REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE TORAJA AREA, SULAWESI
THE REPUBLIC OF INDONESIA

CONSOLIDATED REPORT

FEBRUARY 1994

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

The Japanese Government, in response to a request extended by the Government of Indonesia, decided to conduct a mineral exploration of the Toraja project, Sulawesi, and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The Government of the Republic of Indonesia appointed the Directorate of Mineral Resources to execute the survey as a counterpart to the Japanese team. The survey was carried out from 1991 jointly by experts from both governments.

The cooperative mineral exploration for gold resources in the Toraja project area has continued for three years. It consisted of geological and geochemical surveys, and drilling exploration. This consolidated report summarizes the result of the work.

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

We wish to express our sincere appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

February 1994

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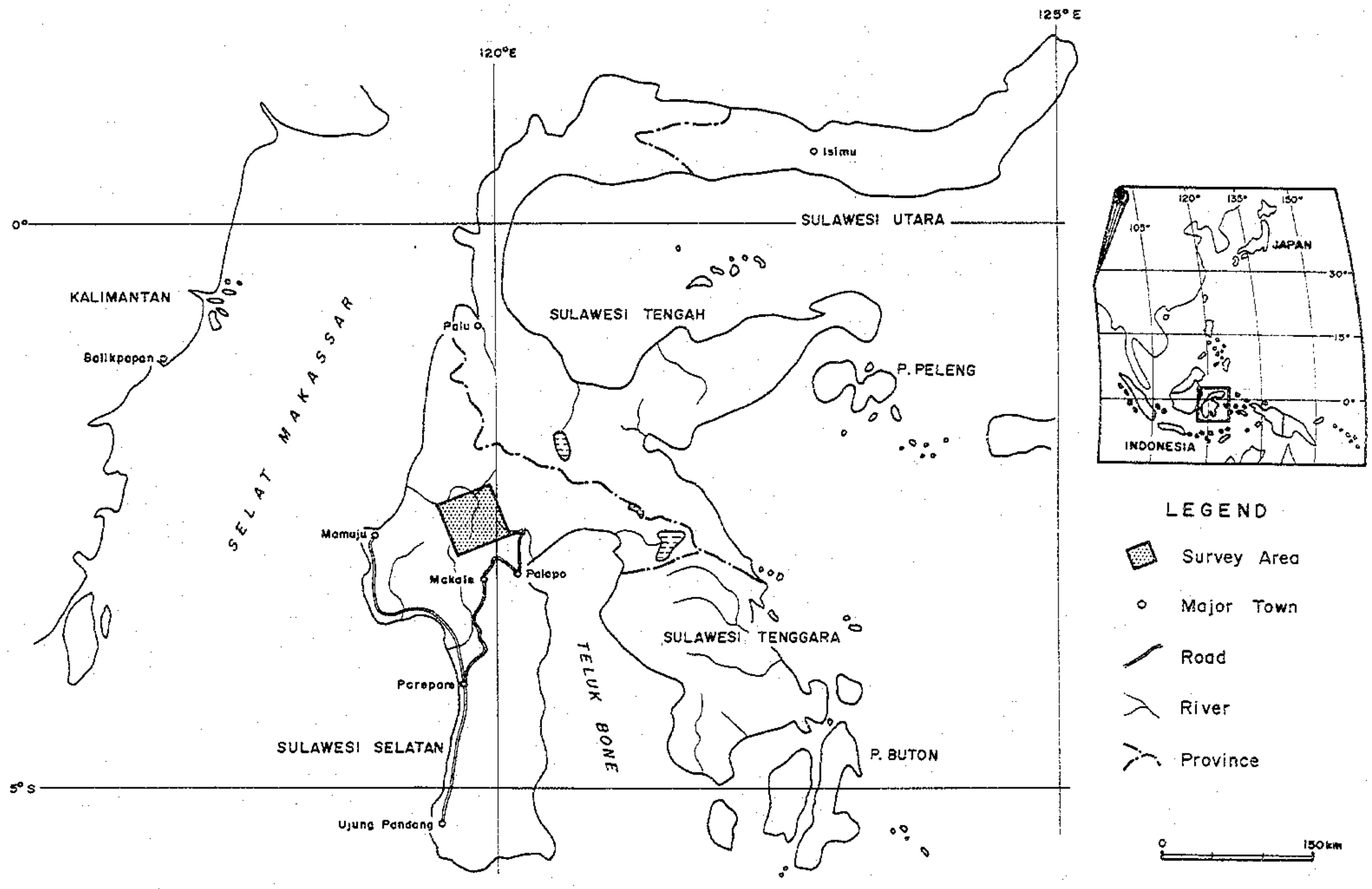


Fig. 1-1 Index Map of the Survey Area

SUMMARY

The cooperative mineral exploration has been carried out for three years in the Toraja project area. At the end of the three-year exploration programme, Batuisi is being been focused on as a promising gold prospect.

In 1991, preliminary investigation and the first phase field survey comprising regional geological survey and geochemical exploration, and semi-detailed geological survey and geochemical exploration were made. Semi-detailed survey was conducted in the Batuisi and Bau prospects. The extensive development of quartz veins and quartz stockworks were found in the Batuisi prospect. Anomalous gold values were detected at the hill northwest of S. Tarawa by preliminary soil sampling.

In 1992, successive field works consisting of detailed geological survey and geochemical exploration in the Batuisi and Bau prospects, and semi-detailed geological survey and geochemical exploration in the S. Lebutang and Kariango prospects continued in the Toraja project area. As a result of the second phase survey, the central part of the Batuisi prospect was selected as the prime target area for gold exploration. Distinctive gold anomalies were delineated over the area in the Batuisi prospect. The geology, geologic structure and the mode of occurrence of gold mineralization were investigated in the second phase. A small scale drilling programme for the reconnaissance purpose was practiced at the upper reaches of S. Tarawa in the Batuisi prospect.

In 1993, drilling exploration was carried out in the Batuisi prospect. It corresponds to the third phase of the cooperative mineral exploration in the Toraja area. The purpose of this phase is to define and evaluate gold resources which were outlined in the previous survey. Three target zones -- the Tondoratte zone, the middle reaches of S. Bone zone, and the Malela-Pongo zone -- were picked up from several geological and geochemical indications in the prospect.

A diamond drilling programme was conducted at the Tondoratte zone and the middle reaches of S. Bone zone in the Batuisi prospect in the third phase. The programme consisted of 4 inclined holes of diamond drilling totalling 680.80 m. They aimed mainly at the deeper extension of the most significant Au anomalies which were defined in the previous survey. More than one hundred samples for ore assay and other samples for laboratory studies were obtained.

The trenching work was carried out at the Malela-Pongo zone in the Batuisi prospect in the third phase. The exploration consisted of 3 lines of shallow trenches totalling 159.90 m. More than thirty samples for ore assay and other samples for laboratory studies were obtained from trenches.

Three holes of 200 m in depth each were drilled at the Tondoratte zone. They aimed at the vertical extensions of some of the most significant gold indications defined by the previous survey. Numerous quartz veins and quartz stockworks with the dissemination of sulphide minerals were caught in every hole nearly at the right depths which have been expected in the drilling programme. Several remarkable intersections of gold, up to 40.22 g/t Au at 36 cm in width, were returned. The existence of ore-grade gold mineralization in the depth below the surface showings, that was predicted in the second phase, was confirmed. On the basis of these results, the potential of gold resources in this area is thought to be high.

Two distinctive zones of auriferous quartz stockworks were found at the middle reaches of S. Bone zone within a geochemical gold anomaly detected in the second phase. A couple of significant gold values was obtained from some of grab samples collected during the surface investigation prior to drilling. One short hole, 80 m deep, was drilled to test one of the quartz stockwork zones. The results were disappointing. However the work this phase has not been sufficient for the evaluation of this mineralized zone. Further drilling to follow up the surface indications is necessary in this area.

A series of quartz veins and silicified zones, which contains a small amount of pyrite and chalcopyrite, was excavated in trenches at the Malela-Pongo zone. At the same period, surface indications of gold mineralization were looked for at the upper reaches of S. Malela and S. Pongo where the Quaternary volcanic rocks lie over the mineralized horizon. Some exposures were newly found and investigated within this zone. The results this year show that the mode of occurrence of quartz veins/stockworks is similar to the Tondoratte zone. It probably corresponds to the northeastern extension of the Tondoratte mineralized zone.

As a result of exploration for three years, gold mineralization which is represented by the distribution of extensive outcrops of quartz veins and quartz stockworks and outlined by the distribution of distinctive geochemical anomalies has been confirmed in the Batuisi prospect. The type and condition of gold mineralization in the prospect were discussed on the basis of petrology, mineralogy, hydrothermal alteration and fluid inclusion studies. It was interpreted that the gold-bearing quartz veins and quartz stockworks were formed under mesothermal conditions. The gold mineralization is hosted by andesite and shale of the Cretaceous Latimojong Formation. The prospect is located on the western flank of an anticlinorium formed by the emplacement of the Mamasa granite which is exposed several kilometers to the south of the Prospect. This geological setting is probably a crucial factor for the formation of gold-bearing quartz veins. Gold was thought to be depleted in the shallow part by the lateritic weathering process. Ore-grade gold was returned from the lower part of oxidized zone below 100 m from the surface.

The grade of gold intersections caught at the Tondoratte zone by the third phase drilling is significant. However they are rather narrow. The maximum width among three holes at a cut-off grade of 1 g/t Au is 66cm (14.31 g/t). The question whether it is a small scale mineralization or there may exist a bigger orebody in another place is open to further discussion. The surface indications are distributed within an area of 2,500 m (NE-SW) x 1,500 m (NW-SE), centered at the top of the ridge near Tondoratte and extending from the middle reaches of S. Tarawa and S. Bone up the northeastward to the Malela-Pongo area. The scale appears to be medium from their indications. Based on these considerations, it is concluded that the drilling in the third phase has not been sufficient for the full-evaluation of the mineralization. Drilling exploration is still necessary in the Batuisi prospect. The confirmation of the scale and structure of gold mineralization has been carried over to the next stage

It is recommended that the mineralized zone defined by the third phase survey in the prospect would be fully drill-tested in the future exploration. The purpose of the exploration must be bilateral; ① to make an evaluation of the entire mineralized zones which are delineated by the surface indications, ② to follow-up the Tondoratte zone in order to investigate the details of grade distribution and structure.

Two styles of mineralization were distinguished through the second phase detailed geological survey in the Bau prospect. One consists of fissure filling quartz veins, and another is pyrite dissemination near dioritic stocks. The geologic environment is interpreted to be similar to that of the Batuisi prospect.

Some of the quartz veins showed significant Au assay results. Each of the veins is small and discontinuous. Soil anomalies of Au and Cu obtained in the area are of low level and sporadic. From these evidences, it is concluded that the gold mineralization of this style had no sign of extensive development.

Pyrite dissemination was found at the northern part of the prospect. Assay results were discouraging. Au anomalies of soil and rock-chip samples found near the pyrite dissemination are of low level and patchy. This style of mineralization probably has low potential.

Therefore, no further work is recommended in the Bau prospect.

Gold mineralization associated with pyrite dissemination or stringers in massive andesite was found at S. Taroto in the S. Lebutang prospect in the second phase survey. A series of Au anomalies of moderate to low degrees was found to extend from S. Kanan through S. Taroto and S. Peko up to S. Talodo Basisi. Although the surface indications of this zone are significant, the assay results of ore samples were disappointing. It is believed to be a gold mineralization probably associated with pyrite dissemination within shear zones. The details of mineralization have not been fully investigated. It is presumed to be a low-grade gold mineralization on the basis of the data obtained during the second phase survey. The other outcrops of quartz veins and geochemical anomalies found in the prospect are estimated to be of minor importance.

Therefore, no further work is recommended in the S. Lebutang prospect.

A limonite network zone and the subordinate Au anomaly of low level were found near S. Suluan in the Kariango prospect in the second phase survey. It is interpreted to be the product of small scale hydrothermal activity by a subsurface igneous intrusion. Other indications of gold mineralization have not been discovered in the prospect. The potential of this prospect appears to be very small.

Therefore, no further work is recommended in the Kariango prospect.

CONTENTS

CONTENTS

PART II DETAILED DISCUSSIONS

LIST OF FIGURES

LIST OF TABLES

PLATE

PART I OVERVIEW

PART I OVERVIEW

Chapter 1 Outline of the Project

1-1 Background and Objective

The Indonesia-Japan Cooperative Mineral Exploration has been carried out in six areas of the Republic of Indonesia; Sulawesi (1970-1972), Kalimantan (1974-1977), West Kalimantan (1979-1981), North Sumatra (1982-1984), South Sumatra (1985-1987), and Pegunungan Tigapuluh (1989-1990). As a result of these works, a large amount of information regarding metallic mineral resources was obtained. The exploration also contributed to the technical progress of the Geological Survey of Indonesia and the Directorate of Mineral Resources, as well as to the acquisition and accumulation of knowledge regarding geology and mineral deposits of the country.

The Ministry of Mines and Energy of Indonesia planned to conduct mineral exploration of the Toraja project, Sulawesi, and requested the cooperation of the Japanese Government. In August 1991, the Japanese Government, complying with the request, sent a mission for project-finding, discussing the Scope of Work and to make a preliminary survey trip to the area. As a result of consultations with the Directorate General of Geology and Mineral Resources, the counterpart of the Metal Mining Agency of Japan, an agreement was reached for the cooperative mineral exploration in the Toraja project area on September 5, 1991.

The principal objective of this project was to find a new mineral deposit in the Toraja project area through the exploration and examination of geology and mineralization. It was also important to pursue technology transfer to the Indonesian counterpart organization in the course of the project.

In 1991, preliminary investigation and the first phase field survey were carried out for the purpose of assessing the potential of mineral resources in the Toraja project area. The major works conducted during the first phase were satellite imagery photogeological interpretation, regional geological survey and geochemical exploration, semi-detailed geological survey and geochemical exploration, and application tests of plant leaf biogeochemistry and mercury gas geochemistry to the tropical rainforest land. The entire survey area was 3,000 km^2, and the semi-detailed survey was made in two prospects -- Batuisi and Bau.

In 1992, successive field works continued in the Toraja project area. It corresponded to the second phase of the exploration programme. The major purpose of the second phase was to define target zones for the further exploration within the survey area. It was also required for the further exploration to elucidate the nature of mineralization in the survey area. Exploration efforts were concentrated on the prospective areas which were extracted in the first phase survey. They were composed of detailed geological survey and geochemical exploration in the Batuisi and Bau prospects, and semi-detailed geological survey and geochemical exploration in the S. Lebutang and Kariango prospects. A small scale drilling programme for the reconnaissance purpose was practiced at the upper reaches of S. Tarawa in the Batuisi prospect. The area was 130 km² in total.

In 1993, drilling exploration was carried out in the Batuisi prospect. It corresponded to the third phase of the cooperative mineral exploration in the Toraja area. The purpose of this phase was to define and evaluate gold resources which were outlined in the previous survey. Three promising target zones for drill testing were picked up from several geological and geochemical indications in the prospect. The area of the exploration in the third phase was 3.75 km² in total.

1-2 Survey Area

The area of the first phase regional survey was approximately 3,000 km², and was surrounded by the coordinates listed below. It is located in the central part of western Sulawesi. Semi-detailed geological survey and geochemical exploration were made on two prospects -- Batuisi and Bau -- in the first phase. It was approximately 100 km² in total.

1	2° 12′ 40″ S	119° 53′ 40″ E
2	2° 37′ 40″ S	120° 05′ 20″ E
3	2° 50′ 40″ S	119° 37′ 20″ E
4	2° 25′ 40″ S	119° 25′ 40″ E

The area of the second phase survey corresponded to the northwestern to the central-northern part of the first phase regional survey area. It was approximately 130 km², and was composed of four prospects; two detailed survey prospects -- Batuisi and Bau, and two semi-detailed survey prospects -- S.

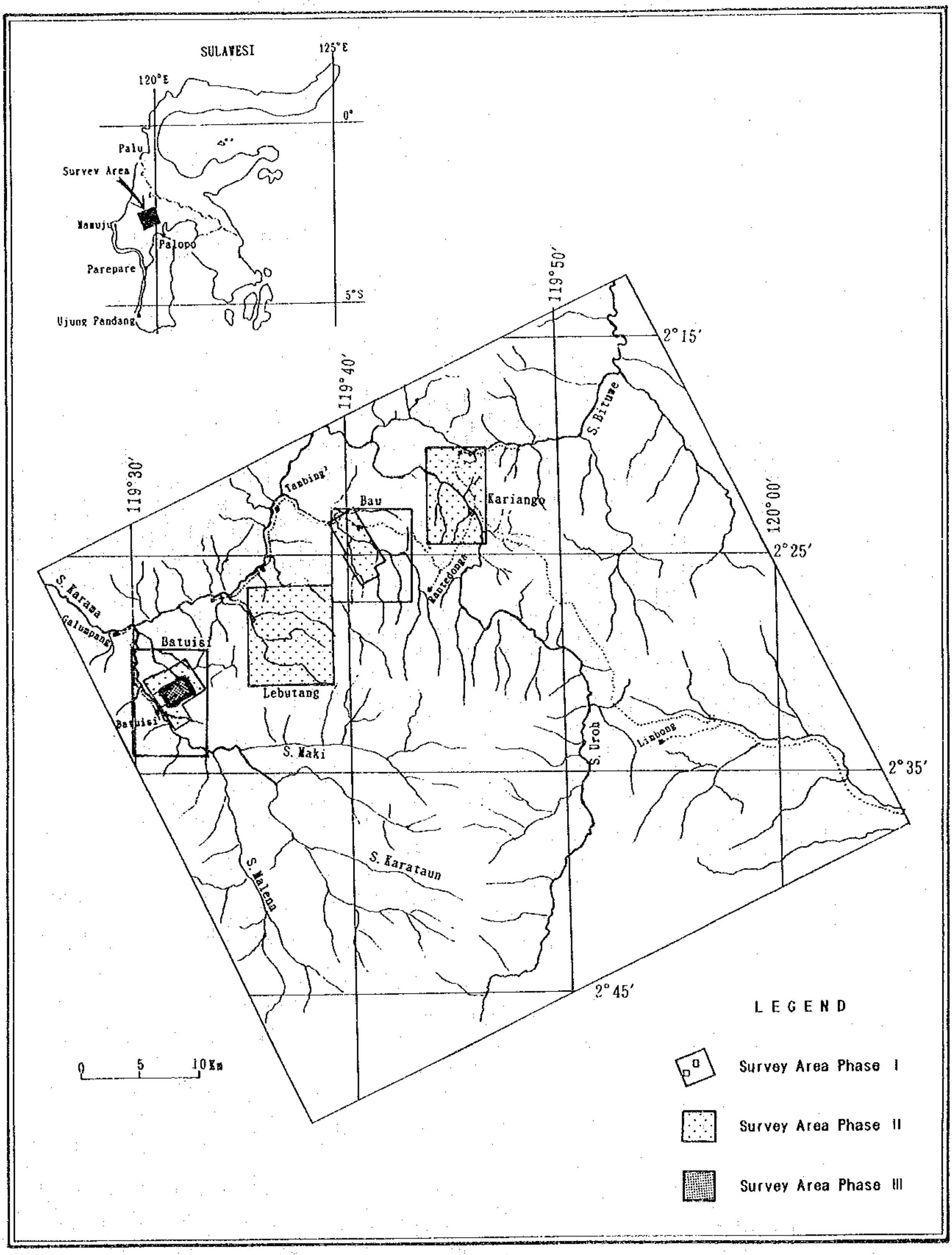


Fig. 1-2 Map Showing the Areas of the First, Second and Third Phase Surveys

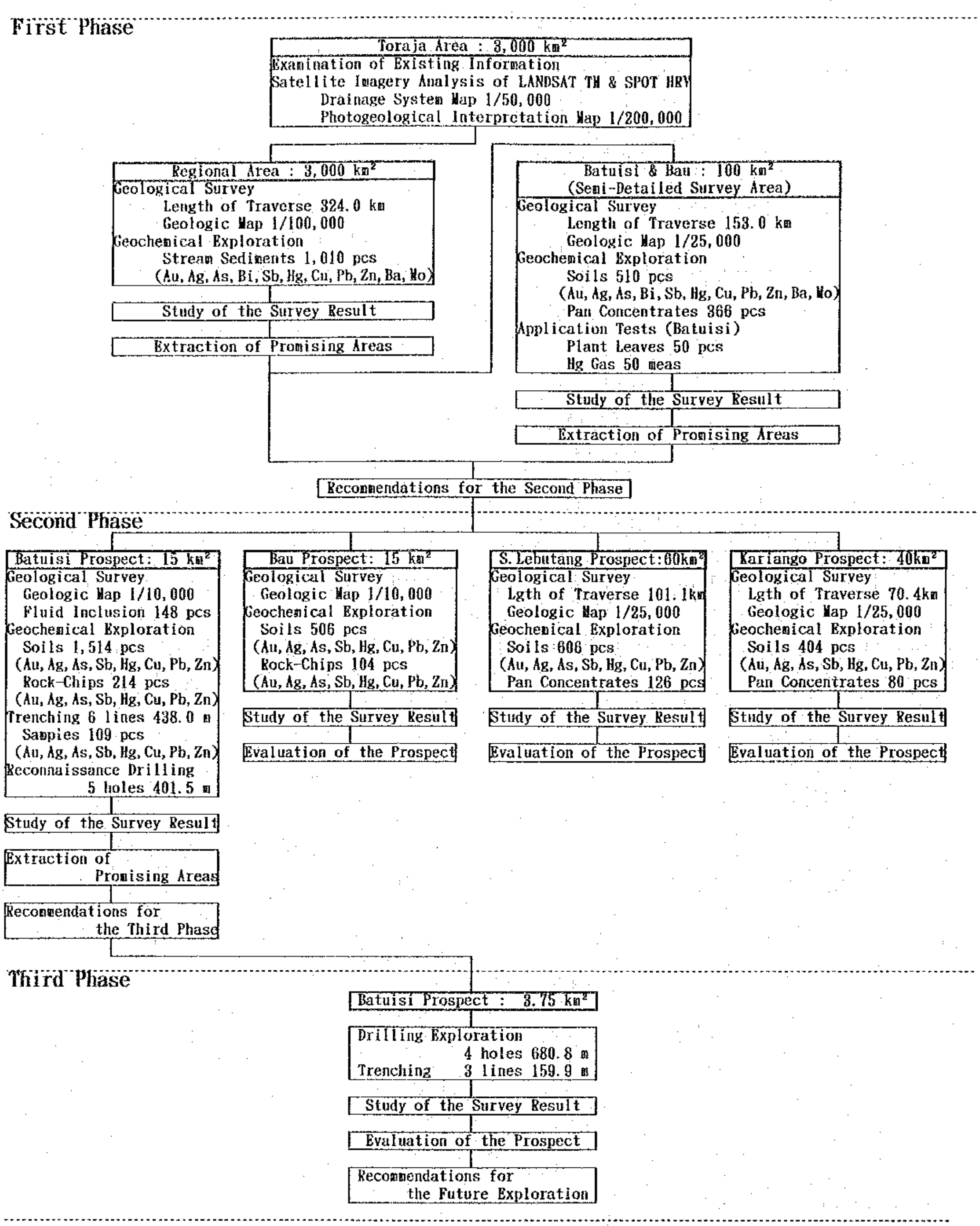


Fig. 1-3 Flowsheet of Survey in the Toraja Area

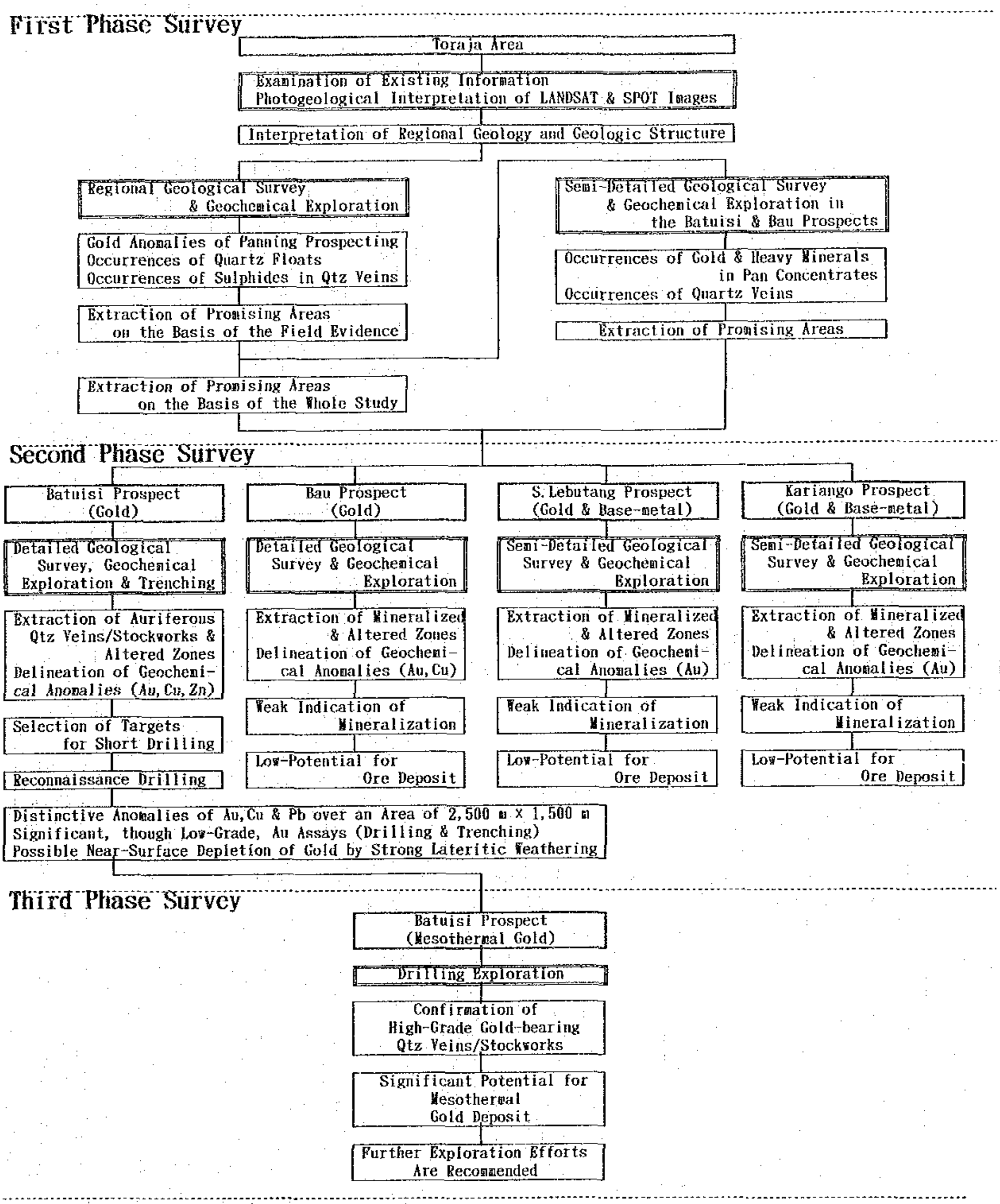


Fig. 1-4 Flow Chart Illustrating the Exploration Steps in the Toraja Area

Table 1-1 Summary of Exploration Work in the Toraja Area

Phase	Survey	Area	Amount of Work
First	·Satellite Imagery Analysis	Regional Area	Area 3,000 km² LANDSAT TM 1 scene, SPOT HRV 1 scene
	·Regional Geological Survey and Geochemical Exploration	Regional Area	Area 3,000 km², Length of Traverse 324.0 km Stream Sediments 1,010 pcs
	·Semi-Detailed Geological Survey and Geochemical Exploration	Batuisi Prospect Bau Prospect	Area 100 km², Length of Traverse 153.0 km Soils 510 pcs Pan Concentrates 366 pcs Plant Leaves 50 pcs Hg Gas 50 pcs [Lab Work] Thin Sections 70 pcs Polished Sections of Ore 10 pcs X-Ray Diffraction Analysis 51 pcs Absolute Age Determination 5 pcs Chemical Analysis Whole Rocks 50 pcs Stream Sediments 1,010 pcs Soils 510 pcs Ore Assay (Au, Ag, Cu, Pb, Zn) 31 pcs Plant Leaves 50 pcs
Second	·Detailed Geological Survey, Geochemical Exploration, and Drilling	Batuisi Prospect	Area 15 km² Soils 1,514 pcs Rock-Chips 214 pcs Trenching 438.0 m (Geochemical Samples 109 pcs) Drilling (5 Holes) 401.5 m
		Bau Prospect	Area 15 km² Soils 506 pcs Rock-Chips 104 pcs
	·Semi-Detailed Geological Survey and Geochemical Exploration	S.Lebutang Prospect	Area 60 km², Length of Traverse 101.1 km Soils 606 pcs Pan Concentrates 126 pcs
		Kariango Prospect	Area 40 km², Length of Traverse 70.4 km Soils 404 pcs Pan Concentrates 80 pcs [Lab Work] Thin Sections 28 pcs Polised Sections of Ore 45 pcs X-Ray Diffraction Analysis 53 pcs Fluid Inclusion Studies 148 pcs Chemical Analysis Soils 3,030 pcs Rock-Chips 428 pcs Ore Assay (Au, Ag, Cu, Pb, Zn) 306 pcs
Third	·Drilling	Batuisi Prospect	Area 3.75 km² Drilling (4 Holes) 680.8 m Trenching (3 Lines) 159.9 m [Lab Work] Thin Sections 6 pcs Polished Sections of Ore 25 pcs X-Ray Diffraction Analysis 20 pcs Fluid Inclusion Studies 20 pcs Chemical Analysis Ore Assay (Au, Ag, Cu, Pb, Zn) 139 pcs

Lebutang and Kariango. A small scale drilling programme for the reconnaissance purpose was conducted in the Batuisi prospect.

The area of the third phase drilling exploration corresponded to the central part of the Batuisi prospect. It was approximately 3.75 km^2. It was composed of three zones; the Tondoratte, the middle reaches of S. Bone, and the Malela-Pongo mineralized zones. The location map of each phase survey area is shown in Fig. 1-2.

1-3 Exploration Work

Methods and amount of work in each phase are summarized in Table 1-1.

1-4 Duration and Survey Team

(1) Mission for the Project Finding and Scope of Work

The Japanese mission for project finding visited to Indonesia from August 26 to September 7, 1991. The Scope of Work was concluded at September 5, 1991 among the Japan International Cooperation Agency, the Metal Mining Agency of Japan, and the Directorate General of Geology and Mineral Resources, Ministry of Mines and Energy of Indonesia.

The members participated in the discussion were as follows:

[Indonesian members]

Dr. Adjat Sudrajat	Director General, Directorate General of Geology and Mineral Resources, Ministry of Mines and Energy (DGGMR)
Kingking A.Margaeidjaja	Director, Directorate of Mineral Resources (DMR)
Yaya Sunarya	Head, Metallic Mineral Exploration Division
Subandi Widasaputra	Chief, Precious Metals Section
Poedjosudjarwo	Staff, Precious Metals Section
Yayat Ruchiyat	Chief, Foreign Technical Cooperation Sub Section
Nenen Adriyani	Staff, Foreign Technical Cooperation Sub Section

[Japanese members]

Makoto ISHIDA	Metal Mining Agency of Japan
Mitsuaki INOUE	Ministry of International Trade and Industry
Masato YONEDA	Ministry of Foreign Affairs

Nobuyuki OKAMOTO	Japan International Cooperation Agency
Kenzo MASUTA	Metal Mining Agency of Japan

(2) First Phase Survey

The survey of the first phase was carried out during the period from November 4, 1991 to January 22, 1992. Laboratory work and reporting were followed to the field work. The organization of the survey team was as follows:

[Metal Mining Agency of Japan]

Kenzo MASUTA		Coordinator and geologist
Kenichi TAKAHASHI		Coordinator

[Indonesian members]

Subandi Widasaputra	(DMR)	Coordinator and geologist
Pudjosudjarwo	(DMR)	Team leader and geologist
Banbang Pardiarto	(DMR)	Geologist
Wahyu Widodo	(DMR)	Geologist
Eko Palmadi	(DMR)	Geologist
Atok S Prapto	(DMR)	Geologist

[Japanese members]

Kohei IIDA	(NED)	Team leader and chief geologist
Hideya KIKUCHI	(NED)	Geologist
Yoshihiro KIKUCHI	(NED)	Geologist
Tetsuo SATO	(NED)	Geologist and photogeologist
Masami IWAYA	(NED)	Geologist
Saburo TACHIKAWA	(NED)	Geologist

*Note: NED means Nikko Exploration and Development Co., Ltd.

(3) Second Phase Survey

The geological survey and geochemical exploration of the second phase were carried out during the period from July 13 to November 12, 1992. Drilling was conducted from August 18 to December 13, 1992. Laboratory work and reporting were followed to the field work. The organization of the survey team was as follows.

[Metal Mining Agency of Japan]

Kenzo MASUTA	Coordinator and Geologist

[Indonesian members]

Simpwee Soeharto	(DMR)	Team Leader and Geologist
Pudjosudjarwo	(DMR)	Geologist
Wahyu Widodo	(DMR)	Geologist
Atok S Prapto	(DMR)	Geologist
Tata Henda	(DMR)	Geologist
Suratman	(DMR)	Drilling Engineer

[Japanese members]

Kohei IIDA	(NED)	Team Leader and Chief Geologist
Hideya KIKUCHI	(NED)	Geologist
Takashi YOSHIE	(NED)	Geologist
Tetsuo SATO	(NED)	Geologist
Hatsuo KUMANO	(NED)	Drilling Engineer
Fumio ENDO	(NED)	Drilling Engineer
Yoshio SASAKI	(NED)	Drilling Engineer

(4) Third Phase Survey

The drilling exploration was conducted from July 1 to November 2, 1993. Laboratory studies and reporting succeeded to the field work. The organization of the survey team was as follows.

[Metal Mining Agency of Japan]

Satoshi SHIOKAWA	Coordinator and Geologist
Tetsuo SUZUKI	Coordinator and Geologist
Yoshiaki IGARASHI	Coordinator and Geologist

[Indonesian members]

Simpwee Soeharto	(DMR)	Team Leader and Geologist
Wahyu Widodo	(DMR)	Geologist
Moe'tamar	(DMR)	Surveyor
Sudarman	(DMR)	Assistant
Suratman	(DMR)	Drilling Engineer

[Japanese members]

Kohei IIDA	(NED)	Team Leader and Chief Geologist
Hatsuo KUMANO	(NED)	Drilling Engineer
Mitsuo SASAKI	(NED)	Drilling Engineer
Fumio ENDO	(NED)	Drilling Engineer

Chapter 2 Geography of the Survey Area

2-1 Location and Access

Sulawesi is the fourth biggest island in Indonesia. The area is 179,400 km^2 and the population is more than ten millions. It forms K-shaped land.

The survey area is located in the central part of western Sulawesi, where is called the Toraja area. The Toraja is the name of a tribe, whose name means mountain people. The Toraja people live mainly in mountains. They have many interesting traditional customs. The people within the survey area are composed mainly of Christians propagated by Dutch missionary at the turn of the century.

Access to the area is; from Jakarta to Ujung Pandang (Makassar) by air, from Ujung Pandang to Rantepao by car on sealed road or by charter airplane. Rantepao, which is located some 30 km due south of the survey area, is the major town of the Toraja area.

The survey area (regional survey area), shaped as a rectangular of approximately 56 km x 51 km, is in a mountainous land. A mountain range runs northeast to southwest through the area, dividing the area into two; the eastern part and the western part. Access inland is slow and mainly on foot, generally following drainages. The eastern area is accessible by unsealed road from Saban which is at the end of sealed road from Rantepao. Limbong is the second biggest village in the eastern area, located at the end of the road, and is one of coffee producing places. There is no other vehicle road in the area. Only horse tracks and footpaths are available.

The western area is only accessible by boat through up a river S.(Sungai) Karama. Mamuju is the terminal town on sealed road, and is located about 70 km west-southwest of the survey area. From Mamuju to Tarailu, there is an unsealed road running along the coast. It takes some six hours from Tarailu to Galumpang, the biggest village in the area, by engine canoe. There are several little villages in the area. Rivers and footpaths are the only ways connecting these villages.

2-2 Topography and Drainage System

The survey area is situated in a steep mountainous land. The topography is rugged. The greater part of the area is more than 500 m in elevation. There are several high mountains of more than 2,000 m in the survey area. The altitude of the highest peak, name unknown, is 2,914 m . B.(Bukit) Malimongan is the fifth highest peak (2,224 m) lying near the center of the regional survey area.

A series of mountains running northeast-southwest in the area forms the dividing range. It is called Pengunungan Takolekaju. In the east of the range, rivers flow down to east into Teluk Bone. S. Rapakang is the major drainage system in the eastern area. Whereas in the central and western area, rivers flow down to west into Selat Makassar. S. Karama is the major drainage system in the western area.

2-3 Climate and Vegetation

Even though it is situated in a tropical rain forest zone, the climate of the area is rather mild due to its peculiar land structure -- mountainous bony frame and surrounded by the sea on all sides. It has two seasons, rainy and dry. From June to October is usually a kind of dry season. The rainy season generally starts from November and continues till May. In this meaning, it belongs to the tropical monsoon climate area.

The mean temperature and monthly precipitation in the rainy season are 26 °C and 400 mm respectively. The mean temperature and monthly precipitation in the dry season, on the other hand, are 27 °C and 70 mm (climatological data for Makassar).

The lower part of mountains in the area is covered by tropical rain forest. The major part of the mountainous area, however, belongs to the tropical highland forest -- broad leaved evergreen vegetation and coniferous vegetation. Alluvial patches and even flanks of hills among the mountains are reclaimed, and paddy rice is cultivated in such place. On steep hills among the mountains, dry field rice and coffee plant are rather extensively cultivated by the slash-and-burn farming.

Chapter 3 Geology of the Survey Area

3-1 General Geology of the Central Part of Western Sulawesi

Sulawesi is formed of three major tectonic units -- western Sulawesi, eastern Sulawesi, and easternmost islands of Banggai-Sula and Buton --, and consists of four geographic arms -- north, south, east, and southeast arms. The western section, comprising north and south arms, is made up of a series of overlapping volcano-plutonic arcs of Mesozoic to Recent age.

The geology of the central part of western Sulawesi is composed of three major units:

① Cretaceous subduction complexes which are overlain by sediments perhaps deposited in an outer-arc basin.

② Upper Paleogene continental shelf strata deposited on the Cretaceous sediments.

③ Neogene sedimentary and volcanic rocks. They are intruded by Neogene granitic rocks.

The oldest rocks of the area are Mesozoic gneiss and schist from the broad view of the western arc. Cretaceous volcanic-sedimentary complexes (metasediments) are widely distributed in the area. It consists of mostly clastic rocks - slate, black shale, turbiditic siltstone, greywacke, and minor limestone. Some of the rocks are partly sheared and weakly metamorphosed.

Overlying the Cretaceous turbiditic facies are the Upper Paleogene continental shelf sections, deformed only moderately. It is composed of marine and marly shale, quartz sandstone, and limestone.

At the Miocene time, the stable platform conditions changed drastically into active magmatism and extensive volcaniclastic sedimentation. Batholiths and stocks are widely developed in the area. Biotite granite and quartz monzonite are the dominant granitic rocks. According to age dating on the granitic rocks, the magmatism occurred at least mostly within the Middle and Late Miocene time. Extensive submarine volcanism, a major orogenic event started at the beginning of the Early Miocene and continued to the Pliocene time, took place elsewhere in the western arc. It consists of dacitic to andesitic volcanism. Renewed volcanic activity in the Plio-Pleistocene produced dacitic to andesitic pyroclastic rocks. Fig. 1-5 shows the regional geology of the central part of western Sulawesi.

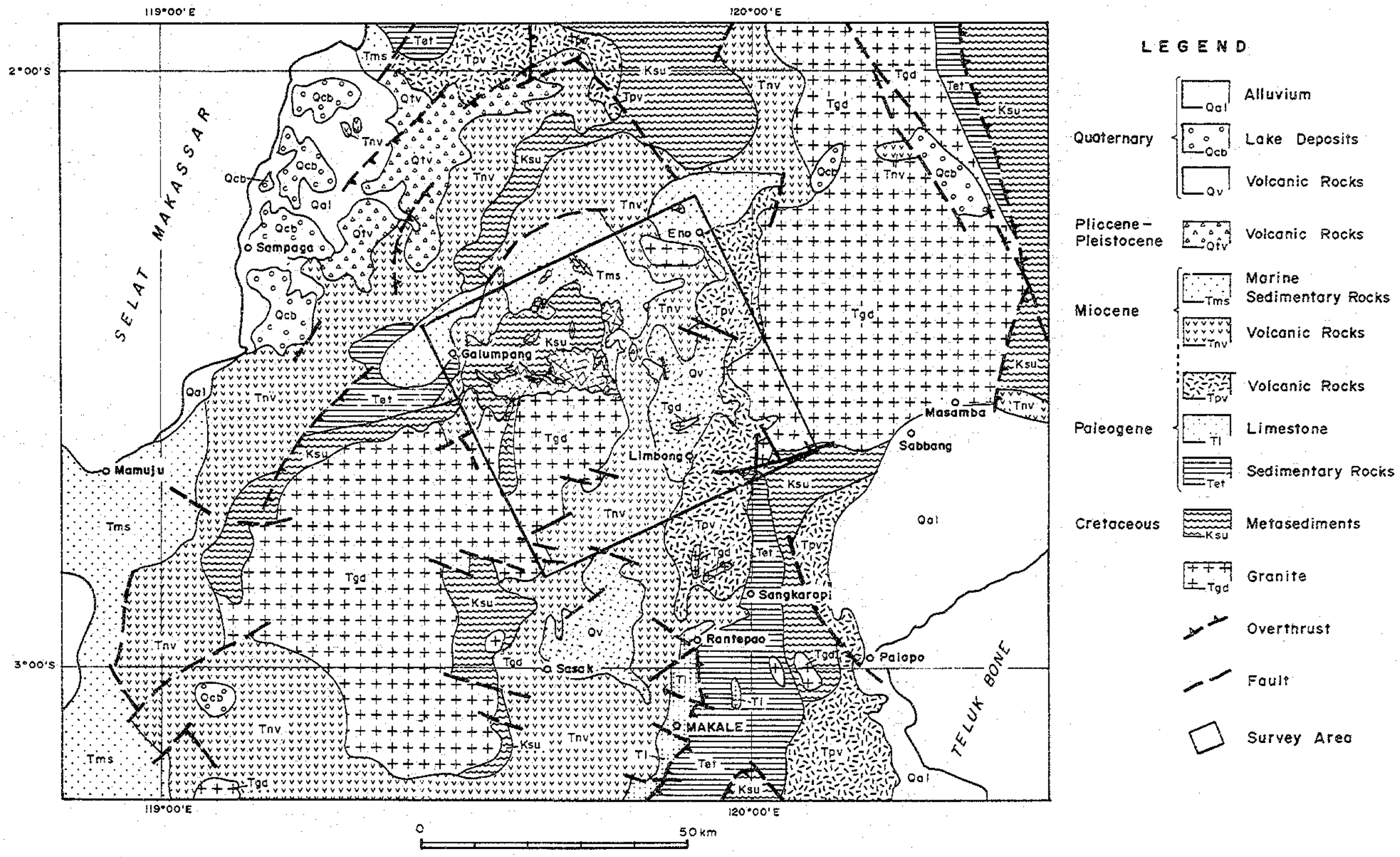


Fig. 1-5 Regional Geology of the Central Part of Western Sulawesi

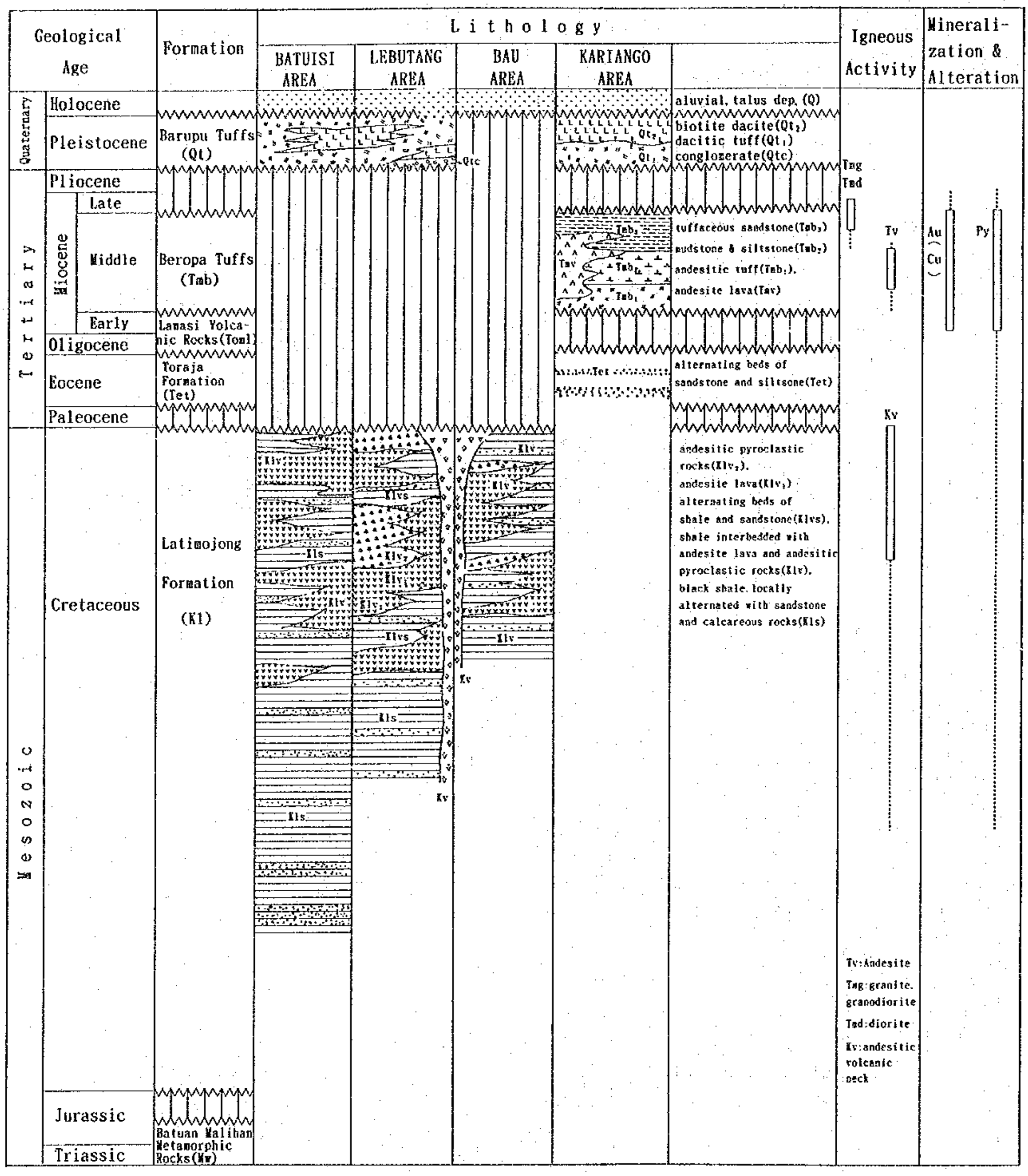


Fig. 1-6 Stratigraphy of the Survey Area

3-2 Geology and Geologic Structure of the Survey Area

The oldest rock in the survey area (regional survey area) is biotite gneiss and mica schist of the Batuan Malihan metamorphic rocks. It occurs locally at the southwest of the survey area.

Metasediments are widely distributed in the area. It is composed of slate, phyllitic shale, and siltstone. It is called the Latimojong Formation, and supposed of Cretaceous age according to the existing geological information. Thin layers of andesite lava and dolerite are intercalated mainly in the upper part of the metasediments.

Overlying unconformably on the Cretaceous metasediments are Paleogene shelf sediments. It is composed of shale, sandstone, and limestone. It is called the Toraja Formation.

The eastern part of the survey area is covered by the Lower Miocene series called the Lamasi Volcanic Rocks. Acid to intermediate volcanic and pyroclastic rocks such as pumice tuff, tuff and dacite lava are the major constituents of the rocks. Shale and basalt lava occur in the lower part of the pyroclastic sequences in some places.

The alternation of calcareous sediments and basic tuffs occurs overlying the acid to intermediate pyroclastic rocks. The upper part gradually changes to basic lava. These rocks of the Middle to Upper Miocene series are subdivided into three sequences - the Beropa Tuffs, the Sekala Formation, and the Talaya Volcanic Rocks in ascending order.

Two granite batholiths are developed to the east and to the southwest of the area. Each batholith occurs with several small stocks. The eastern batholith is called the Kambuno granite, and the southwestern one the Mamasa granite.

Dacite lava and tuff of probably Pleistocene age occur at high altitudes in the survey area. Dacitic crystal tuff is the representative facies of the rocks. It is called the Barupu Tuffs.

The prominent direction of NNE to N-S system was embossed in the distribution of lineaments and fracture traces in the survey area through the satellite imagery photogeological interpretation in the first phase.

A regional anticlinal structure and some local folds were distinguished in the area. They have the axes of N-S direction.

Minor faults trending NW to WNW, E-W and NE were recognized in the survey area.

Attached map shows the geology of the survey area. Fig. 1-6 shows the stratigraphy of the survey area.

3-3 Mineralization

There are three kinds of mineralization known in the central part of western Sulawesi. Those are; mesothermal gold-bearing quartz veins, massive sulphide deposits (Sangkaropi type) and porphyry copper-gold deposits (Sassak type).

The Sangkaropi deposit is located 20 km south of the survey area, where is in the Pt. Aneka Tambang concession. The Sangkaropi sulphide deposit is found within the Miocene acid to intermediate pyroclastic rocks. It is composed of stratiform massive and fragmental ores and underlying stockwork ore. Sphalerite, galena, pyrite and barite are the major constituent minerals of massive and fragmental ores. The top of ores is generally covered by a thin layer of barite. The stockwork ore consists of veins of quartz and sulphide minerals (Yoshida et al., 1982).

The Sassak deposit is located 25 km from the southern border of the survey area, and also belongs to the Pt. Aneka Tambang concession. The Sassak porphyry copper-gold mineralization is found within monzonite and syenite stocks of Miocene age. The hypogene mineralization occurs both in disseminated form and as veinlets. The disseminated mineralization consists of magnetite, pyrite, chalcopyrite, and electrum. Sulphides in veinlets are usually associated with quartz, and consist of pyrite and chalcopyrite with a minor amount of galena and sphalerite. The most prominent alteration is a quartz-clay-sericite assemblage (Taylor and Leeuwen, 1980).

In the course of the regional survey in 1991, no positive indication of massive sulphide mineralization and porphyry copper-gold mineralization has been found.

Indications of mesothermal gold mineralization were caught at several places in the regional survey area. Semi-detailed and detailed geological survey and geochemical exploration have been carried out in four prospects -- Batuisi, Bau, S. Lebutang, and Kariango. Geological characteristic features of gold mineralization in the area are summarized as follows:

① Host rock is mainly metasediments of the Latimojong Formation.
② Extensive development of massive quartz veins.
③ Occurrence of comparatively coarse gold.
④ Associated with sulphide minerals such as pyrite, arsenopyrite, chalcopyrite, sphalerite, and galena.
⑤ The major constituents of veins are quartz, ankerite, and calcite
⑥ Hydrothermal alteration mainly composed of silicification, chloritization, and sericitization.

From these evidences the mesothermal conditions of formation have been presented. Results of the fluid inclusion studies in the Batuisi prospect substantially supported the mesothermal origin of auriferous quartz veins.

Fissure patterns of quartz veins show the dominant NNW trend in both Bau and Batuisi prospects. The Batuisi prospect is situated on the western flank of an anticlinorium (whose axis is N-S) formed by the emplacement of the Mamasa granite batholith. A granite body was supposed to exist beneath the prospect. This geologic environment was thought to be the crucial factor for the formation of vein pattern in the prospect.

Geochemical features of gold mineralization figured out during the survey are summarized as follows:

① Close spatial distribution among the occurrences of gold and some heavy minerals -- cinnabar, chalcopyrite and arsenopyrite -- in a broad scale (pan concentrates).
② Analytical values of Au do not show any intimate correlation with the other elements statistically (stream sediments and soils).
③ The occurrence of distinctive Au anomalies especially in the Batuisi prospect (soils). They are surrounded by anomalies of some basemetal elements such as Cu and Zn.

Chapter 4 Conclusions and Recommendations

4-1 Conclusions

4-1-1 Batuisi Prospect

On the basis of the results of three-year exploration comprising detailed geological survey, grid soil survey, geochemical rock-chip sampling, shallow trenching and drilling, the following conclusions are obtained. The results of exploration are summarized in the attached map.

(1) Three holes of 200 m in depth each were drilled at the Tondoratte zone in the third phase. They aimed at the vertical extensions of some of the most significant gold indications defined by the previous survey. Numerous quartz veins and quartz stockworks with the dissemination of sulphide minerals were encountered in every hole nearly at the right depths which have been expected in the drilling programme. Several interesting intersections of gold, up to 40.22 g/t Au at 36 cm in width, were obtained. The existence of ore-grade gold mineralization in the depth below the surface showings, that was predicted in the second phase, was confirmed. On the basis of these results, the potential of gold resources in this area is thought to be high.

(2) In the third phase, two distinctive zones of auriferous quartz stockworks were found at the middle reaches of S. Bone zone within a geochemical gold anomaly detected in the second phase. A couple of significant gold values was obtained from some of grab samples collected during the surface investigation prior to drilling. One short hole, 80 m deep, was drilled to test one of the quartz stockwork zones. The results were disappointing. However the work in the third phase has not been sufficient for the evaluation of this mineralized zone. Further drilling to follow up the surface indications is necessary in this area.

(3) A series of quartz veins and silicified zones, which contains a small amount of pyrite and chalcopyrite, was excavated in trenches at the Malela-Pongo zone. At the same period, surface indications of gold mineralization were looked for at the upper reaches of S. Malela and S. Pongo where the Quaternary volcanic rocks lie over the mineralized horizon. Some exposures were newly found and investigated within this zone. The results in the third phase show that the mode of occurrence of quartz veins/stockworks is similar to the Tondoratte zone. It probably corresponds to the northeastern extension of the Tondoratte

mineralized zone.

(4) As a result of exploration for three years, gold mineralization which is represented by the distribution of extensive outcrops of quartz veins and quartz stockworks and outlined by the distribution of distinctive geochemical anomalies has been confirmed in the Batuisi prospect. The type and condition of gold mineralization in the prospect were discussed on the basis of petrology, mineralogy, hydrothermal alteration and fluid inclusion studies. It was interpreted that the gold-bearing quartz veins and quartz stockworks were formed under mesothermal conditions. The gold mineralization is hosted by andesite and shale of the Cretaceous Latimojong Formation. The prospect is located on the western flank of an anticlinorium formed by the emplacement of the Mamasa granite which is exposed several kilometers to the south of the Prospect. This geological setting is probably a crucial factor for the formation of gold-bearing quartz veins. Gold was thought to be depleted in the shallow part by the lateritic weathering process. Ore-grade gold was returned from the lower part of oxidized zone below 100 m from the surface.

(5) The grade of gold intersections caught at the Tondoratte zone in the third phase is significant. However they are rather narrow. The maximum width among three holes at a cut-off grade of 1 g/t Au is 66 cm (14.31 g/t). The question whether it is a small scale mineralization or there may exist a bigger orebody in another place is open to further discussion. The surface indications are distributed within an area of 2,500 m (NE-SW) x 1,500 m (NW-SE), centered at the top of the ridge near Tondoratte and extending from the middle reaches of S. Tarawa and S. Bone up the northeastward to the Malela-Pongo area. The scale appears to be medium from their indications. Based on these considerations, it is concluded that the drilling in the third phase has not been sufficient for the full-evaluation of the mineralization. Drilling exploration is still necessary in the Batuisi prospect. The confirmation of the scale and structure of gold mineralization has been carried over to the next stage

4-1-2 Bau Prospect

(1) Two styles of mineralization were distinguished through detailed geological survey in the prospect. One consists of fissure filling quartz veins, and another is pyrite dissemination near dioritic stocks. The geologic environment is interpreted to be similar to that of the Batuisi prospect.

(2) Some of the quartz veins showed significant Au assay results. Each of the veins is small and discontinuous. Soil anomalies of Au and Cu obtained in the area are of low level and sporadic. From these evidences, it is concluded that the gold mineralization of this style had no sign of extensive development.

(3) Pyrite dissemination was found at the northern part of the prospect. Assay results were discouraging. Au anomalies of soil and rock-chip samples found near the pyrite dissemination are of low level and patchy. This style of mineralization probably has low potential.

4-1-3 S. Lebutang Prospect

(1) Gold mineralization associated with pyrite dissemination or stringers in massive andesite was found at S. Taroto. A series of Au anomalies of moderate to low degrees was found to extend from S. Kanan through S. Taroto and S. Peko up to S. Talodo Basisi. Although the surface indications of this zone are significant, the assay results of ore samples are disappointing. It is believed to be a gold mineralization probably associated with pyrite dissemination within shear zones. The details of mineralization have not been fully investigated. It is presumed to be a low-grade gold mineralization on the basis of the data obtained during the second phase survey.

(2) The other outcrops of quartz veins and geochemical anomalies found in the prospect are estimated to be of minor importance.

4-1-4 Kariango Prospect

A limonite network zone and the subordinate Au anomaly of low level were found near S. Suluan. It is interpreted to be the product of small scale hydrothermal activity by a subsurface igneous intrusion. Other indications of gold mineralization have not been discovered in the prospect. The potential of this prospect appears to be very small.

4-2 Recommendations for the Future Exploration

Batuisi prospect

It is recommended that the mineralized zone defined by the third phase survey in the prospect would be fully drill-tested in the future exploration. The purpose of the exploration must be bilateral; ① to make an evaluation of the entire mineralized zones which are delineated by the surface indications, ② to follow-up the Tondoratte zone in order to investigate the details of grade distribution and structure.

The major promising locations for drilling are listed below. The depth of drill holes must be deep enough to penetrate the oxidized zone.

① Southwest of MJT-7 at the Tondoratte zone

② At the middle reaches of S. Tarawa

③ At the upper reaches of S. Bone

④ At the middle reaches of S. Bone

⑤ At the top of the ridge near Tondoratte

⑥ Northeast of S. Malela

⑦ Southwest of S. Pongo

Bau prospect

No further work is recommended in the Bau prospect.

S. Lebutang prospect

No further work is recommended in the S. Lebutang prospect.

Kariango prospect

No further work is recommended in the Kariango prospect.

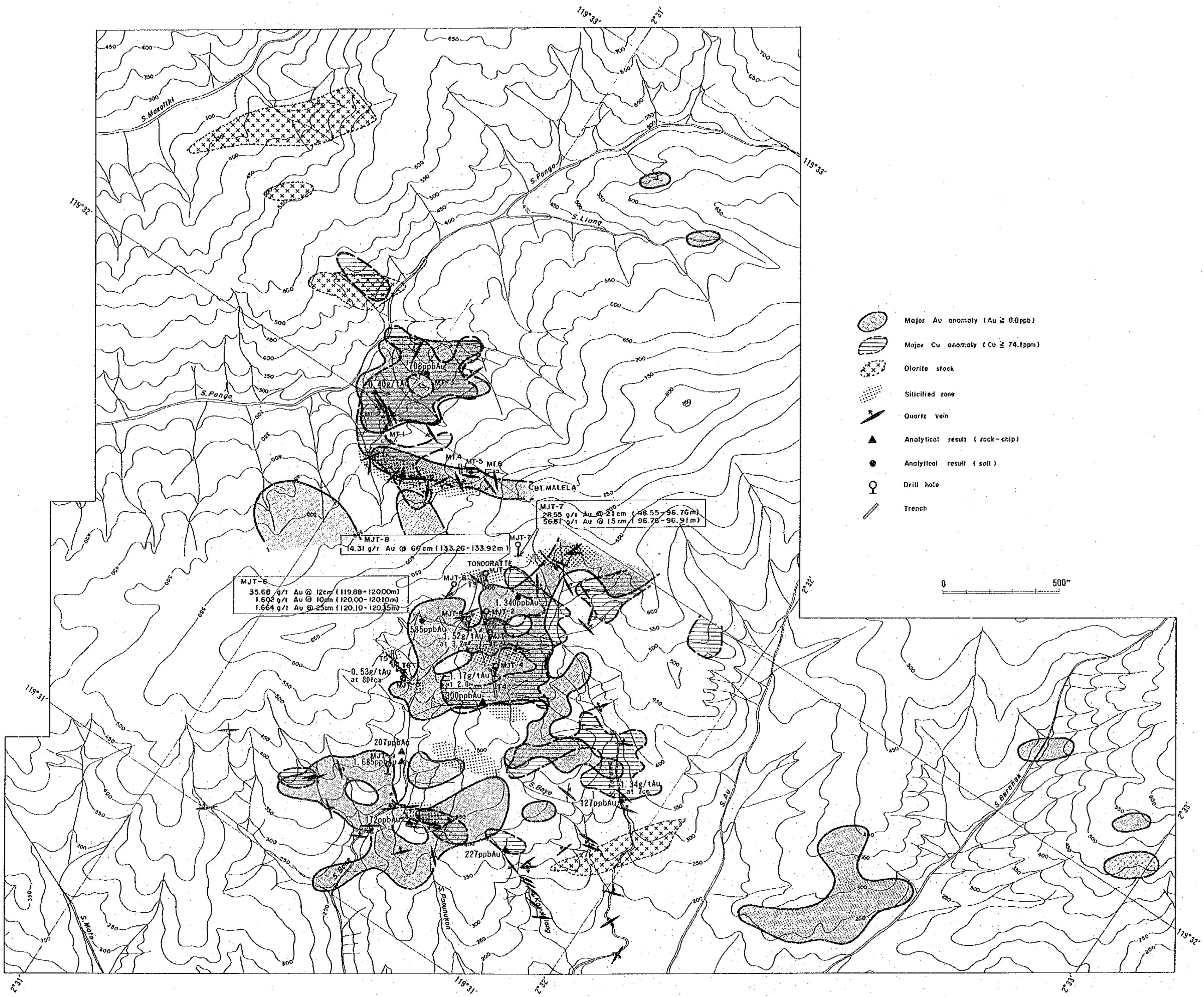


Fig. 1-7 Integrated Interpretation of the Survey Results in the Batuisi Prospect

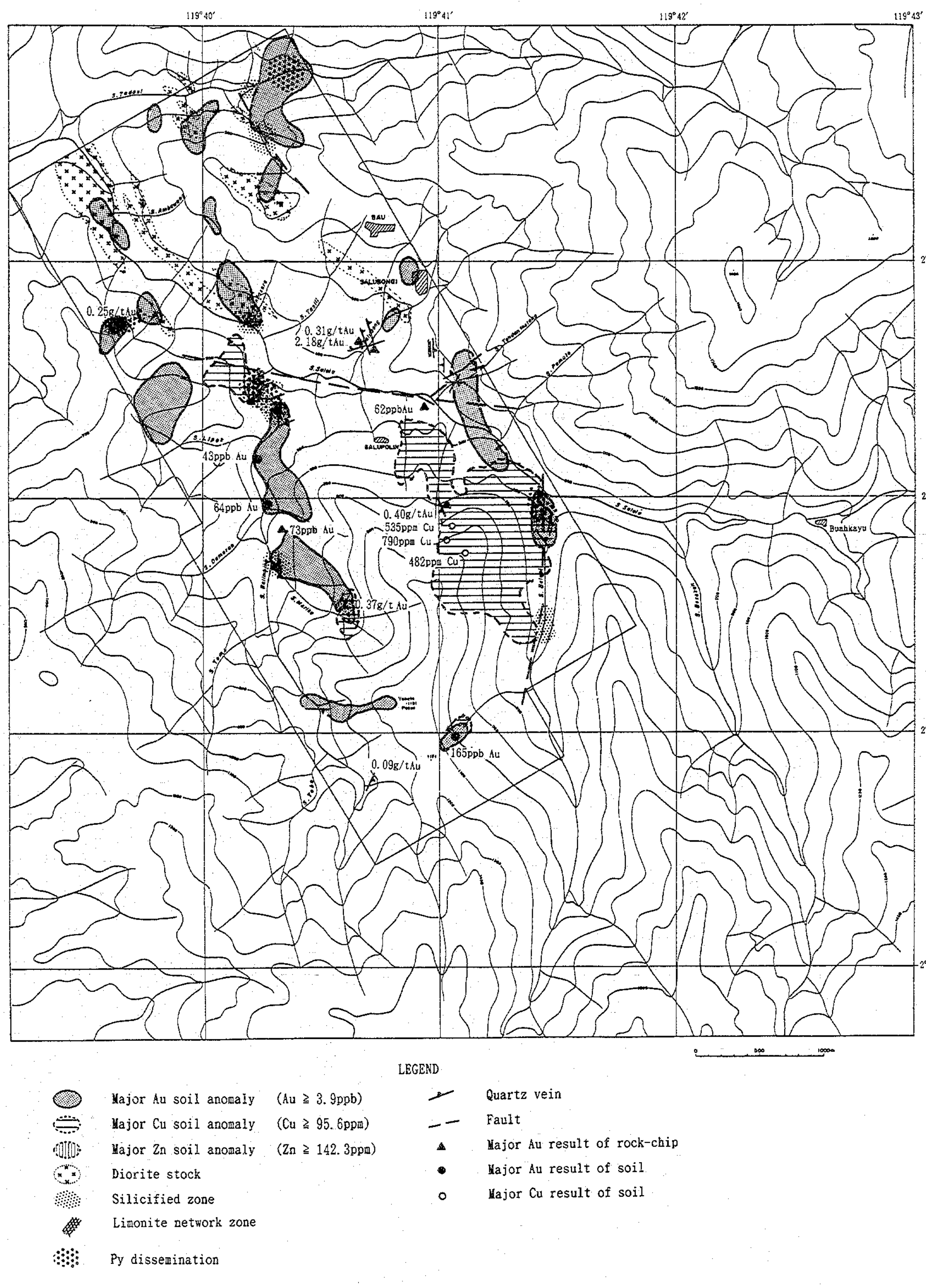
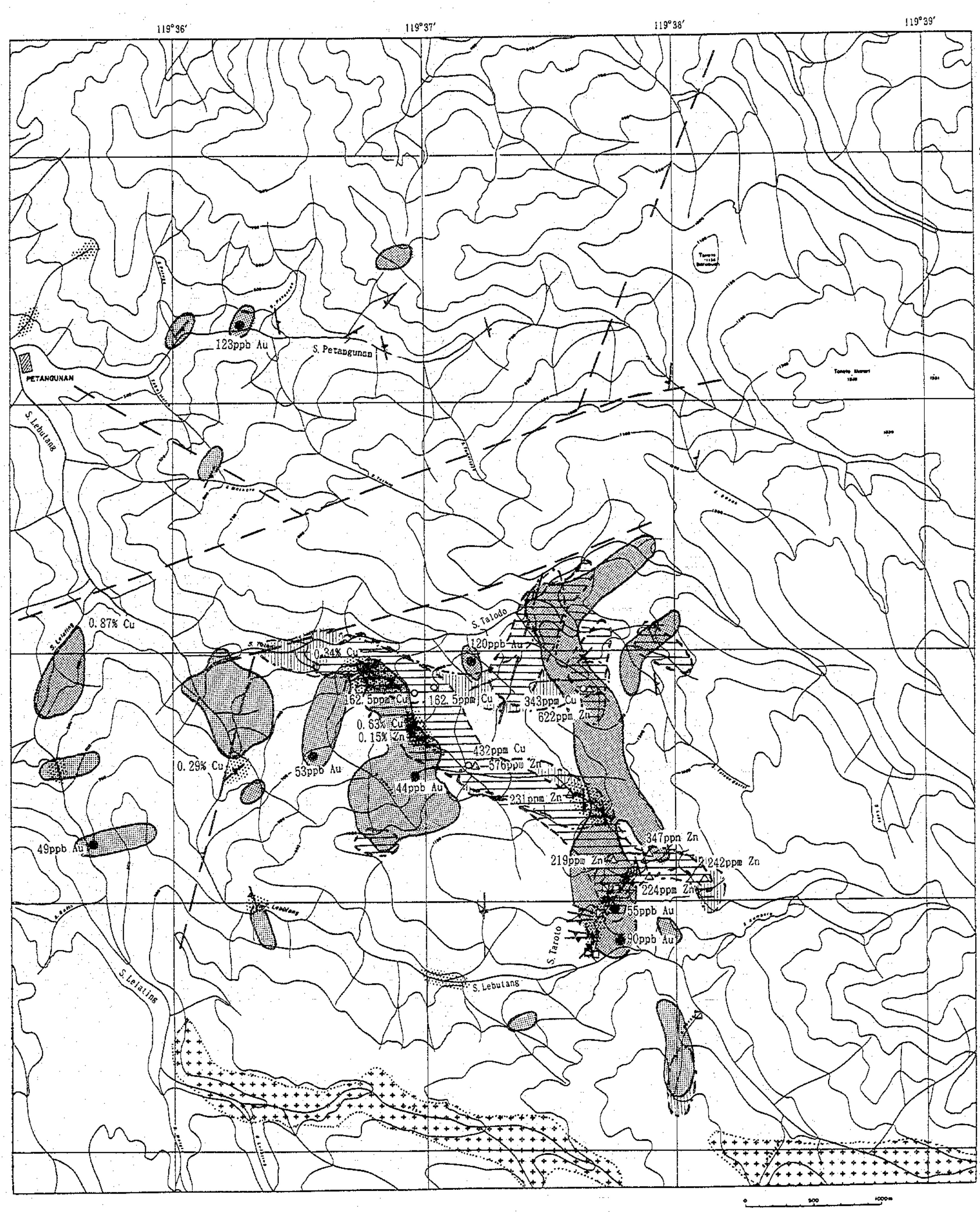


Fig. 1-8 Integrated Interpretation of the Survey Results in the Bau Prospect



LEGEND

	Major Au soil anomaly	(Au ≧ 3.0ppb)		Quartz vein
	Major Cu soil anomaly	(Cu ≧ 61.5ppm)		Fault
	Major Zn soil anomaly	(Zn ≧ 102.2ppm)	●	Major Au result of soil
	Granite		○	Major Cu result of soil
	Silicified zone		△	Major Zn result of soil
			□	Pan concentrate anomaly

Fig. 1-9 Integrated Interpretation of the Survey Results in the S. Lebutang Prospect

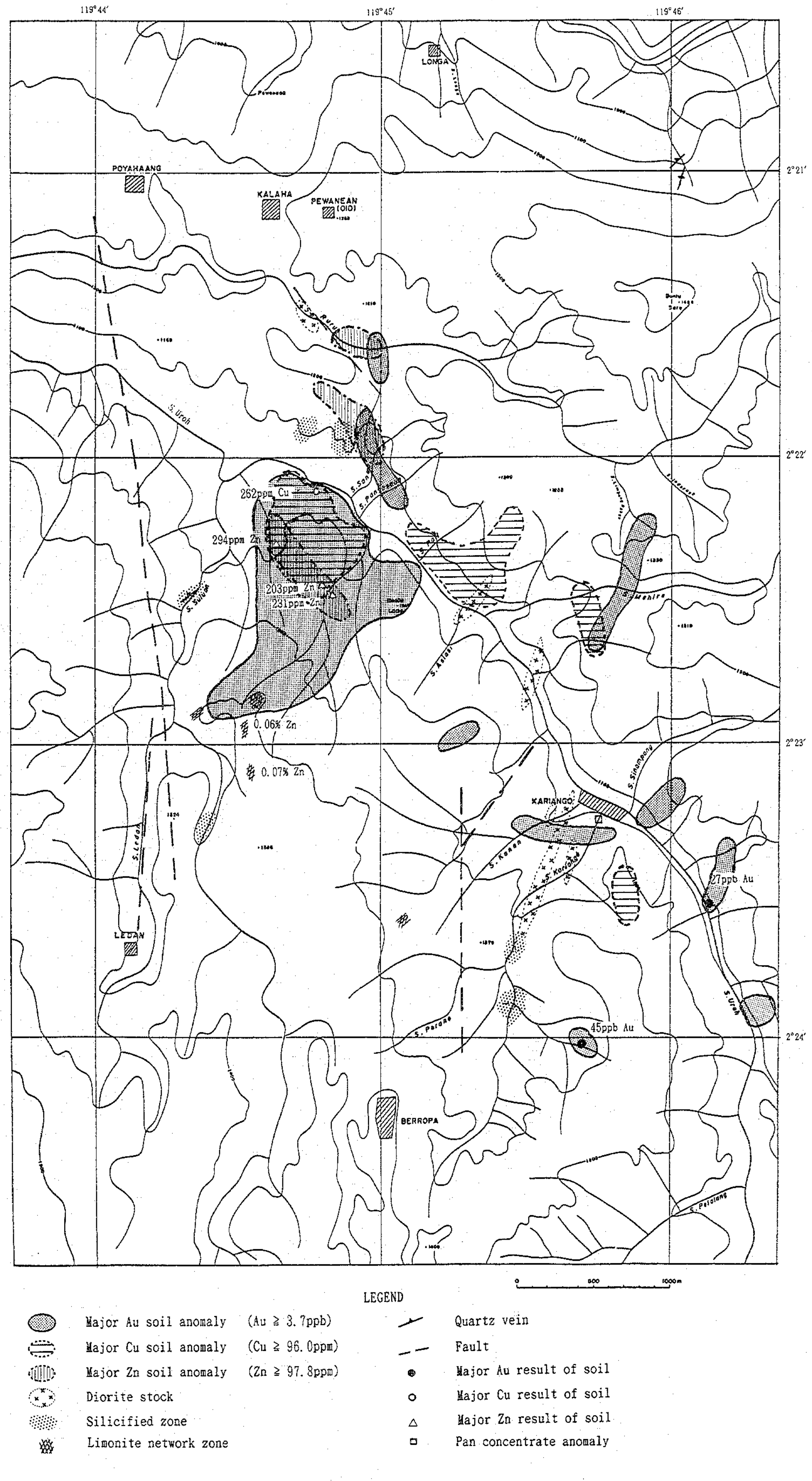


Fig. 1-10 Integrated Interpretation of the Survey Results in the Kariango Prospect

PART II DETAILED DISCUSSIONS

PART II DETAILED DISCUSSIONS

Chapter 1 Regional Survey

1-1 Outline of the Survey

Prior to the field survey, the analysis of existing information and satellite imagery photogeological interpretation were made. The major purpose of these preliminary studies is to define the geological setting of the survey area.

The regional survey was carried out over the area of approximately 3,000 km^2 in the first phase. It was composed of regional geological survey and stream sediment geochemical exploration.

On the basis of the results of the regional survey, two areas -- Batuisi and Bau -- were picked up for semi-detailed survey prospects. Semi-detailed geological survey, panning prospecting and preliminary soil survey were carried out during the first phase field survey.

In addition to those, application tests of mercury gas geochemistry and plant leaf biogeochemistry to the tropical rainforest land were conducted in the Batuisi prospect.

1-2 Satellite Imagery Photogeological Interpretation

1-2-1 Methodology

The purpose of photogeological interpretation is; ① to produce the drainage system maps for field survey, and ② to obtain guidelines for geological survey and geochemical exploration by elucidating the geologic units and the regional geologic structure of the survey area. As was already explained in the previous chapter, topographic information of the survey area was not available in the first phase, thus the first purpose of satellite imageries had been very important, as well as the second one.

The imageries used in the examination were the Landsat TM and SPOT HRV false color prints of 1:100,000 scale. Band-1, -2 and -3 of the multispectral mode were selected and assigned to blue, green, and red respectively in case of SPOT imagery. The configuration of TM bands was made for the purpose of coherency. Band-2, -3 and -4, which are usually suitable for geological interpretation in the vegetation area were selected. The imageries cover the

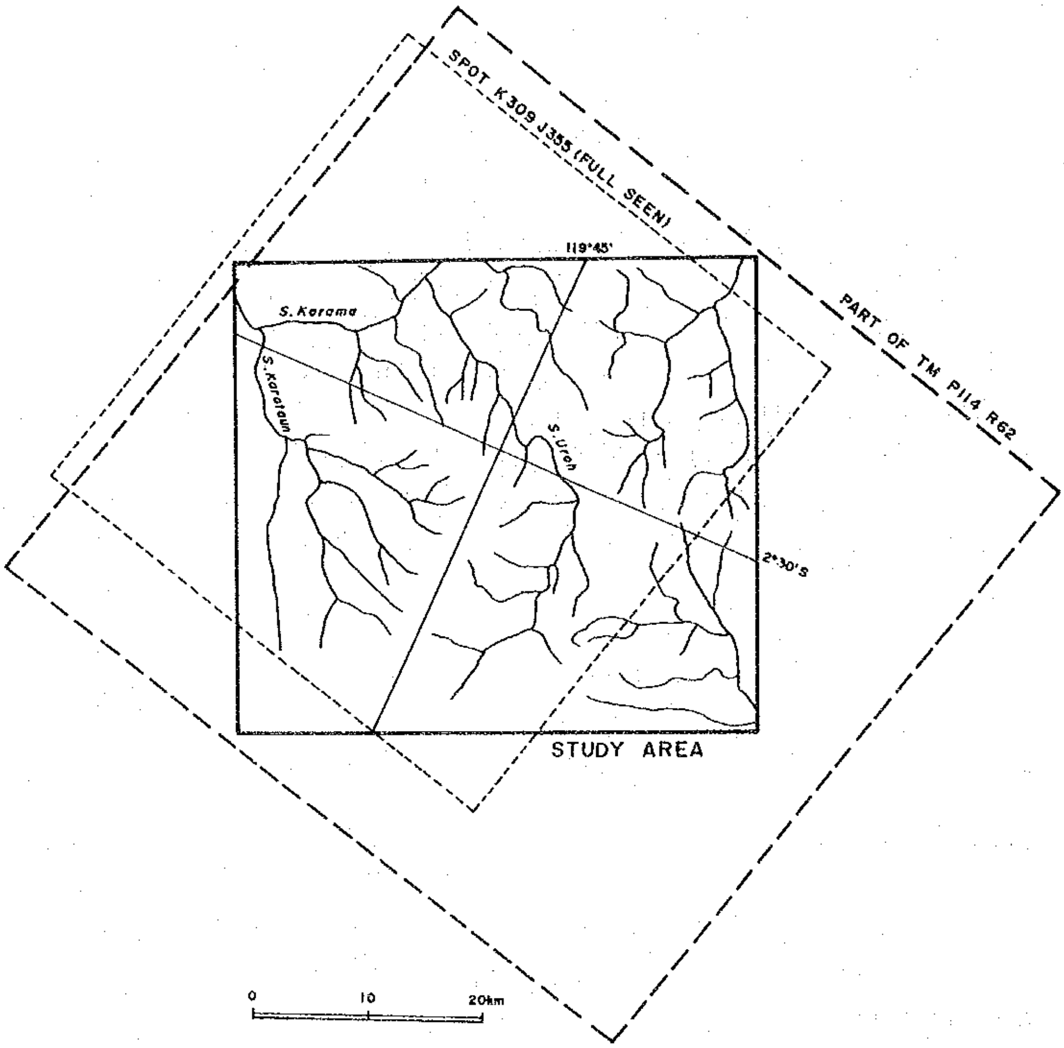


Fig. 2-1-1 Map of the Coverage Areas of Satellite Imageries

area shown in Fig. 2-1-1. Details of the imageries are listed in the tables below.

Generally speaking, the SPOT multispectral imagery has to be high resolution in itself. The specific scene, however, showed a misty view, something like covered by a thin film which was caused by evapotranspiration in the tropical rainforest land. The southeastern part of the survey area is not covered by the SPOT scene. These faults were compensated by the TM imagery, which had slightly bigger cloud covers. Results of geological interpretation using both TM and SPOT imageries were compared each other. No significant difference has been obtained in the analyses.

LANDSAT TM DATA (LANDSAT-4)	PATH	ROW	DATA ACQUISITION DATE	CLOUD COVER	ID NO
	114	062	Dec 16, 1990	10 %	Y4307501350XO
BAND SELECTION	2,3,4 = B,G,R				

SPOT HRV (SPOT-1)	K	J	DATA ACQUISITION DATE	CLOUD COVER	QUALITY
	309	355	Sep 18, 1987	0～25 %	E
MODE SELECTION	MULTISPECTRAL (XS)				

As the survey area is situated in the tropical rainforest zone, it was presumed that vegetation cover would prevent the interpretation in some of the area. In addition to that, sedimentary structures, which could be ordinarily utilized to follow the succession of geologic units, were rather obscure in this area. A special attention was thus paid into the topographic features and texture, drainage pattern and density, and linear structures. The boundary of granite bodies was the other important point that deserved an attention.

1-2-2 Results of the Interpretation

(1) Geologic Units

Based on the photogeological characteristics, four major geologic units were classified and identified in the survey area. It is composed of a high resistance igneous rock unit (G), a high to moderate resistance sedimentary rock unit (K), a moderate to low resistance clastic rock unit (T), and a very low resistance unconsolidated sediment unit (Q). The K and T units were further studied in details, and were subdivided into K_1 and K_2, and T_1 to T_5 respectively. Results of the photogeological classification are summarized in

Table 2-1-1. The interpretation map is shown in Fig. 2-1-2.

① Units K_1 and K_2

Unit K_1 is a high to moderate resistance rock unit. It occurs in the western area, within the distribution of igneous body (unit G). It shows some sedimentary features, and has minor fracturing/bedding textures within itself. It corresponds to metamorphic rocks of Mesozoic formation.

Unit K_2 is developed in the northwestern area, mainly on the southern side of the upper reaches of S. Karama. It roughly corresponds to the distribution of metasediments of the Latimojong Formation. It is characterized by a moderate resistance rock unit. From the morphological features of the image, this unit appears to have a brittle nature. It means that the rock unit probably consists of argillaceous sedimentary rock, such as massive shale and siltstone.

② Unit G

Unit G is a hard, massive, and high resistance rock, implying igneous body. There were several occurrences observed in the survey area. The largest one is in the western area. Other bodies were found in the eastern area too. They almost correspond to the distribution of granite intrusions.

Within the western unit, minor lineaments of mainly NNE to N-S trend are extensively developed. They were supposed to be fractures or igneous joints. Major drainage patterns within and surrounding the body, composed mainly of the second order, show the similar trend (NNE to N-S).

③ Units T ($T_1 \sim T_5$)

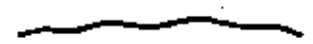
A group of units (T) generally has moderate to low resistance. These units cover most of the area, apart from the distribution of metasediments and igneous bodies. Most of them show massive rough texture, lacking of sedimentary structure in general. These features, combined with the existing information, indicate that the units correspond to the volcaniclastic rocks of Paleogene to Neogene Tertiary and Pleistocene age.

The members were subdivided into five ($T_1 \sim T_5$) on the basis of minor differences within the units. The differences of textures distinguished were; massive vs. bedded, and rough vs. smooth. Photographic tone and the pattern of drainage system were also considered in the subdivisions.

④ Unit Q

This unit occurs at two locations. One is in the northwestern area on the northern side of S. Karama. Another location of the unit is in the northeastern area near Eno along the uppermost reaches of S. Bituwe.

Table 2-1-1 Summary of Photogeological Interpretation

Characteristics / Geologic units	Image-Characteristics			Morphological Expression					Correlation
	Tone	Texture	Vegetation	Drainage		Landform			
				Pattern	Density	Cross Section	Resistance	Surface	
Q	Blueish to pale blue	Very fine	Low glass land	Meandering	Low		Very low	Smooth	Alluvial or fluvial and talus deposits
T_5	Dark blue to Dark brown	Fine	Moderate~high	Subdendritic	High		Low	Horizontal Smooth	Clastics and Pyroclastics
T_4	Reddish brown	Medium to coarse	High	Subdendritic to subparallel	High		Moderate	Massive	Volcanics (mainly lavas)
T_3	Dark brown	Coarse	Moderate~high	Subdendritic	High		Low to moderate	Rough	Tuff breccias or lavas
T_2	Dark brown	Coarse	High	Subdendritic to subparallel	Moderate		Moderate to high	Massive	Tuffs, lavas and some sediments
T_1	Brown	Medium to coarse	Moderate	Subdendritic	Moderate		Low	Moderate	Tuffs
K_2	Blueish brown	Fine	Low	Subdendritic	High to moderate		Moderate	Rough and smooth	Sediments and pyoclastics
K_1	Reddish pale brown	Coarse to medium	Moderate	Subdendritic Partly subparallel	High		Moderate to high	Moderate	Sediments
G	Reddish brown	Medium	Moderate	Subdendritic to subrectangular	High		High	Massive	Granites

It is characterized by the very low resistance. The unit shows the development of meandering drainage system with low density. It also shows flat and smooth topography and very fine-grained texture. This unit was inferred to be composed of Quaternary unconsolidated sediments. It also indicates the area of cultivated field and plantation land.

(2) Geologic Structure

Bedding and other sedimentary structures were generally very obscure in the survey area. Successions and mutual relationship were hardly distinguishable among the units. Photolineaments representing faults and fracture zones, and fracture traces indicative of igneous joints/minor fissures or weak bedding were observed in the area. Small scale synclinal structures were recognized.

① Lineaments

A total of 176 lineaments was counted throughout the area.
The prominent direction of the lineaments is NNE. N-S and NE are the next dominant directions. These lineaments were characteristically found in the western area, especially within and around the G unit. The other dominant direction of lineaments is E-W. The distribution of lineaments is shown in Fig. 2-1-2. Frequencies and total lengths of lineaments in each direction are counted as follows:

DIRECTION		FREQUENCY		TOTAL LENGTH	
			%	km	%
E-W	S78.75°E - N78.75°E	14	8	61.5	11
ENE	N78.75°E - N56.25°E	10	6	43.0	8
NE	N56.25°E - N33.75°E	24	14	85.5	16
NNE	N33.75°E - N11.25°E	59	34	161.5	29
N-S	N11.25°E - N11.25°W	38	21	90.0	16
NNW	N11.25°W - N33.75°W	8	4	33.5	6
NW	N33.75°W - N56.25°W	11	6	37.0	7
WNW	N56.25°W - N78.75°W	12	7	38.0	7
TOTAL		176	100	550.0	100

② Fracture traces

Numerous fracture traces were recognized in the western area. Most of them were found within K_1, K_2, and T_2 units. The major direction of fracture traces is NNE to N-S, same as the direction of lineaments.

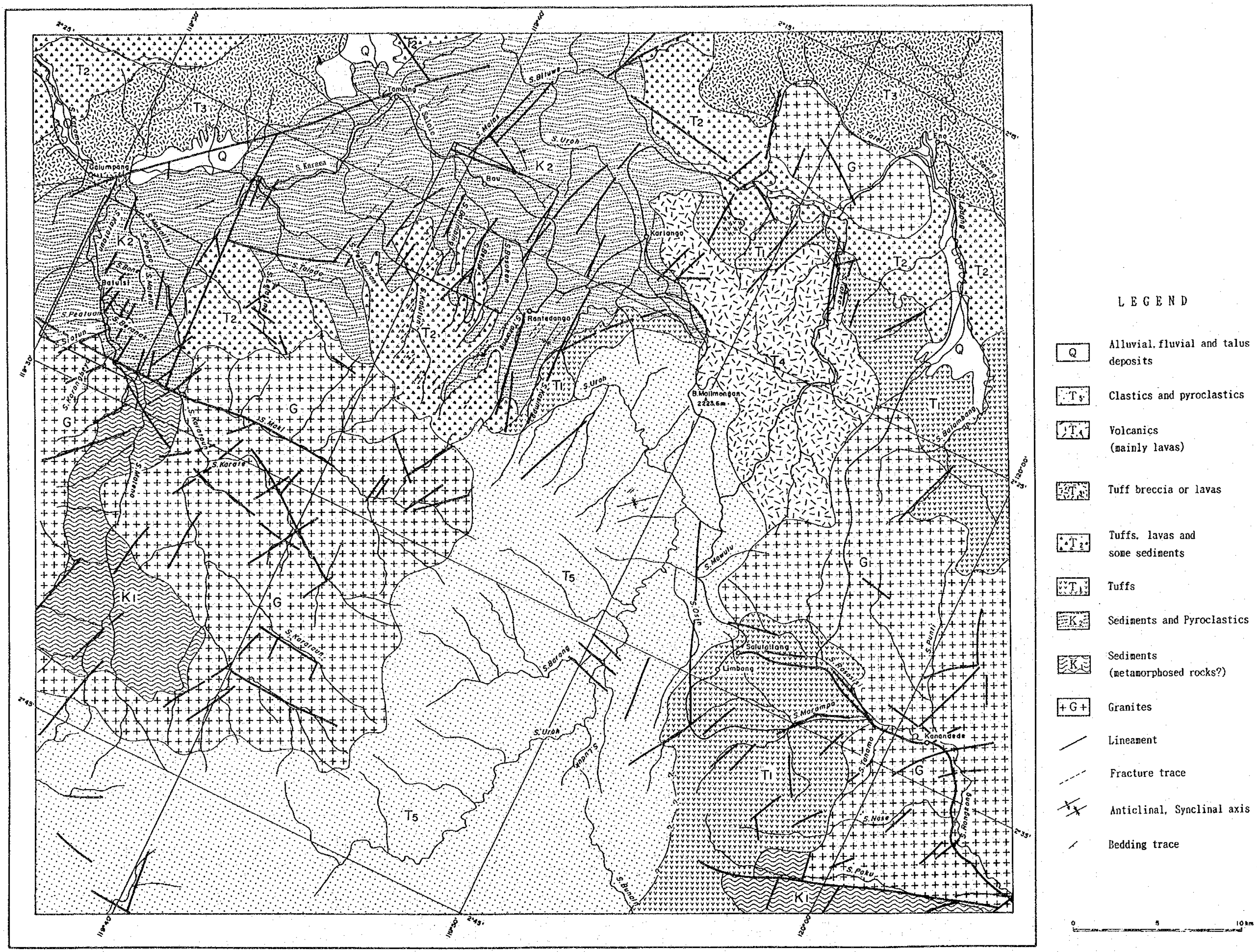


Fig. 2-1-2 Results of Satellite Imagery Photogeological Interpretetion

③ Synclinal structure

Small scale synclinal structures were observed in Unit K_2 and Unit T_5. The axes of the synclines are N-S and NE respectively.

④ Drainage pattern

The tertiary and higher order drainage systems run meanderingly. The lower order drainage systems have dendritic to subparallel pattern in general. Some of them, however, show parallel or subrectangular pattern having particular directions. Those in the western area, especially within and around the distribution of Unit G, show the distinctive NNE to N-S trend.

1-3 Geological Survey

1-3-1 Survey Method

The first phase regional operations consisted of geological survey and geochemical exploration, based on the analysis of existing geological information and satellite imagery photogeological interpretation, through which the geological setting of the survey area was defined.

Prior to the field work, the drainage system maps of 1:100,000 scale were prepared from the satellite imageries (TM and SPOT) which were used in the photogeological interpretation. A series of 1:50,000 drainage system maps enlarged from the satellite imageries was utilized in the regional survey. Several sets of GPS instruments were employed for locating major surveying points in the field.

In the course of the regional geological survey and stream sediment sampling, a couple of mineralized areas was found. Combined these field results with the existing information of alteration and mineralization on the area, semi-detailed geological survey and geochemical exploration comprising panning and soil sampling were carried out in two areas; ① Bau prospect, and ② Batuisi prospect. The route maps of 1:10,000 scale were produced during semi-detailed survey, using foot pacing or 50-meter tape with a Brunton-type compass. The important mineral showings were studied in much detail, and samples were taken for laboratory analysis.

A total length of 324 kilometers was explored during the regional survey, and the geological information was compiled into a 1:100,000 map. A total of other 153 kilometers was explored in the course of the semi-detailed survey, with the compilation of 1:25,000 geological maps.

The number of samples collected in the survey is; 1,010 stream sediment samples, 366 pan concentrate samples, 510 soil samples, more than 50 rock samples for thin sections and for whole rock analysis, more than 50 altered rock and clay samples for X-ray diffraction analysis, 5 igneous rock samples for age-dating, and more than 30 ore samples for assay and polished sections. Results of the laboratory works are briefly summarized in Tables 2-1-2 to 2-1-6.

1-3-2 Stratigraphy

As is already explained in the previous chapter, the geology of the regional survey area is composed of seven units.

① Mesozoic gneiss and schist (Batuan Malihan metamorphic rocks - basement of the area).

② Metasediments of supposed Cretaceous age, comprising slate, shale, siltstone, andesite lava, and dolerite (Latimojong Formation).

③ Paleogene shelf sediments, such as shale, sandstone, and limestone (Toraja Formation).

④ Lower Miocene volcanic and pyroclastic rocks and sediments, mainly composed of acidic to intermediate pyroclastic rocks such as pumice tuff, tuff, dacite lava, and shale (Lamasi Volcanic Rocks).

⑤ Middle to Upper Miocene volcanic and pyroclastic rocks and sediments, mainly composed of calcareous sediments, and basic tuff and lava (Beropa Tuffs, Sekala Formation, and Talaya Volcanic Rocks).

⑥ Neogene granitic batholiths and stocks (Mamasa and Kambuno granites).

⑦ Pleistocene acid volcanic and pyroclastic rocks, predominantly dacitic crystal tuff (Barupu Tuffs).

Regarding the geologic structure of the survey area, NW and E-W trending fault systems which cut Mesozoic to Neogene volcanic-sedimentary sequences occur. This area is situated at the south of the NW to NNW trending Fossa Sarasina fracture zone. The regional north-northwest trending structure runs parallel to the Fossa Sarasina. The emplacement of granite batholiths makes another significant feature of the area. The major part of the area is sandwiched by two granite bodies from east and west.

The geology and geologic profile of the regional survey area are shown in the attached plate. Fig. 1-6 shows the stratigraphy and outline of igneous activity in the area.

(1) Batuan Malihan Metamorphic Rocks

It is the oldest rock in the survey area. Biotite gneiss is the representative facies of the rock member in the western area. It crops out spatially associated with the Mamasa granite.

It shows light grey color, gneissose to schistose texture. It is composed of medium grain quartz, plagioclase, biotite, hornblende, and some opaque minerals. It shows lepidoblastic texture under the microscope.

Biotite gneiss and mica schist of the Batuan Malihan metamorphic member also occur locally along S. Paku in the southeastern part of the area.

(2) Latimojong Formation

The Latimojong Formation is composed of slate, shale, siltstone, altered andesite, and altered basalt/dolerite. It is widely distributed in the northwestern area. It also occurs partly in the southeastern area.

The lower part of the formation is generally composed of slate and black shale. The upper part, on the other hand, is composed of rather massive siltstone. Quartz sandstone and lenticular limestone are locally interbedded within the lower part.

Andesite, basalt and dolerite occur within the metasediments. In S. Salole and S. Karataun, andesite which shows dark green propylitic features occurs. In S. Salole and S. Taroto, doleritic/diabasic facies occurs within the metasediments. Under the microscope, the rock shows ophitic texture. It consists of fine to medium grain plagioclase, pyroxene, hornblende, epidote, and some augite. Chloritization and weak sericitization were observed in the rock.

An intrusive body of olivine gabbro was found in metasediments at S. Tarawa. The rock occurs at the middle reaches of S. Tarawa, and is moderately chloritized. This rock (D38R) was provided to K-Ar age dating (Table 2-1-2). The result showed 205 ± 10 Ma (Jurassic). It shows that some part of the Latimojong Formation is probably older than that by the existing geological information.

(3) Toraja Formation

Overlying unconformably on the Mesozoic strata are shale, sandstone, and limestone of the Paleogene Toraja Formation. The distribution is limited in the northwest and southeast, and is mainly located at the southern outside of the area. The formation in the northwestern area is made up of calcareous shale and siltstone.

(4) Lamasi Volcanic Rocks

The Lower Miocene volcanic and pyroclastic rocks of acid to intermediate composition are widely developed from S. Marampa and S. Rasasisi up to the north in the eastern area. Dacite and hornblende andesite lava, quartz porphyry dome, and fine tuff and lapilli tuff are main constituents of the rocks. Lavas generally have massive porphyritic features, whereas some part shows hyaloclastic texture. Sericitization and chloritization were weakly recognized. The strong alteration of chlorite-kaoline-pyrite assemblage was observed in dacite lava along S. Marampa.

Thin layers of basalt lava and basaltic tuff occur within the Lamasi Volcanic Rocks along S. Rasasisi. Shale and limestone are associated with basaltic layers. This facies was interpreted as the lower member of the Lamasi Volcanic Rocks, and probably of late Paleogene in age.

(5) Beropa Tuffs

The Middle to Upper Miocene volcanic-sedimentary rocks are subdivided into three sequences; Beropa Tuffs, Sekala Formation, and Talaya Volcanic Rocks.

The Beropa Tuffs consists of the alternation of andesite and basalt lavas, andesitic to basaltic tuffs, siltstone, and sandstone. It occurs mainly along the middle reaches of S. Uroh. Chlorite-carbonate alteration was observed in the Beropa Tuffs.

(6) Sekala Formation

The Sekala Formation consists mainly of black shale and siltstone. Thin layers of basalt lava and basaltic tuff are interbedded. Sedimentary facies is slightly metamorphosed in some places, showing phyllitic features. Limestone lenses occur within the Sekala Formation. The Sekala Formation is widely distributed in the northern part of the area.

(7) Talaya Volcanic Rocks

Volcanic rocks of intermediate to basic composition occur at the uppermost part of the Neogene Tertiary system. It is mainly composed of andesite lava and volcanic breccia. Basalt lava and basaltic tuff are interbedded with the volcanic rocks. The major part of the high mountain area in the southwestern to northeastern part is covered by the Talaya Volcanic Rocks. Near Galumpang in the northwestern area, tops of hills and mountains are covered by these volcanics.

(8) Barupu Tuffs

The Barupu Tuffs mainly consists of dacite lava and dacitic tuff. It is widely developed at the high altitudes in the eastern part of the survey area. Dacitic crystal tuff is the representative facies of the rocks. Under the microscope, it is composed of biotite, plagioclase, quartz, and pyroxene fragments set in a spherulitic and microcrystalline feldspar. Lithic fragments were sometimes contained.

1-3-3 Intrusive Rocks

(1) Kambuno Granite

The Kambuno granite batholith in the southeastern part of the survey area consists of quartz monzonite and diorite. Aplite dykes occur within the body in some places. Under the microscope, quartz monzonite is composed mainly of plagioclase, orthoclase, quartz, and biotite. Muscovite, hornblende, apatite, sphene and zircon were also observed as accessory minerals. It generally shows fine- to medium-grained, holocrystalline, hypidiomorphic-granular texture.

Several small stocks and dykes of the Kambuno granite are distributed in the eastern area. The largest stock, approximately 2 km x 5 km in size, occurs at the upper reaches of S. Betuwe. It represents granodiorite facies, consisting of plagioclase, biotite, and some pyroxene phenocrysts. It shows fine- to medium-grained subhedral to euhedral porphyritic texture.

K-Ar age dating yielded 11.4 ~ 10.4 Ma (late Miocene). The results of age dating are shown in Table 2-1-2.

(2) Mamasa Granite

The Mamasa granite batholith consists mainly of quartz monzonite and porphyritic quartz diorite. It is developed widely in the southwestern part of the survey area. Under the microscope, quartz monzonite shows medium-grained, holocrystalline, hypidiomorphic granular texture. Plagioclase, orthoclase, biotite, quartz and hornblende represent phenocryst minerals. Apatite, sphene and zircon occur as accessory minerals.

Porphyritic quartz diorite boulders, which contain feldspar phenocrysts as big as one's fist, were sometimes observed along the upper reaches of S. Karataun and S. Matena. This facies is one of the representative members of the Mamasa granite.

Table 2-1-2 Results of Potassium-Argon Analysis

Sample No.	Locality	Rock Name	Sample Type	K wt%	Rad ^{40}Ar $10^{-6}cc/gr$	K-Ar age Ma	$\%^{40}Ar$
C12R	S.Marampa (1)	Quartz Monzonite	Whole Rock	3.46	0.140		62.0
				3.47	0.140	10.4±0.5	56.8
C23R	S.Betuwe (2)	Granodiorite	Whole Rock	3.50	0.156		72.0
				3.50	0.155	11.4±0.6	71.0
C33R	S.Karataun (3)	Quartz Monzonite	Whole Rock	3.26	0.089		56.2
				3.24	0.090	7.1±0.4	66.4
D30R	S.Matena (3)	Quartz Monzonite	Whole Rock	4.43	0.128		59.3
				4.39	0.128	7.5±0.4	61.8
D38R	S.Tarawa (4)	Gabbro	Whole Rock	0.27	0.231		73.8
				0.27	0.225	205±10	73.7

※ Samples are;

(1) Kambuno granite, (2) Stock of Kambuno granite, (3) Mamasa granite

(4) Dyke rock intruded in metasediments of the Latimojong Formation.

※ Analysis conducted by Teledyne Isotopes, USA.

Small stocks and dykes of granodiorite and diorite occur mainly within metasediments of the Latimojong Formation in the northwestern part of the survey area.

K-Ar age dating yielded 7.5 ~ 7.1 Ma (late Miocene).

(3) Porphyritic Andesite

Porphyritic andesite which makes up domes and dykes is the most popular intrusive rock in the survey area. It intrudes into from metasediments of the Latimojong Formation up to volcanic breccias of the Talaya Volcanic Rocks. It shows medium-grained porphyritic texture. According to the microscopic observation, most of them are hornblende andesite, and some are biotite andesite.

Several small stocks and dykes of quartz porphyry are distributed in the survey area. It occurs within from metasediments of the Latimojong Formation up to volcanic breccias of the Talaya Volcanic Rocks.

(4) Whole Rock Analysis

Fifty rock samples were provided for whole rock analysis. Thirteen elements including BaO and LOI were analyzed at Chemex Labs Ltd. Results of chemical analysis and CIPW norm calculation are shown in Table 2-1-3. Rock names of igneous and volcanic rocks identified from field observations and thin sections were checked through the analysis.

Several compositional comparisons among the granitic rocks were made based on the chemical analysis (Fig. 2-1-3). In the normative quartz－plagioclase－orthclase diagram, the Kambuno granite mostly occupies quartz-monzonite region. A few samples from the Kambuno granite were plotted in the granodiorite region. Whereas the Mamasa granite shows wider variation in its composition. Data of the Mamasa granite spread over the regions of quartz-monzonite, granodiorite and diorite. In the K_2O-Na_2O-CaO compositional diagram, the Kambuno granite shows rather rich in K_2O. The Mamasa granite, on the contrary, shows comparatively rich in Na_2O.

On the Fe^{3+}/Fe^{2+}－SiO_2 diagram, which is applied for distinguishing between magnetite series and ilmenite series divisions of granite, most of the samples were plotted in the region of magnetite series granite (refer to Sato & Ishihara, 1983). No specific difference between the Kambuno and Mamasa granites has been recognized on the diagram. Some other comparisons -- DI (Differentiation Indices) and A/CNK Values (Al_2O_3／[CaO+Na_2O_3+K_2O] values) -- show little difference between two granitic rocks.

These results show that there is no difference in their magmatic series between the Kanbuno and Mamasa granite bodies, though they have their own compositional characters.

1-3-4 Geologic Structure

(1) Fold Structure

Several fold systems, from regional anticline to local minor foldings, were observed in the survey area.

Regional anticlinal structure is distinctive in the northwestern to central area within metasediments of the Latimojong Formation, tuffaceous siltstone of the Beropa Tuffs, and black shale of the Sekala Formation. Slate and shale along S. Karataun generally dip to the west. Whereas black shale and siltstone along S. Betuwe commonly show east dipping. Tuffaceous siltstone along the middle reaches of S. Uroh has a trend of gentle east dipping. This anticlinorium has an axis of approximately north-south direction.

Local anticlines and synclines of similar trend were observed in the area between S. Pongo and Kp. Rantedonga. A couple of local anticline and syncline of north-south axes was recognized within black shale in the Bau prospect.

Mesozoic to Neogene structures in the eastern part of the survey area were not clear in most cases because of the indistinct bedding of formations.

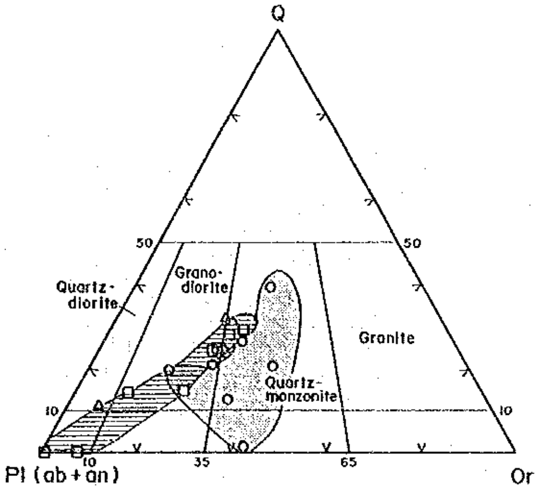
(2) Fault

Faults of NW to WNW systems were found within the Middle to the Upper Miocene volcanic-sedimentary rocks in the northeastern part of the survey area.

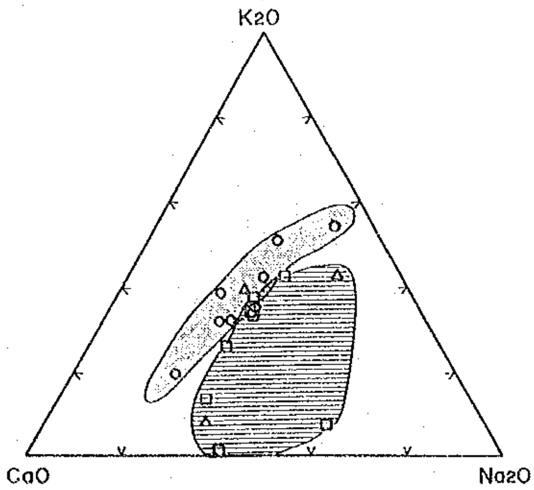
Faults of E-W trend occur within the Mamasa granite and the Barupu Tuffs in the southwestern area.

A couple of faults of NE trend was found within metasediments near the mineralized zones in the Batuisi prospect.

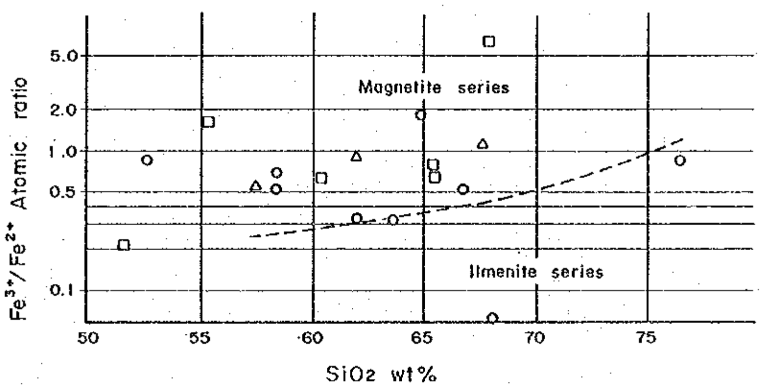
Faults of NNE to N-S systems, which were picked up through the satellite imagery photogeological interpretation, have not been encountered during the geological survey. This type of fractures probably exists as igneous joints and/or minor faults of small displacement. Some of intrusive rocks showed the similar trend in the survey area.



Normative Quartz - Plagioclase - Orthoclase Diagram



K2O - Na2O - CaO Diagram



Fe^{3+}/ Fe^{2+} Ratio - SiO_2 Diagram

LEGEND

- ○ Kambuno Granite (Tmk)
- □ Mamasa Granite (Tmg)
- △ Stocks and Dykes

Fig. 2-1-3 Normative and Chemical Composition Diagrams of Granitic Rocks

Table 2-1-3 Results of Whole Rock Analysis and Norm Calculation (1/3)

/S.No	A01R	A03R	A05R	A06R	A28R	A29R	A30R	B02R	B09R	B10R	B25R	B30R	B31R	B35R	C04R	C07R	C08R	C13R
SiO_2	67.590	72.850	58.900	68.110	47.050	61.120	57.550	64.850	60.460	57.290	49.120	50.480	49.000	45.350	67.580	51.450	71.570	52.640
TiO_2	0.440	0.440	1.000	0.450	0.540	0.470	0.690	0.630	0.710	0.640	1.340	1.530	1.450	1.880	0.510	0.680	0.380	1.180
Al_2O_3	15.960	13.450	13.630	13.060	8.910	17.160	17.850	15.490	15.820	13.460	16.410	13.600	14.080	15.730	15.250	18.390	14.530	17.180
Fe_2O_3	3.210	1.840	3.563	1.629	2.718	1.615	2.034	1.997	1.456	2.837	2.236	2.349	3.056	3.015	1.543	3.598	1.539	3.530
FeO	0.360	0.270	1.770	0.910	3.700	3.550	3.380	1.910	3.810	3.620	7.130	8.180	7.400	8.310	0.960	3.700	0.640	3.860
MnO	0.160	0.005	0.040	0.050	0.150	0.100	0.100	0.060	0.110	0.190	0.160	0.220	0.190	0.170	0.040	0.120	0.030	0.130
MgO	0.870	0.560	4.180	0.980	7.460	2.830	4.290	2.230	3.200	6.200	5.420	7.480	8.120	9.100	1.310	3.430	0.850	2.400
CaO	2.210	0.000	3.750	3.860	12.550	2.540	7.120	3.810	4.070	5.950	5.530	9.410	9.250	6.390	2.950	7.240	1.530	5.520
Na_2O	3.010	2.160	0.690	2.360	1.640	4.990	4.350	2.660	3.660	3.070	4.890	3.280	3.240	3.680	2.340	4.390	3.110	3.030
K_2O	4.260	4.750	4.920	3.340	0.130	1.160	0.900	4.210	3.850	3.080	0.150	0.130	0.120	0.060	3.030	0.780	4.270	5.420
P_2O_5	0.150	0.360	0.760	0.200	0.090	0.140	0.120	0.290	0.320	0.240	0.190	0.110	0.100	0.200	0.220	0.260	0.190	0.750
BaO	0.110	0.080	0.200	0.070	0.010	0.010	0.010	0.090	0.120	0.100	0.005	0.005	0.005	0.005	0.140	0.020	0.090	0.290
LOI	2.500	3.420	6.010	5.670	15.160	4.240	2.040	2.390	1.760	2.210	5.560	0.800	1.230	3.660	4.710	5.730	1.600	2.520
Total	100.830	100.185	99.413	100.689	100.108	99.925	100.434	100.617	99.346	98.887	98.141	97.574	97.241	97.550	100.583	99.788	100.329	98.450
Formation	Qt	Toml	Toml	Toml	Kl	Dyke	Dyke	Qt	Dyke	Dyke	Kl	Kl	Kl	Kl	Toml	Toml	Qt	Tmk
Locality	Uroh	Marampa	Marampa	Marampa	Karataun	Karataun	Karataun	Uroh	Uroh	Uroh	Petagunan	Taroto	Taroto	Lebutang	Rasasisi	Rasasisi	Rasasisi	Kakea

/S.No	C14R	C15R	C16R	C17R	C24R	C30R	C31R	C32R	C34R	C36R	C37R	D07R	D08R	D11R	D12R	D18R	D24R	D25R
SiO_2	44.110	45.790	47.170	49.430	58.450	47.000	65.510	65.590	60.510	65.500	40.860	51.290	61.460	46.220	62.050	61.300	46.520	59.270
TiO_2	1.050	1.060	1.070	0.970	0.740	1.500	0.690	0.630	0.910	0.710	0.300	1.160	0.960	0.920	0.760	0.460	0.290	0.980
Al_2O_3	16.750	16.520	12.140	15.790	13.400	15.730	14.980	15.490	16.800	15.090	17.560	16.380	14.980	16.950	16.140	18.980	17.530	16.900
Fe_2O_3	5.806	4.912	7.650	3.968	2.443	1.741	1.964	1.441	2.180	1.741	3.597	5.696	3.225	6.316	3.024	4.411	2.914	3.146
FeO	3.540	4.740	3.320	4.330	3.120	6.820	2.210	2.060	3.140	2.420	2.540	3.360	1.300	3.720	3.020	0.440	4.010	2.370
MnO	0.180	0.170	0.160	0.160	0.130	0.140	0.070	0.080	0.090	0.070	0.310	0.140	0.060	0.160	0.070	0.110	0.120	0.070
MgO	5.870	6.060	6.510	6.410	5.880	6.620	2.820	1.410	3.860	2.840	8.250	4.370	2.700	5.140	2.920	1.900	10.970	4.020
CaO	8.420	10.760	9.970	8.480	5.250	6.150	3.800	3.740	5.330	3.740	24.430	6.760	3.480	9.950	1.020	1.670	10.260	5.300
Na_2O	3.030	2.690	2.390	2.470	2.980	5.380	3.210	3.050	3.480	3.180	0.360	4.620	3.400	1.870	3.480	5.070	2.240	3.180
K_2O	2.280	1.600	2.970	2.840	3.850	0.070	3.610	3.260	3.090	3.600	0.050	2.270	6.280	3.420	3.430	2.390	0.050	4.000
P_2O_5	0.570	0.600	0.570	0.530	0.450	0.180	0.240	0.280	0.350	0.270	0.005	0.820	0.760	0.640	0.340	0.370	0.010	0.460
BaO	0.100	0.110	0.130	0.190	0.130	0.005	0.070	0.070	0.080	0.070	0.005	0.330	0.260	0.180	0.100	0.150	0.005	0.160
LOI	7.050	3.370	4.160	3.640	2.100	6.520	0.870	3.550	0.970	0.970	1.640	1.990	1.180	3.630	3.140	3.570	4.130	0.005
Total	98.756	98.382	98.210	99.208	98.917	97.856	100.044	100.651	100.790	100.201	99.907	99.186	100.045	99.116	99.494	100.821	99.049	99.861
Formation	Tmt	Tmt	Tmt	Tmt	Tmk	Kl	Tmg	Qt	Tmg	Tmg	Dyke	Tmt	Tmb	Tmb	Dyke	Dyke	Dyke	Mw
Locality	Kakea	Kakea	Kakea	Kakea	Bituwe	Salore	Maki	Maki	Karate	Karataun	Karataun	Uroh	Uroh	Kasimpo	Kasimpo	Bau	Karataun	Matena

Abbreviations: Qt;Barupu Tuffs, Tmt;Talaya Volcanic Rocks, Tmk;Kambuno granite, Tmg;Mamasa granite, Tmb;Beropa Tuffs, Toml;Lamasi Volcanic Rocks, Kl;Latimojong Formation
Mw;Batuan Malihan Metamorphic Rocks

Table 2-1-3 Results of Whole Rock Analysis and Norm Calculation (2/3)

/S. No	D27R	D29R	D31R	D40R	E01R	E03R	E05R	E07R	E09R	E13R	E23R	E44R	E47R	G01R
SiO_2	68.130	67.800	67.930	44.690	66.750	63.630	61.970	58.470	64.950	76.560	55.220	62.090	51.640	67.730
TiO_2	0.620	0.620	0.630	4.350	0.590	0.700	0.780	1.000	0.540	0.080	0.570	0.430	1.550	0.420
Al_2O_3	15.240	15.160	15.650	12.080	15.760	15.520	16.420	16.710	15.630	13.290	18.010	17.680	16.500	15.060
Fe_2O_3	0.000	1.669	2.413	2.695	1.053	1.017	1.024	2.242	2.578	0.273	3.855	1.647	1.441	2.239
FeO	3.820	1.360	0.330	11.450	1.860	2.990	2.930	3.840	1.190	0.330	2.110	3.350	6.460	0.550
MnO	0.050	0.050	0.030	0.240	0.050	0.070	0.060	0.110	0.060	0.010	0.140	0.100	0.130	0.040
MgO	1.700	1.670	1.390	3.210	1.510	3.980	2.540	4.460	2.630	0.210	3.250	2.530	4.900	1.120
CaO	3.390	3.350	2.460	6.520	3.010	4.430	2.210	6.490	3.630	0.710	6.390	3.410	3.960	2.420
Na_2O	2.980	2.920	3.400	4.470	2.980	2.910	2.810	2.390	3.220	3.260	3.630	5.110	7.070	2.050
K_2O	3.790	3.830	4.300	0.070	4.400	3.530	5.200	2.190	3.720	4.730	1.520	1.080	0.840	4.380
P_2O_5	0.310	0.290	0.400	0.450	0.140	0.250	0.300	0.240	0.240	0.080	0.410	0.120	0.290	0.260
BaO	0.080	0.080	0.130	0.010	0.060	0.070	0.120	0.060	0.080	0.010	0.090	0.030	0.060	0.030
LOI	1.160	1.750	1.180	6.290	2.140	1.360	3.810	1.410	2.450	0.570	4.770	2.630	5.230	3.380
Total	100.245	100.549	100.243	96.525	100.303	100.457	100.174	99.612	100.918	100.113	99.965	100.257	100.081	99.729
Formation	Tmg	Dyke	Tmg	Tmg	Tmk	Tmk	Tmk	Tmk	Tmk	Tmk	Tmg	Dyke	Tmg	Qt
Locality	Matena	Matena	Matena	Tarawa	Rongkong	Rongkong	Rongkong	Rongkong	Punti	Rongkong	Malas	Pongo	Makalik	Uroh

Abbreviations: Qt;Barupu Tuffs, Tmt;Talaya Volcanic Rocks, Tmk;Kambuno granite, Tmg;Mamasa granite, Tmb;Beropa Tuffs, Toml;Lamasi Volcanic Rocks, Kl;Latimojong Formation, Mw;Batuan Malihan Metamorphic Rocks

Table 2-1-3 Results of Whole Rock Analysis and Norm Calculation (3/3)

/S.No	A30R	C13R	C24R	C31R	C34R	C36R	D12R	D27R	D29R	D31R	D40R	E01R	E03R	E05R	E07R	E09R	E13R	E23R	E47R
Q	7.618	0.993	8.783	21.038	11.734	20.972	22.235	24.221	27.231	25.660	0.000	23.527	17.159	16.528	15.097	20.975	37.777	11.062	0.000
C	0.000	0.000	0.000	0.000	0.000	0.000	5.656	0.810	0.811	2.173	0.000	0.958	0.000	2.864	0.000	0.279	1.708	0.000	0.000
or	5.319	32.032	22.754	21.335	18.262	21.276	20.271	22.399	22.635	25.413	0.414	26.004	20.862	30.732	12.943	21.985	27.954	8.983	4.964
ab	36.787	25.624	25.201	27.146	29.430	26.893	29.430	25.201	24.694	28.753	37.802	25.201	24.609	23.764	20.212	27.231	27.569	30.698	48.573
an	26.530	17.273	11.821	15.809	21.100	16.273	2.861	14.809	14.740	8.816	12.700	14.023	18.865	9.021	28.403	16.451	3.004	28.366	10.821
ne	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
wo	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
di-wo	3.342	2.195	4.721	0.620	1.283	0.221	0.000	0.000	0.000	0.000	6.984	0.000	0.622	0.000	0.932	0.000	0.000	0.282	2.899
di-en	2.302	1.443	3.551	0.464	0.917	0.158	0.000	0.000	0.000	0.000	2.810	0.000	0.420	0.000	0.641	0.000	0.000	0.243	1.648
di-fs	0.770	0.596	0.696	0.094	0.251	0.044	0.000	0.000	0.000	0.000	4.240	0.000	0.154	0.000	0.217	0.000	0.000	0.000	1.127
hy-en	8.377	4.531	11.087	6.556	8.692	6.912	7.269	4.232	4.157	3.460	3.735	3.759	9.487	6.323	10.462	6.547	0.523	7.847	0.000
hy-fs	2.803	1.870	2.173	1.332	2.378	1.920	1.923	6.929	0.188	0.000	5.637	1.664	3.470	3.358	3.536	0.000	0.267	0.010	0.000
ol-fo	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7.394
ol-fa	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.686	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.569
mt	2.947	5.116	3.460	2.846	3.160	2.523	4.382	0.000	2.418	0.000	3.906	1.526	1.474	1.484	3.250	2.466	0.396	5.587	2.088
hm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.412	0.000	0.000	0.000	0.000	0.000	0.876	0.000	0.000	0.000
il	1.311	2.242	1.406	1.311	1.729	1.349	1.444	1.178	1.178	0.761	8.264	1.121	1.330	1.482	1.900	1.026	0.152	1.083	2.964
tn	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.563	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ap	0.284	1.776	1.065	0.568	0.829	0.639	0.805	0.734	0.687	0.947	1.065	0.331	0.592	0.710	0.568	0.568	0.189	0.971	0.687
Total	98.390	95.660	96.700	99.110	99.760	99.170	96.260	99.020	98.740	98.950	90.230	98.100	99.030	96.250	98.150	98.380	99.540	95.120	94.810
A/CNK	1.443	1.230	1.109	1.411	1.412	1.434	2.035	1.500		1.540	1.092	1.517	1.428	1.507	1.510	1.479	1.528	1.561	1.390
D.I.	49.724	58.649	56.738	69.519	59.426	69.141	71.936	71.821		79.826	38.216	74.732	62.630	71.024	48.252	70.191	93.300	50.743	53.537
Fe^3/Fe^2	0.542	0.823	0.693	0.800	0.625	0.647	0.901		1.104	6.579	0.212	0.509	0.306	0.315	0.525	1.949	0.744	1.644	0.201