Preface

In response to the request for the Government of the Republic of 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 the survey program and final report submission to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ, at present Japan Oil, Gas and Metals National Corporation).

A JICA and MMAJ official team was sent to the Republic of Fiji Islands to conduct the survey headed by Mr. Makoto Miyoshi from September 4th to December 8th, 2003.

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

We hope that this report will serve for the development of the project objectives and contribute to the promotion of friendly relationship 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 assistance and cooperation extended to the team.

March 2004

Tadashi IZAWA
Vice President
Japan International Cooperation Agency

Hidejiro OHSAWA
President
Japan Oil, Gas and Metal National Corporation

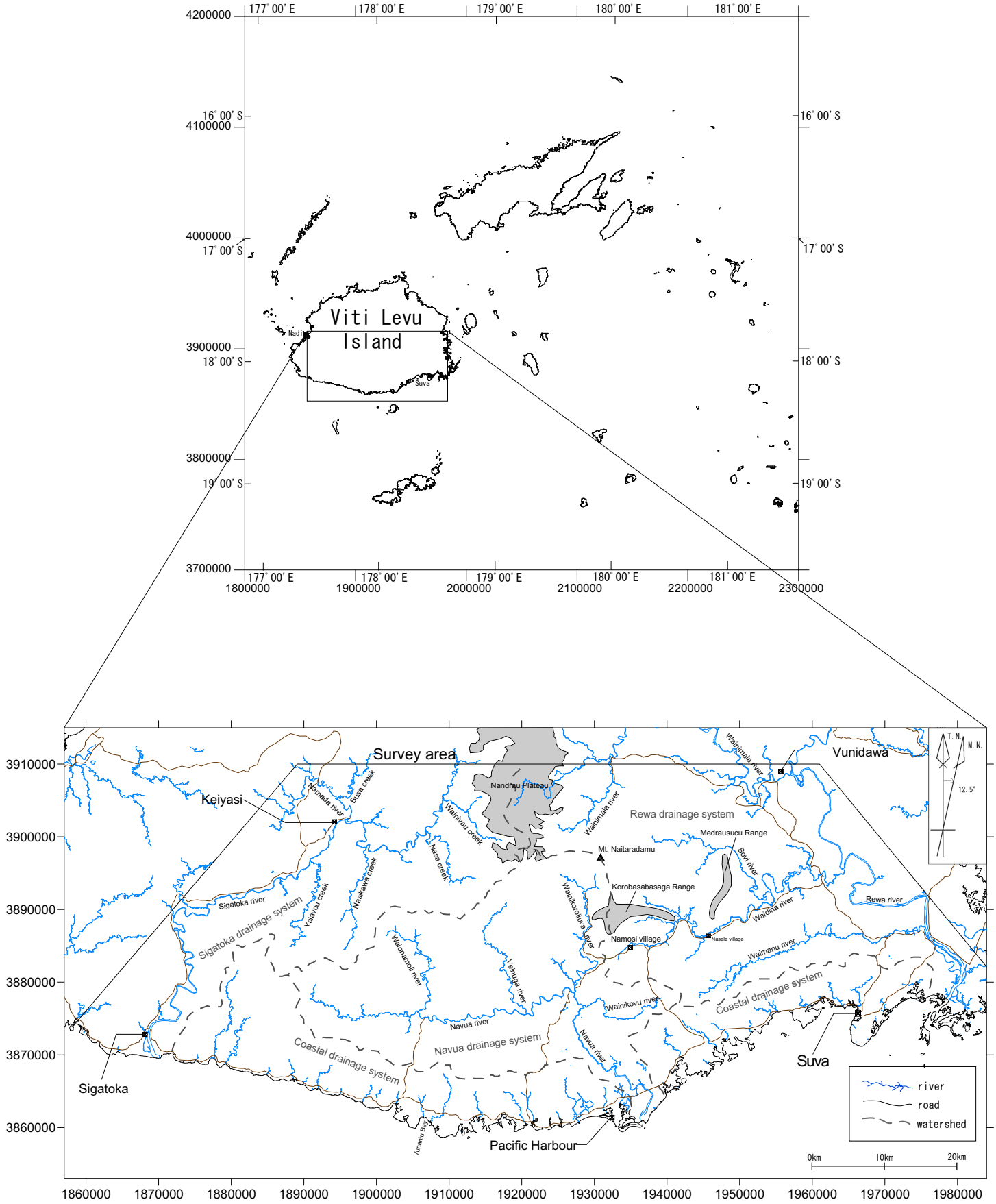

Fig. I-1-1 Location map of the survey area

Summary

This survey corresponds to the Phase II program (fiscal year 2003) 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 background data regarding the natural environmental field that conform to domestic environmental law of Fiji and to compile this data. This is based on an important point of view to grasp the background data of natural environment undisturbed by human activities, to evaluate for future effect of mining activities, deforestation, sewage and waste from human activities. This year's dispatch of the survey team was executed from September 4th to December 8th, 2003.

The survey area covers the southern 2/5 side of Viti Levu Island, the main island of the Republic of Fiji Islands. The area covers approximately 4,000km^2 and the range from east to west is approximately 71-129 km and from 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 quite rugged peculiar to volcanic islands. From the centre to southeastern side of the area, thick tropical rain forest is well developing and the biological diversity is abundant, such as birds. Meanwhile croplands and pastures are distributed along the Queens Road, the plains along the Rewa River catchment between Suva, Nausori and Vunidawa, and also there are relatively cultivated hills and plains along Sigatoka to Keiyasi. Village and urban district are developing in these areas.

There is no active metallic mineral mine in the survey area, however a giant porphyry type copper deposit has been located in the centre of the area. In addition, the small-scale gold mineral occurrences are known in the eastern part of the area, which are thought as epithermal gold deposits.

Stream sediment survey and hydrological survey were executed in the Phase II survey.

In the stream sediment survey, total 1845 samples (1717 points) were chemically analyzed for 29 chemical elements. Based on geochemical maps, geochemical characteristic of the stream sediments was grasped. The Ca, Mg and Na indicate high values in the northwest part of the area within the main rock forming elements such as Al, Ca, K, Na, Mg and P. Among them, Ca and Mg show specifically high values in the middle stream of the Sigatoka River, which is due to surrounding carbonate rocks such as limestone. While Ba, Cr and V reflect the background geology. The Cr shows specifically high value in distribution range of the Verata group on the eastern part of the area. In general, Ag, As, Au, Cd, Cu, Hg, Mo, Pb, S, Sb and Zn are associated with hydrothermal mineralization. Among them, high ranges of Ag, As and Hg are scattered in the area. The Au anomalies are concentrated on a large-scale mineralized zone in Namosi area, some Au mineral occurrences of the upper Waimanu River and Wainadoi River, and also small sized Au anomalies are scattered in throughout the area. The Cu values are specifically high around the large-scale mineralized zone in Namosi area, which is currently undergoing with exploration activities. The anomalies of Mo, Pb and Zn are surrounding the Cu anomalies. A small anomaly of Mo was detected at the eastern side of Wainaleka mineral occurrence that is known as a porphyry type deposit (Echo Creek).

As for the hydrological survey in during the Phase I, field measurement including water flow, field measurement of water quality and water quality analysis were executed at the 80 points from 4 drainage systems in the Rewa River, the Navua River, the Sigatoka River and the Coastal Rivers during the dry and rainy season. The water analysis of the Sigatoka River drainage system shows higher Ca and HCO_3 concentration in comparison with the other three drainage

systems. This is due to influence of sedimentary rocks such as limestone, which exist inside this drainage system area in particular. The general character of the river water in the survey area shows the tendency, almost similar quality to the average river water of the world, which shows neutral pH, Ca as principal cation, HCO_3 as principal anion. The value of electric conductivity and major dissolved compositions in rainy season are lower than those in dry season. This means that major dissolved compositions were diluted by river water derived from high precipitation in rainy season. While, trace elements of Al, As, Cr and Zn in rainy season are higher than those in dry season.

One weather station was set up inside the Namosi Secondary School. In addition, meteorological data of the past 1 year was acquired from Fiji Meteorological Service, Nadi.

Through this survey for two years, a large amount of data including hydrology, meteorology, stream sediment geochemistry, flora and fauna, soil bacteria and archaeology were collected. These basic data will be useful for environmental assessment of future industrial development in this area.

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Part I General Remarks

Chapter 1 Introduction

1 - 1 Background of the survey

The Government of the Republic of Fiji Islands has attached importance to the Environmental Impact Appraisal (EIA) with a view to preserve natural environment from mining development although they have promoted mining development positively. They aim at an acquisition of the background data of natural environment in keeping with future sustainable development. Hence the Fiji Government has requested the Japanese Government a cooperative survey (September 4th, 2001, communication F 644). The two governments decided upon deliberation a 2 year's environmental baseline study and technology transfer to the counterpart organization of Fiji. On July 4th 2002, the Scope of Work (S/W) agreement and the Minutes of Meeting (M/M) were sealed between Japanese International Cooperative Agency (JICA) and 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 Fiji Islands preceding the field mission. This survey continued for 2 years from 2002 - 2003 fiscal year and this year corresponds to the second phase.

1 - 2 Outline of the Phase I survey

1-2-1 Conclusion of the Phase I survey

The hydrological survey, stream sediment survey, flora and fauna survey, soil bacteria survey and archaeological survey were executed in the Phase I survey. The period of the survey was from September to November (dry season) and as for hydrological survey from January to February (rainy season) once again.

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 little 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 area. 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. One weather station was set up inside the Namosi village elementary school. 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.

For the stream sediment survey, total 905 samples from 822 points were analysed for 29 chemical elements. The characteristic of the element concentration of each drainage system is summarized as follows; the Rewa River drainage system is the most strongly influenced by hydrothermal deposits, which shows higher values of Cu, Zn, As and Au than those of other drainage systems and relatively high values of Cd and Sb. The Navua River drainage system is partly influenced by hydrothermal system, which indicates relatively high values of Zn, Cd, Sb and Au. Meanwhile, sedimentary rocks such as limestone influence the Sigatoka River drainage system, which shows higher values of Ca and Mg than those of other drainage systems and

relatively high values of Cd and Sb. The Coastal River system shows lower values of Mg, P, K, Ni, Sr and Ba than those of other drainage systems.

The fauna and flora survey consists of fauna survey, 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 of the tropical rain forest, 34 species of birds including Pink-billed Parrotfinch were recognized, which is a 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.

In the chemical analysis of fishes & benthos, 26 samples of the typical eel and freshwater clam (corbicula) were sampled and chemically analyzed. Arsenic contents of the eels indicate maximum 1.39mg/kg and average 0.57mg/kg. Arsenic contents of the freshwater clams indicate maximum 4.44mg/kg and average 2.58mg/kg and Cadmium contents of the freshwater clams indicate maximum 3.55mg/kg and average 1.78mg/kg.

Flora of the survey area is divided characteristically to 8 ecosystems according to topography and climate. A total of 81 rare and endangered species of vascular bundle plant are distributed in the 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 boundary of floras, which are verified in the ground truth survey. From interpretation of the ASTER images, the vegetation distribution in the survey area is divided largely to 5 classifications.

Regarding the soil bacteria survey, 5 soil samples were collected from Namosi area. 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 some samples. This suggests the potential of microbes applicable to bacteria leaching and mine wastewater treatment.

The archaeological survey clarified that 213 cases of historical relics or cultural assets are distributed in the survey area. These include settlement ruins that are so-called early Lapita (earliest human settlement ruins before approximately 3000 years), late prehistorical sites (before approximately 1000 years) and late historical sites. Many of the ruins are distributed in plains and adjacent hills, such as Sigatoka, Keiyasi, Suva and Nausori.

1-2-2 Proposal for the Phase II survey

(1) Stream sediment survey

For stream sediment survey, the similar survey as to Phase I was proposed for Phase II survey in the upper stream of each drainage system, especially in the upper stream of the Rewa River such as Sovi Basin, Waidina River and Waimanu River and the upper stream of the Navua River, where the survey had been uncompleted in Phase I. In addition, various types of rock, which represent geological basements, should have been chemically analyzed for comparison and examination with the analysis data of the stream sediment samples.

(2) Synthetical analysis

It was desired to sample and to analyze river water, stream sediment, soil, rock and animal at a same point in order to analyze synthetically the data of the Phase I survey. The mutual comparison, examination and verification of reappearance of the analysis data are necessary.

As for hydrological survey of the Phase I, only the data of dry season was analyzed. Therefore, in the Phase II, synthetical analysis of river water that considers seasonal variation was desired in addition to the annual meteorological data.

1 - 3 Outline of the Phase II survey

1-3-1 Objective of the survey

Viti Levu South area including Namosi area, which has potential of future mining activity, is worried about an environmental impact by not only mining aspects, but also deforestation, cultivation, sewage and waste of human activities. It is necessary to know the background values of chemical elements and to understand the present situation of fauna, flora and archaeological sites. Hence, the objective of this survey is to collect and to integrate background data on natural environment in conformity with the planned natural environmental law of FIJI. The survey team has executed "Environmental Baseline Study" to prepare a report and to compile preliminary data for the mining exploitations in the future. In addition, another objective is to transfer the survey technology to the counterpart organization through this survey.

1-3-2 Survey area

The survey area covers approximately 4,000km^2 of the southern side of Viti Levu Island, which occupies 2/5 part of this main island of the Republic of Fiji Islands. The area extends over Rewa Province, Tailevu Province, Naitasiri Province, Namosi Province, Serua Province and Nadroga&Navosa Province. The distance from east to west is approximately 71-129 km and from north to south is approximately 32 - 36 km. The area includes the capital Suva City in eastern side and some small towns such as Navua, Korolevu and Sigatoka along southern coastal line.

Some prominent landmarks including the Nadrau Plateau (altitude more than 1,000m), Korobasabasaga Range (1,147m), Medrausucu Range (738m) and Mt.Naitaradamu (1,152m) are located in the central part of the survey area. Most of the mountain ranges extend from northeast to southwest and form watersheds, which divide drainage systems such as the Rewa River drainage system, the Navua River drainage system and the Sigatoka River drainage system. The Rewa River and the Navua River flow in the southeastern side, while the Sigatoka River flows in the northwestern side of the area.

1-3-3 Survey methods

The Phase I survey was composed of hydrological survey, stream sediment survey, fauna and flora survey, soil bacteria survey and archaeological survey. During the Phase II survey, stream sediment survey and hydrological survey were executed in the survey area.

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

(1) Stream sediment survey

In the stream sediment survey, samples were collected from the rivers or upper courses of the rivers, where the sampling had been uncompleted in Phase I. These samples were analysed for

29 chemical elements and compiled with the Phase I data in order to confirm the regional geochemical background in the area.

(2) Hydrological survey

1) Water quality survey

In order to supplement the survey of dry and rainy season in Phase Ⅰ, water quality survey was carried out.

2) Arrangement of hydrological data in the rainy season

The results of rainy season survey in the Phase Ⅰ were arranged.

3) Discussion of hydrological survey

The results of dry season and rainy season survey were compiled, and analyzed.

4) Collection of meteorological data

One weather station was installed inside the survey area, and weather data was collected

1-3-4 Quantity of the survey

Table I-1-1 shows survey contents, laboratory examination items and respective quantities of this survey.

Table I-1-1 Contents of the survey

(1) Contents and quantity of the survey

Contents	Quantity	
Stream sediment survey	Phase I (2002)	Phase II (2003)
Sampling Chemical analysis	822 points (905 samples)	895 points (940 samples)
Hydrological survey	Phase I (2002)	Phase II (2003)
Flow measurement (only Phase I) Sampling Water quality analysis	Dry season 80 points (88 samples) Rainy season 80points (88 samples)	Dry season 10 points (10 samples) (Only sampling)
Meteorological survey	Setting of weather station and observation: 1 point	

(2) Laboratory examination and quantity

Laboratory examination	Quantity
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)	1845
Hydrological survey Water quality analysis (As, Cd, Cr, Cu, Pb, Ni, Zn)	10

1-3-5 Survey team personnel

Government of Japan		Government of Fiji	
(Field Survey Team)		(Counterpart)	
Makoto Miyoshi	(JICA/MMAJ (NMC))	Isireli Nagata	(MRD)
Akira Shimizu	(JICA/MMAJ (NMC))	Moape Navia	(MRD)
Ryuta Okubo	(JICA/MMAJ (NMC))	Rudra Deo	(MRD)
		Isei Rayawa	(MRD)
		Filipe Drutai	(MRD)
		Sakiusa Waqanisau	(MRD)

(Supervision of Operation)
Natsumi Kamiya (JICA/MMAJ)

1-3-6 Period of the survey

The schedule of Phase II survey is as follows.

(Field survey)
Environmental Baseline Study September 4th, 2003 ～ December 8th, 2003 (96 days)

(Supervision of Operation)
Natsumi Kamiya (MMAJ) December 1st, 2003 ～ December 6th, 2003 (6 days)