

Preface

In response to the request of the Government of the Republic of the Fiji Islands, the Japanese Government has granted approval to conduct a Mineral Exploration Project (Environmental Baseline Study) in the Viti Levu South Area, and entrusted this survey by the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ, at present Japan Oil, Gas and Metals National Corporation).

The studies have been conducted from September 2002 to March 2004 and have been completed in cooperation with the Mineral Resources Department of the Ministry of Lands and Mineral Resources of the Government of the Republic of the Fiji Islands. This is the final report of the two years studies.

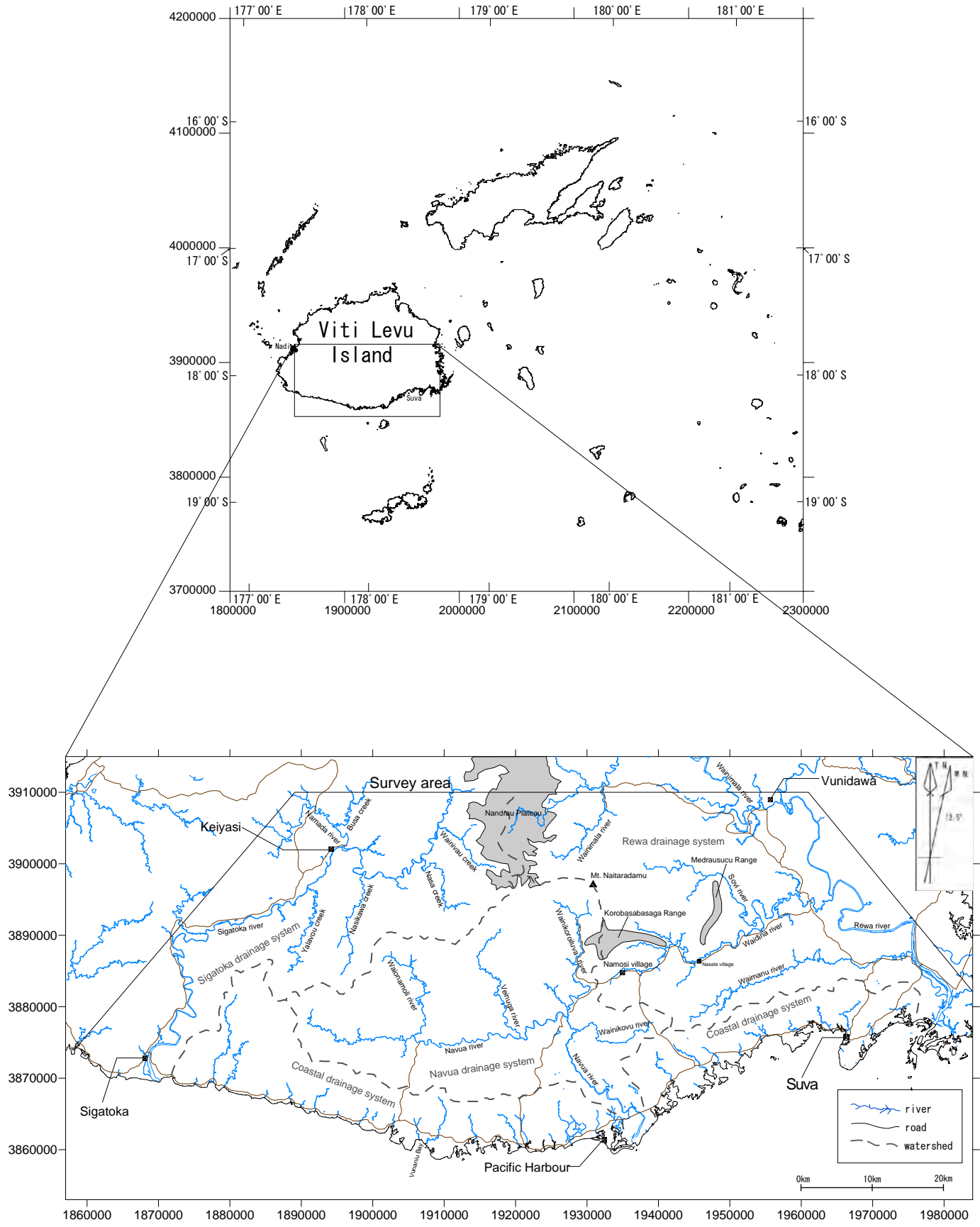
We hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

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

March 2004

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Location of the Viti Levu South Area

ABSTRACT

This report presents the result of the environmental baseline study in 2002 and 2003 fiscal years in the Viti Levu South Area of the Republic of the Fiji Islands. There is a large possibility that the environmental load of the area will increase owing to mining activities, loggings, and discharge of domestic waste and wastewater; therefore it has been necessary to acquire the environmental background data such as naturally transported elemental levels, and the present status of fauna and flora, and archeological sites in conformity with domestic environmental laws of Fiji. The outlines of the results are as follows.

a) Hydrological survey

The surface water quality study was programmed both during the dry season and the rainy season. The measurement of flow rate and water quality was conducted at 80 sites, and 186 samples were collected and analyzed chemically. Surface water in the area shows generally neutral pH, Ca rich among major cation, and HCO_3 rich among major anions. The compositions of major components are slightly different among drainage systems. Thus water in the Sigatoka River system contains relatively rich in Ca and HCO_3 . The high values could be influenced by the distribution of carbonate rocks. A weather station was installed in the Namosi village secondary school and two years' meteorological data was observed. The data were statistically compiled with the surrounding six stations data obtained by the Department Meteorology of Fiji government.

b) Stream sediment survey

Stream sediment samples were collected from 1717 locations and conducted multi-element chemical analyses of 1845 samples. The geochemical map revealed the outline of geochemical characteristic in the study area. The concentrations of major rock forming mineral constituents such as Al, Ca, K, Na, Mg and P were controlled by geological background. For example, the area rich in Ca, Na and Mg was dominated in the northwestern part, and in particular the middle reaches of Sigatoka River indicated high Ca and Mg where carbonate rocks are widely distributed. The Ba, Cr and V were also controlled by background geology; thereby the area of the Verata Group was specifically high in Cr. The elements including Ag, As, Au, Cd, Cu, Hg, Mo, Pb, S, Sb and Zn were generally accompanied by porphyry copper or hydrothermal mineralization. Among these, anomalies of Ag, As and Hg dispersed over the area. Au anomalies almost overlapped with the mineralized zone from Namosi area to the south. The Cu anomalies also widely spread over the Namosi area, and it is surrounded by the anomalies of Mo, Pb and Zn. A Mo anomaly was also detected to the east of the Wainaleka occurrence where a porphyry-type mineralization was known at Echo Creek.

c) Fauna and flora survey

A total of 84 species of vertebrates, mainly of birds, are known in the study area. During the fauna field study some 34 kinds of birds including a very rare species, the Pink-billed parrotfinch, was recognized. A family of skink, *Emoia mokosariniveikau* that had been known only in Vanua Levu Island was possibly recognized. The flora study revealed that the area was divided into eight forest types by the characteristics of the different topography and climate. The lowland rain forest predominates in the area, and the upland rain forest and the cloud forest were found in the inland. In the flora field study, nine rare and endangered species were observed. The ratio of endemic species was high, approximately 60%. A total of five eels and 21 freshwater clams were obtained and chemically analyzed after drying and pulverizing. The vegetation map was based on the pseudo color image of ASTER optical sensor, and it was verified by ground truthing.

d) Soil bacteria survey

A total of five soil samples were collected from the Namosi area and examined primarily screening of useful microbes for bacteria leaching and wastewater treatment. Sulfur oxidative bacteria, iron oxidative bacteria, and heavy-metal resistant filamentous fungi and yeast were detected in the samples. This suggests the possibility of the in situ microbes application for a bacteria leaching and a biological wastewater treatment.

e) Archaeological survey

A total of 213 historical relics and cultural assets in the area are mainly situated in the plains and valleys, and its also adjacent hills. They consist of the early Lapita sites (earliest ruins before approximately 3000 years) and the sites from late prehistory to fairly recent to current. The principal ruins are fortifications called ring ditch and hill fort, and the old village and settlement ruins called Koromakawa, Naga site or Yavu.

CONTENTS

Pages

Preface

Location of the Viti Levu South Area

Abstract

Chapter 1. Outline of the Environmental Baseline Study 1

 1.1. Study area and objective..... 1

 1.2. Content of study and schedule..... 1

Chapter 2. General information of the study area 4

 2.1. Location and access..... 4

 2.2. Topography and drainage system 4

 2.3. Climate and vegetation 4

 2.4. Geological outline and mineral occurrences 5

 2.5. Environmental regulations 7

Chapter 3. Result of the environmental baseline study 8

 3.1. Hydrological survey 8

 3.2. Stream sediment survey..... 18

 3.3. Fauna and flora survey 24

 3.4. Soil bacteria survey 35

 3.5. Archeological survey..... 38

Chapter 4. Conclusion and recommendation..... 41

 4.1. Conclusion..... 41

 4.2. Recommendation..... 43

Figures	Pages
Fig.1-2-1. Flow chart of the program	3
Fig.2-4-1. Geologic map and mineral occurrences in the Viti Levu South Area.....	6
Fig.3-1-1. Stiff diagrams of the surface water chemical compositions	10
Fig.3-1-2. Piper plot of the surface water chemical compositions	10
Fig.3-1-3. Geochemical map of the surface water (1)- (2).....	11
Fig.3-1-4. Quality of the surface water samples.....	15
Fig.3-1-5. Monthly precipitation in the Viti Levu South Area	17
Fig.3-2-1. Geochemical map of the stream sediments (1)- (2).....	19
Fig.3-2-2. PCA scores of the stream sediments.....	23
Fig.3-3-1. Satellite images and vegetation distribution.....	34
Fig.3-5-1. Location of the archaeological sites	40

Tables

Table 1-2-1. Contents of study	2
Table 2-3-1. Summary of the meteorological statistics in Suva, 2001	5
Table 3-1-1. Comparison with chemical composition and the values of guidelines	14
Table 3-2-1. Covariance and correlation coefficient matrices of the stream sediment samples	22
Table 3-3-1. Terrestrial vertebrates of south east Viti Levu (1)-(2).....	25
Table 3-3-2. Rare and endangered plants of the Viti Levu South Area	29
Table 3-3-3. Classification summary of the vascular plants identified in Waivaka South	30
Table 3-3-4. Origin and conservation status of Waivaka South	30
Table 3-3-5. Chemical composition of eels and fresh water clams (dried samples)	32
Table 3-3-6. Satellite images for interpretation.....	33
Table 3-3-7. Interpretation of vegetation.....	33
Table 3-3-8. Result of vegetation ground truth survey.....	33
Table 3-4-1. Characteristics of the soil samples for bacteria.....	35
Table 3-4-2. Types of the culture mediums for screening	35
Table 3-4-3. Condition of the culture mediums.....	35
Table 3-4-5. Result of screening sulfur-oxidizing bacteria	36
Table 3-4-6. Result of screening iron-oxidizing bacteria	36
Table 3-4-7. Result of screening heavy metal resistant filamentous fungi.....	37
Table 3-4-8. Result of screening heavy metal resistant yeast.....	37
Table 3-5-1. Summary of archaeological sites	39

Chapter 1. Outline of the Environmental Baseline Study

1.1. Study area and objective

The Government of the Republic of the Fiji Islands has attached importance to the Environmental Impact Assessment (EIA) with a view to the environmental preservation for mining activity, although they have positively promoted mining development. They aim at an acquisition of the environmental background data 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 Minutes of Meeting (M/M) were sealed between Japanese International Cooperative Agency (JICA), Metal Mining Agency of Japan (MMAJ, at present Japan Oil, Gas and Metals National Corporation) and Ministry of Land & Mineral Resource of the Republic of the Fiji Islands.

The objective of this two year's Environmental Baseline Study is to collect and to integrate the background data implemented in relation to the scheduling environmental law, concerning the environment in the Viti Levu South Area, where is expected to develop a new mine. In addition, another objective is to transfer the survey technique to the counterpart through the study.

The study area covers the southern parts of the Viti Levu Island and three large rivers including Rewa, Navua and Sigatoka rivers all flow from the central uplands into the Pacific Ocean. There is no active mine in the area, however large-scale porphyry copper deposits have been discovered in the central part of the area.

There is a large possibility that the environmental load of this area will increase owing to mining activities, in addition, loggings, and discharge of the domestic waste and wastewater. Therefore it has been necessary to acquire the environmental background data such as naturally transported elemental distributions and levels and also the data of the present status of fauna, flora and historical sites.

1.2. Content of study and schedule

This environmental baseline study consists of hydrological survey, stream sediment geochemistry, fauna and flora, soil bacteria, and archeological survey. At least three fieldworks were conducted during 2002-2003. The duration of fieldworks were as follows.

September 9, 2002 to December 14, 2002	(97days)
January 16, 2003 to February 8, 2003	(24 days)
September 4, 2003 to December 8, 2003	(96 days)

During the year 2002, the work was undertaken including hydrological survey, stream sediment geochemistry, fauna and flora, soil bacteria, and archeological survey. On rainy season in 2003, only hydrological survey was conducted in order to compare with the survey of the dry season. During the dry season in 2003, the stream sediment survey to inaccessible drainage and hydrological survey was carried out.

The content of study are shown in Table 1-2-1. The flow chart of the study process is shown in Fig. 1-2-1.

Table 1-2-1. Contents of study

(1). Content and quantity

Content	Quantity	
1. Hydrological Survey	Phase1 (2002-2003)	Phase 2 (2003)
Surface water quality , flow rate, sampling and chemical analyses	Dry season 80 sites, 88 samples Rainy season 80 sites, 88 samples	Dry season 10 sites, 10 samples (sampling and chemical analyses)
Weather observation	Setting of a weather station and observation	
2. Stream Sediment Survey	Phase1 (2002)	Phase 2 (2003)
Sampling and chemical analyses	822 sites, 905 samples	895 sites, 940 samples
3. Fauna and Flora Survey	1 area (Waivaka south area)	
Fauna and Flora study		
Sampling and chemical analyses	Eel: 5 samples Clams: 21 samples	
Vegetation distribution	Satellite image study, including ground truth	
4. Soil Bacteria Survey		
Sampling and screening	5 sites	
5. Archeological Survey		
Compilation	Whole area (4,000 km ²)	

(2). Laboratory work and quantity

Content	Quantity
1. Hydrological Survey	
Chemical analyses of water quality	
-Phase 1 (Total dissolved solid ,hardness ,COD ,Cl ,SO ₄ ,HCO ₃ ,CO ₃ , CN , N(NH ₃) , N(NO ₃) , N(NO ₂), Ag , Al , As , B , Ba , Ca , Cr , Cu , F , Fe ,Hg ,K , Mg ,Mn , Mo ,Na ,Ni ,P, Pb ,Se ,Sb ,Zn ,Sulfide)	176 samples
-Phase2 (As, Cd, Cr, Cu, Ni, Pb, Zn)	10 samples
2. Stream Sediment Survey	
Chemical analyses of geochemical samples	
(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)	1850 samples
3. Fauna and Flora Survey	
Chemical analyses of dried eels and dried clams	
(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)	26 samples
4. Soil Bacteria Survey	
Cultured bacteria (Sulfate-reducing bacteria , sulfur-oxidizing bacteria , iron-oxidizing bacteria ,heavy metal resistant filamentous fungi ,heavy metal resistant yeast)	5 sets

Environmental Baseline Study (the Viti Levu South Area)
4,000 km²

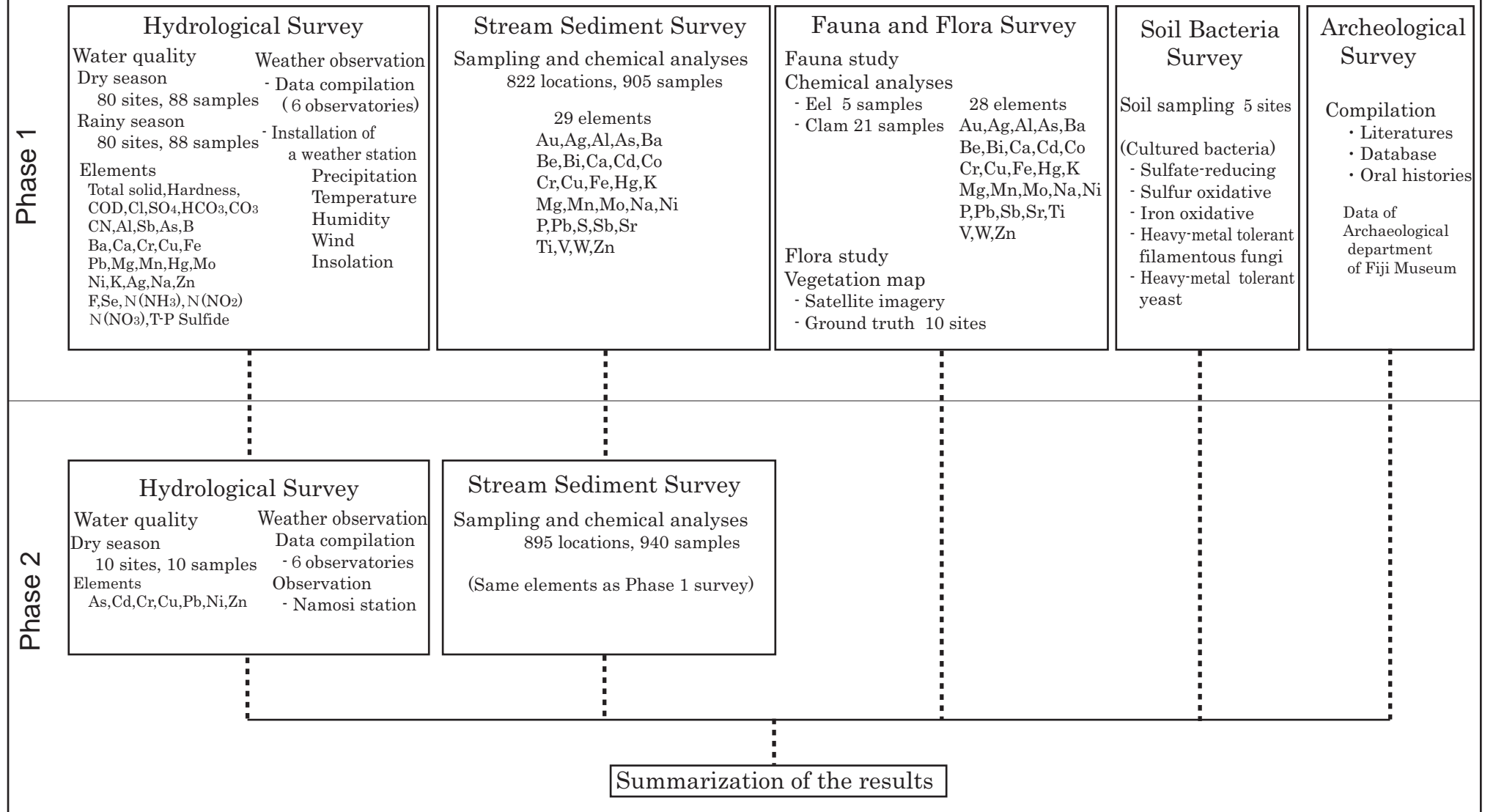


Fig. 1-2-1. Flow Chart of the program

Chapter 2. General information of the study area

2.1. Location and access

The Viti Levu South Area is located in the southern part of the Viti Levu Island within the range from 177°25' E to 178°30' E of longitude and from 17°45' S to 18°15' S of latitude, and within the range from 1858250mE to 1987650mE and from 3874000mN to 3910000mN in FMG (Fiji Map Grid). It covers the southern two fifth parts of the Viti Levu Island, approximately 4,000 km². Administratively, the area covers the Rewa Province, the Namosi Province, the Serua Province, the Tailevu Province, the Naitasiri Province and the Nandroga & Navosa Province.

The tropical rain forests predominate in the center and the southeast of the area, where biological diversity is well conserved, especially birds, while farmland extends widely into the large plains along Rewa River and Sigatoka River.

Suva City is the capital of Fiji, is located in the easternmost part of the area, and has a population of approximately 70,000. The Queen's Road is a completely paved road running through the south coastline in the Viti Levu Island that connects Suva City and several other main towns, such as Navua, Sigatoka, and Nadi. It takes 4 hours driving between Suva City and the Nadi international airport, and 1.5 hours between Suva City and Sigatoka by car along the Queen's Road. Other roads leads from the Queen's Road to the villages in mountains, but most of those roads are not paved and become often impassable during a rainy season. Many old logging roads are also described on topographic map, but almost all are impassable by car because of dilapidation.

2.2. Topography and drainage system

The area mainly consists of steep mountainous district and ranges in altitude from 0 to 1,000 meters above the sea level. The central uplands are composed of ranges and a plateau including the Nadrau Plateau with an altitude of more than 1,000 m is in the northern part of the survey area. Korobasabasaga Range (the highest peak is 1,147 m), Medrausucu Range (738 m) and Mt. Naitaradamu (1,152 m) show steep mountain ridges in the central part of the area and form watersheds that separate the main drainage basins.

The area can be divided into four large drainage basins: Rewa, Navua, Sigatoka and Coastal basins. The Rewa River in the east flows southward, and it forms of many small plains, dissected gentle hills and delta, while the Sigatoka River in the west of the area flows southwestward, and it forms a plain and dissected gentle hills. Hence the Navua River flows eastward, and then turns southward between the Rewa River and the Sigatoka River in the middle of the area. All of small coastal rivers in the south coast area run southward.

2.3. Climate and vegetation

The climate of the area is tropical marine and under influence of a southeast trade wind. The dry season is during May to October, and the rainy season falls in November through April. The southeastern side of the Viti Levu Island faces a southeast trade wind, and rainfalls are frequent all the year. The annual precipitation in Suva City is around 3,000 mm, and that in mountainous district reaches up to 6,000 mm. The monthly average precipitation around Suva City is 100 mm in a dry season, while 400 mm in a rainy season. Daily tropical showers are seen especially in the rainy season. Moreover the rainy season overlaps with a cyclone season;

therefore rarely this area has a record rainfall.

Suva City has a mild climate with the minimum temperature ranging from 21 to 24°C, and the maximum temperature ranging from 26 to 32°C. The mean daily temperature is approximately 26°C all the year, and relatively high humidity reaches 80 % (Table 2-3-1).

A tropical rain forest grows thick from the central to the southeast part of the area owing to a high precipitation through all the year. The core area of the tropical rain forest consists of a primeval forest of endemic species in particular.

The northwest to west of the area is located behind the central uplands from a southeast trade wind; the annual precipitation is less than 3,000 mm. The grassland after cultivation predominates over dissected hills, and forests and shrubs grow along rivers. Major croplands spread to plains and deltas formed by major rivers, especially Sigatoka River and Rewa River.

Table 2-3-1. Summary of the meteorological statistics in Suva, 2001

Items	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Rainfall (mm)	354	248	363	443	94	111	96	229	79	304	317	296	2935(mm) Total
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() Average
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() Average
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() Average
Mean Relative Humidity (%)	82	80	82	83	79	80	80	79	78	77	77	78	79.6(%) Average

2.4. Geological outline and mineral occurrences

The Republic of the Fiji Islands is composed of volcanic arcs after 65Ma and marine sedimentary basins developing nearby the arcs. The area consists of Cenozoic rocks after 40Ma. The basement is the Yavuna Group that crops out in the western part of the area. The Wainimala Group overlies the Yavuna Group. The Medrausucu Group overlies the Wainimala Group. While the Colo Plutonic Suite intruded into these rocks. The geologic map and mineral occurrences are shown in Fig.2-4-1.

- The Yavuna Group, probably of Late Eocene age, consists of basaltic pillow lava and related rocks, accompanied with gabbro and reef limestone.
- The Wainimala Group forms from Late Oligocene to Middle Miocene. The lower part of the Wainimala Group consists of volcanic breccias and volcanic conglomerates and the upper part consists of lutites, sandstones, limestones and volcanoclastic rocks. The rocks of Wainimala Group were covered unconformably by the rocks of the Medrausucu Group. The Savura Volcanic rock composed of andesite around Suva and the Sigatoka Group dominantly of sedimentary rocks in the northwest area, might be equivalent with the Wainimala Group.
- The Medrausucu Group, Middle Miocene to Pliocene age, is divided into the Namosi Andesite and the Korobasabasaga Pyroclastic Rocks in ascending order. The hornblende andesite in the Namosi Andesite gives the age 5.9Ma. The equivalent strata composed mainly of sedimentary rocks are distributed in the east and the west of the area. The Verata sedimentary rocks are distributed in the east and the Tuva Group and the Navosa Group are in the west of the area.
- The Ba volcanic rocks widely cover the north of the area.
- The Colo Plutonic Suite consist mainly of gabbro to tonalite accompanied by diorite and hornblende andesite in its margin. The ages range from 12.5 to about 8 or 7 Ma. Quartz diorite porphyry and

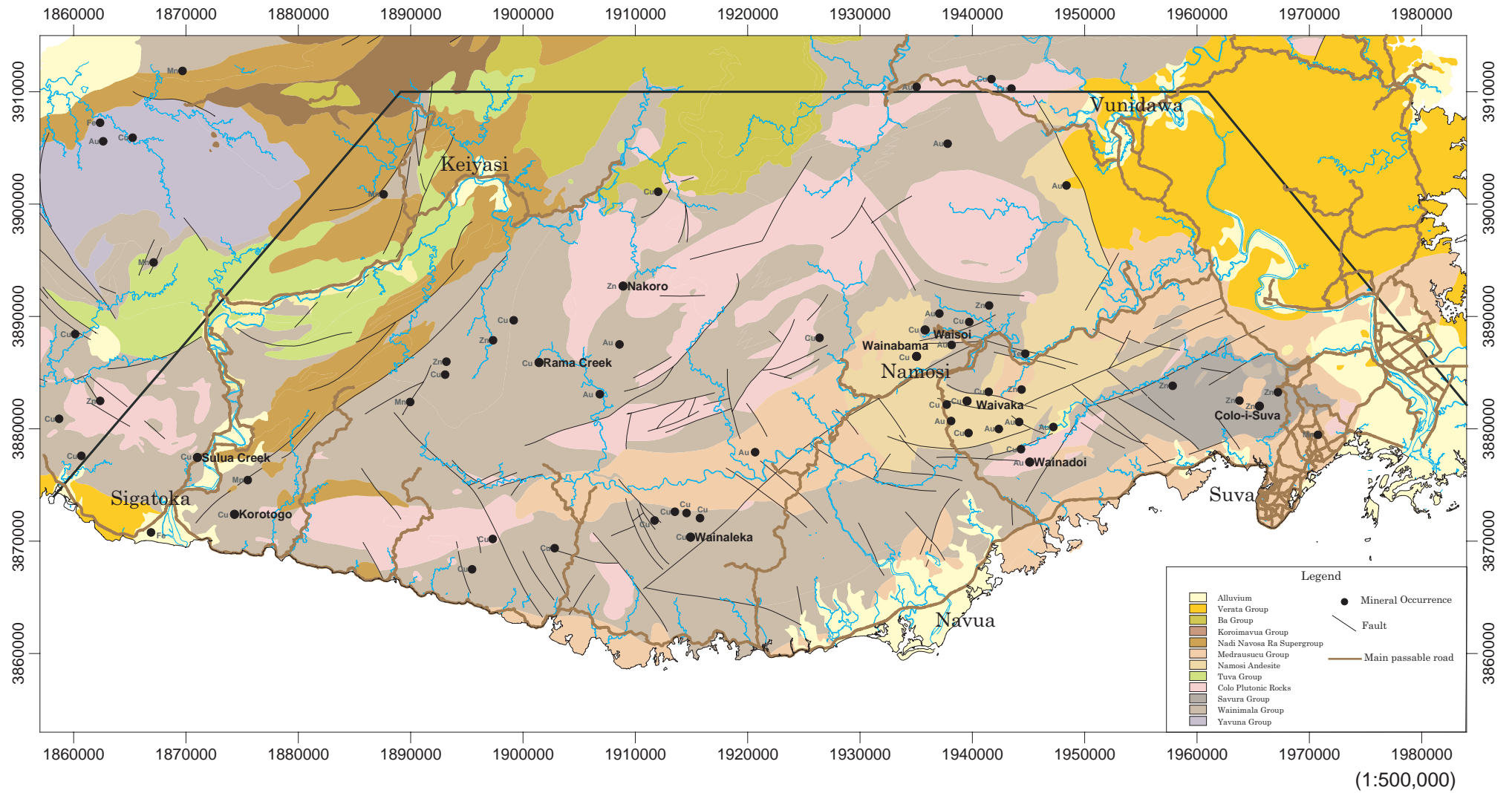


Fig.2-4-1. Geologic map and mineral occurrences in the Viti Levu South Area