No. 24

REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE CENTRAL SABAH AREA
MALAYSIA

(PHASE II)

MARCH 1996

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JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of Malaysia, the Japanese Government agreed to conduct a Mineral Exploration Project in the Sabah area and entrusted the project to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to Malaysia a survey team headed by Mr. Masatsugu Okazaki from July 17, 1995 to November 7, 1995.

The team exchanged views with the officials concerned of the Government of Malaysia and conducted a field survey in the central Sabah area. After the team returned to Japan, further studies were made and the present report has been prepared. This report includes the survey results of geological, geophysical and drilling surveys in Phase II.

We hope that this report will serve for the development of the mineral resources and contribute to the promotion of friendly relations between Japan and Malaysia.

We wish to express our deep appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the team.

March, 1996.

Kimio Fujita
President
Japan International Cooperation Agency

Shozaburo Kiyotaki
President
Metal Mining Agency of Japan

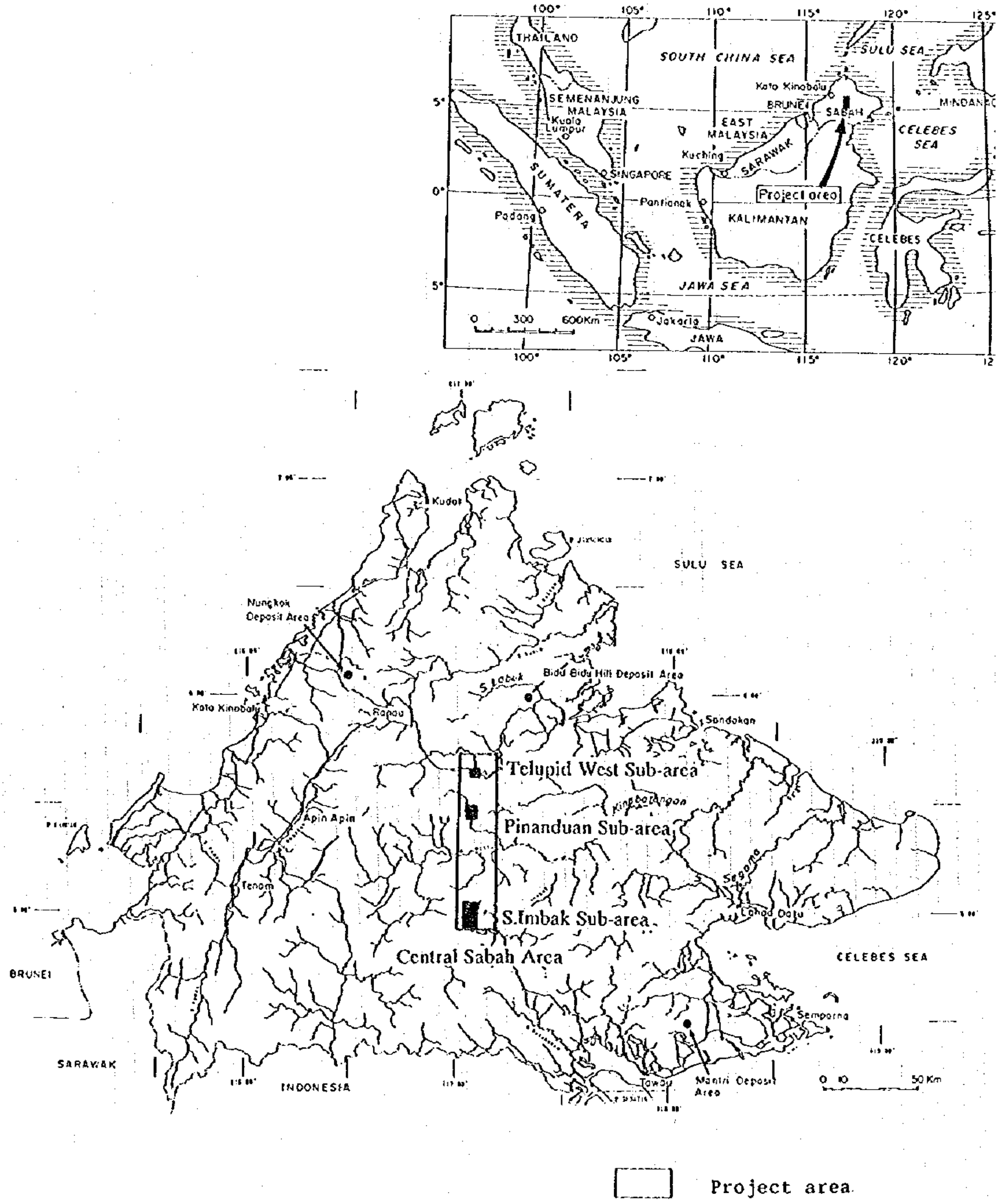


Fig. 1 Location map of the project area

ABSTRACT

The Government of Malaysia and the Government of Japan agreed a three-year mineral exploration project, starting from 1994, in the central Sabah area. The Scope of Work for this project was signed by both governments on 1st September 1994. The objective of this project is to explore and to assess the mineral potential of the survey area. This report includes the survey results of the second year (Phase II).

Detail geological survey including drilling and geophysical survey were conducted in S. Imbak Sub-areas North and semi-detail geological survey was conducted in the S. Imbak Sub-area South.

1. S. Imbak Sub-area North

The S. Imbak Sub-area North consists of the early to middle Miocene Tanjong Formation and the diorite porphyry intruding to the Tanjong Formation. The mineralization of the area, closely associated with the intrusion of the diorite porphyry, occurs in the silicification/pyrite dissemination zone in the center to south part of the area and it shows mainly two types of occurrences: quartz sulfides veins in the sedimentary rocks and network veins of sphalerite and dissemination of sulfides in the diorite porphyry.

The quartz-sulfides (pyrite, arsenopyrite, sphalerite, galena, chalcopyrite) veins of few cm to 25 cm wide sporadically occur in the sedimentary rocks of silicification/pyrite dissemination zone. These quartz-sulfides veins are classified into three types: Type ① Au and Ag vein, Au≧Ag, Type ② Au and Ag vein, Ag>Au, Type ③ Pb and Zn vein. Type ① and Type ② occur in a zone of higher alteration corresponding to phyllic zone in the west of the silicification/pyrite dissemination zone, while Type ③ tend to occur in the east part of the silicification/pyrite dissemination zone.

Among the five holes, the most prominent mineralization was found at MJSI-4 where sphalerite-(chalcopyrite) network veins and patches with Zn grade ranging from 0.40 % to 1.00 % occur in the diorite porphyry for 15 m . This Zn mineralization zone includes 3 m long Ag rich (Ag 37.2 g/t to 90.5 g/t) zone.

The geological information, mineral assemblage of ore minerals, filling temperature of fluid inclusion (300°C to 400°C) suggest that the most possible geological environment of mineralization in the S. Imbak Sub-area is that of similar to the outer margin of the porphyry copper environment.

Geophysical and subsequent drilling surveys based on IP anomaly of type 2 showed indications of finding promising mineralization zones in this survey area. For the case of a porphyry copper type deposit, the finding of IP anomaly of Type 1(low resistivity and high chargeability) is the ideal condition to select the drilling site. However, in this area IP anomalies

of Type 2 (medium resistivity and high chargeability) seem to be better target, because the extension of mineralization/alteration zone on the surface and in the holes does not seem to be wide.

Two strong IP anomalous zones (NAa and NAb), which showed a medium to high chargeability values of more than 20 mV/V, were detected by the geophysical survey (IP method) in Phase I and Phase II. Above-mentioned IP anomalies of Type 2 were generally detected in both areas.

The various surveys conducted in the S. Imbak Sub-area North suggest that following two areas are most promising for the mineral potentiality.

(1) The west part of the silicification/pyrite dissemination zone (NA), corresponding to center to south part of the geophysical survey lines D and E (NAa).

Reasons for selection

a) Alteration zoning and filling temperature of fluid inclusion suggest that the area is the center of mineralization in the S. Imbak Sub-area.

b) The quartz-sulfides veins with Au-Ag (Type ① and Type ②) occur in the area.

c) The area is covered by Au, Ag and Cu anomalies of rock geochemical survey.

d) Distribution of IP anomalies (chargeability of more than 25 mV/V and resistivity of less than 100 Ω-m) in the area.

e) The mineralization is more intensive in the drill holes located in the south (MJSI-4 and MJSI-5).

(2) The north part of the silicification/pyrite dissemination zone (NAb)

Reasons for selection

a) The intense mineralization in the diorite porphyry and the occurrences of Au-Ag quartz-sulfides veins close to the intrusion of the diorite porphyry were confirmed. The distribution of the diorite porphyry is expected underneath the surface in the area.

b) Distribution of Ag, Au and Cu anomalies of rock geochemical survey in the area.

d) Distribution of IP anomalies (chargeability of more than 25 mV/V and resistivity of less than 100 Ω-m) in the area.

2 S. Imbak Sub-area South

The S. Imbak Sub-area South, similar to the S. Imbak Sub-area North, consists of the early to middle Miocene Tanjong Formation and the diorite porphyry intruding to the Tanjong Formation. The mineralization of the area, closely associated with the intrusion of the diorite porphyry, occurs in the silicification/pyrite dissemination zone in the center of the north part (SA), center part (SB) and east part (SC).

The mineralization zone SA is considered to be the south extension of the silicification/pyrite dissemination zone of S. Imbak Sub-area North (NA) and characterized by Ag and Cu enriched quartz-sulfides veins and Type ② vein of the S. Imbak Sub-area North. The west part of the zone is covered by Au, As and Cu high value zones and alteration is slightly intensive than the surrounding area. The mineralization zone SB (mineral showing IMS-2) is characterized by dissemination of pyrite and chalcopyrite in the diorite porphyry and the sedimentary rocks and it is covered by anomalies of Au, Cu and S. The Cu grade is slightly low, however, it shows similar mineralization to that of porphyry copper. Distinguished mineralization and clear geochemical anomaly were not found in the mineralization zone SC. The alteration zoning and fluid inclusion temperature suggest a similar environment to the phyllic zone of porphyry copper type mineralization for the mineralization zones SA and SB.

The survey results suggest that the most potential areas for mineralization in the S. Imbak Sub-area South are the west part of the mineralization zones SA and the mineralization zone SB and further detail survey should be conducted in future.

CONTENT

Part II Survey Results

Part III Conclusions and recommendations

Part I General

Chapter 1 Introduction

1-1 Background and objectives

In accordance with the Scope of Work signed between the Government of Malaysia and the Government of Japan on 1st of September 1994, the mineral exploration was carried out in the Central Sabah area in the state of Sabah, Malaysia. Based on the results of the Supra-regional survey in central Sabah conducted during a period of 1989 to 1993, the Central Sabah Area (Fig. 1) was selected as an area of the highest mineral potential in Sabah. This project is three years project starting from 1994 and this report includes the survey results of Phase II.

The results of Phase I survey conducted in three sub-areas (Telupid West, Pinanduan and S. Imbak) of the Central Sabah area revealed that an Au mineralization in the S. Imbak Sub-area has the highest potential. Therefore, the Phase II survey was conducted in the S. Imbak Sub-area to explore and to assess the mineral potential.

The survey of Phase II includes detail geological survey, geophysical survey and drilling survey in the S. Imbak Sub-area North and semi-detail geological survey in the S. Imbak Sub-area South.

1-2 Coverage and outline of Phase II survey

The Central Sabah Area, with a rectangular shape (NS 90 km × EW 20 km) extending southward from Telupid, is located in the central part of the Sabah and in the southern part of the Labuk Area of the Supra-regional survey (Fig. 1). The surveys of the Phase II were conducted in S. Imbak Sub-area. The amount and content of the work for Phase II survey are given in Table I-1 and Table I-2.

In the Phase I survey, semi-detail geological survey and geophysical survey were conducted in the S. Imbak Sub-area North (28 km^2) and soil geochemical survey was conducted in the S. Imbak Sub-area South (70 km^2). Based on the results of the Phase I survey, the Phase II survey was conducted in the smaller area of higher potential in both of the S. Imbak Sub-area North and South. As shown in Fig I-1, the coverage of the both areas are, respectively, 14.75 km^2 and 45.50 km^2 for S. Imbak Sub-area North and South.

For detail understanding of geology and mineralization of the area and pursuing the IP anomaly obtained in the Phase I survey further to the south, detail geological survey, geophysical survey and drilling survey were conducted in S. Imbak Sub-area North. While, in the S. Imbak Sub-area South, semi-detail geological survey was conducted for understanding the geology and mineralization of the area.

The field work was conducted establishing a base camp along the logging road at the nearest point to the S. Imbak Sub-area. The actual work was done making camps within the S. Imbak Sub-area.

1-3 Member of the project

The members of the project are as followings:

1. Inspection of field work

Yoshiaki Igarashi	Metal Mining Agency of Japan
Tetsuo Suzuki	Manila office, Metal Mining Agency of Japan

2. Field survey

Japanese Counterpart

Masatsugu Okazaki	Team leader Geol. and Dril. Survey	Bishimetal Exploration Co., Ltd.
Kazutoshi Sugiyama	Geological Survey	Bishimetal Exploration Co., Ltd.
Masatane Kato	Geophysical Survey	Bishimetal Exploration Co., Ltd.
Kazuto Matsukubo	Geophysical Survey	Bishimetal Exploration Co., Ltd.
Hiroshi Hyodo	Geophysical Survey	Bishimetal Exploration Co., Ltd.
Susumu Endo	Geophysical Survey	Bishimetal Exploration Co., Ltd.
Takashi Matsuoka	Drilling Survey	Bishimetal Exploration Co., Ltd.

Malaysian Counterpart

Alexander Yan	Deputy Director	Geological Survey of Malaysia
Joanes Muda	Geologist	Geological Survey of Malaysia
Wong Vui Chunug	Geologist	Geological Survey of Malaysia
Dzazali b. Hj Ayub	Geophysicists	Geological Survey of Malaysia
Salleh Adanan	Assistant	Geological Survey of Malaysia
Japili Samin	Assistant	Geological survey of Malaysia

1-4 Survey period

The surveys were conducted in Malaysia during the period shown below.

Inspection of field work			
	May 18, 1995	to	May 25, 1995
	October 6, 1995	to	October 13, 1995
Geological survey			
Field Work	July 17, 1995	to	September 20, 1995
Compilation Work	September 21, 1995	to	September 27, 1995
Geophysical Survey			
Field Work	July 20, 1995	to	September 1, 1995
Compilation Work	September 2, 1995	to	September 8, 1995
Drilling Survey			
	August 3, 1995	to	November 7, 1995

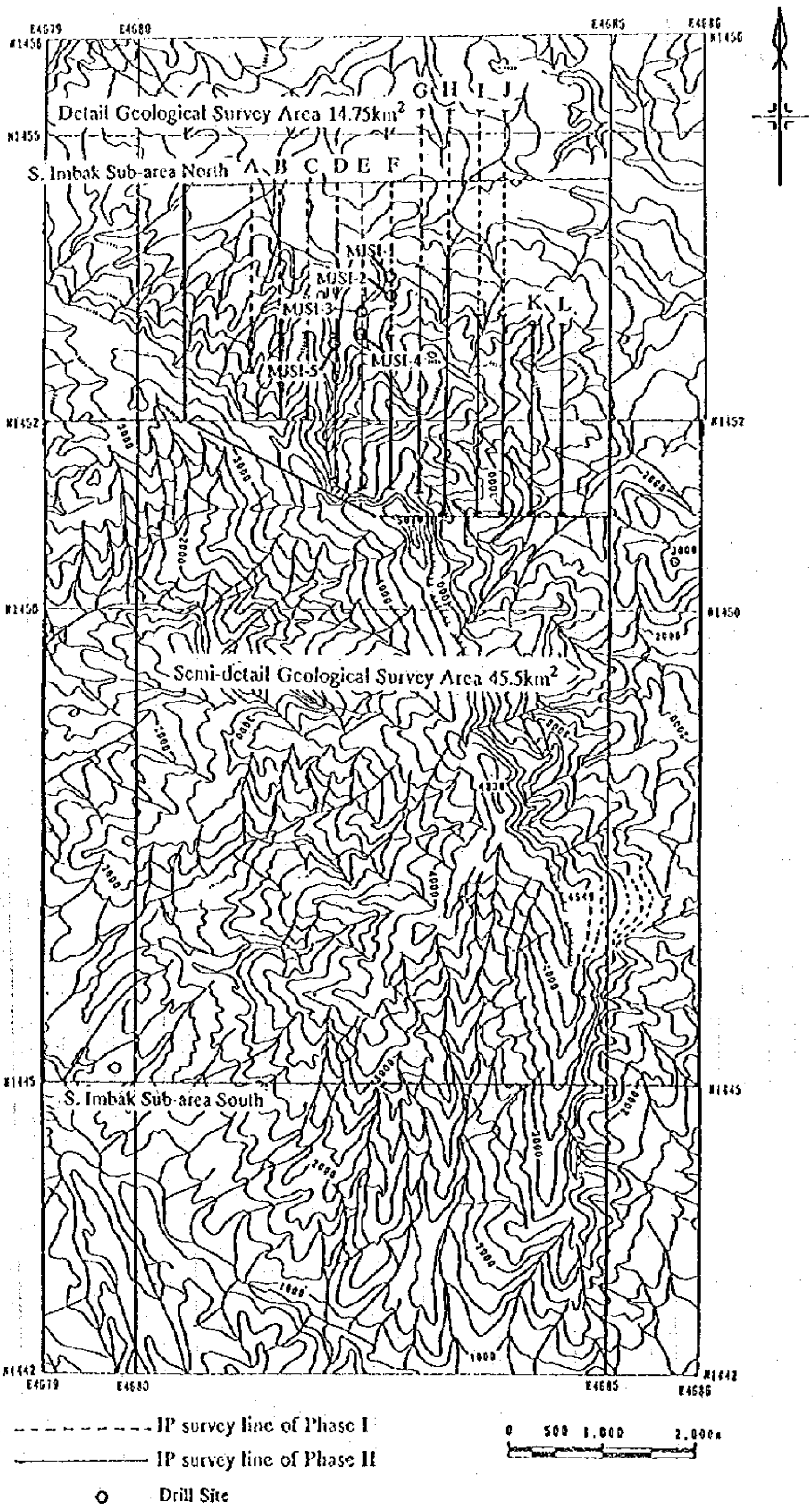


Fig. I -1 S. Imbak Sub-area

Table I-1 Summary of work amounts

Survey Method	Work Amount		
(1) Geological Survey			
1) S. Imbak Sub-area North	Survey Area	14.75	km^2
(detail survey)	Survey Route	41.7	km
2) S. Imbak Sub-area South	Survey Area	45.5	km^2
(semi-detail survey)	Survey Route	77.0	km
	Rock Samples for Geochemical Survey	300	samples
(2) Geophysical Survey (IP method)			
S. Imbak Sub-area North	Total Line Length	19.7	km
	Number of Lines	11	Lines
	Number of Measurement	637	Times
(3) Drilling Survey	Hole No.	Depth	Inclination
S. Imbak Sub-area North			
	MJSI-1	201.25 m	-90°
	MJSI-2	200.30 m	-90°
	MJSI-3	200.84 m	-90°
	MJSI-4	202.20 m	-90°
	MJSI-5	200.20 m	-90°

Table I -2 Work amounts of laboratory studies

Laboratory Studies	Geological Survey	Drilling Survey	Total
1) Thin section	40 samples	11 samples	51 samples
2) Polished sectoion	20 samples	14 samples	34 samples
3) X-ray diffraction analysis	70 samples	12 samples	82 samples
4) Fluid inclusion filling temperature	10 samples	—	10 samples
5) Chemical analysis			
a)Rock (15 elements: Au, Ag, Cu, Pb, Zn, Sb, As, Hg, K, Na, Sr, Rb, Ca, Mg, S)	300 samples	--	300 samples
b)Ore Assay (7 elements:Ag, Au, Cu, Mo, Pb, S, Zn)	50 samples	47 samples	97 samples
3. Geophysical survey			
1) Resistivity measurement	21 samples		
2) Porlarizability measurement	21 samples		

Chapter 2 Geography of the survey area

2-1 Location and access

Malaysia, a principal member of ASEAN countries, consists of Western Malaysia occupying the Malay Peninsulat and East Malaysia occupying the northern and the northwestern parts of the Borneo island. The total population of West and East Malaysia is 18.0 millions. The area of the whole country is approximately 330,000 km^2.

The East Malaysia comprises the State of Sabah and State of Sarawak. The State of Sabah, occupying area of 73,700 km^2 in the northeastern part of the Borneo island, has population of approximately 1.393 millions. It is facing Kalimantan of Indonesia on the south, Sarawak on the southeast and surrounded by the sea such as South China, Sulu and Celebes, respectively, on the west, north and east.

The state capital is Kota Kinabalu on the west coast of Sabah. Direct flights from various cities, including outside of the country (Singapore, Hong Kong, Taiwan, Philippines, Japan) and domestic (Kuala Lumpure, Tawau, Sandakan) connecting the Kota kinabalu International Airport make an easy access to the state of Sabah. The principal roads of shielded run connecting major cities such as Kota Kinabalu-Telupid-Sandakan and Sandakan-Lahad Datu-Tawau.

The Central Sabah area, occupying 1,800 km^2(NS 90 km, EW 20 km), extends southward from Telupid in the center of Sabah (Fig I -2). The major road connecting Kota Kinabalu and Sandakan runs northern part of the area. However, other than this, existing roads in the area are the one that goes toward southeast from Telupid connecting small villages and the another one, a timber road, that goes south from Telupid along the project area. The latter one is recently connected to the timber road that goes up northward from Tawau. There is no road within the area of the S. Imbak Sub-area.

2-2 Topography and drainage system

The state of Sabah is occupied by four characteristic topographic features. Steep, rugged mountains, trending in north to northeast, dominate in the western part of Sabah along the coast. Highland occupies the eastern area and volcanic mountains are found in the southern part. Flat plain occurs along rivers and their lower tributaries. Mt. Kinabalu, which is the highest mountain in the southeast Asia, rises up to 13,455 ft in western end of the Kinabalu area where being occupied by steep topography. Highland dominates in the Labuk and Segama areas. Swamps are found at the lower part of main rivers where they are extremely meandered. Highland dominates in the Semporna area except the young volcanics region with volcanic topography.

The main drainage systems in Sabah are Sungai Pegalan, Sungai Sugut, Sungai Labuk, Sungai Kinabatangan, Sungai Segama, Sungai Tingkayu, Sungai Kalumpang, Sungai Kalabakan. Among these river systems, Sungai Pegalan flows into the South China Sea, Sungai Kalumpang and Kinabatangan flow down to the Celebes Sea and other river systems flow into the Sulu Sea in the east. These river systems generally form deep valley at the upper stream and extremely meandered at down stream. The river also forms swamp area at the mouth to the sea.

2-3 Climate and vegetation

The survey area is situated in the tropical monsoon region. Generally, it is northeastern monsoon during early November to March. While, northeastern monsoon starts in May and ends in August. Annual precipitation varies depending on the region from 1,500 mm to 4,000 mm. In the west cost area, rainy season correspond to the season of the southwestern monsoon, while the east coast has rainy season during northeastern monsoon. In recent years, these distinction of rainy season and dry season is not clear. Temperature is 22 C° to 33 C° throughout the year.

The maximum and minimum temperature for each month and monthly rainfall in Kota Kinabalu on the west coast, Sandakan on the east coast and Tawau on the south coast are shown in Table I-3. As shown in this table, east coast has more rainfall than the west coast.

The north to central part of the Central Sabah area is mainly covered by secondary jungle, while, in the south part primary jungle remains in many places. The S. Imbak Sub-area, which is located at the south end of the Central Sabah area, is totally covered by primary jungle.

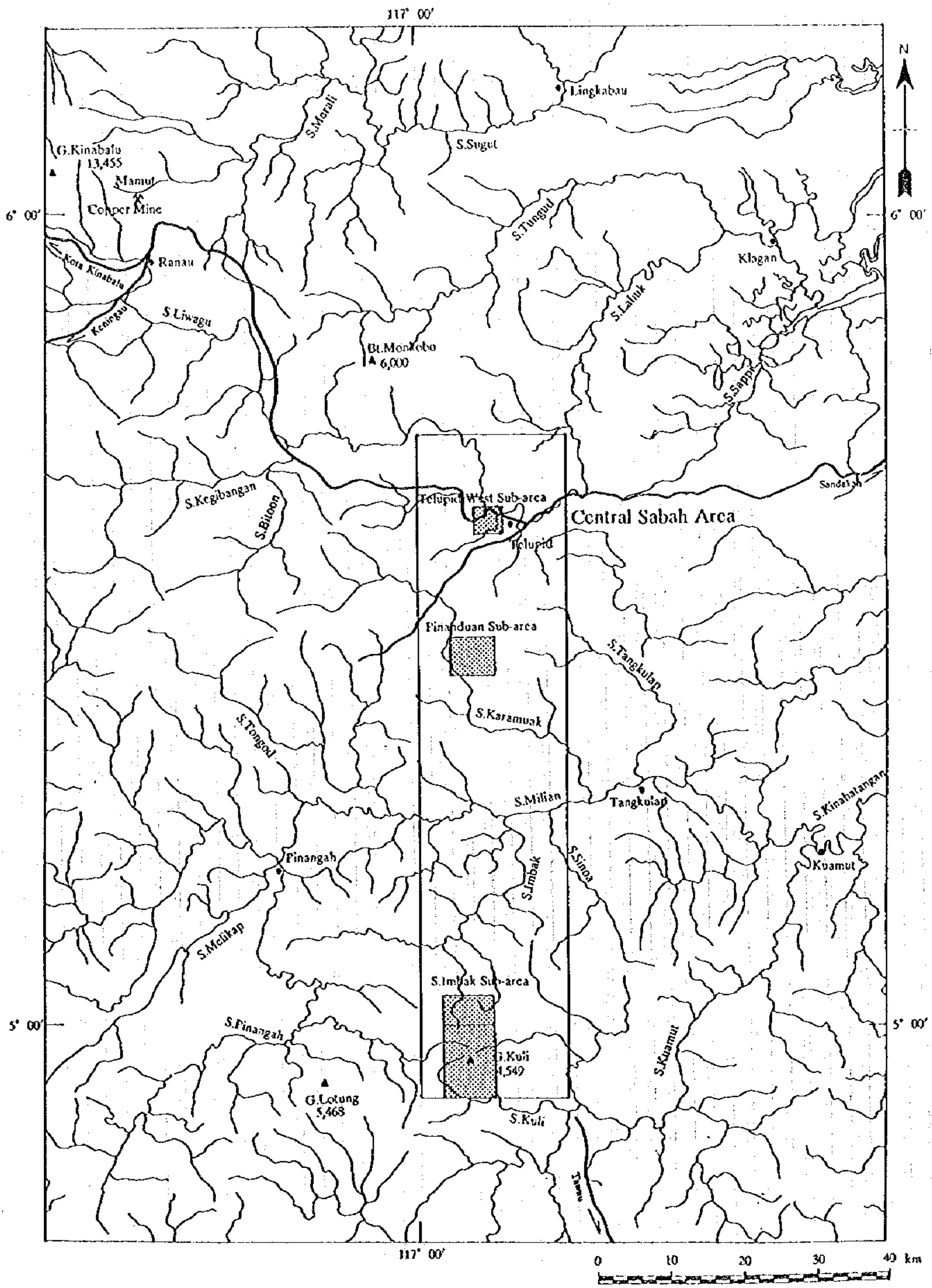


Fig. I -2 Location of the Central Sabah Area

Table I -3 Statistics of temperature and rainfall

Month	Kota Kinabalu			Sandakan			Tawau		
	Temperature (℃)		Rainfall	Temperature (℃)		Rainfall	Temperature (℃)		Rainfall
	Max.	Min.	(mm)	Max.	Min.	(mm)	Max.	Min.	(mm)
January	30.5	22.4	95.1	29.7	24.2	398.2	31.4	22.2	161.4
February	31.6	22.5	61.6	30.5	23.6	229.9	31.9	22.3	132.4
March	31.8	22.8	47.1	31.0	23.8	120.0	32.4	22.6	107.7
April	32.5	23.4	137.5	32.2	23.8	87.5	32.6	22.8	101.3
May	32.5	23.9	287.9	32.5	24.3	110.8	32.8	23.5	113.6
June	31.7	23.3	248.7	32.8	23.6	209.3	32.3	23.0	185.5
July	31.6	23.0	257.2	32.4	23.5	214.5	31.6	22.7	226.3
August	31.7	23.3	263.4	32.9	23.5	183.6	31.3	22.6	217.7
September	31.8	23.2	315.8	32.3	23.5	241.2	31.7	22.5	196.9
October	32.0	23.5	292.9	31.8	23.6	271.9	31.9	22.8	188.1
November	31.4	23.2	314.6	31.2	24.0	324.8	32.4	23.1	174.0
December	31.3	22.7	149.7	29.8	24.4	453.0	32.4	22.4	135.3

Temperature: 1989 and 1990　　Rainfall: average of last 10 years(1981 - 1990)

Chapter 3 Geology and economic geology of Sabah, Malaysia

3-1 General geology

Sabah is geologically complex resulting from active tectonism since Mesozoic. The geological members constituting Sabah are metamorphic rock of Crystalline Basement(Cb), Cretaceous to Eocene sedimentary rocks accompanied by basaltic eruption (K, KP), Eocene to middle Miocene sedimentary rocks characterized by flysch sediments (P1, P2, P3 and P4) and early Miocene to Pleistocene sedimentary rocks (N1, N2, N3, N4 and N5). The geological map (Y.E. Heng, 1985) of Sabah including the survey area is shown in Fig.I-3.

The Crystalline Basement(Cb), consisting of schist, gneiss and amphibolite, is pre-Triassic rock and forms a basement in this area.

The Chert-Spilite Formation (KPSC) and Sapulat Formation (KPCp) are the Cretaceous to Eocene rocks. The Chert-Spilite Formation consist of limestone, radiolaria chert, sandstone, conglomerate, spilite, volcanic breccia, agglomerate dolerite and pillow lava. Together with ultramafic rocks and gabbro (Ub), these rocks of the Chert-Spilite Formation are considered to be fragments of ophiolite sequence rocks, a part of the oceanic lithosphere of early Cretaceous age. The blocks of dismembered ophiolite, being scattered all over the Sabah, are emplaced by complicate tectonic movement during Oligocene to Miocene, and are thrusting up over Eocene to middle Miocene sedimentary rocks. The Sapulat Formation mainly consists of mudstone accumulated at the center of oceanic trough.

The Palaeocene to Oligocene sedimentary rocks are distributed in west and north parts of Sabah and they are Trusmadi Formation and Crocker Formation. The former consists of weakly metamorphosed slate, phyllite and quartzite and the latter consists of flysch type sediments of sandstone and mudstone.

The Miocene to Pliocene sedimentary rocks occur in south, north and southwest part of Sabah. They are Kalabakan Formation, Kalumpang Formation, Garinono Formation, Labang Formation, Ayer Formation and Kuamut Formation. The latter four formation of slump sediments consist of blocks of older age rocks, such as chert, limestone, gabbro, sandstone and serpentinite with mud matrix. They are considered to be a chaotic formation of tectonic melange. The late Miocene sedimentary rocks are Tanjong Formation and Sandakan Formation consisting of a sequence of sandstone and mudstone of shallow marine sediments.

Three main periods of igneous activities are found in Sabah. The earliest one is early Triassic intrusion of tonalite, granodiorite, trondhjemite and granite intrusion which are associated with the pre-Triassic basement rocks. The second period is the early Cretaceous igneous activity of ophiolite sequence rocks such as gabbro, dolerite and basalt. The third period occurred in Late

Miocene to Quaternary times and is represented by post-orogenic intrusives and extrusives. The former one corresponds to the intrusion of granitic rocks such as adamellite and granodiorite in Gunong Kinabalu area and the latter corresponds to the calc-alkaline effusive rocks, such as dacite, andesite and basalt, in the Semporna Peninsula.

In the Central Sabah Area, bodies of dismembered ophiolite consisting of ultramafic rocks and basalt with pillow structure are scattered over the north part. The sedimentary rocks of the Central Sabah Area consist of Sapulat Formation (late Cretaceous to late Eocene), Kulapis Formation and Crocker Formation (Eocene to Oligocene), Labang Formation (Oligocene), Garinono Formation (Oligocene to middle Miocene), Tanjong Formation (early Miocene to middle Miocene). The Sapulat Formation is distributed in the south part of the Central Sabah area surrounding the ultramafic body and is overlain by Labang Formation and Tanjong Formation. The Crocker Formation is widespread in the center of the Central Sabah Area surrounding the body of ultramafic rocks, while Kulapis Formation occur central east of the area. Garinono Formation, a tectonic melange, occurs at the eastern margin of ultramafic rocks.

3-2 Mineralization and mining activities

Principal metallic ore deposits in the survey area comprise porphyry copper deposit closely related with plutonic rocks, Cyprus-type massive sulfide deposit related to spilite extrusion and hydrothermal gold-silver deposits closely related with volcanic rocks. Chromium and platinum deposits are related to the ultra-basic rocks, lateritic aluminum and nickel deposits and manganese deposits in sedimentary rocks are also found. The distribution map of the main metallic ore deposits and mineral showings in the project area (after K.M. Leong, 1976) are shown in Fig. I-4.

The Mamut mine is the only active mine in Sabah. The Mamut deposit, a porphyry copper type, is located to the north of Ranau in the Kinabalu area. This ore deposit was discovered by a geochemical survey conducted by the United Nations Development Program (UNDP). The Overseas Mineral Resources Development Co., Ltd., Japan obtained the exploration right on the Mamut area through international tender in 1968, and carried out further exploration work from 1968 to 1972. The development work of the mine was commenced by them in 1973 and, then, operation of the mine started in May, 1975. The current production of crude ore is 20 thousand tons per day with the grade of 0.47% Cu. Staffs and workers of the Mamut Copper Mining Sdn. Bhd. are about 1,200.

The Bidu Bidu Hill ore deposit is in the latest stage of the exploration work and the development work will be commenced in the near future. This is a Cyprus-type massive sulfide deposit emplaced in basalt lava. Exploration work for this ore deposit is being carried out by Leadstar Sdn. Bhd. The ore reserves of 3,600 thousand tons with Cu 3.6 %, Au 1 - 2 g/t and Ag 8-15 g/t have been confirmed by drilling work (approximately 40,000 m) for this deposit.

The exploration work of gold-silver deposits occurred in volcanic rocks in the Semporna area is being carried out by Zamia Sdn. Bhd. The area surveyed by them covers a wide area from the west of Semporna to northern Tawau. The survey consists of mainly soil geochemical survey and trenching. A few drill holes have been completed for the Mantri area.

Within the Central Sabah area, exploration work, including drilling, augering and pitting was conducted in 1964 by the Soriamont Investment Co. in Pinanduan, an eastern tributary of the S. Karamuak. The boreholes showed that uncommercial zones of sulfides mineralization in peridotite, although at the surface there are more than a million tones of limonitic clay containing Cu 0.7 % as secondary oxides.

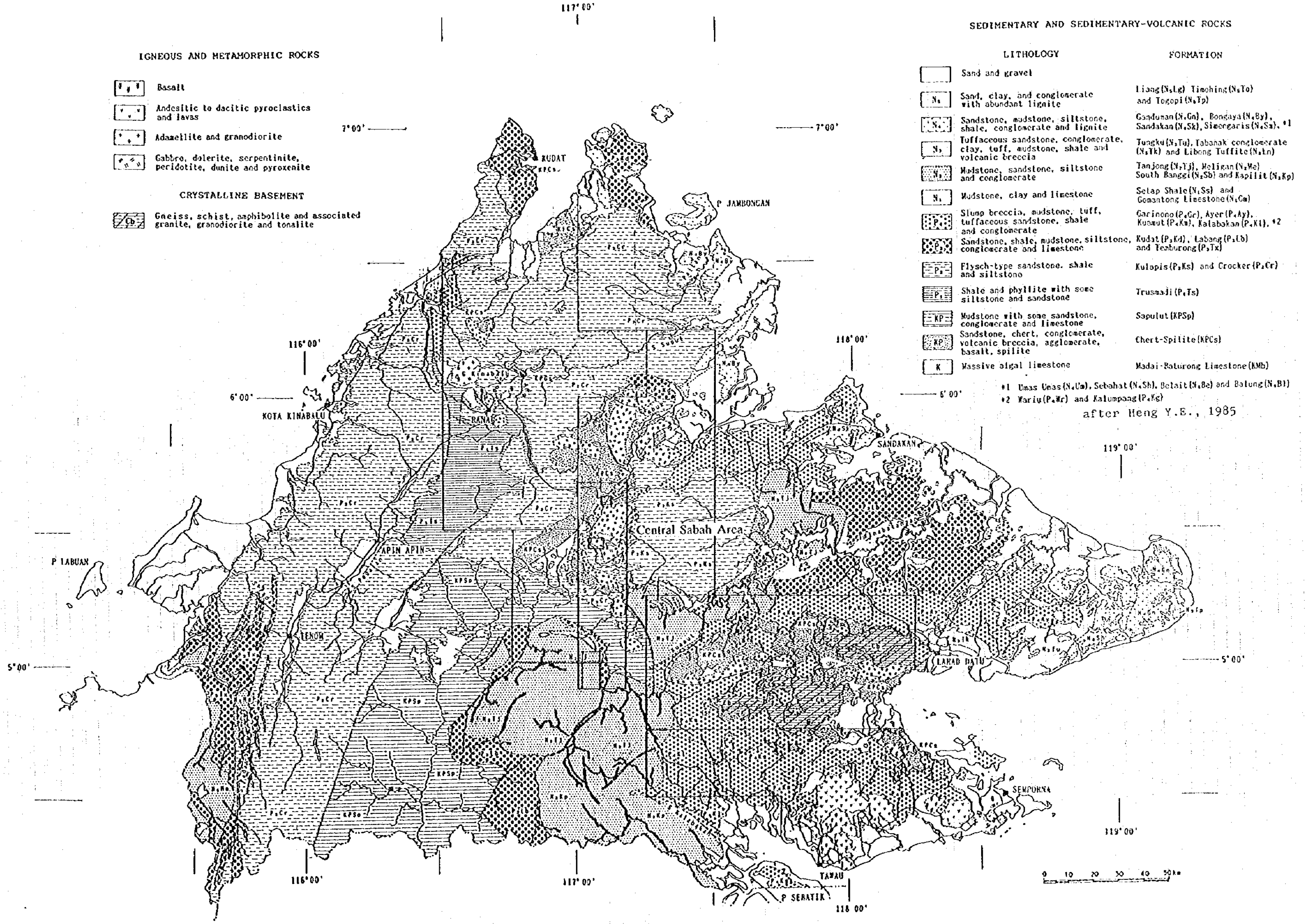


Fig. I -3 Geologic map of Sabah, Malaysia

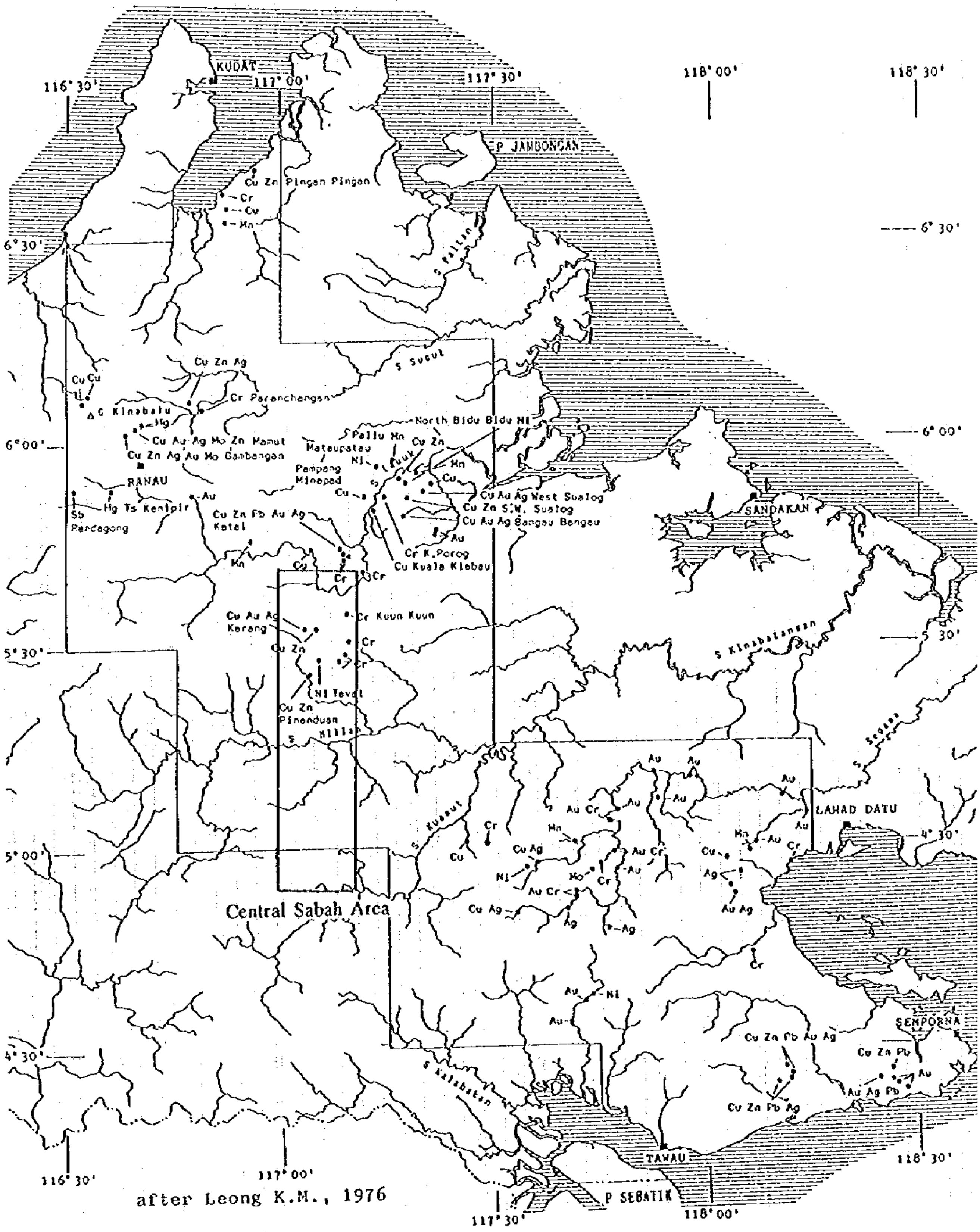


Fig. I-4 Distribution of mineral occurrences in the project area

Chapter 4 Survey results

4-1 S. Imbak Sub-area North

The S. Imbak Sub-area North is overlain by the Tanjong formation (NT_2j) of early to middle Miocene and the Tanjong Formation is intruded by many small bodies of diorite porphyry. Silicification/pyrite dissemination zone occurs in the sedimentary rock closely associated with the intrusion of the diorite porphyry.

The mineralization and alteration of the area occur in the silicification/pyrite dissemination zone located in the central to southeastern part of the area where many small intrusions of diorite porphyry occur. In the zone, quartz-sulfides veins of few cm to 25 cm sporadically occur. Although a large scale mineral showing and additional Au rich veins were not found in Phase II survey, a wide distribution of quartz-sulfides veins with Ag, Pb and Zn was confirmed all over the silicification/pyrite dissemination zone. Further, the distribution of Au-Ag type quartz-sulfides veins seem to be restricted in the southwest part of the silicification/pyrite dissemination zone, while, Pb and Zn veins occur in the northeast part of the silicification/pyrite dissemination zone.

The drilling survey shows that the mineralization is more intensive in the diorite porphyry than in the sedimentary rocks. The most prominent mineralization is 15 m wide Zn mineralization with an Ag rich zone of 3 m wide at MJSI-4. The occurrence of Au rich quartz-sulfides veins were confirmed close to the diorite porphyry at MJSI-5 and native gold is associated with arsenopyrite.

The mineralization in the area characterized by Au-Ag, Cu, Pb, Zn is closely related to a igneous activity of the diorite porphyry. The geological environment of the area, mineral assemblages of ore minerals, alteration, filling temperature of fluid inclusion (300° C to 400° C) suggest that the mineralization of the area is not an epithermal type. However, the temperature of the mineralization is not so much high as a mineralization occurs at the center of magmatism. The most possible geological environment for the mineralization of S. Imbak Sub-area is outer margin of the mineralization similar to a porphyry copper type environment. The center of the alteration in the S. Imbak Sub-area, characterized by an abundant sericite, is located in the center to west part of the silicification/pyrite dissemination zone and it is considered to correspond to the phyllic alteration zone of the typical porphyry copper type mineralization. A chlorite rich zone corresponding to the propylitic zone of typical porphyry copper type, also, occur in the S. Imbak Sub-area North surrounding the sericite rich zone. The Au rich quartz-sulfides vein with arsenopyrite occur within the sericite rich zone close to the diorite porphyry. The mineral assemblages of ore mineral (pyrite-pyrrhotite-arsenopyrite) suggest that hydrothermal solution related to the mineralization of the S. Imbak Sub-area North was in intermediate sulfidation state.

Geophysical and subsequent drilling survey based on IP anomaly of type 2 showed indications of finding promising mineralization zones in this survey area. For the case of a porphyry copper type deposit, the finding of IP anomaly of Type 1(low resistivity and high chargeability) is the ideal condition to select the drilling site. However, in this area IP anomalies of Type 2 (medium resistivity and high chargeability) seem to be better target, because the extension of mineralization/alteration zone on the surface and in the holes does not seem to be wide.

Two strong IP anomalous zones (NAa and NAb in Fig.III-1-1), which showed a medium to high chargeability values of more than 20 mV/V, were detected by the geophysical survey (IP method) in Phase I and Phase II. Above-mentioned IP anomalies of Type 2 were generally detected in both areas.

NAa area, located in the central to southeastern part of the area, corresponds well with distribution of silicification/pyrite dissemination zone near/around intrusive rocks, diorite porphyry. The strongest IP anomaly was detected from center of Line-D to center of Line-F in the silicification/pyrite dissemination zone. According to the results of the drilling survey (drill hole MJSI-1) carried out into the IP anomaly source, pyrite rich zone in mudstone exists from the surface to a few tens meters.

According to the above results and the results of drilling survey at the drill holes MJSI-4 and MJSI-5, NAb area located in the central to southern part of the area is considered to bear some mineralization near/around intrusive rocks with sulfide in the depths.

4-2 S. Imbak Sub-area South

The S. Imbak Sub-area South is overlain by the Tanjong Formation (NT_2j) of early to middle Miocene. In addition to this, many small bodies of diorite porphyry (I_1) occur intruding to the sedimentary rocks of the Tanjong Formation.

The main mineralization and alteration in the S. Imbak Sub-area South occur in the silicification/pyrite dissemination zone of central north part (SA), center part (SB) and east part (SC). The occurrences of many intrusive bodies of the diorite porphyry in the mineralization zones suggest the mineralization and alteration in the S. Imbak Sub-area South are closely related to the diorite porphyry. Geological information and geochemical survey suggest that mineralization zone SA is the south extension of the mineralization zone NA of the S. Imbak Sub-area North. It is characterized by the quartz-sulfides veins in the silicification/pyrite dissemination zone. The most prominent veins were observed in the mineral showing IMS-1 where Ag and Cu rich veins with maximum width of 35 cm occur. Other than this, Type ② vein with Ag occur in the mineralization zone SA. The mineral showing IMS-2 of the mineralization zone SB shows the mineralization similar to that of porphyry copper type with dissemination of pyrite and chalcopyrite both in the diorite porphyry and the sedimentary rocks. In the mineralization zone SC, distinguished mineralization was not found.

Rock geochemical survey of S. Imbak Sub-area North and South shows that the most prominent geochemical anomalies occur in the area covering the mineralization zone NA of the North to the west part of the mineralization zone SA of the South characterized by Au, As and Cu associated by Pb and Zn. The area covering the mineral showing IMS-2 in the mineralization zone SB is characterized by Cu, Au and S. While, clear chemical anomaly is not found in the mineralization zone SC. The elements such as Ca, Mg, Na and Sr are considered to be indicator of the alteration. All these elements are depleted in the mineralization zones. While, an enrichment of K through the mineralization and alteration is presumed only in the mineralization zone NA of the S. Imbak Sub-area North.

In the S. Imbak Sub-area North, a clear alteration zoning similar to typical porphyry copper mineralization was obtained. The center of the alteration, corresponding to the phyllic zone, is located in the west part of the mineralization zone NA and it is surrounded by propylitic zone and argillic zone. Although, clear zoning of the alteration was not found in the S. Imbak Sub-area South, the alteration in the mineralization zones SA and SB are slightly higher than surrounding areas because of the occurrences of quartz rich samples and sericite abundant samples.

The filling temperature of fluid inclusion collected in the mineralization zones NA, SA and SB show that average temperature of all the samples fall in a range of from 300° C to 400° C correspond to the temperature of phyllic zone of the typical porphyry copper type.

From the above, the mineralization zone NA of the S. Imbak Sub-area North is the center of the mineralization and alteration in the S. Imbak Sub-area. While, the mineralization zones SA and SB are the centers of the mineralization and alteration in the S. Imbak Sub-area South and more intense alteration and mineralization are expected underneath the surface. Therefore, two zones are considered to be the most promising area in the S. Imbak Sub-area South.

Chapter 5 Conclusions and recommendations

5-1 Conclusions

1. S. Imbak Sub-area North

The S. Imbak Sub-area North consists of early to middle Miocene Tanjong Formation and the diorite porphyry intruding to the Tanjong Formation. The mineralization of the area, closely associated with the intrusion of the diorite porphyry, occurs in the silicification/pyrite dissemination zone in the center to south part of the area and it shows mainly two types of occurrences: quartz sulfides veins in the sedimentary rocks and network veins of sphalerite and dissemination of sulfides in the diorite porphyry.

The quartz-sulfides (pyrite, arsenopyrite, sphalerite, galena, chalcopyrite) veins of few cm to 25 cm wide sporadically occur in the sedimentary rocks of silicification/pyrite dissemination zone. These quartz-sulfides veins are classified into three types: Type ① Au and Ag vein, Au≧Ag, Type ② Au and Ag vein, Ag>Au, Type ③ Pb and Zn vein. Type ① and Type ② occur in a zone of higher alteration corresponding to phyllic zone in the west of the silicification/pyrite dissemination zone, while Type ③ tend to occur in the east part of the silicification/pyrite dissemination zone.

Among the five holes, the most prominent mineralization was found at MJSI-4 where sphalerite-(chalcopyrite) network veins and patches with Zn grade ranging from 0.40 % to 1.00 % occur in the diorite porphyry for 15 m . This Zn mineralization zone includes 3 m long Ag rich (Ag 37.2 g/t to 90.5 g/t) zone.

The geological information, mineral assemblage of ore minerals, filling temperature of fluid inclusion (300° C to 400° C) suggest that the most possible geological environment of mineralization in the S. Imbak Sub-area is that of similar to the outer margin of the porphyry copper environment.

Geophysical and subsequent drilling surveys based on IP anomaly of type 2 showed indications of finding promising mineralization zones in this survey area. For the case of a porphyry copper type deposit, the finding of IP anomaly of Type 1(low resistivity and high chargeability) is the ideal condition to select the drilling site. However, in this area IP anomalies of Type 2 (medium resistivity and high chargeability) seem to be better target, because the extension of mineralization/alteration zone on the surface and in the holes does not seem to be wide.

Two strong IP anomalous zones (NAa and NAb), which showed a medium to high chargeability values of more than 20 mV/V, were detected by the geophysical survey (IP method) in Phase I and Phase II. Above-mentioned IP anomalies of Type 2 were generally detected in both areas.

The various surveys conducted in the S. Imbak Sub-area North suggest that following two areas are most promising for the mineral potentiality .

(1) The west part of the silicification/pyrite dissemination zone, corresponding to center to south part of the geophysical survey lines D and E (NAa).

Reasons for selection

a) Alteration zoning and filling temperature of fluid inclusion suggest that the area is the center of mineralization in the S. Imbak Sub-area.

b) The quartz-sulfide veins with Au-Ag (Type ① and Type ②) occur in the area.

c) The area is covered by Au, Ag and Cu anomalies of rock geochemical survey.

d) Distribution of IP anomalies (chargeability of more than 25 mV/V and resistivity of less than 100 Ω-m) in the area.

e) The mineralization is more intensive in the drill holes located in the south (MJSI-4 and MJSI-5).

(2) The north part of the silicification/pyrite dissemination zone (NAb)

Reasons for selection

a) The intense mineralization in the diorite porphyry and the occurrences of Au-Ag quartz-sulfide veins close to the intrusion of the diorite porphyry were confirmed. The distribution of the diorite porphyry is expected underneath the surface in the area.

b) Distribution of Ag, Au and Cu anomalies of rock geochemical survey in the area.

d) Distribution of IP anomalies (chargeability of more than 25 mV/V and resistivity of less than 100 Ω-m) in the area.

2. S. Imbak Sub-area South

The S. Imbak Sub-area South, similar to the S. Imbak Sub-area North, consists of early to middle Miocene Tanjong Formation and the diorite porphyry intruding to the Tanjong Formation. The mineralization of the area, closely associated with the intrusion of the diorite porphyry, occurs in the silicification/pyrite dissemination zone in the center of the north part (SA), center part (SB) and east part (SC).

The mineralization zone SA is considered to be the south extension of the silicification/pyrite dissemination zone of S. Imbak Sub-area North (NA) and characterized by Ag and Cu enriched quartz-sulfide veins and Type ② vein of the S. Imbak Sub-area North. The west part of the zone is covered by Au, As and Cu high value zones and alteration is slightly intensive than the surrounding area. The mineralization zone SB (mineral showing IMS-2) is characterized by dissemination of pyrite and chalcopyrite in the diorite porphyry and the sedimentary rocks and it is covered by anomalies of Au, Cu and S. The Cu grade is slightly low, however, it shows similar mineralization to that of porphyry copper. Distinguished mineralization and clear geochemical anomaly were not found in the mineralization zone SC. The alteration zoning and fluid inclusion temperature suggests a similar environment to the phyllic zone of porphyry copper type mineralization for mineralization zones SA and SB.

The survey results suggest that the most potential area for mineralization in the S. Imbak Sub-area South are the west part of the mineralization zone SA and the mineralization zone SB and further detail survey should be conducted in future.

5-2 Recommendations

1. S. Imbak Sub-area North (Fig. I -5)

For understanding the detail distribution of mineralization/alteration for deciding the drill sites in the two high potential areas of NAa and NAb, detail geophysical surveys such as electro-magnetic survey (EM method at 50 m grid), IP method at 100 m grid and Mise-a-la-Masse method applied to borehole or outcrop are recommended prior to the drilling operation. For both areas of NAa and NAb, a total 7 drill holes are recommended. The each hole should be declined hole (-60°) with depth not shallower than 300 m.

2. S. Imbak Sub-area South (Fig. I -6)

For the two mineralization zones SA and SB, detail geological survey and IP survey are recommended for understanding the mineralization of the area. Based on the results of IP survey, few drill holes should be examined for each area.

Mineralization zone SA

Area: 3.15 km^2 (1.5 km × 2.1 km)

IP survey lines: 12 km (1.5 km × 8 lines)

Mineralization zone SB

Area: 4.20 km^2 (2.0 km × 2.1 km)

IP survey lines: 16 km (2.0 km × 8 lines)

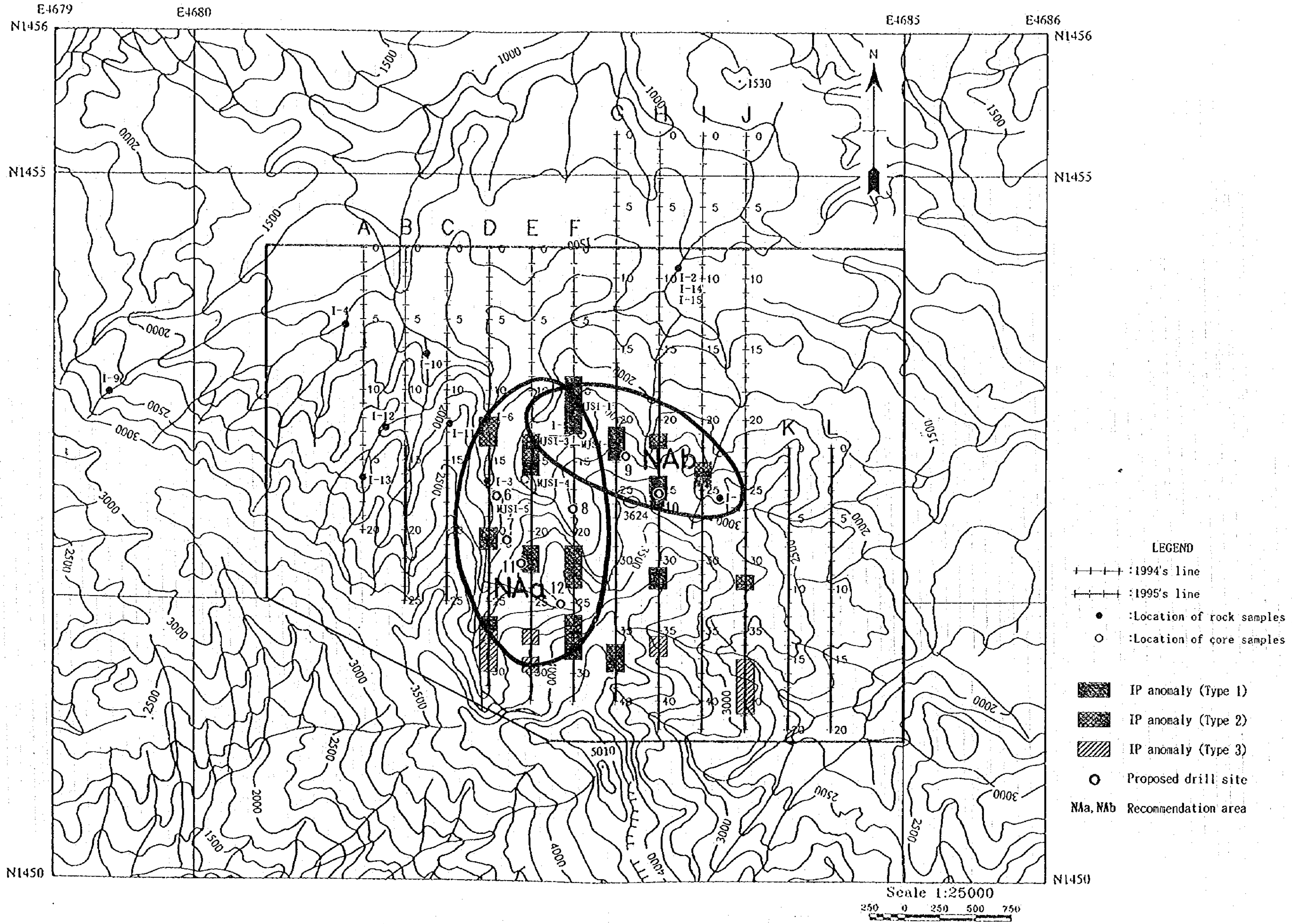
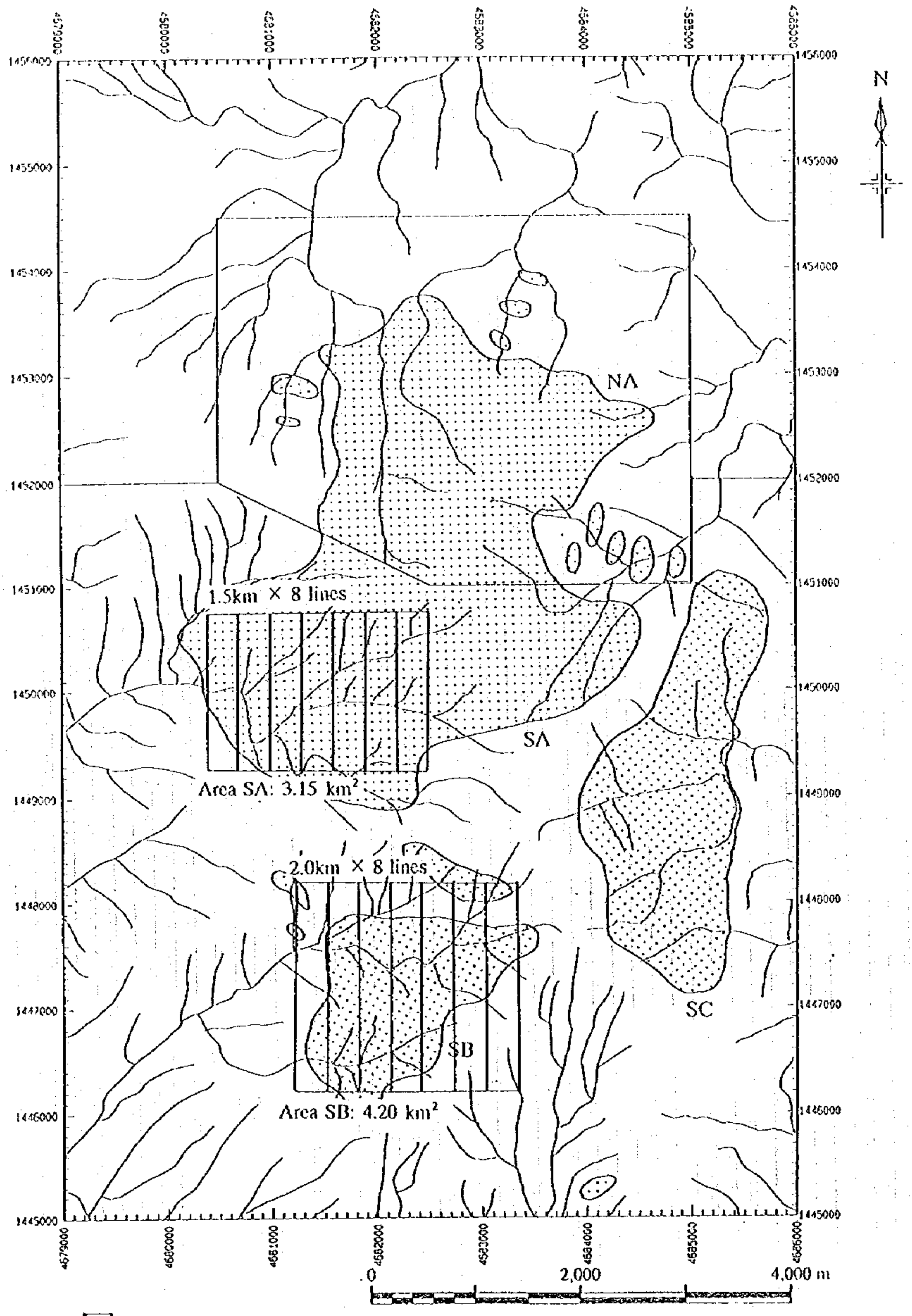


Fig. I -5 Recommendation for future work in S. Imbak Sub-area North



Area of recommendation for future work

IP survey line

Silicification/pyrite dissemination

Fig. I -6 Recommendation for future work in S. Imbak Sub-area South

Part Ⅱ Survey Result

Chapter 1 S. Imbak Sub-area North

1-1 Introduction

1-1-1 Survey area

The S. Imbak Sub-area is located in the south end of the Central Sabah area and is separated into two parts, S. Imbak Sub-area North and South, by the south end line of Labuk area of the Supra-Regional Survey. The S. Imbak Sub-area North is a southern part of the Area T of Supra-Regional Survey, in where soil geochemical survey was conducted in 1993, while, the S. Imbak Sub-area South is located immediate south of the Supra-Regional Survey area.

For the Phase II survey, the S. Imbak Sub-area North was re-established to the area of 14.75 Km^2 (NW 4.5 km × EW 3.5km) and it occupies center to south part of the S. Imbak Sub-area North of Phase I. The south end of the area is slightly extended to the south for tracing the continuity of the mineralization of the area.

The main drainage system of the S. Imbak Sub-area North, which flows from south to north, belongs to southern tributaries of S. Imbak except southeast part of the area where streams flow to Sungai Kuamut. The area is occupied by the steep mountainous topography. The elevation of the north part of the area is 400 m then it reaches more than 1,500 m in south part of the area where a ridge with Gunong Kuli runs NNW-SSE direction.

The entire area of the S. Imbak North is covered by primary jungle and no trace of human activities such as cultivation and logging is found in the area. The access to the area is poor, only by a small trail. The base camp was established along the logging road at the closest point to the area, then a trail of approximately 7 km long was constructed along ridge for transportation of geophysical equipment and various supplies. The geological survey and geophysical survey were conducted establishing advanced camp inside the area. For the drilling survey, a helipad was constructed to each drill site and mobilization and remobilization of drilling equipments were done chartering helicopter.

1-1-2 Background

The S. Imbak Sub-area, which had been lacking detail geological information, had been considered to be an area of monotonous Tertiary sedimentary rocks. The stream sediments with high concentrations of Au and Hg (maximum Au 6.530 ppb, Hg 24,735 ppb) obtained near the mouth of southern tributary of S. Imbak leaded to the subsequent semi-detail soil geochemical survey in the Area T, covering the catchment area of the tributary, during the Supra-regional Survey. Through the soil geochemical survey of the Area T, various evidences of Au and Ag mineralization were found in the southern part of the area, such as intrusions of diorite porphyry at 8 locations, silicification/pyrite dissemination in sedimentary rocks surrounding the intrusions, Au, Cu, Hg, S and Zn anomalies of soil geochemical survey and occurrences of high Au and Ag (maximum Au 18.4 g/t, Ag 931.4 g/t) thin quartz veins and float along the main stream. These evidences strongly support a high potentiality of Au and Ag mineralization in the Area T and a possibility of the mineralization to be continued further south from the Area T.

For further investigation and evaluation of the Au and Ag mineralization, the S. Imbak Sub-area was established in south part of Area T (S. Imbak Sub-area North) and south extension of the Area T (S. Imbak Sub-area South).

In the Phase I of the Central Sabah Project, semi-detail geological survey and geophysical survey were conducted in the S. Imbak Sub-area North for the understanding the mineralization of the area and following results were obtained.

The main mineralization and alteration occur within approximately 2 km × 2 km wide zone of silicification/pyrite (arsenopyrite) dissemination in the central south part of the area where many intrusive bodies of diorite porphyry occur. Au and Ag bearing quartz-sulfides (pyrite, arsenopyrite) veins and lens of 10 cm to 25 cm wide occur, sporadically, in the silicification/pyrite dissemination zone. Assay results of them show Au ranging from 8 g/t to 72 g/t and Ag ranging from 30 g/t to 196 g/t. The mineral assemblages of them are pyrite, arsenopyrite, chalcopyrite and two samples show small grains of native gold within arsenopyrite grains.

The mineralization in the area is characterized by Au - Ag type related to intrusion of diorite porphyry. Considering from the geological environment, mineral assemblages of ore minerals and alteration minerals, this mineralization is not an epithermal type. However, type of silver minerals occurring in the area and relatively high Ag compared to Au suggest temperature of mineralization to be relatively low. One of the possibility is that this area is located at the outer margin of a porphyry copper type mineralization. The intrusion age of the diorite porphyry is contemporaneous to the intrusive rocks of Mamut mine, which is Au rich porphyry copper type mine.

The distribution of IP anomalies obtain by the survey correspond well with distribution of silicification/pyrite dissemination zone in the central south of the area and anomaly seems to extend further south. The strongest anomaly is located from south end of Line D to central south of Line F in the silicification/pyrite dissemination zone. The Au anomaly of rock geochemical survey in the southern part of the area correspond to the medium to strong chargeability anomaly with more than 20mV/V. The strong chargeability anomaly with 30mV/V at the central south of Line F correspond to the location where Cu and S anomalies overlap. Consequently, there is strong indication of an existence of sulfide in the area surrounding the central south of Line F.

Based on the above results, the Phase II survey was conducted focused on the area of geochemical and geophysical anomalies to evaluate the potentiality for the mineralization.

1-1-3 Survey method and amount of work

An area of 14.75 km^2 including the silicification/pyrite dissemination zone at the center was re-established for the S. Imbak Sub-area North and detail geological survey, geophysical survey and drilling survey were conducted. The survey consists of detail geological survey of 41.7 km long traverse, IP geophysical survey of 19.7 km (11 lines) and five vertical drill holes of 200 m deep.

1-2 Geological Survey

A detail geological survey was conducted in the area of 14.75 km^2.

1-2-1 Survey Method

A 1:10,000 scale topographic map covering the S. Imbak Sub-area North (14.75 km^2) was prepared from the aerial photograph. A geological survey was conducted along drainage system using 1 : 5,000 scale map produced by an enlargement of the 1 : 10,000 scale map. Other than streams, wherever outcrop is expected, ridges, slopes of mountainous and geophysical survey lines were traversed. Typical rock and ore samples were collected for thin section and polished section. Ore assaying of 7 elements (Au, Ag, Cu, Mo, Pb, Zn and S) and X-ray diffraction analysis were done for mineralized and altered samples. For an estimation of temperature of the mineralization, measurement of the filling temperature of fluid inclusion was conducted from the quartz of quartz-sulfide veins.

1-2-2 Geology

The S. Imbak Sub-area North is overlain by the Tanjong formation (NT_2j) of early to middle Miocene and the Tanjong Formation is intruded by many small bodies of diorite porphyry. Silicification/pyrite dissemination zone occurs in the sedimentary rock closely associated with the intrusion of the diorite porphyry.

The geologic map of the S. Imbak Sub-area North together with cross sections are given in Plate II-1-1 and Fig. II-1-1 and schematic lithological succession is shown Fig. II-1-2. The sample location of laboratory studies and location of mineral showings are given in Fig. II-1-3. The results of laboratory studies are given on Table II-1-1 (thin section), Table II-1-2 (polished section), Table II-1-3 (X-ray diffraction analysis) and Table II-1-4 (ore assaying). In addition to them, measurement of filling temperature of fluid inclusion was conducted and the results is given in Table II-1-5 and Appendix 1.

The Tanjong Formation of the area was sub-divided into three formations. They are, from bottom to top, mudstone formation, alternation of mudstone and sandstone formation and sandstone formation.

The mudstone formation, mainly found in the area of relatively lower elevation, occurs in north and west parts of the area. At the higher location mudstone layers with a thickness of less than 100 m occur in the sandstone formation. The mudstone formation consists of dark gray to black, slightly soft mudstone and it is occasionally intercalated by gray to dark gray, hard sandstone layers of few cm to 1 meter wide. The upper horizon of the mudstone formation, close to the boundary to the alternation of mudstone and sandstone formation and sandstone formation, is intruded by small bodies of diorite porphyry and mudstone is silicified and pyrite disseminated. In the southeast part of the area, mudstone rarely includes pyrite nodule of few cm across.

The alternation of mudstone and sandstone formation, occupying at the horizon between mudstone formation and sandstone formation, appears to be a gradational zone between them. It occurs in the west part of the area at the elevation between 500 m to 700 m and it does not continue to east part of the area. The abundance of mudstone and sandstone varies from sandstone dominant alternation to mudstone dominant alternation and a thickness of each single layer ranges from few cm to few m. The mudstone is dark gray, slightly soft rock and sandstone is gray to dark gray and fine grained. Because of silicification in the center of the area, the distinction of sandstone and mudstone is obscured.

The sandstone formation occupies south and southwest part of the area where being dominated by steep topography of more than 700 m high. Gray to dark gray, hard, fine sandstone is predominant lithological facies. The sandstone found at the higher elevation near the ridge is bleached and shows pale gray color, while in the central south, the sandstone is silicified and hard rock with pyrite dissemination.

Microscopic observation of mudstone shows that quartz fragment of 0.02mm to 0.03 mm size is the main constituent with occasional association of plagioclase fragments. The matrix is filled by fine quartz and accessary minerals such as zircon, tourmaline and apatite. Sericite is most common alteration minerals covering over detrital grains. Kaolinite and chlorite, also, occur as alteration minerals. When alteration increases, that is commonly observed at the vicinity of intrusion of diorite porphyry, amount of sericite and secondary quartz increase.

The sandstone is well sorted, fine arkose sandstone of 0.1 mm to 0.3 mm grain size, consisting mainly fragments of quartz with subordinate plagioclase, K-feldspar, rock fragments (mudstone, andesite, tuff). The matrix is filled by fine quartz grains associated by zircon and tourmaline. When alteration increases, amount of sericite network increase with secondary quartz.

The strike and dip of the Tanjong formation in the S. Imbak Sub-area North are consistent over the entire area. It shows a monoclinic stricture, striking in NNW-SSE to WNW-ESE and dipping toward SW at 20° to 50° . Regardless of formations, there is a tendency of the strike gradually inclines to the west toward west part of the area. In the southeast part of the area a general strike is NNW-SSE (10° to 30° W) and in the center to west part of the area the strike gradually change to WNW-ESE (45° to 70 ° W). The sandstone in the higher location has a slightly a gentle dip, however, other than this, dip is consistently 20° to 40° SW in the entire area.

A N-S trending fault occurs in the east part of the area. Although only one fault is shown in the geological map, N-S trending small scale fault and sheared zones observed in many places suggest an existence of other N-S trending faults along the N-S trending valley.

The diorite porphyry is a gray porphyritic rock with plagioclase and hornblende phenocrysts of a few mm across. The intrusions mainly occur near the boundary between mudstone formation and sandstone formation in northwest part to southeast part of the area, and they are concordant to sub-concordant to the sedimentary rocks. The size of intrusion varies from few meters to 100 meters wide and the size of intrusive body increases toward east. There is, also, variation in grain size. The diorite porphyry of a small body is, generally, dark, fine grained rock with fine hornblende phenocryst and it shows similar appearance to andesite. While, the diorite porphyry of larger intrusive body is gray color, coarse grained rock with an appearance similar to plutonic rock. The diorite porphyry shows a different degree of alteration at each site and their appearances vary from gray color rock with clear porphyritic texture to a totally argillized, white color rock consisting of quartz and sericite. The argillized diorite porphyry commonly occur as small scale intrusion in the center part of the area. Microscopic observation of the less altered rock shows clear porphyritic texture with plagioclase and hornblende phenocrysts of 0.5mm to few mm across. In addition to them, biotite and clinopyroxene phenocrysts occasionally appear. There seem to be a compositional variation in the diorite porphyry. The one with predominant hornblende phenocryst is slightly basic than other one with phenocryst of predominant plagioclase and subordinate hornblende and biotite. Alteration and pyrite dissemination tend to occur to the latter one. Hornblende is generally altered to chlorite and calcite, while plagioclase is altered to sericite. The texture of groundmass, consisting of fine plagioclase and opaque minerals, varies from fine intergranular texture similar to andesite to hypidiomorphic granular texture. In strongly altered rock the primary minerals are totally replaced by alteration minerals such as quartz, sericite, calcite, chlorite and the original texture is completely modified.

The K-Ar dating done in Phase I suggest that intrusion of diorite porphyry took place in early Pliocene (7.25±0.18 Ma to 7.82±0.20 Ma).

1-2-3 Mineralization

The main mineralization and alteration of the area occur within the zone of silicification/pyrite dissemination in the center to southeast part of the area where many intrusive bodies of diorite porphyry and sandstone occur. In the zone silicification, rarely argillization, and pyrite (arsenopyrite) dissemination with thin pyrite veinlet along fracture occur to the sandstone and mudstone of the Tanjong formation. Generally, pyrite dissemination is more intensive in the sedimentary rocks compared with the diorite porphyry. Furthermore, quartz-sulfides (pyrite, arsenopyrite, sphalerite, galena) veins and lenses of 10 cm to 25 cm occur in the sedimentary rocks. With few exceptions, these veins commonly cut the sedimentary structure trending mainly in N-S with a steep dip of more than 60° to both east and west. In many cases, these veins occur associated with fracture zone of few cm to few 10 cm wide.

The mineral showings of IM-1 to IM-5 were found in Phase I survey . In addition to them IM-6 to IM-10 were found in the S. Imbak Sub-area North during the Phase II survey. The main mineral showings are summarized below and Table II-1-6. Fig. II-1-4 shows sketch of main mineral showings.

IM-6 : Quartz-sulfides (pyrite, arsenopyrite, chalcopyrite) veins of 2.5 to 7 cm wide are scattered in silicified and argillized sandstone. They occur cutting the bedding structure of sandstone, striking N-S and dipping 70° W to vertical. Assay result shows that they are Au (Au 2.6 g/t and 2.5 g/t) and Ag (Ag 52.8 g/t and 51.3 g/t) bearing veins with minor amount of Cu (Cu ±0.1%).

IM-7 : Quartz-sulfides veins (strike: NNE-SSW to NE-SW, dip: 80° W) of 1 cm to 3 cm wide occur both in silicified sandstone and argillized diorite porphyry. The sulfides of the veins consist of pyrite, arsenopyrite, sphalerite, galena, marcasite and chalcopyrite. Sulfide rich part of the vein is high in Ag, Pb and Zn (Ag 148.2 g/t, Pb 5.22 %, Zn 4.27 %).

IM-8 (sketch 1A, 1B) : Sulfide rich lenses of few cm wide occur along fracture of pyrite disseminated sandstone and mudstone at the vicinity of diorite porphyry. The sulfide of the lenses consist of arsenopyrite, sphalerite, galena, marcasite and small amount of pyrite. The sample collected from the 20 cm span including sulfide lenses and host rock gives assay result of Ag 21.7 g/t, Pb 0.96 % and Zn 1.07 %.

IM-9 (sketch 2) : Sulfide rich lenses and veins with the maximum width of 4 cm occur along the fracture in mudstone at the vicinity of diorite porphyry. General trend of the lenses and veins are parallel to fracture and cut the bedding structure of the mudstone, striking 80° E, dipping 80° W. Pyrite, sphalerite, galena, marcasite and chalcopyrite are sulfides included in the lenses and veins. The sample collected from the 20 cm span including sulfide veins and host rock gives assay result of Ag 47.3 g/t, Pb 3.14 % , Zn 1.66 % and low Cu of less than 0.10%.

IM-10 (sketch 3) : Sulfide rich lenses and veins with the maximum width of 4 cm occur along fracture of pyrite disseminated mudstone. General trend of the lenses and veins are parallel to fracture and cut the bedding structure of the mudstone, striking 25° E, dipping 60° W. Pyrite is the main sulfide associated by sphalerite, marcasite and chalcopyrite. The assay result of the vein shows Au 3.5 g/t, Ag 64.2 g/t, Pb 0.12 % and Zn 0.77 %.

Other than above, there are minor quartz-sulfides veins of few cm wide scattered in the zone of silicification/pyrite dissemination (P107, P108, P122, S123, S124). The main sulfides of the quartz-sulfides veins are pyrite and arsenopyrite with subordinate amount of chalcopyrite, sphalerite and marcasite. Au and Ag of these veins, respectively, range from Au 2.8 g/t to 3.8 g/t and from Ag 2.8 g/t to 46.8 g/t. Base metals of these veins are generally low.

An encouraging assay results were not obtained from the host rock of these veins, silicified and pyrite disseminated sedimentary rocks and strongly argillized diorite porphyry.

Although a large scale mineral showing and Au rich veins were not found in Phase II survey, a wide distribution of quartz-sulfides veins with Ag, Pb and Zn was confirmed all over the silicification/pyrite dissemination zone.

Together with the results of Phase I, the mineralization of the S. Imbak Sub-area North is summarized as follows;

The mineralization and alteration of the S. Imbak Sub-area North is characterized by silicification and pyrite dissemination of the sedimentary rocks closely associated with intrusions of diorite porphyry. Quartz-sulfides (pyrite, arsenopyrite, sphalerite, galena and chalcopyrite) veins of few cm to 25 cm wide are scattered over the zone of the silicification/pyrite dissemination and some of the veins are rich in Au and Ag. Base on the metallic elements and sulfides minerals, the quartz-sulfides veins are classified into three types.

Type ①: Au and Ag rich type with a relation of Au≧Ag. Cu is slightly high (0.2 % to 0.5 %), however, Zn and Pb are very low. The sulfides of this type is mainly pyrite and arsenopyrite and native gold occurs within the arsenopyrite grains. IM-4 is a example of this type.

Type ②: Au and Ag rich type with a relation of Ag>Au. Cu is ±0.1 % and Zn and Pb are very low. The sulfides of this type are mainly pyrite, arsenopyrite and native gold occurs in arsenopyrite grains. IM-3, IM-6 and IM-10 are examples of this type.

Type ③: Pb and Zn rich type. Ag is high but Au and Cu are very low. The sulfides of this type are pyrite, arsenopyrite, sphalerite and galena. IM-5, IM-7, IM-8, IM-9 are examples of this type.

As shown in Fig. II-1-3, Type ① and Type ② occur in a relatively restricted area of southwest part of the silicification/pyrite dissemination zone, while Type ③ occurs in the northeast part of the silicification/pyrite dissemination zone.

Despite of a strong alteration of argillized diorite porphyry, it does not show a clear mineralization. Although silicified and pyrite disseminated sedimentary rocks are slightly high in Au and Ag at the vicinity of the diorite porphyry and at the contact to the quartz-sulfides veins, a disseminated mineralization of Au and Ag do not seem to occur in wide extent in the sedimentary rocks.

1-2-4 Fluid inclusion filling temperature

1. Method

A measurement of filling temperature of the fluid inclusion trapped in quartz was conducted using the heating/cooling stage (TH600RH, Linkam, England) and temperature controller of the same company. The temperature was controlled at 40 ° C/minute and 4° C/minute to avoid a decrepitation and volume increase of the fluid inclusions. After homogenization, the temperature was lowered at 10 to 40° C/minute to confirm the appearance of vapor phase at approximately 30° C below homogenizing temperature. For the specimen with enough inclusions, measurement was done for more than 30 inclusions and each inclusions were measured twice.

2. Results

Filling temperature measurement of four samples collected from quartz sulfide veins of the S. Imbak Sub-area North was conducted. All of the samples include many fluid inclusions of 5 to 25 μm across. Although manner of their distributions are not same within one sample, being aligned along certain plains or showing a random distribution, there is no difference in the filling temperature respect to the manner of distribution. S136 shows a wide range of temperature, some of them being shifted to lower temperature side away from the main population. For a calculation of average temperature, lower temperatures away from the population were excluded for S136.

Almost all of the obtained temperature of the four samples ranges from 300° C to 400° C and their average temperature varies from 318.1° C to 379.7° C. The temperatures obtained are high compared to those of epithermal type mineralization. Among these four samples, P108 (Average 379.7° C) and S132 (Average 369.5° C) show similar temperatures with almost all of the individual inclusions range from 350° C to 400° C, and their temperatures are slightly higher than others. While, S122 collected close to S132 has a lower average temperature of 337.3° C. S136, collected away from other samples at the north end of the silicification/pyrite dissemination zone, show the lowest temperature of 318.1° C.

According to the classification of quartz-sulfides veins mentioned above, P108 belongs to Type ① (Au≧Ag) and S122, S132 and S136 belong to Type ② (Ag>Au). There is no clear tendency of temperature differences between Type ① and Type ②.

1-3 Geophysical survey

1-3-1 Survey method

1. Purpose

The purpose of the survey is to clarify the relation of the IP results obtained during the present survey with the existing mineralization, the geochemical anomalies and the extension of the IP anomaly zones detected by IP survey in Phase I in the survey area. An investigation of the electrical structure of the survey area was carried out by clarifying the distribution of IP anomalies in the survey area obtained by using of the time domain IP method.

The measurements were done by using the time domain IP method adopting a dipole-dipole electrode configuration with a separation factor "n" from 1 to 4. Based upon the geological structure, 11 survey lines of 19.7 line-km in total were set along a N-S direction with a 300m line spacings. The numbering of IP survey stations were set from the south end of each line with 100m spacing from the north to the south. Survey specifications are shown in Table II-1-7. Location of survey lines, rock and core samples from the five drill holes in Phase I and Phase II, are illustrated in Fig.II-1-5.

2. Method of IP measurement

The time domain IP method used in this survey utilized a battery-driven portable equipment from Scintrex Ltd. (receiver IPR-12) and transmitter. The transmitter has a maximum output of 1500 volts in 10 steps and a maximum current of 10 amps sent to a pair of grounded electrodes. The receiver is connected to another pair of electrodes. The signal (Vp) observed during the on-time of transmitter is used together with the current and electrode geometry to obtain the resistivity.

The signal received (Vs) by the receiver during off-time of transmitter will fall instantaneously to zero unless there is polarizable material like sulfides present. In the presence of such material there will be a slow decay of received potential with time as shown in Fig.II-1-6. Standard pulse duration was 2 seconds, 11 chargeability values (unit in mV/V) were sampled on the decay curve (Fig.II-1-7). The most convenient array was found to be a dipole-dipole array illustrated in Fig.II-1-8.

3. Electrical measurement of rock samples

Electrical measurement of core samples from five drill holes were carried out in order to determine the actual electrical properties of rocks distributed on/in the survey area. The core samples collected from the drill holes were formed into a cylindric shape. Their measurements were realized in water saturated condition after the core samples were soaked in water during 2 days. The receiver used is the same type of receiver of Scintrex Ltd.(IPR-12) in the field survey.

4. Survey equipment

Survey equipments used for the IP survey, manufactured by Scintrex Ltd. in Canada, are shown in Table II-1-8.

1-3-2 Analysis method

Fig. II-1-9 shows the procedure used for IP data analysis and interpretation.

1. Terrain correction

Since the geometrical factor is calculated as a function of the location of current and potential electrodes on half-infinite plane, spacings of electrodes are affected by the topography depending upon the location of electrodes, even if the terrain is homogeneous. For example, for the case of a dipole-dipole configuration, spacings of electrodes appear to be high beneath a hill and low beneath a valley. On the other hand, chargeability is less affected by topography because it is rather proportional to the ratio of the primary and secondary voltage of the decay curve.

Since the topography of the survey area is comparatively steep and rugged, the correction was performed for all survey lines by means of a finite element method assuming a two dimensional half space topography. The pseudo-sections and plan maps were drawn using the terrain corrected values.

2. Simulation analysis

For the analysis and interpretation of IP data, two methods are mainly used: one qualitative and another quantitative.

The qualitative method correlates the anomaly patterns of the profiles and the maps in reference to precomputed standard anomaly patterns derived from various simple electrical structural models of the subsurface. The quantitative method compares the observed data with theoretical data calculated from the simulated electrical structure.

These two methods were combined to obtain optimum results. Pseudo-sections were modeled by using the meshes of the model which assumed resistivity and chargeability values on the basis of geology, standard models and IP properties of rock samples. The theoretical values were calculated by a numerical analysis using two-dimensional finite element techniques.

Further comparisons between the calculated values and observed data permitted to change the various parameters of the model in order to approach efficiently the observed values. By the iterative procedure and guided by existing geological information of the area, it was possible to obtain the most reasonable model of the underground electric structure.

Simulation analysis were mostly carried out for the strong IP anomalies detected on the lines, to clarify the lateral and vertical extension of the mineralization zone.

1-3-3 Survey results

1. Results of rock sample measurements

Resistivity and chargeability were measured for 21 core samples collected from five drill holes in this area. The location of rock and core samples collected in Phase I and Phase II(1995) are shown in Fig. II-1-5, and the corresponding measurement results are indicated in Table II-1-9. Collected rock and core samples consist of mudstone (13 samples), sandstone (10 samples), diorite porphyry (10 samples) and ores (2 samples).

Resistivity of rock and core samples ranges from 3 to 4040 Ω-m and from 71 to 14600 Ω-m. Rock samples of I-3 and I-7 are ores which contain considerable sulfide with some amount of Au grade. These samples indicate a low resistivity of less than 10 Ω-m. Rock samples of I-9, I-13, I-15 which contain many micro-fractures, indicate medium resistivity values. The other rock samples show a higher resistivity than core samples. Some core samples, GP-1-4 (mudstone with chalcopyrite and pyrite vein of a few mm in width), GP-3-1 (mudstone, chloritized), GP-3-4 (coarse sandstone), GP-4-2 (mudstone with weak alteration) and GP-4-4 (diorite porphyry, silicified and argillized) show a relatively lower resistivity of around 100 Ω-m. Chargeability values of rock and core samples, which are generally indicative of sulfide contents, range from 1.7 to 124.2 mV/V and from 3.3 to 187 mV/V, respectively. The ores, rock and core samples with much pyrite, such as I-3, I-7, I-1, GP-4-3, GP-5-1, GP-1-4 and GP-3-2 show highest chargeability values between 49 and 187mV/V. Some core samples with alteration, such as GP-3-1, GP-4-4, GP-4-5, GP-5-2 and GP-5-3 show a higher chargeability values between 39 and 180 mV/V, however, the others indicate a low chargeability values of less than 10 mV/V.

The following table shows a classification based on the rock resistivity and chargeability of the rock types summarized from the above-mentioned results.

Classification of rock resistivity and chargeability

Rock	Case 1 (Background)		Case 2 (include Py,Po,Cp etc.)	
	AR(Ω-m)	M(mV/V)	AR(Ω-m)	M(mV/V)
Ms	38≤AR≤ 288	10≥M	90≤AR≤ 25	24≤M≤ 67
Ss	32≤AR≤ 2850	10≥M	360≤AR≤ 978	27≤M≤187
Dp	289≤AR≤14600	10≥M	106≤AR≤1060	97≤M≤180

* AR:Resistivity M:Chargeability Py:Pyrite
Po:Pyrrhotite Cp:Chalcopyrite Ms:Mudstone
Ss:Sandstone Dp:Diorite porphyry

2. Distribution of apparent resistivity and chargeability (Fig.II-1-10 to Fig.II-2-13)

In this survey which includes the results obtained in Phase I survey area, apparent resistivity values were detected in the range from 1 to 2000 Ω-m and chargeability values in range from 40 to 77 mV/V. On this basis and in this report, apparent resistivity (AR) and chargeability (M) values were also classified in three groups as follow.

Classification of AR and M

Class	Apparent resistivity(AR) (Ω-m)	Chargeability(M) (mV/V)
High	$65 \leq AR$	$30 \leq M$
Medium	$15 \leq AR < 65$	$10 \leq M < 30$
Low	$AR < 15$	$M < 10$

Apparent resistivities from medium to low values are distributed in the northern part of the area consisting of mudstone, especially low values less than 5 Ω-m are seen distributed at depth in the area. High resistivity zone is distributed in the south-half of the survey area with a steep topography, consisting of silicified sandstone; especially high values in the central to eastern part of the survey area. This high resistivity zone is coincident with a distribution of intrusive rocks (diorite porphyry). A medium to low resistivity zone is located in two areas, one is an area which extends southeastward from station No.16 on line-E, another is the area which extends southward from the station No.17 on line-D.

Distribution of chargeability presents low values of less than 10 mV/V in the northern part of the area, and medium to high values of over 20 mV/V in the southern half of the area. High chargeability zones of more than 20 mV/V extend south-eastward and southward in the central part of the survey area. Highest chargeability values of more than 30 mV/V are detected at shallower part in a southern half of the Line-D to line-G. These high chargeability values suggest a strong mineralization, mainly of sulfide type. In the survey area, the following types of IP anomalies are seen.

Classification of IP anomalies

Type	Item	Alteration/Mineralization
Type 1	Resistivity Low	Strong alteration and strong sulfide mineralization
	Chargeability High	Dissemination type
Type 2	Resistivity Medium	Medium alteration and strong sulfide mineralization
	Chargeability High	Dissemination and/or vein combination
Type 3	Resistivity High	Weak alteration and considerable sulfide mineralization
	Chargeability High	Veins

(1) IP Anomaly of Type 1

This type of IP anomaly is detected in and around the zones:

No.16 to 17 from shallow to medium depth of Line-D,

No.15 to 17 at shallow depth, and No.16 to 17 medium depth of Line-E,

No.10 to 11 at medium depth, and No.11 to 14 from shallow to deep level of Line-F.

No.23 to 24 at medium to deep level of Line-G.

Sources of the IP anomaly are mainly distributed in the mountainous area of the central part of the survey area.

(2) IP Anomaly of Type 2

This type of IP anomaly is detected in and around the zones:

No.12 to 13 from the shallow to deep level, No.20 to 22 at shallow depth, No.29 to 30 at deep level of Line-D,

No.12 to 14 from the medium to deep level of Line-E,

No.22 to 25 at deep level of Line-F,

No.35 to 36 at deep level of Line-G,

No.31 to 32 from the medium to deep level of Line-H,

No.25 to 26 from the medium to deep level of Line-I.

Sources of the IP anomaly are mainly distributed in two areas, one is the area which extends south-eastward from the central part of the area, another is the area which extends south-eastward from the central part of Line-H.

(3) IP Anomaly of Type 3

This type of IP anomaly is detected in and around the zones:

No.24 to 29 at shallow depth of Line-E,

No.40 to 41 at shallow depth of Line-H,

No.38 at shallow depth of Line-I,

No.33 at deep level, No.36 to 41 from shallow to deep level of Line-J. Sources of the IP anomaly are mainly distributed in the higher mountainous area of the south end of the survey area.

3. Simulation analysis

The strong IP anomaly, mentioned above, which probably indicates a strong sulfide mineralization, was considered important for the simulation analysis. The results of the two dimensional model simulation for the IP anomalies on the 7 lines (Line-D to Line-J) are shown in Fig.II-1-14. The drilling survey in the Phase II used the results of the model simulation.

Distribution of strong IP anomalous bodies was already described in the previous item No.2. These IP anomalous bodies continue to extend southward in the southern half of the survey area. IP anomaly of type 1, with low resistivity and high chargeability, is seen in the mountainous area of a central part of the survey area which extends from No.15 on Line-E to No.25 on Line-H. IP anomaly of type 2, with medium resistivity and high chargeability is distributed in two areas, namely, one area which extends southeastward from the central part of the area (around No.13 and No.20 on Line-D to the south end on Line-G), and another area which extends south-eastward from the central part of Line-H (around No.22 on Line-H to No.31 on Line-J). IP anomaly of type 3 is seen in the higher mountainous area of the south end of the survey area (the south end of lines D, E, H and J).

1-4 Drilling Survey

The drilling survey was conducted in the S. Imbak Sub-area North for an understanding of the occurrence of mineralization under the surface. The locations of the five drill holes were decided based on the geological information, IP anomalies and geochemical anomalies.

1-4-1 Survey method

The drilling operation of five holes was conducted over the silicification/pyrite dissemination zone in the S. Imbak Sub-area North. As given in Table II-1-10, all five holes are vertical hole and each hole is 200 m deep. The drill sites are shown in Fig. II-1-15.

1. Mobilization of equipment and set up

The equipments and materials for drilling operation were transported by vehicles from Kota Kinabalu to the base camp located along a logging road at the closest point to the S. Imbak Sub-area North. A long distance winching work was considered to be impossible because of the rugged topography of the area. For minimizing the winching work, a helipad was constructed at a radius of within few 10s of meters from each drill site. Mobilization and demobilization of the equipments and materials for drilling operation were conducted using a helicopter for all five holes. The direct distance between the base camp and each drill site is approximately 7 km. Bell 206 Jet Ranger was deployed for the operation and all the drilling equipments were dismantled to less than 300 kg each. Two drilling machines were deployed for the drilling work and the mobilization and demobilization were conducted in the following order.

1st. helicopter charter

Drill machine No.1	Base camp	to	MJSI-1
Drill machine No.2	Base camp	to	MJSI-4

2nd. helicopter charter

Drill machine No.1	MJSI-1	to	MJSI-3
Drill machine No.2	MJSI-4	to	MJSI-2

3rd. helicopter charter

Drill machine No.1	MJSI-3	to	Base camp
Drill machine No.2	MJSI-2	to	MJSI-5

4th. helicopter charter

Drill machine No.2	MJSI-5	to	Base camp

2. Drilling operation

The drilling work was conducted during a period of August 23, 1995 to October 19, 1995, establishing a camp at each drill site. The work such as preparation, set up, mobilization and demobilization were done only by day sift and actual drilling operation was conducted by two shifts. The drilling operation was done by wire line method using the Mindrill F-30 (Australia).

A summary of the drilling activities, progress record and a list of the drilling equipments are, respectively, given in Appendix 9, Appendix 10 and Appendix 11.

3. Core logging

The description of the drill core was done either at the drill site or base camp during the drilling operation. For the sampling of laboratory work samples, the core was sprite into two portion and a half portion was preserved in the core box. If mineralization continues for the certain length, assay samples were collected for 1 m span to obtain average grade.

1-4-2 Survey results

Description of drill core at 1:200 scale and cross sections of the drill site are, respectively, given in Appendix 12 and Fig. II-1-16. Microscopic observations of the thin sections and polished sections were summarized in Table II-1-11 and Table II-1-12. The results of X-ray diffraction analysis and assaying are, respectively, given in Table II-1-13 and Table II-1-14.

1. MJSI-1

[Geology]: It mainly consists of dark gray mudstone, intercalated by alternation of sandstone and mudstone layers. The intensive alteration is not found all through the core. The lamina and bed dip 20° degree.

0.00 - 3.68	:overburden.
3.68 - 7.85	:dark gray, slightly soft mudstone, brecciated.
7.85 - 31.35	:dark gray mudstone with sandstone lamina and bed of 0.5 to 5.0 cm wide, ratio of mudstone and sandstone is 80 % : 20 %.
31.35 - 45.65	:alternation of dark gray mudstone and gray fine sandstone, mudstone dominant, ratio of mudstone and sandstone is 70 % : 30 %.
45.65 - 101.00	:dark gray mudstone with sandstone lamina and bed of few mm to 10 cm wide.
101.00 - 140.70	:gray sandstone with mudstone lamina of 1 mm to 1 cm wide, a ratio of sandstone and mudstone is 80 % : 20 %, core crushed from 112.20 m to 114.40 m.
140.70 - 201.25	:dark gray mudstone with sandstone lamina and bed of few mm to 30 cm wide.

The thin section of mudstone shows that it consists of mainly quartz and minor plagioclase fragments associated by alteration minerals of sericite and chlorite.

[Mineralization]: Very weak dissemination of pyrite, pyrrhotite, arsenopyrite is observed all through the core associated by fracture filling film of pyrite and pyrrhotite-chalcopyrite of ±1mm thick. Patches and nodules of few cm across consisting of pyrrhotite, pyrite and chalcopyrite occur sporadically. From 120 m to 160 m, they occur at the frequency of a few per 1 meter. In these patches chalcopyrite tends to occur associated by pyrrhotite. The polish section shows mineral assemblages of these patches and nodules to be pyrite-chalcopyrite-sphalerite-marcasite± pyrrhotite±arsenopyrite±galena.

Other than above, quartz-sulfides (pyrite, pyrrhotite, chalcopyrite) veins of few mm to few cm occur at the steep dip of more 60° . Only a small amount of Ag (Ag 2.9 g/t, 1.0 g/t) were obtained from the quartz-sulfides vein (A-1-1) and mudstone with pyrrhotite dissemination (A-1-2). Patches of pyrite-chalcopyrite (A-1-3, A-1-4) shows only Ag 2.4 and 2.2 g/t, Zn 0.15 and 0.24 %.

2. MJSI-2

[Geology]: It mainly consists of dark gray mudstone, intercalated by alternation of sandstone and mudstone layer. These sedimentary rock are intruded by diorite porphyry with hornblende phenocryst from the surface to 47.55 m. The lamina and bed dip 20° degree.

0.00 - 7.20	:overburden.
7.20 - 47.55	:dark gray, fine diorite porphyry with hornblende phenocryst, has an appearance similar to andesite, some parts show pale gray color because of alteration such as chloritization and weak silicification, mineralization occur in those altered part.
47.55 - 159.30	:dark gray mudstone with sandstone lamina and bed of few mm to 20 cm wide, rarely fractured zone with chloritization and argillization occur but generally the alteration is weak.
159.30 - 185.30	:alternation of dark gray mudstone and gray fine sandstone, thickness of each bed varies from few mm to 30 cm, ratio of mudstone and sandstone is 50 % : 50 %, generally core is brecciated.
185.30 - 200.30	:dark gray mudstone with sandstone lamina and bed of few mm to 10 cm wide.

The thin sections of diorite porphyry show that hornblende phenocryst is predominant with subordinate plagioclase. Calcite and chlorite occur as an alteration mineral and when alteration increases abundant quartz and chlorite occur.

[Mineralization]: Alteration is more intensive in diorite porphyry than in sedimentary rocks. Dissemination of pyrrhotite, pyrite and chalcopyrite occur all through the diorite porphyry. Generally, more altered part shows stronger dissemination consisting of pyrrhotite and chalcopyrite, while less altered part shows weaker dissemination of pyrite. In addition to the dissemination, fracture filling film of ±1mm wide with mineral assemblages of pyrite, pyrrhotite-chalcopyrite, pyrite-sphalerite and steeply dipping (70° to 80°) quartz-sulfides (pyrite, pyrrhotite, arsenopyrite) veins of few cm wide occur. The quartz-sulfide vein at 26.10 m (A-2-2) consisting of arsenopyrite, chalcopyrite, sphalerite, galena, pyrrhotite and marcasite shows assay results of Ag 25.2 g/t, Pb 0.13% and Zn 0.51 %. Other than this, assay results of disseminated diorite porphyry and diorite porphyry with quartz-sulfides vein give Ag ranging from 2.6 g/t to 9.6 g/t and Zn ranging from 0.08 to 1.71 %.

In sedimentary rocks, very weak dissemination of pyrrhotite and pyrite and fracture filling film of ±1mm wide consisting of pyrrhotite-chalcopyrite and pyrite occur. The quartz-sulfides vein is very rare in sedimentary rocks. Pyrrhotite or pyrrhotite-chalcopyrite patches and nodules of few cm across sporadically occur in the sedimentary rocks. Any encouraging assay result was not obtained from the sedimentary rocks.

3. MJSI-3

[Geology]: Upper part mainly consists alternation of mudstone and sandstone and lower part is dominated by dark gray mudstone. The lamina and bed dip approximately 20° degree.

0.00 - 5.85	:overburden.
5.85 - 25.15	:alternation of dark gray mudstone and gray sandstone, each lamina and bed are few mm to 1 m wide, ratio of mudstone and sandstone is 40 % : 60 %, the core is fractured and oxidized from 8.10 m to 16.20 m.
25.15 - 43.80	:gray sandstone with mudstone lamina and bed of few mm to few 10s cm wide, ratio of sandstone and mudstone is 90 % : 10 %.
43.80 - 81.65	:dark gray mudstone with sandstone lamina and bed of few mm to few 10s cm, ratio of mudstone and sandstone is 90 % : 10 %, partly chloritized (46.60 m to 59.00 m) and silicified (65.00 m to 69.00 m).
81.65 - 103.45	:gray sandstone with mudstone lamina and bed of few mm to few 10s cm, ratio of sandstone and mudstone is 80 % to 20 %.
103.45 - 136.50	:alternation of dark gray mudstone and gray sandstone, thickness of each bed ranges from few cm to 50 cm, ratio of mudstone and sandstone is 50 % : 50

%.

136.50 – 200.84 :dark gray mudstone with sandstone lamina and bed of few mm to few cm wide, ratio of mudstone and sandstone is 90 % : 10 %.

Microscopic observation shows that sandstone is well sorted fine grained sandstone consisting mainly of quartz and subordinate plagioclase grains. Mudstone consists of abundant quartz grains with minor plagioclase grains. Chlorite and sericite are main alteration minerals for both of sandstone and mudstone.

[Mineralization]: The mineral assemblages of ore mineral change approximately at 100 m. Weak pyrite dissemination and fracture filling film of pyrite with a thickness of ±1 mm prevail in the core shallower than 100 m. While in the core deeper than 100 m, amount of pyrrhotite with association of chalcopyrite increases and exceed the amount of pyrite. The mineral assemblages of fracture filling film consist of the same minerals as dissemination. The dissemination is slightly intensive in mudstone than in sandstone. Quartz–sulfides (pyrrhotite, pyrite, chalcopyrite) veins of few cm wide are scattered between 60 m to 70 m and pyrite–chalcopyrite–sphalerite veins of 0.5 cm to 1.0 cm wide occur between 167 m to 172 m. Sulfide (pyrrhotite, pyrite, chalcopyrite) patches and nodules of few cm across rarely occur at the depths of from 50 m to 60 m and from 95 m to 99 m. The sandstone and mudstone with sulfide veinlets, respectively, at 18 m and 50 m show low assay grade of Ag 4.6 g/t and Ag 0.6 g/t. While, Ag grade is slightly high (Ag 15.8 g/t) in the mudstone with irregular patches of quartz–pyrrhotite–chalcopyrite. The mudstone with ± 1cm wide sulfides (pyrite, sphalerite, chalcopyrite) veins give slightly high Ag (11.8 g/t, 8.4 g/t) and low grade of Pb (0.14 %, 0.15 %) and Zn (0.43 %, 0.14 %).

4. MJSI–4

[Geology]: Sedimentary rocks of mudstone, sandstone and alternation of sandstone and mudstone prevail in the MJSI–4 and diorite porphyry with plagioclase, hornblende and biotite phenocrysts intrudes into the sedimentary rocks between the depth from 62.00 m to 107.00 m. The diorite porphyry is altered and conspicuous mineralization associate with it. The lamina and bed of the sedimentary rocks dip approximately 20°.

0.00 – 12.95 :overburden.

12.95 – 46.15 :gray sandstone with mudstone lamina of few mm to few cm wide, ratio of sandstone and mudstone is 80 % : 20 %, partly chloritized especially along fractures.

46.15 – 62.00 :dark gray mudstone with sandstone lamina of few mm to 1 cm wide.

62.00 - 107.00 :gray diorite porphyry with plagioclase, hornblende, biotite phenocryst, the boundary between mudstone and diorite porphyry is parallel to sedimentary structure, neither clear indication of thermal metamorphism in the mudstone nor chilled margin in diorite porphyry was found, chloritization, silicification, and weak argillization prevail all through the diorite porphyry, porphyritic texture is obscured in the zone of strong alteration and the location of prominent mineralization coincide with location of strong alteration.

107.00 - 118.30 :dark gray mudstone with sandstone lamina and bed of 1 mm to few cm wide, ratio of mudstone and sandstone is 80 % : 20 %.

118.30 - 132.10 :alternation of dark gray mudstone and gray sandstone, thickness of each bed ranges from 1 cm to 50 cm wide, ratio of mudstone and sandstone is 50 % : 50 %.

132.10 - 155.60 :dark gray mudstone with sandstone lamina and bed of 1 mm to 10 cm wide, ratio of mudstone and sandstone is 70 % : 30 %.

155.60 - 190.90 :gray sandstone with 1 mm to few cm wide mudstone lamina, ratio of sandstone and mudstone is 95 % : 5 %.

190.90 - 202.30 :dark gray mudstone with sandstone lamina and bed of 1mm to 10 cm wide, ratio of mudstone and sandstone is 80 % : 20 %.

Thin section observation and x-ray diffraction show that the mudstone at the vicinity of the diorite porphyry intrusion has abundant sericite and other secondary minerals such as quartz, calcite, chlorite and biotite. The phenocrysts of the diorite porphyry are plagioclase, hornblende and biotite, in the order of abundance, and when it altered phenocrysts remain only as pseudomorphs, being completely replaced by secondary minerals. The secondary minerals of the diorite porphyry are quartz-calcite-chlorite in relatively fresh rock. When it is altered, the amount of sericite drastically increase.

[Mineralization]: The main mineralization occur in the diorite porphyry. The weak dissemination of pyrite, chalcopyrite, (arsenopyrite) and (sphalerite) occur all through the diorite porphyry. The intensity of dissemination increases in accordance with alteration. In addition to this, fracture filling film of sulfides (pyrite, sphalerite, chalcopyrite and arsenopyrite) with ±1mm wide occurs. The most prominent mineralization occurs between the depth of 84.10 m to 101.90 m where few mm to 10 cm size network veins and patches of sphalerite-chalcopyrite-pyrite occur all over the diorite porphyry and grade of Zn estimated to be 0.5 % to 1.0 % through this zone. Within this zones, at the depth between 86.70 m to 93.40 m, few cm to few 10s cm size, irregular veins and patches of quartz-sulfides (sphalerite, pyrite, arsenopyrite, chalcopyrite, marcasite) occur overlapping to the sphalerite mineralization. The assay result of 1 m span samples of mineralized diorite porphyry between the depth of 84.10 m to 101.90 m show high Ag (9.0 g/t to 90.5 g/t) and Zn (0.42 % to 2.20 %). Cu (0.08 % to 0.13 %)and Pb (0.02% to 0.79 %) are slightly low. Au ranges from 0.1 g/t to 0.5 g/t.

A weak dissemination of pyrite and pyrite-pyrrhotite occur all through the sedimentary rocks and ± 1 mm wide fracture filling film of the same minerals occasionally associate with this. The sulfides (pyrrhotite, pyrite, chalcopyrite) patches and nodules of few cm across only rarely occur in the MJSI-4. In addition to them, ± 1 cm wide quartz-sulfides (pyrite, arsenopyrite, pyrrhotite, sphalerite, chalcopyrite) veins sporadically occur in the sedimentary rocks. These quartz-sulfide veins show relatively high Ag (1.3 g/t to 26.2 g/t) and low Au (1.3 g/t at the maximum).

5. MJSI-5

[Geology]: It mainly consists of sandstone and subordinate mudstone layers. The diorite porphyry intrudes at the 169.80 m and it continues to the bottom. The sedimentary rocks are slightly silicified and chloritized, while, all through the diorite porphyry silicification and chloritization occur. The lamina and bed dip approximately 20° degree.

0.00 - 2.56	:overburden.
2.56 - 103.35	:dark gray sandstone with mudstone lamina of few mm to few cm thick, the sandstone is slightly silicified and the mudstone shows weak chloritization.
103.35 - 125.00	:dark mudstone with sandstone lamina of few mm to few cm thick, weakly chloritized.
125.00 - 151.40	:gray sandstone with dark gray mudstone lamina of few mm to few cm.
151.40 - 169.80	:dark gray mudstone with sandstone bed of 1 cm to 10 cm.
169.80 - 200.80	:gray diorite porphyry with plagioclase, hornblende and biotite phenocryst, shows a 70° contact and cut mudstone lamina, neither clear indication of thermal metamorphism in the mudstone nor chilled margin in diorite porphyry was observed, weak chloritization and silicification occur all through the diorite porphyry, when alteration increases porphyritic texture is obscured and mineralization associate with it.

Microscopic observation shows that the altered mudstone has an abundant sericite and chlorite is almost absent. The diorite porphyry has phenocrysts of plagioclase, hornblende and biotite in order of abundance and when it is altered, these phenocryst are completely replaced by alteration minerals. The secondary minerals in the diorite porphyry are quartz, k-feldspar, chlorite and calcite in addition to abundant sericite.

[Mineralization]: Dissemination of pyrite and pyrrhotite and fracture filling film of the same minerals occur all through the MJSI-5. In addition to it, quartz-sulfides (pyrite, pyrrhotite, sphalerite, chalcopyrite, arsenopyrite) veins of few cm wide sporadically occur. Mineralization is more intensive in the diorite porphyry than in the sedimentary rocks.

A weak dissemination prevail all through the sedimentary rocks. Mainly pyrite is the dissemination mineral in the sedimentary rocks of shallower than 80 m and deeper than this the amount of pyrite decreases and pyrrhotite associated by chalcopyrite increases. The same mineral assemblages are observed in the fracture filling sulfide films. The sulfides of the steep dipping (60° to 80°) quartz-sulfides veins, also, seem to change at the depth of approximately 80 m. At shallower than 80 m, they mainly consist of pyrite-chalcopyrite-(sphalerite), then, deeper than this, pyrrhotite and arsenopyrite increase and barite appears in the quartz-sulfides veins. The quartz sulfide vein at 123.90 m includes abundant arsenopyrite and three grains of native gold with the maximum size of $110\mu \times 90\mu$ were found in arsenopyrite grains.

The assay results of sedimentary rocks with quartz-sulfides veins show that the samples collected at shallower than 100 m have relatively lower Au (0.1 g/t to 0.3 g/t)and Ag (0.5 g/t to 8.1 g/t) compared to the ones collected at deeper than 100 m which have Au ranging from 0.2 g/t to 12.3 g/t and Ag ranging from 4.1 g/t to 13.8 g/t. The maximum grade of Au (12.3 g/t) was obtained from the samples (A-5-5) with native gold grains, collected at the depth of 123.40 m to 124.00 m.

Dissemination of pyrrhotite, chalcopyrite, (pyrite) is slightly more intensive in the diorite porphyry compared to the sedimentary rocks. In the alteration part of the diorite porphyry amount of sulfides reaches up to 1 %. The fracture filling films of the same minerals and few cm wide quartz-(barite)-sulfides (pyrrhotite, chalcopyrite) veins with steep dip (±80°) , also, occur in the diorite porphyry.

The diorite porphyry with quartz-sulfides vein (A-5-12) has assay results of Au 0.4 g/t, Ag 4.7 g/t and Cu 0.14 %. Other samples show low assay results except Ag ranging from 0.4 g/t to 4.1 g/t.

6. Summary of drilling survey

The lithological facies encountered by the five holes are mudstone, sandstone, alternation of mudstone and sandstone and diorite porphyry. The general dip of the sedimentary rocks is approximately 20° and the intrusion of the diorite porphyry is parallel to the sedimentary structure at MJSI-2 and MJSI-3 and oblique to the sedimentary structure at MJSI-5.

The alteration of the sedimentary rocks is not intensive with sericite and chlorite. The sedimentary rocks of MJSI-5 seem to show the highest alteration with an abundant sericite with absence of chlorite.

The diorite porphyry in MJSI-2 is fine grained with distinguished hornblende phenocryst and has an appearance similar to andesite. While, the diorite porphyry of MJSI-4 and MJSI-5 is more felsic with phenocrysts dominated by plagioclse with subordinate hornblende and biotite. Clear indication of thermal metamorphism in the sedimentary rocks at the vicinity of the intrusion and chilled margin in the diorite porphyry were not observed. In the diorite porphyry mineralization associate with chloritization and silicification.

Weak dissemination of pyrite, pyrrhotite-chalcopyrite occur all the core associated by fracture filling films of the same minerals. Quartz-sulfides veins of few cm wide occur sporadically in both sedimentary rocks and diorite porphyry. The most prominent mineralization is found in MJSI-4 where sphalerite-(chalcopyrite) network veins and patches occur in the diorite porphyry and Zn grade ranges from 0.4 % to 1.0 % for 15 m. This Zn mineralization zone includes 3 m long, Ag enriched (Ag 37.2 g/t to 90.5 g/t) zone of irregular quartz-sulfides veins and patches. The quartz-sulfides veins in the sedimentary rocks within 60 m from diorite porphyry intrusion at MJSI-5 show Au grade of 5.7 g/t and 12.3 g/t and one of samples includes native gold in arsenopyrite.

There is a general tendency of the sulfides assemblage of the dissemination, fracture filling films and quartz sulfides veins. MJSI-1 is dominated by pyrite, while at MJSI-4 both assemblages of pyrite and pyrite-pyrrhotite are common. At MJSI-3 and MJSI-5 pyrite is predominant at the shallower depth and pyrite is taken over by pyrrhotite-(chalcopyrite) associated by arsenopyrite at the deeper depth. At MJSI-2 pyrite is rare and pyrrhotite and pyrrhotite-(chalcopyrite) assemblages occur dominantly.