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

PHASE II

FEBRUARY 1987

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Republic of Indonesia, the Japanese Government decided to conduct a mineral exploration in Southern Sumatra Area and entrusted the survey to the Japan International Cooperation Agency. Considering its technical aspects, the Agency sought collaboration with 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 a counterpart to the Japanese team. The survey is being carried out jointly by experts of both Governments.

For the work 1986, the second phase, the Metal Mining Agency of Japan dispatched the survey team consisting of three geologists, a geophysicist and three drilling engineers to Indonesia during a period from July 6 to December 27, 1986.

This report summarized the results of the second phase, and also forms a part of the final report.

We wish to express our heartful gratitude to the agencies of the Republic of Indonesia and other autholities concerned for their kind cooperation and support to the Japanese survey team.

February, 1987

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Directorate General of Geology and Mineral Resources
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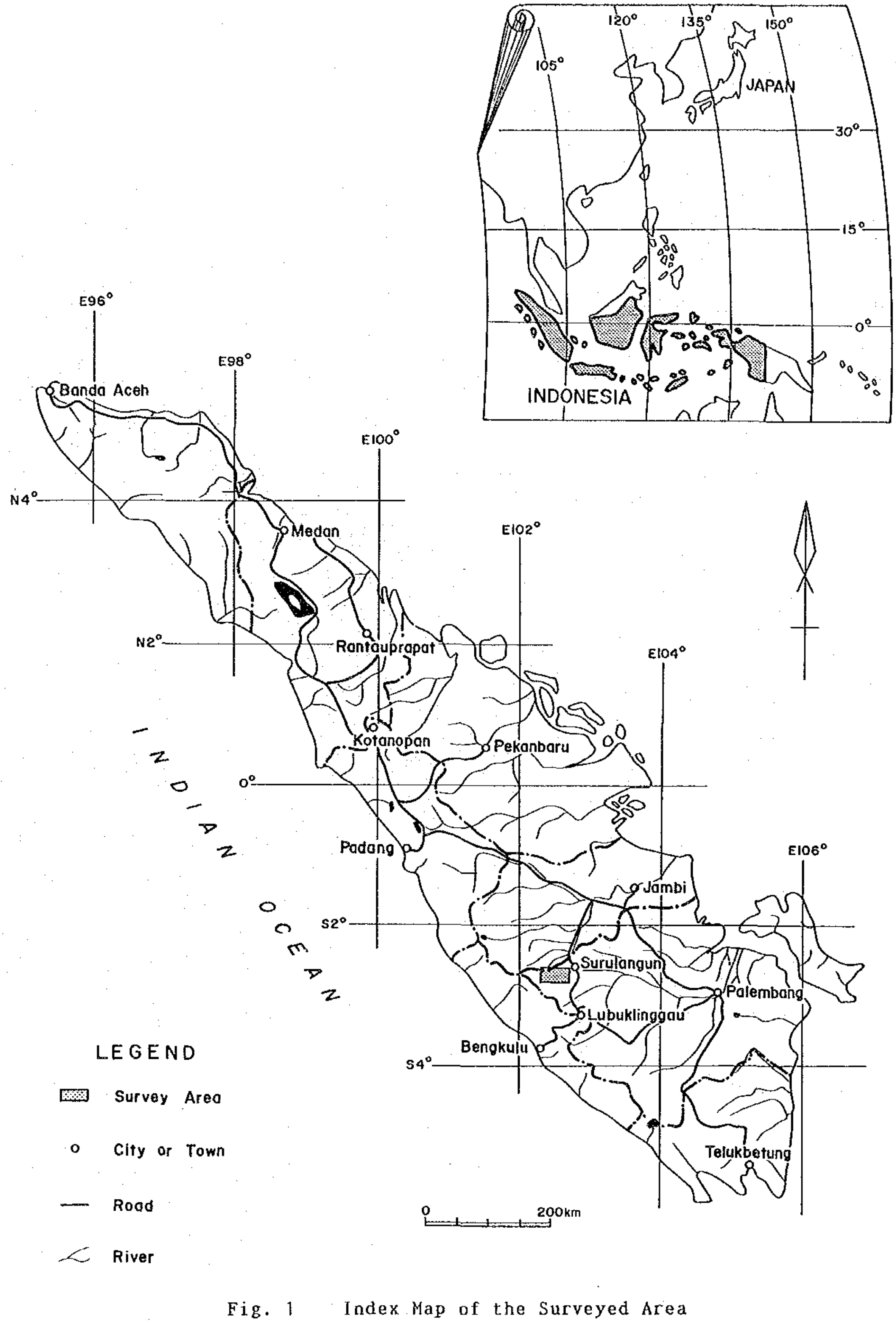

Fig. 1 Index Map of the Surveyed Area

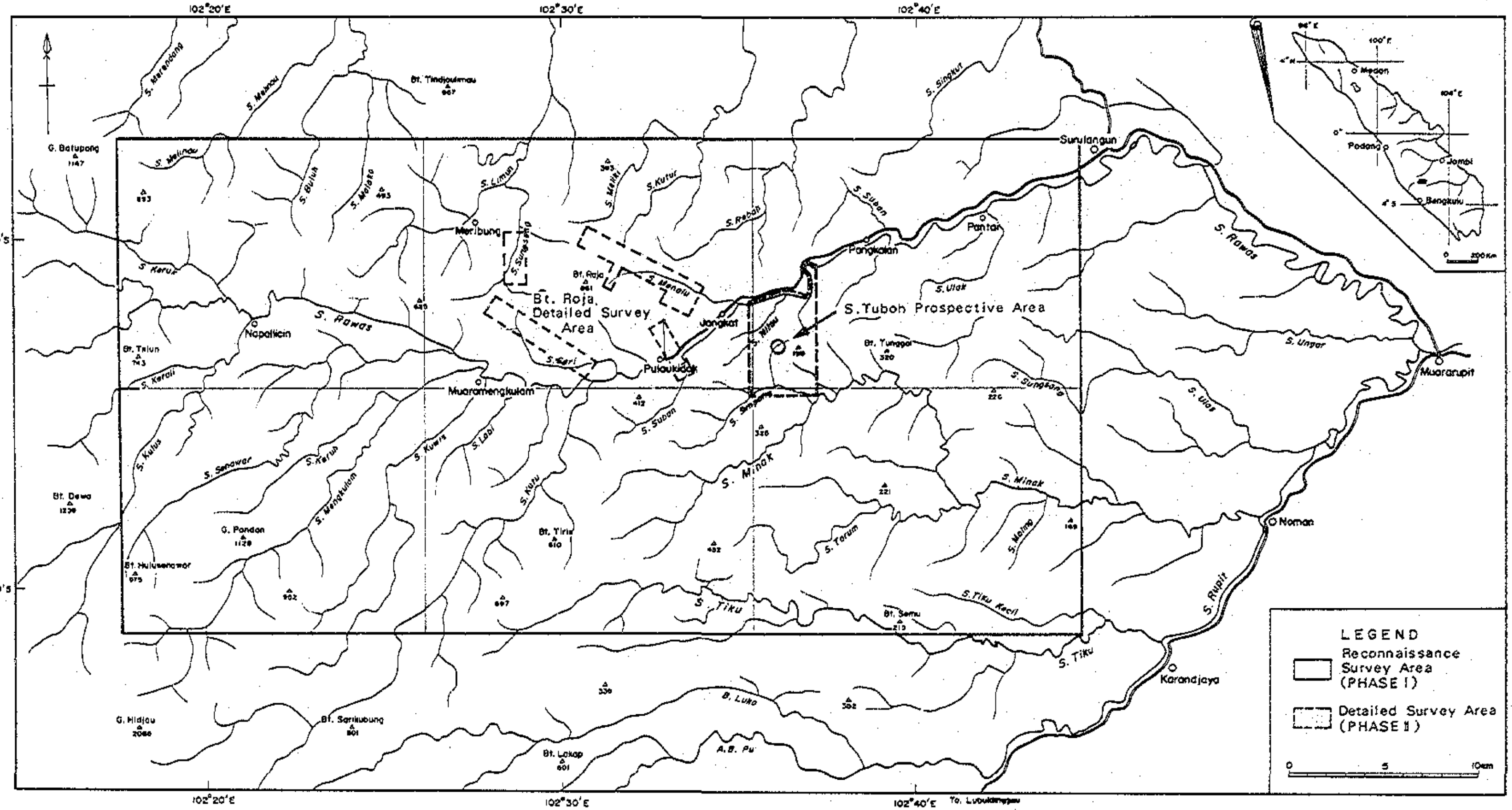

Fig. 2 Location Map of the Surveyed Area for Second Phase

SUMMARY

Within the framework of the Cooperative Mineral Exploration of Southern Sumatra, geological survey(22km^2), geophysical survey(ground magnetic survey 22km^2, 1,730 stations) and geochemical survey(22km^2, 1,619 samples) have been conducted in the Bt.Raja area, and drilling survey(10 holes, total 1,510.80m) was perfomed in the S.Tuboh area. The survey areas and methods were selected on the basis of the result of the initial phase survey.

The surveys suggest that in the Bt.Raja area there is porphyry copper type mineralization resulting from intrusion activity of Raja granites (60～50Ma), and in addition a skarn and a disseminated types are disstributed surrounding the former. It is noted that indications of the porphyry copper type deposit have been discovered in the area, even though it might be very low for an operative grade.

Skarn type mineralized zones accompanied by high-grade Ag, Zn, Pb, and Cu ores occur in 5 of 10 drill holes conducted in the S.Tuboh area. Particularly, two parallel mineralized zones exist,50m in distance, and the zones are expected to extend to strike and dip sides. The ore shoots of mineralized zones appear to be emplaced on the hanging wall or foot wall contact sides, or in both contact sides of small-seale intrusive rocks which strike NE-SW and dip steeply. At present, 7 mineralized zones are recognized in the area, provided that a mineralized zone ("ore zone") is in intrusive contact with the ore shoot.

Isotopic ratios of $^{87}Sr/^{86}Sr$ indicate that the mineralization of S.Tuboh has a genetic relationship to igneous activity which took place during a period from 60 to 50 Ma and successive hydrothermal activity. Metallic elements of the mineralized zone have been derived from the Mersip Limestone Member and correlative hprizon of the S.Rawas Formation. The ratios also suggest that the Mersip Limestone Member and the correlative horizon are Late Jurassic.

The intrusive rocks of the S.Tuboh area vary their rock facies, and the rocks accompanied by the ore shoots consist of alkali dolerite, trachyte, trachy andesite, trachy dolerite, basaltic trachy andesite, monzonite porphyry and so on. The intrusive rock bodies, being of large scale, are composed of quartz monzonite, quartz monzonite porphyry, gabbro and so on. The facts indicate that both rocks, namely small-scale and large-scale intrusive rocks, belong to alkali or alkali-calc rock series, and that they have been derived from a magma series. Accordingly, small-scale intrusive rocks are presumably shallow facies of the large-scale intrusive rock. The data of radiometric age determination of these rocks also support the facts.

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PART 1 INTRODUCTION

CHAPTER 1 OUTLINE OF THE SURVEY

1-1 Introduction

The second phase survey (1986), within the framework of the Cooperative Mineral Exploration of Southern Sumatra, has been conducted in accordance with the Scope of Works signed on August 31,1985 between the Japanese and the Indonesian Governments.

In this phase, geological, geochemical, geophysical and drilling surveys were conducted in two areas selected on the basis of the initial phase survey(1985) which consisted of geological and geochemical reconnaissance and detailed survey.

1-2 Survey Schedule and Survey Members

(1) Survey Period

The second phase survey was performed during a period from July 6 to December 27 ,1986, and Fig. 3 shows the entire survey schedule ;

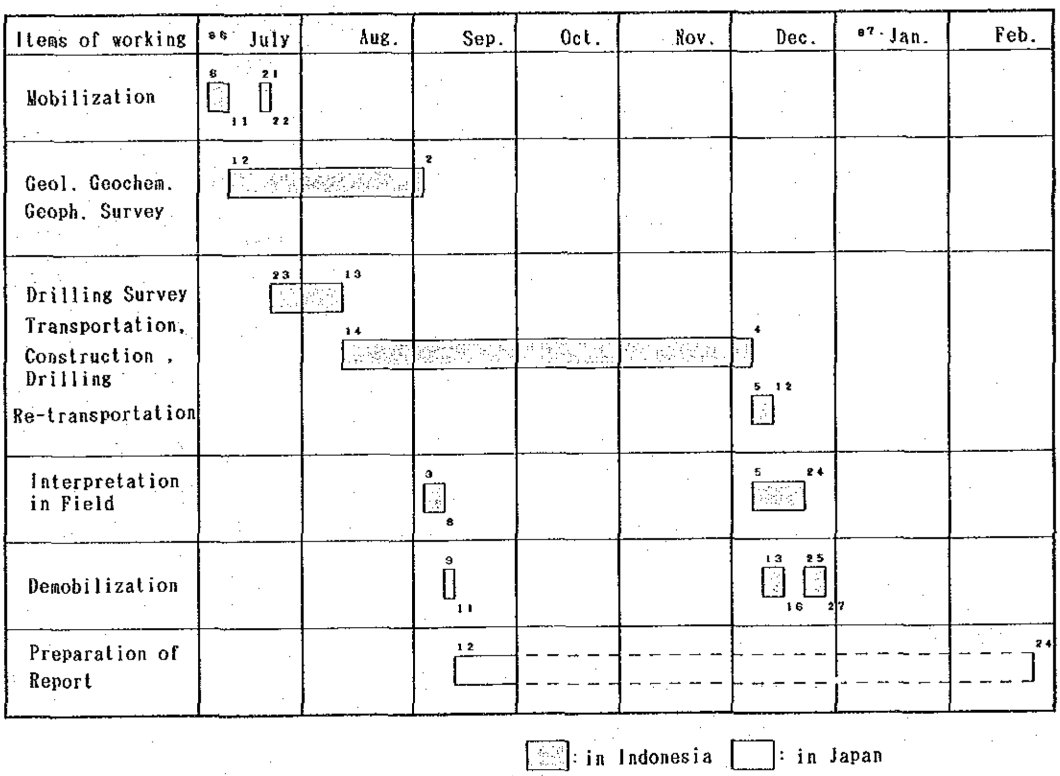


Fig. 3 Time Schedule of the Second Phase Survey

(2) Organization of the survey team

	Japanese Member		Indonesian Member	
Planning and Coordinating				
	Toshio Sakasegawa	(MMAJ)	Salman Padmanagara	(DMR)
	Michihisa Shimoda	(MMAJ)	J.Rainir Dhadar	(DMR)
	Atsushi Osame	(MMAJ)	Machali Mushin	(DMR)
Team leader				
	Yoitsu Oguma	(NED)	Sukirno DJaswadi (Coordinator)	(DMR)
Geological and geochemical surveys				
	Mitsuo Tadokoro	(NED)	B.Bandi	(DMR)
	Hideya Kikuchi	(NED)	Atok S.Prapto	(DMR)
Core logging				
	Yoitsu Oguma	(NED)	Subedjo	(DMR)
			R.Tatto Sudharto	(DMR)
Ground magnetic survey				
	Ikuo Takahashi	(NED)	Empon Ruswandi	(DMR)
			Hario Mustang	(DMR)
			Edi Kurnia	(DMR)
			Zulkifli Bugis	(DMR)
Drilling survey				
	Isamu Nakayama	(NED)	Antonius Harsono	
	Hatsuo Kumano	(NED)	Madtuhi	(DMR)
	Sohji Kannari	(NED)	Saksono	(DMR)
			Agus Mulyadi	(DMR)

MMAJ : Metal Mining Agency of Japan

DMR Directorate of Mineral Resources

NED Nikko Exploration and Development Co.Ltd.

1-3 Survey Area

The southern Sumatra project area is bounded by the following longitudes and latitudes, and covered 1,250 km^2.

Northern line : Latitude 2° 36′ south

Southern line : Latitude 2° 50′ south

East line : Longitude 102° 44′ east

West line : Longitude 102° 17′ east

The two survey areas, Bt.Raja Detailed Survey Area and S.Tuboh Prospective Area were selected as the targets of the second phase on the basis of the results of the initial phase, and they are called, respectively, the Bt Raja area and the S.Tuboh area in this report.

In the Bt.Raja area, six sectors(Sectors A,B,C,D,E,F), surrounding Bt.Raja (849 m above sea level) were set up for the detailed survey. The total area covers 22 km².

The S.Tuboh area is a small area along R.Tuboh 4 km south east of the Bt.Raja area, and sporadic mineral indications are distributed in the area(Fig.2).

1-4 Survey Method and Amount Conducted

In the Bt.Raja area, geological, geochemical and ground magnetic surveys were conducted in the six survey sectors, and in the S.Tuboh area, a drilling survey was performed, as shown in Table 1.

Table 1 Amount Conducted(1)

Bt.Raja Detailed Survey Area		S.Tuboh Prospective Area	
Content	Amount	Content	Amount
Geological survey	22 km²	Assaying	27 pcs
Number of soil sample	1,619 pcs	Rock thin section	16 pcs
Magnetic survey	22 Km²	Polished specimen	23 pcs
Measured point	1,730 points	X-Ray diff.	27 pcs
Rock thin section	13 pcs	EPMA	5 pcs
Polished specimen	15 pcs	Age determination	2 pcs
X-Ray diff.	19 pcs	$^{87}Sr/^{86}Sr$ Ratio	6 pcs
Age determination	2 pcs	Whole rock analysis	2 pcs
Whole rock analysis	10 pcs		
Assaying	16 pcs		
Geochemical analysis	1,619 pcs		
ICP analysis	200 pcs		

Table 1 Amount Conducted(2)

Name of drill hole	Planned length (m)	Conducted length (m)	Inclination (°)	Depth of surface soil (m)	Length of core (m)	Core recovery (%)	Terms of drilling work	
							Commenced	Terminated
MJI-7	150	150.20	-90	6.00	144.00	99.8	S.61. 8.28	S.61. 9. 4
MJI-8	150	151.00	-90	4.50	145.90	99.5	S.61. 9. 8	S.61. 9.13
MJI-5	150	151.00	-90	8.80	139.00	97.7	S.61. 9.23	S.61. 9.26
MJI-6	150	151.00	-90	6.20	144.70	100.0	S.61. 9.30	S.61.10. 4
MJI-4	150	152.40	-90	10.60	141.80	100.0	S.61.10. 7	S.61.10.11
MJI-3	150	151.00	-90	4.00	147.00	100.0	S.61.10.14	S.61.10.17
MJI-1	150	151.00	-90	4.40	140.50	95.8	S.61.10.26	S.61.10.29
MJI-2	150	151.00	-90	12.90	116.40	84.2	S.61.11. 5	S.61.11. 8
MJI-10	150	151.00	-90	15.00	122.80	90.3	S.61.11.18	S.61.11.21
MJI-9	150	151.20	-90	11.20	123.50	88.2	S.61.12. 1	S.61.12. 4
計	1500	1,510.80				95.5		

$$\text{Core recovery}(\%) = \frac{\text{Length of core}}{\text{Conducted length} - \text{Depth of surface soil}}$$

CHAPTER 2 OUTLINE OF THE PROJECT AREA

2-1 Geography

Topography, *stream system*, *climate*, *vegetation*, *transportation*, communication, industry and so on, in the southern Sumatra project area has been described in the initial phase report.

2-2 Previous Surveys and Explorations

BEMMELEN(1970) described and compiled comprehensively on the geology and mineral resources of the entire Sumatra Island. After the publication, geological maps of Sarolangun were compiled by Kartografi Direktorat Geologi(1977) and the Geological Research and Development Centre (1984), but both maps are under preparation for publication.

As for mineral resources, the oldest report by DIECKMAN(1917) described prospecting results in olden times, but most attached maps and figures are missing.

As recent prospecting work, an exploration report by Kennecot Indonesia(1971) and a geochemical prospecting report compiled for their internal report by the Directorate of Mineral Resources (1984) are available.

2-3 Geology and Ore Deposit

In accordance with the survey results of the initial phase, the geology and ore deposit of the project area are summarized as follows :

(1) Geology

A stratigraphic sequence of the project area consists of Jurassic-Cretaceous, Cretaceous, Neogene, and Quaternary systems. The Jurassic-Cretaceous System is divided into the S.Rawas Formation and S.Kuwis Formation in ascending order. The Formations are mainly exposed from the central part to the north part of the project area.

The lower half unit of the S.Rawas Formation is a pelitic flysh sediment facies, and yields flute casts, while the upper half unit consists of limestone, slate with andesitic pyroclastics, phyllite and sandstone. The limestone-predominant unit within the latter is called the Mersip Limestone Member. The sandstone facies is predominant in the upper most unit.

The S.Kuwis Formation mostly belongs to the Cretaceous System, and consists of sandstone, shale, slate, limestone, volcanics of basaltic and andesitic lavas and their pyroclastics. The Formation has undergone a lower-grade metamorphism than the S.Rawas Formation owing to the occurrence of weak schistosity and low a grade of recrystallization.

The Neogene System unconformably overlies the Jurasic-Cretaceous System, and is divided into the Napallicin, Hulusimpang and S.Minak Formations in ascending order.

The Napallicin Formation distributed in the west on marginal part of the project area is of soft sandstone accompanied by hyaloclastite.

The Hulusimpang Formation consists of andesitic pyroclastics in the lower part and dacitic pyroclastics(partly welded) and lavas in middle-upper part. The Formation is extensively exposed from the western to southern parts of the project area and has generally been subjected to regional hydrothermal alteration.

The S.Minak Formation is composed of mudstone, siltstone, sandstone, limestone and dacitic tuff, and accompanied by intercalated lignite in the near base horizon of the Formation. The Formation yields marine fauna fossils.

A Quaternary System is the Surulangun Formation distributed in the eastern marginal part of the project area. The main component of the Surulangun Formation is pale-yellow to pale-grayish pumice-tuff.

(2) Igneous Activities

Volcanic activities of andesite and basalt took place in the period from the S.Rawas age to the S.Kuwis age, basaltic activity during the Napallicin age and of andesitic and dacitic activities during a period from the Hulusimpang age to Surulangun age, in the Neogene and Quaternary respectively. The volcanic activity was probably the most violent during the period from the Hulusimpan age to Surulangun age.

Plutonic rocks of granite, granite porphyry, granodiorite, quartz diorite, diorite, quartz monzonite, and volcanic rocks of basalt, andesite, dacite related to before-mentioned volcanism occur in the project area.

The quartz diorite is mostly exposed along R.Rawas from Napallicin to Mengkulam, and southward. The quartz diorite has been dated as 83.6± 4.2 Ma by the K-Ar radiometric method.

At Bt.Raja and southward, granite, granite porphyry, granodiorite, and diorite have intruded, altering the sedimentary rocks to hornfels. The radiometric age determination by the K-Ar method indicates them to be 51.9± 2.7 Ma and 54.1± 2.7 Ma. (The result of the second phase survey indicates different activity ages of the intrusions , contrary to the above-mentioned considerations, and it will be mentioned in Chapter 2 of Part 2.)

Only a quartz diorite porphyry occurs at R.Rawas. It has intruded into the S.Rawas Formation, but the Formation has not undergone any thermal alteration by the intrusion.

The quartz monzonite is mainly exposed along R.Tuboh to the upper stream. K-Arradiometric age dating indicates it to be 40.1 ± 2.0 Ma.

A number of andesite intrusions are distributed in the S.Minak Formation in southeastern part of the project area. These intrusions form hills, running with same direction.

(3) Metamorphism

The main rocks faciesof the S.Rawas Formation are schistosed pelitic rock, composed of sericite, chlorite, plagioclase, and recrystallized limestone, and has been metamorphosed into green-schist facies.

On the other hand, biotite hornfels zones resulting from a plutonic rock intrusion occur around Bt.Raja, west and east of Pulaukidak, and at Jangkat and eastward.

(4) Geologic Structure

Geologic structure in the project area is characterized by tightly closed folding of NW-SE direction predominant particularly in the Mesozoic Group, and two fault systems of NW-SE and NE-SW directions crossed at right angles to each other. Folding structure is marked by an isoclinal fold and a synclinorium in the project area. The isoclinal fold is defined at the north part of the project area since upturned flute marks are observed on the bottom of a turbidite. The synclinorium is present around Bt.Raja, plunging southeast, and running with its axis within the Mersip limestone Member.

Faults are extensively distributed in the adjacent area of Napallicin, and in the area from Bt.Raja to S.Tuboh. Two systems of faults, namely a NW-SE fault and a NE-WS fault co-exist in the area from the southeast of Bt.Raja to S.Tuboh, and these faults presumably involved an emplacement of plutonic igneous activity and a forming of plutonic rock.

The andesite intrusive rocks are sporadically distributed along lines of NW-SE direction or NE-SW direction, and it reveals that one or both of the two fault systems probably participated in the emplacement and intrusion of the andesite.

(5) Mineralization

Forty-nine mineral indications have been listed by the initial phase survey in the whole.of South Sumatra Area Among them, 15 indications are closely distributed at Bt.Raja and to the southeast, and also 10 indications downstream of R.Senawar, and 3 indications in an area from R.Tuboh to the north.

The indications related to skarn type occur at 8 locations, namely 5 locations around Bt.Raja and 3 locations at and north of R.Tuboh. Others indicate a silicification zone accompanyied by weakly disseminated pyrite or pyrrhotite. Of the 8 skarn type indications, the S.Tuboh indication has the highest grade of Pb,Zn and Cu, is distributed in an exploitable zone, and also is in a favourable geological setting for a skarn type deposit.

Although no worked deposit from previous mining activity is present in the project area, old pittings and tunnels for prospecting exist in the 5 indications of S.Tuboh, S.Kering, S.Sepan, S.Pedan, and S.Suban. All prospectings may have been carried out in 1910's.

PART 2 SURVEY OF BT.RAJA AREA

PART 2 SURVEY OF Bt.RAJA AREA

CHAPTER 1 OUTLINE OF SURVEY

1-1 Survey Area and Survey Method

Six sectors(A, B, C, D, E, F) were chosen as survey targets in the Bt.Raja area for the second phase. These sectors include the 15 mineral indications found through the initial phase survey.

Traverse lines, each 1,000m long and with intervals at 200 m, were set up, in these sectors. Soil samples were collected every 100m or 50 m in distance along the traverse lines depending upon mineralization conditions. A ground magnetic survey was conducted along the traverse lines. A geological survey was also carried out, tracing lines parallel with soil sampling.

All traverse lines and tie lines were set up by slashing trees and grasses because of heavy dense forest cover.

1-2 Outline of Geology and Mineralization

In the Bt.Raja area, Raja granite consisting of granite, granodiorite, granite porphyry have intruded in the axial part of the synclinorium extending NW-SE, and plunging SE. Sedimentary rocks are composed of biotite-hornfels of pelitic-psammitic rock and recrystallized limestone. These rocks have undergone thermal alteration by the granite intrusion. The strata is correlative with middle to upper S.Rawas Formation, and is presumably regarded as a thinning out of the Mersip Limestone Member branching into many thin beds toward the southeast.

Twenty mineral indications are embedded in the sedimentary rocks and Raja granite. Among them, 5 mineral indications are related to a skarn type deposit, and consist of a mineral assemblage of magnetite, hematite and garnet. An indication at S.Menalu is of films accompanied by molybdenite,and chalcopyrite, and pyrite, and an indication at S.Pangi is of garnet bearing veinlets with minute amounts of pyrite.

The other 3 indications are silicification accompanied by pyrite and pyrrhotite. The S.Pedan showing was indicated only by hematite-boulders, but a old tunnel is present in the Raja granites adjacent to the indication.

CHAPTER 2 GEOLOGICAL SURVEY

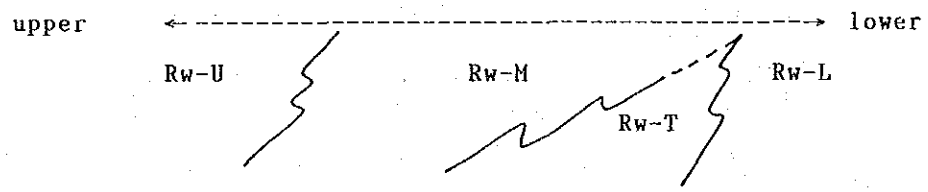
2-1 Outline of the Survey

From the point of view that most mineral indications in the Raja area are of skarn type, two objectives were targeted for investigation in this survey. Namely, the first, to clarify sedimentary condition and scale of calcareous rocks which are most favorable for emplacement of skarn ore deposit, and the second to classify theRaja granites into several intrusive forms and determine their intrusion age in order to specify a granite type having the closest relationship to the mineralization Fig. 4, Fig. 5 As the result, the investigation has obtained the expected information as follows;

2-2 Geologic Setting

Results on general geology are consistent with previous information in that the geology in the area consists of the S.Rawas Formation and Raja granites intruding into the Formation. However, this survey revealed that the S.Rawas Formation is divisable into more detailed members, and identified variations of their rock facies. Also, Raja granites are clarified in detail as to their constitution as will be mentioned next below.

The S.Rawas Formation around Bt.Raja is divided into 3 members and a transition member on the basis of the Mersip Limestone Member ; namely Rw-L, Rw-M, Rw-U in ascending order, and Rw-T as transition member between Rw-L and Rw-M, as shown below :



Rw-L : The member is of pelitic and psammitic flysh facies, and is distributed at the northeastern part and the southeastern part of the Bt.Raja area.

Rw-M : The Member is represented by the Mersip Limestone Member, but is branched into a number of thin beds at the southeastern part, and intercalates beds of rock facies like

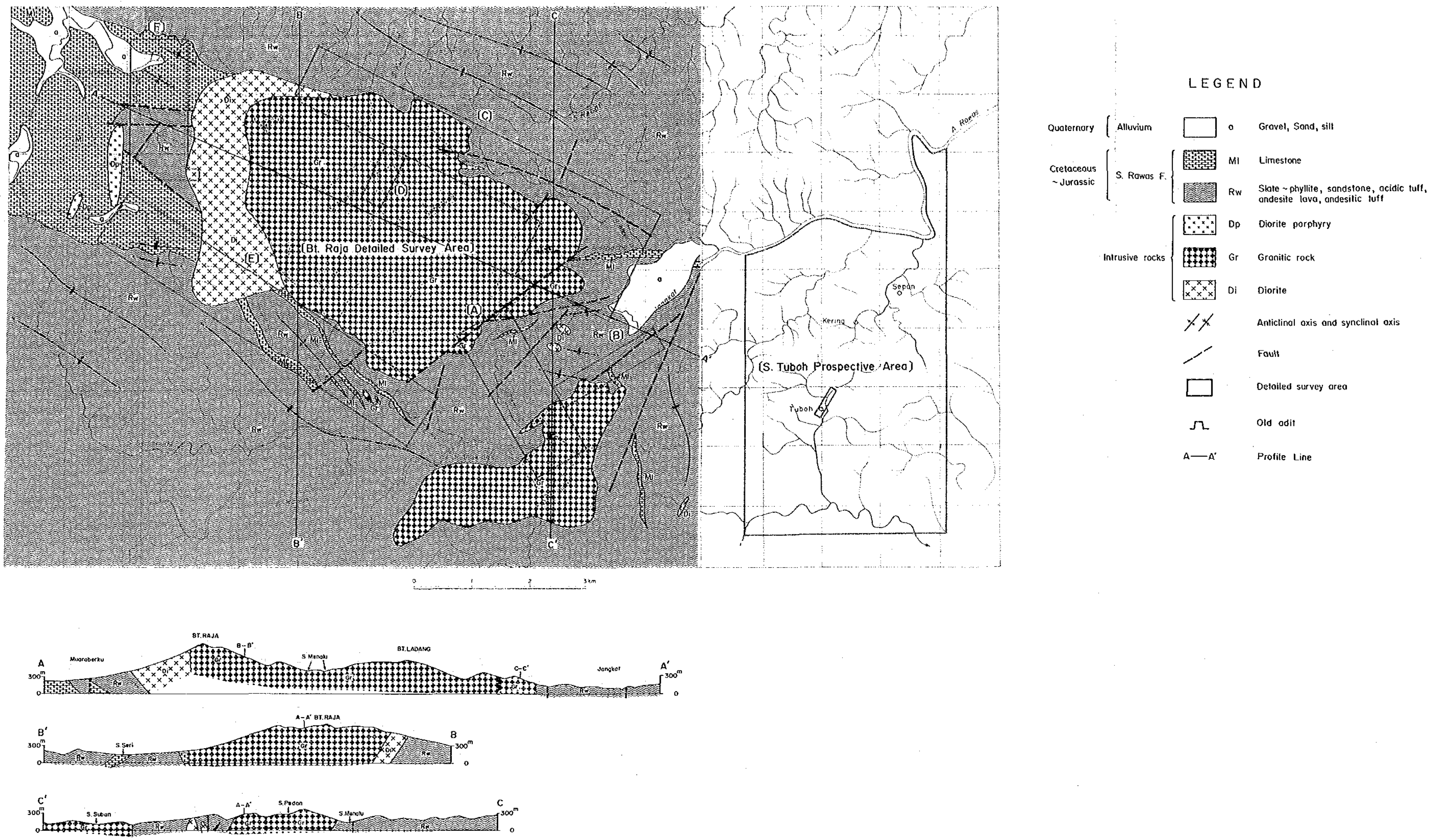
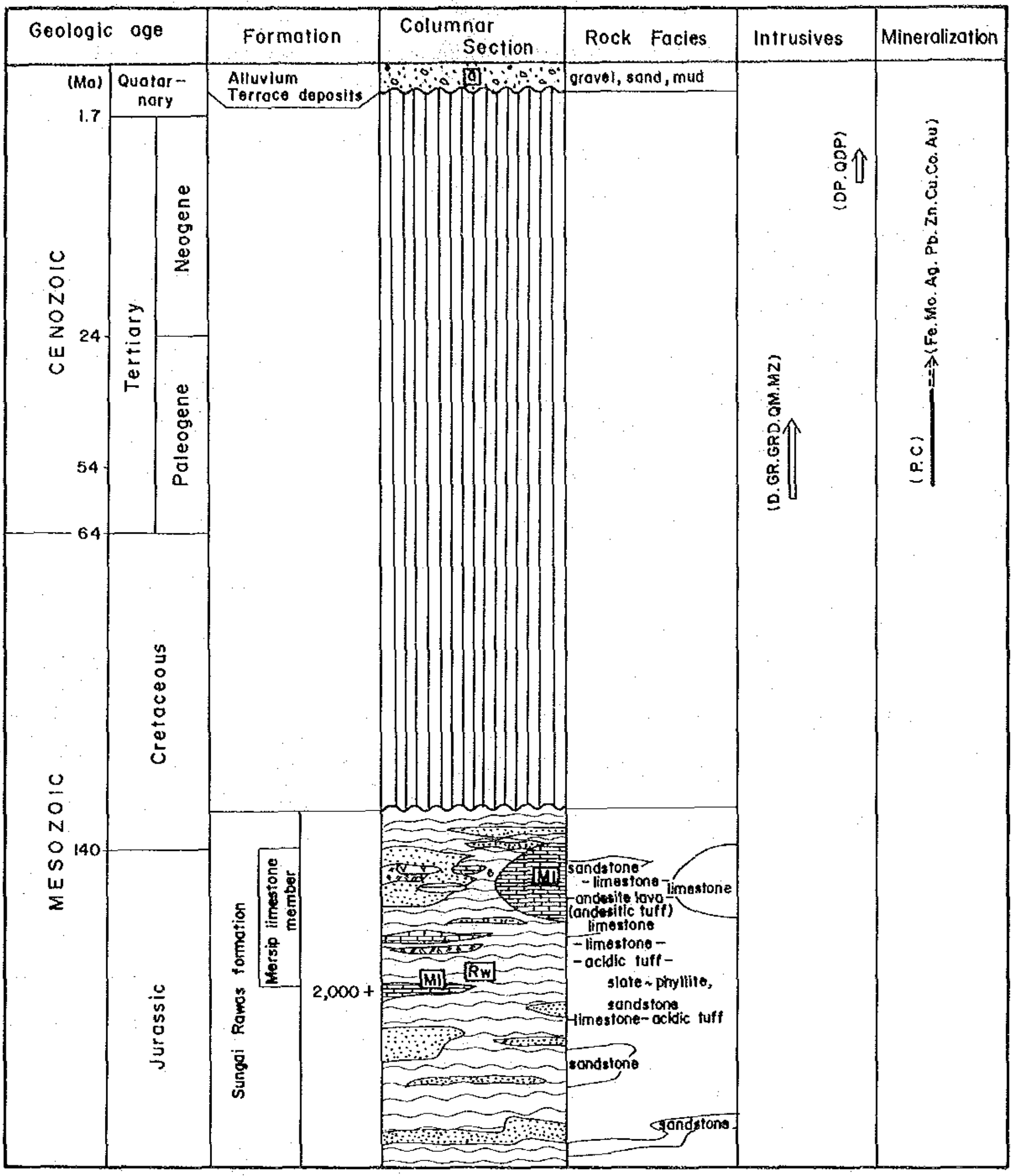


Fig. 4 Geological Map and Profile of Bt. Raja Detailed Survey Area



P.C : Porphyry copper type
QDP : Quartz diorite-porphyry
DP : Diorite - porphyry
GR : Granite
GD : Granodiorite
D : Diorite

Fig. 5 Schematic Geologic Column of Bt. Raja Detailed Survey Area

Rw-L, Rw-T, and Rw-U.

Rw-U : The member consists of sandstone-predominant slate and fine-grained sandstone, and is distributed around the R.Rawas from Pulaukidak to Jangkat

Rw-T : The member is characterized by calcareous facies contained tuffaceous, pelitic and psammitic components. In some places, a thin bed of basalt lava is interclated in the Member.

Raja granite have intruded into Rw-L and Rw-U, but thermal metamorphism is recognized commonly in Rw-M and Rw-U.
As mentioned above, the limestone, which is generally the most reactive host rock to be altered to skarn, rapidly thins to the southeast part,or limestone beds are reduced to very thin layers.

2-3 Intrusive Rocks

The intrusive rocks in Bt.Raja area are divided into various rock facies, namely granite, granodiorite, diorite, diorite porphyry, (quartz)monzonite, granite porphyry and so on, and the former three are the main component facies, distributed extensively in Bt.Raja. They are divisible into three facies as follows, by taking into account their age determination and occurrence :

i) Diorite : The diorite is a component rock of the Raja granites along with granite-granodiorite mentioned next as ii), but is an older intrusive than the latter, considering its occurrence. A radiometric age determination of the rock (BR-9) by means of the K-Ar method indicates the diorite to be 57.8$\pm$ 2.9Ma. It is classified to St-1E, based on the intrusive stage.

ii) Granite-granodiorite : The rocks occur extensively in the central part of the Bt. Raja area, and from southeast Pulaukidak to middle stream of R.Suban. The rock is of various coloured facies from white to dark black, but most of the rock is a pinkish granite. The rocks are composed mainly of granite and granodiorite, and granite porphyry, diorite, monzonite, and aplite occur in part. The granodiorite is presumably a marginal facies of the granite, and granite porphyry and diorite facies are also recognized in the part. Aplite dykes of 2cm～5cm in width cut the granites.

The granite rock body southeast of Pulaukidak has undergone pyrite dissemination, and decolourized and argillized sericite alteration in part. It is noticed that the rock body is of monzonite(or quartz monzonite) at its marginal part, and whole rock analysis indicates that the part belongs clearly in the alkali rock series.

The radiometric determinations by K-Ar method indicate age of the rocks as follows ;

AR-126	:	55.7± 2.8Ma (Bt.Raja)
BR-98	:	54.1± 2.7Ma (Bt.Raja)
85AR-14※	:	51.9± 2.6Ma (southeast of Pulaukidak)

According to the data, AR-126 and BR-98 seem to be older than 85AR-14, but the 51.4 Ma of 85AR-14 could be affected by rejuvenation, supposing from the fact that the rock has been somewhat altered. Therefore, the three rocks are not significantly different from each other, and are grouped into the St-1L stage.

The Raja granites are namely of two stages, an earlier stage St-1E, and a later stage St-1L, and consist presumably of poly-facies series.

iii) Diorite porphyry : The rock is exposed as two small rock bodies extending N-S at the northwest margin of the Bt.Raja area. It is inferred that the rock is close in age and lithologic features with the (quartz) diorite porphyry in the northeast margin of the detailed survey area conducted in the initial phase. The diorite porphyry is divided into St-2.

(※ 85 means sample taken in initial phase)

The relationship of these intrusive rocks in the Bt.Raja area are summarized as follows :

St-1 | St-2
St-1E | St-1L |
Diorite | Granite(Granodiorite) Monzonite | Diorite Porphyry
(60~ 57Ma) | (57~ 50Ma) (Rejuvenation by alteration) | (Neogene)

Raja Granites

These Raja granites are divided into alkali rock series, alkali-calc rock series, calc-alkali rock series, and calc rock series plotted on a ternary figure of $SiO_2 \cdot Na_2O+K_2O$. It shows the rock body is of poly-facies series, and it may be inferred that the Raja granites have been formed by processes of not only differentiation but also contamination. This matter is discussed in part 3.

2-4 Metamorphism

The hornfels metamorphism occur clearly in the rocks of the Bt. Raja area, particularly in the Rw-M and Rw-U Members. Schistose planes formed in these rocks through regional metamorphism were extinguished during the hornfels metamorphism, and the rocks generally have become massive.

The hornfels metamorphism has yielded so-called biotite hornfels, and granoblastic sandstone recrystalized its component grains to coarser.

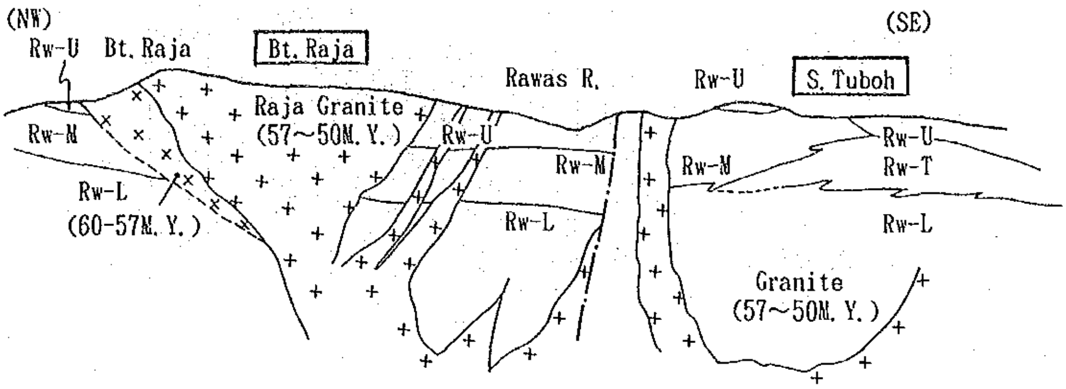
2-5 Geologic Structure

The Bt.Raja area is located in an area of the synclinorium, running with a NW-SE axis, and plunging southeast. The Mersip Limestone Member and Raja granites intruding into the Member occupy the axial part of the synclinorium.

The synclinorium structure has been cut by a fault running NE-SW along R.Rawas at its southeast extention. The southeast block was relatively uplifted. The movement caused the Mersip Limstone Member and its lower

Member, namely Rw-M,Rw-L and Rw-T, to be exposed at the S.Tuboh area.

The generalized structural profile is shown as follows :



On the basis of distribution, emplacement position and form of the Raja Granites, it may be inferred that the following geologic structural factors led to granitic activities :

1) Forming of a deep fracture in the NW-SE system. The folding structure could also have been caused by the fracture.

2) Tectonic stress caused by forming of the folding structure of NW-SE axis plunging southeast.

3) Forming of a deep fracture in the NE-SW system

The diorite ascended the deep fracture of the NW-SE system and intruded along the folding axis. It seems to be concordantly emplaced controlled by the folding structure. Later, vigorous intrusive activity took place at the junction of the two fracture systems, and most Raja granites seem to have been emplaced at that time.

2-6 Mineralization

(1) Outline

Twenty mineral indications have been confirmed in the Bt.Raya area through the initial and second phase surveys. Among them, 10 indications were newly discovered by the second phase survey, and known indications were also confirmed in detail as to their emplacement area, feature and mineral

Table 2 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.Menaru)	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

constitution. The survey results of the indications are listed in Table 2, and their locations are shown in Fig.4, and Fig. 6.

As shown the Table 2, the 9 indications consist of magnetite accompanied with skarns, and hematite, pyrrhotite or pyrite occur in some indications. As a result of this fact, it is concluded that the Mineralization in the Bt.Raja area have been formed as iron-skarn mineralization, and scarecely contain Cu, Pb, Zn, Au and Ag.

(2) Mineral Indications

Weak-mineralized pyrite disseminations are also included in 20 mineral indications mentioned in Table 3. Thus only noticeable mineral indications are explained as follows, omitting the weak pyritization.

① S.Suban mineral indication (3) : Sector A

The indication is located at confluence of R.Rawas and R.Seban, confirmed by the initial phase survey. Four outcrops are confirmed in the indication, continueing along N 25° E direction, as showing in Fig.7. The outcrop of left bank of R.Seban, 40 m upper stream of the confluence, is of garnet skarn with hematite and magnetite. The outcrop might have been prospected by tunneling or trenching, as shown in sketch of Fig.8. In R.Rawas, an outcrop used to be exposed at low water level time during dry season, and it consists of magnetite-disseminated garnet skarn. Another magnetite bearing skarn was found at left bank northwest of above mentioned outcrop. A hematite and a magnetite and scarce pyrrohtite are megascopically observed in ores of these indications.

② S.Betung mineral indication (6) : Sector C

The indication is emplaced in the S.Rawas Formation, near the northeast marginal part of the central part of the Raja granites. It is confirmed by the present survey that magnetite boulders are scattered in a area of east-west 750m and south-east 250m from valley to hill flank.

The indication consists of following two outcrops.

i) A skarn body croped out with scale of 7 m width and 2 m height at right bank, 350m upstream of R.Betung. It is of garnet skarn accompanied quartz fine veins of 1.0cm~1.5cm in thickness with specularite.

ii) Reddish-brown weathered rock with limonite-specularite at confluence of R.Betung

③ S.Padan mineral indication [11] : Sector C

Massive ores are distributed in a area of east-west 400m and south-north 100m, elevating from 250m to 350 m above sea level at 1.5 km upper stream of R.Padan. There are several old prospecting places such as tunnels, trenches and pits as shown in Fig.9 Three massive ore blocks of 10m × 5m × 4m, consisting of hematite and a small amount of magnetite occur, burying in soil at left bank of R.Padan, higher from 500m above sea level. The old prospecting site is located at the outcrop area, but most old trenches and pits are covered surface soil. Geological sketching in the old tunnel drifted 10 m below the ore block, though it is filled by water in some part, indicates that two veins occurr in weathered Raja granites as shown in Fig.10.

A clay vein disseminated a few amount of limonite in 5cm ~ 10 cm wide exposes at 6m from tunnel, and strikes E-W with 70° N dip. Another clay vein , 5cm~ 20cm wide, occurs at 20m from entrance of tunnel,and it strikes N78° NE with 78° NE dip. Inside the vein, pyrite vein is embedded with 5~ 10cm, but no other ore mineral is megascopically observable. Fig.11 is sketch map of old trench near massive ore at right bank of R.Padan, situating at 300 m above sea level.

④ S.Menalu mineral indication [12] : Sector D

Quartz veinlets occur at outcrop in R.Menalu, elevating from 300m to 400m. The indication is located at northeast margin of Raja granites, and is emplaced in joints of the granite as thin quartz veinlets of 0.1~ 0.3cm disseminated chalcopyrite, pyrite, sphalerite, galena and molybdenite. The quartz veinlets exposed in the river are remarkably emplaced in joints, striking N60° ~ 80° W, but their occurrence is not densely. A button shaped (1 cm Φ) crystal of molybdenite is present in quartz vein(2cm wide) in boulder covering the bed of the river..

⑤ S.Seri mineral indication [16] : Sector E

The mineral indication has been newly discovered through the present

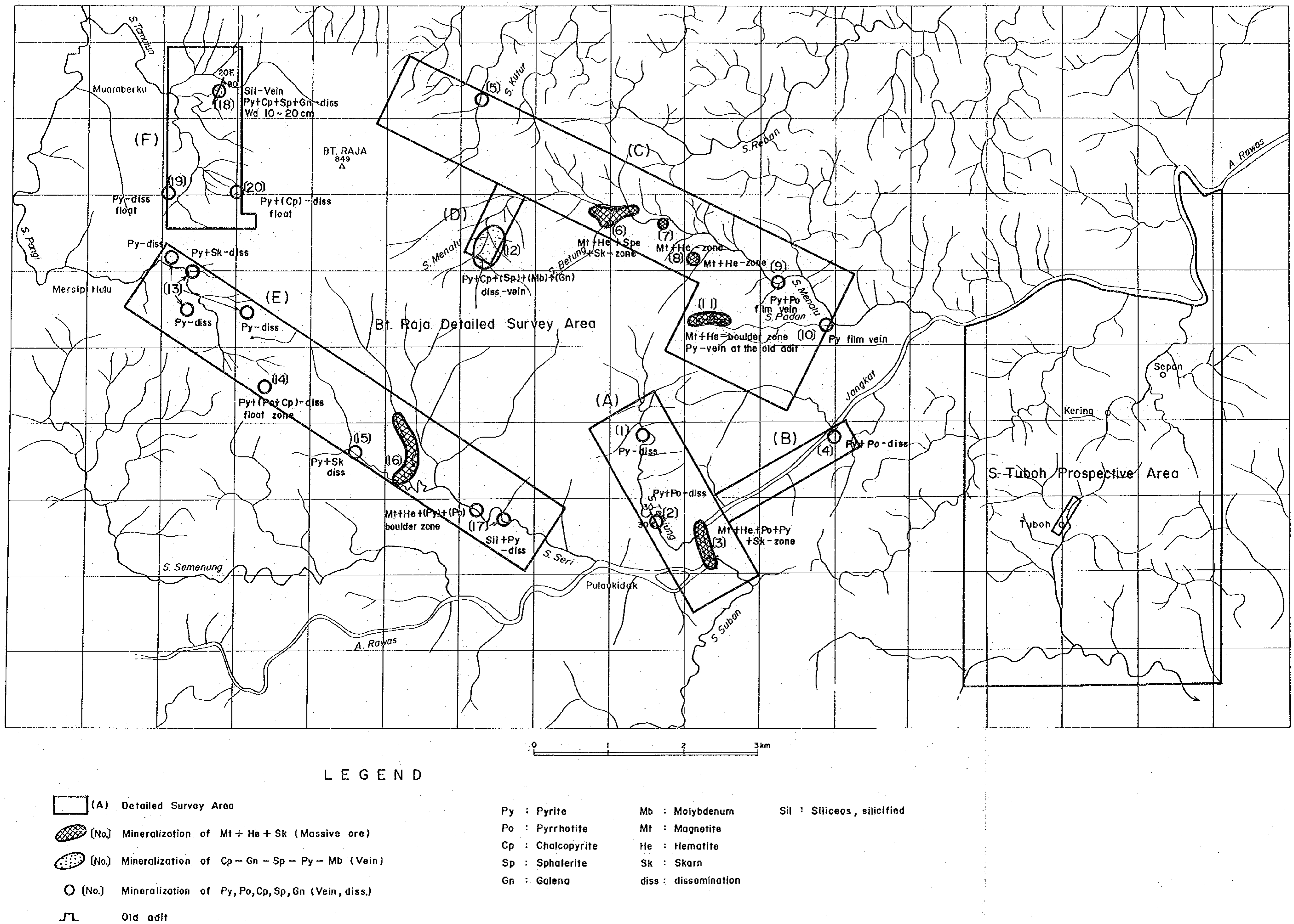


Fig. 6 Distribution Map of the Mineral Indications in Bt. Raja Detailed Survey Area

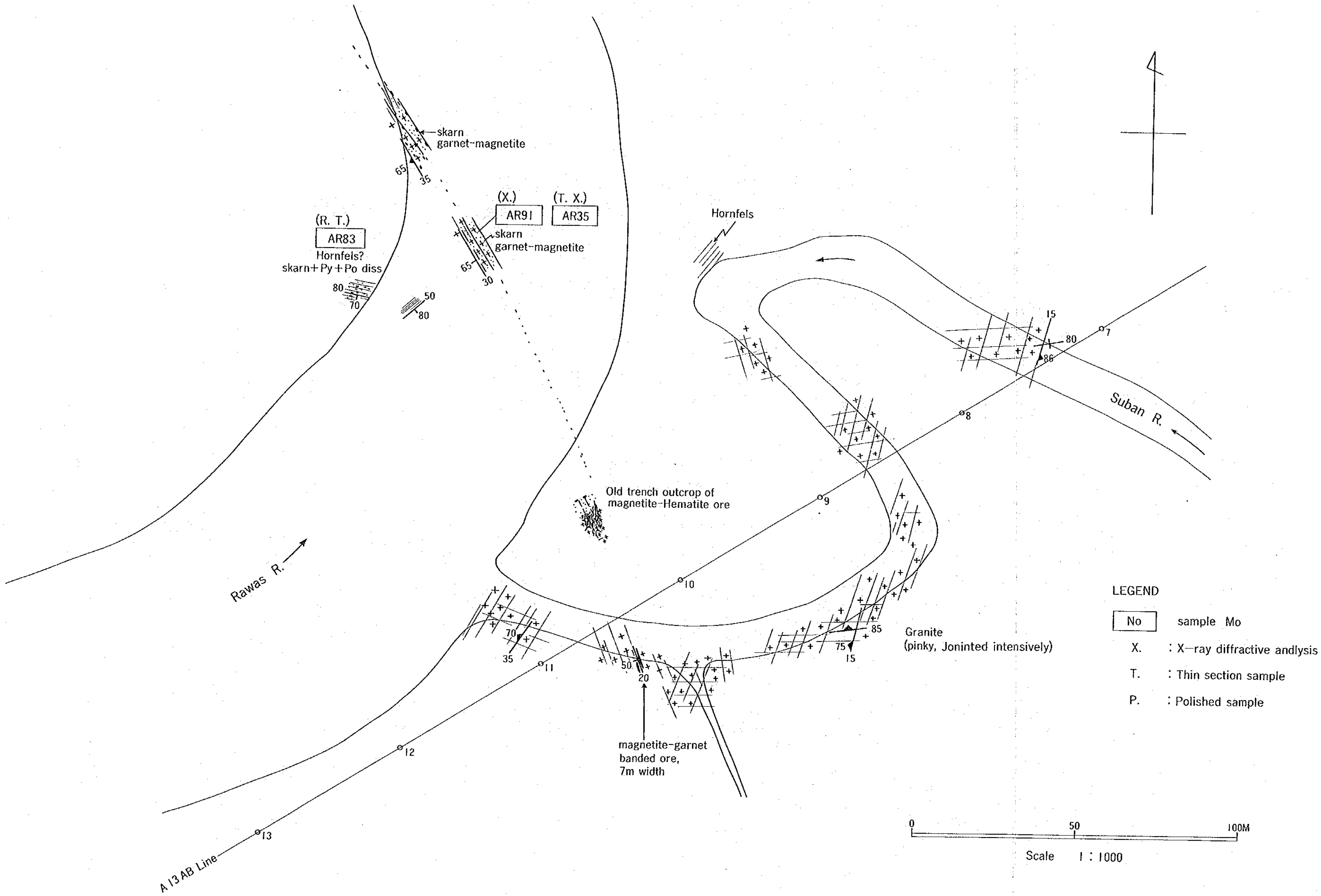


Fig. 7 Distribution Map of S.Suban Mineral Indications

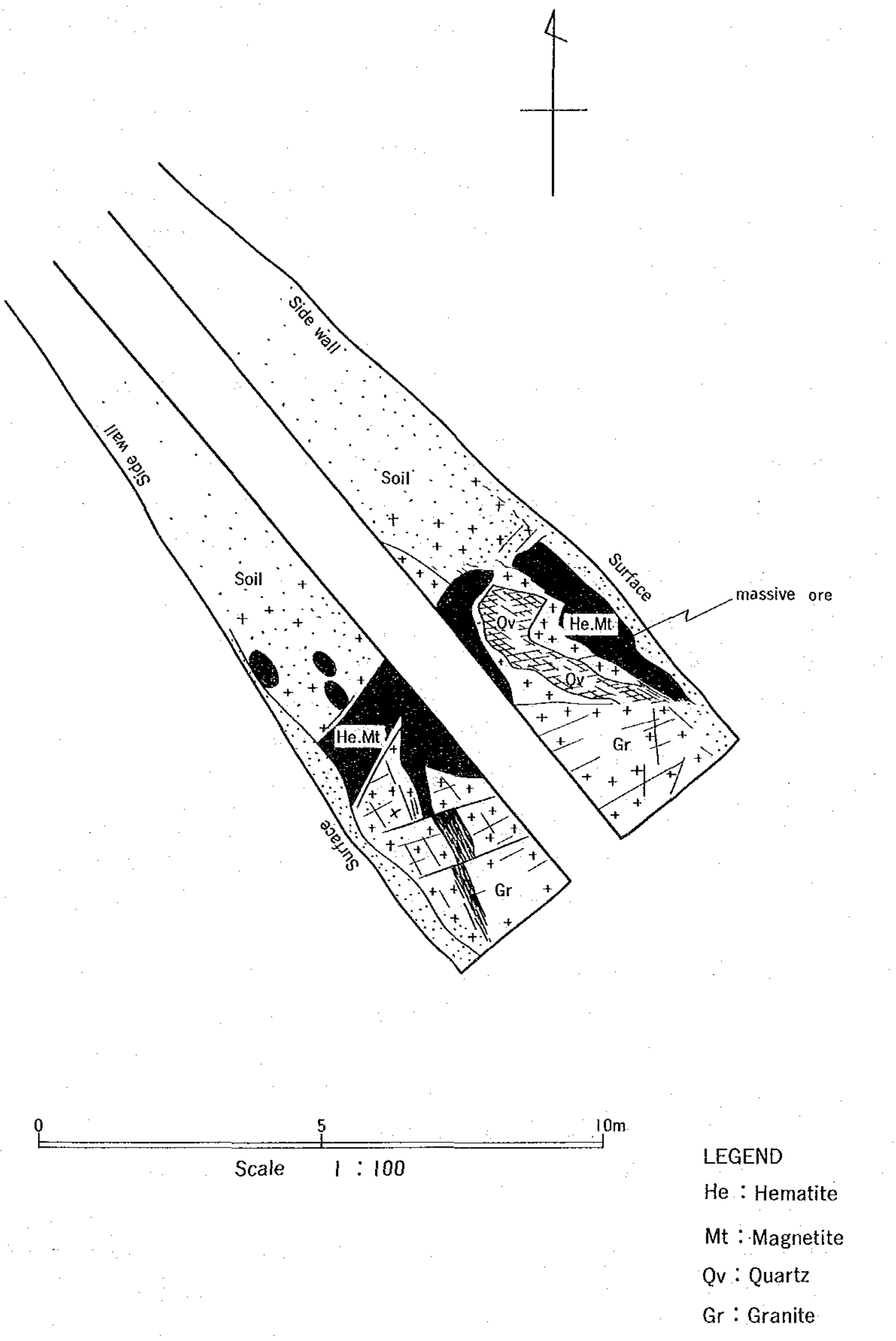


Fig. 8 Sketch of Ore Occurrence in Old Trench, S.Suban Mineral Indication

survey. Boulders of massive ore are distributed in south-north 700m long and 50 m wide. *Massive ores compose of mainly hematite, and assemblage of* magnetite- pyrrhotite-pyrite are visible. These ore boulders exist in surface soil, and are not in definite occurrencee. The boulders range generally from 0.2m to 0.3m, except some largest boulder of 3.5 m in diameter. The bouldrs are distributed in poorer density than that of other indications such 6 and 11.

⑥ S.Pangi mineral indication(14) : Sector E

The mineral indication has been newly confirmed on the hill flank at upper most stream of R.Pangi, elevating at 400m～450m above sea level. Pyrrhotite bearing ore boulders are distributed in small area of south edge of diorite(the Raja granites member) ranging from 50m × 50m. Dark greenish diorite boulders range from 1m to 3 m in diameter and contain mainly pyrrhotite with association of a small amount of pyrite and chalcopyrite.

⑦ S.Tamulan mineral indication (18) : Sector F

The mineral indication has been newly discovered at plain part of norhteast tributary of R.Tamulan. The around area consists predominantly of Mersip Limestone Member.The quartz veins are embedded in the limestone, and strike N 20° W with 80 ° dip. Filmy ore of chalcopyrite-spharelite-galena-pyrite and a few amount of molybdenite accompany the quartz veins. Garnet skarn films are observed at the margin of vein.

(3) Mineralization and igneous activity

As mentioned in section 3, the igneous activity (intrusion activity) took placed in the Bt. Raja area have had a relation with the activity of the Raja granites, particularly very close relation with its later stage (St-1L).

Following facts are observed in the Bt.Raja area on the relation shipbetween mineral indications and Raja granites.

i) Among these mineral indication, pyrrhotite dissemination usually occur around diorite(St-1E) intrusions. The diorite have undergone usually metamorphysm or alteration caused presumably by intrusion of St-1L granite.

ii) Magnetite or hematite bearing skarn zones are emplaced at distribution

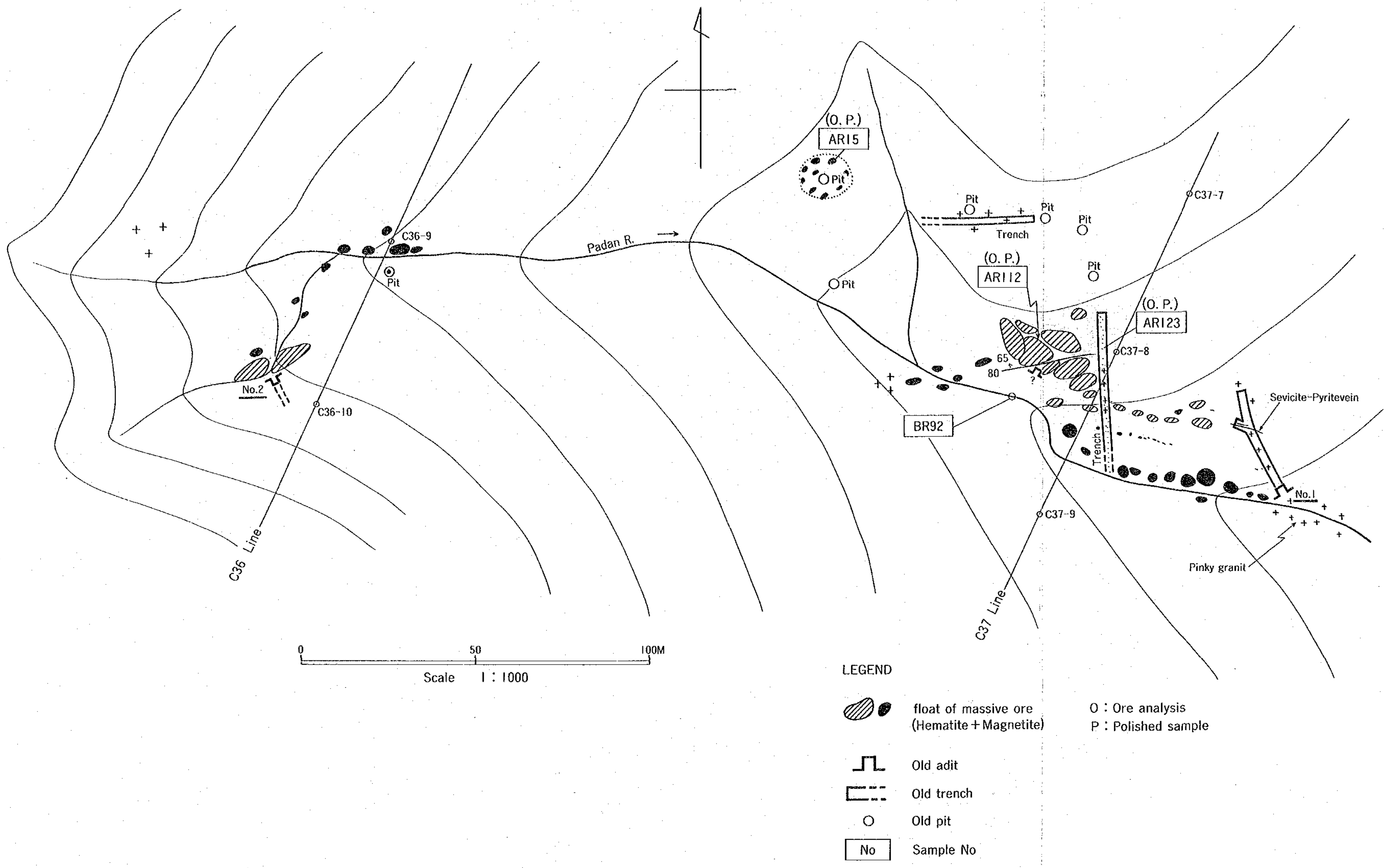


Fig. 9 Distribution Map of S.Padan Mineral Indications

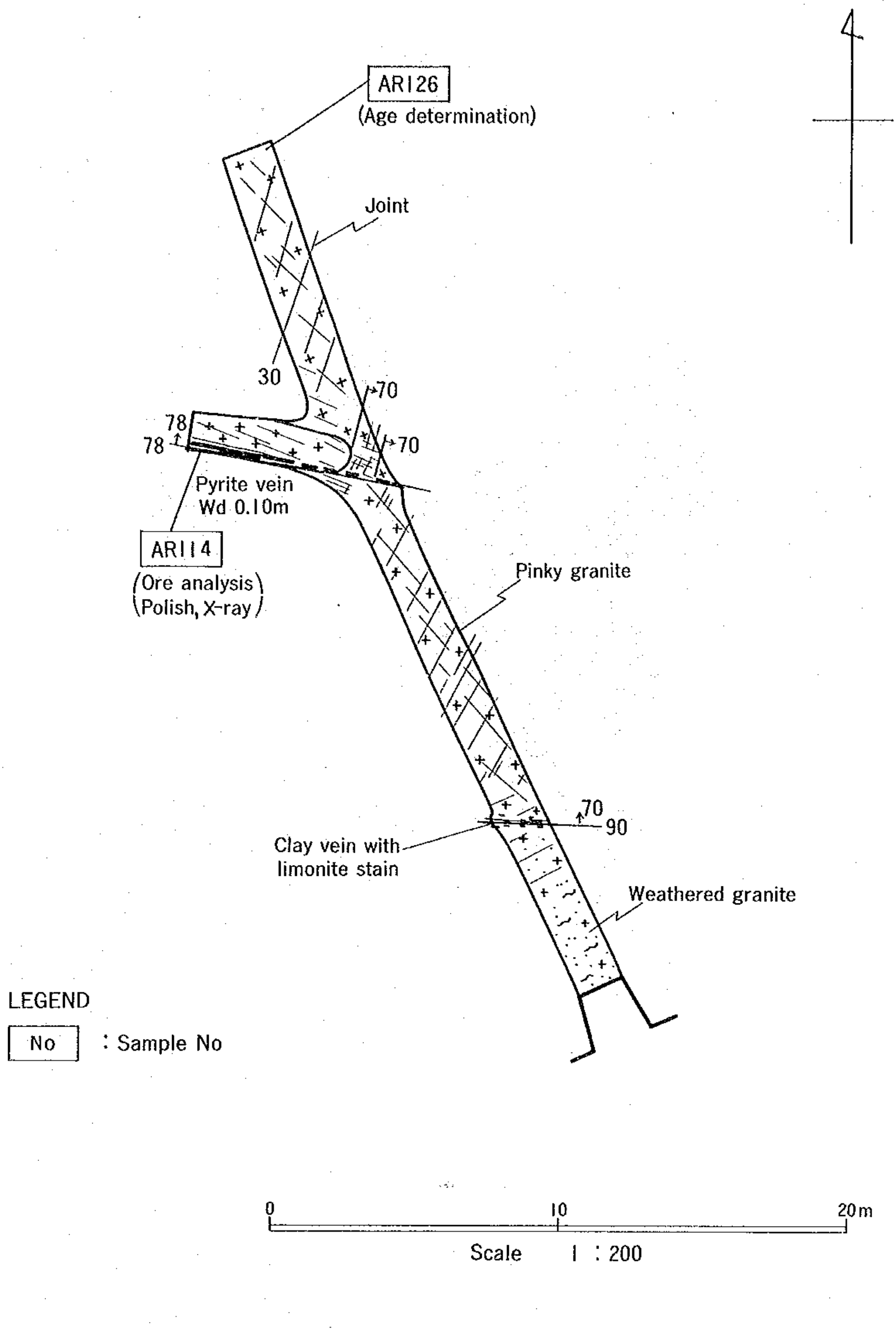


Fig.10 Sketch of an Old Tunnel, S.Padan Mineral Indication

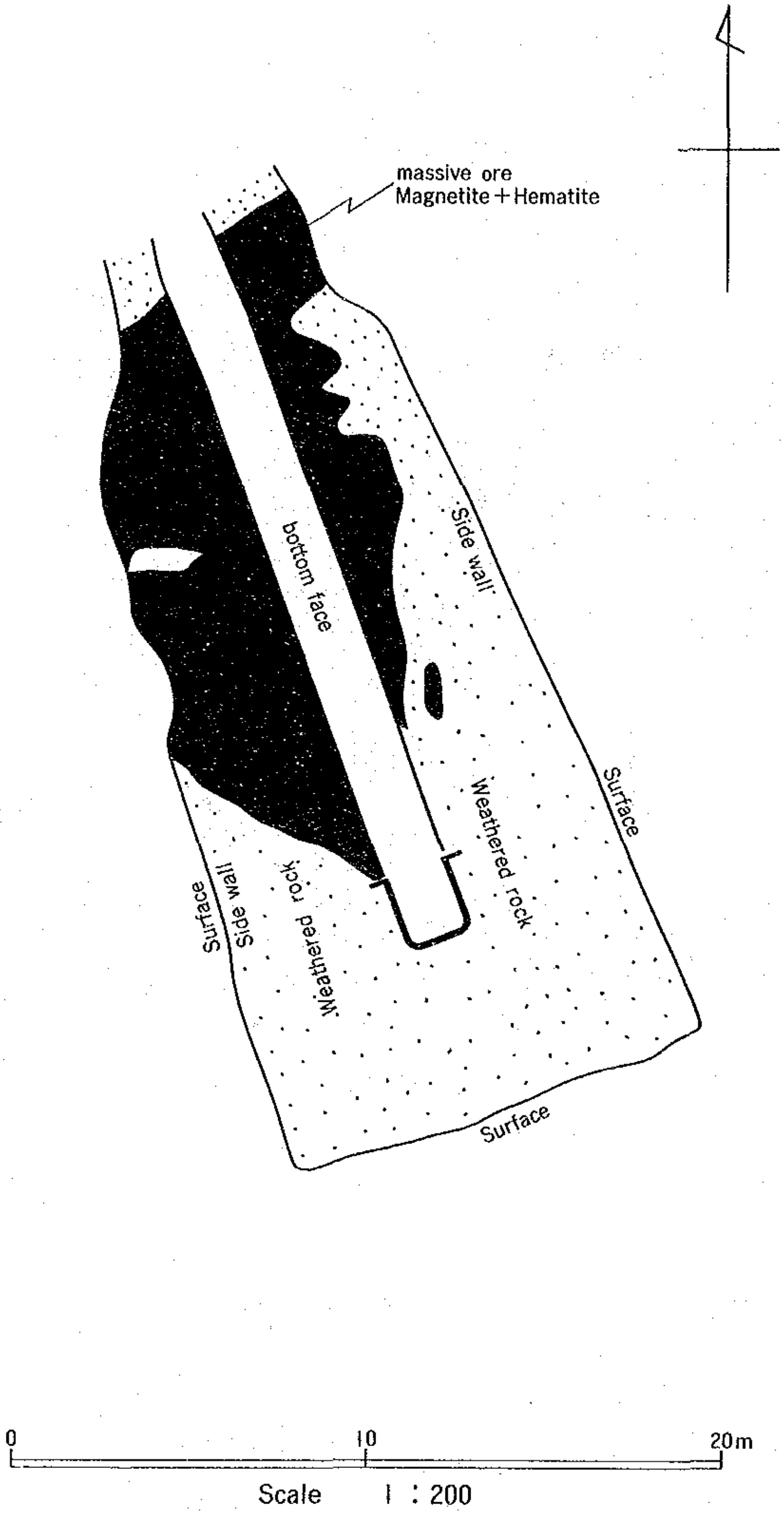


Fig.11 Sketch of Ore Occurrence in Old Trench, S.Padan Mineral Indication

area of St-1L granite.

ii) On the contrary, quartz veinlets and network veinlets with sulphide ore(chalcopyrite, galena, sphalerite, molybdenite and pyrite) occur in Raja granites or in vicinity consisting of the sedimentary rocks.

From the facts mentioned above, it is considered that the mineralization of the Bt.Raja area is a genetically related to the later stage of the St-1 igneous activity.

(4) Mineralization and geologic structure

The present distribution and form of the Mersip Limestone Member (Rw-M) resulted from anticlinorium folding, and formation of the mineral indications were closely restricted to an area of limestone and calcareous rock of Rw-M and Rw-T. It reveals that regional geologic structure and emplacement of the mineralization have a close relationship with each other.

In addition, it is also recognized that the mineralization is closely related to the faulting, from the point of view that Raja granites intruded during the deep-fracturing activity extending in NW-SE and NE-SW directions.

CHAPTER 3 GEOCHEMICAL SURVEY

3-1 Outline

There are many mineral indications in the Bt.Raja area, as mentioned in chapter 3, but most of them are not insitu, that is, they consist of boulders of ore blocks, and it is not clear where they were derived from. In order to trace their original source, and prospect mineralizations of Cu, Pb, Zn, Au and Ag, a soil geochemical survey was carried out in the area. Since surface soil is thin and lacks humus owing to climatic and topographic conditions, the Bt. Raja area is favorable for taking soil samples for detailed geochemical survey.

3-2 Sampling and Indicator Elements

The samples were collected at intervals of 100m or 50m along the traverse lines and from the B horizon of the soil bed. After drying under the sun, the samples for analysis were treated through 80 mesh sieve.

The samples were chemically analyzed with geochemical level for 7 indicator-elements of Cu, Mo, Pb, Zn, Ag, Au, Co. The total number of samples are 1,619 pieces. The results of analysis are shown in the appendix.

3-3 Result of Data Processing

Values were processed by means of statistic method, and threshold values were calculated as in Table 3. Thus, geochemical interpretation was conducted to find an anomalous area.

Table 3 Threshold Values

element	M+σ	M+2σ	M+3σ	Threshold
Cu(ppm)	66.363	196.734	582.223	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	100 (2.5%)
Ag(ppm)	0.165	0.233	0.330	0.2(M+2ρ)
Co(ppm)	13.321	37.906	107.862	35 (2.5%)
Au(ppb)	7.439	27.212	99.537	27 (M+2ρ)

Twenty six geochemical anomalous areas have been obtained on the basis of the above threshold values(Fig.12 and Plate V). Of these anomalous areas, some areas are situated around mineralized indications. Regarding the coefficient of correlation between analyzed elements, some correlations are high, while others are low. According to "main element" 26 anomalous areas are grouped into as follows.

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

The combinations of the elements of each anomalous area are shown in Table 4. In the Table the combined elements are higher toward the left-hand column in their content ratio. It means that elements on the left have larger differences from their threshold value, not shown by absolute value.

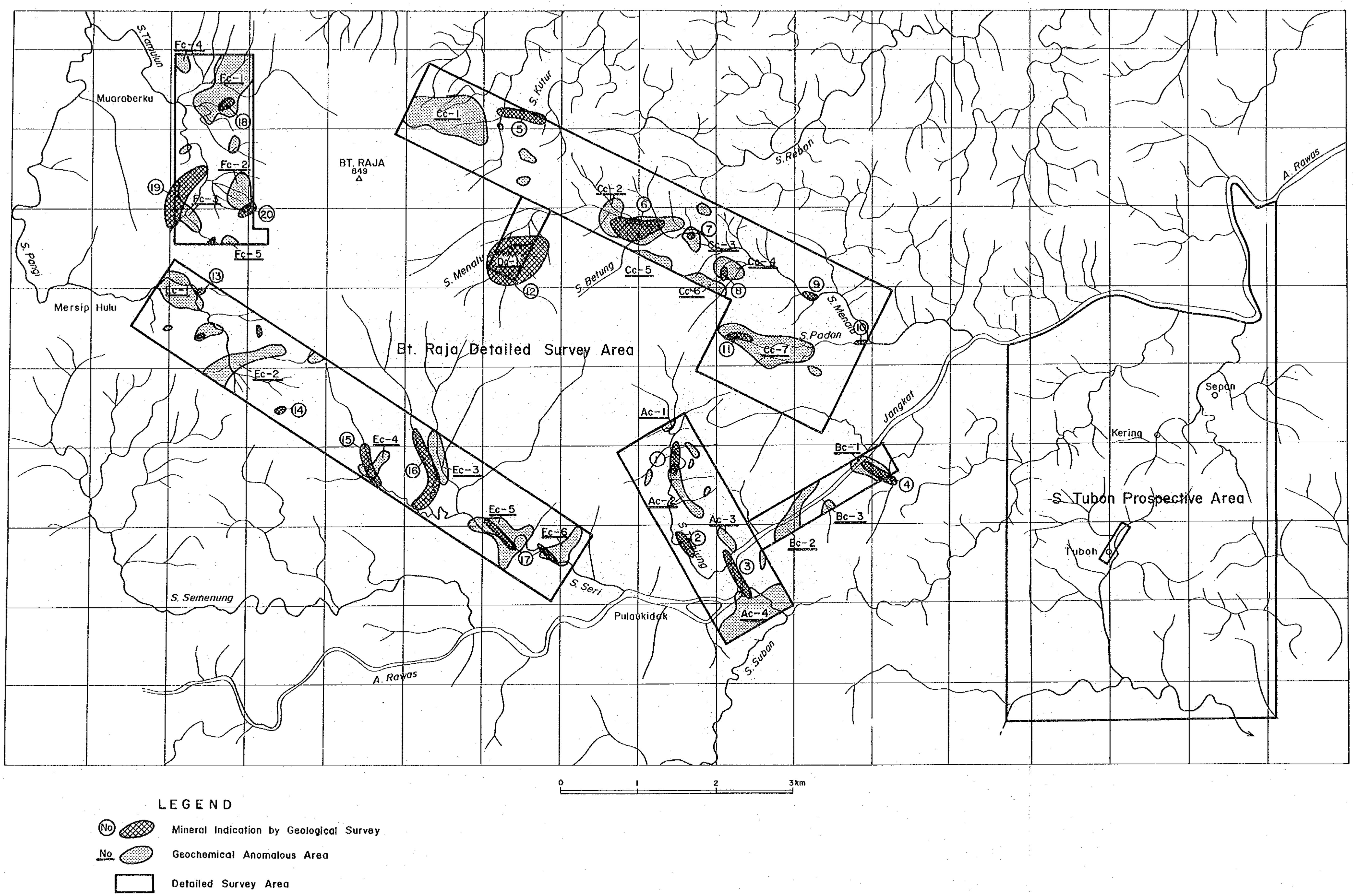


Fig.12 Geochemical Anomalous Areas in the Bt. Raja Detailed Survey Area

Table 4 Anomaly Divisions by Geochemical Indicator Elements and Geochemical Feature of Sectors

Geochemical Indicator Elamant and Geochemical Anomaly			Feature of Geochemical Anomaly
Main Element	Combination of Element	Geochemical Anomaly	
Mo	Mo Mo -------(Pb,Cu,Au,Ag)	Cc-5 Ac-4,Dc-1,Dc-6a	A Sector : Only Ac-4(Mo) shift most to left. B Sector : Au,Ag,or Pb shift most to left C Sector : Au of Mo shift most to left D Sector : Mo is only anomaly element E Sector : Bc-5 and Ec-6 are rich in Mo. Bc-5 and Ec-6,and occur at adjacent granite. F Sector : Fc-1 of north and Fc-2 at(adjacent granite) are most rich in Mo, and others are rich in Au-Co or Au.
	Mo-Au-Ag-Pb-Zn-----Co	Ec-5	
	Mo-Pb-Zn-Co-Au-Ag	Fc-1	
	Mo-Co-------(Au,Ag-Zn)	Fc-2	
	Mo-Au[Mo=Au]	Cc-3	
Au	Au Au-Ag	Ac-1, Fc-4 Fc-5 Cc-2,Cc-7,CC-1, Bc-3	
	Au-Cu-Zn-Ag-Pb----(Mo)	CC-e,Ec-3,Ec-6	
Ag	Ag -------------(Au,Pb)	Bc-1,Ec-2	
Zn	Zn-Co-Cu-Pb	Ac-23,Ec-1	
	Zn-Ag-----(Pb)----(Cu)	Ec-4	
Pb	Pb-Zn-Au	Bc-2	
Co	Co-Au-----(Cu)----(Zn)	Ac-3,Fc-3	
As to combination of elements, ① element shifted the largest to left(larger difference from threshold)is the most anomalous(dense content), ② element marked ( ) is most thin content, and some element is barely recognized its existense.			

Table 4 indicates that the individual groups of main element Au, Ag, Zn, Pb, and Co contain a small amount or a minute amount of Mo, while the group of main element Mo have a high contents of Au, Ag, Cu, Pb, Zn in some cases.

Geologically speaking, the Mo anomalous areas are distributed within or very close to the Raja granites without exception. On the contrary, the Au, Ag, Pb, Zn, and Co anomalous areas are distributed at the outer than the Mo anomalous zones where are distributed farther from the Raja granite. The fact presumes that the mineralizations arrange zonally around the Raja Granites at the Bt. Raja area. The present of the zonal distribution unravels clearly the characteristics of mineralization. That is to say, the mineralization of the Bt.Raja area is polymetallic with Fe-Mo-Au-Ag-Pb-Zn-Co, and occurred during a single period of mineralization. The mineralization has a tight relationship with granite activity because high Mo content anomalous zones are usually present within or adjacent to the Raja granites.

CHAPTER 4 GEOPHYSICAL SURVEY

4-1. Outline

(1) Purpose of the Survey

A ground magnetic survey was conducted to delineate promising mineralized areas through magnetic property of the surveyed area.

(2) Surveyed Area

The surveyed area covered the same area as the geological and geochemical surveys, with measurments taken at the same stations as geochemical sampling(Fig.2).

(3) Amount of the Survey

The survey was conducted at 726 stations with a 50m interval and at 1,004 stations with a 100 m interval, totaling 1,730 stations.

4-2 Survey Method

(1) Measurement of Geomagnetism

The measurement was made with a proton magnetometer to obtain a total magnetic intensity value. The proton senser was supported usually keeping a 2.4 m height from the ground surface at a measured station, and the average value of 3 readings at the station was used as the measured value of the total magnetic intensity.

(2) Rock and Ore Sample Measurment

In order to interpret a geomagnetic property of rocks and ores distributed in the survey area, a total of 75 samples were cllected from along the survey lines, as shown in Plate Ⅶ.

A Sector	12 samples
B Sector	1 samples
C Sector	34 samples

D Sector	5 samples
E Sector	12 samples
F Sector	11 samples

(3) Instruments used

The following instruments were used for the survey ;

Magnetic survey	Proton Magnetometer		
		Geometrics G 816	1 set
		Geometrics G 826	1 set
Base observation	Proton Magnetometer		
		Geometrics G 836	1 set

Magnetic susceptibility measurement Bison Ins. Model 31-1 A

Specifications of the proton magnetometers are as follows:

Sensitibity	1 nT throughout range
Range	20,000 to 90,000 nT
Sampling rate	Manual push-button, one reading each 6 seconds
Output	5 digit numeric display with readout directly in nT

(4) Geomagnetic Diurnal Variation Correction

For observation of the diurnal variation, the proton magnetometer was set up on the ground in front of Jangkat Elementary School, located southwest of the surveyed area. The diurnal variation of geomagnetism ranged from 40 to 50 nT. The standard value of geomagnetism at the observation base was determined as 43,490nT, which was the highest value during the observation. Diurnal variation correction tables were compiled by calculating the differnce from the standard value, and correction work of the measured values was done with the correction tables(see Appendex).

(5) Total Magnetic Intensity Map

The total magnetic intensity map has been compiled, based on the corrected values mentioned above, with contour line intervals of 20nT (omitting the 20nT contour lines in the high gradient part).

(6) Measurement of Magnetic Susceptibility

The rock and ore(magnetite) samples were collected from the survey area. Magnetic susceptibility was measured in Japan. An acrylic resin sample container was filled with crushed rock sample, and was inserted in the specimen holder of the susceptibility meter. The susceptibility of rock and ore was measured, with an accuracy of 10^{-6} emu/cc.

(7) Geomagnetic Component

The geomagnetic components in the surveyed area were as follows ;

Total magnetic intensity	43,400 nT
Inclination	-25°
Declination	0°

4-3 Interpreted Result of the Ground Magnetic Survey

(1) Result of the Magnetic Susceptibility of the Rocks and Ores

The magnetic susceptibility values of rocks and ores measured(K in 10^{-6} emu/cc units) are shown in Table 5～Table 6, and in Fig13. The result indicates that distinct corresponding relationships exist between rock types and magnetic susceptibility values. Diorite, granodiorite and granite, distributed extensively in the surveyed area, are of hign magnetic susceptivility. The diorite has an average high susceptibility of K=2,400, varying narrowly. The granodiorite has K=2,100(average value), and granite has K=1,400 (average) including low values. Hornfels intruded by these granitoids are grouped into two susceptibilities of around K=100 and over K=1,000. Susceptibility values of sedimentary rocks (limestone, slate, sandstone and phyllite) are generally less than K=100, and they have significant differnce from that of the granitoid. Susceptibility of ore mineral and skarn related closely to mineralization shows distinct features as follows ;

i) ore(magnetite) shows an exceedingly high value of K=165,484

ii) skarn(K=169),quartz(K=39) and silicified rock(K=29) have low values.

The result of magnetic susceptibility measurement expects that magnetic anomalies in the area result from ore (magnetite), diorite, granodiorite and a part of the granite and hornfels.

Table 5 Physical Properties of Rock and Ore Samples

No.	Sample No.	Rock Type	Suscep. (emu/cc)	Den. g/cm³	No.	Sample No.	Rock Type	Suscep. (emu/cc)	Den. g/cm³
1	AR- 1	Granite	2,541	2.65	39	BR-62B	Limonitized skarn	218	1.71
2	AR-10	Hornfels	120	2.86	40	BR-64	Silicified rock	29	2.56
3	AR-14	Hornfels	898	2.76	41	BR-65	Granodiorite	2,291	2.61
4	AR-17	Granite	679	2.61	42	BR-67	Qz vein	51	2.75
5	AR-18	Hornfels	4,856	2.80	43	BR-69	Granodiorite	2,375	2.72
6	AR-20	Hornfels	95	2.78	44	BR-74	Skarn with Mt,Hm	241	3.23
7	AR-23	Hornfels(Py)	1,629	2.85	45	BR-75	Mt ore	88,877	4.57
8	AR-30	Hornfels	2,364	2.77	46	BR-79	Skarn with Sp	119	1.78
9	AR-31	Granite	723	2.64	47	BR-80	Mt ore	244,227	4.44
10	AR-35	Skarn	162	3.37	48	BR-84	Mt ore	196,588	3.46
11	AR-38	Granite(Py)	2,297	2.64	49	BR-86	Granodiorite	1,511	2.71
12	AR-41	Granite(Py)	1,931	2.60	50	CR- 1	phyllite	40	2.30
13	AR-75	Limestone	236	3.03	51	CR- 3	Limestone	11	2.71
14	AR-83	Siliceous slate	136	3.01	52	CR- 6	Diorite	1,922	2.76
15	AR-112	Hm-Mt ore	16,957	3.91	53	CR- 8	Limestone	31	2.69
16	BR- 3	Diorite	2,447	2.88	54	CR- 9	Phyllite	28	2.27
17	BR- 8	Diorite	2,932	2.76	55	CR-10	Limestone	4	2.71
18	BR-12	Limestone	21	2.70	56	CR-14	Limestone	13	2.72
19	BR-15	Phyllite	59	2.55	57	CR-16	Hornfels	2,190	2.78
20	BR-19	Slate	37	2.62	58	CR-17	Silicified slate	102	2.72
21	BR-26	Hornfels	78	2.82	59	CR-18	Diorite	3,433	2.76
22	BR-33-2	Hornfels	115	2.87	60	CR-20	Cry limestone	18	2.72
23	BR-35	Siliceous slate	97	3.06	61	CR-21	Hornfels	89	2.71
24	BR-38	Silicified lime	155	2.69	62	CR-23	Silicifed slate	52	2.70
25	BR-41	Qz vein with Py	27	2.62	63	CR-28	Sandstone	38	2.56
26	BR-43	Sandstone	137	2.68	64	CR-29	Granodiorite	2,474	2.75
27	BR-44	Slate	50	2.55	65	CR-32	Granite	2,170	2.65
28	BR-45	Granite	1,698	2.64	66	CR-36	Granite	1,205	2.63
29	BR-46	Silicified slate	77	2.65	67	CR-40	Granite	1,231	2.63
30	BR-47	Sandstone	26	2.65	68	CR-46	Mt ore	218,691	4.73
31	BR-48	Slate	93	2.69	69	CR-48	Weathered skarn	106	1.81
32	BR-49	Sandstone	133	2.77	70	CR-49	Mt ore	227,566	4.58
33	BR-51	Granite	1,727	2.63	71	CR-54	Sandstone	100	2.68
34	BR-53	Slate	139	2.72	72	CR-56	Granite	595	2.61
35	BR-54	Diorite	1,378	2.65	73	CR-58	Slate	67	2.46
36	BR-55	Hornfels	58	2.71	74	CR-60	Slate	59	2.52
37	BR-57	Granite	368	2.59	75	CR-61	Slate	40	2.76
38	BR-62	Granodiorite	1,715	2.66					

Abbreviations

Suscep:susceptibility　Den:density

Qz:quartz　Py:pyrite　Hm:hematite

Mt:magnetite　Sp:sphalerite　Cry:crystalline

Table 6 Average Values of Physical Properties by Rock Types (1)

Rock Type	Sample No.	Sector	Suscep($\times 10^{-6}$emu/cc)		Density(g/cm^3)	
			MV	Average	MV	Average
Limestone	AR-75	E	236	61	3.03	2.75
	BR-12	E	21		2.70	
	BR-38	F	155		2.69	
	CR- 3	E	11		2.71	
	CR- 8	E	31		2.69	
	CR-10	E	4		2.71	
	CR-14	E	13		2.72	
	CR-20	F	18		2.72	
Slate	AR-83	A	136	79	3.01	2.71
	BR-19	F	37		2.62	
	BR-35	F	97		3.06	
	BR-44	C	50		2.55	
	BR-46	C	77		2.65	
	BR-48	C	93		2.69	
	BR-53	C	139		2.72	
	CR-17	F	102		2.72	
	CR-23	F	52		2.70	
	CR-58	C	67		2.46	
	CR-60	C	59		2.52	
	CR-61	C	40		2.76	
Sandstone	BR-43	C	137	87	2.68	2.67
	BR-47	C	26		2.65	
	BR-49	C	133		2.77	
	CR-28	C	38		2.56	
	CR-54	C	100		2.68	
Phyllite	BR-15	E	59	42	2.55	2.37
	CR- 1	E	40		2.30	
	CR- 9	E	28		2.27	
Hornfels	AR-10	A	120	93	2.86	2.79
	AR-20	A	95		2.78	
	BR-26	F	78		2.82	
	BR-33-2	F	115		2.87	
	BR-55	C	58		2.71	
	CR-21	F	89	(1,136)	2.71	
	AR-14	A	898	2,387	2.76	
	AR-18	A	4,856		2.80	
	AR-23	A	1,629		2.85	
	AR-30	B	2,364		2.77	
	CR-16	F	2,190		2.78	

Table 6 Average Values of Physical Properties by Rock Types (2)

Rock Type	Sample No.	Sector	Suscep($\times 10^{-6}$emu/cc)		Density(g/cm^3)	
			MV	Average	MV	Average
Diorite	BR- 3	E	2,447	2,422	2.88	2.76
	BR- 8	E	2,932		2.76	
	BR-54	C	1,378		2.65	
	CR- 6	E	1,922		2.76	
	CR-18	F	3,433		2.76	
Granodiorite	BR-62	C	1,715	2,073	2.66	2.69
	BR-65	D	2,291		2.61	
	BR-69	D	2,375		2.72	
	BR-86	C	1,511		2.71	
	CR-29	C	2,474		2.75	
Granite	AR- 1	A	2,541	1,850	2.65	2.63
	AR-38	A	2,297		2.64	
	AR-41	A	1,931		2.60	
	BR-45	C	1,698		2.64	
	BR-51	C	1,727		2.63	
	CR-32	C	2,170		2.65	
	CR-36	D	1,205		2.63	
	CR-40	C	1,231	(1,430)	2.63	(2.63)
	AR-17	A	679	591	2.61	2.61
	AR-31	A	723		2.64	
	BR-57	C	368		2.59	
	CR-56	C	595		2.61	
Silicified rock	BR-64	D	29	29	2.56	2.56
Quartz	BR-41	C	27	39	2.62	2.69
	BR-67	D	51		2.75	
Skarn	AR-35	A	162	169	3.37	(3.30)
	BR-62B	C	218		1.71	
	BR-74	C	241		3.23	2.38
	BR-79	C	119		1.78	
	CR-48	C	106		1.81	(1.77)
Ore	AR-112	C	16,957	165,484	3.91	4.28
	BR-75	C	88,877		4.57	
	BR-80	C	244,227		4.44	
	BR-84	C	196,588		3.46	
	CR-46	C	218,691		4.73	
	CR-49	C	227,566		4.58	

Suscep:susceptibility MV:Measurement value

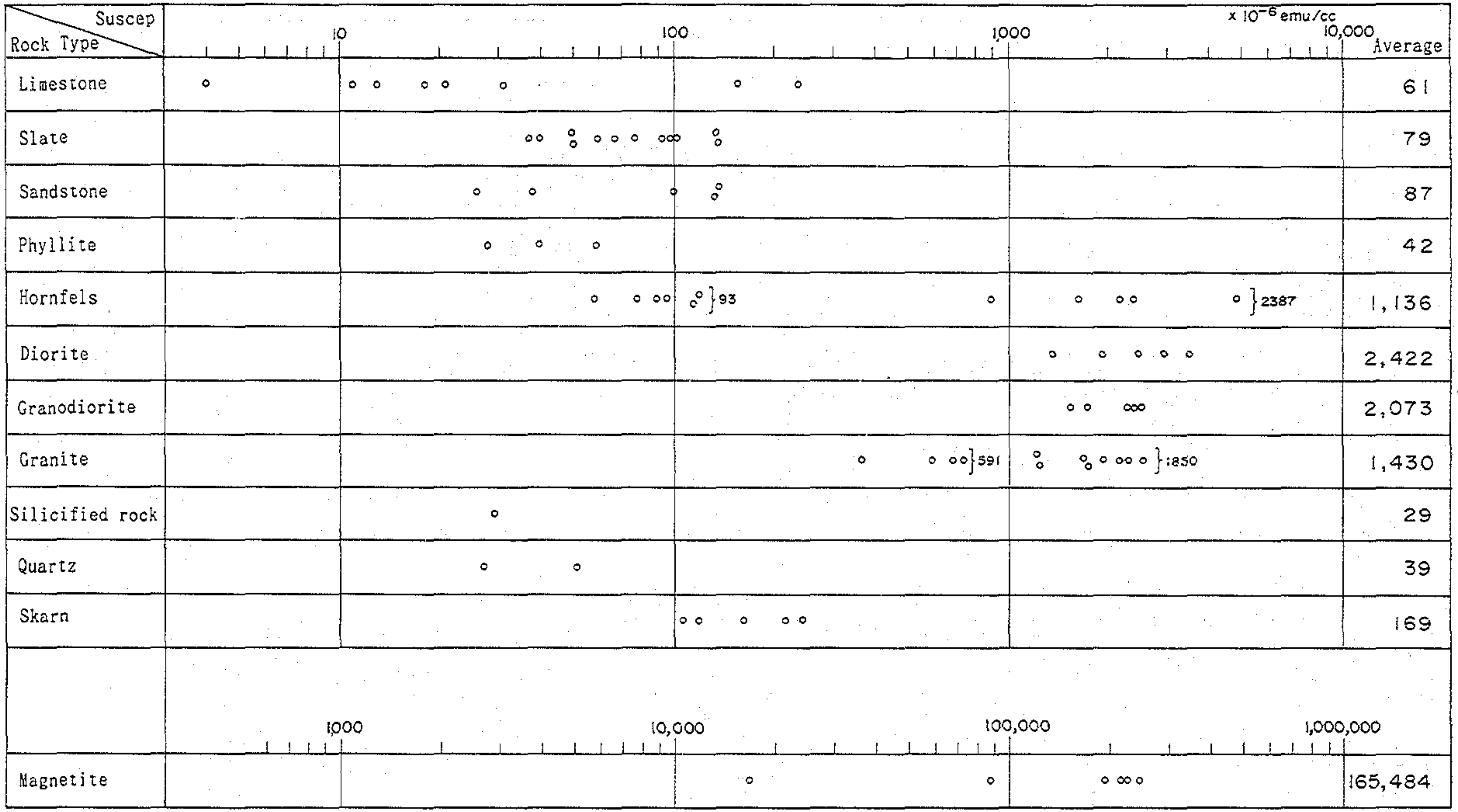


Fig.13 Distribution Map of Magnetic Susceptibility of Rocks and Ores

(2) Magnetic Intensity Map

Many small and distinct magnetic anomalies are distributed in the whole surveyed area, havng strong significant correlations with configuration of survey stations as shown in Plate Ⅶ. The anomalies are attributed to magnetized bodies on the ground surface or in the shallow part, because the sensor of the magnetometer was set up close to ground surface(2.4m height) during measurement

At sites of high-magnetic intrusive rocks, magnetite-pyrrohtite containing outcrops, and areas where ore boulders are scattered, anomalies are observed as composite values of a strong local-magnetic anomaly and a deep magnetic anomaly. Areas crowded with magnetic anomalies are numbered by A-I , F-I , and are shown in Fig.14. In the figure, mineral indications, confirmed by geological survey, are also shown with their number.

(3) Interpretation of Magnetic Anomaly

The interpretation works on magnetic anomalies were done by means of the two dimensional Talwani method. The parameters used were width, depth, shapes (classified to slab or dyke) and magnetic susceptibility of a magnetic anomaly source body. Since all these parameters were generally not defined, the interpretation work was conducted applying methods ③ and ④ on the parameter conditions of ① and ② as follows :

① Width and depth of magnetic anomaly source :

The features of the magnetic contours in the total magnetic intensity map (high-amplitude positive and negative anomalies having strong and significant correlations with the configuration of surveyed stations) infer that many high-amplitude magnetic anomalies are attributed to magnetic sources having their scales within distances equal to station intervals.

Accordingly, it is presumed that the magnetic anomaly source is emplaced downward from the ground surface, and its width is equivalent to the distance between positive and negative peaks in a pair of anomalies on the total magnetic intensity map.

For the anomalies inferred to be caused by mineralization during the course of interpretation mentioned above, the magnetic profile analysis is as follows in (4)

② Shape and magnetic susceptibility of magnetic anomaly source :

Taking the measured magnetic susceptibility values of rocks and ores into consideration, magnetic susceptibility, types and shapes of the analysis models were presumed as in Table 7 :

Table 7 Models Used in Magnetic Analysis

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

③ Relationships between magnetic anomaly amplitude and width of dyke-model for different magnetic susceptibilities :

Fig. 15 shows a result calculated on the dyke-models by means of the Talwani method. The amplitude of the magmatic anomaly can be calculated from the width of a known anomaly source in the figure. Namely the type of anomaly sources can be certainly defined by comparing calculated and observed values.

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

In the case where the that a thickness of the slab-model anomaly source is sufficiently thin enough compared with its width, the amplitude of magnetic anomaly is attributed only to thickness, not to width.

The relationship between amplitude and thickness for thin slab-model was calculated by means of the Talwani method, and its result is shown in Fig.16.

The magnetic susceptibility used in the calculation was 165,000 × 10^{-6} emu/cc. A thickness of the mineralized zone (it is called equivalent

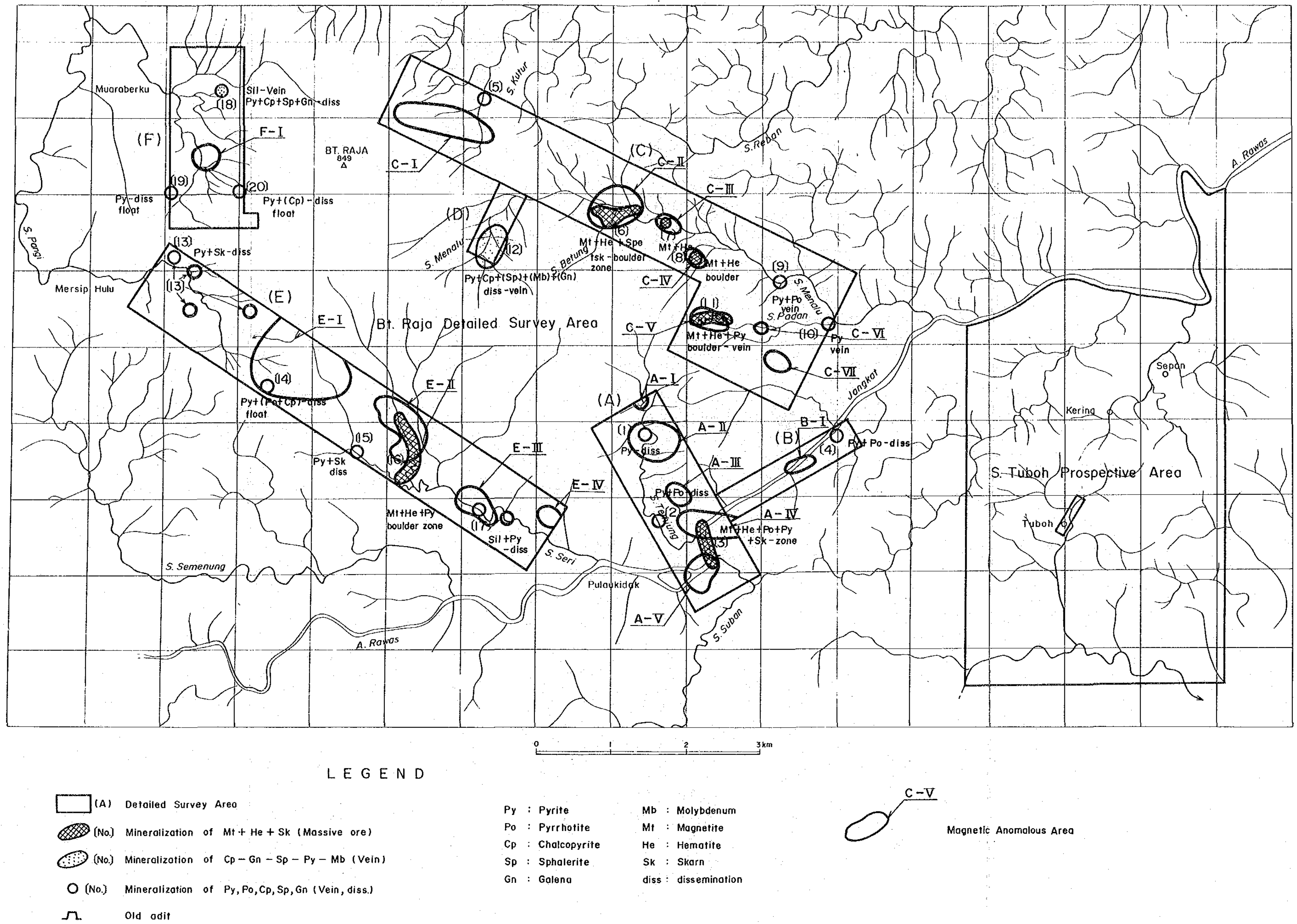


Fig.14 Distribution Map of Magnetic Anomalous Areas and Mineral Indications

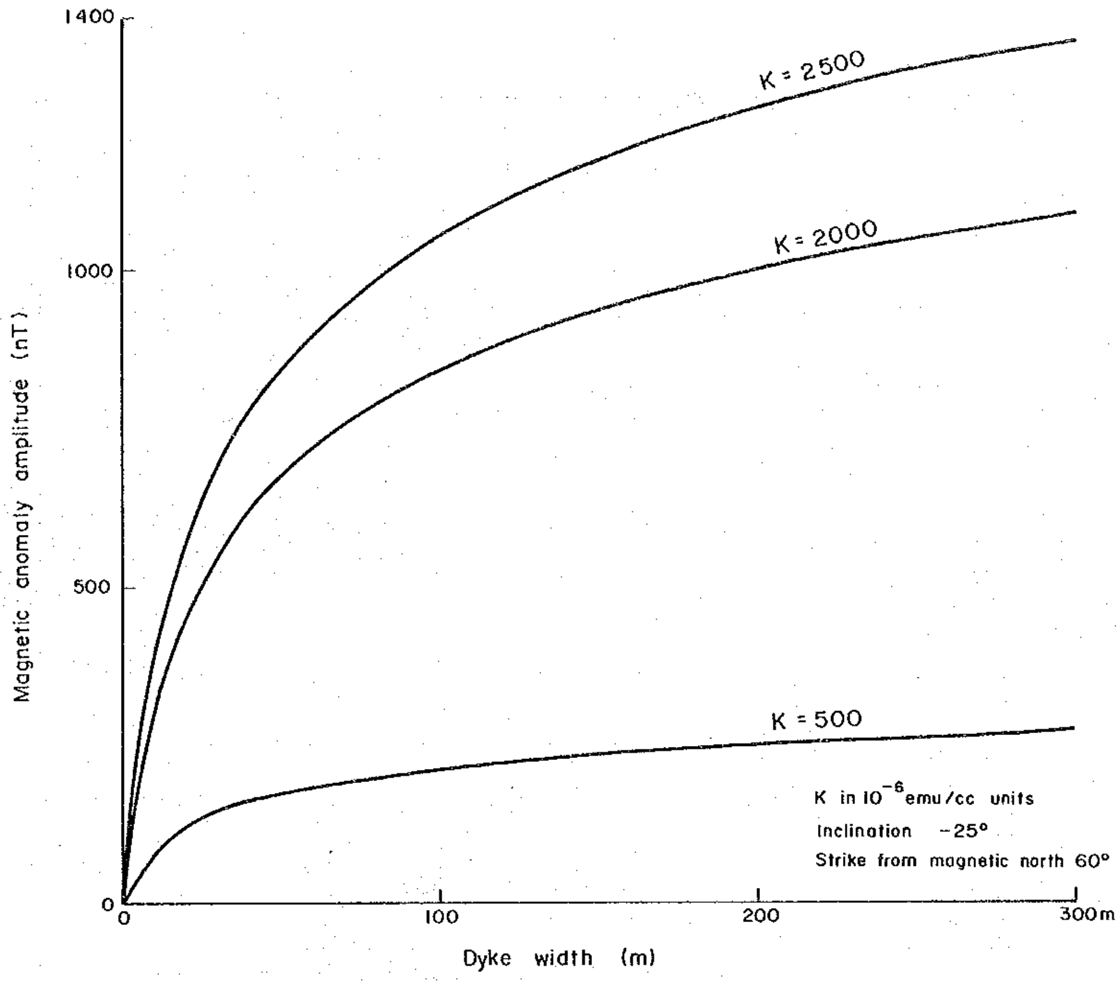


Fig.15 Magnetic Anomaly Amplitude versus Width of Dyke for Different Susceptibilities

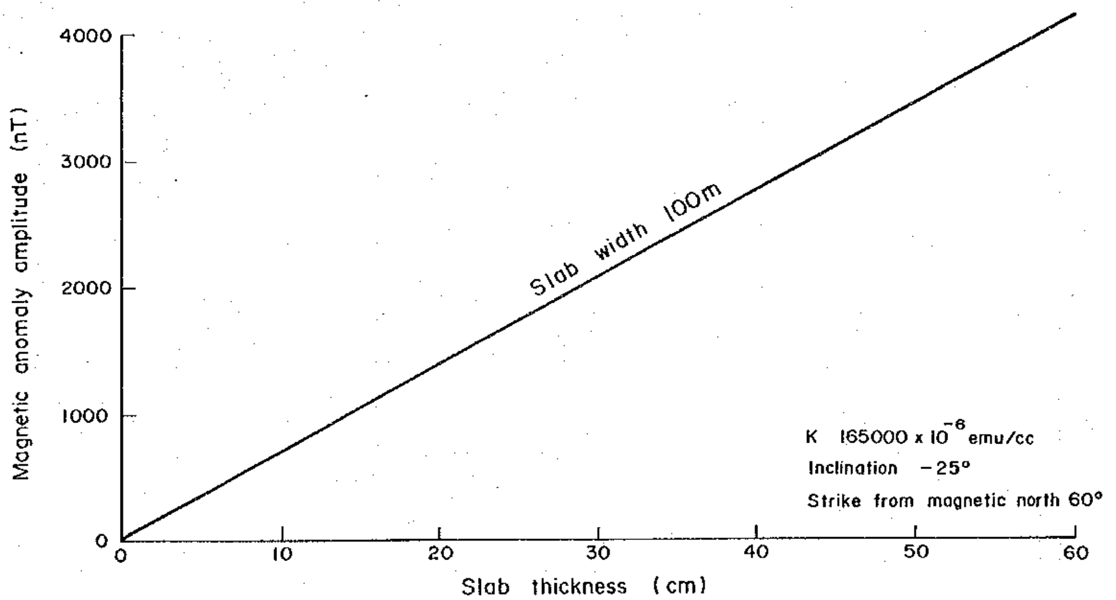


Fig.16 Magnetic Anomaly Amplitude versus and Thickness of Thin Slab

Table 8 Results of Magnetic Anomaly Analyses

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	15
	II	7	22	7	200	720	250	1000	1250	10	Granite (Ore?)	Rw	15
	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

thickness) can be calculated using the figure, provided the observed magnetic anomaly is caused by ore.

The results calculated and interpreted by procedures ③ and ④ are shown in Table 8.

In the case of the amplitude of the magnetic anomaly observed being significantly larger than that calculated by procedure ②, it is regarded as the anomaly caused by mineralization. The 8 anomalies shown in the Table 9 are recognized as such anomalies.

In some mineral indication area listed in Table 10, magnetic anomaly are not detected or obtained only small amplitude value.

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	2,520	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	---

Table 10 Mineral Indications Without Magnetic Anomalies

Sector	number of anomalous area	number of anomaly	plitude of anomaly (nT)	equivalent thickness (cm)	number of mineralized indications
A	V	8	600	10	3
C	II	9	760	10	6
C	II	10	690	10	6
C	IV	14	710	10	8
C	V	15	640	10	11
E	II	6	510	5	16
E	II	7	720	10	16

(4) Magnetic Profile analysis

A magnetic profile analysis was carried out on the 8 magnetic anomalies extracted as anomalies by mineralization.

The first, a magnetic profile is prepared, and then a mineralized zone model is detected, matching its calculated profile to the observed one. The magnetic susceptivility used in the profile analysis was 165,000 × 10^{-6} emu/cc, which is the average value of ore sample.

The results are shown in Fig 17～ Fig 23. In the figures, the thin slab-model magnetic anomalies analysed as in section (3) are also shown.

4-4 Discussion on the Interpreted Results

(1) Relationship between the Mineral Indication and the Magnetic Anomaly

Among 20 mineral indications confirmed by geological survey, 9 indications (No. 2, 3, 4, 6, 7, 8, 11, 14, 16) contain highly magnetized minerals such as magnetite, pyrrhotite, etc.

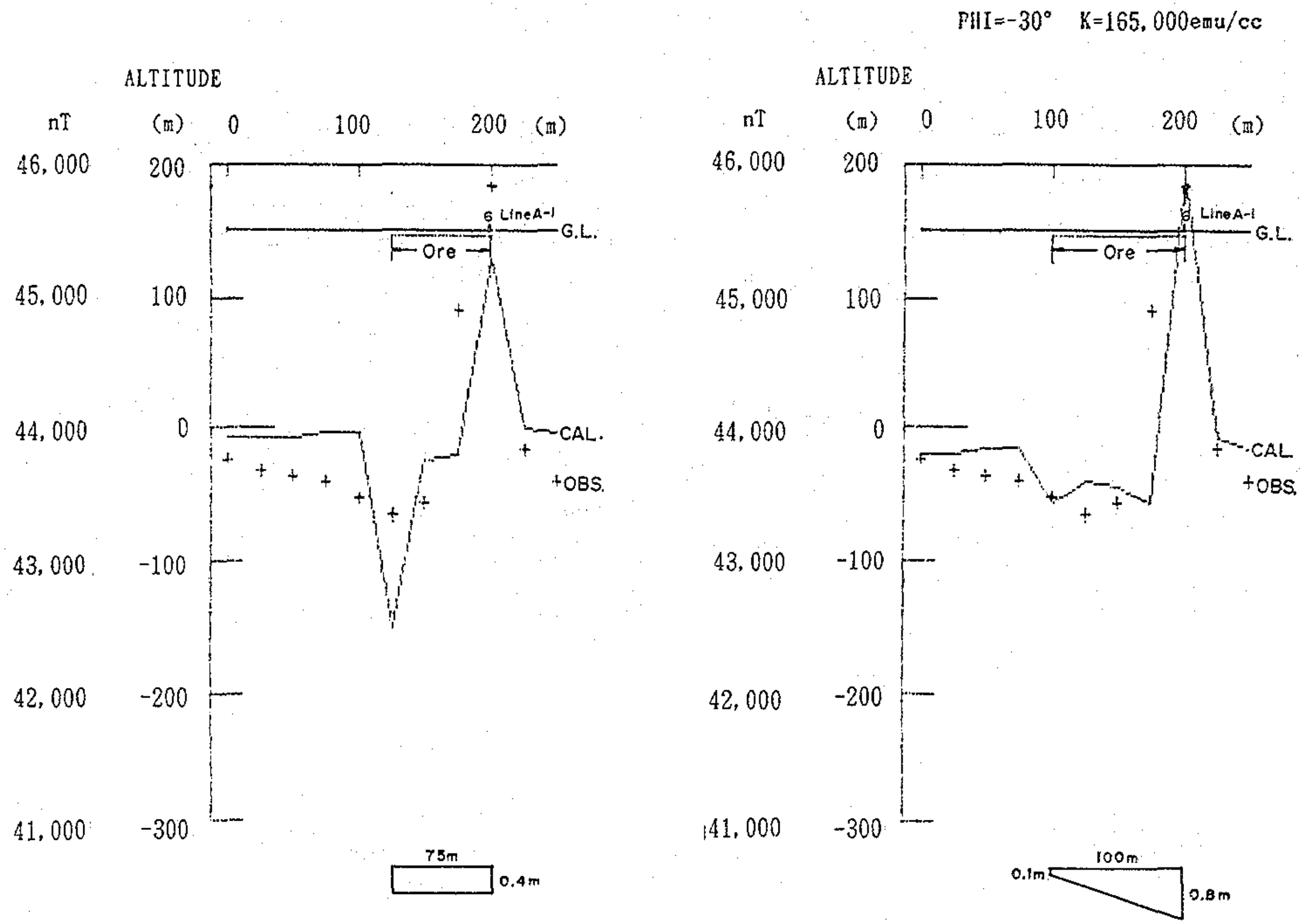
On the other hand, 6 magnetic anomalous areas of A-Ⅰ , A-Ⅴ , C-Ⅱ , C-Ⅲ , C-Ⅴ , and E-Ⅳ , contain 8 interpreted magnetic anomalies, attributed to mineralization (see Fig.14). Of them, A-Ⅴ (mineral indication No.3), C-Ⅱ (mineral indication No.6) C-Ⅲ (mineralized zone No.7), C-Ⅴ (mineral indication No.11) are correlative with intensely magnetized mineral indications, and A-Ⅰ and E-Ⅳ are not correlative with indications.

The 11 mineral indications No.1, 5, 9, 10, 12, 13, 15, 17, 18, 19, and 20 do not contain intensely magnetized minerals, and are not identified by the magnetic survey as mineralized zones.

(2) Size of the mineralized zone

The size of a mineralized zone is interpreted from the magnetic anomaly, on the condition that the mineralized zone consists only of ores. The results are shown in Fig 17～Fig 23. The mineralized zones analyzed lie in the range from 50m to 200m in horizontal extension and from 20cm to 150cm in thickness.

An occurrence of the strongly magnetized ore is of massive or disseminated magnetite and pyrrhotite. For instance, massive magnetite ores of 1m～10m in size are sporadically distributed in the granite at the Padan area. Such an occurrence of ore indicates that the average magnetic susceptibility of the mineralized zone should be estimated as lower than that of only ore. How the calculated thickness of the mineralized zone varies with volume ratio of ore in the mineralized zone was studied through the process of magnetic anomaly analysis as follows ;

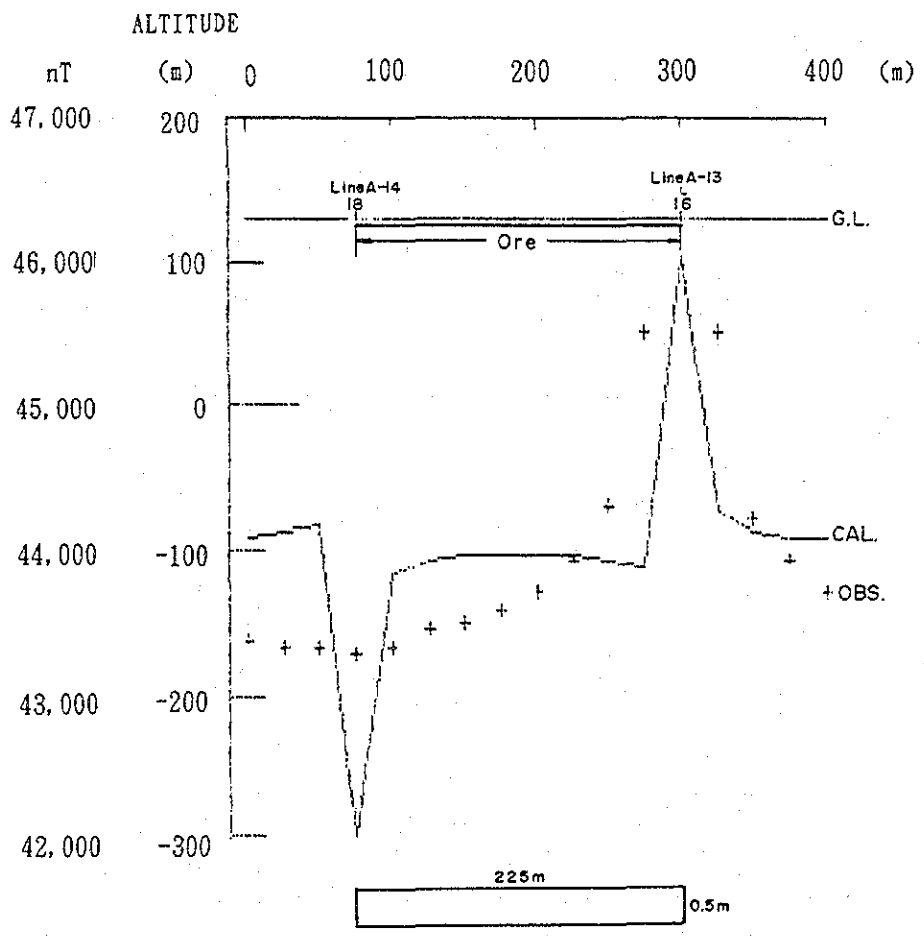


(a) Thin slab model

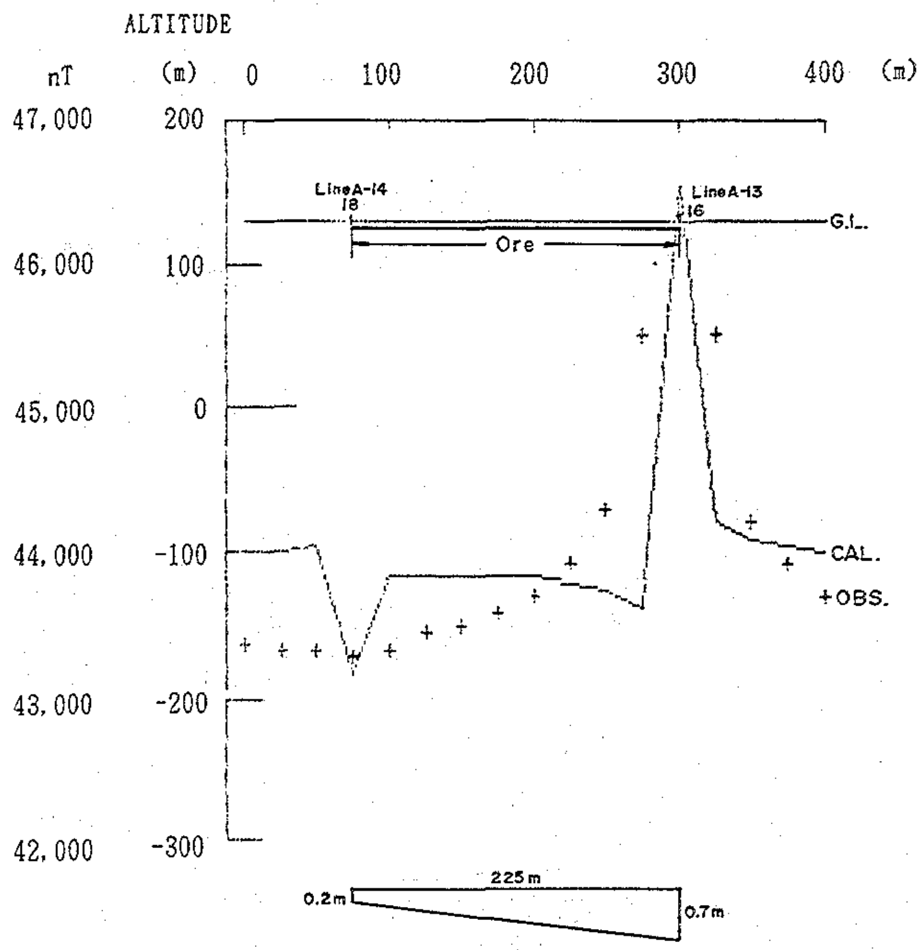
(b) Profile analysis result

Fig.17 Result of Magnetic Profile Analysis (A-I -1)

PHI= -4° K=165,000emu/cc

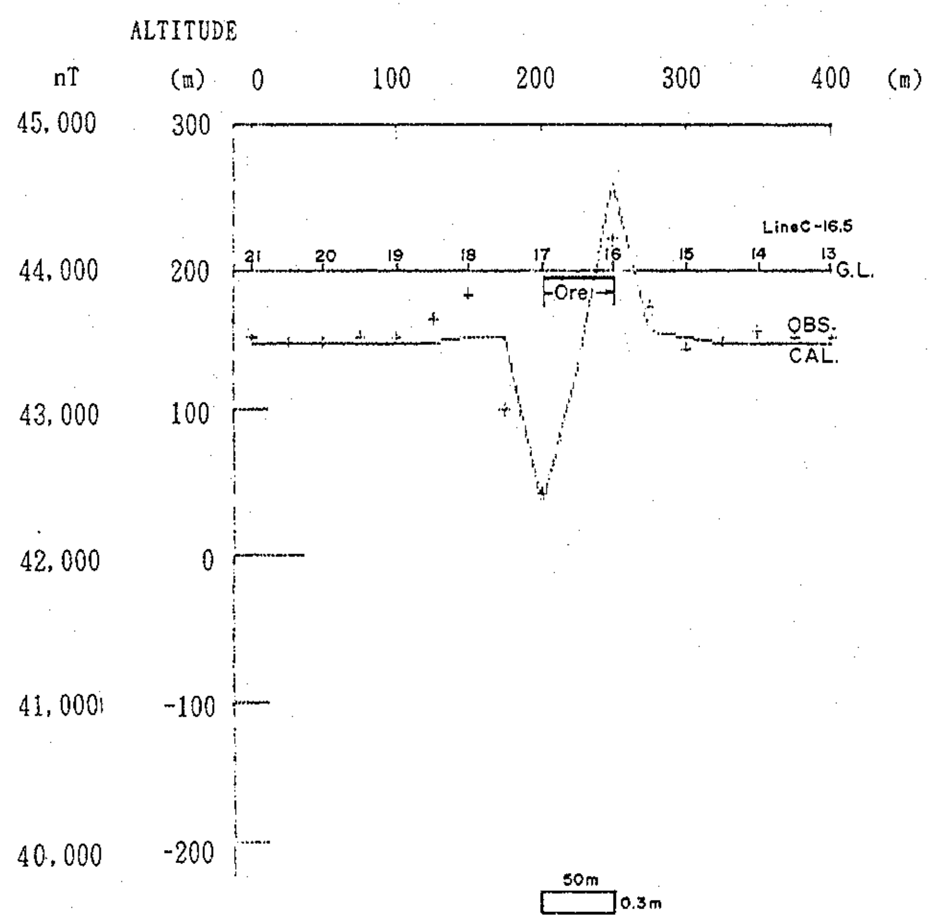


(a) Thin slab model



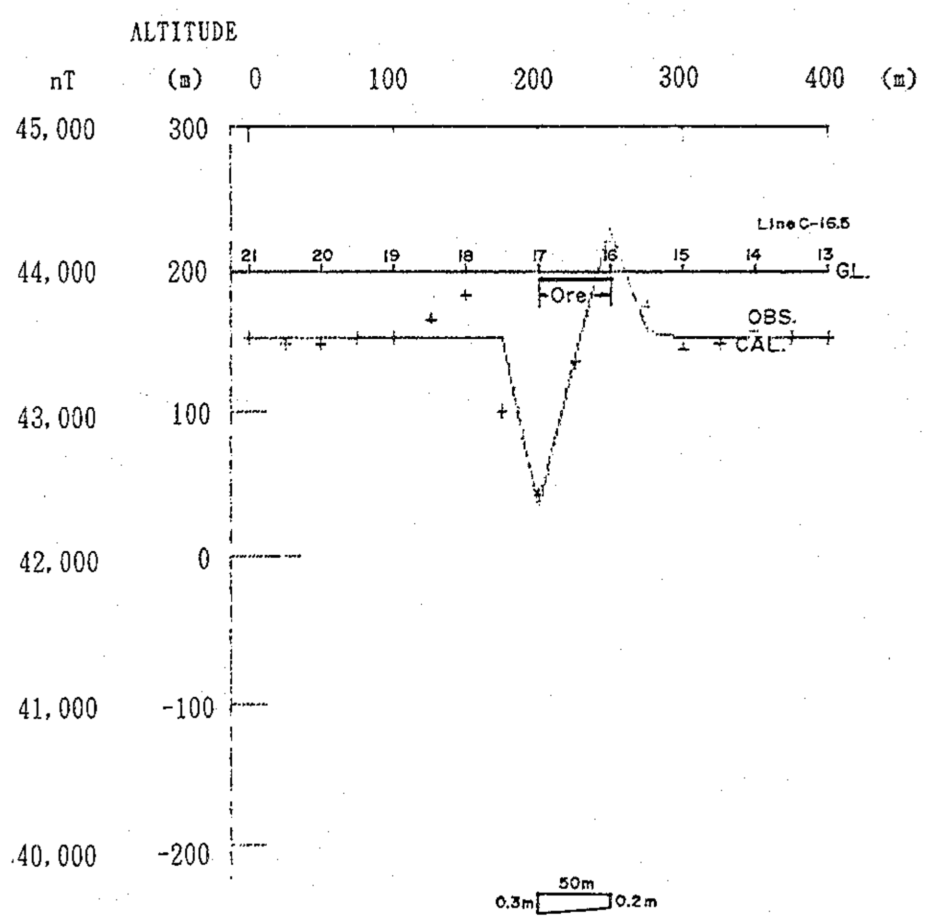
(b) Profile analysis result

Fig.18 Result of Magnetic Profile Analysis (A-V -7)



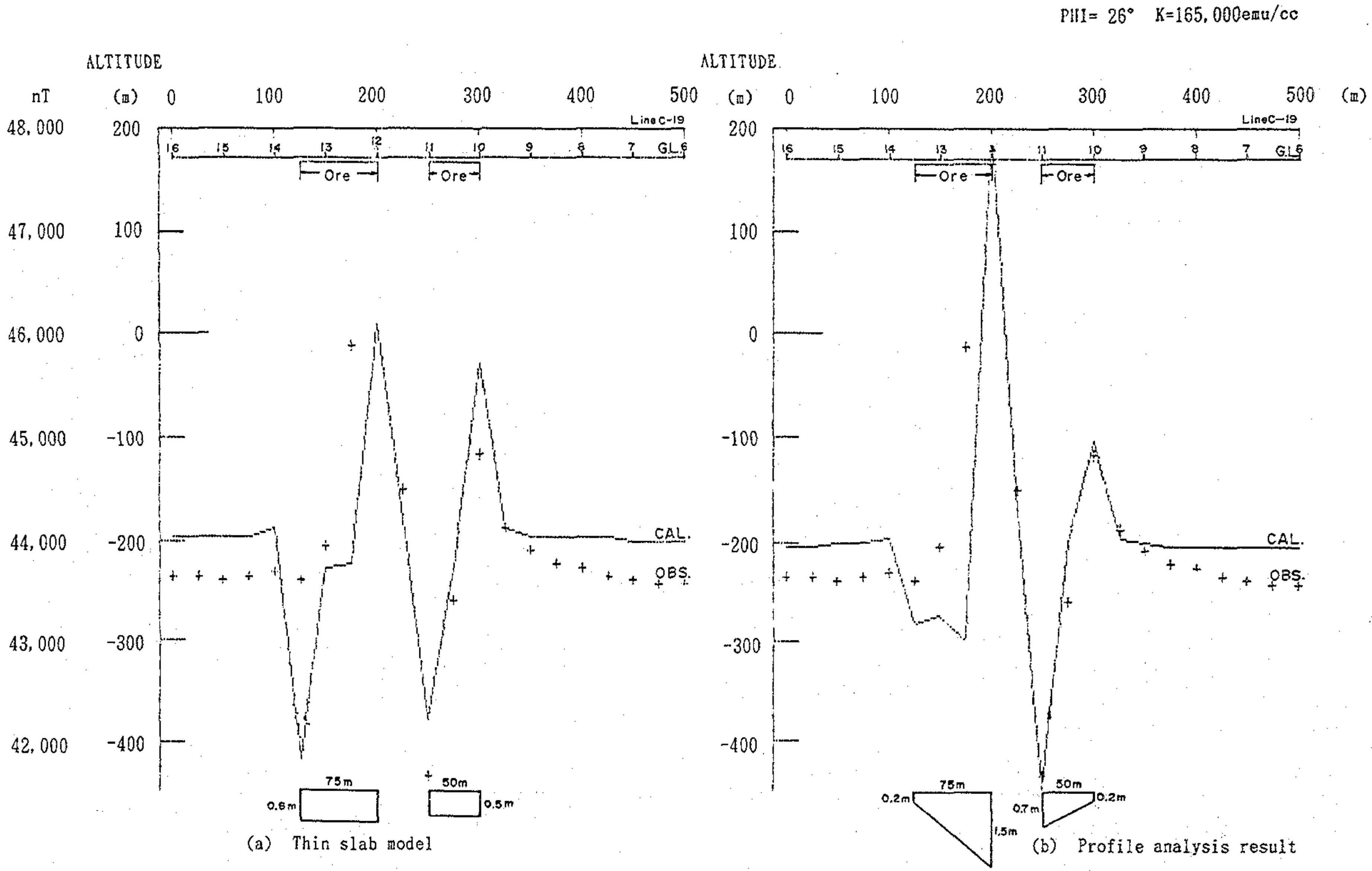
(a) Thin slab model

PHI= 26° K=165,000emu/cc



(b) Profile analysis result

Fig.19 Result of Magnetic Profile Analysis (C-Ⅱ -6)

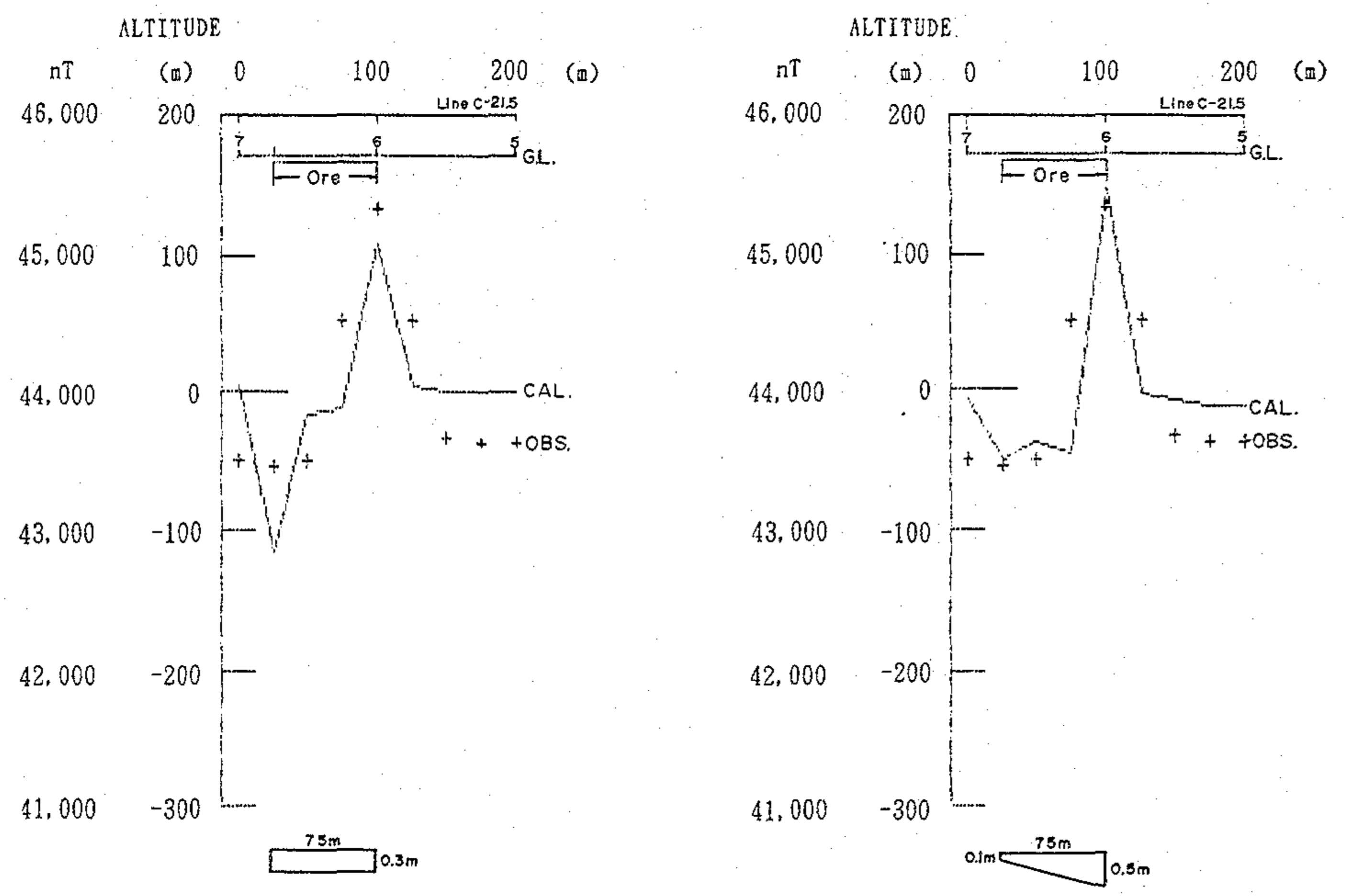


(a) Thin slab model

(b) Profile analysis result

Fig.20 Result of Magnetic Profile Analysis (C-Ⅱ-11,C-Ⅱ-12)

PHI= 26° K=165,000emu/cc

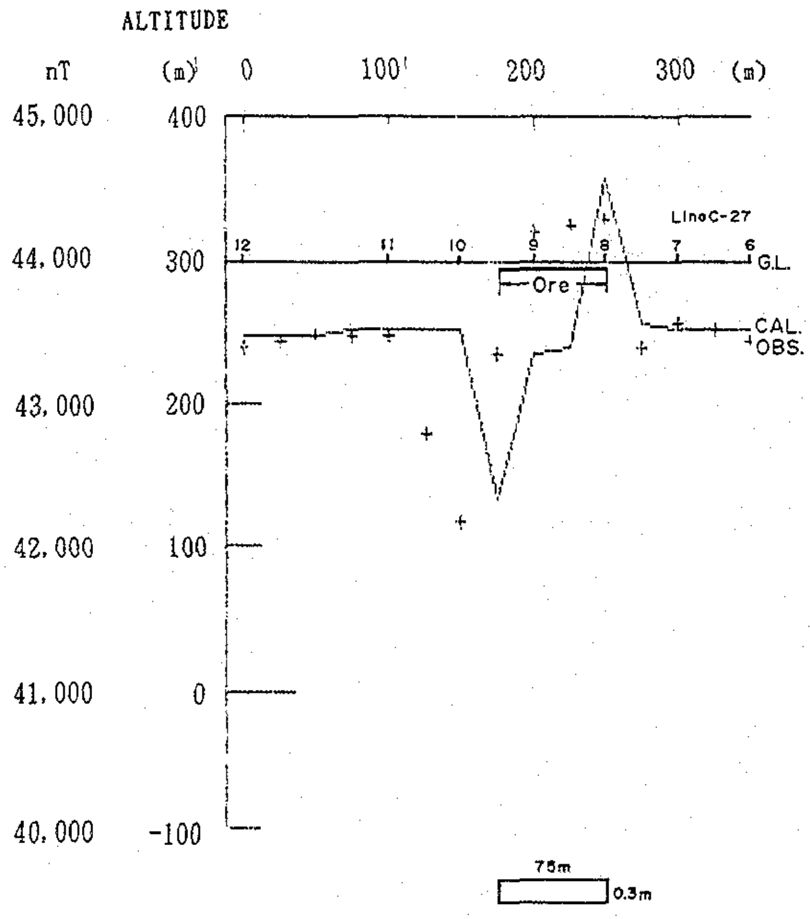


(a) Thin slab model

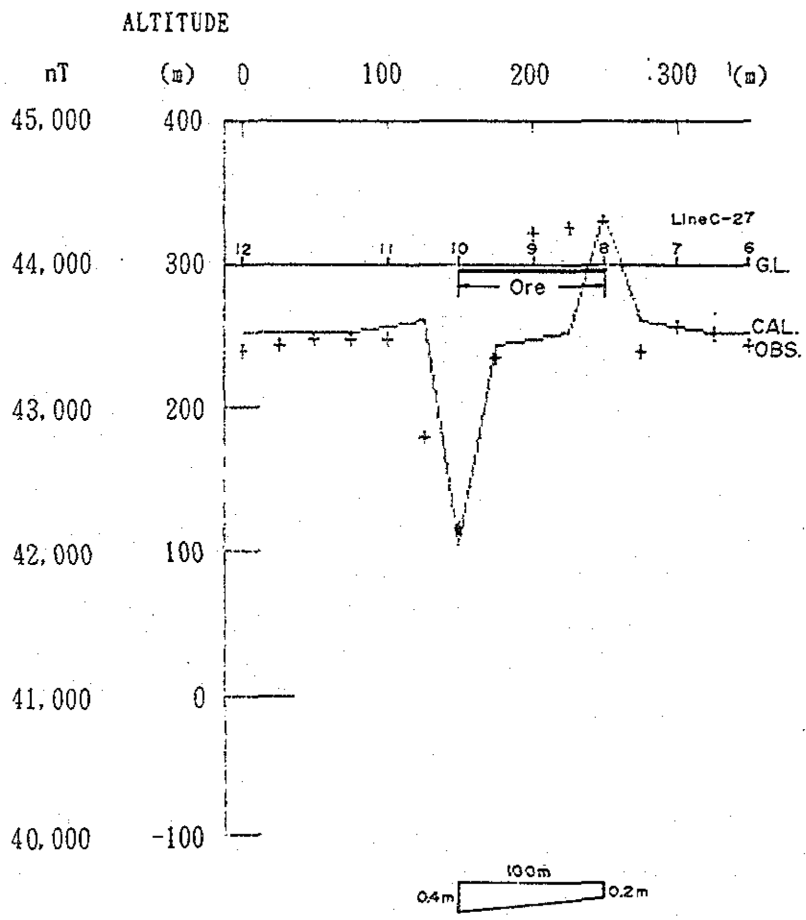
(b) Profile analysis result

Fig.21 Result of Magnetic Profile Analysis (C-Ⅲ-13)

PHI= 26° K=165,000emu/cc



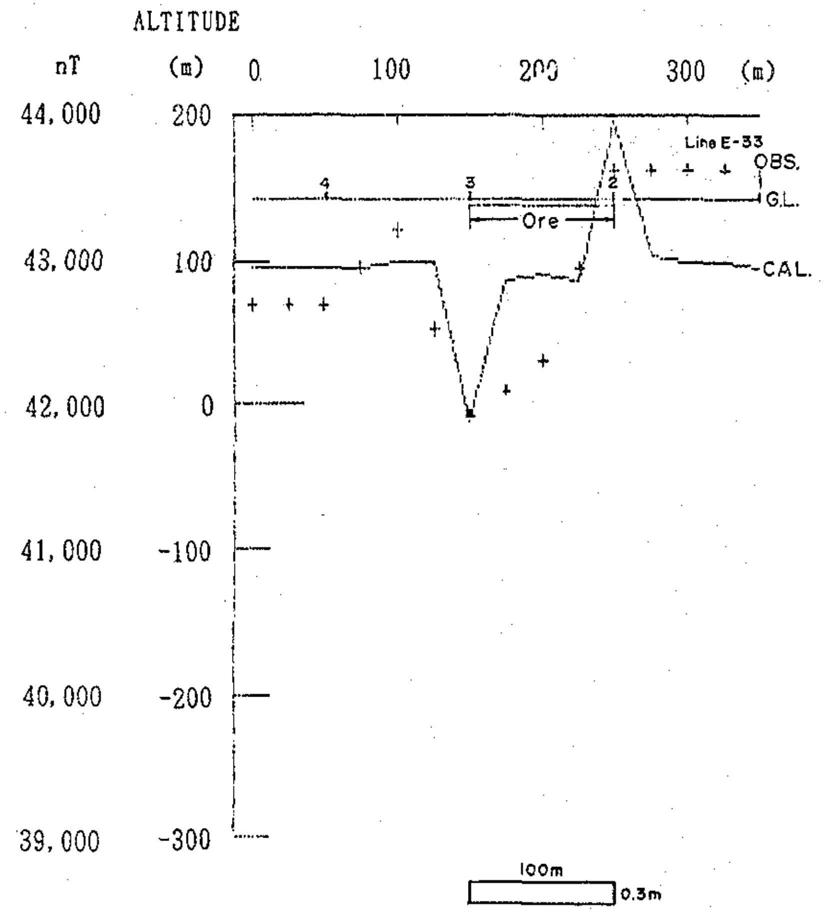
(a) Thin slab model



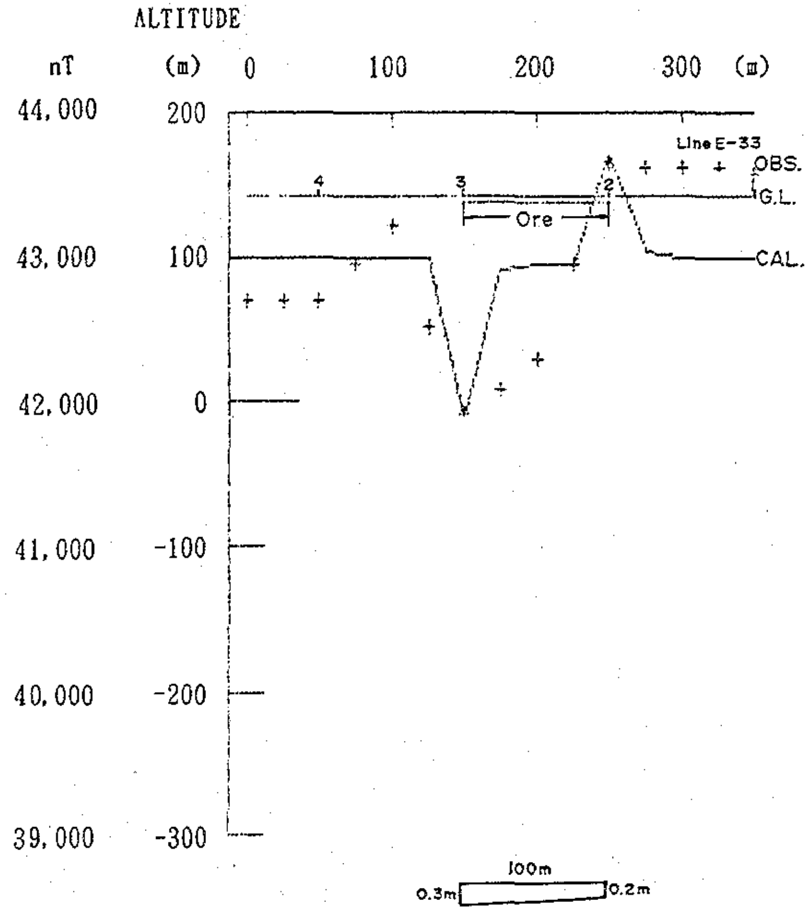
(b) Profile analysis result

Fig.22 Result of Magnetic Profile Analysis (C-V-16)

PHI= 33° K=165,000emu/cc



(a) Thin slab model



(b) Profile analysis result

Fig.23 Result of Magnetic Profile Analysis (E-IV-14)

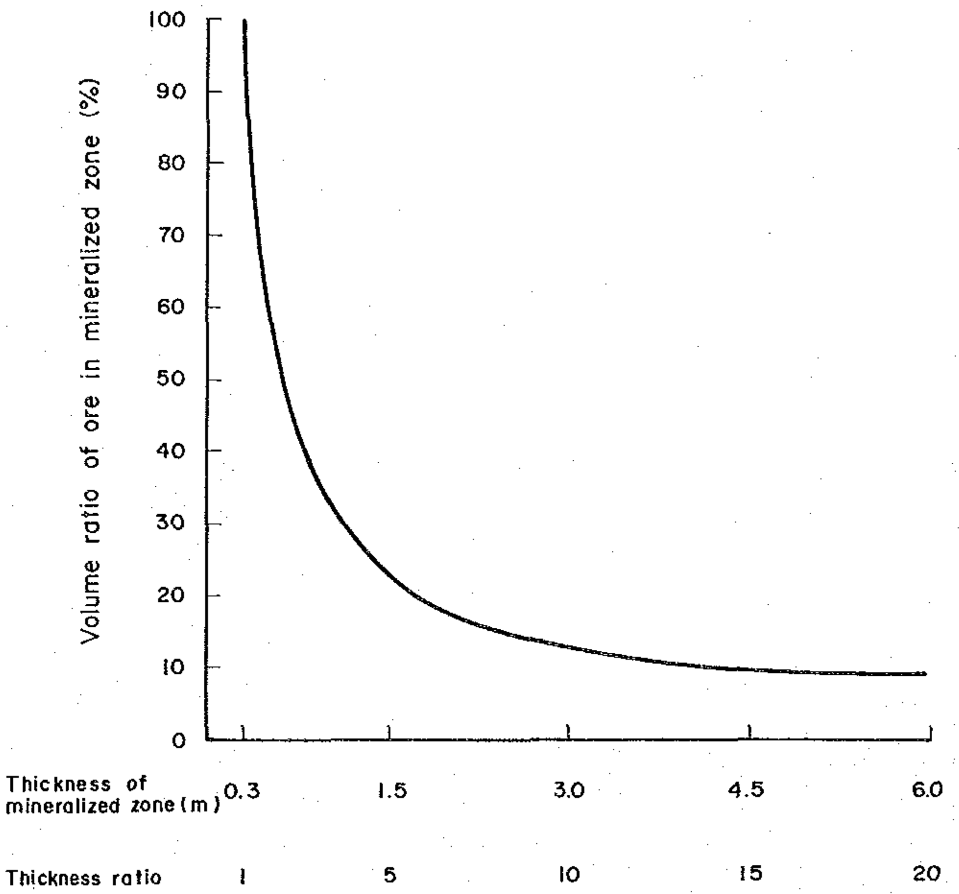


Fig.24 Volume Ratio of Ores in Mineralized Zone versus Thickness of Mineralized Zone

Fig.24 shows the relationship between the volumetric ore ratio and the thickness of the mineralized zone, modeled with a 100m width and 30cm equivalent thickness. Compared to the thickness(equivalent thickness) of the zone consisting only of ore, the thickness of the mineralized zone becomes 2, 4, 6, and 16 times greater with the ore volumetric ratio decreasing to 50%, 30%, 20% and 10% respectively.

In accordance with the occurrence of the ore confirmed by geological survey, if the volmetric ore ratio is estimated at 10%~20% in the mineralized zone, its thickness is around 10 times that of equivalent thickness.

The 8 mineralized zones (equivalent thicknesses : 20cm~150cm) determined by the present ground magnetic survey may be emplaced in the range from surface to around several m ~10 m in depth, on the condition that the above mentioned volumetric ore ratio applies.

Most magnetic anomalies in the non- mineralized zones are presumably located in, comparing the geologic sequence, relatively strongly magnetized intrusive rock areas. Of them, some anomalies delineate possibly small scale mineralized zones, but it seems they are limited ground surface, with an estimated 10% volumetric ore ratio.

CHAPTER 5 SYNTHETIC CONSIDERATION OF BT. RAJA AREA

5-1 Synthetic Analysis of Survey Methods

The survey results mentioned in chapter 2 Geological Survey, chapter 3 Geochemical Survey and chapter 4 Geophysical Survey are synthesized with respect to mineralization as follows :

(1) Geological survey

Twenty mineral indications occur in Raja granites and adjacent areas. Among the mineral indications, 9 indications consist of mainly magnetite (or hematite) accompanied by skarn. Some pyrrhotite and pyrite are recognized in part, but other ore minerals are rarely found in the indications. The indications are composed of round ore blocks in small or large size, and it is not sure whether they are emplaced insitu or not. The boulder- distribution zones are also recognized along a stream, extending more than several hundred meters.

There are occasionally pyrite-chalcopyrite-galena-sphalerite-molybdenite bearing quartz networks, quartz veins accompanied by pyrite-chalcopyrite-galena-sphalerite-molybdenite with skarn, showings of disseminated pyrite (or pyrrhotite), and "mineralized rock" occur occasionally.

The intrusive rocks in Raja area have intruded in 2 stages, St-1 during the period 50～60Ma, and St-2 after 25 Ma. In St-1(Raja granites), alkali and calcic granites co-exist. It may be inferred that the Raja granites consists of earlier intrusion and later intrusion, and granitic rock is somewhat later than dioritic rock. The later stage granite appears to has a relation to the mineralization in the Bt. Raja area.

(2) Geochemical survey

Twenty six anomalous areas were found by geochemical survey. The anomalous areas can be classified into 6 kinds based on main element - namely Mo, Au, Ag, Zn, Pb and Co, respectively - provided the main element is defined as the highest content element from threshold value compared to other assayed elements. The main element Mo has an unreversible relation to the other 5 main elements. That is, the anomalies of Au, Ag, Zn, Pb, and Co do not have anomalous Mo content, while Mo anomalous areas contain considerable amounts of Au, Ag, Zn, Pb, and Co.

The Mo anomalous zone usually occurs in Raja granites and its adjacent area, supposing a genetic relationship with granite. On the other hand, the anomalies of Au, Ag, Pb, Zn, and Co extend from the Raja granites area to a the outer in a broader distribution compared to that of Mo.

This fact reveals that the mineralization consists of molybdeneum minerals in a limited area, and polymetallic minerals of Ag, Au, Pb, Zn and Co occur,covering the Mo mineralization area and extending to more far-outer area, suggesting a zonal distribution of these elements and an origin of poly-metallic unit type in mono stage.

(3) Geophysical survey

The ground magnetic survey, a method of geophysical survey, obtained 6 magnetically anomalous areas. Of them, 4 areas are distributed at mineral indications consisting of intensely magnetizable minerals, while the other 2 areas do not correspond to such mineral indications.

Consequently, among intensely magnetizable mineral bearing indications, 5 indications were not confirmed by the ground magnetic survey. The survey was also unsuccessful in obtaining magnetic anomalies at 11 non-magnetized mineral indications.

A reason for the absence of a magnetic anomaly,even though there are intensely magnetized minerals, is that those minerals occupy only a small volume of the equivalent thickness. They are presumably emplaced only on the surface or in shallow.

5-2 Synthesis of Geology and Mineralization

(1) Geologic setting

The geologic sequence of the Bt.Raja area consists of the Mersip Limestone Member, middle Rawas Formation, and its correlative horizon (Rw-M). Raja granites have intruded into the Formation. In the area,Mersip Limestone Member seems to be thin, while tuffaceous, pelitic and psammitic facies predominantly thickens in the upper or lower beds of the Member. The transitional facies(Rw-T) of Rw-L and Rw-M becomes also predominant in the area.

(2) Geologic structure

The Bt.Raja area is located in an area of a synclinorium, running with a NW-SE axis plunged SE, and occupied by the Rw-M member and Raja granites in the axial part.

Folding structure of a small scale, trending NW-SE, and faults of NW-SE and NE-SW systems occur in the area. The synclinorium has been cut by the NE-SW faults running along R.Rawas, and the southeastern part (the S.Tuboh area) was elevated, bringing the Rw-M up by the fault.

The 2 fault systems could be deep fractures and they resulted in intrusion of igneous rock.

(3) Intrusive rocks

Of the intrusive rocks in the Bt.Raja area, the granite emplaced during the St-1 stage of 50～60 Ma is related to mineralization because of its rock series and diversity of its rock facies, as detailed below mention as follows:

(i) Raja granites were possibly derived from an alkali rock series magma. Calc-alkali rock series and calcic rock series of the granites were presumably formed as a production of magma differentiation.

(ii) The more alkalic melanocratic rock was older, while the calcic leucocratic rock was younger, during their igneous activity in the Raja granites. The former is of diorite, and the latter is of granite and granodiorite.

(iii) The younger leucocratic rock has presumably a close relationship with mineralization.

(4) Mineralization

The mineralization of the Bt.Raja area seem to be a porphry copper type with sulphid ores, rather than a magnetic(hematite)skarn type on the based of geologic,geochemical and geophysical synthesis.

Although studes on alteration zoning,mineral distribution, mineral forming temperature, and so on are not yet processed, the following facts suggest that the mineralization is of porphyry copper type :

The mineralizations of the Bt.Raja area are divided into 5 types by the mineral indications and the geochemical anomalies as follows ;

a-1) Fe-oxide※[1] + sulphide-1※[2] + skarn※[3]
a-2) Fe-oxide + sulphide-2※[2] + skarn
b-1) Quartz network veinlets accompanied by sulphide-1
b-2) b-1) + skarn
c) Fe-sulphide and very low-grade Cu-sulphide

※1) : Magnetite (or Hematite)
※2) : Sulphide-1 : sulphide minerals of Fe, Mo, Ag, Pb, Zn, Co, Cu + Au
: Sulphide-2 : sulphide-1 - Mo sulphide
※3) : Skarn : usualy andradite of garnet skarn

The sulphide minerals are commonly contained in all 5 types. These mineral indications extend slightly farther than the Fe-oxide distributon area, and it is presumed that the sulphide is of essential mineralization in the Bt.Raja area. Taking into the common features of the mineralizations into consideration, the b-1) type is regarded as the essential type of mineralization among the 5 types.

The b-1 type mineralization is characterized by the follows :

[ore mineral assemblage]	: Molybdenite, pyrite, chalcopyrite, sphalerite, and galena
[gangue minerals]	: Quartz (many), sericite(common), chlorite(few) (gangue minerals are generally of small amount)
[occurence]	: Network and filmy veinlets with quartz veins
[country rock]	: Raja granites(later stage leucocratic rock)

The features, namely ore mineral assemblage and their occurrence, the kind and amount of the gangue minerals, granitic rock as country rock and so on suggest that the mineralization of the Bt.Raja area is porphyry copper type.

Other types are inferred to be variations of the b-1) type, and features of the others are explainable as follows :

b-2) : This type contains skarn, differing from the b-1) type, and the difference is due to features ofthe calcareous country rocks among the S.Rawas Formation. The skarn type mineralization is emplaced in a farther zone from the granites than the b-1) type.

c) : This type is distributed at outer side of the b-2) type, and occurs as disseminated or weak mineralization. The country rock of this type is dioritic rock(melanocratic rock) of the early stage of the Raja granites, differing from the case of the b-2) type.

a-1), a-2) : The a-1) type is accompanied by Mo-sulphide while a-2) lacks Mo-sulphide. It may be inferred that this difference between both types is due to less dispersion ability of Mo, compared to other metallic sulphides. That is to say, Mo was deposited near the mineralization center (within the intrusive rock body), whereas other metallic sulphides spread farther, and consequently, the two type haveformed different type mineralizations. In actuality, a-1) type indications are emplaced at the middle stream of R.Menalu, and a-2) type indications are distributed at R.Seban and R.Padang. This can be attributed to distance from mineralization center and intensity of mineralization among them.

The Fe-oxide minerals of the a-1) and a-2) types have the following occurrence ;

i) Fe-oxides are usually ore(rounded ore) blocks which look like floating boulders

ii) Most of the ore boulders are presumably distributed on the ground surface in accord with the interpretation by ground magnetic survey.

iii) The indication is often accompanied by Fe-sulphide in its deeper part or lateral part. Geochemical anomalies also occur at the same place.

iv) No Fe-oxide ore has been found in the country rocks, except in a part of the S.Suban mineral indication.

At present,the Fe-oxide mineralization is not defined on its forming process, but it seems to be secondary origin, otherwise it could be a skarn type deposit since Fe-oxide deposit is commonly associated with skarn type deposit. This remains to be determined by a future assignment.

PART 3 SURVEY OF S.TUBOH AREA

PART 3 SURVEY OF S.TUBOH AREA

CHAPTER 1 OUTLINE OF DRILLING SURVEY

1-1 Summary of Drilling Survey

Investigated results on the geology and mineralization in the S. Tuboh area obtained by drilling survey (total length 1,510.80 m of 10 holes) are summarized as follows :

(1) The mineralization in the S. Tuboh area consists of two ore blocks, the west ore block and the east ore block. The former has a somewhat defined form and grade, while the latter is not traceable in its continuity.

(2) The east ore block has the following two cases, determined on the basis of mineral assemblage:

i) quartz-sphalerite ore in MJI-2 and MJI-10

ii) hedenbergite-galena-sphalerite ore in an adjacent old shaft(Sh-2)

(3) The west ore block extends from around the old shaft, Sh-1, to the west. It is emplaced on the foot wall side, hanging wall side, or both sides of a small intrusive body, and is of massive ore consisting of an ore mineral assemblage of sphalerite-galena-chalcopyrite-pyrite-pyrrhotite, and skarn minerals of predominant garnet.

(4) The west ore block consists of "two ore zones", one shallow, and one deep.

(5) A structure of the west block is merely depend on a intrusive rock bodies.

(6) A marble predominant rock facies distributed over the entire S.Tuboh area is of pelitic-calcareous, tuffaceous-calcareous, and psammitic-pelitic-calcareous limestone origin, correlating with the slightly lower horizon of the Mersip Limestone Member. The marble has a tendency to be of coarse grained in the original limestone, and fine grained in the calcareous rock, despite several exceptions.

The calcareous limestone origin marble yields water escaped structure, slump structure and grade bedding

(7) The sedimentary rocks fold in an anticline and a syncline with a NE-SW

axis. The large-and small-scale intrusive rocks trenching NE-SW with steep dip to the SE have intruded along the folding structure. The S.Tuboh area is located at the southeast flank of the syncline (northwest side or northwest flank of the anticline at the southeast).

(8) The intrusive rocks in the vicinity of the mineralized part are presumed to be a member of the quartz monzonite or its shallow facies distributed extensively at the northeast part and the southeast part of the S.Tuboh area,

(9) It may be inferred by determination of $^{87}Sr/^{86}Sr$ and age dating that the materials(metallic element) of the ore deposit have been derived from the Mersip Limestone Member by igneous activity of the quartz monzonite and succeeding hydrothermal activity.

(10) EPMA analysis reveals that silver bearing galena and gustavite are identified as the silver minerals.

Fig. 25 shows is the geological map with drilling location. The map was compiled, refering the results of drilling, and Fig 26 shows is schematic geological column.

1-2 Previous Survey Result

The geological and the geochemical surveys conducted in the initial phase revealed that three mineral indications are distributed at S.Sepan, S.Kering, and S.Tuboh in a detailed survey area of 18 km^2.

The former two are exposed along R.Sepan, a tributary of R.Rawas, and along R.Kering, a tributary of R.Sepan. Cherty quartz blocks containing dissemination of fine-grained pyrite are sporadically distributed in the indication area, and are smaller and poorer than those of the S.Tuboh indication.

On the other hand, in the S.Tuboh area there are two old shafts and many trenches prospected around three outcrops. The survey results indicate that the showing has some extention, and contain high grade ores. Five ore blocks bear Ag-Pb-Zn labelled as B_1, B_2, B_{3-1}, B_{3-2}, and B_4 are present along a contact zone of quartz monzonite, arranged in a NE-SW direction.

1-3 Survey Programme

A drilling survey (150m/hole × 8 holes = 1,200m) was planed in the S.Tuboh area within the second phase survey on the basis of the above-

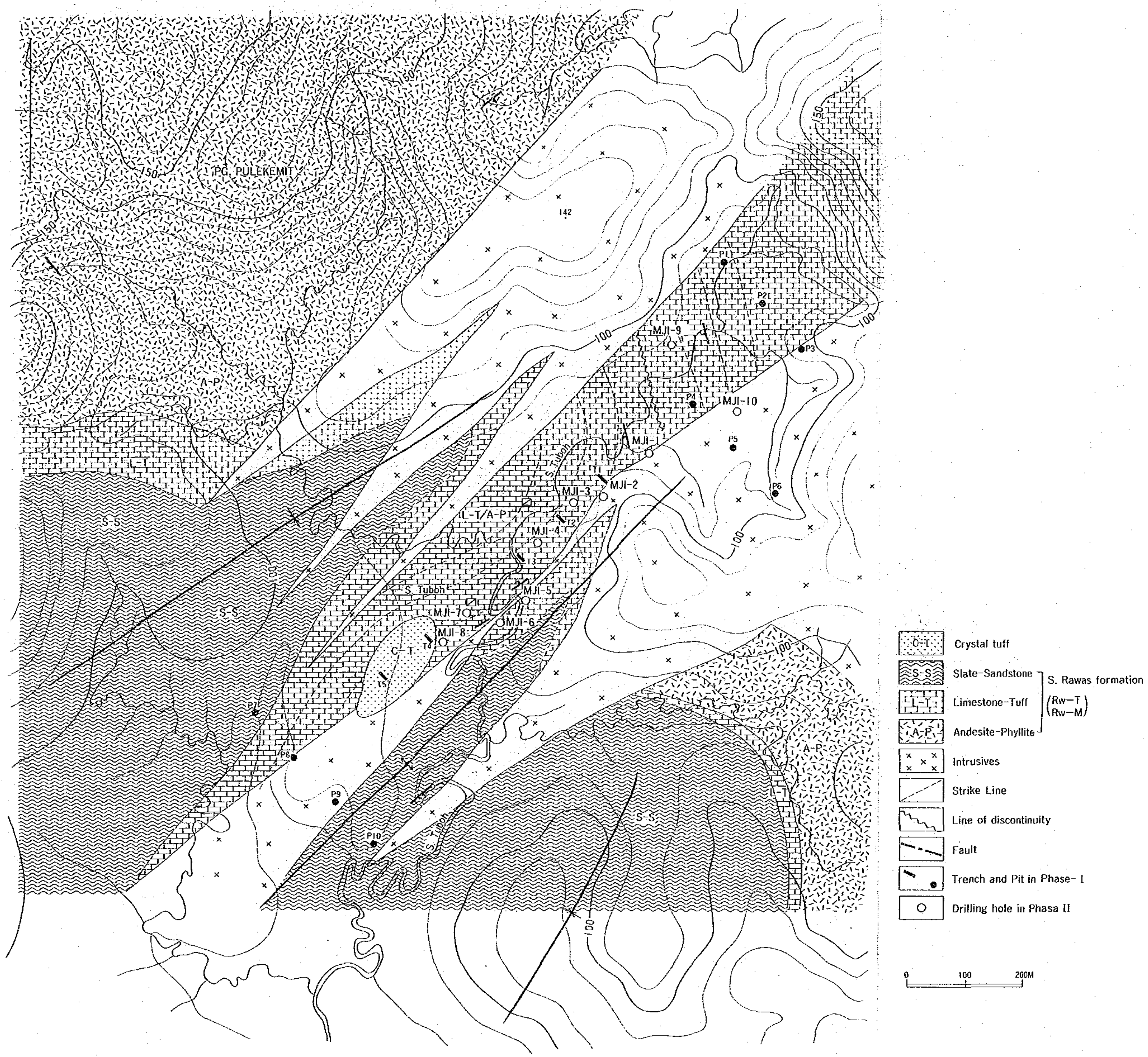


Fig.25 Geological Map of the S.Tuboh Prospective Area

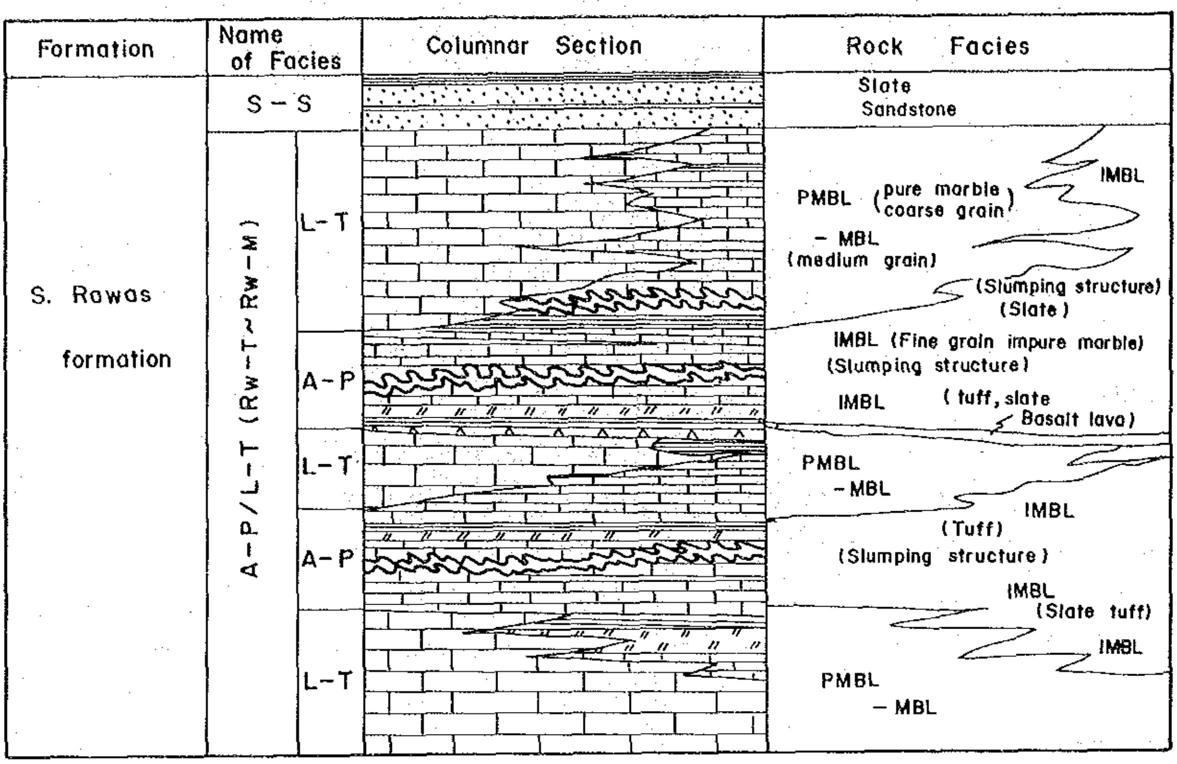


Fig.26 Schematic Geologic Column of the S.Tuboh Prospective Area

mentioned results, but the actual amount of the survey was increased to 150m/hole × 10 holes = 1,500m. Since it was a first stage drilling survey, the drilling was conducted with the aims of confirming extention and continuity of the ore blocks, and of unraveling characteristics of the mineralization, such as ore assemblage, grade, and relationship with igneous rocks

1-4 Drilling Operation and Drilling Record

Taking geologic and mineralogic condition into considerations, the drills were conducted following the order

MJI-7 → MJI-8 → MJI-5 → MJI-6 → MJI-4 → MJI-3 → MJI-1 → MJI-2 → MJI-9 → MJI-10.

The drilling machine, equipment and consumables used are listed in Table 11 and 12. The records of the drilling operation are shown in Table 13～Table 15. The drilling progresses are illustrated in Fig 27.

The drilling operation was performed very smoothly without delay by trouble and accident. It was extended by only a month even though two holes (total length 300m)were added. The smooth operation was attributed to the following reasons :

1) The process of PP-19 and customs clearance of machine and equipment at Palembang sea port progressed very smoothly, owing to outstanding coordination by the Directorate of Mineral Resources.

2) The machine, equipment and consumables were transported from base to site, from site to site by mobile power.

3) Local wokers were very capable of learning the drilling operation.

4) The operation was not stopped because care was taken to prevent accidents and maintain health control for the workers.

5) Geologic conditions were favourable for drilling.

The drilling machine, equipment and some consumables shipped from Japan were unloaded at Palembang sea port, and were transported from Palembang to Sulurangun by truck and from Sulurangun to S.Tuboh drilling base by helicopter. Some consumables, such as fuel and cement, were purchased at Lubuklinggau, the nearest city from the drilling site.

The operations of the move-in and move-out from site to site and

Table 11 Specifications of Drilling Machine and Equipments used

Drilling Machine. Model " OE - 8BL "	1 set		
Specifications :			
Capacity	300m (BQ WL)		
Dimensions L X W X H	1,550mmX700mmX1,260mm		
Hoisting capacity	2,000Kg		
Spindle speed	Forward 100,190,320,530,rpm		
Engine Model NS - 130CG	13 HP/2,200rpm		
Drilling pump. Model " MG - 10 "	1 set		
Specifications :			
Piston diameter	68mm		
Stroke	100mm		
Capacity	Discharge capacity	120 l/min	
	Max pressure	70 Kg/cm²	
Dimentions L X W X H	1,690mm X 580mm X 980mm		
Engine Model NS - 110C	11 HP/2,200 rpm		
Water supply pump. Model " TA - 500 "	1set		
Specifications :			
Capacity	Discharge capacity	60 l/min	
	Max pressure	20 Kg/cm²	
Engine Model NS - 50C	5.5 HP/2,400 rpm		
Wire line hoist. Model " WLH - 4 "	1 set		
Specifications :			
Rope capacity	500m		
Hoisting speed	8 ~ 105 m/min		
Engine Model NS - 40C	5 HP/2,400 rpm		
Mud mixer. Model " MCE - 250 "	1 set		
Capacity	200 l/ 1,000 rpm		
Engine Model NS - 50C	5.5 HP/2,400rpm		
Generator Model " NDY - 3.2S "	1 set		
Generator Model " YSC - 2S "	1 set		
Drilling tools			
Drilling rod	NQ-WL-- 3m --- 60pcs,	BQ-WL-- 3m --- 60pcs	
Casing pipe	HX ---- 1m ---- 3pcs,	NW ---- 3m --- 10pcs	
	NW ---- 1m ---- 3pcs,	BW ---- 3m --- 40pcs	
	BW --- 10m ---- 3pcs		
Derrick	1 set		
Specifications :			
Hight	9.5m		
Max load capacity	6,000Kg		
Crane carrier. Model " YFC - 2 "			
Capacity	960Kg		
Dimensions L X W X H	3,349mm X 1,692mm X 1,836mm		
Engine. Model " NS - 110C "	11 HP/2,200 rpm		

Table 12 Consumables Used

Discription	Specifications	Unit	Quantity										TOTAL
			MJI-7	MJI-8	MJI-5	MJI-6	MJI-4	MJI-3	MJI-1	MJI-2	MJI-9	MJI-10	
Light oil		l	960	975	1,045	960	1,450	980	1,090	930	1,060	1,310	10,760
Engine oil		l	28	31	30	25	30	30	35	20	35	135	399
Hydraulic oil		l	25	25	20	25	18	15	15	20	15	20	198
Gear oil		l	15	15	20	15	15	20	15	15	15	20	165
Grease		Kg	13	15	20	18	15	20	17	20	18	15	171
Bentonite		Kg	1,600	2,000	1,375	1,500	2,000	1,400	1,750	2,000	1,500	1,500	16,625
C.M.C.		Kg	80	100	65	70	75	70	80	70	60	60	730
Tel-stop		Kg	100	100	60	70	75	70	100	120	100	95	890
Sea clay		Kg	80	85	60	80	70	75	95	110	95	95	845
Cutting oil		l	80	100	80	70	80	70	75	80	80	75	790
Cement		Kg	120	520	120	120	120	120	120	120	120	120	1,600
Diamond bit	NQ-WL	pc	3	1	2	2	2	2	2	1	-	-	15
Diamond bit	BQ-WL	pc	-	2	2	2	2	1	1	2	2	2	16
Diamond reamer	NQ-WL	pc	2	1	1	-	-	-	1	1	-	-	6
Diamond reamer	BQ-WL	pc	-	1	1	1	1	1	1	1	1	1	8
Casing shoe	HX	pc	2	2	2	2	2	2	2	2	2	2	20
Casing shoe	BX-BW	pc	1	1	1	1	1	1	1	1	1	1	10
Core barrel Ass'y	NQ-WL	set	1	-	-	-	-	1	-	-	-	-	2
Core barrel Ass'y	BQ-WL	set	1	-	-	1	-	-	-	1	-	-	3
Inner tube	NQ-WL	pc	1	-	1	-	-	1	-	-	1	-	4
Inner tube	BQ-WL	pc	1	-	-	1	-	1	-	-	1	-	4
Core lifter case	NQ-WL	pc	1	1	1	1	1	1	1	1	1	1	10
Core lifter case	BQ-WL	pc	-	1	1	2	1	2	2	1	2	1	13
Core lifter	NQ-WL	pc	2	2	2	2	2	2	2	1	1	1	17
Core lifter	BQ-WL	pc	1	2	2	2	2	2	2	2	2	2	19
Thrust ball bearing	NQ-WL	pc	-	2	2	-	-	2	-	-	2	-	8
Thrust ball bearing	BQ-WL	pc	-	2	-	2	-	-	2	-	-	2	8
Innertube stabilizer	NQ-WL	pc	1	-	-	1	-	-	1	-	1	-	4
Innertube stabilizer	BQ-WL	pc	1	-	-	-	1	-	-	-	1	-	3
Chack pice	NQ-WL	set	1	-	-	-	1	-	-	1	-	-	3
Chack pice	BQ-WL	set	1	-	-	-	-	-	1	-	-	-	2
Cylinder liner	68mm	pc	2	-	-	-	-	-	-	-	-	-	2
Piston rod		pc	2	-	-	-	-	-	2	-	-	-	4
piston rubber	68mm	pc	4	-	-	4	-	-	-	4	-	-	12
Wire rope	6m/m, 200m	roll	1	-	-	-	-	1	-	-	-	-	2
Core box	NQ-WL	pc	22	8	11	8	8	8	8	5	4	4	86
Core box	BQ-WL	pc	-	10	9	9	9	9	9	12	13	12	92
Casing bit	NX-NW	pc	-	-	1	-	1	-	-	-	-	-	2

Table 13 Drilling Life of the Diamond Bits Used (1)

Item	Size of bit	Type of bit	Carats per bit (Ct)	Matrix	Stones per carat	Waterway	Total bit Used
	79.0mm	NQ-WL	30	E	1/15	6	15
	79.0mm	NQ-WL	---	---	----	---	----
	79.0mm	NQ-WL	---	---	----	---	----
	79.0mm	NQ-WL	---	---	----	---	----
Diamond Bit	62.0mm	BQ-WL	22	C	1/15	4	15
	62.0mm	BQ-WL	22	CE	1/15	4	1
	62.0mm	BQ-WL	---	---	----	---	----
Total			74	---	----	---	31

E : for ordinary rock

CE : for ordinary rock

C : for hard rock

Table 14 Drilling Life of the Diamond Bits Used (2)

Item	Size	Bit No.	Drilling Meterage by hole Unit : Meter										Total(m)
			MJI-7	MJI-8	MJI-5	MJI-6	MJI-4	MJI-3	MJI-1	MJI-2	MJI-10	MJI-9	
Diamond bit	NQ	NNI- 1	50.60										50.60
		NNI- 2	53.50										53.50
		NNI- 3	40.10	11.00									51.10
		NNI- 4		38.50									38.50
		NNI- 5			32.20								32.20
		NNI- 6			31.00								31.00
		NNI- 7				35.70							35.70
		NNI- 8				27.00							27.00
		NNI- 9					33.00						33.00
		NNI-10					30.80						30.80
		NNI-11						38.50					38.50
		NNI-12						32.50					32.50
		NNI-13							49.30				49.30
		NNI-14							27.30	18.10			45.40
		NNI-15								14.00	21.80	6.80	42.60
Total(15)			144.20	49.50	63.20	62.70	63.80	71.00	76.60	32.10	21.80	6.80	591.70
	Drilled length/Bit(591.70m / 15ｹ)												39.40
Diamond bit	BQ	NBI- 1		50.10									50.10
		NBI- 2		46.90									46.90
		NBI- 3			35.00								35.00
		NBI- 4			44.00								44.00
		NBI- 5				55.00							55.00
		NBI- 6				27.00	15.00						42.00
		NBI- 7					48.00						48.00
		NBI- 8					14.40	48.00					62.40
		NBI- 9						28.00	22.00				50.00
		NBI-10							48.00				48.00
		NBI-11								56.00			56.00
		NBI-12								50.00			50.00
		NBI-13									59.50		59.50
		NBI-14									58.70		58.70
		NBI-15										58.00	58.00
		NBI-16										60.20	60.20
	Total			97.00	79.00	82.00	77.40	76.00	70.00	106.00	118.20	118.20	823.80
	Total		Drilled length/Bit (823.80m / 16ｹ)										51.50
Grand Total			Drilled length/Bit (NQ and BQ) (1,415.5m / 31ｹ)										45.66

Table 15 Summarized Table of the Drilling Operation (1)

Hole No.	Terms of drilling	Drilling				Shift		Working man		Working Time						S.Total
		Bit Size	Drilling	Core length	Core recovery	Drilling	Total	Engineer	Worker	Drilling	Other working	Recovering	Total	Removing	Road construction and other	
MJI-7	8.28.1986	HX	6.00(m)	0(m)	(%)	1(shift)	10(shift)	42(man)	104(man)	5°00′(h)	1°00′(h)	(h)	6°00′(h)	24°00′(h)	40°00′(h)	70°00′(h)
	~	NQ	144.00	144.00		15	16	36	79	80°00′	24°50′	32°40′	138°00′			138°00′
	9.4.1986	Total	150.00	144.00	99.8	16	26	78	186	85°00′	25°50′	32°00′	144°00′	24°00′	40°00′	208°00′
MJI-8	9.8.1986	HX	4.50	0		1	3	18	40	4°00′	1°00′		5°00′	12°00′	12°00′	29°00′
	~	NQ	49.50	48.90		4	4	9	12	20°30′	8°00′	11°00′	39°30′			39°30′
	9.13.1986	BQ	97.00			10	7	27	47	54°30′	16°30′	28°30′	99°30′			99°30′
		Total	151.00	145.90	99.5	15	21	54	99	79°00′	25°30′	39°30′	144°00′	12°00′	12°00′	168°00′
MJI-5	9.23.1986	HX	8.80	0		1	9	60	137	6°00′	1°00′		7°00′	24°00′	40°00′	71°00′
	~	NQ	63.20	60.00		5	5	13	15	30°30′	7°00′		37°30′			37°30′
	9.26.1986	BQ	79.00	79.00		6	8	21	33	41°30′	10°00′	8°00′	59°30′	8°00′		67°30′
		Total	151.00	139.00	97.7	12	22	94	185	78°00′	18°00′	8°00′	104°00′	32°00′	40°00′	176°00′
MJI-6	9.30.1986	HX	6.30	0		1	6	16	50	5°00′	30′		6°20′	32°00′	16°00′	54°20′
	~	NQ	62.70	62.70		5	5	13	15	31°10′	7°00′		38°10′			38°10′
	10.4.1986	BQ	82.00	82.00		6	8	13	27	41°00′	9°30′	9°00′	59°30′			59°30′
		Total	151.00	144.70	100.0	12	19	42	92	78°00′	17°00′	9°00′	104°00′	32°00′	16°00′	152°00′
MJI-4	10.7.1986	HX	11.20	0.60		1	4	24	62	6°00′	1°00′		7°00′	20°00′	12°00′	39°00′
	~	NQ	63.80	63.80		5	5	13	15	31°00′	8°00′		39°00′			39°00′
	10.11.1986	BQ	77.40	77.40		7	18	27	38	42°00′	10°00′	6°00′	58°00′			58°00′
		Total	152.40	141.80	100.0	13	17	64	115	79°00′	19°00′	6°00′	104°00′	20°00′	12°00′	136°00′
MJI-3	10.14.1986	HX	4.00	0		1	4	19	65	5°00′	30′		5°30′	24°00′	8°00′	37°30′
	~	NQ	71.00	71.00		5	5	13	15	32°30′	8°00′		40°30′			40°30′
	10.17.1986	BQ	76.00	76.00		6	8	24	60	40°30′	9°30′	8°00′	58°00′			58°00′
		Total	151.00	147.00	100.0	12	17	56	140	78°00′	18°00′	8°00′	104°00′	24°00′	8°00′	104°00′
MJI-1	10.26.1986	HX	4.40	0		1	7	40	140	5°00′	30′		5°30′	28°00′	28°00′	61°30′
	~	NQ	76.60	70.50		6	6	15	18	31°00′	10°30′	3°00′	44°30′			44°30′
	10.29.1986	BQ	70.00	70.00		5	7	33	92	34°00′	12°00′	8°00′	54°00′			54°00′
		Total	151.00	140.50	95.8	12	20	88	250	70°00′	23°00′	11°00′	104°00′	28°00′	28°00′	160°00′
MJI-2	11.5.1986	HX	12.90	0		1	6	40	83	6°00′	1°00′		7°00′	20°00′	28°00′	55°00′
	~	NQ	32.10	10.40		2	2	5	6	13°00′	12°00′		25°00′			25°00′
	11.8.1986	BQ	106.00	106.00		9	11	35	102	54°00′	10°00′	8°00′	72°00′			72°00′
		Total	151.00	116.40	84.2	12	19	80	191	73°00′	23°00′	8°00′	104°00′	20°00′	28°00′	152°00′

Table 15 Summarized Table of the Drilling Operation(2)

Hole No.	Terms of drilling	Drilling				Shift		Working man		Working Time						G.Total
		Bit Size	Drilling	Core length	Core recovery	Drilling	Total	Enginer	Worker	Drilling	Other working	Recovering	Total	Removing	Road construction and other	
MJI-9	12.1.1986	HX	11.20	0		1	8	44	155	5°00′	30′		5°30′	16°00′	48°00′	69°30′
	~	NQ	21.80	9.35		1	1	3	3	7°00′	2°30′		9°30′			9°30′
	12.4.1986	BQ	118.20	114.15		10	12	31	59	66°00′	15°00′	8°00′	89°00′			89°00′
		Total	151.20	123.50	88.2	12	21	78	217	78°00′	18°00′	8°00′	104°00′	16°00′	48°00′	168°00′
MJI-10	11.18.1986	HX	26.00	0		1	8	45	148	4°00′	30′		4°30′	16°00′	48°00′	68°30′
	~	NQ	6.80	6.25		1	1	3	3	7°00′	1°30′		8°30′			8°30′
	11.21.1986	BQ	118.20	116.65		10	12	30	26	64°00′	19°00′	8°00′	91°00′			91°00′
		Total	151.00	122.90	90.30	12	21	78	177	75°00′	21°00′	8°00′	104°00′	16°00′	48°00′	168°00′
Grand Total			1,510.80	1,365.70	95.5	128	203	712	1,652	773°30′	208°20′	138°10′	1,120°00′	224°00′	280°00′	1,624°00′

※ Core recoverry : excspt soil part

preparation at the drilling site were done by one shift per day, while the drilling operation was carried out by three shifts per day. The each of drilling shift was organized by a Japanese engineer, an Indonesian counterpart and two Indonesian workers.

The drilling operation was performed by means of wire line method using an oversized diamond bits NQ(79 mm diameter) and BQ(62 mm diameter) with conventional drilling using HX single bit through the surface soil and weathered rock(approximately 4.00~15.00m in depth). Circulating water often leaked out through a cracks and caves in the limestone, and Sea clay(asbestos fraction) and Telstop(vermiculite fracture) were used to stop the leakage.

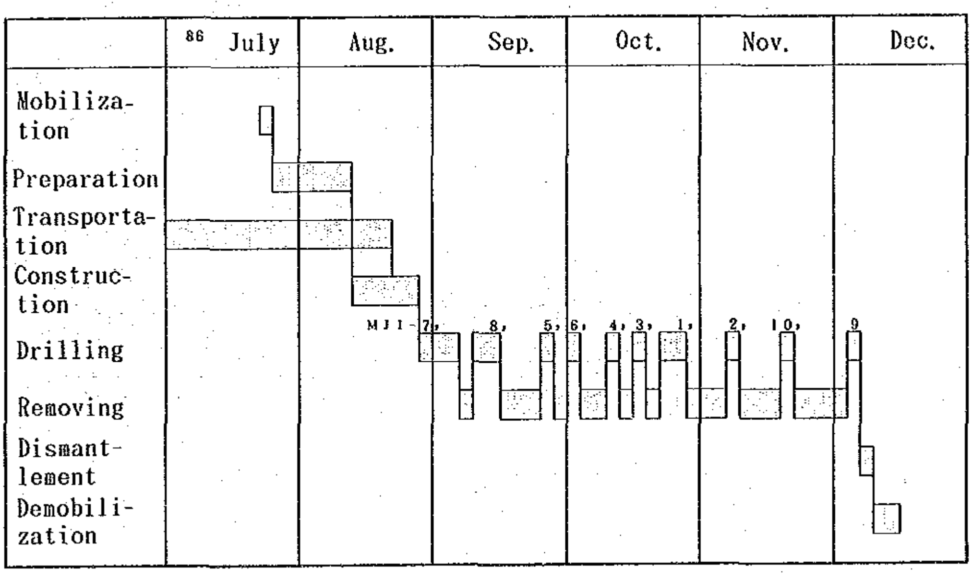
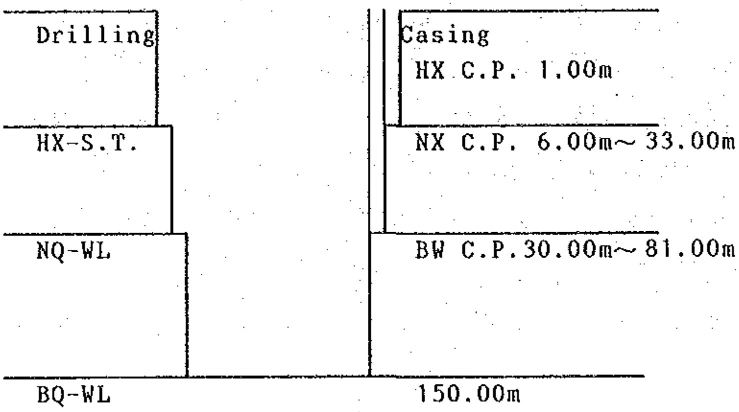


Fig. 27 Progress of Drilling Work

The casing programme is shown in the following figure.



The records of the operations are summarized in Table 16.

Table 16 Summerized Table of the Drilling Operation

Number of holes	10 hole	Used diamond bit
Total drilling length	1,510.80m	NQ 15pcs : Drilled length
Total core recovered	1,365.70m	Bit life 39.4m/pcs
Core recovery	90.40%	BQ 16pcs : Drilled length 623.80m
-ditto-(except surface soil)	95.50%	Bit life 44.7m/pcs
Total shift of drilling work	128 shift	
Total shift	203 shift	
Man-day(Engineer)	712 man-day	
man Man-day(worker)	1,652 man-day	
Working hours (Drilling)	773°30′	
(Other))	208°20′	
(Recovery)	138°10′	
(Sub-total)	1,120°00′	
(Removing)	224°00′	
(Road construction and others)	280°00′	
(Sum total)	1,624°00′	

CAPTER 2 GEOLOGY AND MINERALIZATION BY DRILLING.

The geology and mineralization obtained by drilling survey are described as follows , and the geologic profiles are shown in Fig. 28~Fig.37.

2-1 MJI-1

[Purpose] : The mineralized zone of B_1, even though it has been strongly weathered, is observed with about a 20m extention 40m west of the drill site. Also the zone is situated at the marginal part of the quartz monzonite, judging from the geological condition around the area. The drill was planned to prospect the ore shoot of B_1 and the mineralization, presumably embedded in the vicinity of quartz monzonite.

[Result] : A garnet skarn occurs from 8.89m to 8.94m. It is accompanied by a small number of pyrite and a minimum number of sphalerite. A similar skarn from 114.03m to 114.13m is very thin and barren of ore mineral. A marble seems to be of marl and tuffaceous limestone origin, and is slightly coarse-grained. Slump structure occurs from 58.50m to 61.10m, and grading structure from 80.00m to 85.00m.

[Consideration] : The large quartz monzonite body extending southeast on the surface ground did not appear in the drill hole, but it may be distributed several meters southeast of the hole considering the existence of coarse-grained marble in the hole. Although the hole is very close to the quartz monzonite, it did not penetrate any noticeable mineralized parts. There is no small intrusive dyke, and it indicates lack of mineralization in the hole

2-2 MJI-2

[Purpose] : Weathered and decomposed quartz diorite occurs at the bottom of trench T-1 in the vicinity of the site. The drill is aimed at unravelling the contact of the quartz diorite with sedimentary rocks, and the prospecting possibility of mineralization emplaced at depth.

[Result] : The drilling yielded an ore body at a depth from 12.90m to 13.30m, and from 39.17 m to 39.50m. A core was not recovered from 13.30m to 26.00m and from 39.50 to 43.90m beneath the ore bodies because of the presence of caves.

The ore of 12.90m～13.30m is of a quartz-sphalerite-galena assemblage with a small amount of garnet, pyrite, and a minimum number of molybdenite.

An assay result of the ores is as follows :

Sample No.	Depth (m)	wd (m)	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Co %	Mo %
MJI-2-1	12.90～13.30	0.40	0.14	72.5	0.77	0.52	9.20	0.017	0.001
MJI-2-2	39.17～39.50	0.33	0.14	58.0	0.06	0.23	6.72	0.012	0.002

White coarse-grained massive marble occurs from 43.90m to 112.50m. A water escaped structure is clearly observed from 132.95m to133.35m, and slumping structure consisting of fine-grained tuffaceous or pelitic thin beds or patches is common below 133.35m.

[Consideration] : The ore seems to be of a different feature compared to those of MJI-6,7 and 8, mentioned later, as a result of the fact that the ore is emplaced in the vicinity of a large quartz monzonite body, and contains rich quartz.

It may be inferred that the two caves below the ore zones are not old stoped area, because traces of ore-dissolution are observable at the boundary of the caves. If these caves were filled by ores, the following two cases are considered:

i) The case of ores with gangue minerals : Insoluable part, such as quartz, should remain as residuals after dissolution of ores. Thus it would probably not be ores.

ii) The case of massive ore with a small amount of gangue minerals : In the cases of MJI-6,7 and 8, high-graded massive ores contain fine-grained garnet and green skarn or massive pyrite ore. In this case, whole components might be dissolved away. This type could be of high-grade massive ore or massive pyrite ore.

The coarse-grained marbles are of limestone origin from 43.90m to 112.50m and of tuffaceous, pelitic, sandy-pelitic limestone origin below 112.50m. Water escaped structure, slumping structure and graded bedding are observed in the marble. It may possibly be inferred that sand, mud, and tuff materials were secondarily moved as turbidite current and deposited mixing with calcareous sediments.

2-3 MJI-3

[Purpose] : The drilling was conducted to prospect the extension of ore shoot B_{3-1} with MJI-4. Ore shoot B_{3-1} is inferred from evidence from the old shaft 80m west of MJI-3 and 65m north-northwest of MHI-4, and from lumpy ores around Sh-2.

[Result] : An altered pale-orange intrusive dyke occurs from 92.90m to 94.50m, but with no ore. Chlorite-hematite is observed in 2 cm of the upper boundary, and films of pyrite at the lower boundary.

Another pale-orange dyke occurs from 23.45m to 23.75m, and a breccia dyke from 23.95m to 24.15m is also presumed to be a member of the dyke. Quartz and quartz-pyrite veinlets are extensively distributed from 4.70m to 85.20m. These quartzes are dark brown to black transparent chert, and contain very fine-grained pyrites.

A basalt lava is present from 122.35m to 123.60m. Tuffaceous slates above (121.20m to 122.35m) and below (123.60m to 124.25m) the lava have been altered to biotite hornfels.

Though the muddy or tuffaceous limestone origin marble is not common as compared with that of MJI-2, a cloudy patterned marble below 41.30m and very fine-grained marl might be correlative with the marble.

[Consideration] : No ore in the hole could be due to a difference of physico-chemical condition as discussed in chapter 3, in spite of the existense of igneous dykes.

A rock facies resembling the lava of 122.35m to 123.60m is exposed at the uppermost area of R.Larang, a north on tributary of R.Tuboh (1km north of Sh-1), associated with calcareous sericite-chlorite schist. The horizon is correlative with the lower horizon(Rw-L) or transitioned horizon(Rw-T) of the limestone predominant rock facies.

2-4 MJI-4

[Purpose) : The drilling was aimed at unravelling the features of ore shoot B_{3-1}, along with MJI-3.

[result] : In general, geology of the hole is similar to that of MJI-3, except there was no occurrence of the dyke rock, skarn or mineralization. Rocks from 100.40m to 108.20m possess slumping structure, and thin talc

layers are visible from 107.30m to 108.80m. The basalt lava is also present from 115.30m to 115.80m

[Consideration] : The ore shoot B_{3-1} inferred from slump ores at Sh-2 does not extend to the site, or it dips steeply and thus the drill did not catch the ore. The area is, stratigraphically,a slightly deeper horizon than that of MJI-3, because cloudy patterned limestone occurs from surface, and also the basalt horizon is slightly shallower than that of MJI-3.

2-5 MJI-5

[Purpose] : The purpose of the drilling was to unravel the extention and features of ore shoot B_2. The B_2 is hanging on quartz diorite like blanket, and hanging wall consists of coarse-grained. It is high grade Pb-Zn-Cu ore, but is of a small scale of 3.0m× 3.5m× 0.8m(thickness) at its outcrop.

[Result] : A pale-orange coloured altered rock of" quartz monzonite(Dk-1)" occurs from 19.10m to 22.60m, possessing veinlets of quartz-pyrite-garnet. Hematite, epidote, and magnetite replace phenocryst minerals at 19.10m~ 20.20m and 22.25m~ 22.60m. However mineralization like outcrop B_2 was not found in this section. Components of 61-ST-42(argillized part) and 61-ST-43 sampled from the rocks were detected by X-ray diffractive analysis and microscopic observation as follows :

61-ST-42(X-ray) : Quartz > calcite > grossular - epidote - pyrite - chlorite - mixed layer mineral ?

61-ST-43(thin section): Quartz - plagioclase > opaque mineral - calcite - chlorite (most quartz are "secondary"

It is not clear why grossular occurs in 61-ST-42. It is only pointed out that the occurrence of grossular is in reverse relation to the emplacement of the ore shoot, as will be mentioned in the next chapter. 61-ST-43 is probably altered trachy andesite, as mentioned in the supplementary note..

The intrusive rock is present at 92.80m~ 97.00m, but contains only garnet, epidote, and hematite.

Quartz-pyrite bearing veinlets 10mm~ 2mm in thickness exist at 14.10m, 14.20m, 16.00~ 16.15m, 17.90~ 18.10m, 26.20~ 29.50m, 28.80m, 30.20m, and 106.65m. The basalt lava occurs from 99.69m to 100.15m, and it has undergone skarnitization. Several grains of sphalerite and galena are observed at 10 cm in the hanging part of the skarn. The boundaries of the hanging and foot sides of the lava are horizontal.

[Consideration] : The hole was drilled at 10m depth from outcrop B_2, nevertheless the hole was unsuccessful in finding ore. This fact indicate that the outcrop of B_2 is of a knob-shaped shoot , and that hematite existing in the dyke indicate the terminal part of an ore zone. A large number of quartz-pyrite veins presumably show also the end part or shallow facies of a mineralization.

2-6 MJI-6

[Purpose] : The hole was conducted to confirm the continuity of the ore shoot B_1 near the old shaft(Sh-1) to its dip side, and to unravel the variation of the ore mineral assemblage and the structural control of the mineralization.

[Result] : A mineralized zone was discovered from 128.70m to 133.28m. The zone is divided into following three sections based on their appearance :

128.70～129.50m : Browny red sphalerite(hanging wall)-black sphalerite (foot wall side)-calcite- quartz-hedenbergite zone. A bandded structure dipping 35° occurs from 128.70m to 128.76m.

129.50～131.80m : Skarnitized intrusive rock(DK-2)

- 129.50～130.98m : Grayish green, bands dipping 85°
- 130.90～13138m : Mostly consists of quartz with disseminated and button-shaped pyrite and molybdenite.
- 131.38～131.80m : Green skarn zone

131.80～133.28m : Chalcopyrite-sphalerite(black)-galena-calcite-hedenbergite-garnet zone

- 131.80～132.80m : High-grade ore
- 132.80～132.93m : Quartz-siderite
- 132.93～133.08m : High-grade ore
- 133.08～133.23m : Galena-sphalerite-hedenbergite banded ore

133.23~133.28m : Calcite-hedenbergite-sphalerite banded ore

High grade ore sections are emplaced holding a skarn body dipping 85° at the upper and 50° at lower boundaries, between them. The ore part is in contact with marble, dipping 35° and 26° at upper and lower boundaries respectively. Assay results of the ore zone are shown in following table ;

A gustavit ($AgPbBi_3S_6$) and a silver bearing galena have been detected from 61-ST-55 collected at 131.90m (refer to Note-8).

Sample No.	Depth (m)	wd (m)	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Co %	Mo %
MJI-6-1	128.70~129.50	0.80	0.07	36.0	1.15	0.06	1.99	0.022	<0.001
MJI-6-2	129.50~130.50	1.00	<0.07	11.5	0.01	0.04	0.03	0.004	<0.001
MJI-6-3	130.50~131.50	1.00	0.96	205.0	0.03	0.79	0.02	0.008	<0.001
MJI-6-4	131.50~131.80	0.30	<0.07	9.5	0.02	0.03	0.07	0.005	<0.001
MJI-6-5	131.80~132.80	1.00	0.75	280.0	6.10	0.54	11.30	0.053	<0.001
MJI-6-6	132.80~133.28	0.48	0.07	132.0	4.49	0.15	17.90	0.051	<0.001
Mean		4.58	0.39	129.2	2.01	0.33	4.71	0.024	<0.001

Cream-yellowish or pale-orange coloured intrusive rocks occur at 14.25~15.20m and 42.20~46.20m, and the latter contains network pyrite-quartz veinlets.

A breccia dyke-like part and marble breccias embedded in a ground mass consisting of greyish black coloured limestone and fine fragments of cherty quartz in the rock are found from 44.20m to 66.25m..

A fine-grained marble from 66.25~91.60m has a dissemination of hematite between 67.10m and 69.60m. A very fine-grained marble occurs from 91.60m to 101.40m, and within this marble, dark-green hornfelsic tuffaceous rock which occurs in 98.85 to 99.20 is presumably derived from basalt product.

[Consideration] : The ore zone of 128.70~133.28m continues possibly to "an ore deposit zone" combining ores at 44.20~47.92m and 52.93~56.20m of MJI-7 and 63.85~65.73m of MJI-8 as a (intrusive rock + ores). (MIJ-7 and MJI-8 have found another ore deposit at a deeper horizon, and in MJI-6 the ore horizone could be emplaced at a depth of more than than 200m.)

The intrusive rock of 42.20m~46.20m would be correlative with the intrusive rocks at 19.10~22.60m of MJI-5, and it also shows a barren zone.

The brown to black quartz-pyrite veins occurring at the deeper part below 9.05m to 29.50m is also in sequence with the veinles at 14.10~30.20m of MJI-5. The fine-grained facies of marble from 66.25m to 139.90m is correlative with the facies of MJI-2 at 112.50 m and deeper.

2-7 MJI-7

[Purpose] : The hole aimed at unravelling the emplacement condition and mineralized condition of B_1 ore shoot adjacent to old shaft(Sh-1). It was the first hole in the programme.

[Result] : The ore shoots were discovered at 44.20~47.92m, 52.93~56.20m 134.98~135.18m, 136.94~137.24m, and 138.30~138.55m, associated with intrusive rocks. The ore zones are as follows in detail :

44.20~47.92m : Massive ore consisting of reddish sphalerite-galena-chalcopyrite-quartz-garnet-hedenbergite-calcite. The ore is divided into two parts by a skarnitized intrusive rock occurring at 46.50~47.05m. The boundary between both dips 70° .

52.93~ 56.20m : Massive ore

- 52.93~ 53.35m : hedenbergite-calcite-reddish sphalerite
- 53.35~ 54.69m : black sphalerite-chalcopyrite-galena
- 54.69~ 54.95m : Galena-calcite-green skarn banded ore, mostly consisting of sphalerite
- 54.95~ 55.22m : calcite (marble)
- 55.22~ 56.20m : banded green-skarn-sphalerite ore

furthermore, skarnitized intrusive rock at 56.20~59.63m consists of green skarn at 56.20~56.98m and banded green skarn at 57.45~57.50m, dipping 60° with the lower intrusive rock.

134.98~135.18m : Mosaic-patterned massive ore of sphalerite-galena-chalcopyrite

136.94~137.24m : banded ore of calcite-green skarn-sphalerite

138.30~138.55m : Banded part of calcite-green skarn-garnet with sporadic sphalerite

A dark green fine-grained rock occurs from 138.55m to 142.35m, and within this rock, 138.55~139.20m is decolourized to pale-orange and contains garnet. At the lower boundary at 142.35m, garnet is present in 1～5mm in thickness.

Assay results are shown in the following table ;

Sample No.	Depth (m)	wd (m)	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Co %	Mo %
MJI-7-1	44.20~45.20	1.00	0.21	790.0	0.20	2.87	14.60	0.024	0.001
MJI-7-2	45.20~46.20	1.00	0.14	420.0	0.46	1.45	32.50	0.051	0.001
MJI-7-3	46.20~46.60	0.40	<0.07	77.0	0.07	0.27	3.84	0.009	0.001
MJI-7-4	46.60~47.05	0.45	<0.07	7.0	0.01	0.03	0.34	0.004	0.001
MJI-7-5	47.05~47.92	0.87	<0.07	88.0	0.05	0.98	6.94	0.015	0.001
MJI-7-6	52.93~53.35	0.42	<0.07	138.0	0.84	0.61	6.01	0.012	0.001
MJI-7-7	53.35~54.35	1.00	0.14	355.0	4.73	10.60	13.60	0.020	0.001
MJI-7-8	54.35~54.95	0.60	0.07	200.0	0.12	2.03	10.90	0.021	0.001
MJI-7-9	54.95~55.22	0.27	0.14	11.0	0.01	0.11	0.33	0.002	0.001
MJI-7-10	55.22~56.20	0.98	0.07	114.0	0.21	0.87	7.81	0.016	0.001
MJI-7-11	134.98~135.18	0.20	0.07	285.0	1.74	15.80	19.90	0.021	0.001
MJI-7-12	136.94~137.24	0.30	0.07	202.5	0.08	1.31	3.65	0.008	0.001
MJI-7-13	138.30~138.55	0.25	0.07	35.0	0.o1	0.22	0.94	0.004	0.001
M(1～5)	44.20~47.92	3.72	0.09	355.0	0.20	1.42	14.74	0.025	0.001
M(6～10)	52.93~56.20	3.27	<0.07	198.1	1.64	3.96	9.30	0.016	0.001
M(1～10)		6.99	0.07	281.6	0.87	2.61	12.19	0.021	0.001

An intrusive rock occurs in the range from 36.83m to 37.13m, and from 38.05 to 38.20m. The former zone is a garnet bearing dark greyish rock, and the ltter part is pale-orange altered rock with flow bands.

Below 19.25m, cloudy patterned structure occurs commonly in the rock, and there are laminated fine-grained facies at 82.50～106.90m and 112.60～138.30m, intercalatied layers of biotite-hornfelsic slate and fine-grained tuff, and andesite or basalt lava occur at 106.90～107.27m.

[Consideration] : The ore deposit from 44.20～59.63m is located 20m south of from old shaft(Sh-1) and resembles naturally the outcrop in their occurrence and relationship to the dyke. However the ratio of the ores contained are differnce, (the ores in the holes :sphalerite>galena and ores of the outcrop sphalerite≦galena). The difference of the ore ratios between both depends probably on varying occurrence of galena through the ore shoot.

The ore deposit and intrusive rock at 134.98~142.35m are unknown on the ground surface. The position of the ore deposit is projected to 50m northwest of the MJI-7 site on the ground surface, assuming that the deposit dips 70° SE with reference to the boundary dip(70°) in the core. The rock(61-ST-2) has been dated as 51.9 + 2.6 Ma by K/Ar method. A small amount of plagioclase phenocrysts(possibly albite) are embedded in the ground mass consisting probably of alkalic feldspar through microscopic observation. The whole rock analysis indicated the rock to be of the alkali rock series, and it is regarded as alkali-gabbro.

The presence of the cloudy patterned structure below 19.25m, and very fine-graded marble and lava below 96.00m reveals that the hole drilled through the same stratigraphic sequence as MJI-6 and others.

2-8 MJI-8

[Purpose] : Purpose of the drilling was to prospect the southwest extention of the B_1 ore shoot.

[Result] : The drill discovered ore zones at two horizons 63.85~65.73m and 126.37~126.37m. The intrusive rocks relevant to the mineralization occur also at 66.32~71.31m and at 129.75~133.14m. Results of the assay of the ore zones are as follows ;

Sample No.	Depth (m)	wd (m)	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Co %	Mo %
MJI-8-1	63.85~ 64.11	0.26	0.07	50.0	0.35	0.24	2.66	0.016	<0.001
MJI-8-2	64.11~ 65.11	1.00	0.07	265.0	1.51	2.22	26.50	0.046	<0.001
MJI-8-3	65.11~ 65.73	0.62	0.07	176.0	2.61	1.87	30.10	0.054	<0.001
MJI-8-4	126.25~126.37	0.12	0.07	158.0	0.42	20.00	18.00	0.026	<0.001
MJI-8-5	133.14~134.00	0.86	0.07	520.0	0.84	17.40	216.90	0.029	<0.001
mean	63.85~65.73	1.88	0.07	205.9	1.71	1.83	24.39	0.044	<0.001

The geologic sequence yields the cloudy patterned texture below 4.50m, and is predominantly fine-grained marble all over. The basaltic lava occurs at 103.55~103.85m.

The features of the ore zones are in detail as follows :

63.85~65.73 : This part is divided as follows

63.85～64.11m : Quartz-rich banded ore, quartz-calcite-hedenbergite-sphalerite(red)-galena
64.11～64.51m : Massive ore, sphalerite(black)-galena-chalcopyrite-calcite-hedenbergite
64.51～64.96m : Sphalerite(black)-chalcopyrite-hedenbergite
64.96～65.53m : Massive ore, sphalerite(black)-galena-chalcopyrite-calcite-green skarn
65.53～65.73m : Banded ore, sphalerite(red)-green skarn-chalcopyrite

Below the ore zone, medium～fine-grained marble from 65.73m to 66.32m, and sukarnitized intrusive rock from 66.32 to 71.31m occur. The skarn intrusive rock is not in contact with ore. An interlayer at 66.32m contains green skarn 2～10mm in thickness, and a calcite-quartz-green skarn zone accompanied by a minimum number of sphalerite appears at 71.31～71.46m.

126.25～126.37m : Mlack sphalerite-galena ore with mosaic-texture
133.14～134.00m : Co-existence of banded ore, consisting of red sphalerite-green skarn-quartz and galena-quartz-red sphalerite, with massive ore of black sphalerite-galena and black sphalerite-chalcopyrite galena.

The section above of the ore zone yields skarn intrusive rock from 129.75m to 133.14m, and a hedenbergite-chlorite skarn zone is present within the intrusive rocks at 131.20m～133.14m. The upper boundary of the intrusive rock apparently intersects at 70° with the core.

[Consideration] : The ores and rocks at 63.85～71.73m resemble that of MJI-7 at 44.20～59.63m in their occurrence, and this fact indicates that they are in a line as one mineralized zone, considering also their positions and depths of ores.

Provided that the ore zone, including rock, of 126.25～134.00m is regarded as the mineralized zone, the deep ore zone is presumably connected with that of MJI-7 of 134.98～142.35m. Namely, two parellel mineralized zones are embedded in the MJI-7 and MJI-8 area.

The sequence of MJI-8 is composed of wholly predominant marble with a cloudy patterned structure, and it could be in a similar horizon with that of MJI-7.

2-9 MJI-9

[Purpose] : The drill site is located 160m northwest of MJI-10 and 175m north-northeast of MJI-1. A certain large-scale quartz monzonite rock body is exposed 40m northwest of the site, striking NE-SW, and dipping probably southeast . The drill prospected in a hanging horizon of the quartz diorite. The hole was situated at the center of a small hill running northwest to southeast. Sporadic outcrops of silicification (it may be float block) are distributed at the southeast part (40m southeast from the drill site.) of the hill.

[Result] : A quartz-red sphalerite ore was found at 41.85～42.05m. However, at the upper and lower parts of the ore zone, namely at 40.35～41.85m and 42.05～44.10m, no core was recovered due to the existence of caves.

A silicified-argillized zone occurs at 14.15～29.35m, and pyrite dissemination is observed in the non-limonitized part.

From 29.35m to 40.35m, intrusive rock occurs. The intrusive rock varies from pale-greyish, browny and greyish,dark green in colour downward, and like a volcanic, has lath texture with chloritized mafic minerals(pyroxene or hornblende?) and feldspars, and porphyritic texture. Coarser and porous xenolith of the same components are contained in the rock, and a great number of hematite-calcite veinlets cut the rock.

A similar rock occurring at 46.80～52.90m is more metamorphosed and strongly altered than the above rock, having fluidal texture caused by metamorphism. A banded garnet-quartz vein of 1.5cm thickness at 52.20m, and an irregular garnet-quartz thin vein at 51.80～52.90m occur in the rock.

In the seemingly low-altered dark-green part at 50.30～50.90m, a minimum number of sphalerite and galena are sporadically present. The section of 50.90～52.90m shows pale green colour resulting from decolouring.

From 52.30m to 53.00m, a banded zone consisting of dark-green(chlorite) and white (calcite-quartz) bands occurs, containing several grains of galena in the dark green bands.

Thin beds of biotite-hornfelsic slate are observed at 92.80～93.10m, 104～104.85m, 106.45～106.65m,108.45～108.7m, and the beds, except at 129.85～0.55m, are accompanied by garnet-pyrrhotite and black spots(probably minute carbon material) at their upper and lower parts.

Garnets and pyrrhotites occur in a skarnitized tuff at 132.45～133.05m.

The marble of muddy or tuffaceous origin tends to be coarse in grain throughout the whole core, suggesting it has undergone higher metamorphism.

Water escaped structures are observable in a part from 89.70m and 90.40～90.70m7.

A assay result of the ore is shown in the following table ;

Sample No.	Depth (m)	Wd (m)	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Co %	Mo %
MJI-9-1	41.85～42.05	0.20	0.07	97.0	0.03	0.41	16.30	0.034	0.001

[Consideration] : The assemblage of the ores at 41.85～42.05m consists of quartz and red sphalerite, and it resembles the ore zone of MJI-2. Both ores are also characterized by porous texture after dissolution of ore. The ore zone occurs at the center part of a cave from 40.35m to 44.10m, and it still remains a question as to whether the cave is the same as that of MJI-2.

In view of the resemblance of relations between the ore zones and intrusive rocks of this hole and MJI-6,7,8, and the feature of quartz rich ore at low the grade section or upper zone of the ore zone in the MJI-6,7,8, the cave could have been filled by high grade ore.

Intrusive rock bodies found at 29.35～40.35m and 46.80～52.90m have undergone apperantly weaker alteration than that of other holes, and no skarn occurs in the former case(29.35～40.35m). The skarn might have dissolved away as will be discussd in a later paragraph. 4 samples taken from the intrusive rock(Dk-4) were analysed for mineral component by X-ray analysis and microscope observation as follows :

61-ST-67(argillized part X-ray analysis)	:	Quartz > kaoline > sericite - pyrite - sphalerite (?) > calcite
61-ST-68(upper part of Dk-6 X-ray analysis)	:	Plagioclase - quartz > sericite - pyrite - calcite - kaoline. They are secondary except plagioclase.
(thin section)	:	Trachy dolerite
61-ST-68(upper part of Dk-6 X-ray analysis)	:	Plagioclase - quartz > sericite - pyrite - calcite - kaoline. They are secondary except plagioclase.