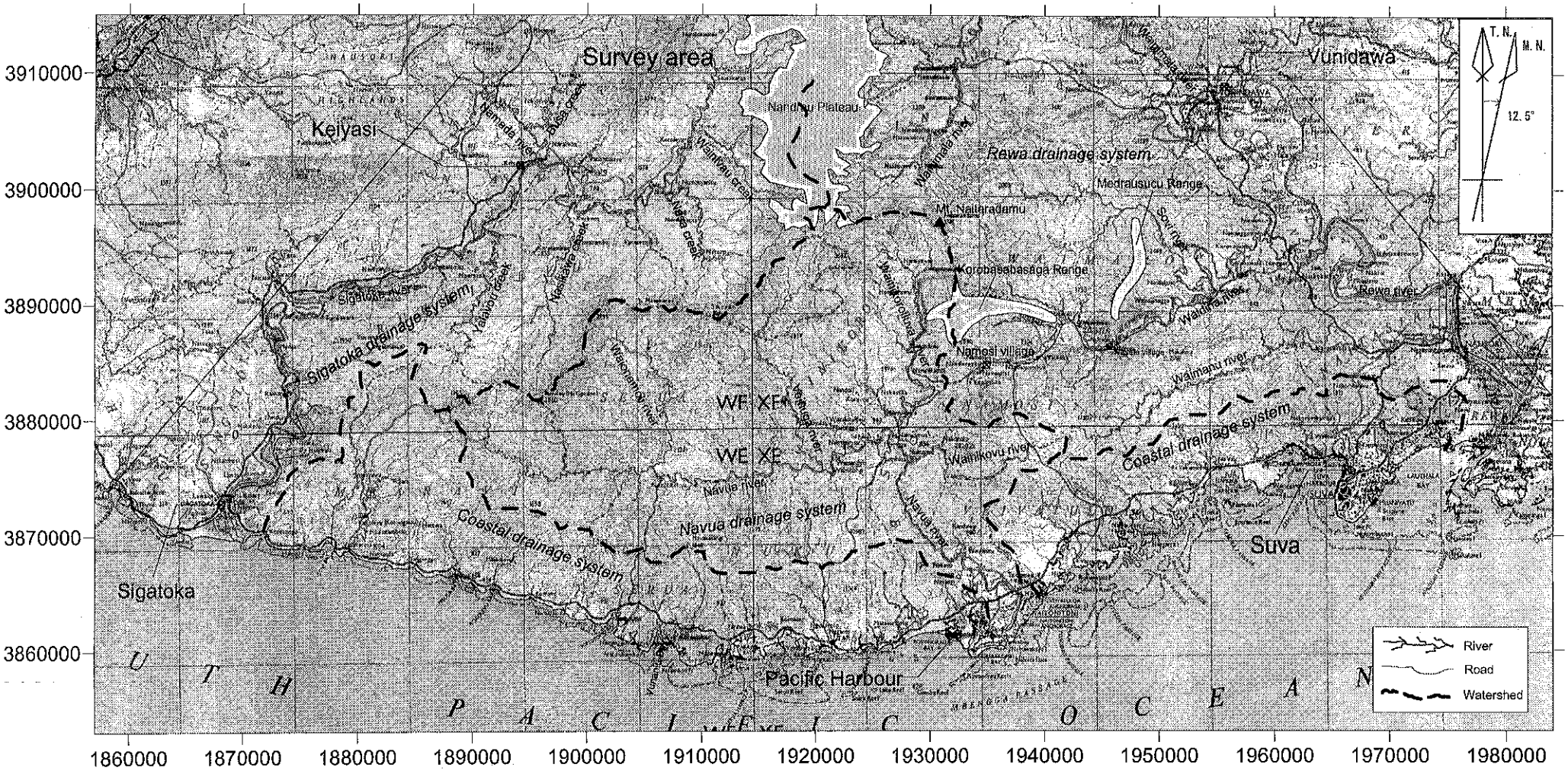


Fig.I-2-1 Topographic map of the Viti Levu South Area

Chapter 3 General geology

The Republic of the Fiji Islands is located in the junction between the Pacific Ocean Plate and the India-Australia Plate that continues from New Guinea through Solomon and Vanuatu to Fiji Island. Besement of the Fiji Islands is composed of volcanic arcs after 65Ma and marine sedimentary basins developing nearby the arcs. Fiji Islands forms a portion of so-called Circum-Pacific Volcanic Zone.

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

Yavuna Group forms basement of the area accompanied with pillow lavas, gabbros and reefal limestones of 40 - 36Ma.

Wainimala Group is composed of Middle Miocene - Late Pliocene sedimentary rocks. The lower part of Wainimala Group consists of volcanic breccias and volcanic conglomareates and the upper part consists of lutites, sandstones, reefal limestones and volcaniclastic rocks. The rocks of Wainimala Group were altered to various extents and coverd unconformably by Medrausucu Group. Savura volcanic rock which consists of andesites around Suva and Sigatoka Group which consists dominantly of sedimentary rocks in the northwest area, are the equivalent strata of Wainimala Group.

Middle Miocene - Pliocene Medrausucu Group consists of Namosi andesites in the lower part, Korobasabasaga Pyroclastic Rocks in the upper part. The amphibole andesite in 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. Verata sedimentary rocks are distributerd in the east and Tuva Group and Navosa Group are distributed in the west of the survey area. Pliocene Ba volcanic rocks are widely distributed in the north of the survey area.

Colo plutonic rocks, in which old one indicates the age of 12Ma, consisit mainly of gabbros to tonalites, in the margin of which diorites and amphibole andesites are distributed. Quartz diorite porphyry and amphibole porphyry outcrop in Namosi - Waisoi mineral occurences of the central part of the survey area. These porphyries underwent potassic alteration and silicification.

More than 15 independent porphyry copper mineral occurences were found out around Namosi region in the center of the area, such as Waisoi, Waivaka and Wainabama. Mineralizations are recognized at the contact between Namosi andesites of Medrausucu Group and Colo plutonic rocks. In east of Namosi region, some placer gold deposits are known in Waimanu River basin and Wainadoi-Au mineral occurence was recognized at the contact between Wainimala Group and Colo plutonic rocks. Colo - I - Suva mineral occurence (Zn - Cu - Au - Ag), which consists of small massive sulfide ore in dacites, is distributed at north side of Suva.

In addition, Wainaleka mineral occurence (Cu-Zn) and Rama Creek mineral occurence (Cu-Au), which resemble to Kuroko type deposit, are distributed in Navua River drainage system. Nakoro mineral occurence (Zn-Cu-Pb-Ag-Au), which consists of volcanogenic massive sulfide dipsit, is hosted by Wainimala Group distributed in Sigatoka River drainage system. Small-scale Sulua

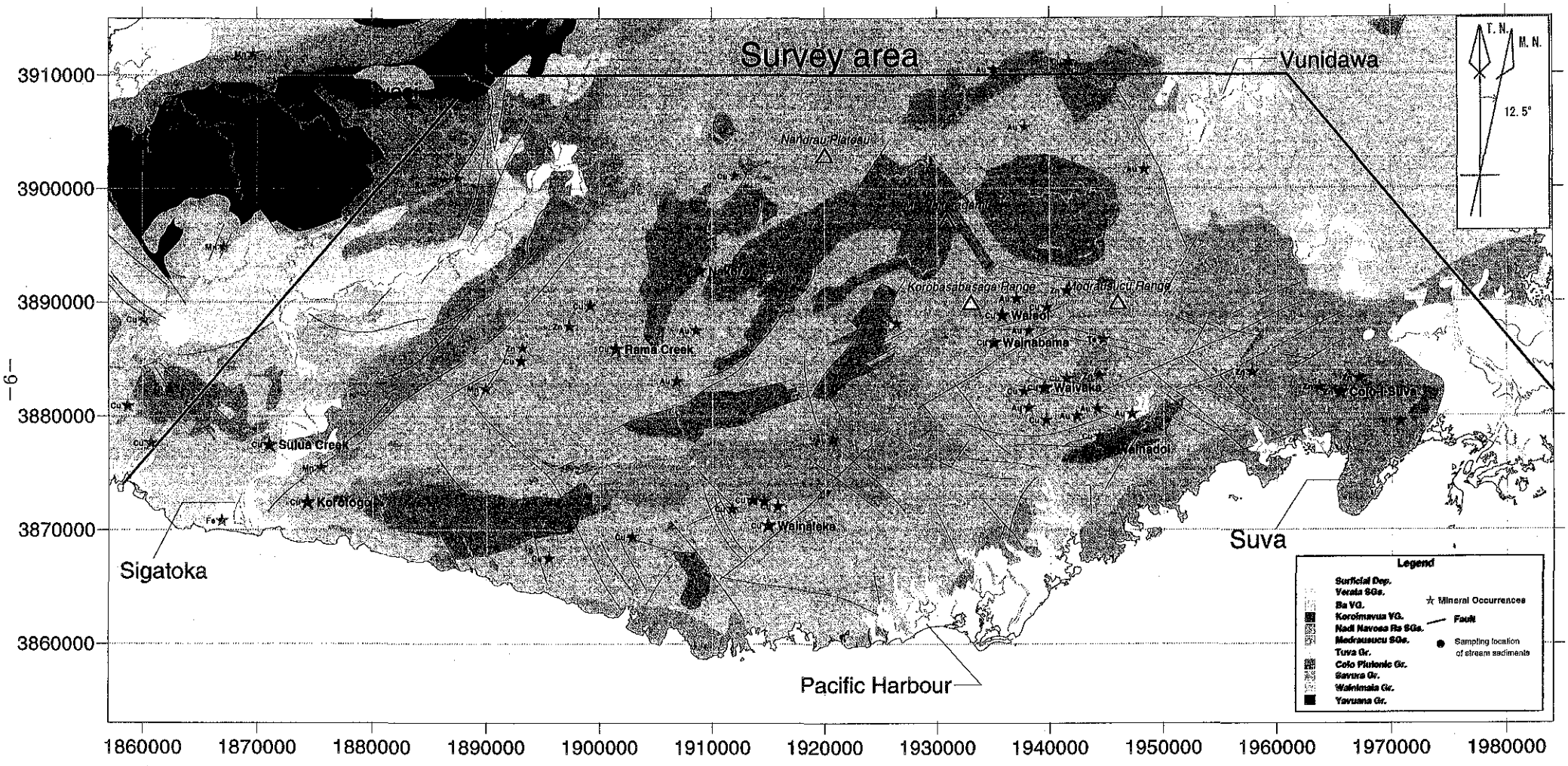


Fig.I-3-1 Geologic map and mineral occurrences of the Viti Levu South area(1:500,000)

creek and Korotoga mineral occurences (Cu-Zn) are hosted by Wainimala Group distributed in the lower reach of Sigatoka River.

Chapter 4 The legal regulation regarding natural environments

Fiji Government is now making a policy regarding the environment in the Republic of the Fiji Islands. Ministry of Environment has administered the Biodiversity Strategy and Action Plan. In addition, the bill "Sustainable Development Act" is deliberated to stipulate Environmental Impact Assessment (EIS).

The Sustainable Development Act presently deliberated, stipulates the contents and proccess of the EIS that intended for all development action including mine development, mine mark treatment and tailing diposal, the regulation for the environment, the natural resource administrative plan and the violation and the penalty.

There are regulations below as the law regarding the recognition, the survey and the protection of the area of environments in the Fiji Islands.

・National Trust for Fiji Act and Amendment Act

Nature conservation areas of Fiji are stipulated in this regulation. The survey area of this time includes Sovi Basin, Monosavu - Nadrau Plateau and Rewa Delta, which are selected as the nature conservation areas.

The legal regulation regarding the recognition, the survey and the protection of cultural heritage are stipulated below in addition to National Trust for Fiji Act and Amendment Act.

・Preservation of Objects of Archaeological and Palaeontological Interest Act

The WHO standard is adopted for the water quality standard regarding environment.

Chapter 5 Summary of the result of the survey

5 · 1 Hydrological survey

The hydrological survey is to investigate the location of flow, the amount of flow and the water quality and to record the change of water flow of rivers or creeks inside the survey area and to acquire the data which reveal the relationship between topography, geology and the behavior of surface water and underground water. In addition, one weather station was installed inside the survey area to acquire the meteorological data.

The survey points are total 80 points (88 samples, 8 samples are duplication); 37 points from Rewa River drainage system, 15 points from Navua River drainage system, 19 points from Sigatoka River drainage system and 9 points from Coastal Rivers. At the fields, the water quality measurements of river flow, water temperature, pH, electric conductivity, turbidity and DO and the water samplings were excuted. At the laboratory, these samples were analysed regarding chemical components of 33 elements

As results of the water quality measurements and the analysis of the major components of the river water, the following points were clarified. The electric conductivity differs between each drainage system. The average conductivity is 8.44 mS/m in Rewa River drainage system, while 25.6mS/m in Sigatoka River drainage system. The pH also differs between each drainage system. The average pH of Rewa drainage system is 7.5, while that of Sigatoka drainage system is 8.11. Concerning the anion, HCO_3 is dominant in all darainage systems. Concerning the cation, Ca is dominant in Navua River drainage system and Sigatoka River drainage system, but no big difference of the cation concentration is seen in Rewa River drainage system and Coastal Rivers. Sigatoka River drainage system shows higher total concentration of the principal cations and anions in comparison with the other 3 drainage systems. This may be a primary factor that raises electric conductivity and pH. Furthermore the cause, why the concentration of Ca and HCO_3 are high in Sigatoka River drainage systems, is thought to be influence of sedimentary rocks such as limestones along Sigatoka River drainage system.

Although some component concentrations and component ratios somewhat differ inside the survey area, the general character of the river water of the survey area shows neutral pH, Ca as principal cation and HCO_3 as principal anion. The water which has the quality of this kind of alkaline earths carbonate is thought to be circulating free groundwater. Because Fiji Islands belongs to the climate of tropical rain forest, the air temperature is high and the precipitation is much, the peculiar characteristic condition had been expected. However 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 ADWG (Australian Drinking Water Guidelines). As a result, the following number of samples showed the higher values in comparison with ADWG.

Se: 16 samples, Ni: 2 sampes, Pb: 2 samples, Fe: 2 samples, Al: 3. In the future suvey, the sampling of stream sediments and rocks in addition to water sampling are desired around the anomalous water sampling points to execute comparing examination, confirming reappearance and monitoring drinkable well.

One weather station was set up inside the Namosi village elementary school, which observes air temperature, wind direction, wind velocity, relative humidity, insolation and precipitation. In addition, meteorological data of the past 4 years, which had been observed at 6 points inside the

survey area, were acquired from Fiji Meteorological Service, Nadi. This data are used as a database for the future hydrological survey.

5 - 2 Stream sediment survey

Stream sediment samples were collected from rivers or creeks inside the survey area and analysed for chemical composition to understand the regional geochemical characteristics. The number of samples is 905 within which 83 samples are as duplicated samplse.

The drainage system off the survey area is divided broadly to Rewa River drainage system, Navua River drainage system, Sigatoka River drainage system and Coastal River drainage system. The characteristic of the element concentration of each drainage system is summarized as follows. Rewa River drainage system is the most strongly influenced by hydrothermal deposits and Cu, Zn, As, Cd, Sb and Au show anomalies. Navua River drainage system is also influenced by hydrothermal deposits after Rewa River drainage system and Zn, Cd, Sb and Au show anomallies. Sigatoka River drainage system is influenced by sedimentary rocks such as limestone and Ca and Mg show higher values than those of other drainage systems, though they are the crustal average levels. In Sigatoka River drainage system, Cd and Sb also show high values similarly to other drainage systems. As for Coastal rivers system, Mg, P, K, Ni, Sr and Ba show lower values than those of other drainage systems.

As a tendency common to all drainage systems, S, Ti, V, Cr, Mn, Fe, Zn, As, Cd, Sb and Au show high values as compared with the abundance of elements in average crustal rocks. From the fact that some samples include much magnetite, there is a possibility that high values of Co, V, Zn, Mn and Cd, which are easy to coexist with Fe, have relations to high contents of magnetites in the samples. In all drainage systems, Cd, Sb and Au show especially high value in comparison with the abundance of elements in average crustal rocks. The anomalies of Cd and Sb are scattered in all the survey area, therefore it is suggested that the background value itself is high and also the content of these elements in igneous rocks nearby is high. On the other hand, Au shows more limited distribution of anomalies, such as Namosi region - upper stream of Waimanu River in Rewa River drainage system and Wainikovu River in Navua River drainage system, where exist influence of hydrothermal deposits. As (arsenic) anomly distribution is similar to that of Au. In all drainage systems, Be, Na, Al, P, K, Ni, Sr, Ba, Hg and Pb show lower values than the crustal average, and especially P, K, Ni, Sr and Ba are low.

In next year, the same method survey as 1st phase is desired in the virgin area and the anomalous area inside the survey area. In addition various types of rocks, which represent geological basements, should be chemically analyzed for comparison and examination with the analysis data of the stream sediment samples.

5 - 3 Fauna and flora survey

Fauna and flora survey consists of fauna survey, sampling and chemical analysis of fishes & benthos, flora survey and vegetation distribution survey.

As for inland Vertebrata, Birds are most abundant, approximately 150 species, and Reptiles, and Amphibians follow after the Birds. Fauna in the South East Viti Levu that represents the survey area coverd by tropical rain forest consists of total 84 species including introduced species. Birds have 51 species, Mammals have 11 species, Reptiles have 19 species and Amphibians have 3 species. During the field survey in the tropical rain forest, 34 species of birds were recognized

including Pink-billed parrotfinch which is worldwide rare species. The area is not disturbed as to biodiversity of birds. As for Reptiles, *Emoia mokosariniveikau*, which is a kind of Skink that was detected only in Vanua Levu Island, was discovered in the field suvey.

As for the sampling and chemical analysis of fishes & benthos, 26 samples were collected (corbicula: 21, eel: 5) and chemically analyzed (28 elements). The feature of each element concentration in fishes and shellfishes shows almost same tendency, but fishes tend to concentrate Ca, Mg, Na, K and as trace elements B and Sr, the other hand, shellfishes concentrate As, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Ti and V.

Flora of the Fiji Islands can be divided characteristically to 8 ecosystems according to the topography and the climate, such as Small island vegetation (mangrove, bush and grass), Mangrove forest and shrubs (on large Islands) (mangrove forest and bush), Coastal vegetation (mangrove, bush and grass), Freshwater wetland vegetation (swamp), Lowland rain forest (tropical rain forest), Upland rain forest (highland tropical rain forest), Cloud forest (wet rain forest) and Grassland vegetation (grassy plain). The most widely distributed ecosystem is Lowland rain forest (tropical rain forest). Upland rain forest and Cloud forest that should be protected are distributed in inland ravine area. The Grassland vegetation is widely distributed in Sigatoka area. Total 81 of rare and endangered species of vascular bundle plant are distributed in the Viti Levu South Area that hosts the tropical rain forest which represents the survey area. In the field survey of the tropical rain forest, almost 100% (173 species) of the plants are indigenous species and 60% among them (104 species) are endemic species. The ratio of endemic species is high. 9 rare and endangered species such as *Agathis macrophylla* - dakua or epiphytic orchid are distributed in the area. The area can be concluded to have rich biodiversity.

The vegetation distribution map based on the pseudo color image that acquired from the optical sensor of ASTER agrees with the vegetation distribution confirmed in the field survey. The vegetation ditribution of the survey area is divided largely to 5 vagetation territories from the image interpretation. Red-Purple territory corresponds to high mountain zone that distributes Upland rain forest and Cloud forest or part of Tropical rain forest. Red-Purple - Dark blue territory corresponds to mountain hillside zone that distributes Lowland rain forest. Blue territory corresponds to topographically gentle land that ditributes part of Grassland vegetation. Green-Yellow territory corresponds to geassy plain along rivers and swamp where distributes part of Grassland vegetation and Freshwater wetland vegetation. White territory corresponds to cloud.

5 - 4 Soil bacteria survey

In order to examine the possibility that applicable microbes which can be used for the bacteria leaching and the biological mine wastewater treatment in the survey area where a new metal mining development is expected, 5 soil samples were collected from Namosi region. These samples were screened primarily for the detection of useful microbes. The target microbes for the bacteria leaching are iron oxidative bacteria and sulphur oxidative bacteria and for the biological mine wastewater treatment are iron oxidative bacteria, sulphate reductive bacteria, heavy-metal tolerant filamentous fungi and yeast. The samples of time are cultivated under some conditions of culture media. As a result, some microbes were detected, which may possess

the function similar to sulphur oxidative bacteria, iron oxidative bacteria, heavy-metal tolerant filamentous fungi and yeast. Further examination is necessary to confirm whether these microbes can be applicable to the bacteria leaching and the mine wastewater treatment. However, this suggests the potential of microbes applicable to the bacteria leaching and the mine wastewater treatment.

5 - 5 Archaeological survey

As a result of archaeological survey, it has been clarified that 213 cases of historical relics or cultural assets are distributed in the survey area. These are the settlement ruins that are so-called early Lapita (earlist human settlement ruins before approximately 3000 years), the late prehistorical sites (before approximately 1000 years) and the late historical sites. The principal ruins are ring structure and fortress ruins that are called Ring dintch and Hill fort and village and settlement ruins that are called Koromakawa, Naga and Yavu. Many of the ruins are distributed in the plains, the valleys and the adjacent hills such as Sigatoka, Keiyasi, Suva and Nausori.

This survey covers almost information about the existences of the principal known historical relics or cultural assets, but the detailed investigation for the archaeological cultural heritage is not satisfied. Archaeological Impact Assessment (AIA) will be necessary for the future development.

Chapter 6 Conclusion and proposal

6 - 1 Conclusion

This survey, which is a 1st phase of the environmaental baseline survey, consists of hydrological survey, stream sediment survey, fauna and flora suvey, soil bacteria survey and archaeological survey in the Viti Levu South area of the Republic of the Fiji Islands. The climate of the survey area is divided to 2 seasons; dry season from May to October and rainy season from November to April. The 1st phase survey was executed from September - November 2002 (dry season). As for the hydrological survey, the field suvey was executed from January to February 2003 (rainy season) to get data of rainy season.

As for hydrological survey, field measurement of water flow, field measurement of water quality and water quality analysis were executed at the 80 points (88 samples) from 4 drainage systems: Rewa River, Navua River, Sigatoka River and the Coastal Rivers. The summarized feature of the river water quality is as follows. All 4 rivers drainage systems are characterized by dominant HCO_3 ion. Navua River drainage system and Sigatoka River drainage system are characterized by dominant Ca ion. Sigatoka River drainage system is characterized by high values in Ca and HCO_3 ion concentration, pH and electric conductivity in comparison with Rewa River drainage system. The cause, by which the water of Sigatoka River drainage system shows high concentration of Ca and HCO_3 ion, is due to influence of sedimentary rocks such as limestones, which exist inside this drainage system.

Although some component concentrations and component ratios somewhat differ inside the survey area, the general character of the river water of the survey area shows neutral pH, Ca as principal cation and HCO_3 as principal anion. The water, which has the quality of this kind of alkaline earths carbonate, is thought to be circulating free groundwater. Because Fiji Islands belongs to the climate of tropical rain forest, the air temperature is high and the precipitation is much, the peculiar characteristic condition had been expected. However 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.

One weather station was set up inside the Namosi village elementary school to establish the weather observation system. In addition, meteorological data of the past 4 years, which had been observed at 6 points inside the survey area, were acquired from Fiji Meteorological Service, Nadi. This data are used as a database for the future hydrological survey.

In the stream sediment survey, total 905 samples (822 points + 83 duplicate samples) were chemically analyzed. As for geochemical characteristic of the stream sediments of each drainage system, Rewa River drainage system is the most strongly influenced by hydrothermal deposits and Cu, Zn, As, Cd, Sb and Au show anomalies. Navua River drainage system is also influenced by hydrothermal deposits after Rewa River drainage system and Zn, Cd, Sb and Au show anomallies. Sigatoka River drainage system is influenced by sedimentary rocks such as limestones and Ca and Mg show higher values than those of other drainage systems, though they are the crustal average levels. In Sigatoka River drainage system, Cd and Sb also show high values similarly to other drainage systems. As for Coastal rivers system, Mg, P, K, Ni, Sr and Ba show lower values than those of other drainage systems.

In all drainage systems, Cd, Sb and Au show especially high values in comparison with the

crustal average. The anomalies of Cd and Sb are scattered in all the survey area, therefore it is suggested that the background value itself is high and also the contents of these elements in igneous rocks nearby is high. On the other hand, Au shows more limited distribution of anomalies, such as Namosi region · upper stream of Waimanu river in Rewa River drainage system and Wainikovu River in Navua River drainage system, where exist influence of hydrothermal deposits. As (arsenic) anomly distribution is similar to that of Au. In all drainage systems, Be, Na, Al, P, K, Ni, Sr, Ba, Hg and Pb show lower values than the crustal average, especially P, K, Ni, Sr and Ba are low.

Fauna and flora survey consists of fauna survey, sampling and chemical analysis of fishes & benthos, flora survey and vegetation distribution survey. Fauna of the survey area consists of total 84 species of animals, which are mainly comosed of Birds. In the field survey of the tropical rain forest, 34 species of birds including Pink-billed parrotfinch were recognized, which is worldwide rare species. The area is almost not disturbed as to biodiversity of birds. As for Reptile, *Emoia mokosariniveikau* that is a family of Skink, which had been detected only in Vanua Levu Island, was recognized.

Flora of the survey area is divided characteristically to 8 ecosystems according to the topography & the climate. The most widely distributed ecosystem is Lowland rain forest (tropical rain forest). Upland rain forest and Cloud forest wich should be protected are distributed in the inland ravine area. Coastal vegetation is widely distributed along the coastal line and Grassland vegetation is widely distributed in Sigatoka area.

Total 81 of rare and endangered species of vascular bundle plant are distributed in the Viti Levu South Area that hosts the tropical rain forest. In the field survey of the tropical rain forest, almost 100% (173 species) of the plants are indigenous species and 60% among them (104 species) are endemic species. The ratio of endemic species is high. 9 rare and endangered species such as *Agathis macrophylla* · dakua or epiphytic orchid are distributed in the area. The area is rich in the biodiversity of plants.

The vegetation distribution, which is based on the pseudo color image of the ASTER optical sensor, is well concordant with the floras, which are verified in the ground truth survey. From interpretation of the ASTER images, it has been found out that the flora in the survey area is divided largely to 5 floras.

As for the survey regarding fishes & benthos, 26 samples of the typical eel and shellfishes (corbicula) were sampled and chemically analysed. Among the trace elements, As (arsenic) value of the fishes, As (arsenic) and Cd (cadmium) values of the shellfish are relatively high.

In the soil bacteria survey, 5 soil samples were collected from Namosi region. These samples were screened primarily for the detection of useful microbes. Microbes, which may possess the function similar to sulphur oxidative bacteria, iron oxidative bacteria, heavy-metal tolerant filamentous fungi and yeast, were detected in the sample of this suvey. This suggests the potential of microbes applicable to bacteria leaching and mine wastewater treatment.

As a result of archaeological survey, it has been clarified that 213 cases of historical relics or cultural assets are distributed in the survey area. These are the settlement ruins that are so-called early Lapita (earlist human settlement ruins before approximately 3000 years), the late prehistorical sites (before approximately 1000 years) and the late historical sites. The principal

ruins are ring structure and fortress ruins that are called Ring dintch and Hill fort and village and settlement ruins that are called Koromakawa, Naga and Yavu. Many of the ruins are distributed in the plains, the valleys and the adjacent hills such as Sigatoka, Keiyasi, Suva and Nausori.

The central to south side of the Viti Levu South area breeds the well-developed tropical rain forest and the biodiversified Birds. Croplands and pastures are distributed along the Queens Road, the plain along Rewa River between Suva - Nausori - Vunidawa and relatively cultivated hill and plain along Sigatoka to Keiyasi. Village and urban district are developing in these areas. In the meanwhile, the environment load, for example the deforestation accompanied with inhabitant life improvement, the household wastewater and the wastes of chemical substances such as battery etc, is estimated to increase along each river draingae system where human activities widely influences. It is important to collect and arrange the environmental basic data in the early stage because the legal regulation as to the environment of the Republic of the Fiji Islands has just been prepared recently. A great deal of data, which were acquired from this survey, are concluded to be useful for the environmental assessment for the future industrial developments.

6 - 2 Proposal for the 2nd phase survey

The following items of 2nd phase survey are proposed based on the results of 1st phase survey. The objective of the survey is to collect and integrate the background data concerning the natural environment fields and to make the report of Environmental Baseline Study that will serve the basic data for the future industrial development.

(1) Stream sediment survey

The stream sediment survey in the same way as the 1st phase is proposed for 2nd phase in the upper stream of each drainage system, especially in the upperstream of Rewa River such as Sovi Basin, Waidina River and Waimanu River and the upperstream of Navua River where the 1st phase survey has missed. In addition, various types of rocks, which represent geological basements, should be chemically analyzed for comparison and examination with the analysis data of the stream sediment samples.

(2) Synthetical analysis

It is desired to samle and to analyze the river water, the stream sediment, the soil, the rock and the animal at the same point in order to analyze synthetically the data of the 1st phase survey (water quality analysis, stream sediment analysis, fishes and shellfishes analysis). The verification of mutual comparison and examination and reappearance of the analysis data is necessary.

As for hydrological survey of the 1st phase, analysis of the data is based only on the data of dry season. In addition, synthetical analysis of the river water that considers seasonal variation is desired in addition to the annual meteorological data.

Part II Detailed Descriptions

Part II Detailed descriptions

Chapter 1 Hydrological survey

1 - 1 Objectives

The purpose of this survey is to acquire data that clarify relationship of behavior of the surface and underground water to topographic and geological structure by mean of field survey of distribution of current, water quantity, water quality and seasonal change of flow rate of main rivers and streams in the survey area.

In addition, a weather observation station was installed in the survey area, and meteorological data was acquired continuously.

1 - 2 Survey methods

1 - 2 - 1 Periods of the survey

Climate of the survey area is oceanic tropical weather. It is dry season (winter) from May to October, rainy season (summer) from November to April. As flow rate and water quality of rivers is strongly affected by precipitation or rainfall, we have carry out totally two times of field survey in dry season and rainy season. Period of field survey (on site measurement and sampling) is as follows;

Dry season	: 20th/Sept./2002 – 24th/Oct./2002	1 time
Rainy season	: 20th/Jan./ 2003 – 1st/Feb./2003	1 time

1 - 2 - 2 Point of the survey

River system in the survey area is consisted of the following 4 systems;

Rewa river system

Navua river system

Sigatoka river system

Coastal river system

First three river systems have source in the central mountain region of Viti Levu Island. Small rivers in coastal river system are located within approximately 10 km from the coastal line.

Though it is thought that survey should be carried out at each sampling points which represents a small catchments area, as a reason of restriction of amount of survey, main rivers, streams and creaks which have various catchments areas were selected in this survey.

The field survey were carried out at

37 points in the Rewa river system,

15 points in the Navua river system,

19 points in the Sigatoka river system,

9 points in the coastal rivers system.

In total 88 samples ware taken from 80points as duplication samples were taken at 8 points. The survey points of dry season and rainy season are identical positions. Location of the survey points is shown in Fig.II-1-1.

1 - 2 - 3 Field measurements and sampling methods

(1) Measurement of the river flow

Measuring points were selected so that without obstacles in the riverbed, far from the rivers bend and with laminar flow. Depth and flow velocity of river were measured alternately at each points that divide river width equally into 10 or 12 blocks. In the case that depth of river is shallow than 50 cm, measurement of flow rate was carried out at 1 depth. In the case that the depth of river is 50cm or more, that is carried out at 2 depths.

Propeller type current meters (Hiroi electric type, Sanei Sokryouki Ltd.) were used for measurement of water flow, measuring tapes were used for measurement of river width, level rods were used for measurement of the depth of river water. In the case that we could not walk into water because the river is deep or quick, small wooden boats were used for the survey. River flow rate was calculated by adding up flow rates of each block after multiplying flow velocity by area of each block.

(2) Field measuring method for water quality

Water temperature, pH, electric conductivity, turbidity and DO were measured with the multifunctional measurement equipment at every sampling point in the field. Measurements were started after value of indicator has been stabilized by soaking a probe of the equipment into water at the center of rivers. Specification of measurement equipment is as follows;

Measurement equipment type : TOA(WQC- 22 A, water quality checker)
Temperature : platinum resistance temperature sensor system
Dissolved oxygen: diaphragm shape galvanic electric battery system
pH : glass electrode system
Electric conductivity : 4 electrode systems
Turbidity : 90 degree scattered light measurement system
(using intermittent light by infrared LED)

(3) Sampling and pretreatment

Method of sampling and pretreatment of river water is as bellows;

At first, 1 liter of river water was dipped up into 1 liter cup from the center of river, and it was divided into 5 sample containers; 125ml x 2 bottles and 250ml x 3 bottles. Containers were plugged up after filling up the bottle so that the water reached till mouse of bottle to avoid mixing of air. As pretreatment, for samples for analysis of metal elements, sampled water was filtered with the filter of 0.22microns and acidified with nitric acid. For samples for analysis of NH_3, T-Pand and COD, sampled water was acidified with sulfuric acid. For samples for analysis of T-CN, NaOH was added to sampled water. For samples for analysis of sulfide, zinc acetate + NaOH was added to sampled water.

(4) Field record

Photographs were taken with the digital camera in the foreground and the distance so that they include sampling points.

(5) Analysis item and analysis method

In a chemical laboratory, water samples were analyzed. Items, method and precision of analysis are shown in Table II-1-1. B, Ag, Ba, Mo, $N(NO_2)$, $N(NO_2)$and Sb that are stated in ADWG (Australian drinking water guideline) in addition to 23 elements which are stated in the specification.

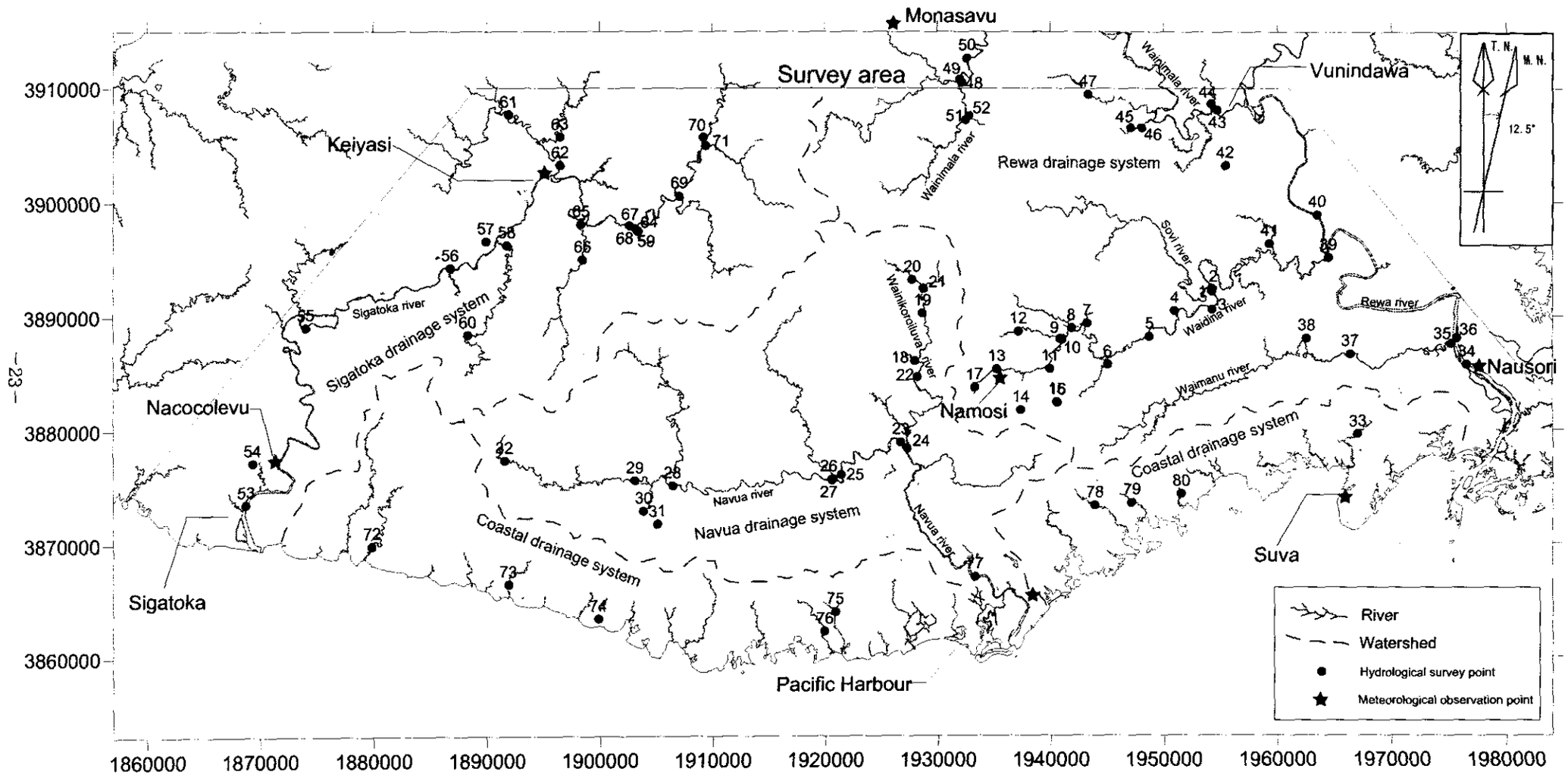


Fig.II-1-1 Sampling location of the surface water samples (1:500,000)

Table II-1-1 Chemical analysis method and limit of reporting

ANALYTE	UNIT	METHOD/REFERENCE	LIMIT OF REPORTING
pH Value		4500H	0.01
Electrical Conductivity @ 25'c	uS/cm	2510B	1
Total Dissolved Solids (TDS)	mg/L	Calculation from E.C.	1
Total Hardness as CaCO3	mg/L	Calc.,2340B	1
Calcium - Filtered	mg/L	ICPAES	1
Magnesium - Filtered	mg/L	ICPAES	1
Sodium - Filtered	mg/L	ICPAES	1
Potassium - Filtered	mg/L	ICPAES	1
Carbonate as CaCO3	mg/L	2320B	1
Bicarbonate as CaCO3	mg/L	2320B	1
Sulphate - Filtered	mg/L	ICPAES	1
Chloride	mg/L	4500CIB	1
Boron - Filtered	mg/L	ICPAES	0.1
Iron - Total	mg/L	ICPAES	0.01
Selenium - Total	mg/L	ICPAES	0.01
Silver - Total	mg/L	ICPMS	0.001
Aluminium - Total	mg/L	ICPMS	0.01
Arsenic - Total	mg/L	ICPMS	0.001
Barium - Total	mg/L	ICPMS	0.001
Chromium - Total	mg/L	ICPMS	0.001
Copper - Total	mg/L	ICPMS	0.001
Manganese - Total	mg/L	ICPMS	0.001
Molybdenum - Total	mg/L	ICPMS	0.001
Nickel - Total	mg/L	ICPMS	0.001
Lead - Total	mg/L	ICPMS	0.001
Antimony - Total	mg/L	ICPMS	0.001
Zinc - Total	mg/L	ICPMS	0.001
Mercury - Total	mg/L	FIMS	0.0001
Total Cyanide	mg/L	4500CN C&N	0.001
Fluoride	mg/L	4500 FC	0.1
Ammonia as N	mg/L	4500 NH3-H	0.01
Nitrite as N	mg/L	4500 NO3 I	0.01
Nitrate as N	mg/L	4500 NO3 I	0.01
Phosphorus as P - Total	mg/L	4500 P H	0.01
Sulphide	mg/L	4500 S2-D	0.1
Chemical Oxygen Demand	mg/L	5220B	1

1 - 3 Result of the survey

Althogh, in total 2 times of hydrological surveys were carried out in dry season and rainy season, only results of survey in dry season were reported here because indoor analyses for the rainy seson have not yet completed at this stage.

Results of analysis using both data from the dry season and the rainy season will be shown in a report of the second year, however results of field measurement and chemical analysis of dissolved composition for rainy season samples are shown in Appendix 13.

1 - 3 - 1 Measurement of the river flow

There are three main river systems and small river systems in the survey area. They are limitted by the central watershed extending from northeast to southwest.

Rewa River and Navua River flow on the southeastern side of the watershed and Sigatoka River flows in the northwest to west side. Navua River and tributaries of Rewa River are flow on the central ravine area from west to east and finally they flow in the Pacific Ocean after changing their courses toward the south. Many small rivers that flow from north to south are distributed along the southern coast that is south border of this study (please refer Fig. II-1-1).

Measurement of flow rate was executed at 80 points selected beforehand from rivers and creaks that are distributed in the survey area. The flow rates of the rivers are in wide range on acount of variety of measuring point from a small branch to estuary of a main stream. The smallest river flow was 0.03 m^3/sec at point 45 while the largest river flow was 339 m^3/sec at point 34. In addition, the river that received the influence of the tide was appeared. For exsample, it could not avoid to take a sample such as point 35 and 36 of the Rewa River estuary and 53 of the Sigatoka River estuary while having flowed backward (please refer Table II-1-2). Date of rever flow will be used for interpretation of water composition and analysis of hydrologic balance considering seasonal effects between rainy season and dry season.

1 - 3 - 2 Examination of the rivers water quality

Measurements of river water quality were carried out for 88 samples (including 8 duplicated samples) at 80 points selected beforehand from rivers and creaks that are distributed in the survey area, and the same measurements were carried out for a spring water and a hot spring water from the survey area.

In each sampling point, temperature of atmosphere and pH, temperature, electric conductivity, dissolved oxygen and turbidity of river water were measured. The chemical components in accordance with the ADWG (Australian drinking water guideline) were analyzed at ALS Environments Co. in Austraria. Results of on site measurement of river water and chemical analyses of dissolved composition were shown in Appendix 1, and statistical data for every river systems were shown in Appendix 2.

(1) Characteristic of river water quality

1) Characteristic of physical description of river water

Water temperature:

The rivers water temperature showed the lowest value of 21.3℃ and the highest value of 30.6℃. The average of the whole survey points was 24.4℃ and is approximately 2℃ lower than atomospheriv temperature (26.3℃). There is not difference of water temperature among river systems.

Turbidity

River waters were almost crystal-clear. The turbidity showed the lowest value of 0mg/l and the highest value of 28 mg/l at point 25 in an upper reache of Navua River. There is not difference of turbidity of water among river systems.

Electric conductivity

Electric conductivity of the river water showed the lowest value of 3.5 mS/m at point 17 in an upper reache of Rewa River, the highest value of 40.7 mS/m at point 56 in the middle reaches of Sigatoka River and the mean of 13.1 mS/m excluding the river waters which are thought that the seawater has mixed and the hot spring water. There was such a tendency that electric conductivity differs depending on water system. For exsample, sveragr of electric conductivity was 8.44 mS/m in Rewa River System, and it was 25.6 mS/m in Sigatoka River system.

2) Characteristic of compositon and composition ratio of dissolved components

pH

pH showed the minimum of 6.39 at point 42 of spring water in Rewa River, the maximum of 8.44 at point 64 and the mean of 7.72. These river waters indicate variation from weak acidity, neutrality to weak alkaline. There was a tendency where pH differs depending on water system, for exsample, pH 7.5 in Rewa River system and pH 8.11 in Sigatoka River system.

DO

DO showed the minimum of 4.78 mg/l at point 78 of coastal river, the maximum of 15.4 mg/l at point 33 in a lower reache of Rewa River system and average of 10.8 mg/l. Difference between water system was not found.

COD

COD showed the minimum of 0.5 mg/l at point 11 of Rewa River system, the maximum of 51.0 mg/l at point 48 of a upper reache of Rewa River system and average of 8.2 mg/l. COD of Rewa River water system were 10.3mg/l, while COD of Sigatoka River system and Navua River system were 7.5 mg/l and 3.9mg/l respectively.

Hardness

Hardness showed wide range of value with the minimumu of 11 mg/l at point 4 in Rewa River

system, the maximum of 153 mg/l at point 56 in Sigatoka River system, excluding point 52 where river water seems to be mixed with seawater and point 64 that is hot spring water. Average values in each separated river system were 25.2 mg/l for Rewa River system, highest value 84.6 mg/l for Sigatoka River system and 45.4 mg/l for Nnavua River system.

Examination of the major dissoluved composition

Water quality of the river water of survey area was examinated with Stiff diagram and piper plotting. Stiff diagram shows chemical constitution of water on 1 graph indicating quantity of dissolved components (cation and anion in meq/l) on horizontal 3 axes lying on the both side of center axis. This diagram has the advantage of being possible to compare the water quality of many places by the shape of diagram showing the absolute quantity of each component. Stiff diagrams for river waters were shown in Fig. II-1-2.

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 Navua River and 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 and the Coastal rivers. Grasping 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. The total concentration of the Waidina River is lowest in the Rewa River system.

Pipper plot shows cations (Na+K, Ca, Mg) and anions (HCO_3+CO_3, SO_4, Cl) in meq/l and expresses the ratio of the individual component. Piper plots of river water composition are shown in Fig. II-1-3. Characteristics of river water can be grasped from the plotted position of sample in pipper plot. Generally, territory of plotted position is devided into the following categories.

I: Non carbonate hardness territory

This is not common in the underground water.

II: Carbonte hardness territory

In this territory water is abundant in $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$. Sample plotted in this territory is mainly of free water, and is the underground water of circulating supply type. Unfined water is also plotted in this region, but it has tendency to spread out III territory.

III: Carbonate alkali territory

In this territory water is abundant in Na_2CO_3 and K_2CO_3. Unfined water is plotted in this territory. As unfined water is of stagnation, points plotted in this territory show water quarity of stagnation characteristic.

IV: Non carbonate alkali territory

In this territory water is rich in chloride and sulfate as mixed with seawater or fossil seawater.

As for the anion of river water in this survey area, HCO_3 is higher than (Cl+SO_4) at almost all points. Navua River system and the Sigatoka River system are higher in HCO_3 than the Rewa River system. As for the cation, (Ca+Mg) is higher than (Na+K) in the Navua River system and the Sigatoka River system while (Na+K) is high than (Ca+Mg) in parts of Rewa River system.

Generally, all 4 river systems in the survey area belong to II Carbonte Hardness territory, and are a circulating characteristic supply type surface water of the unconfined groundwater.

(2) Characteristic of minor components of river water

Fe, Al, Ba, Cu, Mn, Ni and Zn were detected at all surveyed points. Cumulative probability plots for them were drawn as shown in Fig. II-1-4. Threshold values from critical point were analyzed and the concentration maps were drawn as shown in Fig. II-1-5.

Detection and abnormal value of each minor component and comparison with ADWG (Australian drinking water guideline) are mentioned below.

1) Components undetected

B, Mo, Sb, Hg and Sulphide were not detected at any points.

2) Components detected at some points

Se

Results of Se were above the lower limit of reporting (LOR) 0.01 mg/l at 6 points (11, 13, 35, 36, 37 and 38) in the Rewa River system, at 1 point (28) in the Navua River system and at 9 points (54, 55, 58, 59, 60, 61, 65,69 and 70) in the Sigatoka River system. All of them are above control limit by ADWG (0.01 mg/l Se).

Ag

Results of Ag were above the LOR (0.001 mg/l Ag) at 4 points (14, 39, 40 and 51) in the Rewa River system, and all of them are below control limit by ADWG (1 mg/l Ag).

As

Results of As were above the LOR (0.001 mg/l As) at 1 point (8) in the Rewa River system and at 5 points (19, 23,24, 26 and 30) in the Navua River system, and all of them are below ADWG (0.007 mg/l As).

Cr

Results of Cr were above the LOR (0.001 mg/l Cr) at 4 points (34, 35, 36 and 38) in the Rewa River system and at 6 points (61, 62, 63, 69, 70 and71) in the Sigatoka River system, and all of them are below ADWG (0.05 mg/l Cr).

Pb

Results of Pb were above the LOR (0.001 mg/l Pb) at 2 points (14 and 15) in the Rewa River system, are 0.04 and 0.231 mg/l respectively that are above ADWG (0.01 mg/l Pb).

CN

Results of CN were above the LOR (0.001 mg/l CN) at 2 points (7 and 51) in the Rewa River system and at 2 points (75 and 76) in the coastal rivers, and both are below ADWG (0.08 mg/l CN).

F

Results of F were above the LOR (0.1 mg/l F) at 7 points (54, 55, 57, 58, 60, 68 and 72) in the Sigatoka River system, and all of them are below ADWG (1.5 mg/l F).

3) Components detected in the whole area

Fe

Fe was detected widely int the survey area, while it was below the LOR (0.01 mg/l Fe) at some points. The highest value was 0.58 mg/l Fe at point 41 in Rewa River system and the mean was 0.055 mg/l Fe. There are 2 points (41, 25) where Fe was above ADWG (0.3 mg/l Fe). For a threshold value designated as 0.2 mg/l, the points that show abnormal value were recognized in the Rewa River system (points 17 and 41), the Navua River system (point 25) and a Caostal river (point 73).

Al

For a threshold value designated as 0.1 mg/l Al, the points that show abnormal value were recognized in the Rewa River system (points 11, 17 and 41), the Navua River system (point 24, 25 and 27) and the Coastal rivers (point 75). There are 3 points (24, 25 and 41) where Al was above ADWG (0.2 mg/l Al).

Ba

Ba was detected widely int the survey area, while it was below the LOR (0.001 mg/l Ba) at some points. The highest value was 0.014mg/l Ba and the mean was 0.003 mg/l Ba. For a threshold value designated as 0.008 mg/l Ba, the points that show abnormal value were recognized only in the Rewa River system (points 6, 15, 16, 17, 37, 41, 42 and 53), however, all of them are below ADWG (0.7 mg/l Al).

Cu

Cu was detected widely int the survey area, while it was below the LOR (0.001 mg/l Cu) at some points. The highest value was 0.027mg/l Cu in Rewa River system (point 61) and the mean 0.002mg/l. For a threshold value designated as 0.004 mg/l Cu, the points that show abnormal value were recognized in the Rewa River system (points 9, 12, 37 and 41), the Sigatoka River system (points 59, 61, 68, 69 and 70) and a Coastal river (point 72), however, all of them are below ADWG (2 mg/l Cu).

Mn

Mn was detected widely int the survey area, while it was below the LOR (0.001 mg/l Mn) at some points. The highest value was 0.071 mg/l Mn and the mean 0.012 mg/l Mn. For a threshold value designated as 0.03 mg/l Mn, the points that show abnormal value were recognized in the Rewa River system (points 3 and 41), the Sigatoka River system (points 56, 57 and 58) and the Coastal rivers (points 72, 73 and 80), however, all of them are below ADWG (0.1 mg/l Mn).

Ni

Ni was detected widely int the survey area, while it was below the LOR (0.001 mg/l Ni) at some points. The highest value was 0.027 mg/l Ni in Rewa River system (point 44) and the mean was 0.0025 mg/l Ni. For a threshold value designated as 0.008 mg/l Ni, the points that show abnormal value were recognized in the Rewa River system (points 36, 44 and 51), the Navua River system (point 19) and the Coastal river (points 73 and 74). There are 2 points (44 and 51)

where Ni was slightly above ADWG (0.02 mg/l Al).

Zn

Zn was detected widely int the survey area, while it was below the LOR (0.001 mg/l Zn) at some points. The highest value was 0.106 mg/l Zn in the Rewa River system (point 41) and the mean was 0.007 mg/l Zn. For a threshold value designated as 0.004 mg/l Zn, the points that show abnormal value were recognized in the Rewa River system (points 7, 8, 9, 10, 11, 14, 17, 41 and 51), the Navua River system (points 20, 21, 25 and 30), and the Coastal rivers (points 72 and 74), however, all of them are below ADWG (3 mg/l Zn).

Duplication samples

The duplication samples were sampled at 8 points of 80 sampling points at random, and were analyzed by the same method as for regular samples. The result is shown in Table II-1-3. Good correlation can be seen between the regular samples and the duplication samples in most of all components.