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

PHASE II

FEBRUARY 1993

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 in the Toraja area, 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 Second Phase of the Cooperative Mineral Exploration consists of geological survey and geochemical exploration for precious- and base-metal resources in the Toraja area.

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 1993

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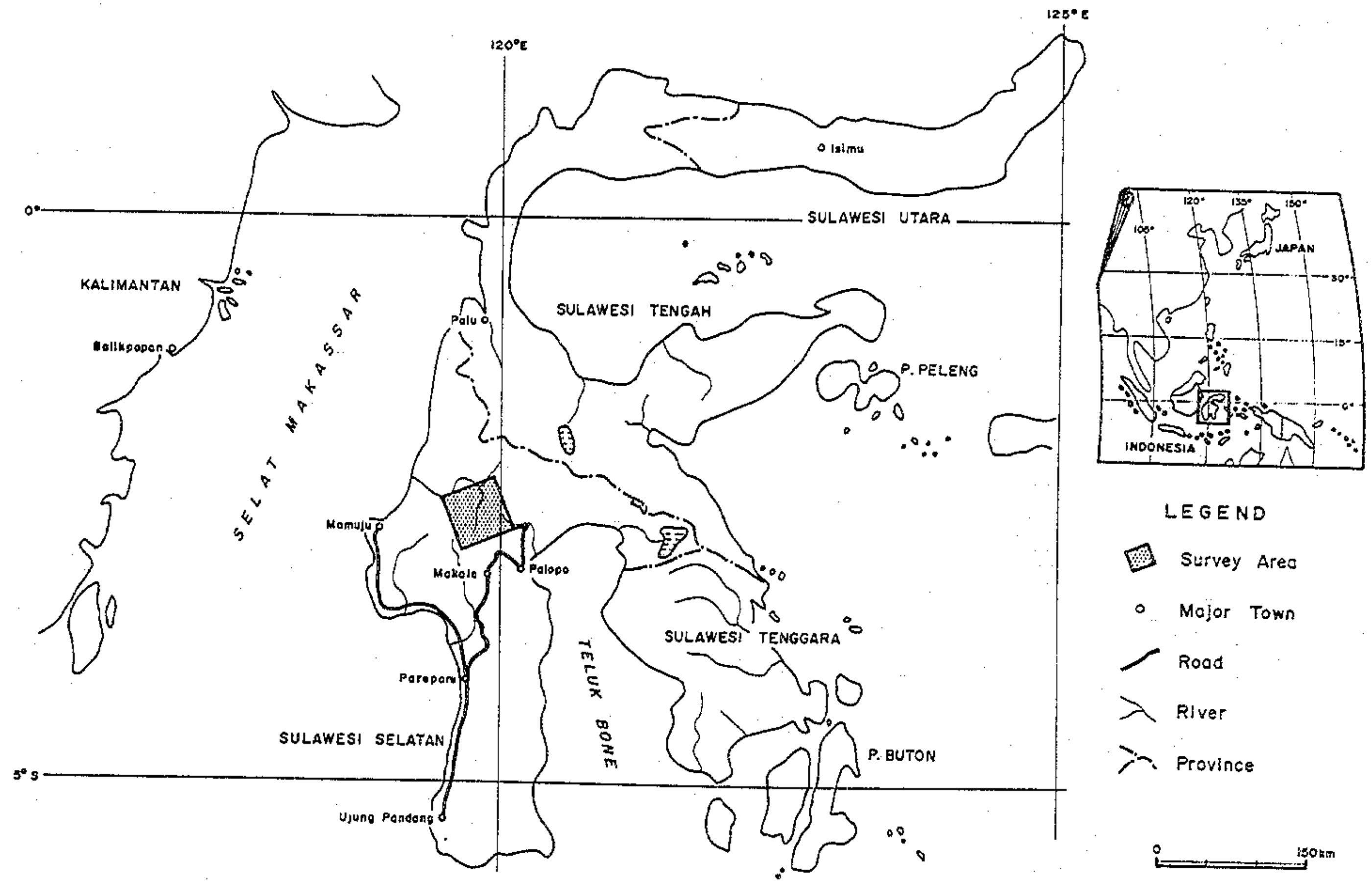

Fig.1-1 Location Map of the Survey Area

SUMMARY

The exploration this year corresponds to the second phase of the three-year cooperative mineral exploration programme in the Toraja area. The principal objective of this project is to find a new mineral deposit in the area through the exploration and the examination of geology and mineralization. The works conducted this year are examination and discussions of the results of the first phase geochemical exploration, detailed geological survey and geochemical exploration in the Batuisi and Bau prospects, semi-detailed geological survey and geochemical exploration in the S. Lebutang and Kariango prospects, and a small drilling programme for reconnaissance purpose in the Batuisi prospect. More than 225 km of survey length were traversed, and more than 3,000 soil samples and 400 geochemical rock-chip samples were collected altogether this year. Five holes of short diamond drilling totalling 401.5 m were conducted in the Batuisi prospect.

As a result of these works, three outstanding zones of gold mineralization which were located within an area of 2,500 m x 1,500 m were delineated in the Batuisi prospect. The type and condition of gold mineralization was discussed on the basis of petrology, mineralogy, hydrothermal alteration and fluid inclusion studies.

The geology of the Batuisi prospect is composed of black shale, siltstone, tuff, and andesite of the Cretaceous Latimojong Formation. The Mamasa granite batholith is exposed several kilometers to the south of the prospect. The prospect is structurally situated on the western flank of an anticlinorium formed by the emplacement of the Mamasa granite.

Extensive development of quartz veins and quartz stockworks was confirmed in the Batuisi prospect. Several vein systems were distinguished, and the formation of the vein pattern was discussed in conjunction with the stress-strain field generated by the emplacement of granite.

Two styles of quartz and sulphide mineralization were distinguished at the central area of the prospect. One is massive quartz veins with dissemination of pyrite and chalcopyrite mainly found at the middle reaches of S. Tarawa and S. Malela. Another is quartz stockworks which accompany an impregnation of pyrite and chalcopyrite within the zone. The stockwork system was caught mainly at the area extending from the upper reaches of S. Tarawa to the upper reaches of S. Bone.

Significant gold values were returned from outcrops, floats, rock-chips and trench samples within the area. An assay result of 1.34 g/t Au at 7 cm in width

was obtained from a part of a massive quartz vein at the middle reaches of S. Tarawa. A quartz rock-chip of 1,685 ppb Au was found at the middle reaches of S. Bone. A value of 0.53 g/t at 80+ cm in width was returned from an outcrop of massive quartz vein at the northern side of the upper reaches of S. Bone. The best result of channel samples in trenches is 1.52 g/t Au at 3.2m in width. A value of 0.40 g/t Au was obtained from a quartz float zone at the S. Pongo area.

It is interpreted that the gold-bearing quartz veins and quartz stockworks were formed under mesothermal conditions. The similarity of the mineralization to the gold-bearing quartz veins of the Oya deposit in northern Japan is considered.

Three distinctive Au anomalies and several minor anomalies were delineated from grid soil survey and rock-chip geochemistry. The major anomalies are located at the upper reaches of S. Tarawa, S. Malela and the middle reaches of S. Bone. These anomalies are distributed within an area of 2,500 m (NE-SW) × 1,500 m (NW-SE) centered at the top of the ridge. They are composed of significant Au values of soil samples. The maximum value is 1,340 ppb Au. Anomalies of Cu and Zn almost overlap on the Au anomalies. The geochemical anomalies are well correlated to the areas where intensive quartz veins/stockworks were found. The size and magnitude of gold mineralization are estimated to be medium from the geochemical features.

As a result of short drilling, low grade gold mineralization was caught in two holes. No ore-grade value has been obtained. However only limited part of the mineralized zone was tested. It was confirmed that the outcrops of quartz veins/stockworks and geochemical anomalies were the indicator of gold mineralization. There is a possibility to find an ore-grade part within the zone. Some evidences of gold depletion by the lateritic weathering process, though circumstantial, are pointed out. Further drilling is necessary for the full-evaluation of this zone.

It is recommended that the mineralized zone delineated by the second phase survey in the Batuisi prospect be fully drill-tested in the third phase. Several prospective locations are chosen and proposed for the major targets of the next stage drilling programme. The importance of the depth of drill holes which should be penetrated through the oxidized zone is emphasized.

Two styles of mineralization were distinguished through detailed geological survey in the Bau prospect. One is 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 detected in the vicinity of the quartz veins are of low level and sporadic. Regarding the pyrite dissemination, assay results were discouraging. Au anomalies of soil and rock-chip samples found near the pyrite dissemination are also of low level and patchy. From these evidences, it is concluded that the gold mineralization in the prospect has no sign of extensive development. 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. A series of Au anomalies of moderate to low degrees were found to extend from S. Kanan through S. Taroto and S. Peko up to S. Talodo Basisi. The surface indications of this zone are significant. However the assay result of ore samples was disappointing. It is believed to be a gold mineralization probably associated with pyrite dissemination within shear zones. Although the details of mineralization have not been sufficiently investigated, it is presumed to be of low-grade on the basis of the present data. 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. It is interpreted to be the product of small scale hydrothermal activity by a subsurface igneous intrusion. Other indication of gold mineralization has not been discovered in the prospect. The potential of this prospect appears to be very small. No further work is recommended in the Kariango prospect.

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PART I OVERVIEW

Chapter 1 Introduction

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 in the Toraja area, 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 cooperative mineral exploration in the Toraja area on September 5, 1991.

The principal objective of this project is to find a new mineral deposit in the Toraja area through the exploration and the examination of geology and mineralization. It is 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 area. The major works conducted during the first phase were satellite imagery photogeological interpretation, regional geological and geochemical surveys, semi-detailed geological and geochemical surveys, 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 geological survey and geochemical exploration continued on the Toraja area. This year corresponds to the second phase of the cooperative mineral exploration programme in the Toraja area. The major purpose of this phase is to define target zones for the further exploration within the survey area. Exploration efforts were concentrated on the prospective areas which were extracted in the previous survey. It is also required for the further exploration to elucidate the nature of mineralization in the survey area. Sequence of exploration steps and current phase in the process is illustrated in Fig.1-3.

1-2 Conclusions and Recommendations of the First Phase Survey

1-2-1 Conclusions of the Geological Survey in the First Phase

The first phase exploration in the Toraja area consisted of satellite imagery photogeological interpretation, regional geological and geochemical surveys, semi-detailed geological and geochemical surveys, and preliminary works for plant leaf biogeochemistry and mercury gas geochemistry. Because of the limited time of the first phase, interpretations and discussions were made only for photogeology, geology and mineralization of the survey area in the period.

Prior to the survey, three potential mineralizations in the survey area were picked up. Those were; primary gold mineralization, massive sulphide mineralization, and porphyry copper-gold mineralization.

In the course of the regional survey, no positive indication of the latter two mineralizations was found.

Indications of primary gold mineralization were caught at several places in the northwestern part of the survey area, and semi-detailed geological survey and geochemical sampling were carried out in two prospects -- Bau and Batuisi. The indications which show primary gold mineralization are; ① occurrence of gold in pan concentrates, ② distribution of floats of vein quartz, and ③ outcrops of quartz veins.

In these prospects, distributions of gold, cinnabar and some sulphide minerals in pan concentrates are closely related to each other. Distribution of quartz veins and quartz floats overlaps on these anomalies in a broad scale.

Quartz veins generally contain a small amount of sulphide minerals. Pyrite, arsenopyrite, chalcopyrite, sphalerite and galena were observed as primary minerals under the microscope. Gold and silver minerals were not found in quartz.

On the basis of these evidences, it was assumed that the source of gold in pan concentrates might be quartz veins/stockworks intensively developed at the upper reaches of creeks in the prospects.

Thirty-one samples of quartz veins and quartz floats were collected from all over the survey area and provided for assaying. The results were disappointing. Almost all samples showed very low gold values. Assay had not proven the origin of gold then.

Petrology, ore microscopy and X-ray diffraction analysis showed several characteristic features of gold mineralization in this area; ① metasediments hosted, ② intensive development of massive quartz veins, ③ associated with sulphide minerals, ④ lack of silver mineral, and ⑤ hydrothermal alteration mainly composed of silicification and chloritization. These features suggest that the gold mineralization in this area may be different from the typical epithermal gold mineralization.

Fissure patterns of quartz veins show the dominant NNW trend in both Bau and Batuisi prospects. It was interpreted as an aggregate of veins arranged en echelon of NNW trend, though overall arrangement of the zones tended to be NW direction in the Batuisi prospect.

Photogeological analysis using satellite imagery shows that the principal direction produced by the emplacement of the Mamasa granite may be NNE to N-S in the northwestern area. An anticlinorium recognized through the geological survey has an axis of N-S direction, and was interpreted to be the product of the granite intrusion. Whereas the patterns of quartz veins are different from the above structure. This structural discrepancy remained to be unsolved in the first phase survey.

The source of gold in pan concentrates was not identified during the first phase survey. It was supposed that gold could be contained either in the quartz veins/stockworks or in the alteration zones adjacent to veins. Samples collected in the prospects in the first phase were limited. Only small part was tested. It was not sufficient for finding and delineating ore zones, as compared with the extensive development of quartz veins/stockworks in the prospects. Much detailed and minute sampling was required for identifying primary gold mineralization. The next phase exploration must be aimed at finding primary gold mineralization and delineating the distribution of ore within the area of extensive quartz veining.

As a result of the regional and semi-detailed survey in the first phase exploration, northwestern area including both Bau and Batuisi prospects was selected for the further investigation in the next stage exploration.

1-2-2 Conclusions of the Geochemical Exploration in the First Phase

Results of the geochemical exploration in the first phase were examined and discussed in 1992.

As a result of regional geochemical exploration by means of stream sediment sampling, six potential mineralized areas were selected. The results of panning prospecting and geological survey were taken into consideration in the evaluation. Semi-detailed survey was undertaken in two of the areas -- Batuisi and Bau -- during the exploration programme in 1991. Among the remaining four areas, S. Lebutang and Kariango appeared to be interesting prospects of gold and basemetal mineralization.

A sizable amount of geochemical anomalies were discovered in the S. Lebutang area. Values of the Au anomalies are distinctive in the prospect. A considerable amount of Au anomalies was also found in the Kariango area. Those two prospects were picked up for the further exploration.

Regarding the results of the semi-detailed geochemical exploration -- panning prospecting and reconnaissance soil survey -- in Batuisi and Bau, several significant anomalous zones were delineated from the integrated examination with the results of geological survey. The major target zones for the further exploration were; the upper reaches of S. Tarawa and the lower reaches of S. Malela in the Batuisi prospect, and the eastern anomalous zone and the western anomalous zone in the Bau prospect.

Much detailed geological survey and geochemical exploration comprising soil geochemistry and rock-chip sampling might be necessary in the two prospects. For the purpose of elucidating the nature and characteristics of gold mineralization in this area, continuous sampling in trenches and/or drill cores could be useful in the most remarkable anomalous zones such as the upper reaches of S. Tarawa and the lower reaches of S. Malela.

1-2-3 Recommendations for the Second Phase Survey

As a result of the first phase survey, four areas were picked up for the next phase exploration prospects. Those were; ① Batuisi prospect, ② Bau prospect, ③ S. Lebutang prospect, and ④ Kariango prospect.

① In the Batuisi prospect, the central part of the intensive quartz veining zone would be checked at first. The major target zones were; the upper reaches of S. Tarawa and the lower reaches of S. Malela. Detailed survey mainly comprising gridding, geological survey and soil sampling was recommended in the prospect. Trenching would be effective for prospecting the nature of primary gold mineralization. Small scale drilling for reconnaissance purpose was recommendable to the most significant anomalous zone.

② In the Bau prospect, detailed survey mainly comprising geological survey and soil sampling was also recommended. The major target zones were; the eastern geochemical anomalous zone and the western anomalous zone. Topographic condition had to be considered in the survey programme.

③ Along S. Lebutang and its tributaries, semi-detailed level of survey consisting of geological survey, pan concentrate sampling and soil sampling was recommended.

④ Along S. Uroh and S. Betuwe at the north of Kp. Kariango, semi-detailed survey was also recommended.

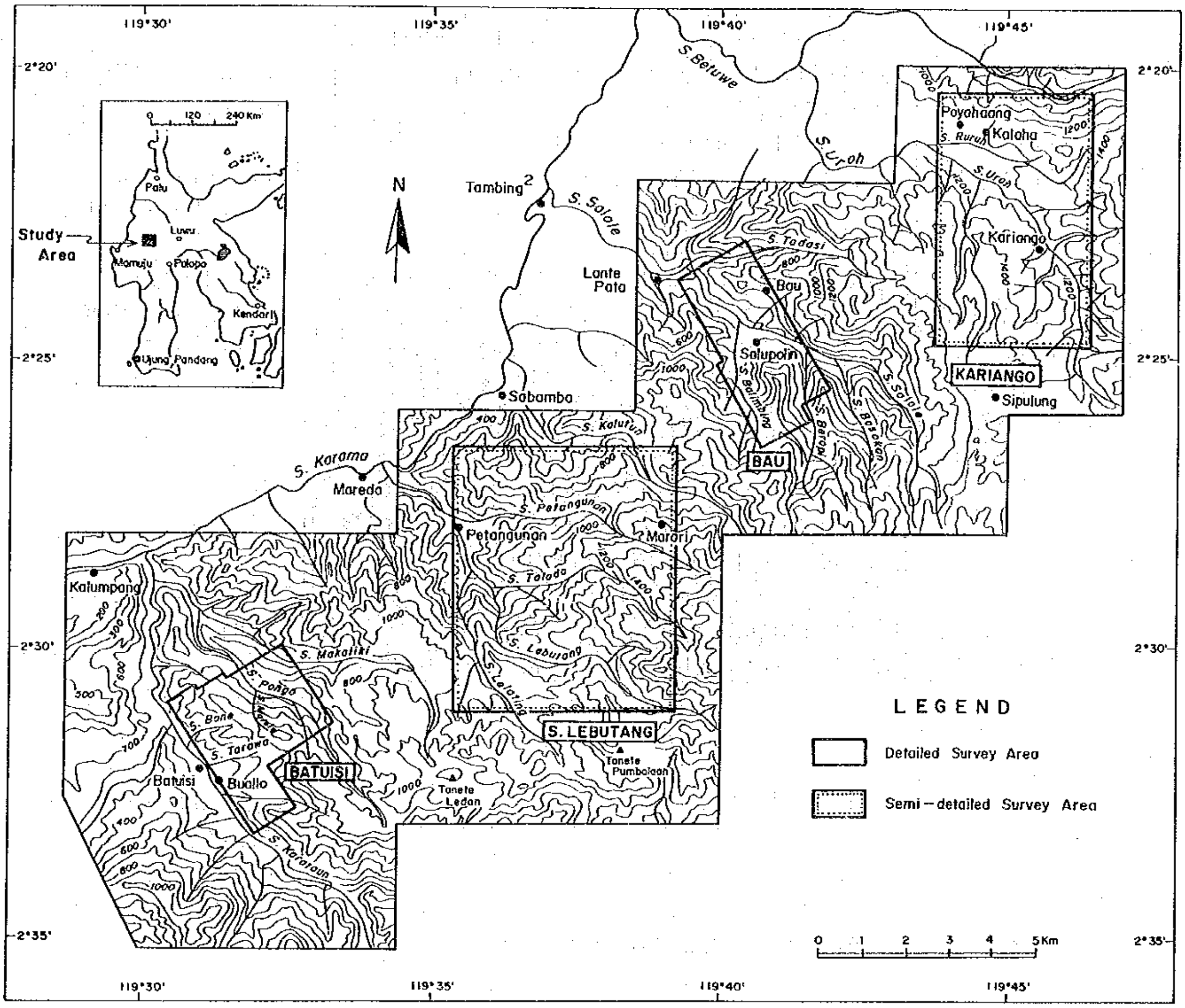


Fig.1-2 Map Showing the Areas of the Second Phase Survey

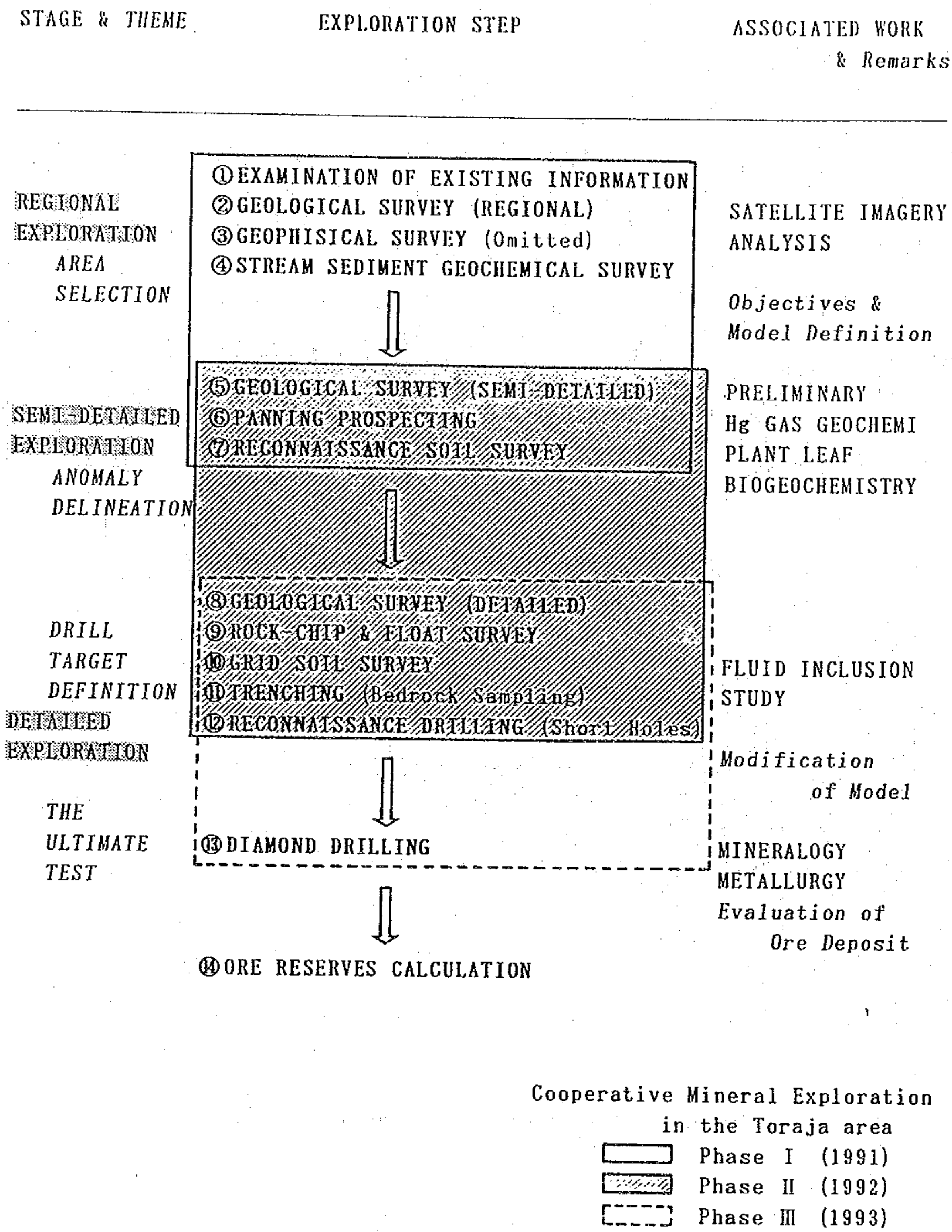


Fig.1-3 Sequence of Exploration Steps and Current Phase in the Process

1-3 Outline of the Second Phase Survey

1-3-1 Survey Area

The survey area, approximately 130 km^2 in total, is located in the central part of western Sulawesi, and corresponds to the northwestern to the central-northern part of the first phase survey area. The survey area was composed of four prospects; two detailed survey prospects -- Batuisi and Bau, and two semi-detailed survey prospects -- S. Lebutang and Kariango. Administration of the area is under the jurisdiction of South Sulawesi Province. The location map of the survey area is shown in Fig.1-2.

1-3-2 Exploration Theme

The exploration this year corresponds to the second phase of the three year cooperative mineral exploration programme in the Toraja area.

The works conducted this year were examination and discussions of the results of the first phase geochemical exploration, detailed geological survey and geochemical exploration in the Batuisi and Bau prospects, semi-detailed geological survey and geochemical exploration in the S. Lebutang and Kariango prospects, and a small reconnaissance drilling programme in the Batuisi prospect.

The major exploration themes of the detailed survey in the Batuisi and Bau prospects were to explore the distribution of quartz veins and associated alteration zones, to elucidate the nature and characteristics of gold mineralization, and to define drill target for the next phase exploration.

The major exploration themes of the semi-detailed survey in the S. Lebutang and Kariango prospects were to investigate the mineral potential of the prospects and to catch geochemical anomalies for the further exploration.

The purpose of the reconnaissance drilling programme was to test the lower part of the soil anomalous zone.

1-3-3 Exploration Work

Detailed geological survey and geochemical exploration

In the Batuisi and Bau prospects, some indications of gold mineralization were caught and significant soil geochemical anomalies were obtained in the first phase semi-detailed survey. Much detailed geological survey and geochemical sampling were undertaken within the prospects in this year. It consisted of approximately 30 km^2 in total area.

The works were composed of geological survey, grid soil survey, geochemical rock-chip sampling, trenching and fluid inclusion study.

A series of 1:10,000 scale route maps were produced through surveying with fifty meter tape and a Brunton-type compass. The results of the geological survey were compiled on a 1:25,000 scale map.

Geological survey and soil sampling were carried out along the grid lines. Soil samples were taken at a line spacing of 200 m and a sample interval of 50 m in the Batuisi prospect. Whereas in the Bau prospect, soil samples were taken only along creeks and hills because of its steep topography.

Geochemical rock-chip samples were collected from most of the outcrops of quartz veins, mineralized rocks, and quartz float zones during geological survey.

Six lines of shallow trenches were excavated by hand digging, and continuous sampling from weathered bedrock and quartz veins was undertaken in the Batuisi prospect.

One hundred and seventeen quartz samples were collected and provided to fluid inclusion study in the Batuisi prospect.

More than 125 km of survey length were achieved, and more than 2,000 soil samples and 400 geochemical rock-chip samples (including samples from trenches) were collected altogether this year.

Semi-detailed geological survey and geochemical exploration

Semi-detailed geological survey and geochemical sampling were carried out in two prospects -- S. Lebutang and Kariango -- where indications of gold and basemetal mineralization were found in the first phase survey. It consisted of approximately 100 km^2 in total.

The works were composed of geological survey, pan concentrate sampling, and soil sampling. The 1:10,000 scale route maps were produced in the semi-detailed survey area. Total length of traverses was more than 170 km. The results of the semi-detailed survey were compiled on a series of 1:25,000 maps.

Numbers of soil samples and pan concentrate samples were amounted to more than 1,000 and 200 respectively this year.

Drilling

A small scale drilling programme was conducted at the upper reaches of S. Tarawa in the Batuisi prospect. The programme consisted of five inclined holes of short diamond drilling totalling 401.5 m. The minimum size of the core was BQ. It targeted mainly to the lower extension of the most significant Au anomalies of soil samples. A series of drill logs of 1:200 scale were produced. One hundred and five ore assay samples and 27 quartz chips for fluid inclusion study were obtained.

Amount of works done this year is summarized as follows:

Survey	Methods and Amount of Samples		
	Area	Length	Geochemical Samples
Detailed Survey			
(i) Batuisi Prospect			
Geochemical Survey	15	--	1,514 pcs (Soils) 214 pcs (Rock-chips)
Trenching	--	438.0m	109 pcs (Geochemical Samples)
Drilling	--	401.5m (5holes)	--
(ii) Bau Prospect			
Geochemical Survey	15	--	506 pcs (Soils) 104 pcs (Rock-chips)
Semi-detailed Survey			
(iii) S. Lebutang Prospect Geological and Geochemical Survey	60	101.1	606 pcs (Soils) 126 pcs (Pan Concentrates)
(iv) Kariango Prospect Geological and Geochemical Survey	40	70.4	404 pcs (Soils) 80 pcs (Pan Concentrates)

Amount of samples for chemical analysis and laboratory work is as follows:

	Geology & Geochemistry	Drilling
① Thin Sections	20 pcs	8 pcs
② Polished Sections of Ore	25 pcs	20 pcs
③ X-Ray Diffraction Analysis	33 pcs	20 pcs
④ Fluid Inclusion Study (Homogenization Temperature)	121 pcs	27 pcs
⑤ Chemical Analysis		
a) Soils (Au,Ag,As,Sb,Hg,Cu,Pb,Zn)	3,030 pcs	--
b) Rock-chips (Au,Ag,As,Sb,Hg,Cu,Pb,Zn)	428 pcs	--
c) Ores (Au,Ag,Cu,Pb,Zn)	201 pcs	105 pcs

1-3-4 Survey Team

The geological and geochemical surveys 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]

Pudjosudjarwo	(DMR)	Coordinator and Geologist
Simpwee Soeharto	(DMR)	Team Leader and Geologist
Wahyu Widodo	(DMR)	Geologist
Atok S Prapto	(DMR)	Geologist
Tata Hendra	(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

*Note: DMR means Directorate of Mineral Resources
NED means Nikko Exploration and Development Co., Ltd.

Chapter 2 Geography of the Survey Area

2-1 Topography and Drainage System

The survey area is located in the central part of western Sulawesi.

Access to the area is; from Jakarta to Ujung Pandang by air, from Ujung Pandang to Mamuju by car on sealed road, from Mamuju to Tarailu by car on unsealed road, and from Tarailu to Galumpang by engine canoe along the river (S. Karama). Galumpang is the biggest village near the survey area. Mamuju, which is located some 70 km due west-southwest of the survey area, is the terminal town of the sealed road at the western coast of the Toraja area.

The survey area is situated on the western flank of a steep mountain range. The topography is rugged. There is a couple of high mountains of more than 2,000 m in the vicinity of the survey area. There are several little villages in the survey area. Access inland is slow and mainly on foot, generally following drainages. There is no vehicle road in the area. Only horse tracks and footpaths are available.

Rivers flow down to the west into Selat Makassar. S. Karama is the major drainage system in the survey area. All rivers in the survey area -- S. Karataun, S. Lebutang, S. Saloie, S. Uroh and S. Betuwe -- flow into S. Karama.

2-2 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 the dry season, and the rainy season generally continues from November till May.

Mean temperature and monthly precipitation in the rainy season is 26 °C and 400 mm. Mean temperature and monthly precipitation in the dry season is 27 °C and 70 mm (climatological data for Makasar).

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 among the mountains and even flanks of the hills are reclaimed, and paddy rice is cultivated in such places. On the steep hills among the mountains, dry field rice and coffee plant are 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 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 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.1-4 shows the regional geology of the central part of western Sulawesi.

3-2 Geology and Geologic Structure of the Survey Area

The oldest rock in the 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. Those 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.

Regional anticlinal structure and some local folds are distinctive in the area. They have the axes of N-S direction.

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

Fig.1-5 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 and around the area. Those are; primary gold mineralization, massive sulphide mineralization (Sangkaropi type) and porphyry copper-gold mineralization (Sasak type). In the course of the regional survey in 1991, no positive indication of massive sulphide mineralization and porphyry copper-gold mineralization was found.

Indications of primary gold mineralization were caught at several places in the survey area. Although the source of gold in pan concentrate has not been identified, gold could be contained either in quartz veins or in the alteration zones adjacent to veins. 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 Associated with sulphide minerals such as pyrite, arsenopyrite, chalcopyrite, sphalerite, and galena.
④ Lack of silver mineral.
⑤ Hydrothermal alteration mainly composed of silicification, chloritization and sericitization.

Fissure patterns of quartz veins show the dominant NNW trend in both Bau and Batuisi prospects. It was interpreted as an aggregate of veins arranged en echelon of NNW trend, though overall arrangement of the zones tended to be NW direction in the Batuisi prospect.

Geochemical features of gold mineralization 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 in the Batuisi prospect (soils). They are surrounded by anomalies of basemetal elements such as Ag, Cu, Pb and Zn.

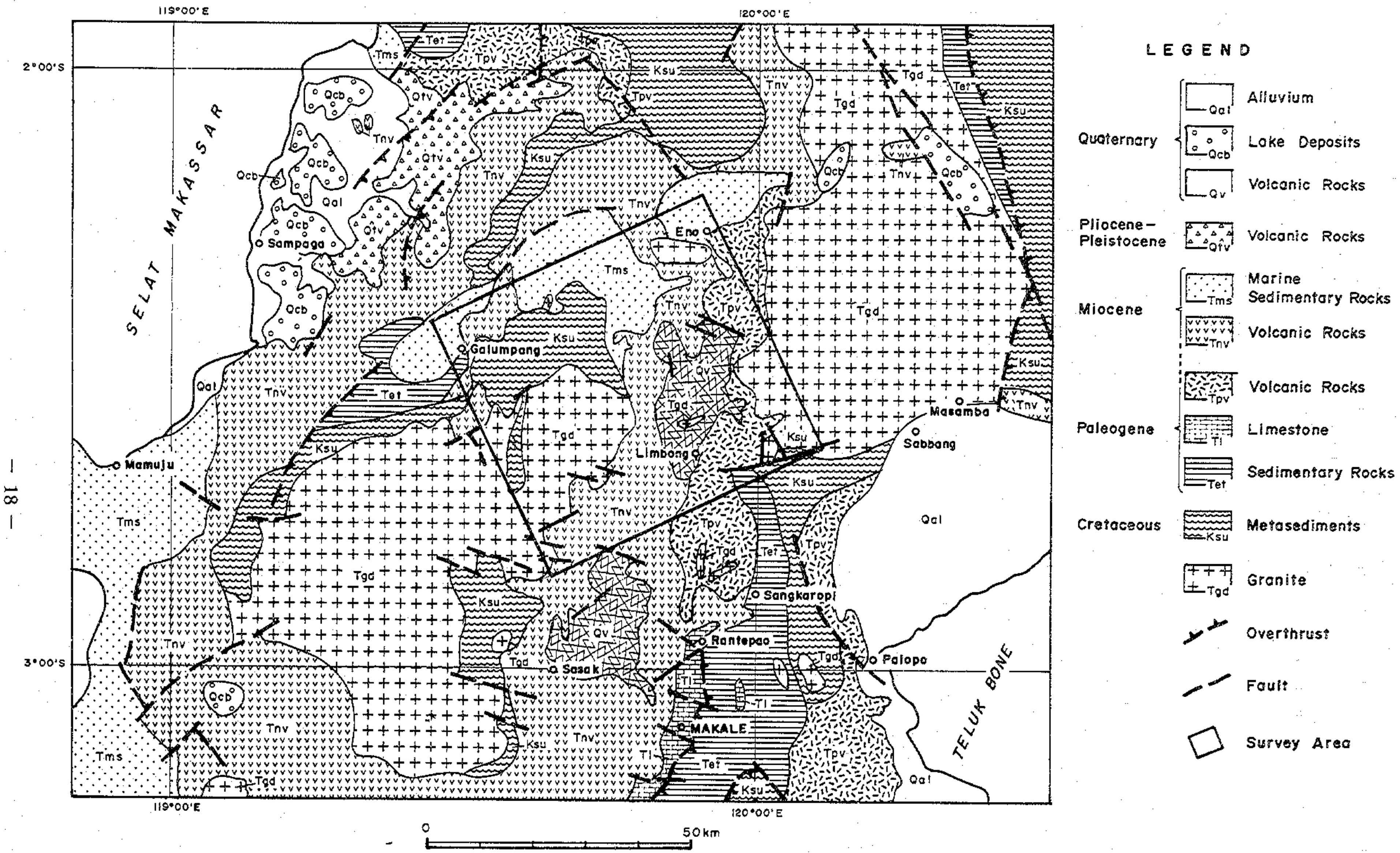


Fig.1-4 Regional Geology of the Central Part of Western Sulawesi

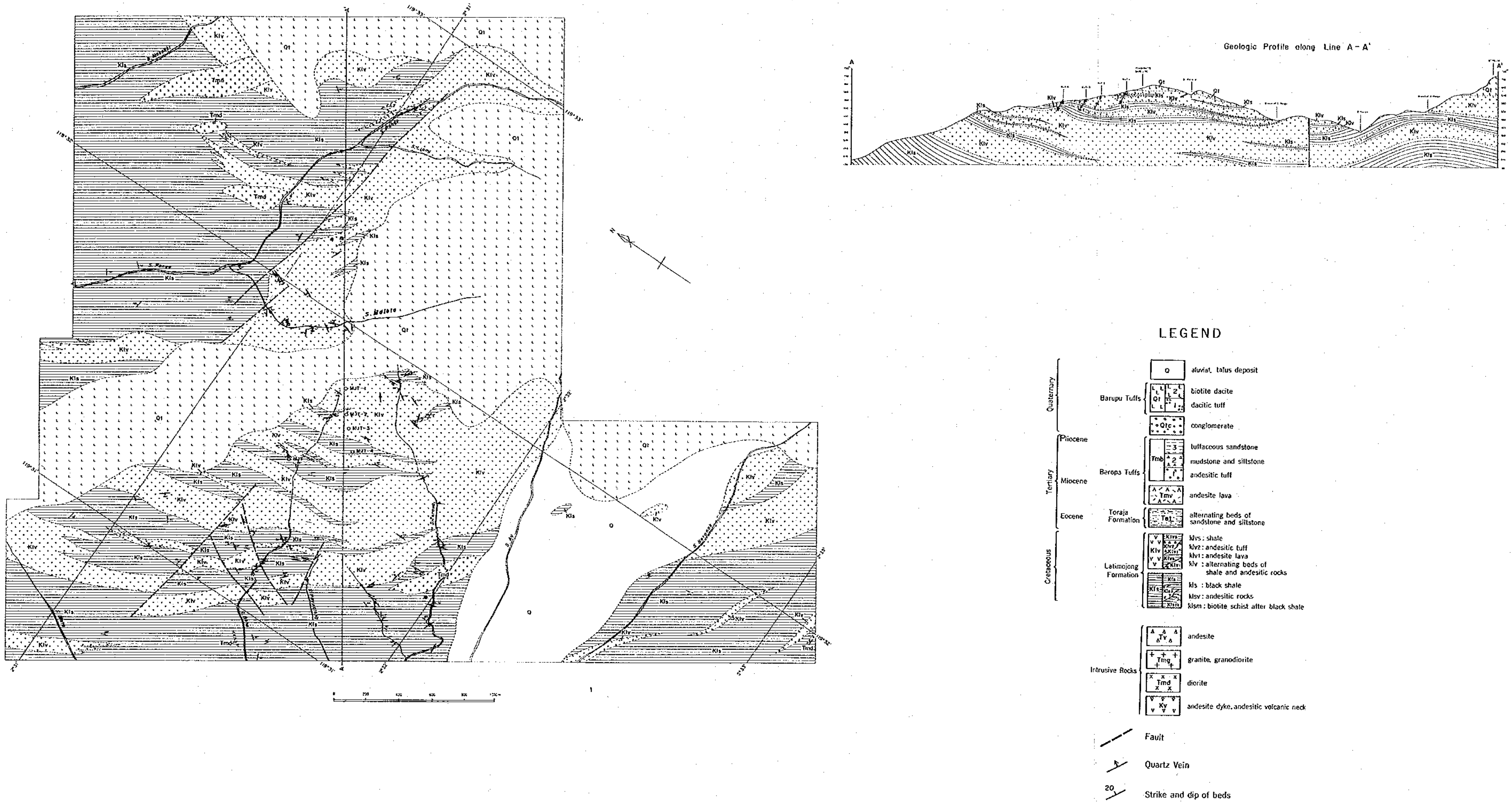
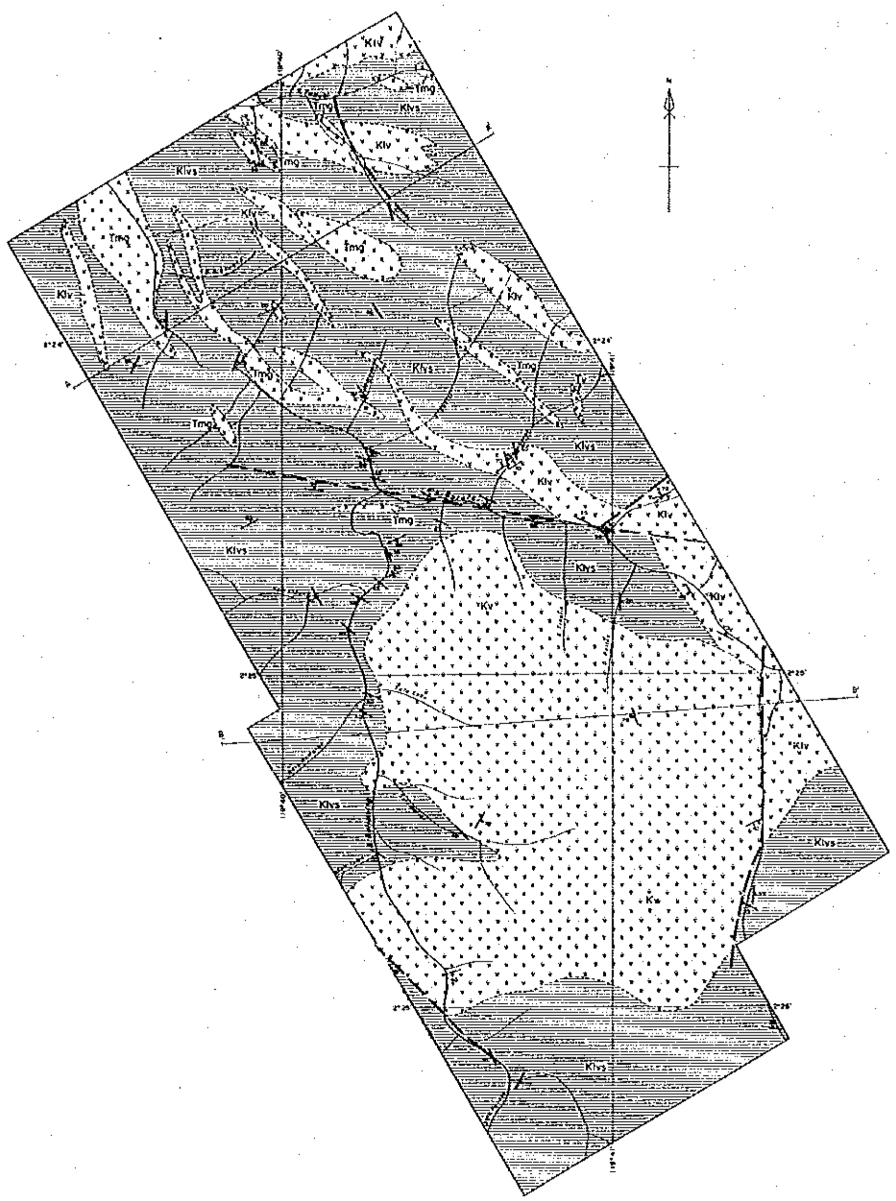
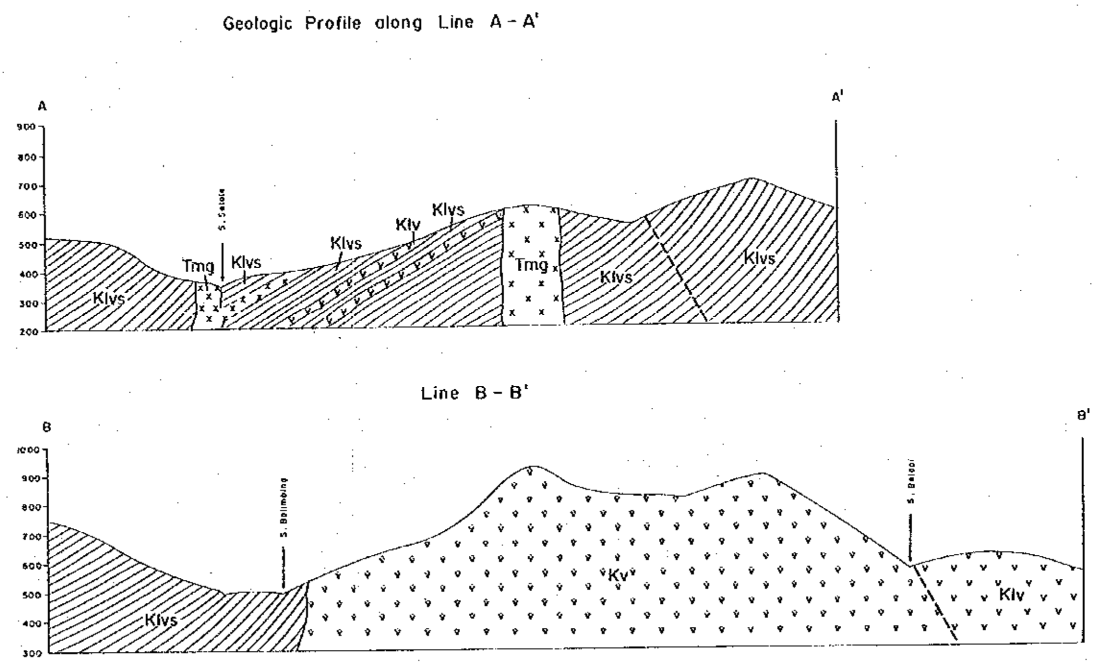


Fig. 1-5 Geology and Geologic Profile of the Survey Area
(Batuisi Prospect)





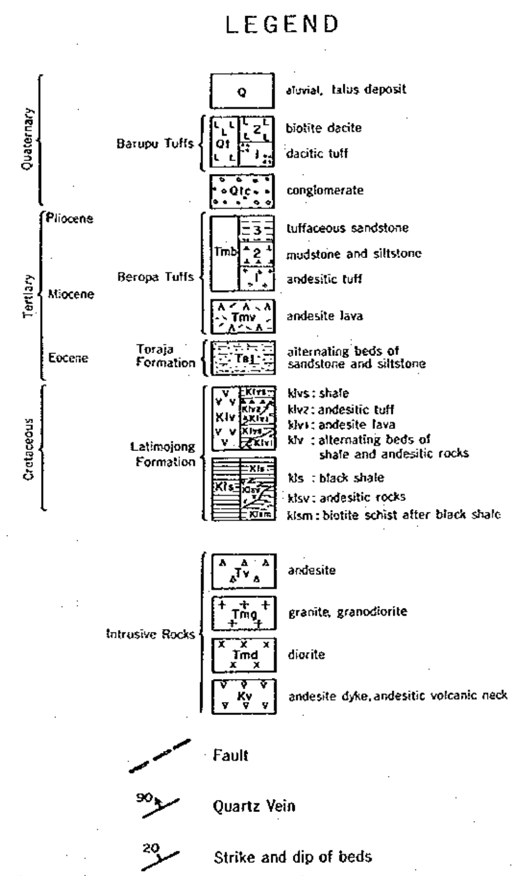
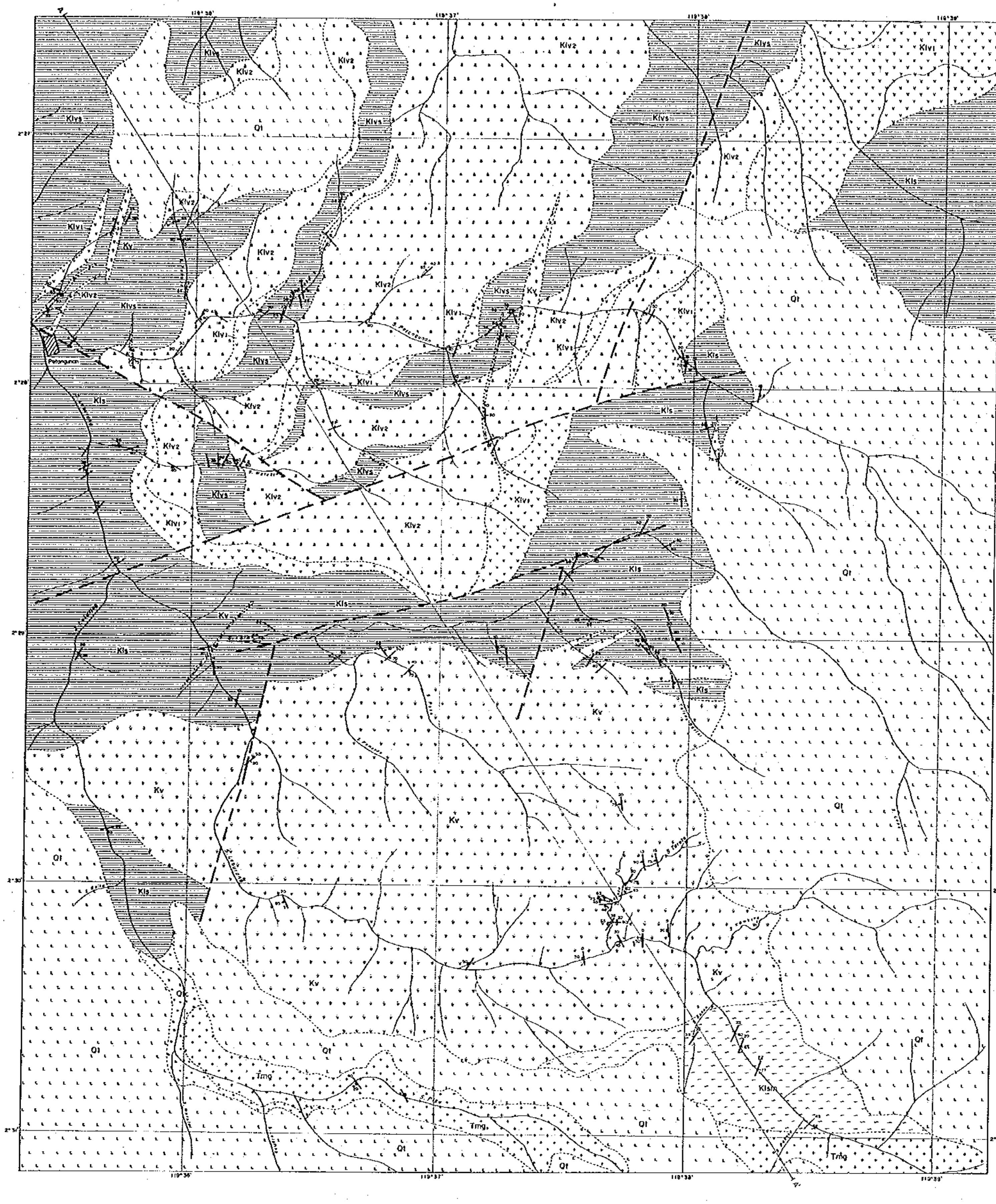
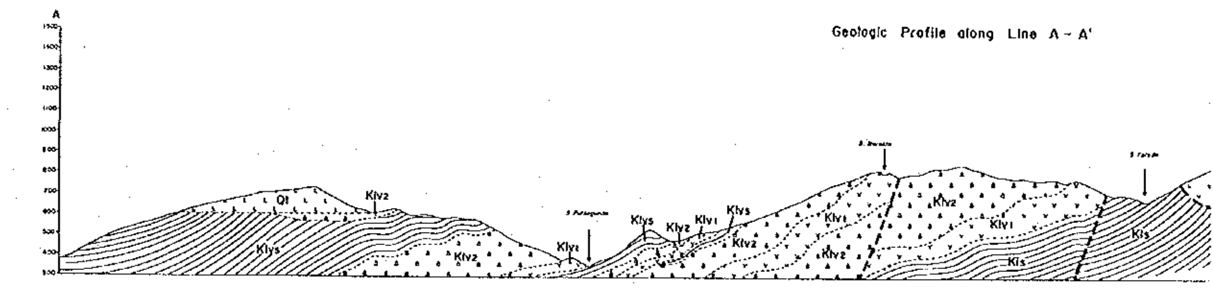
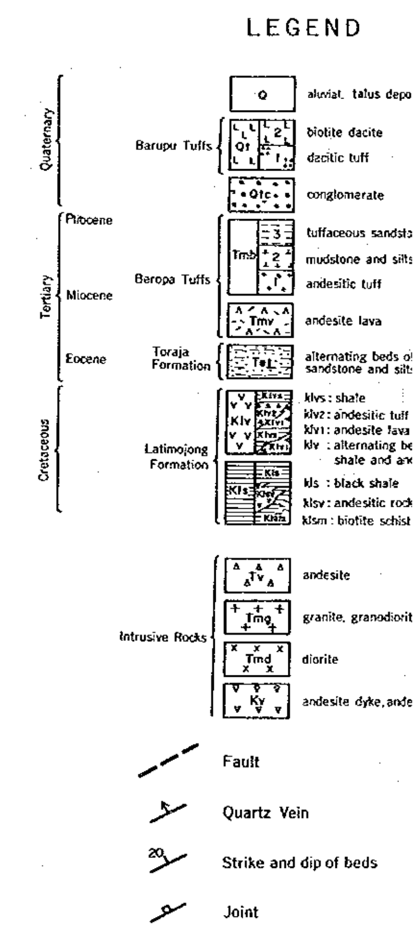


Fig. 1-5 Geology and Geologic Profile of the Survey Area (Bau Prospect)

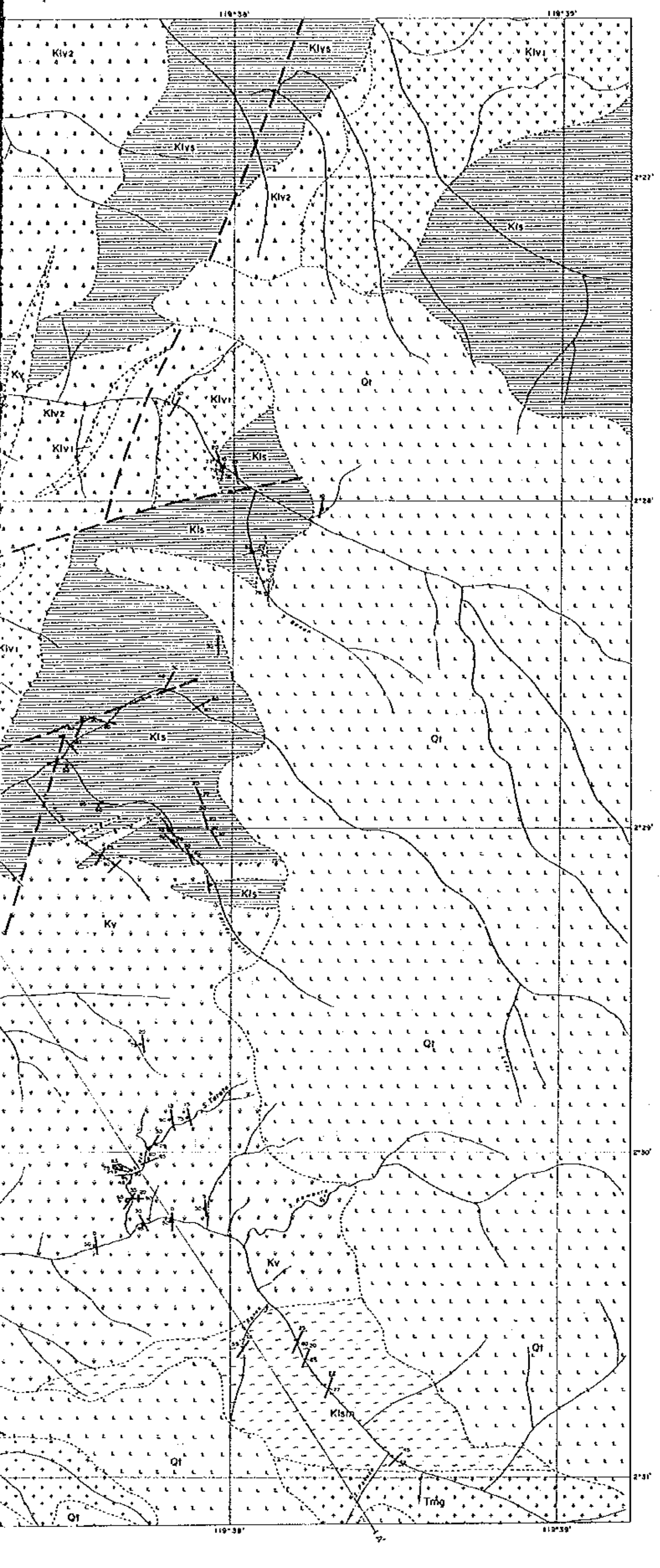


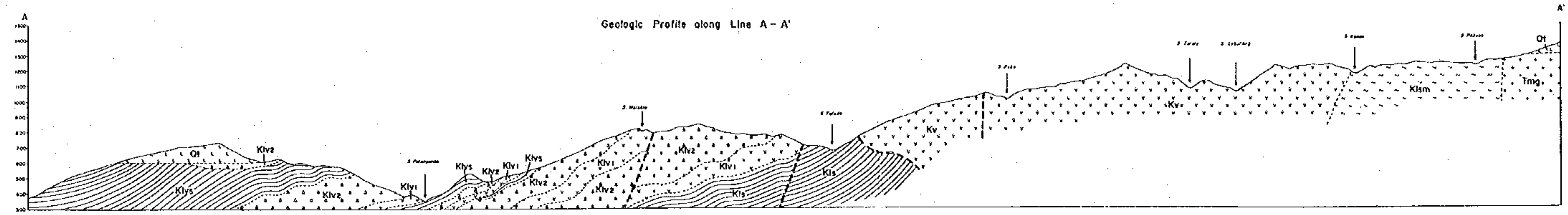


Geologic Profile along Line A - A'
A
Qt
Klvz
Klvs
Klv1
Kls



LEGEND
Quaternary
Tertiary
Pliocene
Miocene
Eocene
Cretaceous
Q aluviat. talus depo
Barupu Tuffs
Qt
biotite dacite
dacitic tuff
Qtc conglomerate
Beropa Tuffs
Tmb
tuffaceous sandst
mudstone and silts
andesitic tuff
Tmv andesite lava
Toraja Formation
TeL alternating beds o
sandstone and silt
Latimojong Formation
Klv
klvs : shale
klvz : andesitic tuff
klv1 : andesite lava
klv : alternating be
shale and an
Kls
kls : black shale
klsv : andesitic roc
klsm : biotite schist
Intrusive Rocks
Tv andesite
Tmg granite, granodiori
Tmd diorite
Kv andesite dyke, ande
Fault
Quartz Vein
Strike and dip of beds
Joint





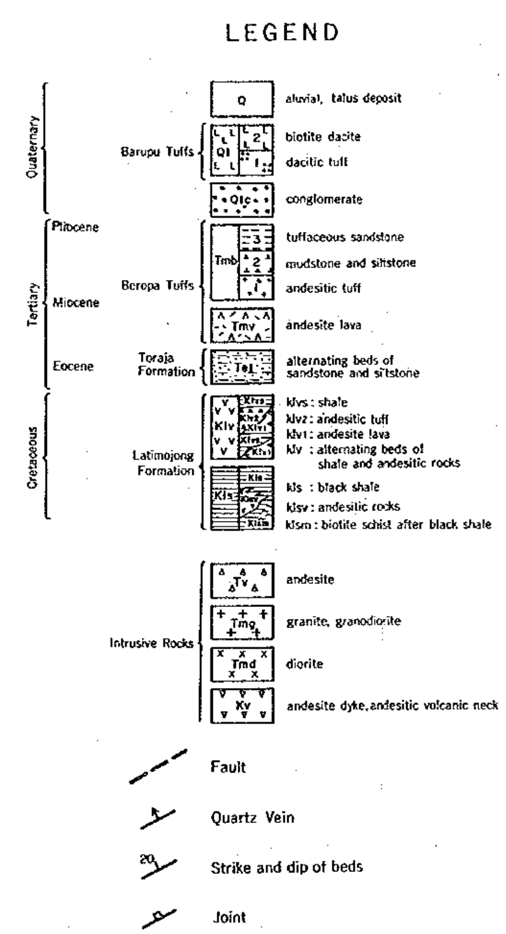
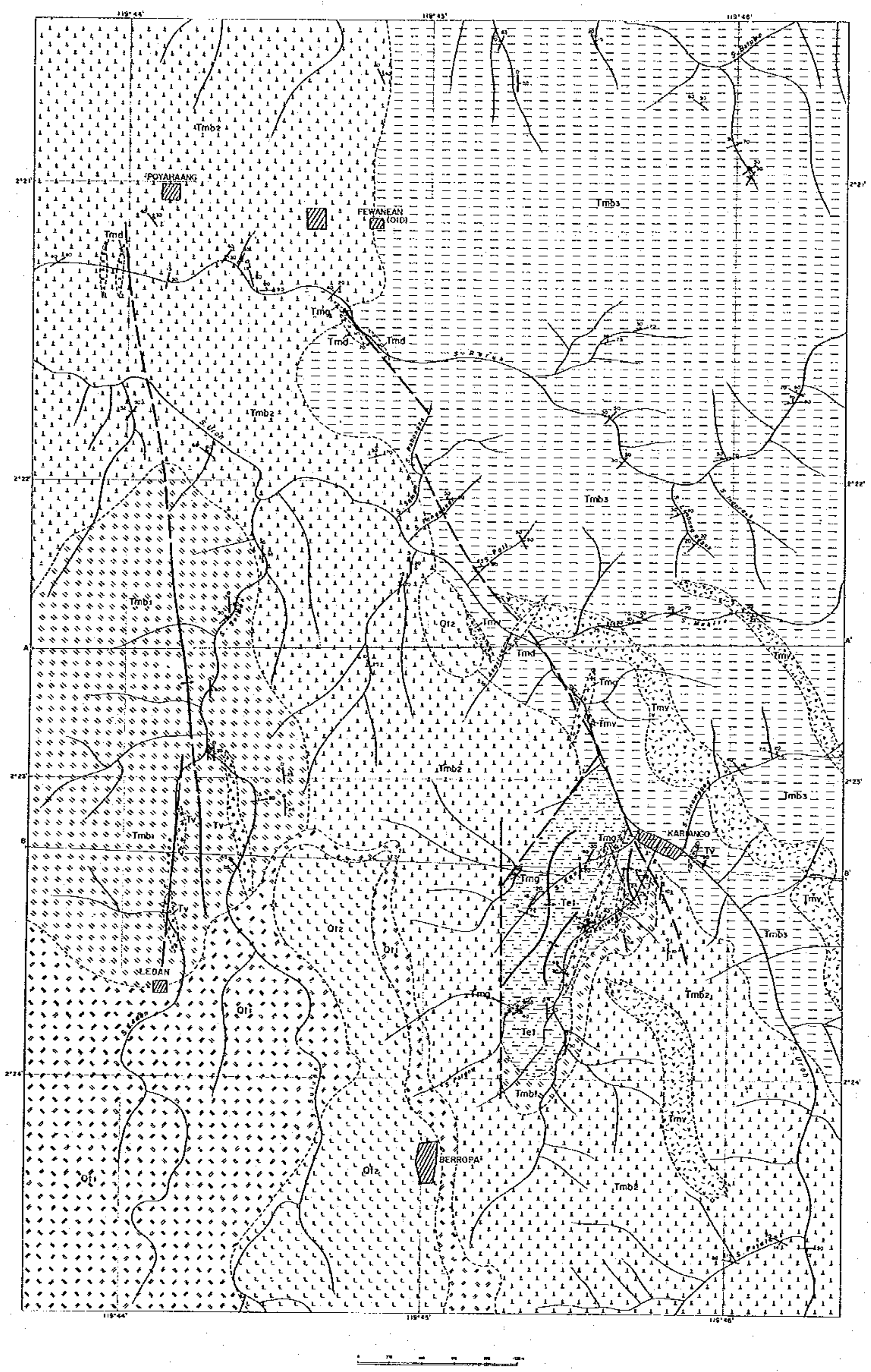
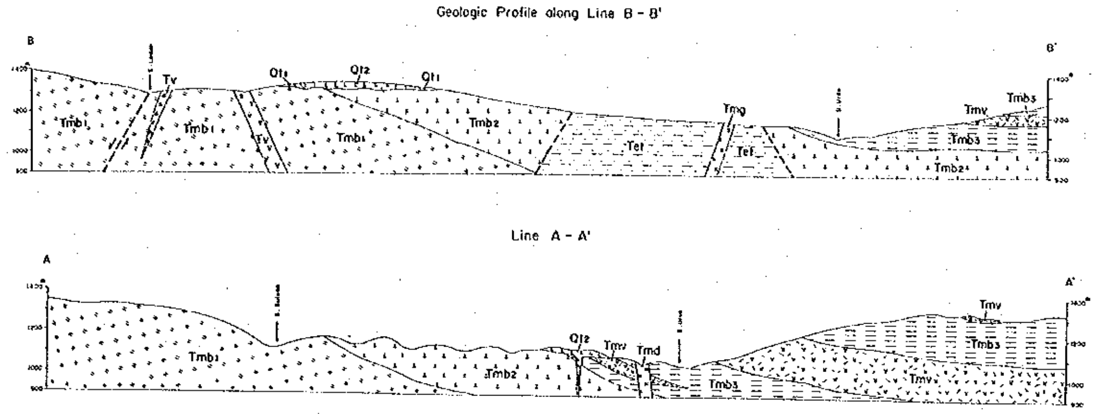


Fig. 1-5 Geology and Geologic Profile of the Survey Area
(S. Lebutang Prospect)





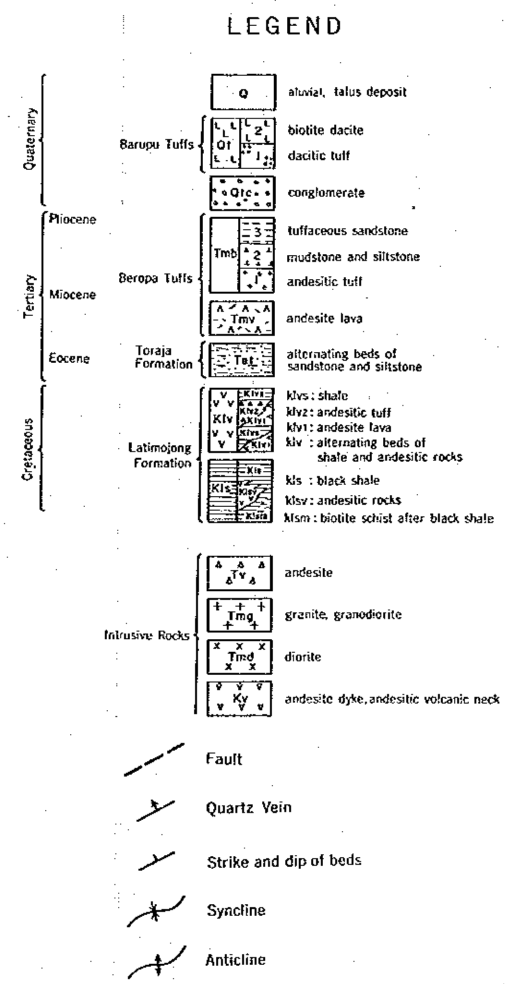


Fig. 1-5 Geology and Geologic Profile of the Survey Area (Kariango Prospect)

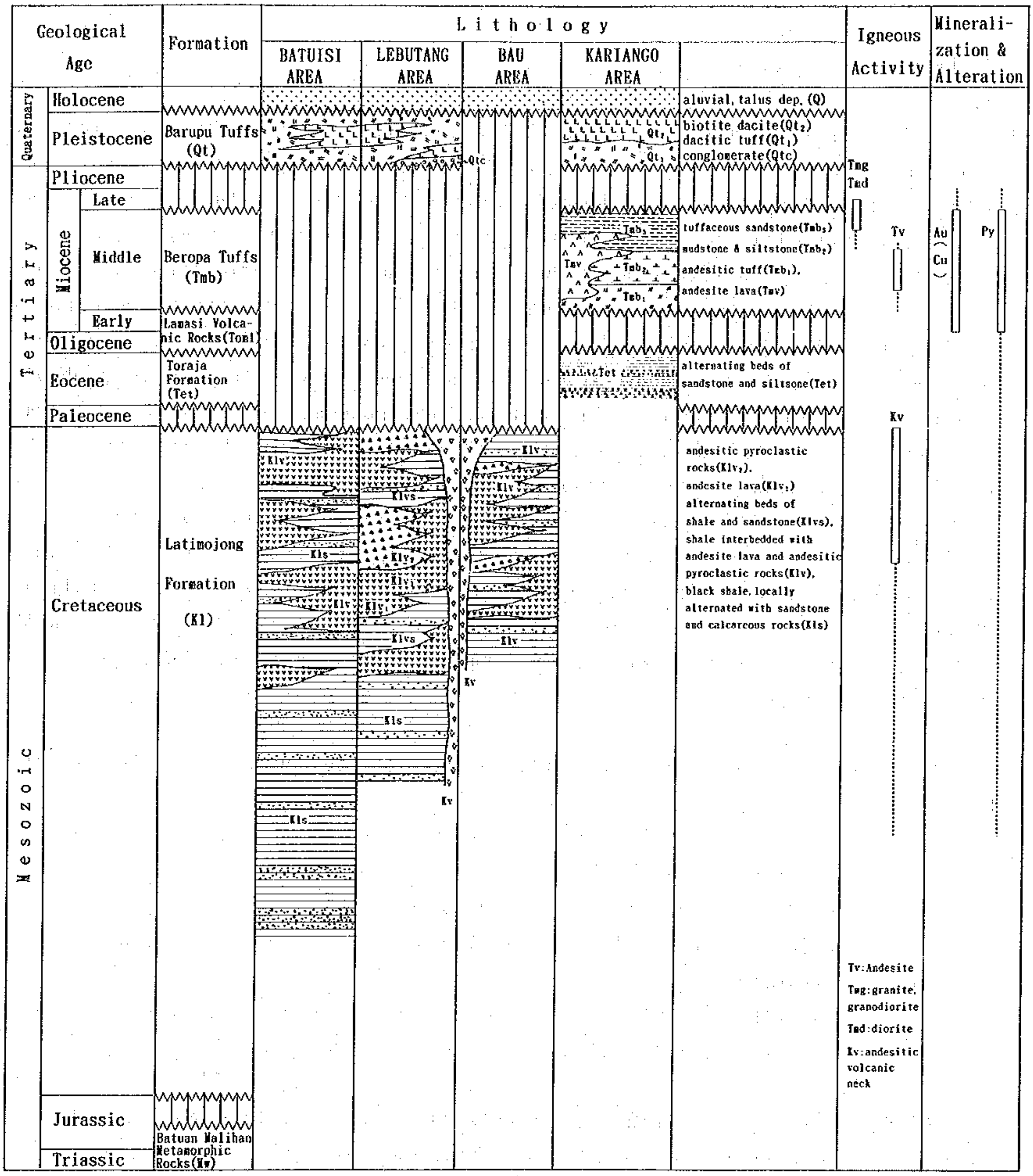


Fig.1-6 Stratigraphy of the Survey Area

Chapter 4 Discussions on the Results of the Second Phase Survey

4-1 Geology, Geologic Structure and Mineralization

(1) Batuisi prospect

Extensive development of quartz veins and quartz stockworks was confirmed at the area along S. Tarawa, S. Bone, S. Malela and S. Pongo. Auriferous quartz veins and quartz stockworks are hosted in the volcanic-sedimentary strata of the Cretaceous Latimojong Formation in the prospect. From the structural point of view, the prospect is situated on the western flank of an anticlinorium (whose axis is N-S) formed by the emplacement of the Mamasa granite. The Mamasa granite batholith is exposed several kilometers to the south of the prospect. Small stocks of diorite occur within the prospect. A granite body probably exists beneath the prospect. This geologic environment is believed to be the most important factor for the formation of vein pattern in the prospect. The principal direction of the compressional stress field generated by the emplacement of granite is considered to be NNW in this particular area of the prospect. Several vein systems were distinguished in the prospect. The most dominant one -- NNW system -- is interpreted to be formed as a normal fault in the direction of the compression. The other two systems -- N-S system and NW system -- probably correspond to the synthetic-antithetic strike-slip faults formed by the compression.

Gold mineralization in this area shows the following four distinctive features:

① Auriferous quartz veins often show massive features.
② Gold grains are comparatively coarse.
③ Gold is associated with sulphide minerals such as pyrite and chalcopyrite.
④ Hydrothermal alteration is mainly composed of silicification, chloritization and sericitization.

Gold-bearing quartz veins and quartz stockworks in this area are hosted mainly by low-grade metamorphosed (sub-greenschist facies) Cretaceous volcanic-sedimentary strata. Quartz veins sometimes have hard, thick, and massive features. Quartz crystals have subrounded to subhedral morphology, and show white to light grey color with silky to resin bright tint. It sometimes shows a chalcedonic appearance. The grain size of quartz crystal is coarse, from slightly less than 1 mm up to several mm. Banded texture was rarely observed in quartz veins. The above morphological features do not coincide with those of epithermal quartz veins. The typical epithermal vein quartz exhibits white to light grey color, semi-transparent to translucent, and sometimes slightly milky nature. It is mostly fine grained, and commonly shows banded texture. The vein quartz in this area rather resembles that of mesothermal veins.

The grain size of gold is estimated to be coarse from the mode of occurrence of gold in pan concentrates in which gold of up to 500 microns was reported in the survey during 1991. Generally saying, the grain size of gold from the typical epithermal deposits is something around a few to several tens of microns. Coarse gold is characteristic of mesothermal deposits, which often bear an erratic nature of gold mineralization.

Some gold assay, though low grade, was returned from a part of quartz veins where a small amount of sulphide minerals were impregnated. Pyrite and chalcopyrite are the minerals most closely associated with gold. Traces of arsenopyrite, sphalerite, galena and bornite were also found in such part. Silver mineral has not been recognized in the sulphide mineral association yet.

Quartz and calcite are accounted for the major part of gangue minerals. Adularia is seldom observed in quartz veins. Neither alunite nor hypogene kaoline has been identified.

Wall-rock alteration in a hydrothermal system changes commonly from silicification-propylitization in the deeper zone to argillic alteration in the upper part. Advanced-argillic alteration appears at the top of the system in some cases. The alteration in this area is very similar to the lower facies of the hydrothermal system.

These evidences, though indirectly, suggest that gold-bearing quartz veins were formed under mesothermal conditions in this area.

Results of the fluid inclusion studies in the Batuisi prospect substantially support the mesothermal origin of quartz veins.

Most of fluid inclusions in quartz are of two-phase liquid-rich type. Homogenization temperature of individual fluid inclusion ranges from 180°C up to 320°C. The temperature range of fluid inclusions in this area is slightly higher than that of the typical Neogene Tertiary epithermal auriferous quartz veins in Japan. It can be correlated to mesothermal gold-quartz veins such as the Oya deposit in northern Japan. Salinity of fluid inclusions has not been measured, but it is assumed to be medium from the microscopic observation of liquid-vapor phase relationship. Polyphase inclusions were discovered in some quartz samples. One of the daughter minerals is believed to be halite.

Indication which implies boiling phenomena has not been observed in the fluid inclusions. Fluid boiling might have been occurred in much higher part of the hydrothermal system in this area.

On the basis of these considerations, the process of vein formation in the Batuisi prospect is inferred.

The Batuisi prospect is situated to the north of the Mamasa granite batholith. A granite body -- batholith or cupola -- probably exists beneath the prospect. The current surface corresponds to the lower part of a hydrothermal system which was originated from the deeper igneous body. An epithermal environment, which might produce a pervasive gold mineralization, had been formed at much higher levels than the present-day surface. It may coincide with the boundary between the pre-Tertiary and Tertiary systems. Further studies, particularly those through chemical and isotopic investigations may provide the direct and concrete evidences for clarifying the process of gold mineralization.

Assay results of drill cores were disappointing. Only low grade values of gold were returned. However, there is a possibility of gold depletion by the lateritic weathering process. Strong weathering was recognized in trenches and drill holes at the hill northwest of the upper reaches of S. Tarawa. Oxidation of sulphide minerals was observed even at the bottom of drill holes. A small amount of kaoline of probably a supergene origin was found in some of the drill holes.
Gold may be leached out and transported away from the original mineralized horizon under such condition. It is worthwhile to test the deeper horizon by the further drilling.

(2) Bau prospect

Two styles of mineralization were distinguished in the Bau prospect. One is fissure filling quartz mineralization accompanied with a small amount of sulphide minerals, and another is pyrite dissemination near diorite stocks. The geologic environment is similar to that of the Batuisi prospect. The prospect is structurally located on the eastern wing of the regional anticlinorium which is interpreted to be formed by the emplacement of the Mamasa granite. The dominant direction of vein system is NNW. Several small stocks of diorite and granodiorite are arranged in the direction of NNW～N-S. The Mamasa granite batholith is exposed several kilometers to the south of the prospect.

Auriferous quartz veins show similar characteristic features as those of the Batuisi prospect. Therefore, the same structural and hydrothermal conditions of formation are assumed in the prospect.

Pyrite dissemination near the contact of dioritic stocks is interpreted to be genetically related to the intrusion of the igneous bodies.

(3) S. Lebutang prospect

Gold mineralization is hosted by andesite of the Latimojong Formation. The prospect is structurally located on the central part of the regional anticlinorium. The dominant direction of vein system is NNW～N-S. The Mamasa granite batholith is exposed a few kilometers to the south of the prospect. These geologic circumstances indicate structural conditions similar to the Batuisi prospect at the time of mineralization in the prospect.

The characteristic features of gold mineralization at S. Taroto are summarized as follows:

① Gold mineralization was found mainly in massive andesite of the Latimojong Formation.
② Gold is intimately associated with pyrite dissemination or stringers which are accompanied with strong silicification.
③ It is overprinted on the zones of intensive quartz veining which are probably controlled by shear zones.

These features are somewhat unique compared with the mineralization in the Batuisi prospect. Tentative measurements of homogenization temperature of fluid inclusions of quartz showed rather high values, higher than the data in the Batuisi prospect. It probably comes from the relative nearness to the granite body.

(4) Kariango prospect

The geology of the Kariango prospect is different from the other three prospects. It consists of the volcanic-sedimentary strata of the Middle to the Upper Miocene series. Significant mineralization has not been discovered in the prospect, except for a small scale limonite network. It occurs within the lower member of the Beropa Tuffs. The network zone has the N-S elongation of 300 m ×20 m. Significant result has not been obtained from ore assay. This network is interpreted to be the product of small scale hydrothermal activity probably caused by some kind of subsurface igneous body.

4-2 Geochemistry

(1) Batuisi prospect

In 1991, panning prospecting, stream sediment survey and reconnaissance soil survey were carried out for an area covering approximately 50 km^2 in the Batuisi prospect. The soil sampling was made along creeks and ridge lines. Two hundred forty-nine soil samples were taken and provided for chemical analysis. Data were statistically processed. The result of geochemistry was examined together with the result of geological survey, and the central part of the prospect was highlighted for the further exploration.

The geochemical works during 1992 consisted of grid soil survey and rock-chip sampling. A total of 1,514 soil samples and 214 rock-chip samples was collected from an area of 15 km^2. Chemical analysis was made for eight elements; Au, Ag, As, Sb, Hg, Cu, Pb and Zn. Statistical data processings including principal components analysis were practiced for extracting some efficient combination of elements.

Three distinctive Au anomalies and several minor anomalies were delineated from grid soil survey and rock-chip geochemistry. The major anomalies are located at; ① the upper reaches of S. Tarawa, ② S. Malela, and ③ the middle reaches of S. Bone. These anomalies are distributed within an area of 2,500 m (NE-SW) × 1,500 m (NW-SE) centered at the top of the ridge. They are composed of significant Au values of soil samples (threshold value of Au$>$8.8 ppb). Au values greater than 100 ppb were obtained from more than 20 samples. The maximum value is 1,340 ppb Au found in the zone ①. Anomalies of Cu and Zn almost overlap on the Au anomalies.

The geochemical anomalies agree well with the areas where intensive quartz veins/stockworks were found.

An outstanding Au anomaly was outlined at the area extending over the upper reaches of S. Tarawa and the upper reaches of S. Bone (1,000 m × 500 m). This anomaly corresponds to the area of intensive quartz stockworking. Anomalies of Cu and Zn were also recognized in this area. Several anomalous values of rock-chip samples of up to 300 ppb Au were obtained within the area.

Au anomaly disappears towards the higher part near the ridge. It is assumed that the anomaly existed there, but the slash-and-burn farming disturbed the original geochemical conditions. The highest part of the ridge is covered by dacitic volcanics of the Barupu Tuffs. Considering these two factors, the area between the upper reaches of S. Tarawa and S. Malela may have a significant potential of gold-quartz mineralization.

A distinctive Au anomaly was found at the area between S. Malela and S. Pongo (500 m × 400 m). This is roughly correlated to the area of quartz veining. Anomalies of Cu and Zn are also confirmed in this area. Assay results of up to 0.40 g/t Au were returned from quartz float samples in this area.

A group of Au anomalies was detected at the area extending over the middle reaches of S. Tarawa and the middle reaches of S. Bone (600 m × 400 m). Several massive quartz veins crop out within this anomaly. Anomalous values of rock-chip samples of up to 172 ppb Au were obtained from this area. A remarkable value of 1,685 ppb Au was found from a rock-chip sample adjacent to this area along the middle reaches of S. Bone.

(2) Bau prospect

In 1991, panning prospecting, stream sediment survey and reconnaissance soil survey were carried out for an area covering approximately 50 km^2 in the Bau prospect. The soil sampling was made along creeks and ridge lines, and 261 soil samples were taken and provided for chemical analysis.

The geochemical works during 1992 consisted of detailed soil survey and rock-chip sampling. A total of 506 soil samples and 104 rock-chip samples was collected from an area of 15 km^2.

Au anomalies were obtained from four places through the soil geochemistry. They are low level anomalies (threshold value of $Au > 3.8$ ppb), and are isolated each other. Significant correlation has not been recognized between Au and the other elements. Anomalous values of rock-chip samples were detected at only limited localities.

These Au anomalies of soil and rock-chip samples were roughly correlated to the small scale outcrops of auriferous quartz veins and pyrite dissemination.

(3) S. Lebutang prospect

Panning prospecting and reconnaissance soil survey were conducted in the S. Lebutang prospect during 1992. A total of 606 soil samples was collected from an area of 60 km^2.

A distinctive soil anomaly (threshold value of $Au > 3.0$ ppb) was caught along S. Taroto extending to the upper reaches of S. Peko. It roughly coincides with the zone of gold bearing pyrite dissemination/stringers.

Several other Au anomalies were found in the prospect. They are small in scale and sporadic.

(4) Kariango prospect

Panning prospecting and reconnaissance soil survey were carried out in the Kariango prospect during 1992. A total of 404 soil samples was collected from an area of 40 km^2.

A low level Au anomaly (threshold value of Au > 3.7 ppb) was found at the southwestern side of S. Uroh. It has an area of 1,500 m × 1,000 m. The source of the anomaly is interpreted to be the limonite network zone in andesitic tuff.

4-3 Potential of Resources

(1) Batuisi prospect

A remarkable mineralized zone was delineated in the Batuisi prospect. It is composed of the significant Au anomalies of soil and rock-chip geochemistry, outcrops of auriferous quartz veins and quartz stockworks, and hydrothermal alteration zones. It has an area of 2,500 m × 1,500 m. It is interpreted that the type of mineralization is mesothermal gold-quartz veins in the Cretaceous Latimojong Formation.

The development of quartz veins and quartz stockworks is strong. The anomalies occur densely. The size and magnitude of gold mineralization are estimated to be medium from the geochemical features.

Based on the considerations of geologic environment, sulphide and gangue mineral assemblages, hydrothermal alteration and fluid inclusion studies, it is assumed that the mineralization in this area shows some similarity to the mesothermal gold-quartz veins of the Oya deposit, northern Japan. The Oya deposit has produced 18 t of gold from 1,280,000 t of ore. Gold occurred as coarse grain electrum in massive quartz veins. Gold grade was reported to have varied considerably. On the analogy of the Oya deposit, the distribution of gold in this area may fluctuate significantly.

The result of drilling in 1992 was disappointing. Low grade gold mineralization was confirmed in two holes. No ore-grade value has been obtained. However, only limited part of the mineralized zone was tested. It was composed of short holes. Further drilling is necessary for the full-evaluation of this zone. Targets of the next stage drilling are selected on the basis of the results of soil and rock-chip geochemistry and geological survey. Proposed targets are listed below in the order of priority. The depth of drill holes must be deep enough (around 200 m) to penetrate through the oxidized zone.

① South of the second phase drill line at the upper reaches of S. Tarawa
② North of the second phase drill line at the upper reaches of S. Bone
③ Area between S. Pongo and S. Malela
④ S. Malela

⑤ Near the top of the ridge (deeper part below dacitic volcanics of the Barupu Tuffs)
⑥ Middle reaches of S. Bone (rock-chip anomaly of 1,685 ppb Au)
⑦ NW extension of the "Old Dutch Pit" vein.

(2) Bau prospect

Gold-quartz veins similar to the Batuisi prospect were found in the Bau prospect. Some of the quartz veins showed significant assay results (up to 2.18 g/t Au). Each of the veins is small (10 cm or so in width) and seems to be discontinuous. Soil anomalies of Au and Cu in the area are of low level and sporadic. From these evidences, it is believed that the gold mineralization of this style has 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 seems to have little potential.

(3) S. Lebutang prospect

Gold mineralization associated with pyrite dissemination or stringers in massive andesite was found at S. Taroto. It shows some unique features compared with the mineralization in the Batuisi prospect. The details of mineralization have not been fully investigated. A series of Au anomalies of moderate to low degrees arranged from S. Kanan through S. Taroto and S. Peko up to S. Talodo Basisi was identified. The total strike length is over 4 km. The surface indications of this zone are significant. However, assay results of ore samples were disappointing. It is interpreted that this is a gold mineralization probably associated with pyrite dissemination within shear zones. The gold mineralization of this style appears to be of rather low-grade from the results of surface investigation so far.

The other outcrops of quartz veins and geochemical anomalies are estimated to be of minor importance.

(4) Kariango prospect

The limonite network zone and the subordinate Au anomaly of low level near S. Suluan are 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.

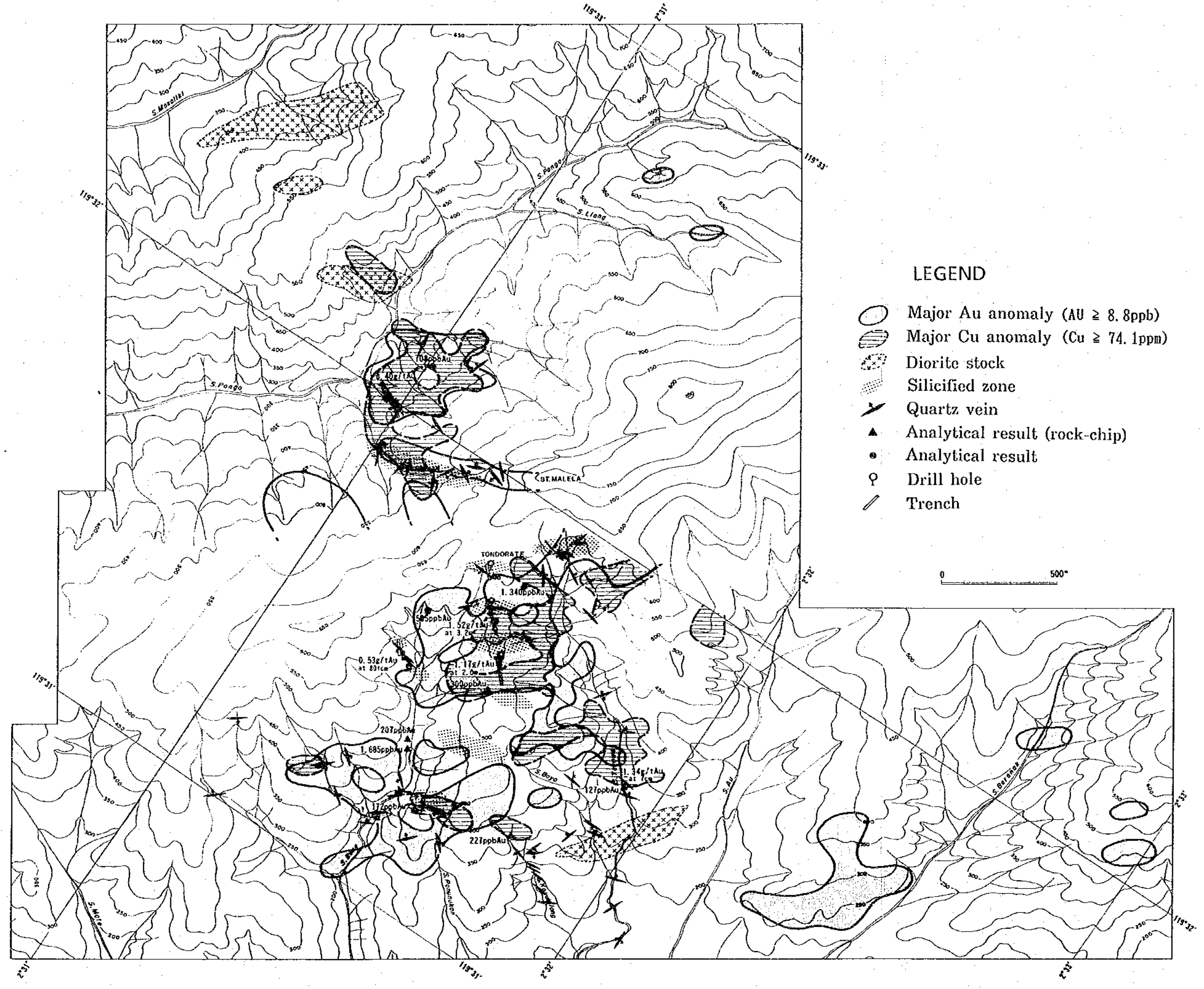


Fig.1-7 Integrated Interpretation of the Survey Results in the Batuisi Prospect

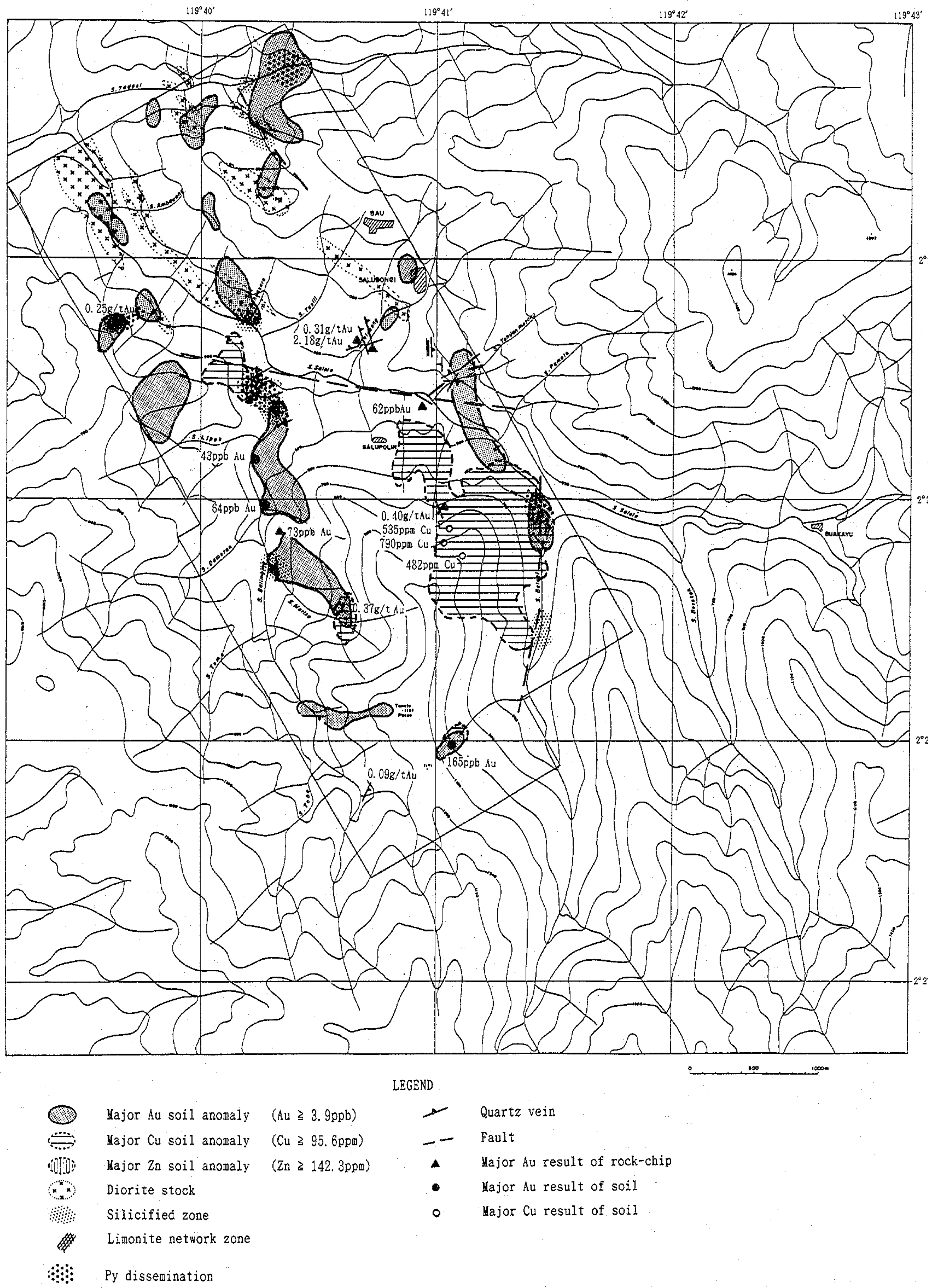


Fig.1-8 Integrated Interpretation of the Survey Results in the Bau Prospect

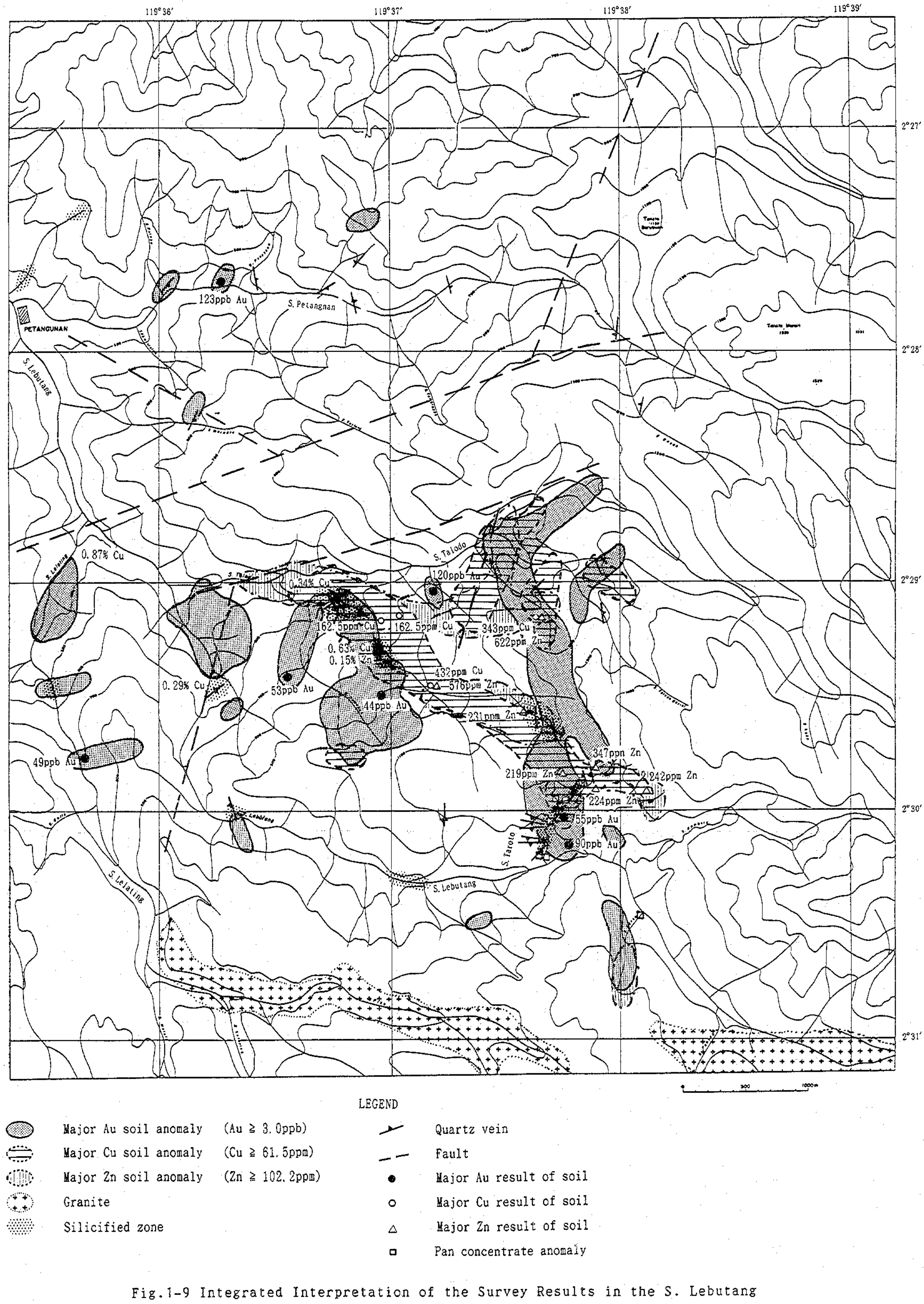


Fig.1-9 Integrated Interpretation of the Survey Results in the S. Lebutang Prospect

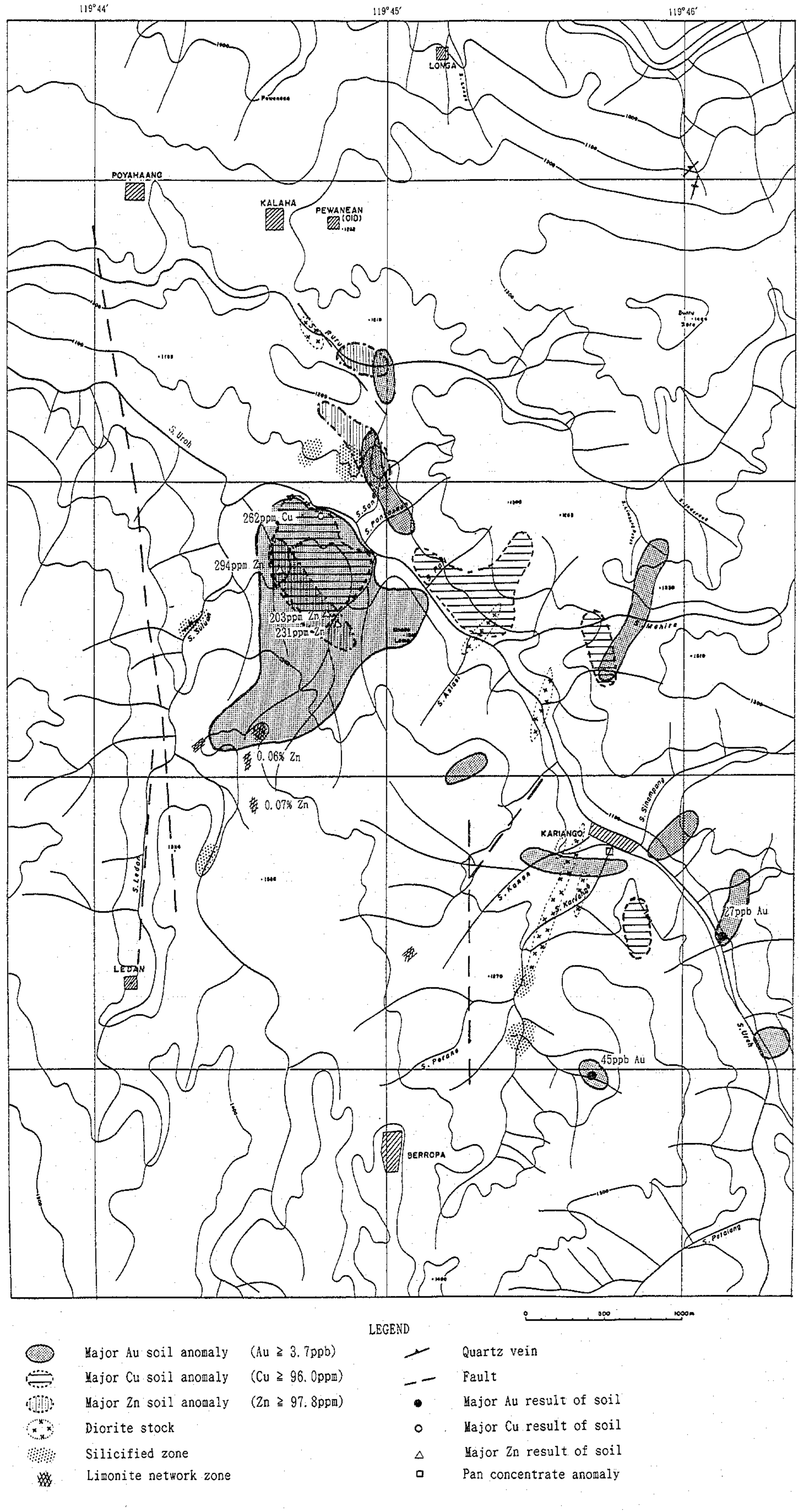


Fig.1-10 Integrated Interpretation of the Survey Results in the Kariango Prospect

Chapter 5 Conclusions and Recommendations

5-1 Conclusions

Batuisi prospect

On the basis of the results of the second phase exploration comprising detailed geological survey, grid soil survey, geochemical rock-chip sampling, shallow trenching and reconnaissance drilling, the following conclusions are obtained.

(1) The geology of the prospect is composed of black shale, siltstone, tuff, and andesite of the Cretaceous Latimojong Formation. The Mamasa granite batholith is exposed several kilometers to the south of the prospect. Small stocks of diorite which are inferred to be related to the granite body occur within the prospect. From the structural point of view, the prospect is located on the western flank of an anticlinorium (whose axis is N-S) formed by the emplacement of the Mamasa granite.

(2) Extensive development of quartz veins and quartz stockworks was confirmed in the prospect. Several vein systems were distinguished, and the formation of the vein pattern was discussed. The most dominant vein system -- NNW system -- is interpreted to be formed as a normal fault in the direction of compression probably generated by the emplacement of a granite body. The other major two systems -- N-S system and NW system -- may correspond to the synthetic-antithetic strike-slip faults formed by the compression.

(3) Two styles of quartz and sulphide mineralization were found mainly along S. Tarawa, S. Bone, S. Malela and S. Pongo in the prospect. One is massive quartz veins with dissemination of pyrite and chalcopyrite mainly found at the middle reaches of S. Tarawa and S. Malela. Another is quartz stockworks which accompany an impregnation of pyrite and chalcopyrite within the zone. The stockwork system was caught mainly at the area extending from the upper reaches of S. Tarawa to the upper reaches of S. Bone.

(4) Significant gold values were returned from outcrops, floats, rock-chips and trench samples within the area. An assay result of 1.34 g/t Au at 7 cm in width was obtained from a part of a massive quartz vein at the middle reaches of S. Tarawa. A quartz rock-chip of 1,685 ppb Au was found at the middle reaches of S. Bone. A value of 0.53 g/t at 80^{+} cm in width was obtained from an outcrop of

massive quartz vein at the northern side of the upper reaches of S. Bone. The best result of channel samples in trenches is 1.52 g/t Au at 3.2m in width. A value of 0.40 g/t Au was obtained from a quartz float zone at the S. Pongo area.

(5) The type and condition of gold mineralization in the prospect was discussed on the basis of petrology, mineralogy, hydrothermal alteration and fluid inclusion studies. It is interpreted that the gold-bearing quartz veins and quartz stockworks were formed under mesothermal conditions. The similarity of the mineralization to the gold-bearing quartz veins of the Oya deposit in northern Japan is considered. This type of ore deposit sometimes shows a large fluctuation of gold grade within the vein. This nature needs to be considered in the evaluation of mineralization.

(6) Three distinctive Au anomalies and several minor anomalies were delineated from grid soil survey and rock-chip geochemistry. The major anomalies are located at the upper reaches of S. Tarawa, S. Malela and the middle reaches of S. Bone. These anomalies are distributed within an area of 2,500 m (NE-SW) × 1,500 m (NW-SE) centered at the top of the ridge. They are composed of significant Au values of soil samples. The maximum value is 1,340 ppb Au. Anomalies of Cu and Zn almost overlap on the Au anomalies. The geochemical anomalies are well correlated to the areas where intensive quartz veins/stockworks were found. The size and magnitude of gold mineralization are estimated to be medium from the geochemical features.

(7) The result of drilling in 1992 was disappointing. Low-grade gold mineralization was found in two holes (0.50 g/t Au at 50 cm in MJT-3 and 0.53 g/t Au at 90 cm in MJT-4). No ore-grade value has been returned. However, only limited part of the mineralized zone was investigated. It was confirmed that the outcrops of quartz veins/stockworks and geochemical anomalies were the indicator of gold mineralization. There is a possibility of finding ore-grade parts within the zone. Some evidences of gold depletion by the lateritic weathering process, though circumstantial, are pointed out. Further drilling is necessary for the full-evaluation of this zone.

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.

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 result of ore samples is 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 1992.

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

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.

5-2 Recommendations for the Third Phase

Batuisi prospect

It is recommended that the mineralized zone delineated by the second phase survey in the prospect be fully drill-tested during the third phase. The major promising locations for drilling to be carried out during the third phase are listed below. The depth of drill holes must be deep enough (around 200m) to penetrate through the oxidized zone.

① South of the second phase drill line at the upper reaches of S. Tarawa
② North of the second phase drill line at the upper reaches of S. Bone
③ Area between S. Pongo and S. Malela
④ S. Malela
⑤ Near the top of the ridge
⑥ Middle reaches of S. Bone
⑦ NW extension of the "Old Dutch Pit" vein.

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.

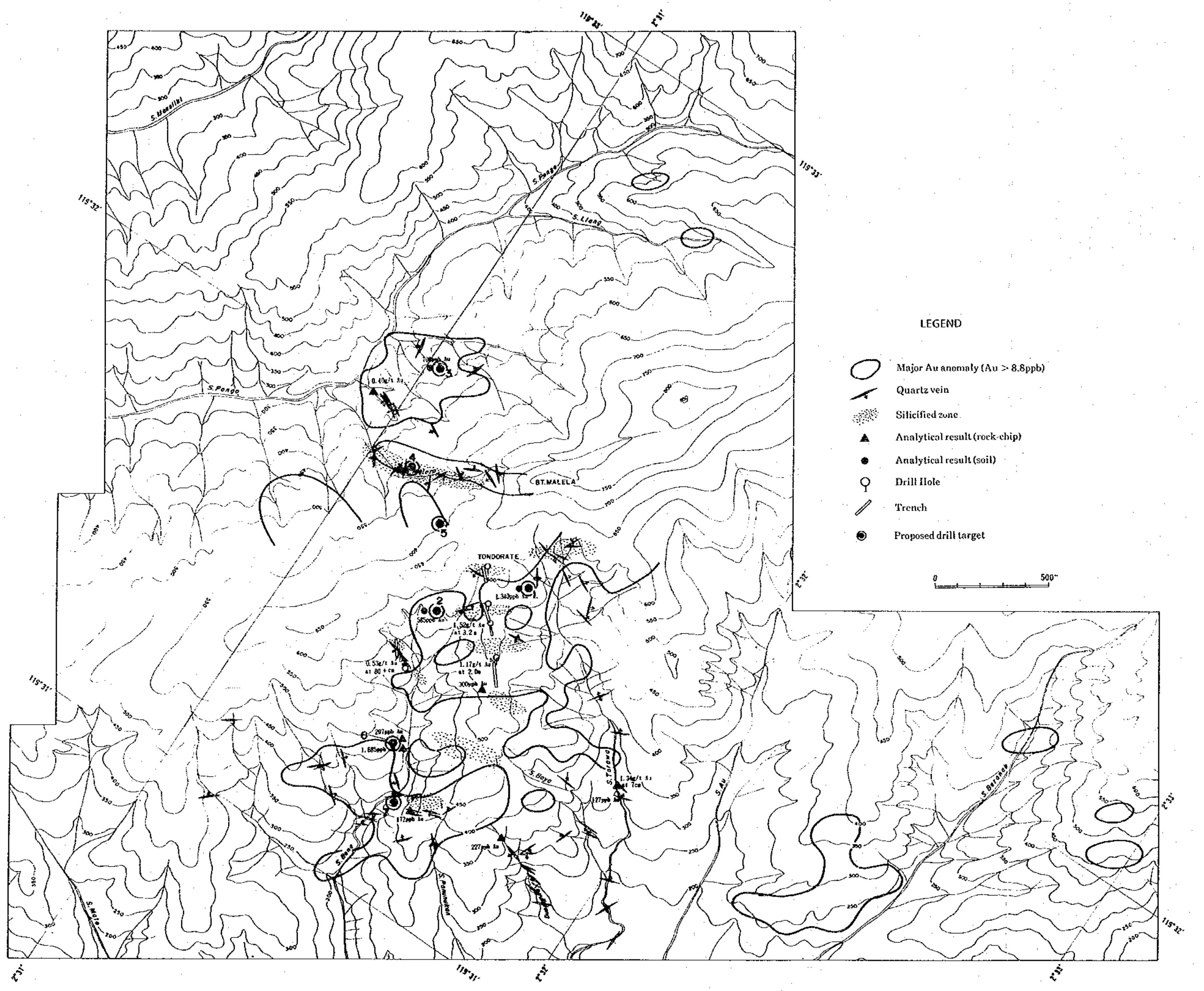


Fig.1-11 Proposed Targets for the Third Stage Drilling Programme in the Batuisi Prospect

PART Ⅱ DETAILED DISCUSSIONS

Chapter 1 Results of Geochemical Exploration in the First Phase

1-1 Stream Sediment Survey

(1) Sampling and chemical analysis

Regional geochemical exploration by means of stream sediment sampling was carried out during the 1991 survey. The entire survey area of 3,000 km^2 was covered by stream sediment sampling excluding some area of granite distribution. The purpose of the exploration was to find hidden mineralized zones which otherwise be undetected by geological survey, as well as to define the extension of mineral occurrences encountered through geological survey.

Fine sand samples of -80 mesh were collected from sediments in major channels and some of the bigger tributaries. The number of samples collected was more than one thousand (1,010), which corresponded to a sampling density of approximately one sample per 3 km^2. The samples, after being air-dried in the field, were analyzed at Chemex Labs Ltd. of Canada for 11 elements; Au, Ag, As, Bi, Sb, Hg, Cu, Pb, Zn, Ba and Mo. The analytical methods and the limits of detection are summarized in Table 2-1.

(2) Statistical data processing

On the assumption that the distribution of geochemical data shows a close approximation to the logarithmic normal distribution, the natural logarithmic conversion of the respective analytical values was adopted in the statistical data processing. When an analytical value was less than the detection limit, a value half of the lower limit was substituted in the calculation.

At first, statistical properties of geochemical data were checked. Basic statistical figures were calculated. Distribution histograms of each element were drawn out. Correlation coefficients among eleven elements were examined.

Then, principal components analysis was practised for extracting some statistically efficient combinations of elements.

Basic statistical figures

Table 2-2 shows the values of geometric mean, maximum and minimum, standard deviation, and proportion of samples less than the detection limit to total number of samples for each element. The proportion of samples with values less than the lower detection limit to the total population is high for Au, Ag, and Hg.

Fig.2-1 shows the frequency distribution of analytical values for each element. As, Bi, Cu, Pb, Zn, Ba and Mo show a distribution of close-to-normal.

Whereas Au, Ag, Hg and Sb present an L-shape distribution.

Table 2-3 shows the matrix of correlation coefficients among eleven elements. Values of the correlation coefficient more than 0.5 were obtained only in As-Sb, Cu-Zn, and Pb-Ba. The remaining combinations of elements indicated very low level of correlation.

Principal components analysis

Four principal components were chosen based on the eigenvalues more than 1.0. Values of the eigenvector, factor loading, proportion, and cumulative proportion were calculated for the four principal components as listed in Table 2-4. Characteristics of each principal component are briefly described as follows.

① The first principal component: Values of the factor loadings more than 0.5 were obtained for As, Sb, Pb, Zn and Mo. The result, together with Cu which showed the factor loading of slightly less than 0.5, may indicate that the first principal component has some association with the behaviour of these basemetal elements. The proportion, however, is less than 0.27. It means that the component itself is not enough to account for the overall behaviour of elements.

② The second principal component: This component is positively correlated, though weakly, to only Bi.

③ The third principal component: This component is positively correlated, though weakly, to only Ba.

④ The fourth principal component: This component is positively correlated, though weakly, to Ag and Hg.

Results of statistical analysis

Analytical values of Au do not show a logarithmic normal distribution at all. Au does not have any intimate correlation with the other elements. Any element or a group of elements which behaved together with Au has not been identified through the principal components analysis.

As for basemetal elements, some correlation was observed between As-Sb, and Cu-Zn. Weak associations among some of the basemetal elements such as As, Sb, Pb, Zn, Mo, and probably Cu were recognized in the first principal component.

Regarding the factor scores of each sample, they were calculated and were plotted on the map. The results were verified with the distribution of geologic units. Any significant correspondence has not been recognized. Thereafter the analysis was undertaken only globally by treating the whole data set indiscriminately.

(3) Anomalies of stream sediment geochemistry

Some elements such as Au and Ag did not show a neat log-normal distribution, as was mentioned above. A set of basemetal elements had a bare cross-relation. It was thus treated by rule to calculate thresholds of anomalies by values of twice the standard deviation added to the mean of each element.

A series of maps showing geochemical anomalies of stream sediments for each element is attached in appendices. Geochemical anomalies for each element were cross-checked on the maps. The results of panning prospecting were taken into consideration. The results of geological survey, those were the distribution of quartz veins, quartz floats and hydrothermal alteration, were also referred.

Those results were integrated together, and several significant anomalous zones were outlined. Six potential mineralized areas thus chosen are described as follows.

① Batuisi: Au anomalies of stream sediments and pan concentrates are densely arranged along S. Karataun and S. Pongo in the Batuisi prospect. Ag and As anomalies of stream sediments are located in the same area. Cu and Zn anomalies of second order were also detected. These anomalies are positioned not far from the locations of quartz veins. Most of them are within a few kilometer distance. It suggests that the quartz veins and their surrounding alteration zones are most likely the origin of these geochemical anomalies. Extensive occurrences of quartz veins and alteration zones were described in the first phase report.

② Bau: Au anomalies of stream sediments and pan concentrates are closely arranged along S. Salole, S. Balimbing and S. Tadasi in the Bau prospect.
Ag and Cu anomalies of stream sediments are located, and As and Zn anomalies of second order were also detected within the area. Occurrences of quartz veins, quartz floats, and alteration zones were recognized in the same area as explained in the first phase report.

③ S. Lebutang: A series of strong Au anomalies of stream sediments was returned from the area which lies along S. Lebutang and its tributaries (S. Petangunan, S. Lelating, S. Talodo and S. Taroto). The strongest one which was obtained near the junction of S. Lebutang and S. Karama was 2,660 ppb Au.

Distinctive values of 1,250 ppb Au and 1,050 ppb Au were also returned from this area. Some significant Au anomalies of pan concentrates were observed in this area, although it has not been fully covered by the panning prospecting. Cu, Zn and Ag anomalies of stream sediments were scattered mainly along the upper reaches of S. Lebutang and S. Talodo. The geology of the area is composed mainly of black shale and dolerite of the Latimojong Formation. Quartz veins and pyrite dissemination were found in this area. This area is situated immediately at the north of the Mamasa granite batholith.

④ Kariango: Several Au anomalies of stream sediments were detected at the north of Kariango along S. Uroh and S. Betuwe. Cu, Pb, Zn and Ag anomalies of stream sediments were sparsely distributed in the area. The geology of the area is composed of andesitic tuff of the Beropa Tuffs and black shale of the Toraja Formation. Any surface indication of mineralization has not known in the area.

⑤ S. Kakea: Sixteen Zn anomalies of stream sediments were detected along S. Kakea. The highest was 273 ppm Zn. Pb and Cu anomalies of second order were associated with the Zn anomalies. The geology is composed of andesitic to basaltic volcanic rocks of the Talaya Volcanic Rocks. The Zn anomalous zone was positioned several kilometers downstream of the occurrences of quartz floats with pyrite dissemination.

⑥ S. Rongkong: Distinctive Ag anomalies of stream sediments accompanying with Pb and As anomalies were observed along the upper reaches of S. Rongkong and its tributaries (S. Rasasisi, S. Marampa, S. Punti and S. Paku). The absolute values of Ag anomalies, however, are generally low. The geology of the area is mainly composed of Miocene volcanic-pyroclastic series of the Lamasi Volcanic Rocks and the Kambuno granite.

Table 2-1 Methods of Analysis and Limits of Detection of Stream Sediment Samples

Element	Methods of Analysis	Detection Limit	Upper Limit
Au	Fire assay with AA finish	5 ppb	10 ppm
Ag	Nitric aqua regia with AA finish	0.05 ppm	0.02 %
As	Aqua regia hydride with AA finish	0.2 ppm	0.5 %
Bi	$HCl/KClO_3$ extraction with AA finish	0.2 ppm	0.5 %
Sb	ditto	0.2 ppm	0.1 %
Hg	HNO_3/HCl cold vapour with AA finish	0.1 ppm	0.5 %
Cu	Nitric aqua regia with AA finish	0.2 ppm	0.5 %
Pb	ditto	0.5 ppm	0.5 %
Zn	ditto	1 ppm	0.5 %
Ba	Total digestion with AA finish	10 ppm	1 %
Mo	Nitric aqua regia with AA finish	0.2 ppm	0.5 %

※ AA means Atomic Absorption Method

Table 2-2 Basic Statistics of Stream Sediment Samples

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Sb (ppm)	Hg (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ba (ppm)	Mo (ppm)
Log Mean (M)	3.2	0.028	6.1	0.6	0.2	0.06	15.7	18.9	60.8	938	0.2
Max Value	2660	0.70	255.0	70.0	160.5	17.1	160.5	155.5	273.0	4700	3.4
Min Value	<5	<0.05	<0.2	<0.2	<0.2	<0.1	0.4	1.0	8	20	<0.2
Std Dev (σ)	2.6	1.377	3.3	2.7	3.1	1.77	2.4	1.9	1.6	2	1.9
M+σ	8.2	0.038	20.2	1.6	0.8	0.11	38.1	35.2	98.7	1883	0.4
M+2σ	21.5	0.053	66.5	4.3	2.3	0.19	92.4	65.7	160.3	3780	0.7
No of Sample less D Lmt %	93.7	86.3	0.1	4.5	47.2	84.9	0	0	0	0	30.3

※ Number of Samples = 1,010

Table 2-3 Correlation Matrix of Stream Sediment Samples

	Au	Ag	As	Bi	Sb	Hg	Cu	Pb	Zn	Ba	Mo
Au	1.00	0.09	0.02	-0.02	-0.00	-0.01	0.18	-0.04	0.17	-0.06	0.16
Ag		1.00	0.28	0.26	0.14	0.10	0.05	0.24	0.11	-0.05	0.26
As			1.00	0.39	0.70	0.03	0.15	0.44	0.19	-0.03	0.41
Bi				1.00	0.14	0.04	-0.11	0.43	-0.06	0.14	0.06
Sb					1.00	0.04	0.16	0.25	0.17	-0.01	0.17
Hg						1.00	-0.00	0.06	0.02	-0.01	0.08
Cu							1.00	0.12	0.72	-0.06	0.33
Pb								1.00	0.39	0.60	0.30
Zn									1.00	0.09	0.43
Ba										1.00	-0.01
Mo											1.00

Table 2-4 Results of Principal Components Analysis of Stream Sediment Samples

	1		2		3		4	
	Eigen-vector	Factor Loading	Eigen-vector	Factor Loading	Eigen-vector	Factor Loading	Eigen-vector	Factor Loading
Au	0.089	0.152	-0.281	-0.376	-0.046	-0.055	0.376	0.392
Ag	0.257	0.440	0.109	0.146	-0.241	-0.287	0.504	0.526
As	0.443	0.759	0.177	0.237	-0.356	-0.424	-0.241	-0.251
Bi	0.237	0.405	0.446	0.597	-0.062	-0.074	0.204	0.213
Sb	0.342	0.586	0.100	0.134	-0.358	-0.426	-0.460	-0.479
Hg	0.064	0.109	0.043	0.057	-0.083	-0.099	0.495	0.516
Cu	0.288	0.494	-0.520	-0.695	0.125	0.149	-0.106	-0.110
Pb	0.419	0.718	0.290	0.388	0.392	0.467	0.014	0.015
Zn	0.370	0.634	-0.424	-0.567	0.269	0.321	-0.044	-0.046
Ba	0.133	0.228	0.299	0.401	0.655	0.781	-0.042	-0.044
Mo	0.373	0.640	-0.211	-0.282	-0.059	-0.070	0.181	0.189
Eigen	2.935		1.791		1.420		1.087	
Prop	0.267		0.163		0.129		0.099	
Cum Pr	0.267		0.430		0.559		0.658	

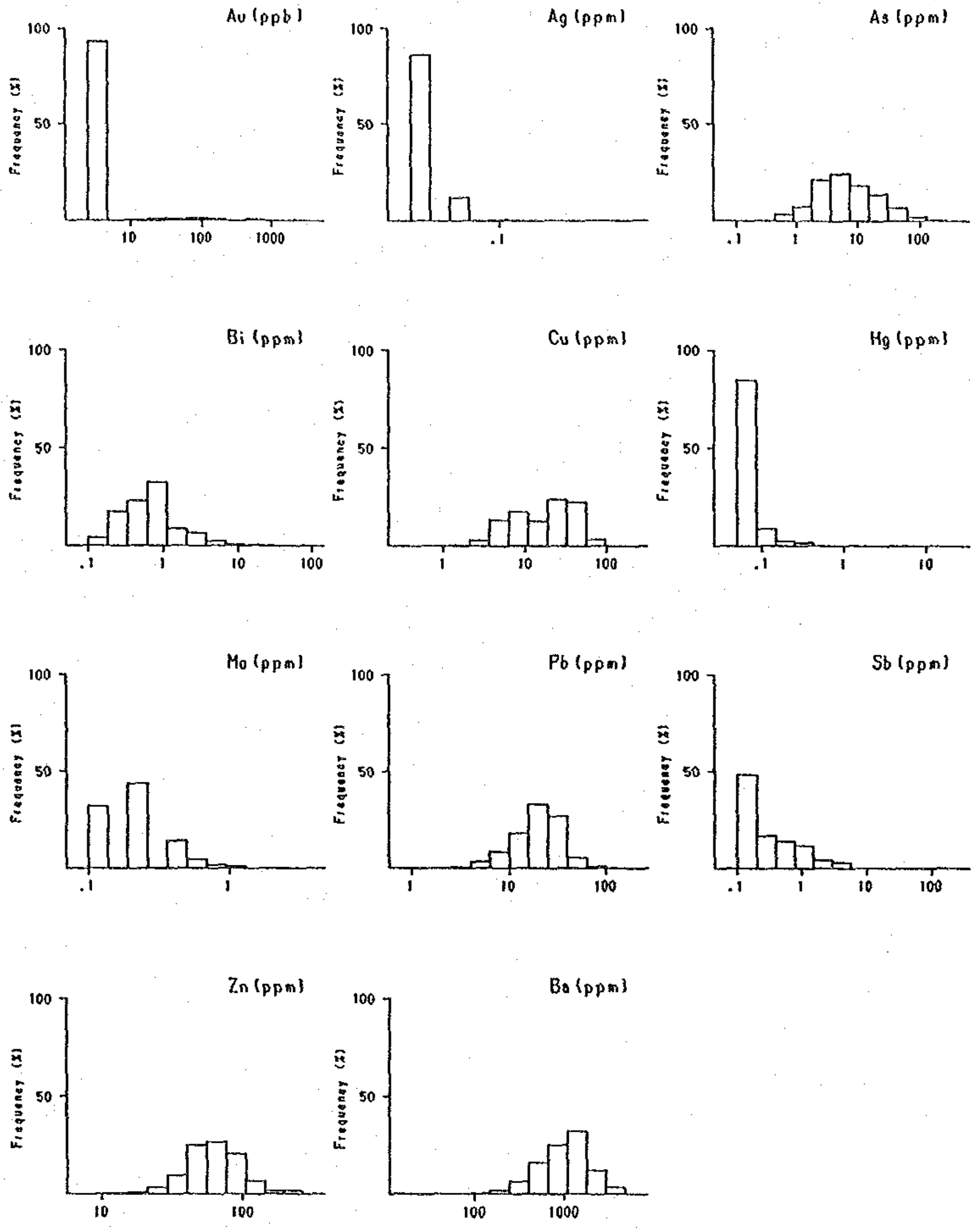


Fig.2-1 Histogram of 11 Elements of Stream Sediment Samples

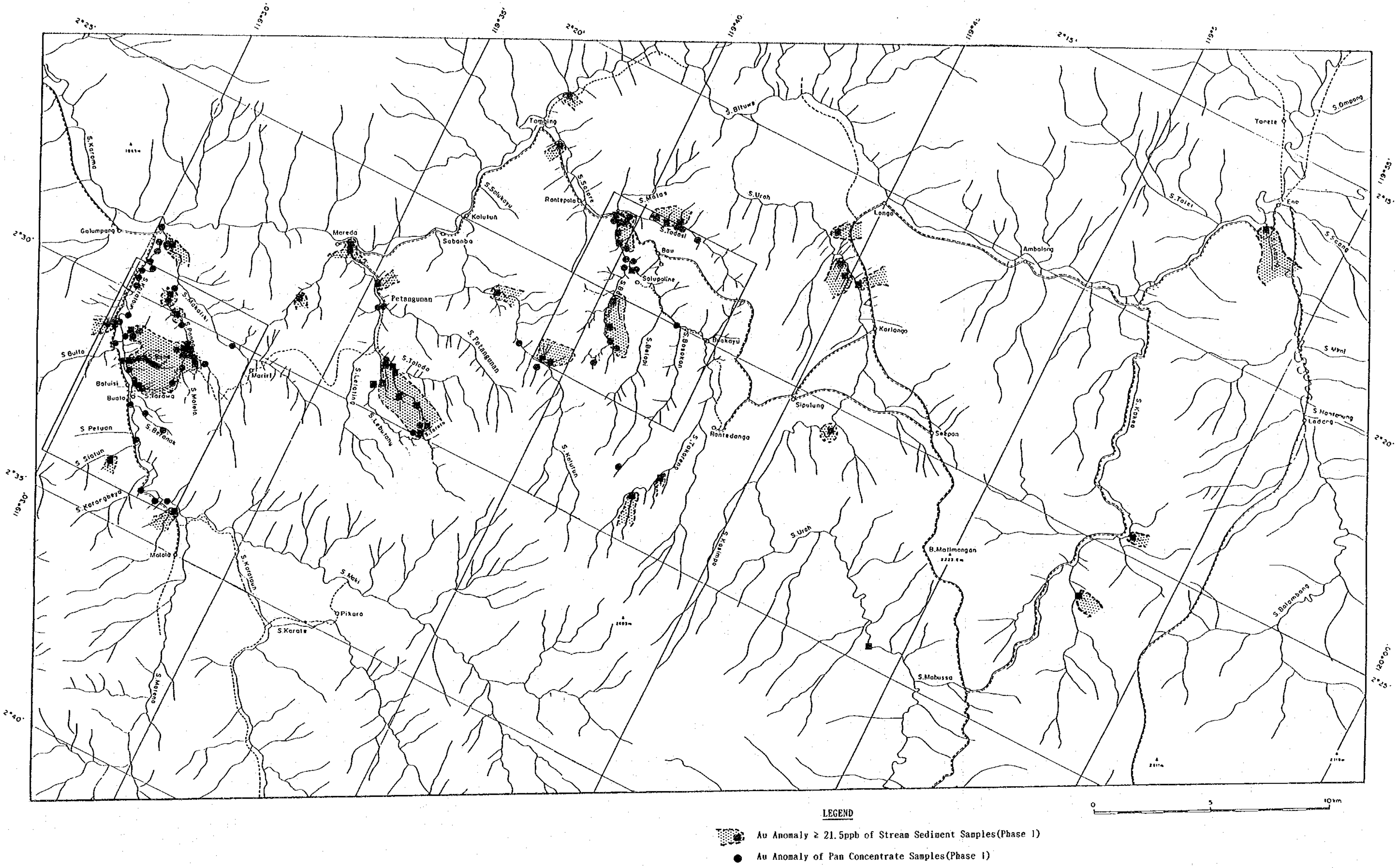


Fig.2-2 Distribution of Regional Geochemical Gold Anomalies in the Northern Part of the Survey Area (1991)

1-2 Panning Prospecting

(1) Outline of sampling and heavy minerals analysis

Panning prospecting was carried out during semi-detailed geochemical exploration in two areas; ① Bau prospect, and ② Batuisi prospect. Some of the topographically important localities such as the junction of major drainage system and its tributaries in the regional survey area were checked by panning prospecting. The number of pan concentrate samples collected in the field in 1991 amounted to 366.

Pan concentrate samples were obtained from trap sites in the active drainage channels. A bucketful of sand and gravel which was about 2 liters was gathered and carefully panned out. Approximately 5 grams of concentrate was collected at every point. Number of gold grains was counted and heavy mineral composition was examined roughly in the field and carefully under the microscope in the laboratory later.

Gold was detected in 74 pan concentrate samples under the microscope. Cinnabar, chalcopyrite, arsenopyrite and galena were observed in 16, 12, 9, and 2 samples respectively. The most common minerals are; magnetite, ilmenite, pyroxene, amphibole, epidote, garnet, zircon, pyrite and quartz. The other minerals such as barite, cinnabar, chalcopyrite, corundum, galena, rutile, gold, arsenopyrite and iron-oxide minerals were observed in some localities. Grain size of gold varies from several ten microns up to 500 microns. Shapes of minerals are mostly subangular or subrounded, with lesser amount of typical crystal of zircon, garnet, magnetite, ilmenite and corundum. Most of gold grains showed subangular, not so much rounded figures.

The methods and procedures of gold and heavy minerals analysis were explained in the first phase report. The results of field observation and laboratory check were listed in Appendix 4 of the first phase report.

(2) Anomalies of panning prospecting

Three areas of intensive distribution of gold and some heavy minerals in pan concentrates were identified; Batuisi, Bau and S. Lebutang. Distributions of gold, cinnabar and sulphide minerals (chalcopyrite, arsenopyrite, galena, etc.) in pan concentrates appear to be closely related each other.

① Batuisi: Occurrences of gold in pan concentrates were widely and intensively distributed in the Batuisi prospect along S. Karataun, S. Pongo and S. Makaliki. Arsenopyrite, chalcopyrite and cinnabar were also detected in pan concentrates in the prospect. Gold anomalies of panning prospecting almost overlap on those of stream sediments.

② Bau: Gold, some cinnabar and chalcopyrite were observed in pan concentrates in the Bau prospect along S. Salole, S. Balimbing and S. Tadasi. Gold occurrences in pan concentrates and Au anomalies of stream sediments roughly coincide each other.

③ S. Lebutang: Gold anomalies were detected in five localities along S. Lebutang. Cinnabar and chalcopyrite were found in a few localities mainly at the downstream of the river. Sampling intervals in the area were very large, because it was not specified as a detailed survey area.

1-3 Soil Survey

(1) Sampling and chemical analysis

Reconnaissance soil survey was carried out in two semi-detailed survey areas; ① Batuisi prospect, and ② Bau prospect, and a total of 510 soil samples was collected during the 1991 survey.

Soil samples were taken from the B-layer of residual soil at depths of 20 to 60 cm from the surface. Sampling traverses were tried to set almost at right angles to the inferred strike direction of mineralization as much as possible. Sampling intervals along the traverses were 300 m on the average. Soil samples were air-dried at the base camp, then crashed to -80 mesh. Chemical analysis was conducted at Chemex Labs Ltd. of Canada for 11 elements; Au, Ag, As, Bi, Sb, Hg, Cu, Pb, Zn, Ba and Mo. The analytical details are given in Table 2-5.

(2) Statistical data processing

The same methods and procedures as in stream sediments were adopted in the data processing of soil samples. Analytical data of Batuisi and Bau were examined together in the statistical processing.

Basic statistical figures

Table 2-6 shows the values of geometric mean, maximum and minimum, standard deviation, and proportion of samples less than the detection limit to total number of samples for each element. The proportion of samples with values less than the lower detection limit to the total population is high for Au and Hg.

Fig.2-3 shows the frequency distribution of analytical values for each element. As, Bi, Cu, Pb, Zn, Ba and Mo show a distribution of close-to-normal. Whereas Au, Ag, Hg and Sb present an L-shape distribution.

Table 2-7 shows the matrix of correlation coefficients among eleven elements. Values of the correlation coefficient more than 0.5 were obtained in As-Pb, As-Mo, Bi-Pb, Pb-Mo, Cu-Zn and Pb-Ba. However the values were significant only in the last two combinations. The remaining combinations of elements indicated very low level of correlation.

Principal components analysis

Four principal components were chosen based on the eigenvalues more than or nearly equal to 1.0. Values of the eigenvector, factor loading, proportion and cumulative proportion were calculated for the four principal components as listed in Table 2-8. Characteristics of each principal component are briefly described as follows.

① The first principal component: Values of the factor loadings more than 0.5 were obtained for Ag, As, Bi, Pb, Ba and Mo. The first principal component indicated an association of these basemetal elements. The proportion, however, is scarcely larger than 0.30. It means that the component itself is not enough to account for the overall behaviour of elements.

② The second principal component: This component is positively correlated to Sb-Cu-Zn.

③ The third principal component: This component is positively correlated, though weakly, to only Hg.

④ The fourth principal component: This component is strongly correlated to Au.

Results of statistical analysis

Analytical values of Au do not show a logarithmic normal distribution at all. Au does not have any intimate correlation with the other elements. Any element or a group of elements which behaved together with Au has not been identified through the principal components analysis. These results suggest that the mode of geochemical dispersion of Au in residual soil may be independent.

As for basemetal elements, some correlations were recognized in Cu-Zn and Pb-Ba. Weak associations among Ag-As-Bi-Pb-Ba-Mo and Sb-Cu-Zn were observed in the first and second principal components respectively.

(3) Anomalies of soil geochemistry

Thresholds of anomalies were obtained automatically through the calculation of twice the standard deviation plus the mean of each element, because the examination of basic statistics provided irrelevant result.

A series of maps showing the geochemical anomalies of soil samples for each element is attached in appendices. Geochemical anomalies for each element were cross-checked on the maps. The results of geological survey, stream sediment geochemistry and panning prospecting were examined too. Those results were integrated together, and several significant anomalous zones were delineated.

① Batuisi: Two distinctive soil anomalies were caught, and several other small anomalies were recognized in the Bastuisi prospect.

One of the distinctive anomalous zones is located on the hill-top at the northwest of S. Tarawa. It consists of several Au anomalies arranged continuously. Anomalies of basemetal elements, such as Cu, Pb, and Zn, stand within and at the surrounding locations of the Au anomalies.

Fig.2-7 shows the geochemical profile along the survey line. Two sharp peaks of Au anomalies were recognized. The eastern peak is approximately 200 m wide, and has the maximum value of 180 ppb.
The western anomaly has the similar size and slightly smaller magnitude as of the eastern one. This zone was traversed during the geological survey in 1991, and some quartz floats were found. One quartz float zone was found just between the two peaks. Another zone was found about 100 m west of the western peak. It was interpreted that the zone was located at the extension of quartz veins at the upper reaches of S. Tarawa.

Another significant Au anomalous zone is situated at the lower reaches of S. Malela. Anomalies of basemetals such as Ag, Cu, Pb and Zn are associated with Au anomaly. This zone corresponds to the location of intensive development of quartz veins at S. Malela.

The other anomalies comprising Au and basemetal elements were found at S. Tarawa, S. Bone, S. Tandiko, S. Mate and S. Beranak. Those anomalies roughly correspond to the locations of quartz veins or their extensions.

② Bau: Two anomalous zones mainly composed of basemetal elements, although they were not densely distributed, were observed in the prospect. Within them, Au anomalies were found in only two localities. Those two zones are arranged parallel to each other in NNW direction.

The eastern zone is composed of Cu, Pb and Zn anomalies. It lies in the area from the junction of S. Saloie and S. Belopi up to the north in the vicinity of Kp. Bau. It almost corresponds to the zone of extensive development of quartz veins. One of the Au anomalies in soil samples is situated at the extension of the zone.

The western zone, composed of sporadic Ag and Pb anomalies, runs from S. Balimbing up to the junction of S. Saloie and S. Tadasi. An Au anomaly in soil, which was detected at the upper reaches of S. Balimbing, is situated at the extension of this zone. The significance of this anomalous zone may be supported by some indications of mineralization, such as Au anomalies of panning and stream sediment geochemistry.

Table 2-5 Methods of Analysis and Limits of Detection of Soil Samples

Element	Methods of Analysis	Detection Limit	Upper Limit
Au	Fire assay with AA finish	5 ppb	10 ppm
Ag	Nitric aqua regia with AA finish	0.05 ppm	0.02 %
As	Aqua regia hydride with AA finish	0.2 ppm	0.5 %
Bi	$HCl/KClO_3$ extraction with AA finish	0.2 ppm	0.5 %
Sb	ditto	0.2 ppm	0.1 %
Hg	HNO_3/HCl cold vapour with AA finish	0.1 ppm	0.5 %
Cu	Nitric aqua regia with AA finish	0.2 ppm	0.5 %
Pb	ditto	0.5 ppm	0.5 %
Zn	ditto	1 ppm	0.5 %
Ba	Total digestion with AA finish	10 ppm	1 %
Mo	Nitric aqua regia with AA finish	0.2 ppm	0.5 %

※ AA means Atomic Absorption Method

Table 2-6 Basic Statistics of Soil Samples

	Au (ppb)	Ag (ppm)	As (ppm)	Bi (ppm)	Sb (ppm)	Hg (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ba (ppm)	Mo (ppm)
Log Mean (M)	2.8	0.043	5.5	0.4	0.3	0.07	35.0	9.9	66.2	217	0.3
Max Value	180	0.40	330.0	21.2	12.6	3.2	620.0	70.5	1080	1600	4.4
Min Value	<5	<0.05	<0.2	<0.2	<0.2	<0.1	0.8	<0.5	5	<10	<0.2
Std Dev (σ)	1.7	1.801	3.1	2.2	2.8	1.81	2.1	3.0	1.8	3	2.4
$M+\sigma$	4.7	0.077	17.2	0.8	0.7	0.12	75.1	29.4	120.0	631	0.6
$M+2\sigma$	8.1	0.139	53.7	1.8	2.0	0.22	161.1	86.8	217.5	1831	1.5
No of Sample less D Lmt %	95.5	43.3	1.2	10.6	39.2	77.1	0	0.8	0	0.4	29.0

※ Number of Samples = 510

Table 2-7 Correlation Matrix of Soil Samples

	Au	Ag	As	Bi	Sb	Hg	Cu	Pb	Zn	Ba	Mo
Au	1.00	0.03	0.05	0.05	0.09	-0.00	0.17	0.02	0.11	-0.03	-0.06
Ag		1.00	0.30	0.24	0.20	0.07	0.11	0.32	0.16	0.33	0.37
As			1.00	0.36	0.41	0.07	0.00	0.56	0.01	0.45	0.56
Bi				1.00	0.06	0.05	-0.12	0.54	-0.01	0.52	0.35
Sb					1.00	0.09	0.24	0.07	0.18	-0.05	0.24
Hg						1.00	0.04	-0.00	-0.07	-0.02	0.07
Cu							1.00	-0.30	0.70	-0.21	-0.03
Pb								1.00	-0.07	0.80	0.55
Zn									1.00	0.07	-0.03
Ba										1.00	0.45
Mo											1.00

Table 2-8 Results of Principal Components Analysis
of Soil Samples

	1		2		3		4	
	Eigen-vector	Factor Loading	Eigen-vector	Factor Loading	Eigen-vector	Factor Loading	Eigen-vector	Factor Loading
Au	0.006	0.010	0.212	0.299	-0.118	-0.127	0.927	0.919
Ag	0.286	0.525	0.211	0.297	0.011	0.012	-0.159	-0.158
As	0.408	0.749	0.130	0.183	0.242	0.261	0.038	0.038
Bi	0.366	0.672	-0.054	-0.076	-0.174	-0.188	0.165	0.164
Sb	0.140	0.256	0.383	0.541	0.487	0.526	0.027	0.027
Hg	0.039	0.072	0.048	0.068	0.581	0.628	0.109	0.108
Cu	-0.096	-0.177	0.623	0.880	-0.128	-0.138	-0.095	-0.094
Pb	0.479	0.879	-0.139	-0.196	-0.147	-0.159	0.063	0.063
Zn	-0.004	-0.007	0.566	0.799	-0.384	-0.415	-0.178	-0.177
Ba	0.440	0.808	-0.103	-0.145	-0.325	-0.351	-0.037	-0.036
Mo	0.405	0.744	0.059	0.083	0.177	0.191	-0.168	-0.166
Eigen	3.367		1.994		1.167		0.983	
Prop	0.306		0.181		0.106		0.089	
Cum Pr	0.306		0.487		0.594		0.683	

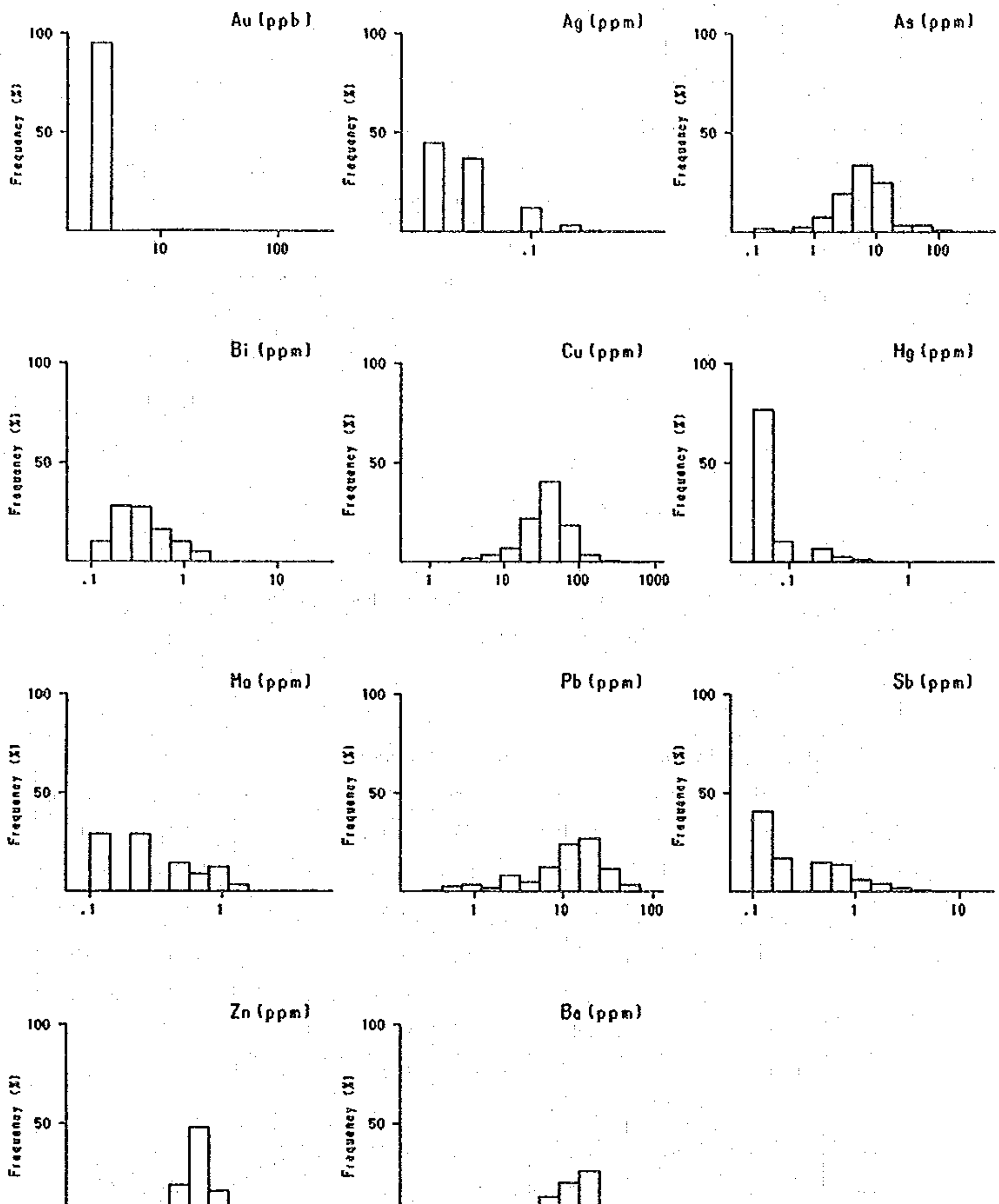


Fig.2-3 Histogram of 11 Elements of Soil Samples

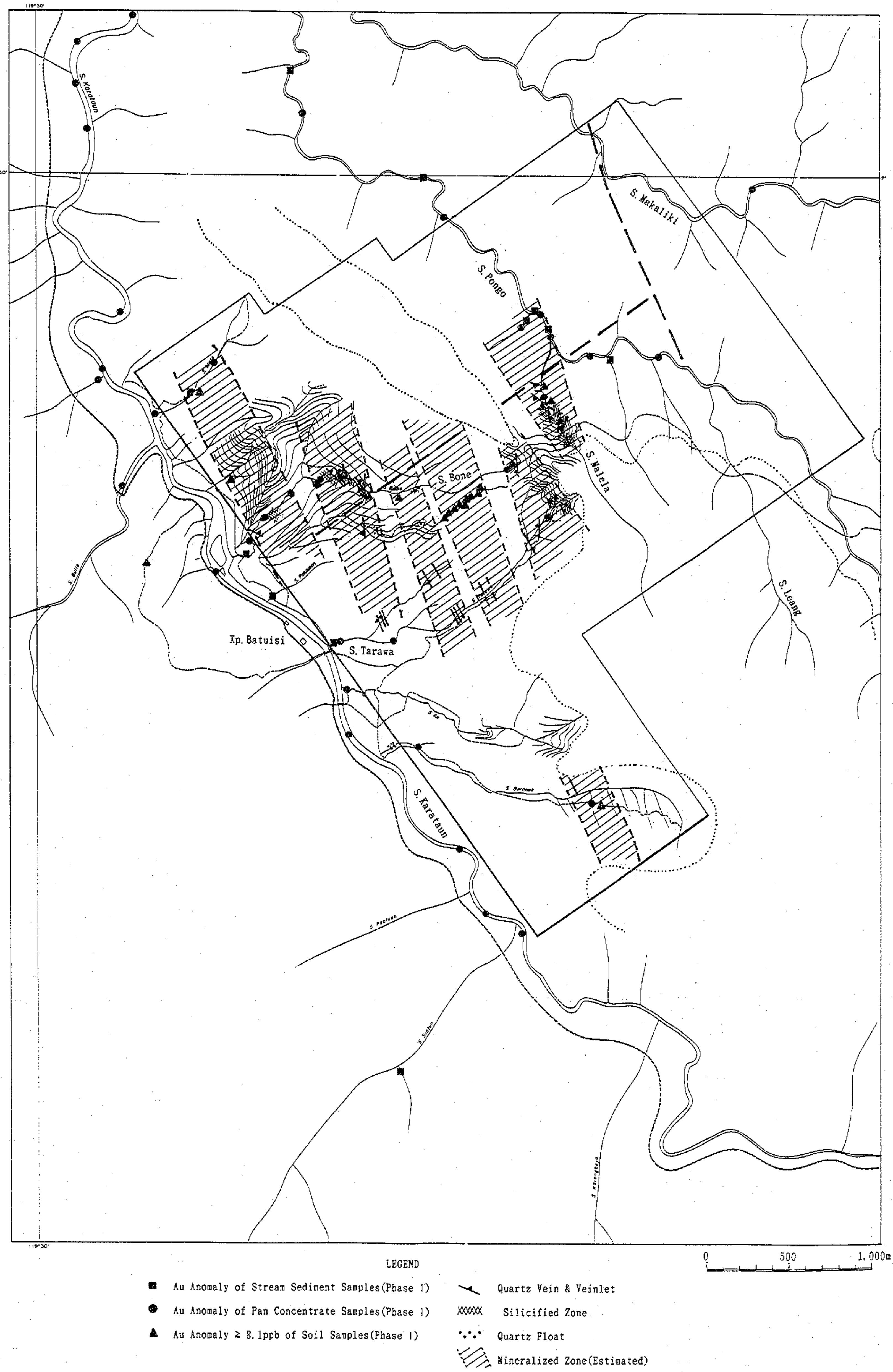
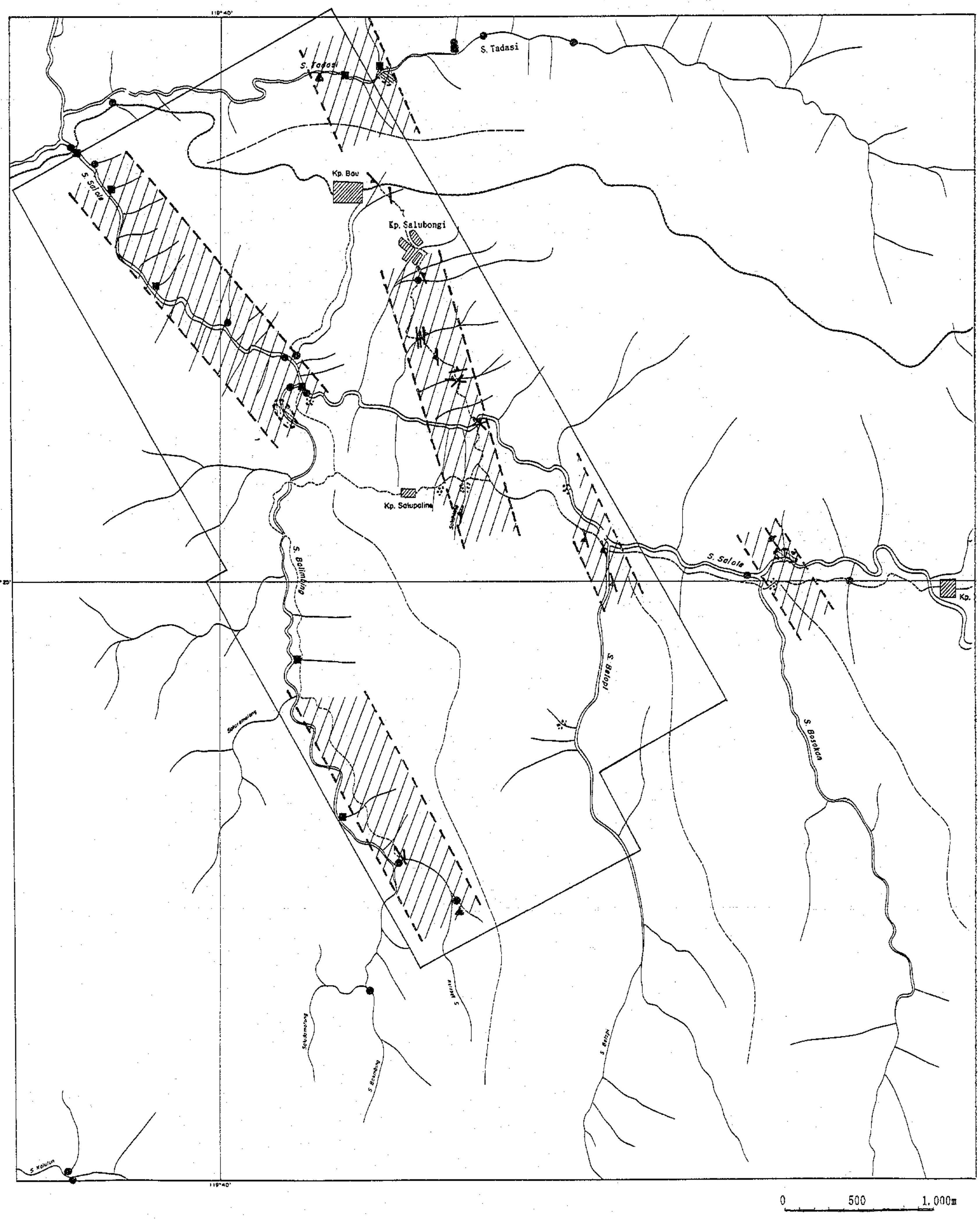


Fig.2-4 Distribution of Indications of Gold Mineralization in the Batuisi Prospect



LEGEND

- ■ Au Anomaly of Stream Sediment Samples(Phase I)
- ● Au Anomaly of Pan Concentrate Samples(Phase I)
- ▲ Au Anomaly ≥ 8.1ppb of Soil Samples(Phase I)
- Quartz Vein & Veinlet
- XXXXX Silicified Zone
- ·.·.· Quartz Float
- ////// Mineralized Zone(Estimated)

Fig.2-5 Distribution of Indications of Gold Mineralization in the Bau Prospect