THE REPUBLIC OF INDONESIA
REPORT ON THE COOPERATIVE MINERAL EXPLORATION
OF
SOUTHERN SUMATRA

CONSOLIDATED REPORT

FEBRUARY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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Preface

The Government of Japan, in response to a request extended by the Government of the Republic of Indonesia, agreed to conduct a metallic mineral exploration survey in Southern Sumatra, Indonesia,and commissioned its implementation to the Japan International Cooperation Agency. The agency, taking into consideration the importance of the technical nature of the survey work, sought the cooperation of the Metal Mining Agency of Japan to accomplish the task.

The Government of the Republic of Indonesia appointed the Directorate of Mineral Resources to execute the survey as counterpart to the Japanese Team.

This survey has been conducted from 1985 to 1987, and has been completaed on schedule with the assistance of agencies of the Government of Indonesia.

This consolidated report hereby submitted, summarized the results of the said survey.

We wish to express our heartful gratitude to the agencies of the Government of the Republic of Indonesia, Ministry of Foreign Affairs, Ministry of International Trade and Industry, and the Japanese Embassy in the Republic of Indonesia for their kind cooperation and support in the implementation of this survey.

February, 1988

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Summary

A survey was conducted in the Southern Sumatra area of the Republic of Indonesia from 1985 to 1987 as follows.

Initial phase : The whole area (1,250 km^2) was investigated by photogeological interpretation,prio to the survey,and the area was divided into a 1,238 km^2 area for reconnaissance survey and an 18 km^2 area for detailed survey. Geological and geochemical survey were then conducted for the reconnaissance survey and detailed survey.

Second phase :

(1) Six survey sectors (total 22 km^2) in the Bt. Raja area were selected from reconnaissance survey area,the initial phase, and a detailed survey including geological, geochemical and ground magnetic surveys was conducted.

(2) A drilling survey (10 holes, 1,510 m) was conducted in the S. Tuboh area (extent: 600 m X 500 m), selected from the initial phase detailed survey area.

Third phase : A drilling survey (13 holes, 3,170 m) was continuously conducted in the S. Tuboh area.

The results of these surveys are summarized below.

1) Geology

The geology of the Southern Sumatra area is as follows :

【Mesozoic】

(Jurassic - Cretaceous) : S. Rawas Formation. A limestone dominant Stratum in the Middle and Upper Formation is named as the Mersip Limestone Member.

(Cretaceous) : S. Kuwis Formation

【Cenozoic】

(Neogene) : Napalicin Formation
Hulusimpang Formation
S. Minak Formation

(Quaternary) : Surulangun Formation
Terrace deposits

The Mesozoic system is made up sandy and muddy facies and pyroclastic rocks, and the Cenozoic system is mainly consists of pyroclastic rocks.

Intrusive rocks include qurtz diorite from igneous activity of 80 ma., granites and alkaline rocks from 60 - 50 Ma., Neogene quartz diorite porphyry,

basalt, andesite and dacite.

The Mesozoic system striks generally NW-SE trend, but the system in S. Tuboh area where the detailed survey was conducted trends NE-SW virtually perpendicular to the general trend.

2) Mineralization

The several mineralization below have been observed or inferred with a high probability. Of these, the skrn type Ag-Zn-Pb mineralization typified by the S. Tuboh indication is the most promising type in this area.

Mineralization in this area is as follows;

(a). Skarn type mineralization (3 indications: S. Tuboh, S. Kering, S. Sepan) in the detailed survey area. Of these, the S. Tuboh indication is of most prominant distribution.

(b). Porphyry copper type mineralization, skarn type mineralization and pyrite dissemination type in the Bt. Raja area, all with low grades and on a small scale.

(c). Pyrite dissemination type mineralization in the lower reaches of the S. Kuwis, with low grade in all indications.

Following types of mineralization has also been inferred.

(d). Metamorphic and segregated gold mineralization inferred in the area of Mesozoic distribution. This may be the source of the alluvial gold collecting in the S.Rawas.

(e). Plio-Pleistocene epithermal gold mineralization inferred from geochemical anomalies discovered in Neogene(Hulusimpang Formation) distribution area.

Other underground resources include limestone from the area around Bt. Bulang in the north, and marble in and around the S. Tuboh indication.

3) Mineralization in the S. Tuboh area

The ore reserves in 9 units of the skarn type Ag-Zn-Pb-(Cu) mineralized zones discovered by the drilling surveys in the S. Tuboh area were provisionally calculated as shown in the table below.

Ore	Grade					Content				
Reserves	Au	Ag	Cu	Pb	Zn	Au	Ag	Cu	Pb	Zn
(X 10^3t)	(g/t)	(g/t)	(%)	(%)	(%)	(kg)	(kg)	(t)	(t)	(t)
1,726	0.1	130	0.8	1.5	10	192	229,760	14,000	25,600	176,000

On the other hand, the two indications of S. Kering and S. Sepan consist of gathering of micro-grained quartz boulders (up to 10 m). These micro-grained quartz boulders contained small amount of pyrite, galena, sphalerite and chalcopyrite. From their occurrence, these two indications may have been brought to their present locations from a collapsed outcrop by clastic mud flow.

Provisional ore reserves of 1,700,000 tons are approximately estimated for the mineralized zones in the S. Tuboh area. It is essential to obtain more accurate estimation of the ore resarves on their quantity and grades. It is recommended that further survey would be performed in the S.Tuboh area, inculding visinity indications from S.Karing to S.Sepan, to evaluate synthsticaily the potential of the area around and including S.Tuboh mineralized zone.

The mable in middle reaches of S.Nilao is also noticeable resources for the future exploitation in the S.Tuboh area.

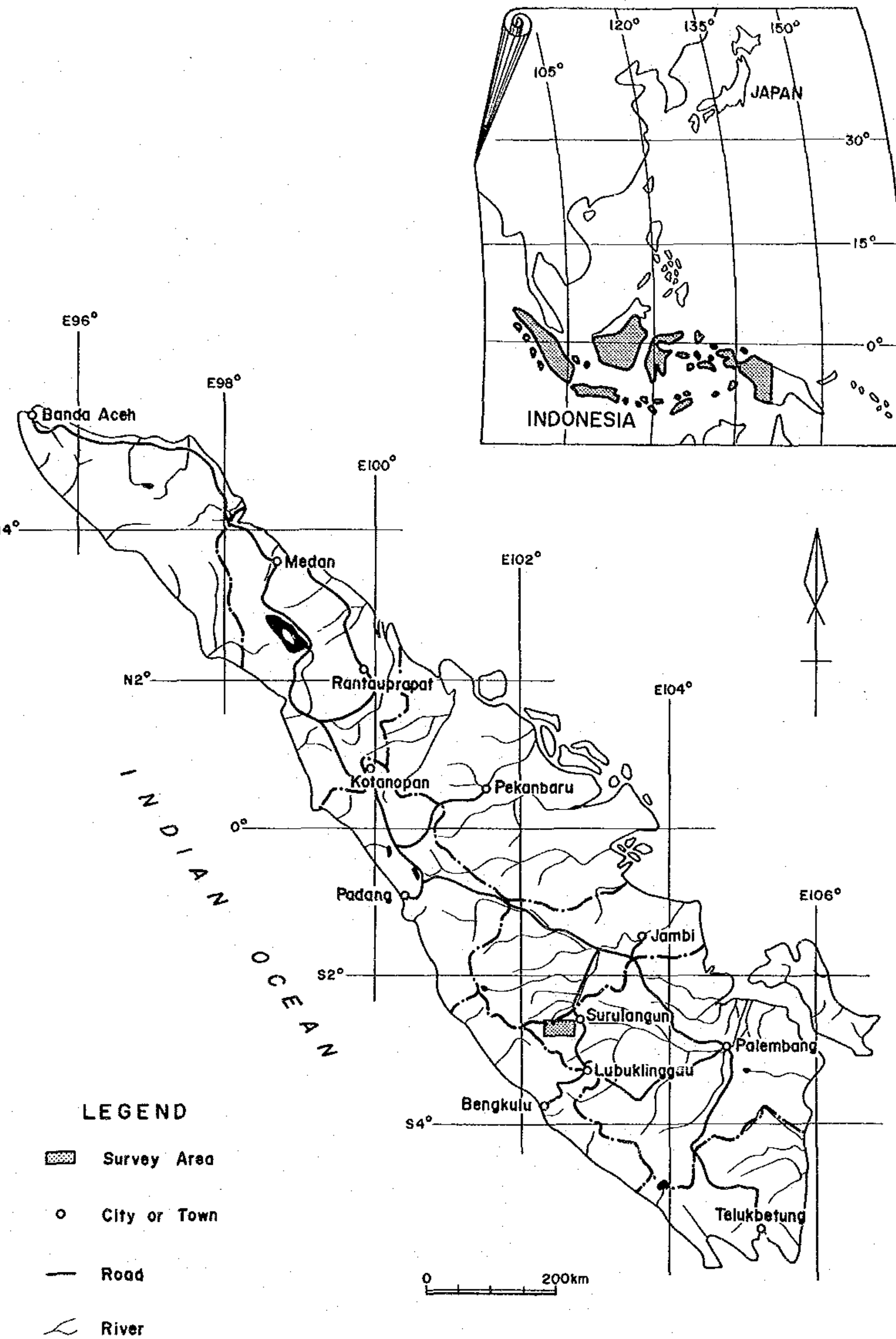

Fig. 1 Index map of the surveyed area

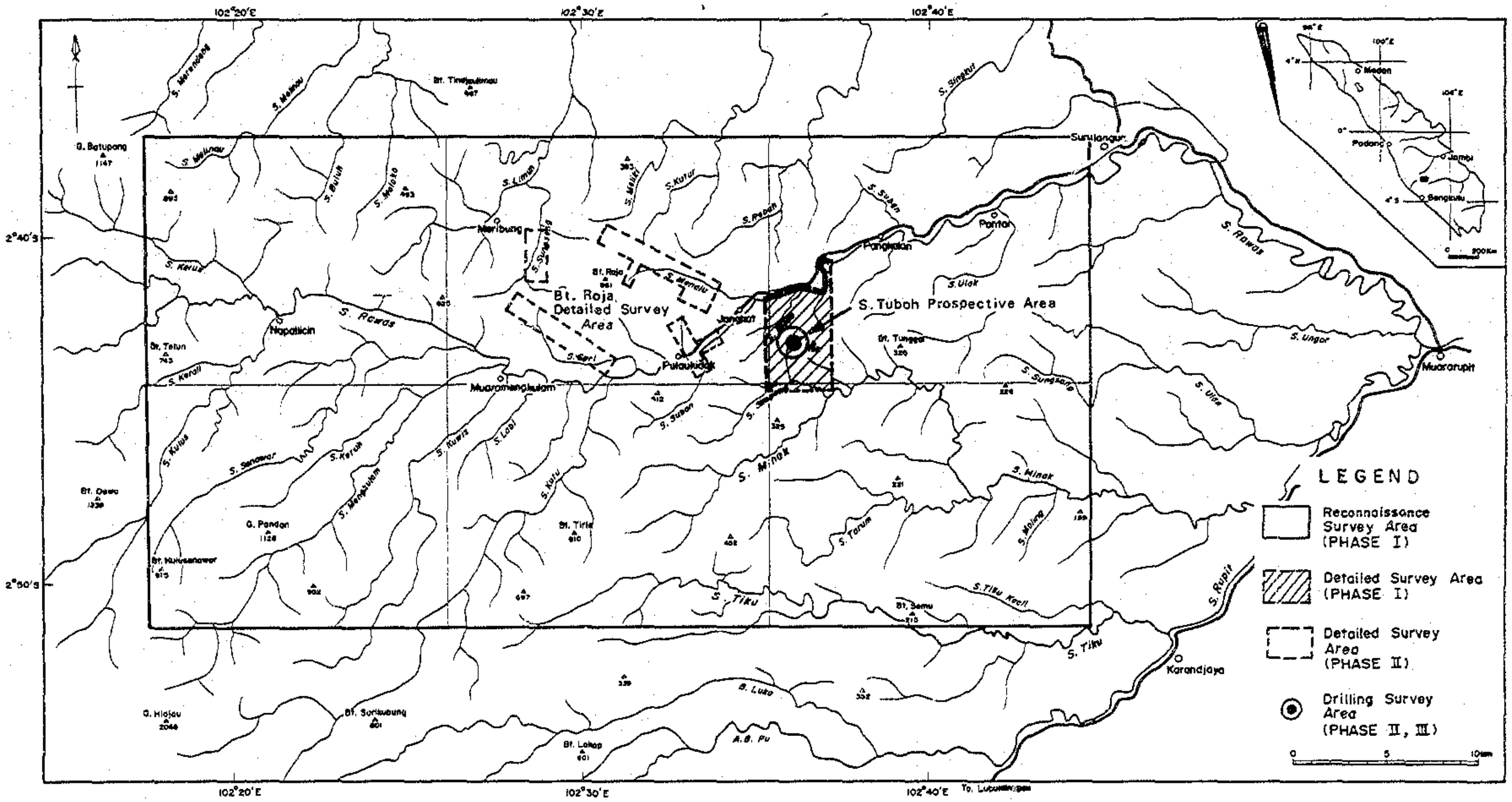

Fig. 2 Location map of the survey area

Content

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Part Ⅳ S. Tuboh area

Part V Conclusions and proposal for the future

TABLE

FIGURE

Part I Introduction

Part I Introduction

Chapter 1 Outline of survey

1-1. Survey area and objective of the survey

The survey area extends over an area of 1,250 km^2, situated at the northernmost edge of South Sumatra Province (Sumatera Selatan), which is a western part of the Republic of Indonesia. Part of the survey area crosses over into Jambi Province, which borders on the north of Southern Sumatra. The area is approximatelydefined by the following latitudes and longitudes.

Northern limit	Lat.	2° 36′ S
Southern limit	Lat.	2° 50′ S
Eastern limit	Long.	102° 44′ E
Western limit	Long.	102° 17′ E

From the little information already available about the Southern Sumatra area, the survey area seems to be an area having non ferrous metallic resources in the Southern part of the island of Sumatra. This three year survey started in 1985 with the objectives of clarifying the geologic and mineralogical situation in the area, and making evaluations of the area's potential of the metallic resources.

1-2. Survey methods and survey conducted

The methods, amount conducted and progress of the survey are shown in Fig.1, and the progress of selecting work on promising areas is shown in Fig. 2. As can be seen from Fig. 1 and Fig. 2, on the basis of investigation of known-data and photogeological interprttation, reconnaissance survey area, covered 1,238km^2 and detauled survey area, including three known mineral indications (S.Tuboh,S.Kuring and S.Sepang) and covering 18km^2 were selected. A geological survey and geochemical survey were respectively conducted in these areas

As a result of the initial survey, a detailed survey consisting of geological, geochemical and ground magnetic survey was conducted in the Bt. Raja area, a drilling survey was conducted in the S. Tuboh area. the other promising area.

In the third phase, the drilling survey in the S. Tuboh area was continously conducted ,following the second phase survey.

1-3. Phase of the survey and members of the survey team

The survey team member for each phases is shown Table 1.

Chapter 2 Previous survey

There have been few substantial surveys of the Southern Sumatra area. Bemmelen (1970) provides a comprehensive summary of the geology and ore deposits for the whole of the Sumatra Island which includes some informations on mineralization in Southern Sumatra area. The source of these informations referred to a report (unpublished) by Dieckman (1917) on prospecting up to 1912. Only some of these documents are remaining. The rest have been dispersed and lost.

The geological data includes maps of Sarolangun, Jambi Province, by the Geological Reserch and Development Centre (1984), and by the Kartografi Direktorat Geologi (1977), but these are both unpublished. These two works have different stratigraphic divisions and notatoin, and also differ in accuracy. Other prospecting conducted in the area includes geological and geochemical investigations by Kennecot Indonesia (1971) and a summary of geochemical prospecting by D.M.R.(1984 : Internal document).

(1) Description by Bemmelen

The description by R. W. van Bemmelen appear in "The Gology of Indonesia" vol. 1A and vol. Ⅱ, published in 1970. Vol. 1A contains a general summary of *the geology of Indonesia, and vol. Ⅱ contains a* general summary of underground resources in Indonesia. The summary in vol. 1A does not describe the geology of any area which include the Southern Sumatra area. The summary of underground resources in veol. Ⅱ,however, describes introduction on the S. the Tuboh, the Aer Kulus, the Aer Seri and the Bt. Raja indications. The description of the S. Tuboh indication includes two other indications of S. Kering and S. Sepan. The Aer Kulus indication is a large boulder of limestone disseminated with sphalerite, discovered in the SW of the Southern Sumatra area. The Aer Seri indication is a of sphalerite and chalcopyrite bearing veins at the south foot of Bt. Raja.

(2) Prospecting by Kennecot Indonesia

In 1970, Kennecot Indonesia carried out reconnaissance geological surveys and geochemical investigation over an area covering the present survey almost entrely. The final report on the project became available in 1971. The

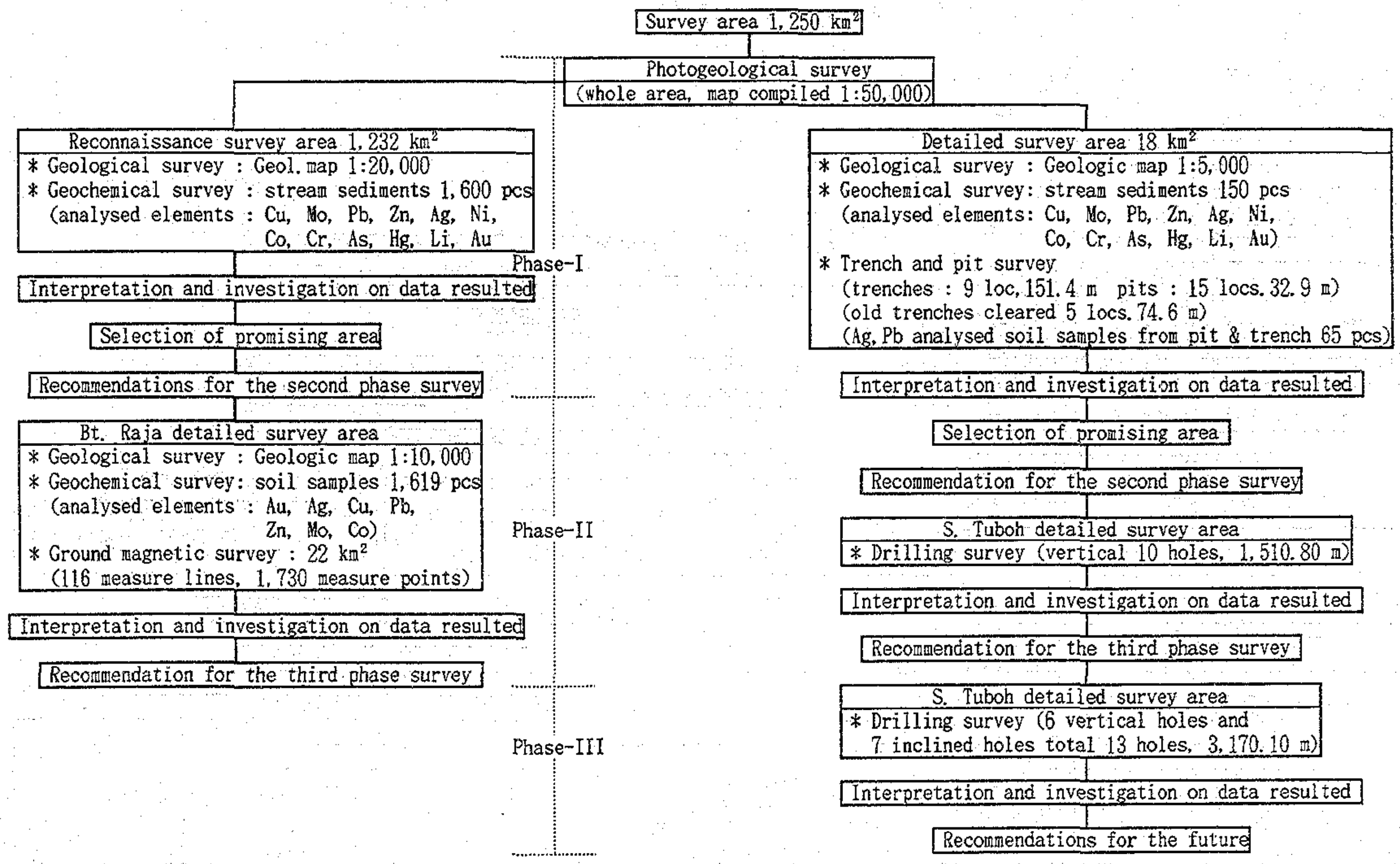


Fig. 3 Flow chart of the survey in the Southern Sumatra area

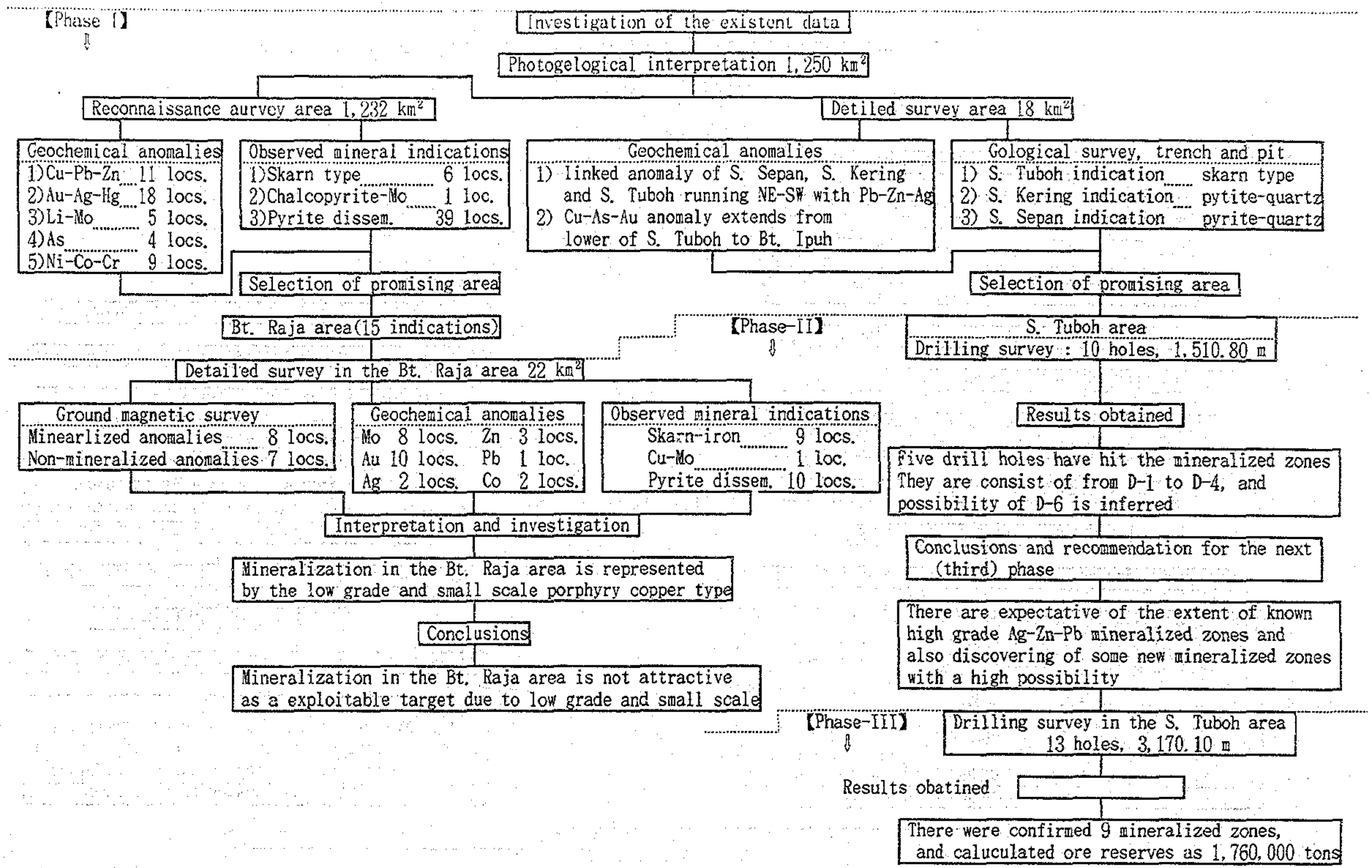


Fig. 4 Flow chart of extraction on valuable mineral indications

Phase-I(1985)	Phase-II(1986)	Phase-III(1987)
Negotiation of the agreement on the Survey (26, Aug.-7, Sep.) Planning and coordination(6/7-12/7) Japan side : Leader:Toshio SAKASEGAWA(MMAJ) Member:Shotaro KISHIMOTO(MITI) Member:Atsushi OSAME(MMAJ) Member:Toshiheko HAYASHI(MMAJ) Planning and coordination:Atsushi OSAME(MMAJ) Indonesia side : Prof. Dr. J. A. Katili(DGGM) Ir. Salman Padmanagara(DMR) Ir. P. H. Silitonga(DMR) Ir. Yaya Sunarya(DMR)	Planning and coordination(21/6-30/6) Japan side : Toshio SAKASEGAWA(MMAJ) Micihisa SHMODA(MMAJ) Atsushi OSAME(MMAJ) Indonesia side : Salman Padmanagara(DMR) J. Rainir Dhadar(DMR) A. Machali Musin(DMR)	Japan side : Natsymi KAMIYA(MMAJ) Atsushi OSAME(MMAJ) Indonesia side : Salman Padmanagara(DMR) : J. Rainir Dhadar(DMR) : A. Machali Musin(DMR) : Sukirno Djaswadi(DMR)
Survey Team(20, Oct.-1, Feb., 1986) Japan side : Leader:Yoitsu OGUMA(NED) Geol. &Geochem. :Hidiya KIKUCHI(NED) Geol. &Geochem. :Osamu MIYAISHI(NED) Geol. &Geochem. :Tetsuo SATO(NED) Geol. &Geochem. :Kazuyasu SUGAWARA(NED) Indonesia side : Leader:Yaya Sunarya(DMR) Geol. &Geochem. :Pudjo Audjarwo(DMR) Geol. &Geochem. :Hendro Wahyono(DMR) Geol. &Geochem. :Bambang Pardiarto(DMR) Geol. &Geochem. :Danny Z. Herman(DMR) Geol. &Geochem. :Atok S. Prapto(DMR)	Survey Team(6, July-27, Oct.) Japan side : Leader:Yoitsu OGUMA(NED) Geol. &Geochem. :Mitsuo TADOKORO(NED) Geol. &Geochem. :Hidiya KIKUCHI(NED) Geophysical :Ikuo TAKAHASHI(NED) Drilling :Isamu NAKAYAMA(NED) Drilling :Hatsuo KUMANO(NED) Drilling :Soji KAN-NARI(NED) Indonesia side : Leader:Sukirno Djaswadi(DMR) Geol. &Geochem. :Bonifatius Bandi(DMR) Geol. &Geochem. :Atok S. Prapto(DMR) Logging :Subedjo(DMR) Logging :R. Tatto Sudharto(DMR) Geophysical :Empon Ruswandi(DMR) Geophysical :Hario Mustang(DMR) Geophysical :Edi Kurnia(DMR) Geophysical :Zulkifli Bugis(DMR) Drilling :Antonius Harsono(DMR) Drilling :Madthui(DMR) Drilling :Saksono(DMR) Drilling :Agus Mulyadi(DMR)	Survey Team(21, June-7, Jan., 1988) Japan side : Leader:Yoitsu OGUMA(NED) Drilling :Isamu NAKAYAMA(NED) Drilling :Susumu HORIGUCHI(NED) Drilling :Soji KAN-NARI(NED) Drilling :Tadateru SUGIBUCHI(NED) Drilling :Hidimitsu TADATERU(NED) Drilling :Mitsuo NOMURA(NED) Indonesia side Logging :Bonifatius Bandi(DMR) Drilling:Saksono(DMR) Drilling:Asus Muliyadi(DMR) Drilling:Encep Sudjana(DMR) Drilling:Kisman(DMR)

Table 1 Team formations for the survey

outline of the report is as follows ;

1) Survey period : Apr. 1 1970 - Oct. 30 1970

2) Survey area : 23,600 km²

Block 10 : N2° - 3° E, E102° - 103°

Block 11 : N3° - 4° E, West of 102° 45′ E

3) Surveyor : Kennecot Indonesia Co., Ltd. staff of 25 (geologist and assistants)

4) Extent : 600 samples of stream sediment/17,000 km²

pH measured at each sampling site.

5) Products : Sample location map : 1:100,000

Geologic map : 1:250,000

6) Expenditure : US$ 407,000 (Direct expenditure in 1970)

Unit cost : US$ 24/km², US$ 68/sample

7) Evaluation based on survey results : No possibility of progressing to the next satge of surveying

(3) Survey by D.M.R.

Geochemical survey, mainly of stream sediments in the S. Tiku, S. Mengkulan, and other rivers. These surveys were conducted between May and October 1984, covered an area of 1,175 km² and taking 875 samples. The conclusion is under processing.

Chapter 3 Outline of geologic features in the Southern Sumatra area

The Southern Sumatra area is situated on the eastern side of the Barisan range which forms the backbone of the Sumatra island. Because of its location, it is an area where the Mesozoic formations which make up the Barisan range are mixed with the Cenozoic formations distributed widely to the east of the range. The Southern Sumatra area is composed of Mesozoic formations intrucded with a wide variety of intrusive rocks(deep facies and shallow facies) ranging from alkaline to calcic, and Cenozoic Neogene and Quaternary formations overlie these formations and intrusive rocks. .

The Mesozoic formations are distributed from the center to the north of this area, and have a distinct general NW-SE strike. The S. Tuboh area alone has a NE-SW strike, almost perpendicular to the generel trend. The different intrusive rocks, ranging from alkaline to calcic, generelly extend in a direction matching with the Mesozoic trend, and can be considered to be due to 80 Ma. activity.

The Cenozoic formations are distributed at west,south and east surrounding around the Mesozoic formations. They consist of different types of pyroclastic rock ranging from mafic to felsic, and of sandy, muddy calcareous sedimentary rocks. Amongst the pyroclastic rocks, there are some formations accompanied by hyaloclastite and welded tuff.

In general, the geologic structure is composed of older fold structures extending NW-SE and fault structures with the same direcion, and of younger fault structures cutting NE-SW across them. In the S. Tuboh area, however, the NE-SW structures are older, and a NNW-SSE (or N-S) fault structure has developed cutting across them.

Over the last three years, this survey has shown the existence of a various types of mineralization, including skarn type, porphyry copper type, metamorphic-segregated type, and epithermal type.

Skarn type mineralization is typified by Ag-Zn-Pb mineralization in S. Tuboh area, and Fe-(Cu) mineralzation in the Bt. Raja area. Mo-Cu-Pb-Zn ores bearing network quartz veinl;ets in the Bt.Raja areais a porphyry copper type mineralization. Metamorphic-segregated gold mineralization is as the source of alluvial gold in part of S. Rawas Formation disribution area. Plio-plicetocene gold quartz veins, presuming their existence from geochemical anomalies, are a epithermal mineralization in the Neogene distribution areas.

Other non-mineral resources in the area include limestone and marble.

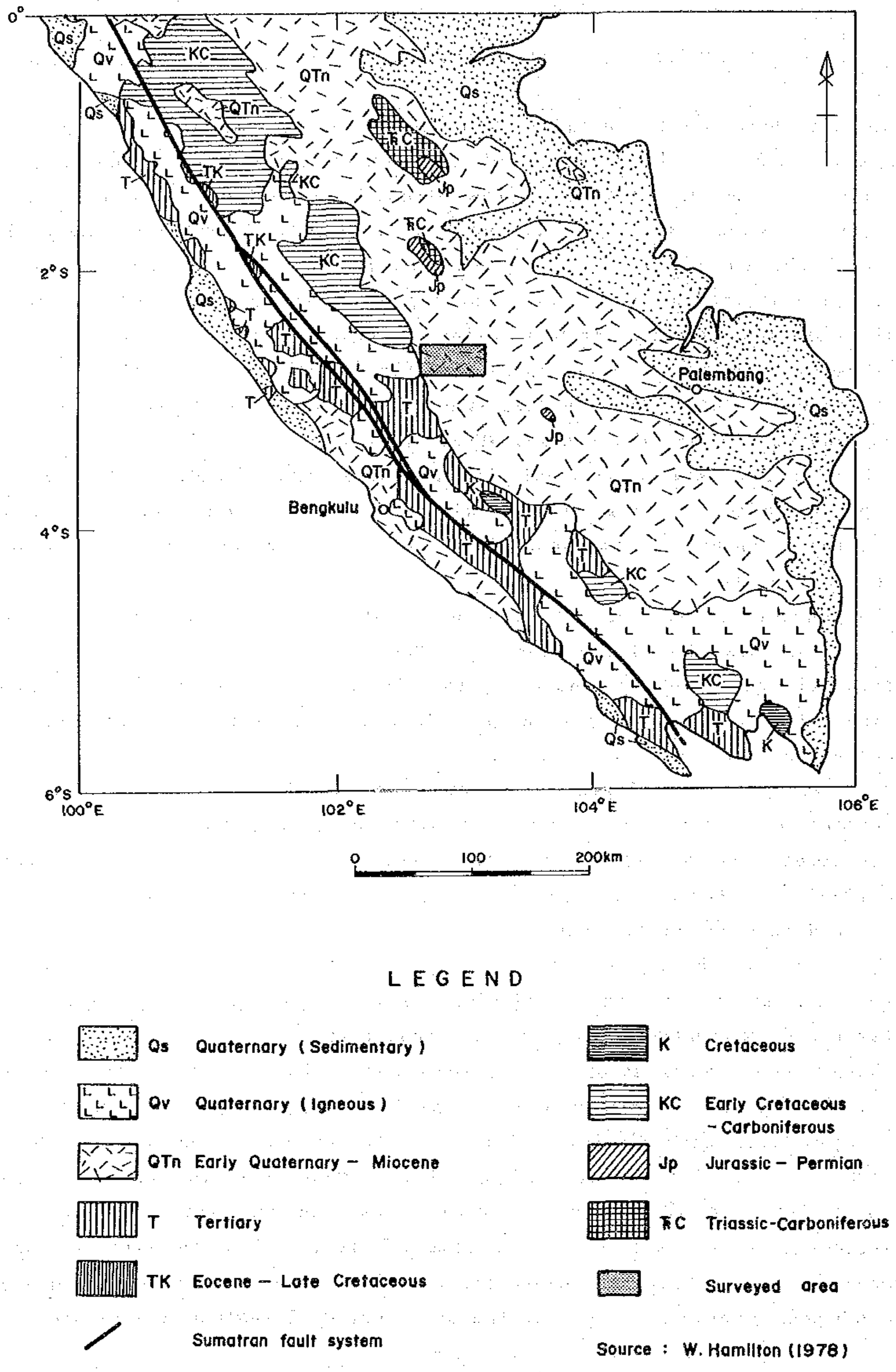


Fig. 5 Generalized geologic map of the Southern Sumatra

Chapter 4 Condition at the site

4-1. Transportation

To reach the survey area from the Jakarta, capital of Indonesia, it is possible to take a scheduled flight to Bengkulu (1 hour). It then takes 3.5 hours by road (130 km) from Bengkulu to Lubuk Linggau (pop. 50,000; hotel accommodation available and the capital of Rawas Prefecture). From Lubuk Linggau, follow the Sumatra Highway to the northeast for 100 km to the village of Surulangun, on the NE edge of the Southern Sumatra area.

Within the survey area, there are no roads passable by car,apart from 7 km along the S. Rawas from Surulangun (although work on rebuilding bridges and renewing the older road for 32 km between Surulangun and Pulau Kidak has been in progress since August, 1987). This meant that boats (river barge) on the S. Rawas is the exclusive means of transport within the survey area.

Including a stretch of walking, it takes 10 hours to reach the western edge of the survey area from Surulangun. However, to reach the S. Tuboh area where drilling surveys were conducted in Phase II and Phase III, it takes only 2 hours from Surulangun to Nilau, followed by 1 hour to walk the 3.5 km from Nilau to the S. Tuboh area. The traveling time varies greatly according to the depth of the S. Rawas, and it is not unusual for journeys to take several times as long during the dry season (May - September) when the water is not deep.

4-2. Survey environment

The Southern Sumatra area is situated at the point of transition between the Barisan range, the backbone of Sumatra island, reducing in height towards the east, and the Palembang plain. Within the survey area, the further west is more undulating the topography. However, the area as a whole is not very high, with the highest point being at 1,000 m above sea level. The area on the eastern side where the Nogene formations are distributed consists of hills around 100 - 200 m high and occasional wide swampy areas.

The area as a whole is classified as tropical rain forest, and it is very hot and humid, with an annual rainfall of more than 3,000 mm. However, there is a period from March to September each year when there is relatively little rain.

The river system in most of the area is dominated by the S. Rawas and its tributaries, part of the S. Musi system which flows into the East China Sea at Palembang. In the NW part of the area, however, are some of the source streams of the S. Tembesi, part of the S. Batanghari system which flows into the East China Sea at Jambi.

There are some huge trees in the virgin forest areas, but there are not many areas like this. Most areas are in use for, or display the scars of slash and burn agriculture.

There are 12 small villages along the S. Rawas (150 - 100 housholds, pop. 500 - 1,000). The inhabitants make a living by slash and burn agriculture for upland rice, and by collecting rubber. There is very little production that bring cash income, and the amount of rice produced does not cover the farmer's own cosumption. In the S. Rawas, there is fishing for personal consumption and collection of alluvial gold on a very small scale.

Chapter 5 Conclusions and proposals for the future

5-1. Conclusions

Over the past three years of the surveys, there have revealed the existence of skarn type mineralization in the S. Tuboh area and its surroundings, porphyry copper type, skarn type and pyrite disseminated type mineralization in the Bt. Raja area, and pyrite disseminated type mineralization at the lower reaches of the S. Kuwis. On the other hand, there have also been able to infer the existence of metamorphic-segregated type gold mineralization distributed in the Mesozoic formation area and epithermal type gold mineralization distributed in the Neogene formation area.

Of these, it has become clear that the Ag-Zn-Pb skarn type mineralization in the S. Tuboh area forms mineralized zones with a substantial distribution.

The ore reserves in 7 of the 9 mineralized zones discovered in the S. Tuboh area have been provisionally caluculated as shown in the table below.

Provisional calculation of S. Tuboh area mineralized zone ore reserves

Ore	Grade					Content				
Reserves	Au	Ag	Cu	Pb	Zn	Au	Ag	Cu	Pb	Zn
(x 10^3 t)	(g/t)	(g/t)	(%)	(%)	(%)	(kg)	(kg)	(t)	(t)	(t)
1,726	0.1	130	0.8	1.5	10	192	229,760	14,000	25,600	176,000

These provisional calculations of ore reserves include some uncertain elements because they only represent the calculations for the first stage of an exploration by drilling survey. These figures signify that development is a possibility if an economical enviorment can be provided by increasing the amount of reserves. There are many parts in the S. Tuboh area which have yet to be surveyed, including the parts around the confirmed mineralized zones in the S. Tuboh area and the area from the S. Kering and S. Sepan to the middle reaches of S. Nilau. It is therefore necessary for surveying to progress to these areas with the aim of finding more ore reserves.

Epithermal gold mineralization is an important type of mineralization which be able to form economical concentrations (ore deposits) of gold. Surveying around the geochemical anomalies discovered in the area of distribution of the Neogene (Hulusimpang Formation) may determine the presence of gold mineralized zones.

Other underground resources in the area are limestone around Bt. Bulang in the north and marble in the S. Tuboh area.

5-2. Recommendation for the future

It is desirable to increase the accuracy of assessments of the ore reserves and grades in the S. Tuboh area, and it is also desirable to survey the areas around the confirmed mineralized zones in the S. Tuboh area and the area of marble distribution from the S. Kering and S. Sepan indications to the middle reaches of the S. Nilau, with the aim of increasing the potential of confirmed resources. It is desirable that feasibility study are conducted, based on the results of these surveys, to evaluate the total resource potential of the area centered around the S. Tuboh area.

In addition to dealing with the technical aspects of development, a feasibility study should cover a wide range of areas, including scale of development and amount of production, estimate of income from sales and mine life, capital investment, running cost, capital cost, raising capital, tax law and tax benefits, labor, transportation, harbors, sales, energy supplies, water supply and discharge, and enviormental controls. This survey should ideally be conducted by setting up a project team to include the experts required to be able to deal with these areas. It is important to investigate fully what sort of impact the mining development would have on the local area.

The possibility of clastic flows should be investigated for both the S. Kering and S. Sepan indications, and if they are found to be results of clastic flows, the source of the clastic flow needs to be traced down.

The area including the geochemical anomaly discovered in the Neogene (Hulusimpang Formation) distribution area in the southern part of the Southern Sumatra area should be surveyed in detail for epithermal gold mineralization.

The quantity of limestone around Bt. Bulang in the north needs to be confirmed, and the quality of marble as construction materials around the mineralized zones in the S. Tuboh area needs to be investigated to determine whether comercial development of the marble is possible.

PART II SOUTHERN SUMATRA AREA

PART II SOUTHERN SUMATRA AREA

Chapter 1 Outline of Survey

On the basis of photogeological interpretation covered 1,250km² in the Southern Sumatra area and known data, the initial phase was performed as follows

① Reconnaissance survey : geological and geochemical surveys in area of 1,238 km²

② Detailed survey : geological (including pitting and trenching prospecting for mineral indications) and geochemical surveys in area of 18km².

Referring to known-data, three mineral indications of the S.Tuboh,S.Kuring and S.Sepang are picked up as promising indications. Photo geological interpretation have revealds that a area in which these indications were embedded consists of limestone, and a igneous rock intruded in the limestone. From this geological environment, it might be inferred that skarn type ore deposit would embedded in the area.

As a result of the survey, the Bt.Raja area was selected by reconnaissance survey, and the S.Tuboh by detailed survey.

Chapter 2 Geology

2-1 Outline of Geology

Geology of the Southern Sumatra area is made up of Jurassic-Cretaceous Formation, Mesozoic, Tertiary-Quarternary Formation, Cenozoic, and igneous rocks which have intruded into Mesozoic formations. Pre-Jurassic formations are not exposed in the Southern Sumatra. Permian and Triassic formations, which are found outside the northwest of the survey area, are presumably basement of the Southern Sumatra.

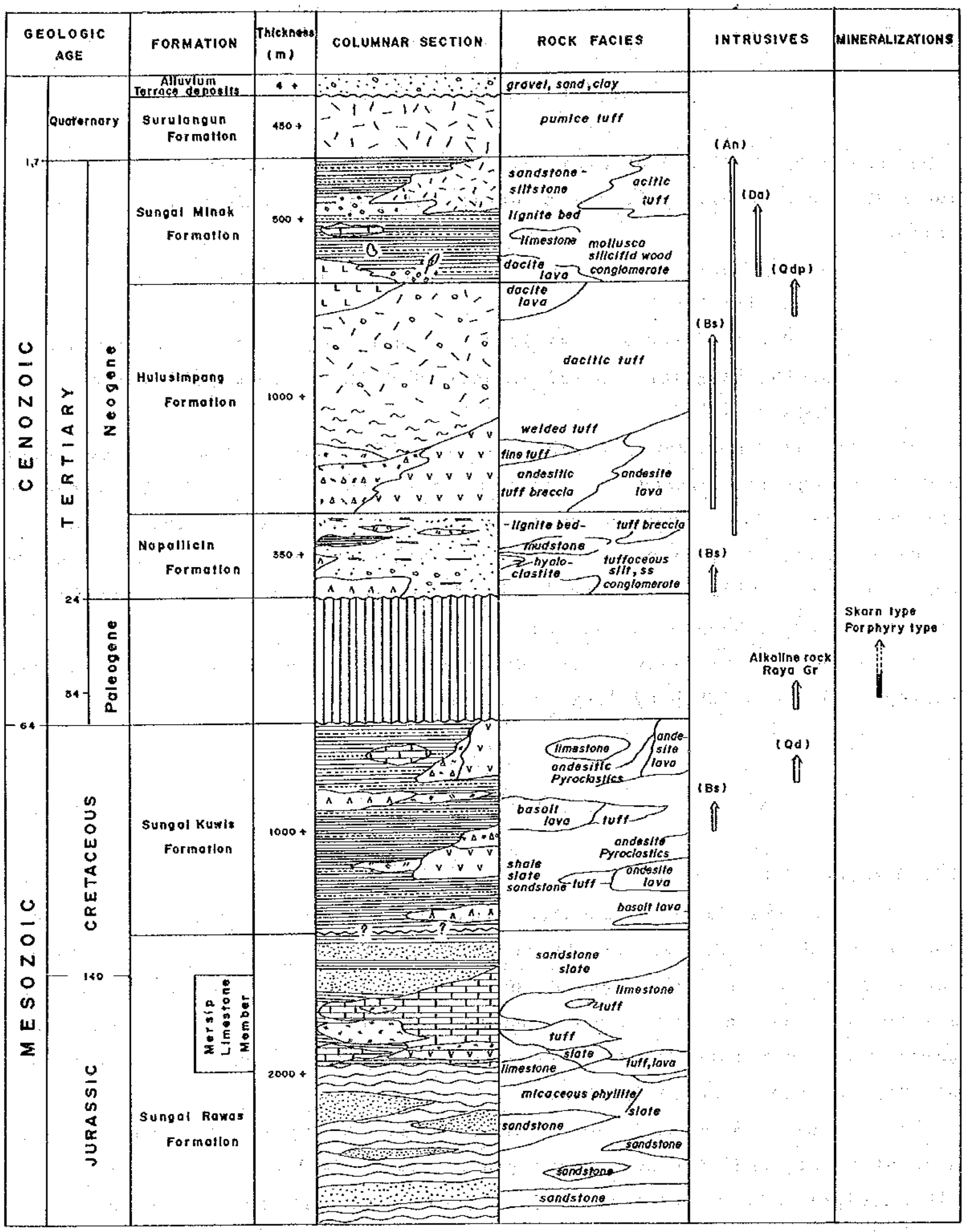
The igneous rock consists of volcanic rocks forming the variaou strata as a constituent, and intrusive rocks ranging from alkaline to calcic rock.

The geological map is shown in Fig.6, and schematic geological colomen in Fig.7.

2-2 Geology in detail

2-2-1 Sedimentary rocks

The Mesozoic formations in the survey area are composes of S.Rawas



Bs : Basalt An : Andesite Da : Dacite

Qdp : Quartz diorite porphyry

Alkaline rock : Alkali gabbro, Monzonite, Tonalite, Quartz monzonite, Diorite, Trachy basalt, Trachy andesite, Trachite, Alkalic basalt, Alkali dolerite etc

Raya Gr : Raya Granitoid (Granite, Granodiorite, Diorite, Diorite-porphyry)

Qd : Quartz diorite

Fig. 7 Schematic geologic column of the surveyed area

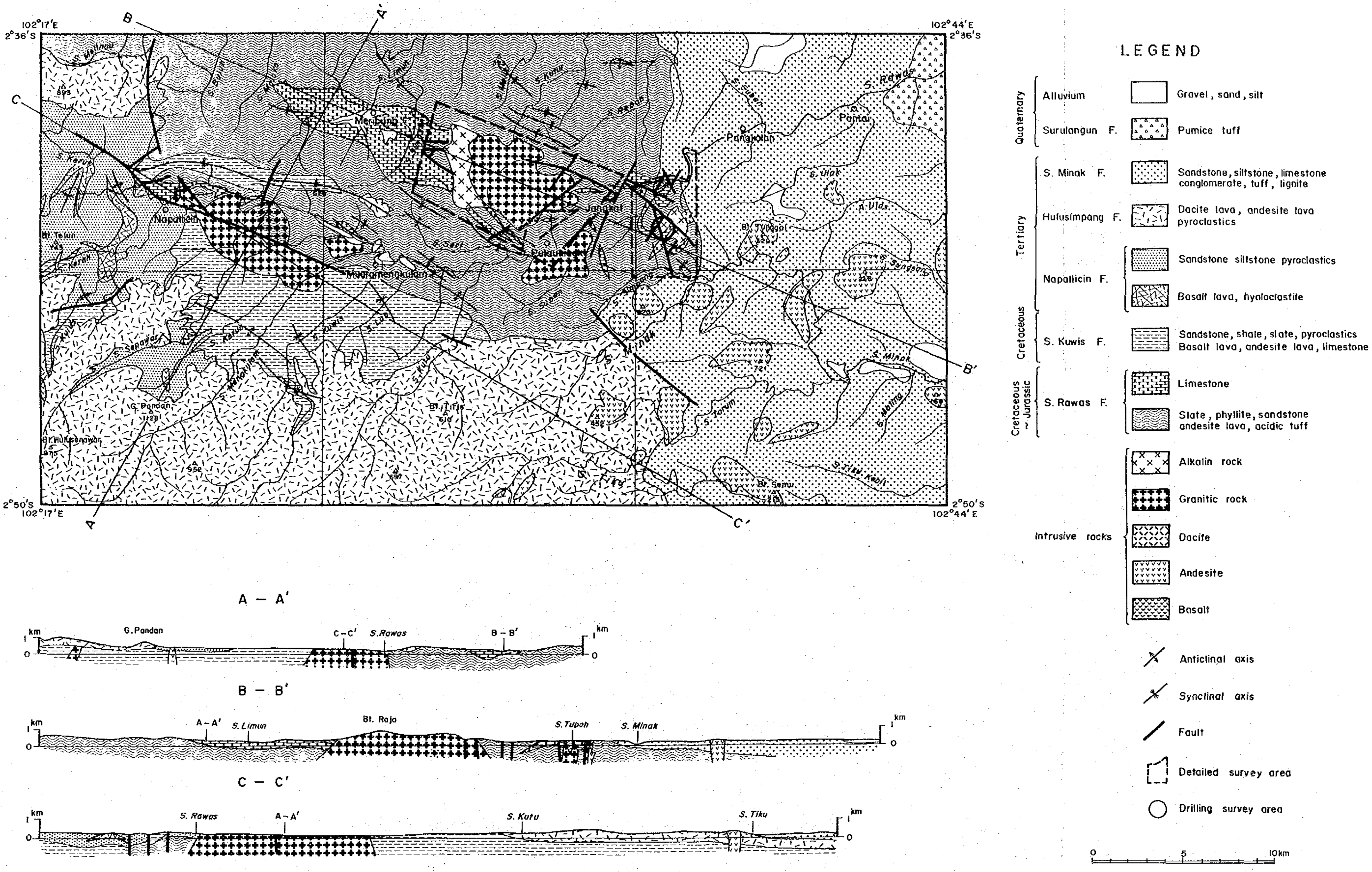


Fig. 6 Geological map and profile of the surveyed area

Formation and above this, S.Kuwis Formation. These Formations are exposed in the Southern Sumatra area mainly the middle northward.

In the low member of the S.Rawas Formation, mud-dominant flysh type sedimentary facies, yielding fluet casting, are predominant. Above this, middle member consists dominantly of slate and phyllite intercalating limestone, andesitic-basaltic pyroclastic rocks, and upper member is of alternated bed of thick sandstone and slate. Among these, limestone-dominant stratum in the middle member is especially called Mersip Limestone Member.

The Mersip Limestone Member is accompanied with andesitic tuff,lava and tuffaceous sandstone.

The S.Kuis Formation, being presumably correlative with the Cretaceous,is composed of sandstone, shale, slate, limestone and pyroclastic rock(basaltic ～ansesitic lava and pyroclastic rock). The S.Kuwis Formation is low metamorphosed owing to lower grade of schistosity and recrystalization in comparison with the S.Rawas Formation.

The Cenozoic formations unconformably overlie the above mentioned formations and is made up Napalicin Formation, Hulusimpang Formation, S.Minak Formation of the Tertiary, Surulangun Formation and terrace deposit of the Quarternary.

The S.Napalicin Formation is of mainly soft sandstone accompanying by hyalocrastite, and is distributed at western part of the south Sumatra.

The Hulusimpang Formetion consists of andesitic pyrocrastic rock in lower, and dasitic pyrocrastic rock (partly welded) in middle～upper, distributing extensively in western to southern Sumatra. They have been undergone green alteration in general.

The S.Minak Formation consists of mudstone,siltstone,calcareous rock and dacitic tuff, with lignite bed near base, and often yields marine fauna fossils.

Most of the Sululangun is of light yellow or pale gray pumice tuff.

Unconsolidated sand-gravel bed and sand-silt sediments of terrace deposits is distributed in low plain part.

2-2-2 Intrusive rocks

These consist of deep and shallow facieses of granite, granite porphyry, granodiorite, quartz diorite, quartz diorite porphyry, diorite, tonalite, quartz momzonite, quartz monzonite porphyry, and alkaline gabbro.

The quartz diorite is exposed along side and the southern side of the S.Rawas running from Napalicin to Mengkukulam in the west part of Southern Sumatra area, and has been dated as 83.6± 4.2Ma by K-Ar method.

The granite, granite porphyry, granodiorite, and diorite are mainly distributed at Bt.Raja and southeast has altered sedimentary rock (S.Rawas Formation) to hornfels. These rock have been dated as 51.9± 2.6Ma and 54.1± 2.7Ma by K-Ar method.

A small stock of quartz diorite porphyry crops out, intruding into S.Minak Formation at S.Rawas northwest of Bt.Raja. It is Tertiary intrusion.

The quartz monzonite, quartz monzonite porphyry, tonalite, and alkaline gabbro are mainly exposed at S.Tuboh area and north, and small intrusives also occur in S.Rawas. By K-Ar method, the alkaline gabbro has been dated as 51.7± 2.7Ma. In the detailed survey area, shallow facies rocks, namely trachy andesite, basaltic trachy andesite, basaltic trachite, trachy dolerite occur parallel intrucives trending NE-SW, and are associated with mineralized zones. A trachy dolerite has been dated as 51.9± 2.6Ma.

Chapter 3 Geological structure

A NW-SE-trend folding structure and a faults running parallel with the folding are common in the reconnaissance survey area.

In the detailed survey area, the relationship apparently is different. NW-SE trend structure (folding structure and fault) is prominent and Younger faults run with NNW-SSE trend, crosscutting the structure. Throughout the South Sumatra, NW-SE structure is apparently older than NNW-SSE structure. However both faults have displaced the Minak Formation, and it is hard to defined which one is older or younger. From the relation, it may be inffered that basically these faults occured at before and after each other, and removed again several times up to present.

The Great Sumatra Fault, which runs across the Sumatra Island trending NW-SE, is the dominant structure in the South Sumatra. The Great Fault was already active middle Cretaceous as the graben structure moving vertical.

It contributed the folding movement in middle Miocene period, and is activing as a Strike-slip fault from early Plicetocene.(Katili and Hehuwat 1967), and runs along volcanic front of the Sumatra Island. The facts indicate that the structure line is clearly regarded as deep fracture. Consequently, the structure caused presumably sedimentarys rock and intrusive rocks to emplace their sedimentation and intrusions since S.Kuwis Formation.

Chapter 4 Mineralization

4-1 Outline

The geological survey in the reconnaissance survey unravelled distribution of 46 mineralized zones, alteration zone, and (mineral indications) throughout the area. Among them, three mineralized zones at S.Tuboh, S.Kuling and S. Sepan have been found in the detailed survey area. The torty six mineralized zones are shown in Fig 8 for their location, and Table 2 for their outline, and three mineralized zones of the detailed area in Fig. 10 for their location.

These mineralized zones and indications can be classified as shown below according to the type ot mineralization

(1) skarn type mineralization

(2) Molibdenite-chalcopyrite disseminated quartz veinlets (porphyry copper type mineralization)

(3) Pyrite dissemined mineralization

(4) Gold mineralization

Among the total 46 indications, 25 indications show a disstribution which breaks down coherently into two mineralized zones. One of these zones is the group of 15 indications distributed around the Bt. Raja granite, and belong to types of (1), (2) and (3). The other is the group located at S.Senawar in the west central part of the survey area. This group consists of 10 indications distributed from the south side southeast of the S.Senawar quartz diorite, and belong to the type (3).

If the 25 indications are broken down into the above type, the result is as follows ;

(1) skarn type -- 6 indications

(2) Molibdenite-copper bearing porphyry copper type --- 1 indication

(3) Pyrite disseminated type -------------------------- 18 indications

The other 21 indications are scattered locally. Although they are very weak pyritization and in some case only silicification, 8 indications of them in the central Hulusimpang Formation area possibly belong to (4) type, and coincide with the greochemical anomaly area.

4-2 Detailed description

4-2-1 Skarn type mineralization

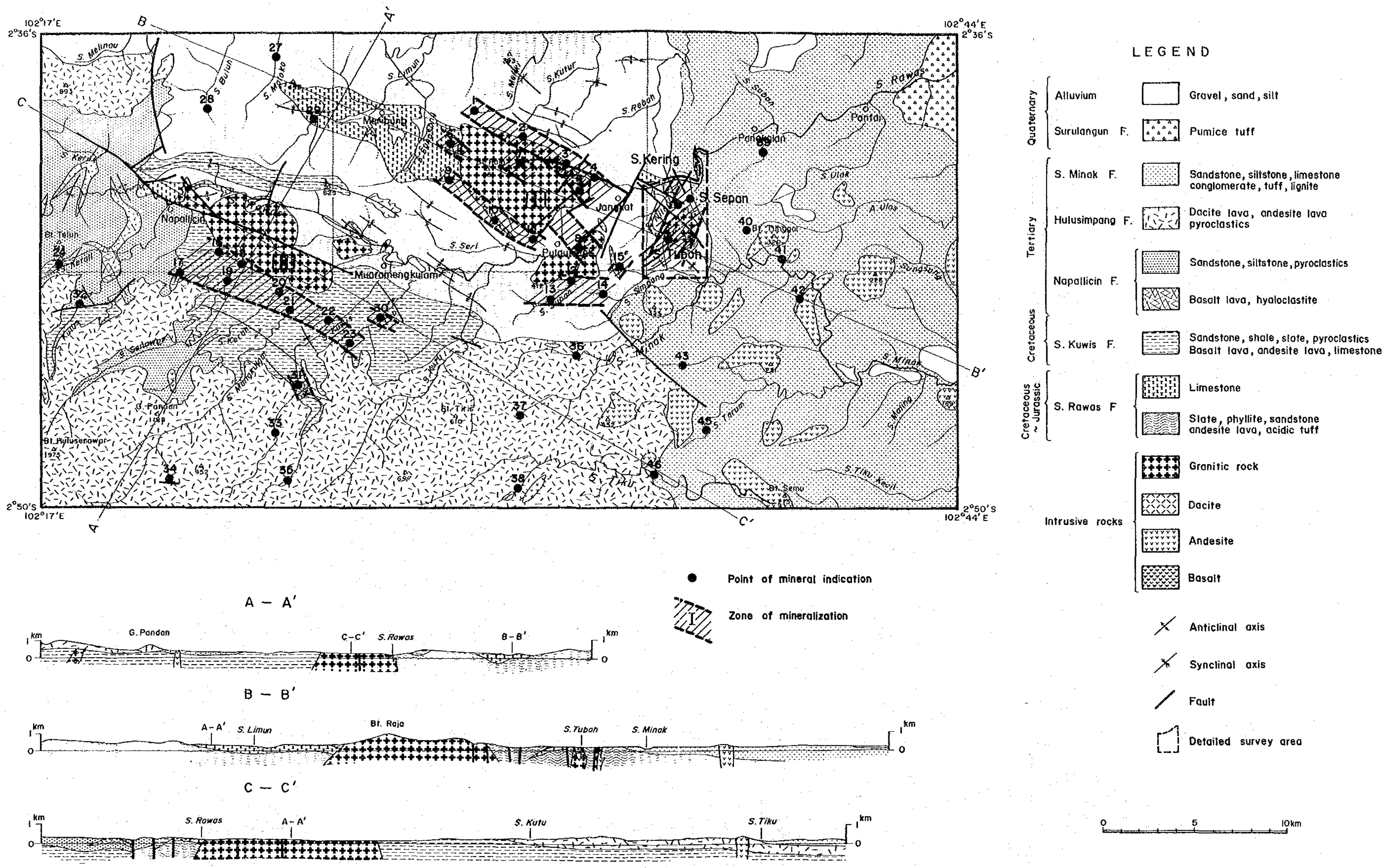


Fig. 8 Distribution map of the mineral indications in the reconnaissance survey area

Mineralized zone	Point of zone	Location	Formation	Host rock	Mode of Mineralization, Altteration	Mineral assemblage	Remarks
【I】	1	S. Meliki	S. Rawas	slate sandoston	silicification	Py	quartz veinlet (N60°W, 70°SW)
	2	S. Kutur	S. Rawas	slate	silicification	Py	dissemination of pyrite
	3	S. Betung	S. Rawas	limestone	skarnitization	Skarn	garnet skarn, weathered outcrop (width 8m)
	4	S. Menalu	S. Rawas	slate limestone	silicification	Po, Py	quartz veinlet with green skarn (N70°W, 55°NE) width 2~5mm
	5	S. Pedang	(Float)	limestone?	skarnitization?	Hm	N30°W tunnel has been situated at a brook where flots were discovered
	6	S. Sungsang	S. Rawas	slate limestone	pyritization	Py	dissemination of pyrite
	7	S. Menalu	-	granite	silicification	Py, Cp, Ga, Sp, Mo	joint filling pyrite vein width 1~2mm
	8	S. Suban	-	limestone?	skarnitization	Skarn Mg	garnet skarn width 7 m
	9	S. Pangi	S. Rawas	limestone slate	skarnitization	Skarn Py	width 0.15 m garnet with green mineral
	10	S. Seri	-	limestone	skarnitization	Skarn Py	green skarnitized(float)
	11	S. Seri	S. Rawas	slate	silicification	Py	dissemination of pyrite
	12	S. Suban	S. Rawas	andesite	pyritization	Py	dissemination of pyrite
	13	S. Suban	S. Rawas	sandstone	silicification	-	silicification only
	14	S. Simpang	S. Rawas	sandstone	silicification	Py	dissemination of pyrite

Table 2 List of mineral indicatios of the reconnaissance survey area (1)

Mineralized zone	Point of zone	Location	Formation	Host rock	Mode of Mineralization, Altteration	Mineral assemblage	R e m a r k s
【I】	15	S. Puar	S. Rawas	slate	silicification	Py	dissemination of pyrite
【II】	16	S. Senawar Seni	S. Kuwis	tuff	silicification	Py	dissemination of pyrite
	17	S. Senawar Seri	S. Kuwis	tuff	silicification	-	silicification only
	18	S. Senawar	S. Kuwis	sandstone	silicification	Py	dissemination of pyrite
	19	S. Senawar	S. Kuwis	tuff andesite	silicification	Py	dissemination of pyrite
	20	S. Keruh	S. Kuwis	slate tuff	argillization silicification pyritization	Py	pyrite dissemination in shear zone (width 0.6 m, N55°W, 65°SW)
	21	S. Mengkulan	S. Kuwis	diorite slate	pyritization silicification	Py	dissemination of pyrite
	22	S. Kuwis	-	diorite	silicification	Py	dissemination of pyrite
	23	S. Labi	S. Kuwis	tuff	silicification	-	silicification only
	24	S. Kerali	-	basalt	silicification	Py	dissemination of pyrite width 100 m
	25	S. Kutur	S. Rawas	slate	argillization	-	argillization only
	26	S. Melki	S. Rawas	andesite	silicification	Py	dissemination of pyrite
	27	S. Maloko	S. Rawas	slate	argillization silicification	Py	quartz vein with pyrite
	28	S. Buluh	S. Rawas	slate	silicification	Py	dissemination of pyrite
	29	S. Limun	S. Rawas	diorite sandoston	pyritization	Py	dissemination of pyrite

Table 2 List of mineral indicatios of the reconnaissance survey area (2)

Mineralized zone	Point of zone	Location	Formation	Host rock	Mode of Mineralization, Altteration	Mineral assemblage	Remarks
【II】	30	S. Labi	-	diorite	pyritization	Py	dissemination of pyrite
	31	S. Kuwis	(S. Kuwis)	diorite tuff	pyritization	Py	dissemination of pyrite.
	32	S. Kulus	Napallicin	tuff	silicification	Py	dissemination of pyrite
	33	S. Kuwis	S. Kuwis	tuff	pyritization	Py	dissemination of pyrite
	34	S. Kasai	-	quartz diorite	argillization	Py	dissemination of pyrite
	35	S. Kuwis	Hulusimpang	tuff	argillization	-	argillization only
	36	S. Minak	Hulusimpang	tuff	argillization	Py	pyrite along joint
	37	S. Minak	Hulusimpang	tuff	silicification	-	silicification only
	38	S. Tiku	Hulusimpang	tuff	pyritization	Py	dissemination of pyrite
	39	S. Pelantingan	S. Minak	shale	pyritization	Py	dissemination of pyrite
	40	S. Grag	S. Minak	siltstone	pyritization	Py	dissemination of pyrite
	41	S. Minak	S. Minak	andesite	silicification	-	silicification only
	42	S. Glagahhflir	S. Minak	tuff	argillization	Py	dissemination of pyrite
	43	S. Semamba	S. Minak	tuff	silicification	Py	dissemination of pyrite
	44	S. Maling	S. Minak	tuff	pyritization (silicification)	Py	dissemination of pyrite
	45	S. Tarum	S. Minak	shale	silicification	Py	pyrite along joint
	46	S. Tiku	S. Minak	tuff	silicification	Py	dissemination of pyrite

Abbreviation Py : Pyrite Po : Pyrrhotite Spe : Specularite
Cp : Chalcopyrite Mo : Molybdenite Hm : Hematite
Sp : Sphalerite Mal : Malachite

Table 2 List of mineral indicatios of the reconnaissance survey area (3)

A Ag-Zn-Pb-(Cu) mineralization in the detailed survey area, and a iron oxide mineralization of the Bt.Raja area belong to this type. The skarn type mineralization of the S.Tuboh area was target for drilling survey performed in the second and third phases, and is detailedly described in Part Ⅳ, and iron oxide mineralization of the Bt. Raja in Part Ⅲ.

4-2-2 Porphyry copper type mineralization

The mineralization embedded in Bt.Raja granite belongs to this type. Mo-Cu-Pb-Zn mineralization accompanied network quartz veins is described in Part Ⅲ.

4-2-3 Gold mineralization

Although not delineated to any mineralized area, indications inferred gold mineralization are found in the survey area, and alluvial golds are being actually collected on a small scale. Following two types of gold mineralization are supposed to be distributed in the area from the facts of distribution of the indications(geochemical anomaly) placer mining state by inhabitants and the products collected.

(1) Gold metamorphic diffentiation type

This gold mineralization type is distributed in the Mesozoic fomation area, and is hypothesized by gold concentration process inferred by information of placer gold mining at S.Rawas. Namely gold concentration was attributed to metamorphism of the S.Rawas Formation, especially a argillaceous facies. A story of a gold concentration through the metamorphism may be inferred as follows ;

" Remarkably dense distribution of segregated quartz veins are obserbed in the argillaceous facies of the S.Rawas Formation. The segregated quartz veins have been derived from a silica included in the argillaceous facies, and recrystalized through a metamorphosed process. A gold has been concentrated with the segregated quartz in the process. The concentrated golds (Mountain gold) have deposited within a alluvial deposit by errosion, and are being mined as placer golds in the present." Such a instance of gole bearing segregated quartz has been known in Suwa ore deposit of Hitachi Mine (bedded cupriferous sulfide deposit). However the concentration occurs accidentally, and sizable mineralized zone is hardly formed.

(2) Epithermal gold ore deposits

In Indonesia, it is known that a gold mineralization in Plio-Plicetocene time occurs along from Sumatra to Sunda archiperago, and Sulawesi, forming a island arc-trench. The mineralization consists mainly of gold bearing quartz veins embedded in Tertiary formations, and is epithermal gold mineralization accompanied by silicification,argolization, breccia dike, and hot spring, and also is related to volcanic activity taken place from 70Ma up to recent.

Chapter 5 Photo geological interpretation

5-1 Outline

In the initial phase, photo geological interpretation was performed whole reconnaissance survey area covered 1,450cm². The 36 aero-photographs used are of monochromatic orint with approximatery 1:10,000 in scale.

5-2 Result of Interpretation

As shown in Table 3, the geology of the reconnaissance survey area can be divided into ten geologic units, namely unit A～F of sedimentary rocks, Q of unconsolidated sediments, and I_1～I_3 of intrusive rocks.

The strata trend largely NW-SE, and folding structure is inferred in the same axial direction. Faults, predominantly shown up by pnoto-linearment, can be seen from the center to eastern part in the interpretation area, striking NE-SW and NW-SE.

In the distribution area of unit B, karst mophology and unit B, unit I_1 can be clearly interpreted from the center to the eastern part in the north from Maribung to Bt. Burang. The karst and units B_1 and I are also interpreted at the S.Tuboh. The unit I_1 cuts the unit B, and there is unconformity between units A,B and units E,F.

5-3 Comparison with surface geology

The results of the photogeological interpretation coincide well with the results of the geological survey performed through the initial phase. The existent of two faults system and of unconformity is very useful to compile results of the geological survey. The comparison of the interpreted units with geological formations from the geological survey is as follows ;

unit	geological interpretation
Q	Terrace deposit
F	Mainly S.Minak Formation
E	Mainly Hulusimpang
D	S.Minak Formation
C	S.Kuwis Formation
B	S.Rawas Formation,S.Kyuwis Formation
A	S.Rawas Formation

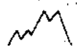
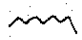
UNITS	Characteristics	PHOTO-CHARACTERISTICS: TONE Vege-tation	PHOTO-CHARACTERISTICS: TONE Culti-vation	PHOTO-CHARACTERISTICS: TEXTURE Vege-tation	PHOTO-CHARACTERISTICS: TEXTURE Culti-vation	MORPHOLOGICAL EXPRESSION: External or Internal	MORPHOLOGICAL EXPRESSION: DRAINAGE Pattern	MORPHOLOGICAL EXPRESSION: DRAINAGE Density	MORPHOLOGICAL EXPRESSION: DRAINAGE Cross-section	MORPHOLOGICAL EXPRESSION: ROCK PROPERTIES Resis-tance	MORPHOLOGICAL EXPRESSION: ROCK PROPERTIES Bedding	MORPHOLOGICAL EXPRESSION: ROCK PROPERTIES Attitude	MORPHOLOGICAL EXPRESSION: ROCK PROPERTIES Lineament	MORPHOLOGICAL EXPRESSION: ROCK PROPERTIES Boun-dary	CONCLUSIONS: Lithology
Uncon-solidated Sediment	Q	medium grey	light grey	fine	speckled	external	meadering	low		Very low	none	horizontal	none	sharp	lluvium
Sedimentary Rocks	F	medium grey	light grey	fine	speckled blocky	external	ub-dendriti	very high		low	massive	gentle	none	vague	clastics
	E	dark grey	–	medium	–	external	ub-dendritic	high		high	massive	moderate	medium density three directions	sharp	pyroclastics
	D	dark grey to medium grey	medium grey	medium to fine	speckled blocky	external	sub-dendritic	high		low to moderate	massive	gentle	low density two directions	vague	clastics and/or pyroclastics
	C	dark grey	–	medium	–	external	sub-dendritic	high		high	massive	moderate	none	vague	clastics
	B	dark grey to medium grey	medium grey	medium to fine	speckled blocky	karst phenomena	sub-dendritic partly trellis	high		high to low	massive partly bedded	moderate to gentle	low density several directions	vague	clastics (partly well bedded)
	A	dark grey	medium grey	medium	speckled blocky	external	dendritic	very high		moderate	massive	gentle to moderate	low dencity several directions	vague	clastics
Intrusive Rocks	I_3	dark grey to medium grey	medium grey	medium to fine	speckled	external	radial	medium		very high	very massive	steep	none	sharp	acidic to intermediate intrusive rocks
	I_2	dark grey	–	medium	–	external	sub-dendritic	low		very high	very massive	steep to moderate	low density several directions	sharp	granitic rock
	I_1	dark grey	medium grey	medium	speckled	external	sub-dendritic	low		very high	very massive	moderate	low density several directions	sharp	granitic rock

Table 3 Photogeological interpretation chart

I_1	Andesite
I_2	unidentified rock
I_3	Granite group

The Napalicin Formation and the Sululangun Formation could not be interpreted owing to low quality of the aerophotographs used.

Chapter 6 Geochemical survey

6-1 Outline of the survey

The geochemical survey was performed in the inithial phase. It consists of reconnaissance survey covering an area of 1,232km², and a detailed survey covering 18km², including three mineral indication areas of S.Tuboh, S.Kerin and S.Sepan. In both cases sample were collected from stream sediment.

6-1-1 Sample collection

stream sediments were collected under 80 mesh in size by sieving at the collection site, and collected 20～100 g per each point. Of the sample used for analysis, 1,600 samples came from the reconnaissance survey area and 150 sampled from detailed survey area. The collection densities were 1.3 sample/km_2 in the reconnaissance survey area, and 8.3 samples/km_2 in the detailed area.

6-1-2 Path-finder element

The follwing 12 elements were analyzed as path-finder elements ;

Cu, Mo, Pb, Zn, Ag, Ni, Co, Cr, As, Hg, Li, and Au.

All the elements were analyzed by atomic absorption photometry, with the detection limits shown below;

Cu : 2ppm	Mo : 1ppm	Pb : 1ppm
Zn : 1ppm	Ag : 0.1ppm	Ni : 1ppm
Co : 1ppm	Cr : 5ppm	As : 1ppm
Hg : 5ppb	Li : 1ppm	Au : 1ppb

6-1-3 Processing and interpretation of analysis data

The sample collection density for the reconnaissance survey area was very different to that of the detailed survey area. Therefor, the statistical processing analysis was performed separately for the these areas in order to prevent any bias due to different in collection density.

As a large amount of data were processed, variance analysis and main element analysis were applied by means of computer. Geochemical analysis

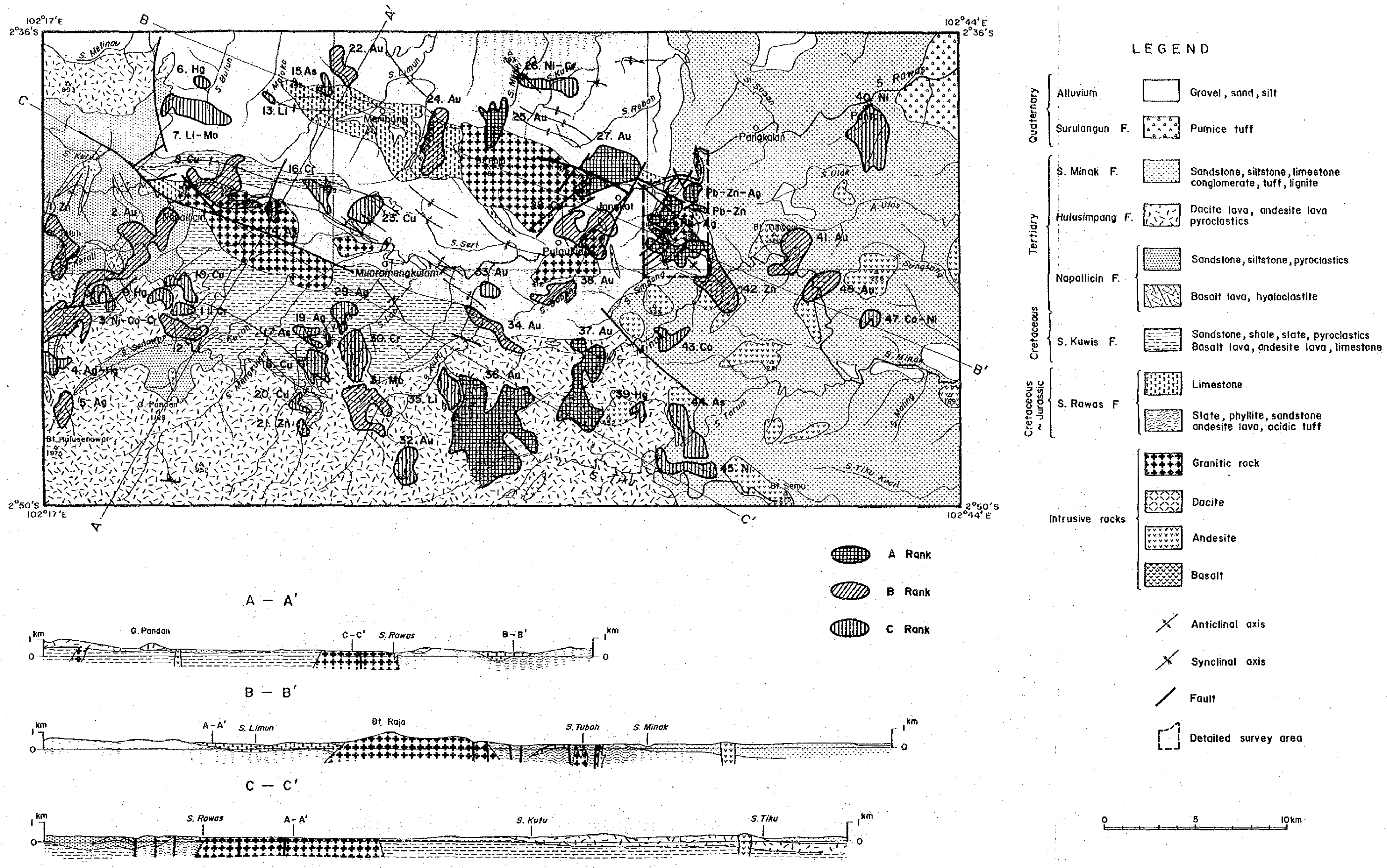


Fig. 9 Geochemical anomalous area in the reconnaissance survey area

No	Location	Number of Anomalous Samples	Main anomalous element and range	Subordinate Anomalous element and the range	Inferred Mineralization	Rank
1	S. Kerali	4	Zn:173 ~775(4)	Pb:25, Co:22(1)	(Pb)-Zn [24]	B
2	S. Kulus	20	Au:38 ~ 141(13) Ag:0.3 ~ 1.9(10) Hg:80 ~ 260(12)	Co:21(1), Li:48(1) Cr:124 ~ 180(2) Zn:176(1), Cu:60 ~ 67(2)	Au-(Ag)-(Hg) [32]	B
3	S. Kulus	4	Ni:52 ~ 74(3) Co:23(3) Cr:220 ~ 270(3)		Ni-Co-Cr	C
4	S. Kulus	4	Hg:70 ~ 180(3) Ag:0.2 ~ 1.8(2)	Cu:48(1), Pb:23(1) Cr:118(1)	Ag-Hg	C
5	S. Senawar	3	Cu:73 ~ 119(2) Au:356 ~ 390(2)		(Cu)-Au	C
6	S. Buluh	2	Hg:60(2)		Hg	C
7	S. Susup	8	Li:48 ~ 92(7) Mo:2 ~ 22(3)	As:20 =01 105(2)	Li-Mo [28]	C
8	Napalicin	13	Cu:55 ~ 81(6)	As:16 ~ 81(3), Hg:60(1) Ni:82 ~ 104(2), Co:38 ~ 41(2), Cr:290(2)	Cu	B
9	S. Senawar Seni	2	Hg:70 ~ 80(2)		Hg	C
10	S. Senawar Seni	4	Cu:35 ~ 81(4)		Cu [17]	C
11	S. Senawar Seni	3	Cr:118 ~ 270(3)	Mo:2(1), Ni:30(1)	Cr	C
12	S. Senawar	5	Li:32 ~ 54(5)		Li	B
13	S. Maloko	2	Li:46 ~ 52(2)		Li	C
14	S. Sosokan	2	As:12 ~ 20(2)		As	C
15	North of Bt. Bulam	2	AS:17 ~ 30(2)	Ni:55(1)	As	C
16	Mengkulam	3	Cr:140 ~ 162(3)	Cu:53(1), Ni:59(1)	Cr	C

Table 4 List of the geochemical anomalous areas (1)

No	Location	Number of Anomalous Samples	Main anomalous element and range	Subordinate Anomalous element and the range	Inferred Mineralization	Rank
17	S. Kuwis	2	As:10 ~ 11(2)		As	C
18	S. Kuwis	6	Ag:0.2 ~ 0.3(3) Cu:74 ~ 91(2)	Pb:21(1), Au:91(1)	Cu 31	C
19	S. Kuwis	2	Ag:0.2 ~ 0.3(2)		Ag [II] zone	C
20	S. Kuwis	3	Cu:50 ~ 82(2)	Pb:25(1), Cr:195(1) Mo:45(1), As:36(1)	Cu [31]	C
21	S. Kuwis	2	Pb:34(1), Zn:345(1)		(Pb)-Zn	C
22	North of Meribung	4	Au:568 ~ 4,130(3)	Ag:0.2(1)	Au	B
23	S. Tunbuk	3	Cu:56 ~ 60(2)	Hg:70(1)	Cu	C
24	S. Pangi	4	Cu:29 ~ 52(2) Au:158 ~ 1,230(2)		(Cu)-Au [6] [9]	B (A)
25	S. Meliki	5	Au:76 ~ 1,200	Pb:200	Au [1]	A
26	S. Meliki~S. Kutur	4	Ni:61 ~ 280(4) Cr160 ~ 720(4)		Ni-Cr	C
27	S. Menalu	7	Au:102 ~ 2,060(7)		Au [3][4][5]	A
28	S. Temiang	8	Cu:71 ~ 102(6)	Co:34 ~ 53(4) Mo:12(1), Pb:28(1)	Cu [8]	B
29	S. Kuwis(lower)	3	Ag:0.2(3)		Ag [29]	C
30	S. Kuwis(lower)	10	Ni:34 ~ 160(7) Co:37 ~ 51(5) Cr:250 ~ 520(8)	As:23(1) Cu:48 ~ 58(2) Ag:0.2 ~ 0.3(2)	(Ni)-(Co)-Cr [23]	C
31	S. Kutu(upper)	7	Mo:2(6)	Li:39 ~ 41(2)	Mo	B
32	S. Kutu(upper)	2	Au:56 ~ 1,710(2)	As:33(1), Ag:0.6(1)	Au	C
33	S. Kutu	2	Au:71 ~ 96(2)	Ag:0.2(1)	Au	C
34	S. Kutu	4	Au:850 ~ 2,100(3)	Ag:0.2(1)	Au	B
35	S. Kutu	3	Li:48 ~ 50(3)		Li	C
36	S. Kutu~S. Minak	17	Au:70 ~ >10,000(16) Ag:0.5 ~ 12.3(11)	As:22(1)	Au-(Ag) [37]	A
37	S. Minak	7	Au:144 ~ 2,420(7) Ag:6.8(1)	As:38(1)	Au-(Ag) [36]	A

Table 4 List of the geochemical anomalous areas (2)

No	Location	Number of Anomalous Samples	Main anomalous element and range	Subordinate Anomalous element and the range	Inferred Mineralization	Rank
38	S. Suban	3	AU:84 ~ 1,250(3)		Au [12] [13] [14]	B
39	Bt. Telumerangin	2	Hg:70 ~ 110(2)		Hg	C
40	S. Mejaja	3	Ni:11 ~ 38(3)		Ni	C
41	S. Minak	3	Au:596 ~ 9,730(3) Ag:7.6 ~ 10.2(3)		Au-(Ag) [41]	B
42	Bt. Ipuh	6	Cu:22 ~ 45(2) Zn:165 ~ 285(2) Co:11 ~ 16(3) Cr:40 ~ 44(3)	Li:20 ~ 22(2) As:7 ~ 9(2) Au:205(1)	(Cu)-Zn-(Co)-(Cr) [S. Tuboh]	B
43	Bt. Meru	3	Co:10 ~ 13(3)	Au:3,630(1)	Co	C
44	S. Tarum	3	As:7 ~ 11(3)	Pb:38(1), Hg:80(1)	As [45]	C
45	S. Tiku	3	Ni:10 ~ 13(3)	Cr:70(1), Zn141(1)	Ni [46]	C
46	S. Minak	3	Au:584 ~ 7,000(2)	Ag:7.0(1)	Au [42]	B
47	S. Minak	2	Co:18 ~ 20(2) Ni:33(1)	Pb:83(1), As:7(1) Hg:70(1)	Co-Ni	C

Abbreviation

□ : 対応する鉱徴地の番号
( ) : ランクがより下位となる元素

Table 4 List of the geochemical anomalous areas (3)

where statistical method is difficult to apply (i.e. in setting threshold value) was performed at the stage of extracting geochemical anomalies.

The analysis reading indicates that the element contents of the samples seem to vary according to rock of the back ground area. The variant analysis was used to find whether or not this differnt was statistically significant. The rocks were defined following "levels"(population) by geological Formation, because back-ground rock of a samples covered various rock types.

Level 1 ---	Quarternary system	: Surulangun Formation
	Tertiary system	: S.Minak Formation
Level 2 ---	Tertiary system	: Hulusimpang Formation
Level 3 ---	Tertiary system	: Napalicin Formation
Level 4 ---	Mesozoic system	: S.Kuwis Formation
Level 5 ---	Mesozoic system	: S.Rawas Formation
Level 6 ---	Intrusive rocks	: Granite,alkaline rocks
Level 7 ---	Intrusive rocks	: Quartz diorite, basalt, andesite, quartz andesite

After calcuration of mean value, standard deviation , and drawing up diagrams of frequency distribution and cumurative frequency distribution on the basis of the Levels, variance analysis was carried out. The results show that the element contents vary according to back ground rock except Mo. Accordingly, threshold value for each element was calculated for each of the above levels.

Because several elements were involved in the mineralization, the relationship between the elements should be taken into consideration. Therefor correlation matrix was drawn up, and main element analysis was carried out based on these. From the correlation matrices, followings showed a correlation coefficient of over 0.5 ;

Cu-Zn, Cu-Ni, Cu-Co, Cu-Cr, Zn-Cr, Zn-Cr, Ni-Co, Ni-Co, Co-Cr

The cumulative proportion for the first six main elements is 81.9%, and the result indicates that over all element behavior can be largely attributed to 6 factors. When the first main proportion is 0.35, the rest are not high and the proportion for main elements 4 to 6 is less than 0.1. From the factor loadings, the main element and element correlations are as follows ;

First main element ----------- Cu, Zn, Ni, Co, Cr

Second main element ---------- Pb, Ag, As, Hg

Third main element ----------- Au, Ag

The result of geological survey was compared with the factor scores in order to know what the main elements indicate. From the behavior of the elements accompanying minerarization and from data concerning the elements of the various rocks, the conclusion are shown as follows ;

1) First main element : Rather than originating in mineralization, it is attributed to a degree of basicity in background rock.

2) Second main element : Shows Ag-Pb mineralization, accompanying As and Hg mineralization.

3) Third main element : Shows Au mineralization and Ag accompanies Au.

After the studying Lepeltir method (1969) and $m + 2\sigma$ (m: mean value, σ : standard deviation) for estimation of the threshold value for each element, the latter was used, i.e. the reading for each of the back ground rock.

6-1-4 Extraction and evaluation of anomolous areas

a) Recconnaissance survey area

When anomaly values were obtained from more than two neibouring sampling points, the whole drainage area was defined to be an anomalous area. Furthermore, Zn and Pb anomalous values are neigbouring to each other, the area including both is also defined as an anomalous area.

There are 47 anomaly areas in the reconnaissance survey area. Among them, there are 11 areas where at leasr one of Cu-Pb-Zn is anomalous, 18 areas where at least one of Au-Ag-Hg, 4 areas where As is anpmalous, and 4 areas where at least one of Mo-Li is anpmalous, 9 areas with anomalous Ni-Co-Cr.

These anomaly areas are listed in Figure, and thier locations are shown in Fig 10.

The Cu-Pb-Zn anomaly areas are widely distributed in the detailed survey area and east of the area nearby. They are not concentrated in any particular area or Formation. The Au-Ag-Hg anomaly areas also occur in whole area and all strata, but are somewhat concentrated in the area of Hulusimpang Formation. Among these, the three areas, S.Kulus(No.3,4),S.Minak (No.46,47) and S.Menalu(No.27) are large anomaly area.

The As anomaly areas are distributed at S.Sosokann(No.14), north of Bt.Bulang (No.15), S.Tarum(No.43), S.Kuwis(No.17), but there are no outstanding features in the background rock.

The Mo-Li anomaly areas are confined to S.Makolo(No.13),S.Senwar(No.12), and S.Kutu(No.35). The Ni-Co-Cr anomaly areas are widely scattered in S.Kurus(No.3), S.Senar-S.Seni(No.10), S.Mengkulan(No.16), S.Labi(No.30), S.Ulak(No.40), S.Tiku(No.45), and the lower reaches of the S.Minak(No.47). Some anomaly areas are presumably related with mafic volcanic rocks.

Taking comparison of magnitude of the anomaly and the average crustal abundance, and results of geological survey into consideration, these anomaly area were evaluated, and classified three rank, A, B, and C as follws;

Rank A. : Five or more consecutive anomalous values occur, and furthermore, the element of two or more samples are more than twice the average crustal avandance.

Rank B : One of the condition of Rank A should be fulfiled.

Rank C : This does not saticefy the condition of Rank A, and is of Ni-Co-Cr anomaly.

According to this classification, four areas were Rank A, and forteen areas were Rank 4. If the areas are categorized according to thier combination of elements , the results is as follows ;

Element combination	Rank A	Rank B
Cu-Pb-Zn anomaly areas	--	4 areas
Au-Ag-Hg anomaly areas	4 areas	8 areas
Mo-Li-anomaly areas	--	2 areas

Among them, the four of Cu-Pb-Zn and a Mo-Li anomaly areas of Rank B are described briefly below;

① No.1 S.Kerali anomaly area : This area includes four Zn (173～775ppm),a Pb(25ppm) and Co (20ppm) anomalous values. There is a narrow pyrite-disseminated silicification zone in the Napalicin Formation, and lead and zinc mineralization are unconfirmed.

② No.8 Napalicin anomaly area : There are many " 6" anomalous Cu values, but their values are 81ppm in maximum, which is not high when compared to the contents of the basalt(100ppm). The anomaly possibly derive from basalt in the Napalicin Formation.

③ No. 28 S.Tamian anomaly area : There are 6 anomalous Cu values, and anomalous Mo, Pb, and Co values. Compared to the content of the basalt (100ppm) and crustal abundance(50ppm), the 71～102ppm anomalous Cu value is not large. However, the back ground rocks is composed of grnite, and its content should be low (average value for granite is 10ppm). Considering the fact, these anomalous values may be due to mineralization.

④ No.31 upper reaches of S.Kutu : There are 6 anomalous Mo values, but all are 2 ppm. The value is not large in comparison with the content of granite and shale.

⑤ No.42 Bt.Ipuh : This is an anomaly area connected to the southeast of the S.Tuboh area, detailed survey area, and as well as anomalous Cu-Zn values it has anomalous Co-Cr value.

Among the anomalous Au-Ag-Hg belonging to this group, the S.Sunawal and

S.Pangi anomaly areas belong to Rank B because of their Au values.

Among the anomalous Au-Ag-Hg areas of Rank A and Rank B, those which are classified as Rank A areas are as follows;

① No.25 S.Meliki : There are five anomalous Au values, showing 76~1,200ppb. These are accompanied by Pb anomalities(1,000ppm). The the background rock of the area is granite and the S.Rawas Formation.

② No.27 S.Menal : There are six anomalous Au values, showing 102~2,060ppb. there are also anomalous Mo, Pb and Co values. The background of geology is the same as for S.Meliki, so there is a possible that it will be anomaly area due to the same geological phenomena, namely metamorpnic differntiated gold deposit, or mineralization by the granite intrusion at Bt.Raja.

③ No.36,37 The upper reach of S.Minak : The area consists of two consecutive anomaly parts at Teku Minak and Minak. 16 anomalous Au values were found at the former, and 7 values at the latter. These are the widest area in reconnaissance survey area. Anomalous Au values of over 10,000ppb were found in the former, and the latter was distinguished by eleven samples with anomalous Ag. Both belong to the Hulusimpang Formation distribution area, so they are very possibly due to epithermal gold mineralization in the Pliocene-Pleistocene time mentioned later.

b) Detailed survey

The detailed survey area covers 18 km^2, and includes the S.Tuboh area from the second phase. The assay values of 150 samples collected were converted into logarithms, in order to obtain the maximum value, minimum value, mean value, and standard deviation for each element.

Then the frequency distribution and cumulative frequency distribution charts were drawn to figure out the anomalous values.

The content per element, apart from Li and Au, was high in all samples in comparison with reconnaissance survey area. Ag in particular was up to 5 times the value of samples taken from reconnaissance survey area. The values of Cu,Mo,Pb,and Zn were also quite high.

In the correlation matrices for the detailed survey area, Cu-Co, Cu-Cr, Cu-As, Pb-Ag, Zn-Ag, Ni-Co, Ni-Cr, As-Li, show correlation coefficients of 0.5 and over. This is smaller than the approximately 0.7 of the reconnaissance suevey area, but correlations of Pb-Ag, Zn-Ag, Cu-As, which were not seen in the reconnaissance survey area, are found, showing the effects of mineralization on the elements.

From the factor lodings, the first main element has a high correlation with Cu, Zn, Ni, Co, Cr and As. and this can be explained as a factor connected to Cu mineralization. For the second main element, there is a high correlation with Pb-Zn and Ag, and this can be seen as connected to Pb-Zn-Ag mineralization. For the third main element, there is a possitive correlation with Zn and Co, and a negative correlation with As-Li is shown, therefor it is very likely that this refrects the back ground rock.

For the threshold values, the contents for elements such as Pb, Zn and Ag are high compared to the reconnaissance survey area, then if threshold values are set at roughly the same level as the reconnaissance survey, there is a danger of over looking some points affected by mineralization. Therefor in the detailed survey area, two level of threshold values $m + \sigma$ and $m + 2\sigma$ were set, and two ranks anomalous figures were designated.

Three mineral indication areas are known at S.Tuboh, S.Kering and S.Sepan in the detailed survey area, and it is main purpose to know how these indicantions extend by the interpretation of these anomnalies. Therefor Cu, Pb, Zn and Ag. were selected as path-finding elements. These anomalous values were divided into three classes by means of two levels of threshold, and extend of anomaly areas were drawn. The anomaly area was defined by two or more consecutive samples with over $m + 2\sigma$.

From the distribution of the anomalous values, two anomaly areas were selected. One is distributing from S.Sepan-S.Kering mineral indications to S.Tuboh area, trending NE-SW, and the other extends east from the lower stream of the S.Tuboh, and reachs to Bt.Ipuh of the reconnaissance survey area. Namely the former indicates that S.Tuboh mineralized zone is Pb-Zn Ag mineralization, and possibly continues to S.Sepan and S.Kering indications, while the latter might be Cu-As-Ag mineralized zone.

On the other hand, the former seem to consist of two echelon anomalous zones connected from the S.Tuboh mineralized zone to S.Larang-S.Sepan-S.Kering indications, extending eastward. From the fact point of view, the S.Tuboh anomaly area is disstributed near east side of the alkaline intrusive rocks(deep facies), while S. Larang-S.Sepan-S.Kering anomaly at northewest side of the intrisive rocks, inferring respectively the two mineralized zones.

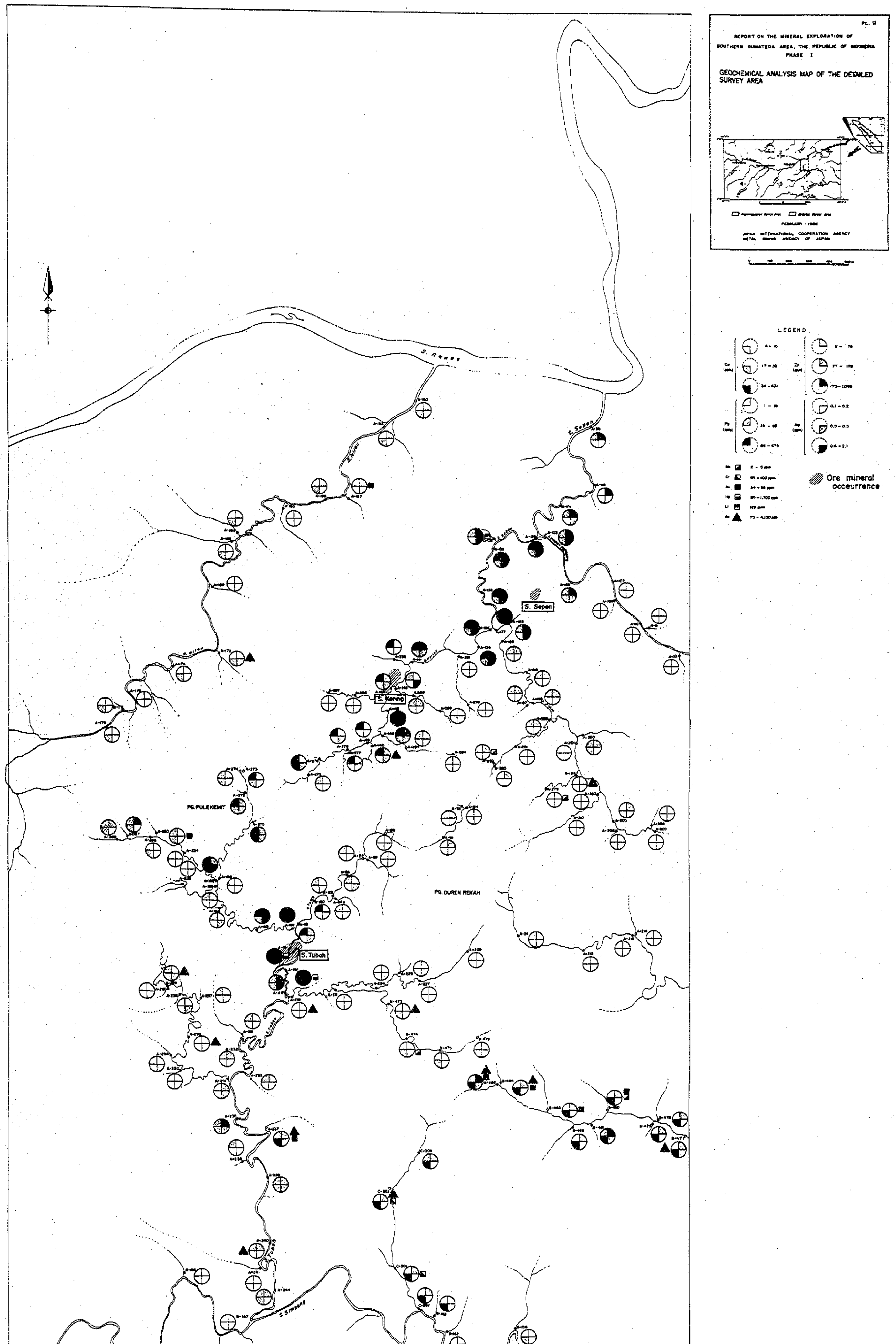


Fig. 10 Geochemical anomalous area in the S.Tuboh detailed survey area

PART Ⅲ BT. RAJA AREA

PART III BT.RAJA AREA

Chapter 1 Outline of Survey

The Bt.Raja area was a survey target area in the second phase, selected through the reconnaissance suevey in the initial survey. In the initial phase, about 15 mineral indications were found around Bt.Raja, Of them, S.Pangi(No.24 in Table 4), S.Meliki(No.25 in Table 4), S.menalu(No.27 in Table 4), and S.Suban(No.38 in Table 4) coincided with geochemical anomaly areas. These indications occur as network quartz veinlets with Mo, areas of boulders of magnetite and hematite. The S.Seban indication apears particularly skarn type mineralization owing to constitution of garnet and magnetite. From the survey result, a area was selected for the second phase survey.

Among these indications, ten indications locating closely Bt.Raja granite were selected as exploration target area, and six small secters of A, B, C, D, E and F, involving these indications and total area of 22km², were set for a detailed surveuy of the second phase.

The detailed survey consists of geological,geochemical and ground magnetic surveys, thd their survey amonnts are as follows;

Geological survey	:	22km², 116 traverse lines
Geochemical survey	:	1,619 soil samples(73.5 pieces/km²)
Ground magnetic survey	:	1,730 stations

As a results, the geological survey discovered 10 new indications, and the geochemical survey found 26 anomaly areas, and the ground magnetic survey detected 15 magnetic anomaly areas.

Chapter 2 Geology

2-1 Outline of geology

The geology of the Bt.Raja area consists of S.Rawas Formation and intrusive rocks intruded the formation.

With some exceptions, the intrusive rocks is Raja granite, intruded in igneous activity of 60～50Ma, and their rock facies are of diorite and granite(Raja granite).

Mineralization in the Bt.Raja area exists in the intrusive rock and the ajacent the S.Rawas Formation, and is essentially a porphyry copper type, as described below.

2-2 Sedimentary rocks

The Rawas Formation is distributed at northeast side of Raja granite, and consists of a lower stratum of sandy-muddy facies(flysh facies), and the Mersip Limestone Member which overlies above. At southeast part of the area, sandstone facies is exposed as upper stratum of the S.Rawas formation. They have undergone hornfels by thermal metamorphism of the intrusive rock.

2-3 Intrusive rocks

The intrusive rocks is extensively distributed in the central part of Bt.Raja area, and is composed of granite in its center and diorite at its margine. At northwest and southwest of the granite, younger and small diorite porphyry intrusives occur at northwest and southwest of the grasnite.

The granite in the Bt.Raja is classified to calcic rock series, in terms of alkali-calsic index, and is plotted in the liparite facies region of non-alkaline rock on the SiO_2-Na_2O_3+K_2O chart. The rock is coloured either pale gray to white or pinkish, and there is also some rock dark in colour. Aplite dykes with 2cm~5cm in width occur in the granite.

The diorite is somewhat alkaline, is correlated with trachyte or trachy andesite in alkaline rock region on the SiO_2-Na_2O_3+K_2O chart, but belongs to calc-alkalic rock series in terms of alkali-lime index.

The small intrusive rocks of diorite porphyry have intruded in Neogene time.

Chapter 3 Geological structure

The geological structure of the S.Rawas Formation is very complexly due to existence of reverse structure inferred by homoclinal structure, composite folding and flute cast, and strike-slip faults. In the Bt. Raja area, the existence of large intrusive rock occupied in the center part makes the geological structure even more complexly. Despite the fact, the S.Rawas Formation in the Bt.Raja area can be generally consider to consist of synclinorium structure with NE-SE trend axis. The Raja granite has intruded in the axial part of the synclinorium.

Two fault system of NW-SE and NE-SW trends are recognized, and the latter system slightly later than the former. Namely the NW-SE faults have been presumably formed before the intrusion of the Raja granite, while NE-SW faults often cut in many case. A old strike fault can be inferred at contact part between the low member(sandy-muddy facies) and Mersip Limestone Member of the S.Rawas Formation, even though the fault become unclear owing to the intrusion of Raja granite. Consequently, it may be inferred that the Raja granite has been emplaced along NW-SE fault.

Chapter 4 Mineralization

4-1 Outline

The second phase survey unravelled mineral indications at 10 locations adjacent to the Raja granite, and also discovered further new indications. As a result of the initial and second phases, mineral indications were discovered at total of 20 locations.

The indications in the Raja area is divided into following paragenesis of ore minerals taking the occurence and geochemical anomalies into consideration ;

Type a	Fe oxide + sulfide-1 + skarn
Type a_1	Fe oxide + sulfide-2 + skarn
Type b_1	Quartz network veins with sulfide-1
Type b_2	Type b_1 + skarn
Type C	Fe-sulfide + a small amount of Cu-sulfide
	(Fe-oxide : magnetite or hematite
	Sulfide-1 : sulfide of Fe,Mo,Pb,Zn,Co,Cu and Au
	Sulfide-2 : Sulfides other than Mo
	Skarn : Garnet, usually andradite

These types all are accompanied by sulfide ores in common, and among these types, type b_1 is representative, and is characterized by the follwings;

Ore minerals : Molibdenite,pyrite,chalcopyrite,sphalerite,galena
Gangue minerals : (all are not frequent) quartz (frequent)
sericite(often), chlorite(sometimes)
Alteration : sericitization, silicification
Occurence : Dissemination accompanied quartz veins
Host rock : the Raja granite

From these fact, namely composition and occurence of ore minerals, a small *amount of gangue minerals, alteration,host rock(granite), the Type b_1* is presumably defined porphyry copper type mineralization.

The other types, except type b_1, are considered as variation of the Type

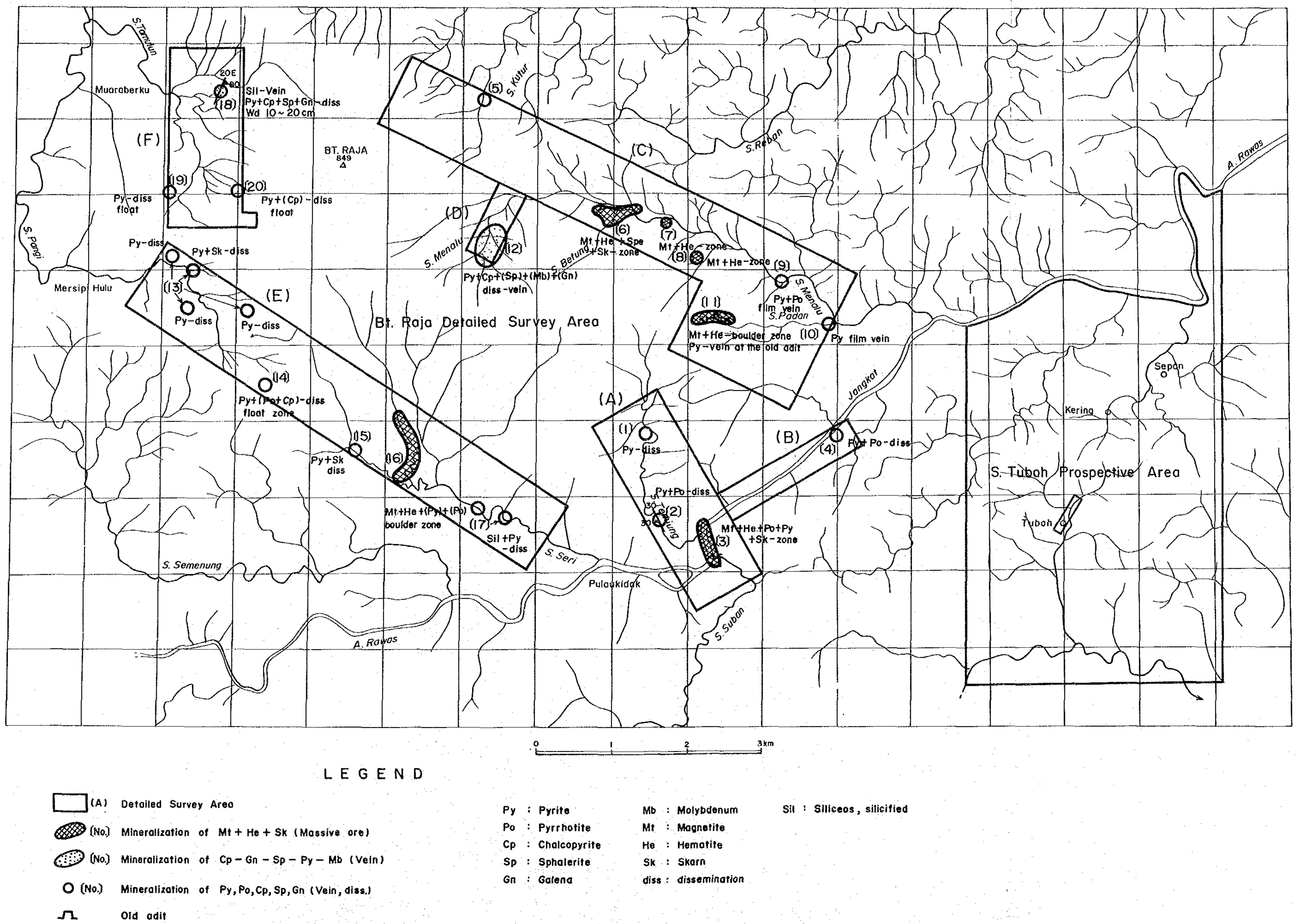


Fig. II Distribution map of the mineral indications in the Bt.Raja detailed survey area

Mineral indication	Location	Host rock (formation)	Rock facies	Mode of Mineralization, Alteration	Mineral assemblage	Remarks
〔 1 〕	A. Line2-4(S.Temiung)	S.Rawas	Hornfelsic slate	Silicification	Py	Dissemination
〔 2 〕	A. Line7-9(S.Temiung)	S.Rawas	Slate	Argillization	Py	Py vein in the shear zone
〔 3 〕	A. Line10-14(S.Suban)	S.Rawas & Intrusive rock	Hornfels. Granite	Skarnization	He+Mt+(Po)+Sk	Massive ore zone
〔 4 〕	B. Line5-6(S.Rawas)	S.Rawas	Slate	Pyritization	Py+(Po)	Dissemination
〔 5 〕	C. Line7-8(S.Kutur)	S.Rawas	Slate	Pyritization	Py	Float
〔 6 〕	C. Line16-20(S.Betung)	S.Rawas & Intrusive rock	Slate Granodiorite	Skarnization	Mt+He+(Spe)+Sk	Massive ore zone
〔 7 〕	C. Line21(S.Menalu)	S.Rawas	Slate	Skarnization	Mt+He+(Sk)	Float of massive ore
〔 8 〕	C. Line24(S.Solok)	S.Rawas	Slate	Skarnization	Mt+He+(Sk)	Float of massive ore
〔 9 〕	C. Line30(S.Menalu)	S.Rawas	Slate	Skarnization	Py+(Po)+(Sk)	Quartz vein (wd 0.3~0.5cm)
〔 10 〕	C. Line34(S.Padan)	S.Rawas	Limestone	Skarnization	Py+(Po)+(Sk)	Quartz vein in joint
〔 11 〕	C. Line35-38(S.Padan)	Intrusive rock	Granite	Skarnization Argillization	He+Mt Py+(Lm)	Massive ore zone Clay vein with Py at the old adit
〔 12 〕	D. Line1-3(S.Menalu)	Intrusive rock	Granodiorite	Net work	Cp+Py+Sp+Gn+Mb	Joint filling quartz vein
〔 13 〕	E. Line1-8(S.Pangi)	S.Rawas	Limestone	Pyritization	Py+(Po)+(Sk)	Py vein in joint
〔 14 〕	E. Line12(S.Pangi)	Intrusive rock	Diorite	Silicification	Po+Py+(Cp)	Float zone.Dissmination
〔 15 〕	E. Line17-19(S.Seri)	S.Rawas	Limestone	Skarnization	Py+(Po)+(Sk)	Veinlet in joints
〔 16 〕	E. Line20-23(S.Seri)	S.Rawas	Slate, limeston	Skarnization	He+(Py)+(Po)+(Mt) +(Sk)	Float of massive ore zone
〔 17 〕	E. Line26-32(S.Seri)	S.Rawas & Intrusive rock	Slate, limestone Granite	Pyritization	Py	Dissemination
〔 18 〕	F. Line3-5(S.Tamulun)	S.Rawas	Limestone	Silicification	Qtz>Cp+Py+Sp+Gn+(Mb)	Quartz vein (wd 0.1~0.2m)
〔 19 〕	F. Line8-10(S.Tamulun)	S.Rawas	Slate	Silicification	Py	Float of Py disseminated rock
〔 20 〕	F.Line10-11(S.Tamulun)	Intrusive rock	Diorite	Silisification	Py+(Po)+(Cp)	Float of sulfide disseminated rock

Abbreviation Py : Pyrite Ga : Galena Mt : Magnetite Lm : Limonite
Cp : Chalcopyrite Po : Pyrrhotite He : Hematite Sk : Skarn minerals
Sp : Sphalerite Mb : Molybdenite Spe: Specularite Qtz: Quartz

Table 5 List of mineral indications in the Bt.Raja detailed survey area

b_1, as descrived below ;

Type b_2 : Being accompanied with garnet skarn is one differnt from Type b_1. This is naturally because the mineralization is embedded in the Mersip Limestone Member. The skarn type minerarization is emplaced on the outside of the intrusive rocks.

Type c : Pyrite-disseminated mineralization and silicification with weak mineralization emplaces further far from the intrusive rock. The type is related to early intrusion of diorite.

Type a_1 : Differ from Type a_2 in being accompanied by Mo. and located closer to the center of mineralization than type a_2, and is considered to reflect the diffusion ability of Mo.

Type a_2 : Lacks Mo. Located further away from the center of the mineralization than Type a_1.Considered to be formed from mineral with a high diffusion ability than Mo.

On the basis of these results from two phases surveys, it may be inferred that the porphyry copper type and skarn type minerarization as variation are embedded in Bt.Raja area.

4-2 Porphyry copper mineralization

The S.Menalu indication (No.12) is typified of the porphyry copper mineralization in tha area. This is an indication found in river close to upper reachs of the S.Manalu around 200～400 m above sea level, locating on the NE margin of the Raja granite. It consists of chalcopyrite-pyrite-sphalerite-galena-molibdenite dissemination accompanied quartz veinlets of width between 0.1 and 0.3cm, trending N60° ～80° W(strike of joints).

The distribution density of the qurtz veinlets is very low. There is accompanying silicification and selicitization. A boulder of molibdenite bearing quattz vein(width : 2cm) was discovered on the river bed closed to this indication.

4-3 Skarn mineralization

This type of mineralization is found in indications 3, 6, 7, 8, 9, 10, 11, 13, 15, and 16 in Tbal 5. Seen in the terms of distribution, these fall into four groups, 3,6-7-8-9-10-11, 13, 15-16. Of these, indication of the S.Suban(No.3) is clearly embedded in situ. No.6 and No.11 also apear to be in situ, while No.15 and No.16 are presumably not in situ.

The S.Suban indication is embedded at adjacent contact between calcareous slate of the S.Rawas Formation and pinkish granite, and has a great deal of magnetite, together with hematite, pyrrhotite, and pyrite. Oxide Cu mineral was also detected by means of Xray diffraction analysis. The magnetite occurs bandding with andradite. The indication has 7m in width, and strikes N20° ~35° E, and is traceable over 200m, crossing S.Rawas.

The indications of S.Betung(No.6) and S.Padan(No.11) are both boulders consisting mainly of magnetite. Quartz veinlets, clay veins and skarn occur nearby.

The indication of S.Seri(No.16) is also boulders extending south-east for 700m, and up to 50m wide, and these boulders contain mainly hematite with magnetite. These boulders are up to 3.5m.

As described above, the main ore mineral in the skarn indication of the Bt.Raja area is magnetite. However, the ground magnetic survey performed in the second phase survey indicates that magnetite is embedded near only shallow surface.

The indication of Tamulun(No.18) may also be a skarn type, but it has a differnt character from the others, and It consists of a ore composition with chalcopyrite, sphalerite, galena,pyrite,molibdenite and andradite.

Chapter 5 Geochemical detailed survey

5-1 Sampling

Six sectors, A, B, C, D, E and F, in the Bt.Raja were selected to cover all indications. This sectors covers a total survey area of $22km^2$. The samples were collected at intervals of 100m or 50m along the travers line, total 116 lines. Total number of the soil samples collected are 1,619 pieces, with 73.6 pieces/km^2 of sampling density. After drying under sun, the samples for analysis were treated, through -80medh sieve.

5-2 Path-finder element

The samples were chemically analysed for 7 path-finder elements of Cu, Mo, Pb, Zn, Ag, Au and Co.

The values obtaind were processed by means of statistic method, and threshold values were calculated as in Table 6, and used in analysis of content.

Fig 6 Threshold Values

Element	m + σ	m + 2σ	m + 3σ	threshold
Cu(ppm)	66.363	196.734	583.223	150(2.5%)
Mo(ppm)	1.790	2.768	4.281	2.0(5%)
Pb(ppm)	26.864	51.472	98.691	45(2.5%)
Zn(ppm)	70.874	122.985	213.412	110(2.5%)
Ag(ppm)	0.165	0.233	0.330	0.2(m+2σ)
Co(ppm)	13.321	37.906	107.862	35(2.5%)
Ag(ppm)	0.165	0.233	0.330	0.2(m+2σ)

Twenty six geochemical anomalous areas have been obtained by means of statistic anomaly(Fig 12). Of these anomalous areas, some area are situated around mineralized indications, while others do not coincide with the situation. Regarding to the correlation between elements, some correlations are high, while others are low. According to "main element", 26 anomalous area are grouped into as follows ;

Anomaly with main element of Mo : 8 locations
Anomaly with main element of Au : 10 locations
Anomaly with main element of Ag : 2 locations
Anomaly with main element of Zn : 3 locations
Anomaly with main element of Pb : 1 locations
Anomaly with main element of Co : 2 locations

The combination of the elements of each main element anomalous area are shown Table 7.

Table 7 Anomaly Division by Geochemical Path-finder Elaments and Geochemical Feature of the Sectors

Main element	Combination of Element	Geochemical Anomaly
Mo	Mo Mo ············(Pb,Cu,Au,Ag) Mo-Au-Ag-Pb-Zn·················Co Mo-Pb-Zn-Co-Au-Ag Mo-Co ··············(Au,Ag,Zn)	Cc-5,Ac-4,Dc-1,Cc-6 Ec-5 Fc-1 Fc-2
Au	Mo-Au[Mo≒Au) Au·························(Pb) Au-Ag Au-Cu-Zn-Ag-Pb-Co·········(Mo)	Cc-3 Ac-1,Fc-4,Fc-5 Cc2,Cc-7,Cc-1,Bc-3,Cc-4 Ec-3,Ec-6
Ag	Ag (Au,Pb)	Bc-1,Ec-2
Zn	Zn-Co-Cu-Pb Zn-Ag (Pb) (Cu)	Bc-1,Ec-2 Ec-4
Pb	Pb-Zn-Au (Ag) (Co)	Bc-2
Co	Co-Au (Cu) (Zn)	Ac-3,Fc-3
As to combination of element	① element shifted largest to left(larger difference from threshold) is the most anomalous(dence content) ② element marked( ) is most thjin content, and some element is barely recognized its existence	

This Table indicate that the individual groups of main element Au, Ag, Zn, Pb and Co contain a small amount or a minute content of Mo, while the groups of main element Mo have a high contents of Au, Ag, Cu, Pb, Zn in some cases.

Geologically, the Mo anomalous area are distributed within or very close to the Raja granite without exception. On the contrary, the Au, Ag, Pb, Zn and Co anomalous area are distributed at the outer than the Mo anomalous area where are distributed faether from the Raja granite. The fact presumes that the mineralizations arrange zonally around the Raja granite. If this is assumed to signify, the zonal distribution of the mineralization, the mineralization is summarized as follows ;

① Porphyry copper type : Mo-(Pb-Cu-Au-Ag) bearing network quartz veinlets embedding within granite.

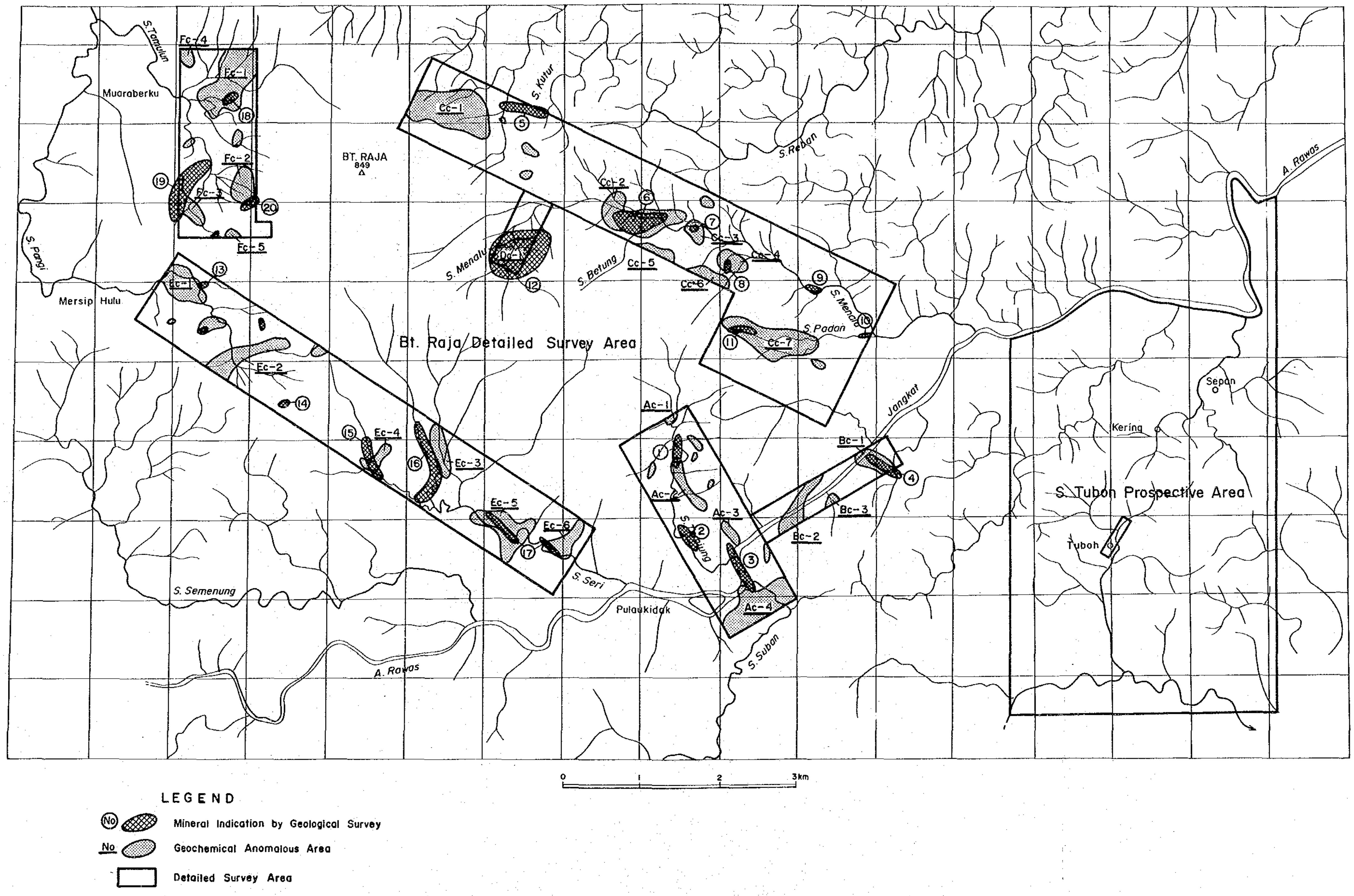


Fig. 12 Geochemical anomalous area in the Bt. Raja detailed survey area

② Skarn type : Fe-(Au-Cu-Zn-Ag-Pb-Co) skarn type mineralization, without Mo, emplaced at outer zone of the porphyry copper type mineralization. It forms magentite-hematite ore deposit in fact.

③ Pyrite dissemination type : pyrite disseminated silicification zone embedded outer of northwest diorite, related to early igneous activity.

Chapter 6 Ground magnetic survey

6-1 Outline of working

The initial survey discovered the mineral indications containing intensely magnetic minerals in the Bt.Raja area. A ground magnetic survey would clarify the distribution and extention of these indications. In the second phase, the ground magnetic survey was conducted in the six sectors A～F. and measurement stations as same these of geochemical survey. There were a total of 1,730 stations, 760 stations at 50m interval and 1,004 stations at 100m interval. A proton magnetometer was used to take the measurement.

6-2 Interpretation of magnetic anomaly

The field measurement were compensated for diurnal variation, and then a total magnetic intensity map was compiled. The magnetic anomalies obtained were then analysed by the two dimentional Talwani method.

The parameters used for the analysis were width,depth,shape(slab or dyke) and susceptibility of the magnetic anomaly source. Since all those prameters were generally not defined, the interretation work was conducted applying method ③ and ④ on the parameter of ① and ② as follows ;

① Width and depth of magnetic anomaly source ;

a. The magnetic anomaly source was assumed to exist from the surface downwards.

b. The width was equivalent to the distance between positive and negative peake in a pair anomalieson the total magnetic intensity map.

c. For the anomalies inferred to be caused by mineralization during the cource of interpretation mentioned above, these anomalies were individually interpreted by magnetic profile.

② Shape and magnetic susceptibility of magnetic anomaly source. ;

The types of magnetic susceptibility and shape of magnetic anomaly source were assumed to be the values shown in Table 8, after reference to the magnetic susceptibility values for rock samples.

Fig 8 Models Used in Magnetic Analysis

type of anomaly source		magnetic susceptibility(10^{-6}emu/cc)		shape of analysis model
		average of rock and ore measured	analysis model	
I	granite (weakly magnetized)	428	500	dyke
II	granite (intensely magnetized) granodiorite	1,850 2,073	2,000	dyke
III	diorite	2,422	2,500	dyke
IV	magnetite	165,483	165,000	thin slab

③ Relationship between magnetic anomaly amplitude and width of dyke-model for differnt magnetic susceptibility ;

In the case where the Talwani method is applied for calculation of the dyke-model,the amplitude of the magnetic anomaly can be calculated from the width of a known anomaly source . Namely, the type of anomaly source can be certainly defined by comparing calcurated and observed values.

④ *Relationship between magnetic anomaly amplitude and thickness of thin* slab-model :

In the case where a thickness of the slab-model anomaly source is sufficiently thin, comparing with its thickness, the amplitude of magnetic anomaly is attributed only thickness,not to width. The magnetic susceptibility used in the calculation is 165,000× 10^{-6}emu/cc, and a thickness of the mineralized zone(equivalent thickness) can be calculated.

If the results of the calculation in (3) and (4) are significantly larger than the result of the calculations in (2), the anomaly is judged to be due to the mineralized zone. Among the total of 15 magnetic anomalies, anomalies of mineralization judged by above mentioned djuging standard were found at 8 locations, while 7 anomalies are not mineralizad zone(Table 9).

Individual magnetic profiles were constructed for each anomaly, and the *shape of mineralized zone models were obtained when the profile and* calculations matched.

6-3 Investigating the results of magnetic analysis.

Of the twenty indications confirmed in the geological survey, intensely magnetic minerals were recognized at nine locations, 2, 3, 4, 6, 7, 8, 11, 14,and 16. The magnet survey discovered six areas of magnetic anomaly, A-I , A-V , C-II , C-III , C-V , E-IV , including the eight locations where magnetic anomalies were considered to be due to mineralized zones. Of these, A-V (indication No.3), C-II (indication No.6), C-III (indication No.7), C-V (indication No.11), match with indication where intensely magnetic minerals had been recognized, and A-I and E-IV anomaly areas discovered at locations where no indications had been found.

Mineralization zones were not deducted from magnetic anomalies despite the recognition of intensely magnetic mineral at indications No.2, 4, 8, 14 and 16. Indications 1, 5, 9, 10, 12, 13, 15, 17, 18, 19 and 20 where intensely magnetic minerals had not been recognized did not show any magnetic anomalies from which mineralized zoned could be deduced.

According to analysis of magnetic anomalies, the extent of the mineralized zones is a planar of 50～200m, and thickness(equivalent thickness) 20～150cm. These values were calculated with the assumption that the whole of each mineralized zones was composed of intensely magnetic muinerals, so if the proportion of intensely magnetic minerals in the total volume is 50%, 30%, 20% or 10% , then the thickness of the mineralized zone model becomes 2, 4, 6, or 16 times equivalent thickness. From the occurence of the mineralized zones confirmed in the geological survey, the proportion of intensely magnetic minerals can be estimated as being between 10 and 20% of the total volume, giving a figure of more than 10m for the thickness (depth from the surface) of the mineralized zones.

Most of the magnetic anomaly which were not considered to be connected with mineralized zones were thought to be due to intensely magnetic rocks.

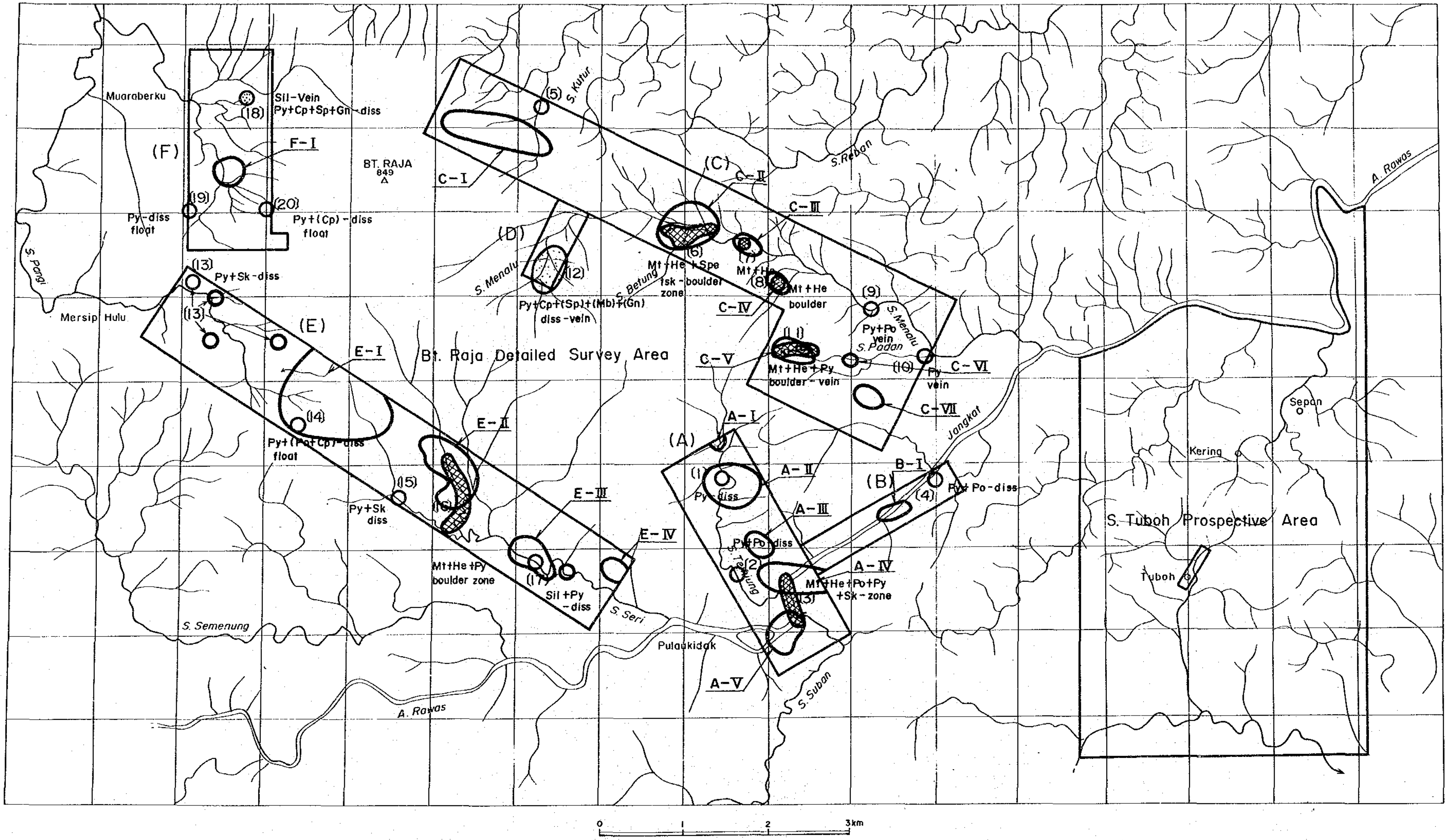
Table 9 Magnetic Anomalies Related to Mineralized Zones

Sector	number of anomalous area	number of anomaly	amplitude of anomaly(nT)	equivalent thickness(cm)	number of mineralized indications
A	I	1	3,520	35	---
A	V	7	3,180	45	3
C	II	6	1,780	25	6
C	II	11	3,190	45	6
C	II	12	4,170	60	6
C	III	13	1,900	25	7
C	V	16	2,100	30	11
E	IV	14	1,700	25	---

Survey Area (Sector)	Magnetic Anomalies						Results of Magnetic Analyses					Geology	
	Anomalous Area No.	Anomaly No.	Locality		Width (m)	Amplitude (nT)	Calculated Amp.(nT), K in 10^{-6}emu/cc units			Equiv. Thickness of Mineralized Zone(cm)	Estimated Magnetic Source	Formation and Intrusives	Mineral Indication No.
			Line No.	Station No.			K=500	K=2000	K=2500				
A	I	1	1	6	75	2520	190	770	960	35	Ore	Gr	
	II	2	3	12	200	830	250	1000	1250	10	Granite	Rw	
	III	3	7	8	200	1010	250	1000	1250	15	Granite	Rw	
	IV	4	10	13	130	760	230	900	1130	10	Granite	Rw	
	IV	5	10	7	200	590	250	1000	1250	10	Granite	Gr	
	IV	6	11	1	225	970	260	1030	1290	15	Granite	Gr	
	V	7	13	16	225	3180	260	1030	1290	45	Ore	Gr	3
	V	8	13	10	225	600	260	1030	1290	10	Granite (Ore?)	Gr	3
B	I	1	5	21	50	840	170	680	850	10	Diorite ?	Rw	
	I	2	5	16	50	390	170	680	850	5	Granite	Rw	
C	I	1	3	10	150	300	230	940	1170	4	Granite	Gr	
	I	2	5	5	150	300	230	940	1170	4	Granite	Rw	
	I	3	5	9	150	380	230	940	1170	5	Granite	Gr	
	I	4	6	5	125	840	220	900	1120	10	Granite	Rw	
	I	5	8	5	125	350	220	900	1120	5	Granite	Gr	
	II	6	16.5	16	50	1780	170	680	850	25	Ore	Gr	6
	II	7	17	10	150	600	230	940	1170	10	Granite	Rw	
	II	8	17	12	50	310	170	680	850	5	Granite	Rw	
	II	9	17	18	150	760	230	940	1170	10	Granite (Ore?)	Rw	6
	II	10	17.5	15	100	690	210	840	1050	10	Granite (Ore?)	Gr	6
	II	11	19	11	50	3190	170	680	850	45	Ore	Rw	6
	II	12	19	13	75	4170	190	770	960	60	Ore	Rw	6
	III	13	21.5	6	75	1900	190	770	960	25	Ore	Rw	7
	IV	14	24	9	75	710	190	770	960	10	Granite (Ore?)	Rw	8
	V	15	36	9	75	640	190	770	960	10	Granite (Ore?)	Rw	11
	V	16	37	9	75	2100	190	770	960	30	Ore	Gr	11
	VI	17	40	3	100	490	210	840	1050	5	Granite	Rw	
	VII	18	42	7	300	530	270	1090	1360	5	Granite	Rw	
D	--	--	--	--	---	---	---	---	---	--	---	Gr	
E	I	1	11	4	100	830	210	840	1050	10	Diorite	Di	
	I	2	12	8	100	700	210	840	1050	10	Diorite	Di	
	I	3	12	6	250	1430	260	1060	1320	20	Diorite	Di	
	I	4	14	4	225	720	260	1030	1290	10	Diorite	Di	
	I	5	15	3	225	1280	260	1030	1290	20	Diorite	Di	
	II	6	21	3	100	510	210	840	1050	5	Granite (Ore?)	Rw	16
	II	7	22	7	200	720	250	1000	1250	10	Granite (Ore?)	Rw	16
	III	8	27	10	75	430	190	770	960	5	Granite	Rw	
	III	9	27	13	75	400	190	770	960	5	Granite	Rw	
	III	10	27	16	75	500	190	770	960	5	Granite	Rw	
	III	11	28	12	100	760	210	840	1050	10	Granite	Gr	
	III	12	29	14	75	990	190	770	960	15	Diorite ? → Gr	Gr	
	IV	13	32	3	200	730	250	1000	1250	10	Granite	Rw	
	IV	14	33	2	100	1700	210	840	1050	25	Ore	Rw	
F	I	1	8	6	325	790	280	1100	1380	10	Granite ?	Rw	

Abbreviations
Gr: Granite and Granodiorite Di: Diorite Rw: S.Rawas Formation

Table 10 Results of magnetic anomaly analysis



LEGEND

(A) Detailed Survey Area
(No.) Mineralization of Mt + He + Sk (Massive ore)
(No.) Mineralization of Cp – Gn – Sp – Py – Mb (Vein)
(No.) Mineralization of Py, Po, Cp, Sp, Gn (Vein, diss.)
Old adit

Py	: Pyrite	Mb	: Molybdenum
Po	: Pyrrhotite	Mt	: Magnetite
Cp	: Chalcopyrite	He	: Hematite
Sp	: Sphalerite	Sk	: Skarn
Gn	: Galena	diss	: dissemination

C-V
Magnetic Anomalous Area

Fig. 13 Distribution map of magnetic anomalous areas and mineral indications