Part II Survey Result

Chapter 1 Telupid West Sub-area

1-1 Introduction

1-1-1 Background

Many large and small bodies of ultramafic rock are occur throughout Sabah. Although the distribution of lateritic soil has been known covering and surrounding these ultramafic rocks, no economical nickel laterite deposit has so far been found in Sabah. The hand auger survey covering an area of 21 km^2 in Telupid area (Area N), conducted during Phase IV (1993) of the Supra-regional survey, showed a zone of relatively high nickel laterite (more than Ni 0.6 %, maximum 1.45 %) covering the hill located west of Telupid. The area was named as Telupid West Sub-area and hand auger and pit survey was conducted in Phase I of the Central Sabah project for further evaluation of the Ni mineralization.

1-1-2 Survey area

The Telupid West Sub-area, 16 km^2 (EW 4km × NS 4 km), is located in the northern part of the Central Sabah Area, immediately west of the town of Telupid. The area is easily accessible by the main road connecting Ranau and Sandakan which passes through the northern part of the area. The Sungai Labuk, one of the main rivers in Sabah, flow eastwords in northern part of the area. The topography of the area is undulating with a flat plain and small hill except in the southern part of the area where a 500 m high ridge runs in WSW - ENE direction. Auguring and pitting were conducted over and around the NE-SW trending hill with altitudes ranging from 150 m to 300 m in the central part of the Telupid West Sub-area. The southern part of the area is covered by secondary jungle and the flat area is used for oil palm cultivation.

1-2 Hand auger and pit survey

1-2-1 Survey method and amount of work

The hand auger and pit survey was conducted over and around the hill located at the center of the Telupid West Sub-area. NS-EW trending grid lines were set by conventional surveying and augering was conducted at 72 sites and pits of 1 m × 1m size were dug at 5 sites. The target depth for both augering and pitting was 4 m. Since Ni is known to be enriched at a zone of weathered ultramafic rock (saprolite) which occurs between laterite soil and bedrock of ultramafic rock, both of the hand auger and pit work were targeted to reach the bed rock penetrating through saprolite zone.

At each auger site, the soil profile was described and a soil sample of 1 m spacing was collected vertically form top to bottom. The walls of pit were sketched for each pit and a soil sample of 50 cm span was collected vertically from the top to the bottom of each pit. Approximately 1 kg soil was collected from both auger and pit sites for chemical analyses. After drying, the -80 mesh fraction was sent for chemical analysis of five elements (Al, Co, Cr, Fe, Ni).

1-2-2 Survey results

The bedrock of the Telupid West Sub-area consists of serpentinized peridotite, chert and basalt. The serpentinized peridotite underlies the hill in the center of the area and the mountain in south of the area, while the flat area is underlain by chert and basalt. The hill at the center of the area is, generally, covered by reddish brown laterite soil and the flat area surrounding the hill is covered by yellow brown soil.

A total of 261 samples were collected from auger sites and a total of 31 samples were collected from 5 pit sites. Their locations are given in Fig. II-1-1.

1. Distribution of soil in the area

The succession of soil in the Telupid West Sub-area consists of thin humic soil at the top, laterite soil, laterite soil with weathered peridotite fragments, saprolite (weathered peridotite) and peridotite bedrock at the bottom. Compared to a typical horizon of nickel laterite soil elsewhere in the world, the soil profile of the Telupid West Sub-area lacks an iron oxide crust at the top.

The laterite soil of the area has thicknesses of 1.5 m to more than 5.0 m. In the northern part of the central hill, where highest Ni values were obtained by the previous survey, the development of laterite is generally poor and hard bedrock or boulder rich horizon was encountered at depths averaging 2.0 m. On the flanks of the central hill, thickness of laterite is 2 m to 4 m and it becomes more than 5 m thick in the flat area. The laterite soil with weathered peridotite fragments, generally, occurs beneath the laterite soil, and it grades to saprolite gradually at the bottom. The typical color of laterite soil is reddish to orange brown in the central hill and dark brown to dark gray in the flat area.

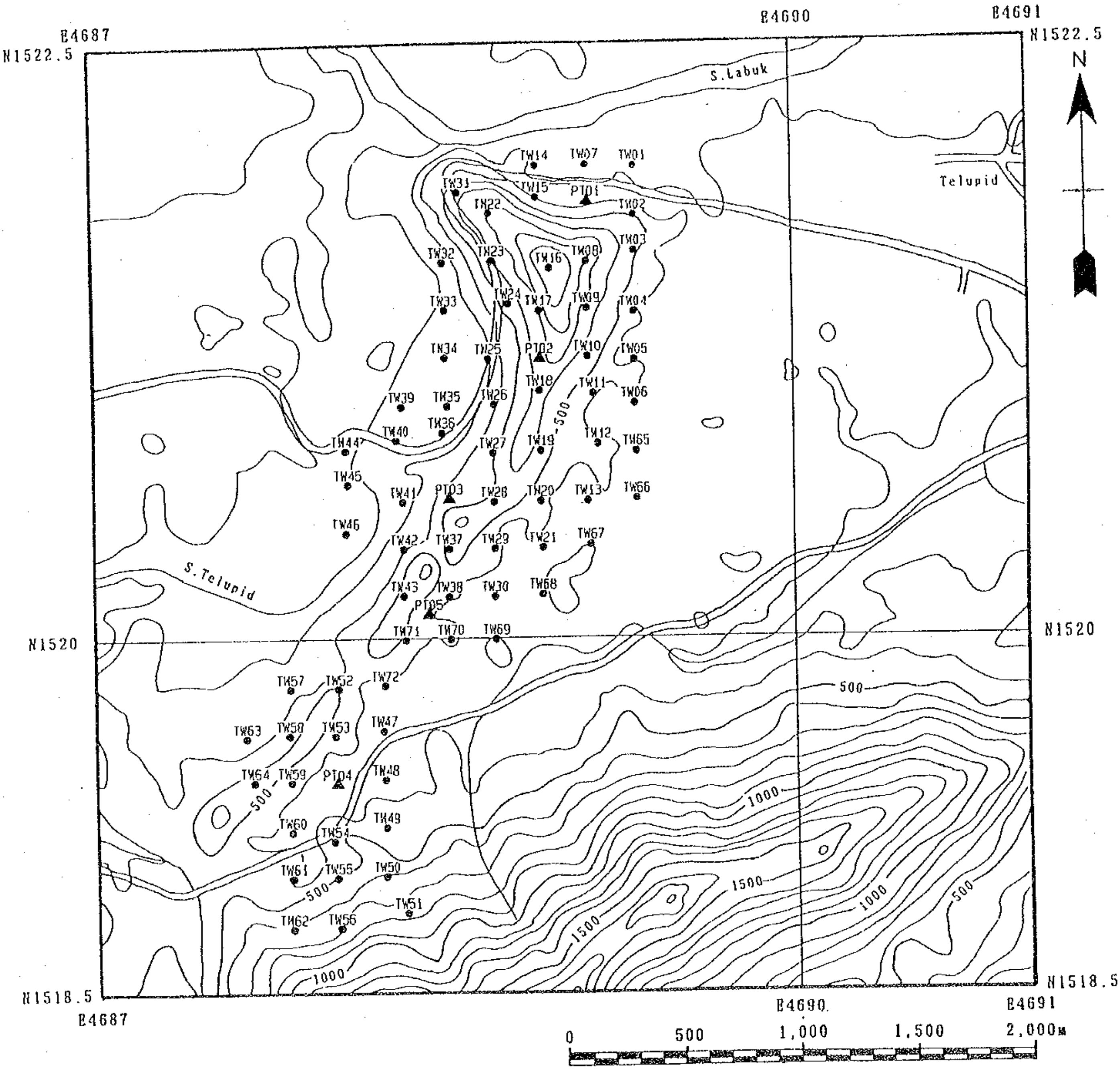
Reddish brown to orange brown saprolite occurs mainly on flanks of the central hill for a thickness of less than 1 m to more than 3 m.

Pitting was conducted at 5 locations with the highest Ni contents obtained by the previous Supra-regional Survey. The sketch of the pit together with analytical results of soil is given in Fig. II-1-2.

The pit survey suggests that the distribution of laterite soil in the northern part of the central hill (PT1, PT2) is poor with thickness of more or less 2 m and the laterite soil directly overlies bedrock without occurrences of saprolite. In the central part of the central hill (PT3, PT4, PT5), saprolite averaging 1.5 m occurs under the 2.5 m thick laterite soil.

2. Analytical result of soil sample

The analytical results of 292 samples collected from auger and pit sites show a wide range of Ni values from 71 ppm to 21,971 ppm (2.20 %) and commonly fall in a range of from few 1,000 ppm to 10,000 ppm. Ni consistently increased with increase of depth and it reaches its maximum at the bottom of the saprolite layer immediately above peridotite bedrock. Al consistently decreases toward bottom, while

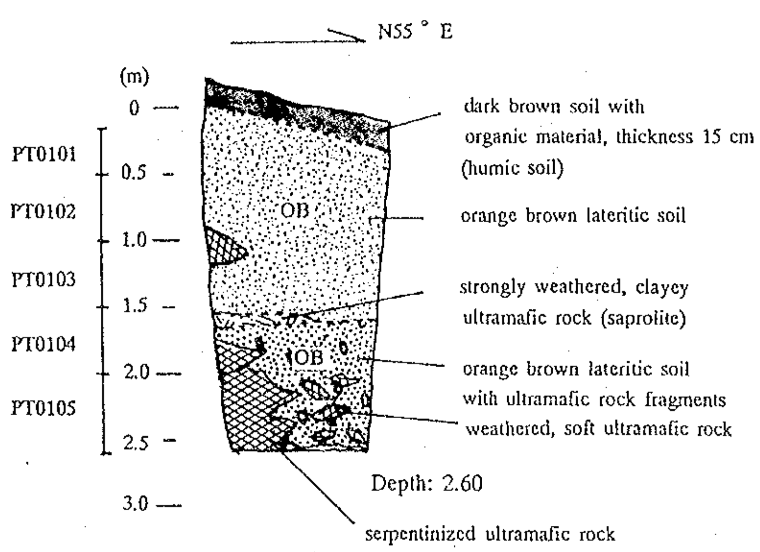


● Location of hand auger

▲ Location of pit

Fig. II -1-1 Location of auger and pit sites

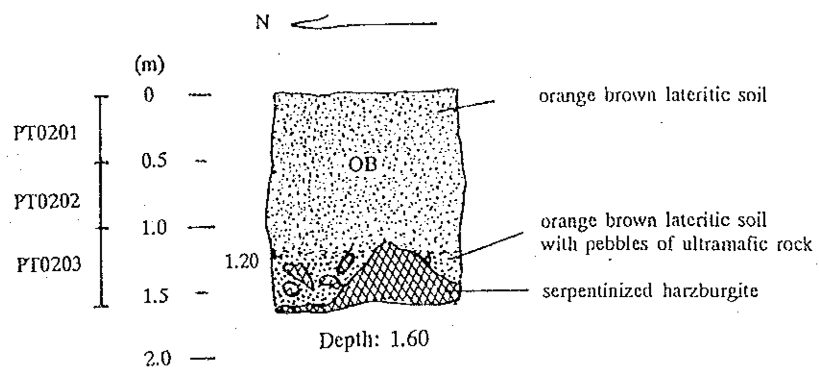
PT1



Coordinates: E4689.12, N1521.83		Vegitation: secondary forest		Slop: moderate		
Sample No.	Depth(m)	Analytical Results				
		Al(%)	Co(ppm)	Fe(%)	Cr(ppm)	Ni(ppm)
PT0101	0.15 - 0.50	2.72	729	53.51	6,498	11,424
PT0102	0.50 - 1.00	2.19	808	51.20	6,534	13,460
PT0103	1.00 - 1.50	1.85	728	46.52	5,862	12,386
PT0104	1.50 - 2.00	0.93	614	36.36	4,471	12,197
PT0105	2.00 - 2.60	1.15	329	21.70	3,946	9,744

Ave. 11,842

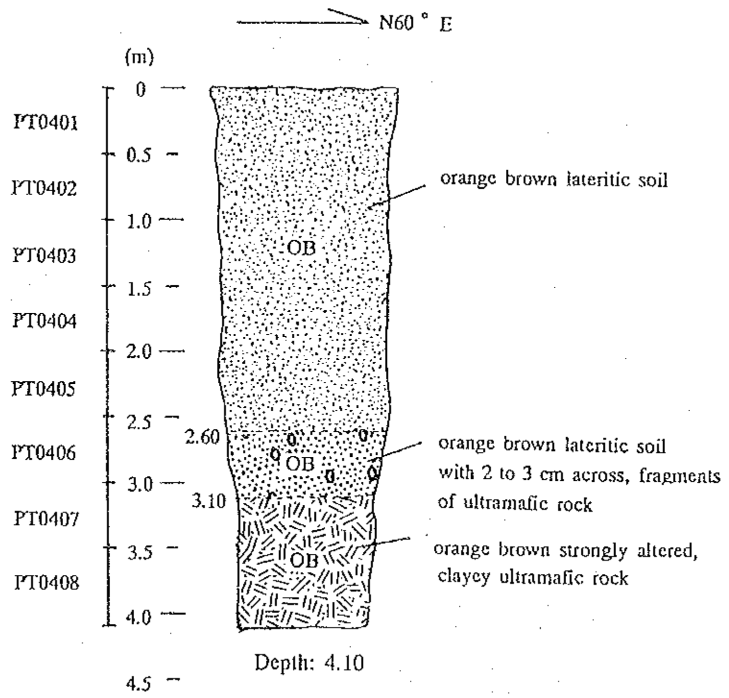
PT2



Coordinates: E4688.91, N1521.17		Vegitation: secondary forest		Slop: steep		
Sample No.	Depth(m)	Analytical Results				
		Al(%)	Co(ppm)	Fe(%)	Cr(ppm)	Ni(ppm)
PT0201	0.00 - 0.50	3.48	576	43.96	9,150	7,686
PT0202	0.50 - 1.00	3.74	687	46.87	11,643	11,037
PT0203	1.00 - 1.60	3.10	675	42.26	11,697	14,564

Ave. 11,096

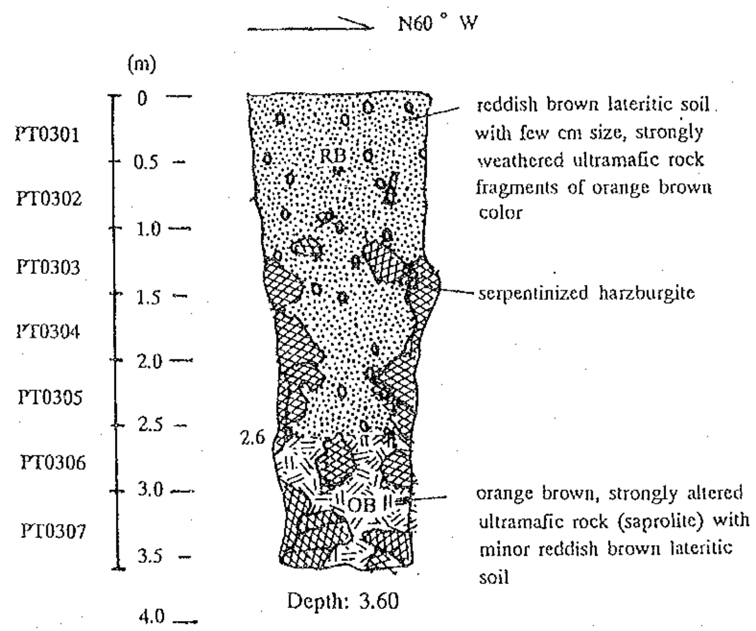
PT3



Coordinates: E4688.02, N1519.38		Vegitation: plantation of oil palm		Slop: flat		
Sample No.	Depth(m)	Analytical Results				
		Al(%)	Co(ppm)	Fe(%)	Cr(ppm)	Ni(ppm)
PT0401	0.00 - 0.50	10.34	198	32.91	6,995	2,687
PT0402	0.50 - 1.00	8.70	258	33.00	7,229	3,111
PT0403	1.00 - 1.50	8.80	279	34.52	8,841	3,532
PT0404	1.50 - 2.00	8.72	356	40.01	10,795	4,239
PT0405	2.00 - 2.50	8.95	266	37.64	12,771	3,771
PT0406	2.50 - 3.00	10.80	167	30.38	7,875	2,936
PT0407	3.00 - 3.50	11.68	413	23.42	7,153	2,332
PT0408	3.50 - 4.10	12.63	869	18.04	7,653	2,113

Ave. 3,090

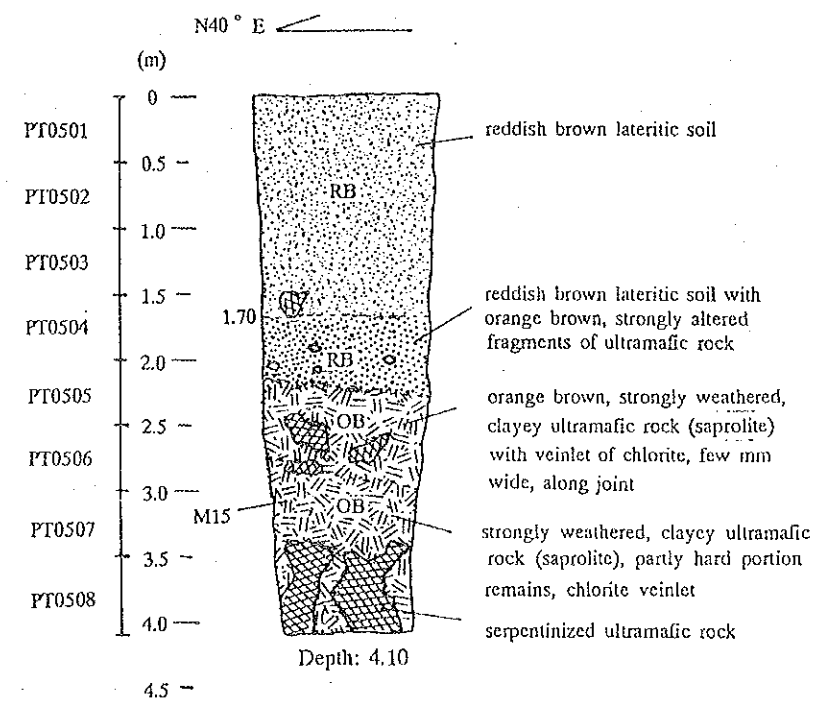
PT4



Coordinates: E4688.51, N1520.58		Vegitation: plantation of oil palm		Slop: steep		
Sample No.	Depth(m)	Analytical Results				
		Al(%)	Co(ppm)	Fe(%)	Cr(ppm)	Ni(ppm)
PT0301	0.00 - 0.50	2.68	534	57.52	8,813	9,971
PT0302	0.50 - 1.00	2.31	1,187	59.03	8,484	12,483
PT0303	1.00 - 1.50	1.81	1,214	57.42	6,204	17,230
PT0304	1.50 - 2.00	1.21	1,018	55.23	5,896	21,971
PT0305	2.00 - 2.50	10.38	1,080	56.27	6,092	19,351
PT0306	2.50 - 3.00	0.59	130	32.20	6,519	3,032
PT0307	3.00 - 3.60	10.34	575	29.77	5,464	7,431

Ave. 13,067

PT5



Coordinates: E4688.42, N1520.10		Vegitation: plantation of oil palm		Slop: moderate		
Sample No.	Depth(m)	Analytical Results				
		Al(%)	Co(ppm)	Fe(%)	Cr(ppm)	Ni(ppm)
PT0501	0.00 - 0.50	3.11	519	34.46	6,124	6,356
PT0502	0.50 - 1.00	3.02	361	32.09	6,840	4,807
PT0503	1.00 - 1.50	4.93	803	53.26	8,828	8,355
PT0504	1.50 - 2.00	4.01	1,064	51.31	10,604	11,829
PT0505	2.00 - 2.50	3.84	791	41.24	6,260	14,974
PT0506	2.50 - 3.00	3.35	463	23.25	5,149	18,668
PT0507	3.00 - 3.50	1.52	465	19.73	3,637	18,346
PT0508	3.50 - 4.10	2.55	231	10.51	1,932	4,080

Ave. 10,989

Fig. II-1-2 Sketch and analytical results of pit

Co, Cr, Fe increase with depth, reaching maximum values at the bottom of laterite soil with rock fragments but before the saprolite layer. Although the results of chemical analysis show a wide range of Ni concentration, the vertical variation of Ni concentration among the samples collected at the same site is small.

Because of a small vertical variation in Ni content between samples collected at different depths of the same auger and pit sites compared with a large lateral variation, Ni grade of each pit and auger site was estimated by averaging the Ni grade of all samples collected at the same site. Using these average grades, the distribution of Ni concentration in the Telupid West Sub-area is as shown in Fig. II-1-3. The figures below show the relation between Ni grades and average depths of auger and pit sites down to bed rock.

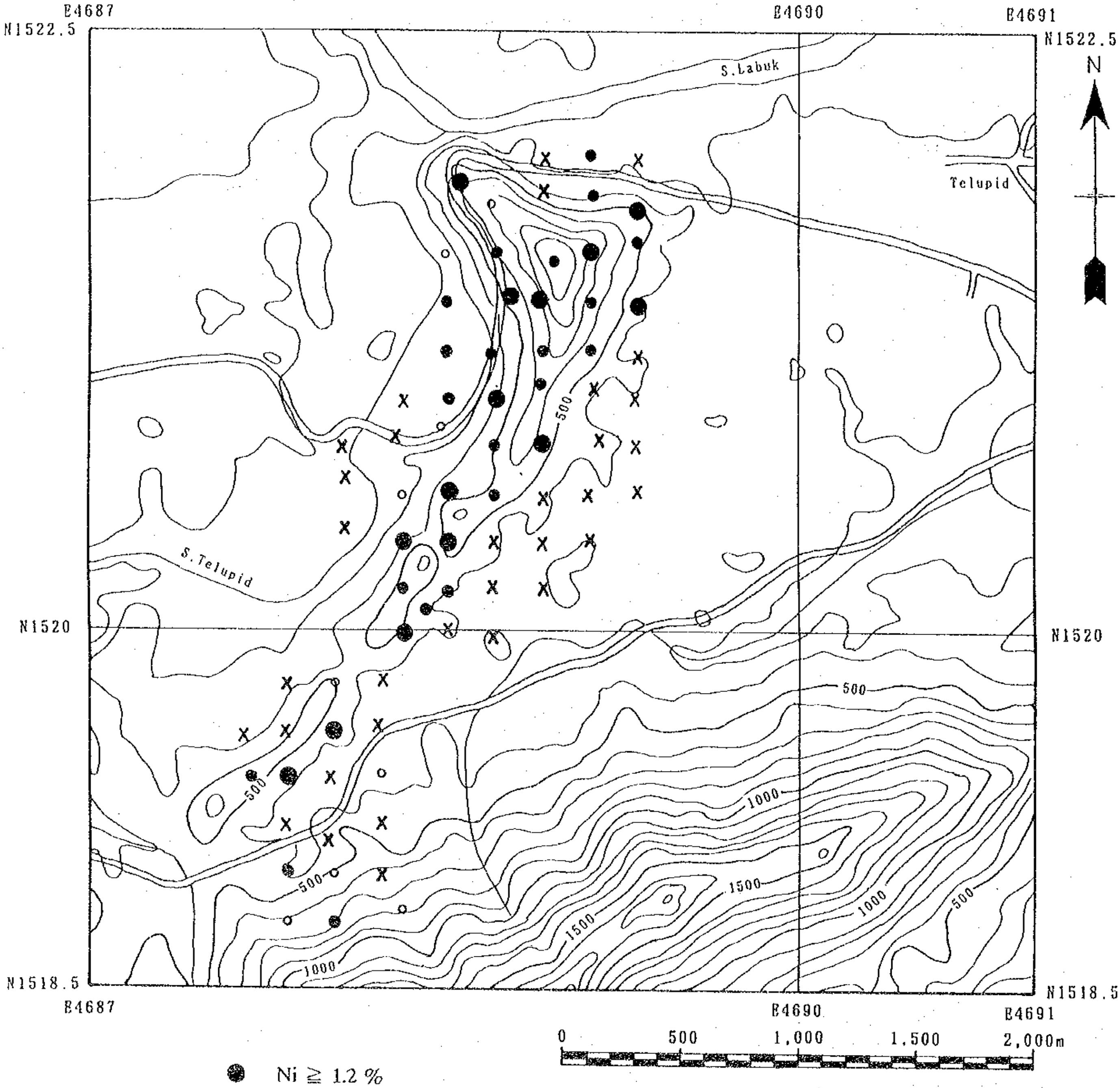
	Number of site	Average depth
Ni ≧ 1.2 %	14 (18.1 %)	2.8 m
1.2 % > Ni ≧ 0.8 %	21 (27.3 %)	3.1 m
0.8 % > Ni ≧ 0.5 %	9 (11.7 %)	3.7 m
0.5 % > Ni	33 (42.9 %)	4.0 m
Total	77 (100 %)	

The highest Ni grade, more than 1.2 %, occurs along the top and on the slope of the central hill and relatively high grade , Ni 0.5 % to Ni 1.2 % occurs on both flanks of the central hill. Poor Ni values occur on the flat area. At the location of the highest Ni grade, occurrences of laterite soil and saprolite is generally thin, especially in northern part of the central hill where the highest grade laterite soil occurs only for 2 m to 3 m deep before reaching to hard peridotite bedrock. On the flat plain, laterite soil occurs to a depth of more than 5 m, but Ni concentration is poor.

1-3 Discussion

Nickel laterite deposit is a residual soil produced by weathering of ultramafic rocks. Olivine which is the dominant constituent mineral of ultramafic rocks, commonly contains 0.3 % to 0.4 % of Ni, while in nickel laterite soil, Ni grades of more than 2 % is obtained by an enrichment of Ni thorough weathering. A characteristic soil profile as observed in the soil of typical nickel laterite deposit(Guilbert and Park, 1986) consists of as iron oxides crust on the top, laterite soil, saprolite (weathered ultramafic rock) and a bedrock of serpentinized ultramafic rock. The zone of highest Ni concentration is saprolite in which occasionally garnierite (Ni serpentine) occurs.

The laterite soil of the Telupid West shows a similar vertical profile and chemical characteristics to the laterite soil of the typical Ni laterite deposit elsewhere in the world. The Telupid West profile consists



● Ni ≧ 1.2 %

● 1.2% > Ni ≧ 0.8 %

o 0.8 % > Ni ≧ 0.5 %

x 0.5 % > Ni

Fig. II-1-3 Distribution of Ni in Telupid West Sub-area of laterite soil, laterite soil with weathered peridotite fragments and saprolite. Al consistently decreases with depth, while, Co, Cr, Fe increase with depth and reaches maximum values at the bottom of laterite soil with rock fragments above the saprolite layer. Ni consistently increases with increase of depth and reaching its maximum at the bottom of saprolite immediately above peridotite bedrock.

A very wide range of Ni grades, ranging from less than 100 ppm to more than 2 %, was obtained from the laterite soil and saprolite of the Telupid West. Although vertical chemical variation exists at each site, it is considerably small compared with a large lateral variation. This fact together with the shallow development of laterite soil especially around the central hill suggest that the laterite soil of the Telupid West is immature.

Although relatively high grade soil (more than Ni 0.8 %) occur along and around crest of the central hill, the thicknesses are restricted in 2 m to 3 m. The thickness of the laterite soil reaches more than 5 m in the flat area but Ni grade is poor. The limited lateral and vertical distribution of relatively high Ni, only along and around the crest of the central hill does not warrant further exploration and exploitation of Ni laterite in the Telupid West Sub-area.

Chapter 2 Pinanduan Sub-area

2-1 Introduction

2-1-1 Background

During the early 1960s, exploration work was conducted within the Pinanduan Sub-area for an evaluation of copper and iron mineralization (Lewis, 1964). The results of hand auguring, trenching and drilling done by the Soriamont Investment Co. showed non-commercial zones of sulfide mineralization with copper in peridotite in the vicinity of small gabbro intrusions and more than a million tones of limonitic clay containing 0.7 % copper as secondary oxides on the surface. Other than this, Fe and Ni exploration conducted on the Tavai Plateau confirmed 76 million tons of lateritic soil with Fe 41 % over the plateau.

The soil and stream sediments geochemical survey conducted during the Supra-regional survey (1993) over an area of 42 km^2 (Area Q) revealed Cu, Au and Ni anomalies in the area west of Sungai Pinanduan. The Pinanduan Sub-area was thus established covering these anomalies for an evaluation of Cu, Au and Ni mineralization of the area.

2-1-2 Survey area

The Pinanduan area, 30 km^2 (EW 6 km × NS 5 km), is located in the northern part of the Central Sabah area, 15 km south of Telupid. The Sungai Karamuak drains the southeastern part of the area and small tributaries of Sungai Karamuak, such as Sungai Kukubon, Sungai Pinanduan Kecil and Besar, Sungai Nobusu Kecil, flow southwards in the area.

The southwestern part of the area, along Sungai Karamuak is occupied by flat plain with an average altitude of 60 m. A flat topography also occurs on the top of mountain at an altitude of approximately 500 m. The area is called as Tavai Plateau and it extends further east from the Pinanduan Sub-area. The area between the plateau and flat low land along the Sungai Karamuak is occupied by relatively steep mountainous slope facing southwest. The vegetation of the area is secondary jungle with dense small trees and bush, which makes traversing and line cutting difficult for the geophysical survey. The area can be reached by a 45 minute drive from Telupid along timber roads. Geological and geophysical surveys were conducted during the Phase I survey and base camp was set up within the area.

2-1-3 Amount of work

Geological survey (semi-detail) and geophysical survey (IP method) were conducted in Phase I to investigate the geochemical anomalies of Cu, Au and Ni found during the Supra-regional survey and to evaluate the sulfide mineralization found by the previous survey. A geological survey was conducted covering an area of 30 km^2 and geophysical survey was conducted along 8 lines with a total length of 14.4

km.

2-2 Geological survey

Geological survey (semi-detail) was conducted using 1 : 5,000 scale map produced from an enlargement of the 1 : 50,000 topographic sheet. Typical rock and ore samples were collected for thin section and polished section studies. Ore assaying and X-ray diffraction analysis were done, respectively, for mineralized and altered samples.

2-2-1 Geology

The peridotite (Pr), consisting mainly of harzburgite is the predominant rock type in the Pinanduan Sub-area with dunite (Du) and small intrusive bodies of gabbro (Gb). The Crocker formation (P_2Cr) of Eocene to Oligocene is found only in a restricted area. The geological map together with cross sections are given in Fig. II-2-1.

The Pinanduan Sub-area is mainly overlain by dark green to black, serpentinized peridotite and common occurrences of orthopyroxene pseudomorphs measuring few mm across indicating that the peridotite belongs to harzburgite. The intensity of serpentinization of the peridotite varies place to place. At a location of weak serpentinization, olivine is still preserved and occasionally peridotite shows layered structure. Wide lenses of dunite bodies averaging 100m occurs in the harzburgite. The flat plateau is overlain by lateritic soil and gossan produced by weathering and oxidation of the peridotite.

Intrusive bodies of gabbro, some 100 m across, occur in southern part of the area. One of them immediately west of Sungai Pinanduan Kecil is slightly epidotized. The others in the western part of the area are medium to coarse grained gabbro consisting of clinopyroxene and plagioclase.

The Crocker formation consisting of sandstone and mudstone is found only in the southwest part of the area along the Sungai Imbak.

The peridotite with lenses of dunite is believed to be dismembered ophiolite of Cretaceous to early Tertiary age thrusting into the Crocker formation in the southwestern part of the area. The gabbro is considered to be a member of the ophiolite sequence rock occurring before the emplacement of the dismembered ophiolite.

2-2-2 Mineralization

The alteration and mineralization found in the area are not extensive. They consists of chloritization of the gabbro with weak pyrite dissemination in the surrounding peridotite with development of lateritic soil and gossan on the Tavai Plateau.

The peridotite at the vicinity of gabbro intrusion shows relatively intense serpentinization accompanied by alteration minerals such as montmorillonite and chlorite. A weak pyrite dissemination occasionally occur in the peridotite at the vicinity of gabbro intrusion. No encouraging result was derived

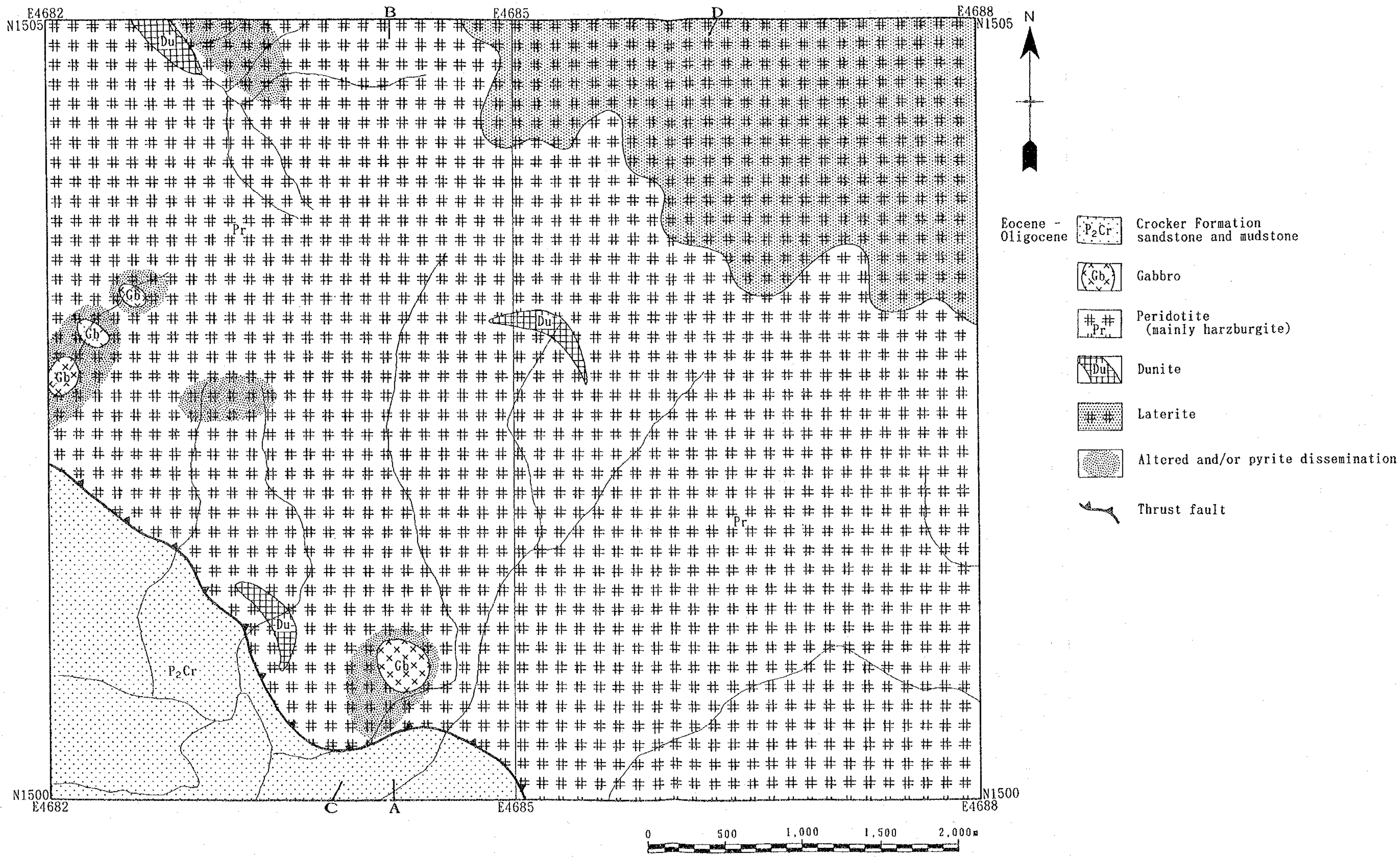


Fig. II -2-1 Geological map of Pinanduan Sub-area

from the rock assay.

Drilling conducted during early 1960s at the vicinity of gabbro intrusion immediate west of Sungai Pinanduan Kecil revealed sulfide veins of 15 cm to 60 cm wide, consisting of mainly pyrrhotite with chalcopyrite and sphalerite. The assay result showed Cu 0.53 %, Ni 0.06 % and Zn 0.15 % for length approximately 1.5 m. Only epidotized gabbro is presently found at the site.

The Tavai Plateau is overlain by widespread gossan with iron oxide pisolites. The X-ray diffraction analysis of gossan showed goethite is the main constituent mineral. No encouraging assay result was obtained.

2-3 Geophysical survey

The purpose of the survey is to clarify the relation of IP result with the existing mineralization reported by Lewis 1964 and the geochemical anomalies extracted during the Supra-regional survey in the survey area. An investigation of the electrical structure of the survey area was carried out to define the distribution of IP anomalies in the survey area.

2-3-1 Survey method

The measurements were done by using the time domain IP method adopting dipole-dipole electrode configuration with a separation factor "n" from 1 to 4. Based upon the geological structure, 8 survey lines of 1.8 km each in length were set along a N-S direction with a 500m line spacing. The numbering of IP survey stations were set from 0 to 18 with 100m spacing from north to south.

The IP survey was conducted using battery-driven potable equipments (transmitter: TSQ-3, receiver: IPR-12) manufactured by Scintrex Ltd. Electrical measurement of rock samples were carried out in order to determine the actual electrical properties of rocks distributed in the survey area.

The specifications of the survey are shown below:.

Method	Specifications
Measuring	Time domain
Configuration	Dipole-dipole
n-spread	n=1 to 4
Survey lines	8 lines
Total amount	14.4 line-km
Line spacings	500 m
IP measurement of rock samples (chargeability and resistivity)	7 pcs.

The procedure used for IP data analysis and interpretation are shown Fig. II-2-2

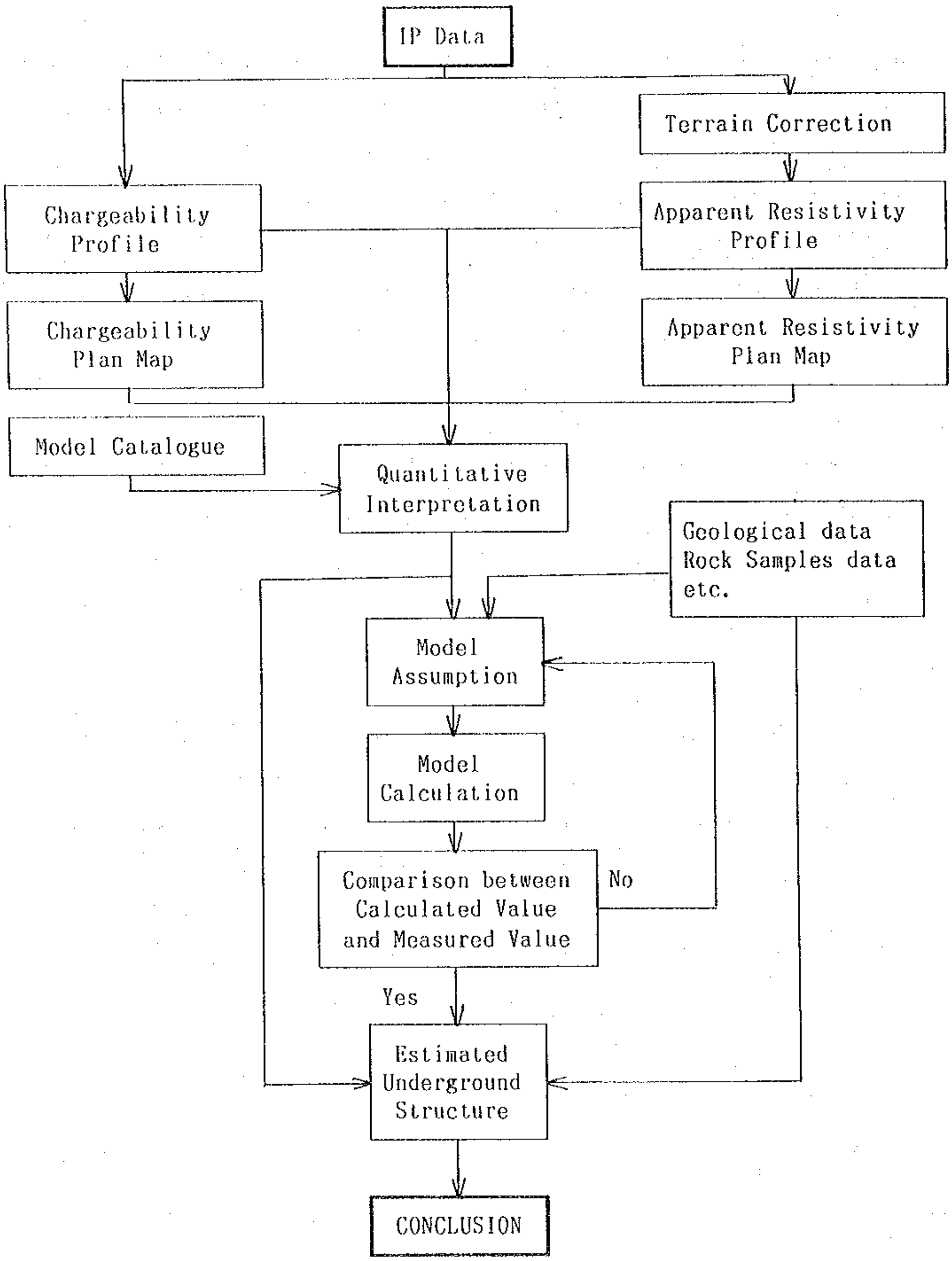


Fig. II -2-2 Flow chart of IP data analysis

2-3-2 Survey result

The results of IP survey were shown in Fig. II -2-3 and Fig. II -2-4. Apparent resistivity values were detected in the range from 1 to 366 ohm-m and chargeability values in the range from -28 to 62 mV/V by the IP survey of the Pinanduan Sub-area. On the basis of this, apparent resistivity and chargeability values were classified into three groups as follows:

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

Distribution of apparent resistivity of less than 5 ohm-m occurs in the north-eastern part of the area from surface to depth. High chargeability zone with over 30 mV/V extends to the north-east of the central part of the survey area. The highest chargeability values of over 40 mV/V are detected at the shallower part in a southern half of Line-F. These high chargeability values suggest a strong mineralization in the areas.

In the survey area, the following types of IP anomalies are seen.

Type	Electrical characteristics	Alteration/mineralization
Type 1	Resistivity Low Chargeability High	Strong alteration and much Sulfidation Dissemination type
Type 2	Resistivity Medium Chargeability High	Medium alteration and much Sulfidation Dissemination and/or vein combination type
Type 3	Resistivity High Chargeability High	Weak alteration and much Vein type

The type 1 IP anomalies are mainly distributed in the flat area of the south-western part of the survey area, while the type 2 IP anomalies are mainly distributed in the mountainous area of the north-eastern part of the survey area except Line-A. The mountainous area of the survey area is covered by Type 3 IP anomalies.

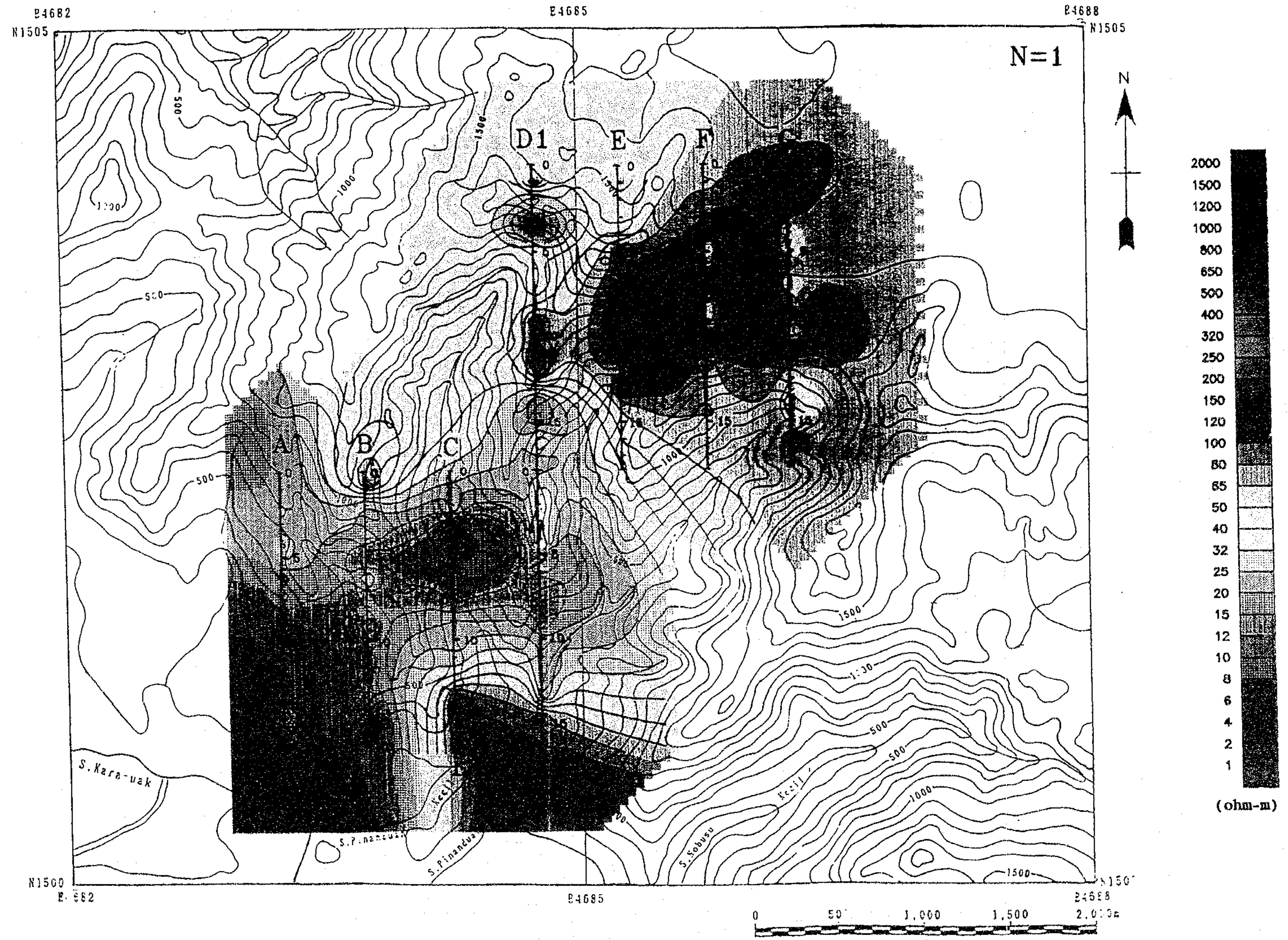


Fig. II-2-3 Plan map of apparent resistivity in Pinanduan Sub-area

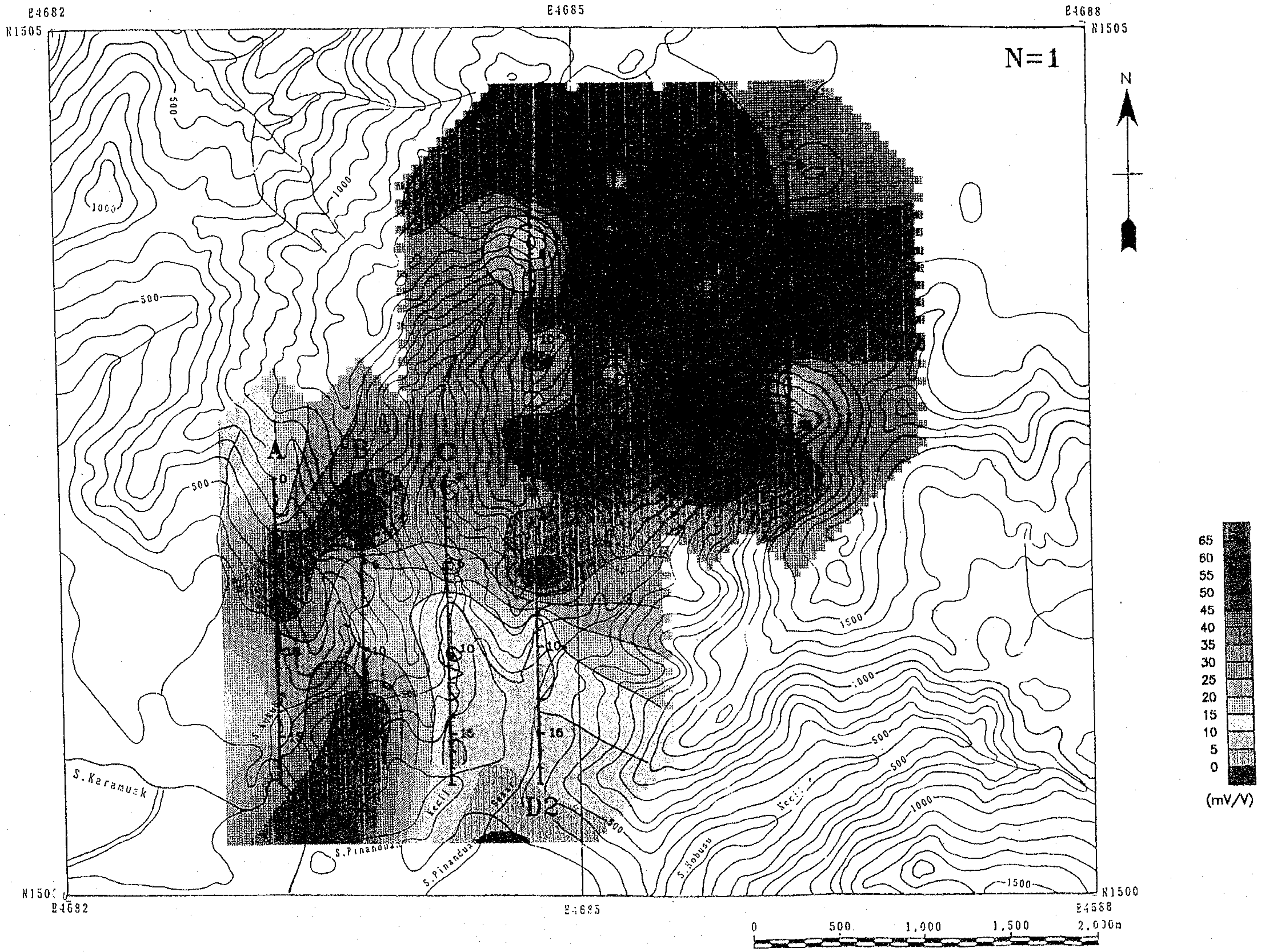


Fig. II-2-4 Plan map of chargeability in Pinanduan Sub-area

The strong IP anomaly, which indicated a promising mineralization of copper was considered important for the simulation analysis. The results of the two dimensional model simulation for the IP anomalies are shown in Fig. II -2-5.

Distribution of strong IP anomalies continues to extend to the north-eastward in central part of the survey area. The IP anomaly type 1, with resistivity low and chargeability high, is seen in the flat area of southwestern part of the survey area except the southern part of the survey area. The IP anomaly type 2 with resistivity medium and chargeability high and IP anomaly type 3 with resistivity high and chargeability high are distributed in the mountainous area of a northeastern part of the survey area.

2-4 Discussion

The geological survey conducted in the area shows that serpentinized peridotite mainly consisting of harzburgite predominantly occur in the area with minor lens of dunite and small intrusive bodies of gabbro. The alteration and mineralization found in the area is not intense. It occurs only in restricted area surrounding intrusive bodies of gabbro where relatively strong serpentinization accompanied by weak pyrite dissemination in the peridotite was found. No clear evidence of the mineralization and alteration that reflects Cu, Ag and Ni anomalies extracted during the Supra-regional survey was found.

The IP anomalies obtained by the survey, on the other hand, coincide very well with distribution of Cu anomalies of the Supra-regional survey (Fig II -2-6). While, no clear indication of IP effect corresponding to the alteration and week pyrite dissemination found by geological survey was obtained.

Relatively intense IP anomaly obtained in the southwestern part of the area corresponds to the location of the sulfide mineralization with chalcopyrite found by the previous survey. This may implies an occurrence of considerable amount of sulfide underneath the surface. The most intensive anomalies were obtained over the area from southwestern part to northeastern part of the area (northern part of Line B north, Line D middle, Line E north, Line F south and Line G middle). No clear alteration and mineralization were found by geological survey over this area, however, these clear anomalies suggests an existence of possible sulfide veins or dissemination underneath the surface of the area.

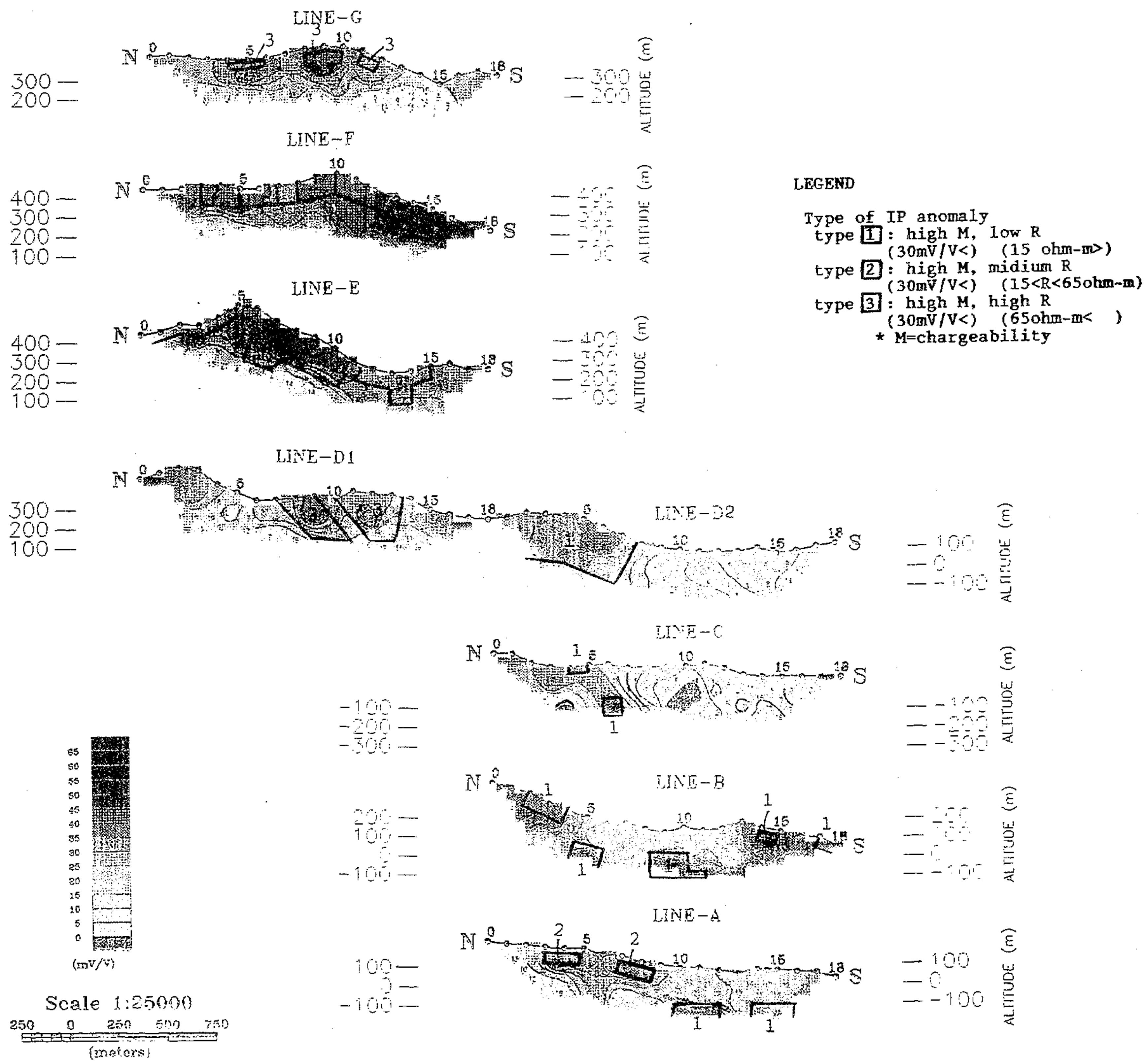


Fig. II -2-5 Results of model simulation in Pinanduan Sub-area

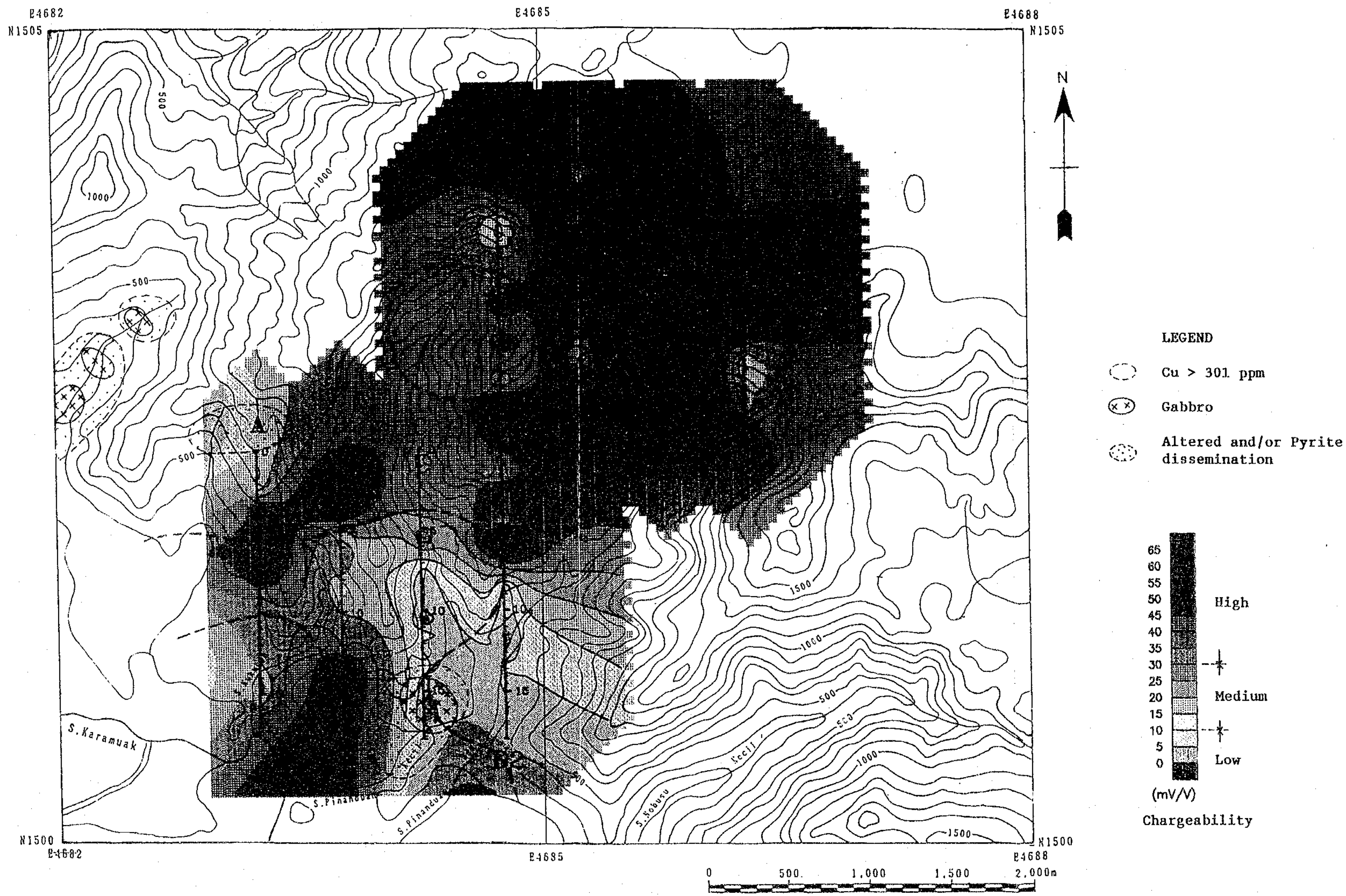


Fig. II -2-6 Compilation of survey results in Pinanduan Sub-area

Chapter 3 S. Imbak Sub-area North

3-1 Introduction

3-1-1 Background

Detailed geological information was not available for the S. Imbak area before the start of the Supra-regional survey. The area was considered to be overlain by undulating Tertiary sediments. The stream sediments yielded high concentrations of Au and Hg (maximum: Au 6,530 ppb, Hg 24,735 ppb) near the mouth and upper stream of the southern tributary of S. Imbak. Subsequent semi-detail soil geochemical survey was carried out in the Area T, covering the catchment area of the tributary during the Supra-regional Survey. The results indicated Au and Ag mineralization in the southern part of the area. The mineralization is indicated by 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) in thin quartz veins and cobble size gravel with sulfides along the main stream. These evidences suggest a high potentiality of Au and Ag mineralization in the Area T and the possibility of a southward extension from the Area T.

For the detailed 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).

3-1-2 Survey area

The S. Imbak Sub-area is located in the south end of the Central Sabah area and consists of two parts, S. Imbak Sub-area North and South and they are separated 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, where soil geochemical survey was conducted in 1993, while, the S. Imbak Sub-area South is located immediately south of the Supra-Regional Survey area..

The main drainage system of the S. Imbak Sub-area North, flowing from northwards, consists of the 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 reaching more than 1,500 m in south where a ridge with Gunong Kuli runs NNW-SSE.

The entire area of the S. Imbak North is covered by primary jungle and no cultivation or logging is found in the area. The area is accessible only by a small trail. The base camp was established along the logging road closest to the area, then the field work were conducted establishing advanced camp inside the area.

3-1-3 Survey method and amount of work

In Phase I, semi-detail geological survey covering an area of 28km² (NS 4 km ×EW 7km) and geophysical survey (IP method) of 21 line-km (10 line) were conducted in the S. Imbak Sub-area North. In addition to these, 201 rock samples were collected during the geological survey to investigate geochemical halos related to the mineralization.

An area of 14.75 km², including the silicification/pyrite dissemination zone found during the Phase I at the center of the area, was selected for the further detail investigation in the S. Imbak Sub-area North for the Phase II survey. Detail geological survey, geophysical survey and drilling survey were conducted in the area during Phase II and Phase III. 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 in Phase II. In the final year of Phase III, the drilling operation of two vertical holes (300m each) was conducted.

3-2 Geological survey

The semi-detail geological survey conducted during the Phase I in the area of 28 km² revealed that some of the encouraging mineralization with high Au and Ag bearing veins occurred in silicification/pyrite dissemination zone of approximately 2 km× 2 km in the center to south of the S. Imbak Sub-area North. Because the occurrences of the mineralization were generally restricted to the area of silicification/pyrite mineralization, the detail geological survey of Phase II was conducted in the smaller area of 14.75 km² covering this zone.

3-2-1 Survey Method

The semi-detail geological survey of the Phase I was conducted using 1:5,000 scale maps produced from enlargement of the 1:50,000 topographic sheet. During Phase II 1:10,000 scale topographic maps covering the more potential part of the area (14.75 km²) in the S. Imbak Sub-area North was prepared from the aerial photograph. A geological survey was conducted using 1 : 5,000 scale map produced by an enlargement of the 1 : 10,000 scale map.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, respectively, for mineralized and alteration samples. For determination of the age dating, K-Ar method was done for four intrusive rocks. To estimate the temperature of the mineralization, measurement of the filling temperature of fluid inclusions was conducted for the quartz take from quartz-sulfide veins.

A total of 201 rock samples were collected during the semi-detail geological survey of Phase I for geochemical investigation. The analytical results of 15 elements (Ag, As, Au, Ca, Cu, Hg, K, Na, Mg, Pb, Rb, S, Sb, Sr, Zn) were computerized and statistical data treatment, EDA (Exploratory Data analysis) and multi-element analysis were conducted. Among the 201 rock samples of geochemical survey, 51 samples were selected for X-ray diffraction analysis.

3-2-2 Geology

The S. Imbak Sub-area North is overlain by the Tanjong formation 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 geological map of the S. Imbak Sub-area North (detail survey) together with cross sections are given in Fig. II-3-1.

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 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 mudstone is silicified and pyrite disseminated in the area close to the intrusion of diorite porphyry.

The alternation of mudstone and sandstone formation appears to be a gradational zone. 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 to mudstone dominant and a thickness of each single layer ranges from few cm to few m. The mudstone is dark gray, slightly soft rock and the 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 the south and southwest part of the area and is characterized by a steep topography of more than 700 m high. Gray to dark gray, hard, fine, arkose 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.

The strike and dip of the Tanjong formation in the S. Imbak Sub-area North are consistent over the entire area. It shows monoclinic trending along NNW-SSE to WNW-ESE and dipping toward SW at 20° to 50° . There is a tendency of the strike direct to gradually more westwards toward in the west part of the area. In the southeast part of the area the general strike is NNW-SSE (10 to 30° W) and in the center to west part of the area the strike gradually changes to WNW-ESE (45 to 70° W). The sandstone in the higher location has a slightly gentle dip, otherwise , the dip is consistently 20 to 40° SW over the entire area.

A N-S trending fault occurs in the eastern part of the area. Although only one fault is shown in

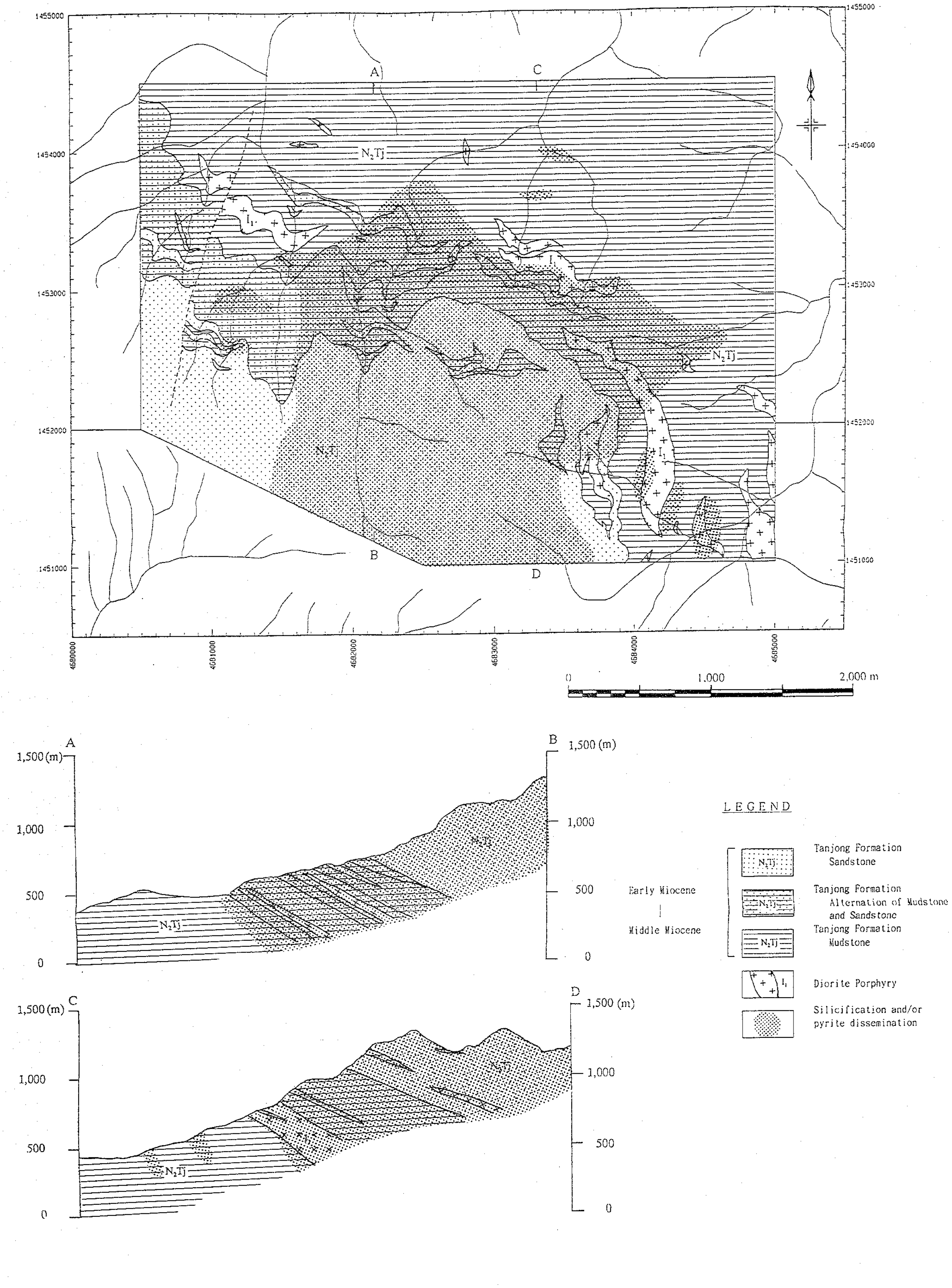


Fig. II-3-1 Geological map and cross section of S. Imbak Sub-area North

the geological map, N-S trending small scale faults and shear 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 the northwest to the southeast parts of the area. They vary from concordant to sub-concordant to the sedimentary rocks. The size of intrusion varies from few meters to 100 meters wide increasing in size towards east. There is, also variation in grain size. The diorite porphyry of a small intrusion is a generally dark fine grained rock with fine hornblende phenocryst and it shows similar appearance to andesite. The diorite porphyry of the larger intrusives is gray 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 colored rock with clear porphyritic texture to a totally argillized, white colored rock consisting of quartz and sericite. The argillized diorite porphyry commonly occur as small scale intrusion in the center part of the area.

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

3-2-3 Mineralization

The main mineralization and alteration occur within the zone of silicification/pyrite dissemination in the center to the southeast part of the area where many intrusive bodies of diorite porphyry intrudes to sandstone. Within the zone silicification with rare argillization and pyrite (arsenopyrite) dissemination with thin pyrite veinlet along fractures occur in the sandstone and mudstone of the Tanjong formation. Generally, pyrite dissemination is more intense in the sedimentary rocks compared with the 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, reaching the maximum grade of (Au 72 g/t, Ag 196 g/t). The gold is generally associated with arsenopyrite These veins commonly cut the sedimentary structure trending mainly N-S with a steep dip of more than 60° to both east and west. In many cases, these veins occur in fracture zone of few cm to few 10 cm wide.

The locations of the main mineralization are shown in Fig.II-3-2 and the summary and sketches of the main mineralization are given in TableII-3-1 and Fig. II-3-3.

Based on the metallic elements and sulfide minerals, the quartz-sulfides veins can be 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 (FigII-3-4).

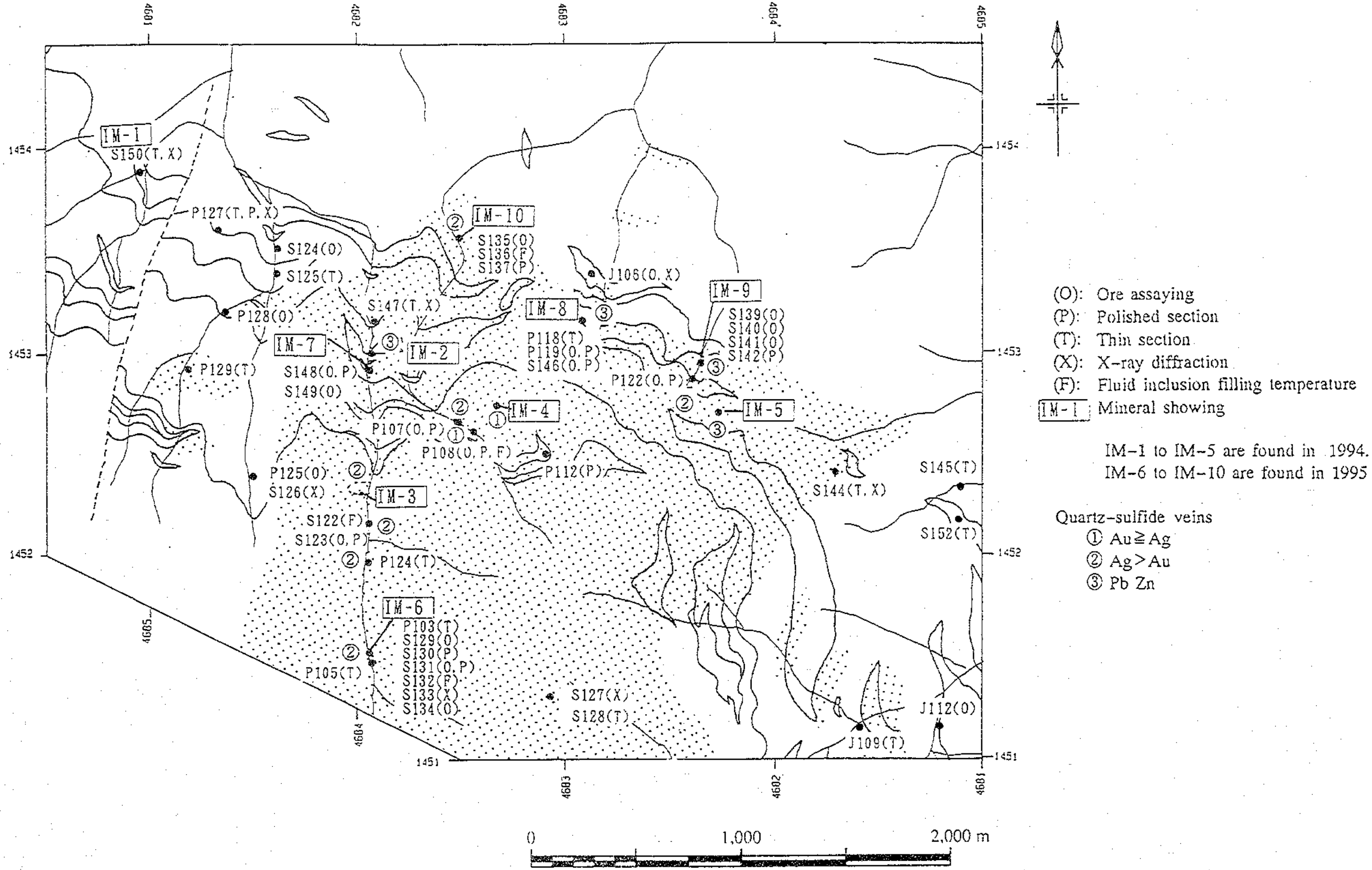


Fig. II -3-2 Location of mineral showings in S. Imbak Sub-area North

Table II-3-1 Mineralization showings of S. Imbak Sub-area North (1)

Mineral Showing No.	Descriptions of Mineralization	Host Rock	Alteration	Assay Results						
				Sample No.	Sampling width (m)	Au (g/t)	Ag (g/t)	Cu (ppm)	Pb (ppm)	Zn (ppm)
IM-1	stlongly argillized diorite porphyry, over an area of 40 m along stream, weak pyrite dissemination. (Sketch 1)	Diorite porhpyry	argillization	M43	1.0	<0.1	<0.1	110	37	118
				M44	0.4	<0.1	<0.1	34	25	45
				M45	1.0	<0.1	<0.1	10	28	32
				M46	1.0	<0.1	<0.1	87	37	111
				M47	1.0	<0.1	<0.1	<1	29	78
IM-2	distribution of abundant, silicified, oxidised boulders few m across with pyrite dissemination.	Mudstone Sandstone	silicification argillization	K26	0.6	<0.1	0.7	26	161	48
				K28	0.7	<0.1	2.2	17	80	136
				K29	grab	<0.1	1.1	15	123	115
				K31	grab	<0.1	4.4	71	116	835
				K33	grab	<0.1	5.2	254	57	81
IM-3	Quartz - sulfides (pyrite, arsenopyrite, sphalerite) veins and lenses, 1 cm to 20 cm wide in silicified mudstone, dominant trend: N-S, dip: 70° to 80° west, cutting structure of mudstone, maximum 15 cm × 11 m (Sketch 2)	Mudstone	silicification	M16	0.1	3.4	67.9	900	181	183
				M17	1.0	<0.1	<0.1	43	24	54
				M18	0.2	0.2	<0.1	7	87	24
				M19	0.05	2.0	32.6	75	155	2,183
				M20	0.01	0.5	41.1	1,663	501	35
				M21	1.0	<0.1	<0.1	122	230	9
				M22	0.2	7.5	196.2	1,483	1,511	325
				M23	grab	24.6	125.0	559	422	73
				M24	0.8	3.9	75.0	143	380	22
				M25	0.15	9.0	116.4	422	350	47
				M26	0.15	8.0	62.9	622	226	108
				M27	grab	8.0	105.5	386	318	81
				M28	0.15	9.5	101.9	206	178	40
				M29	0.05	7.2	22.0	413	121	40

Table II-3-1 Mineralization showings of S. Imbak Sub-area North (2)

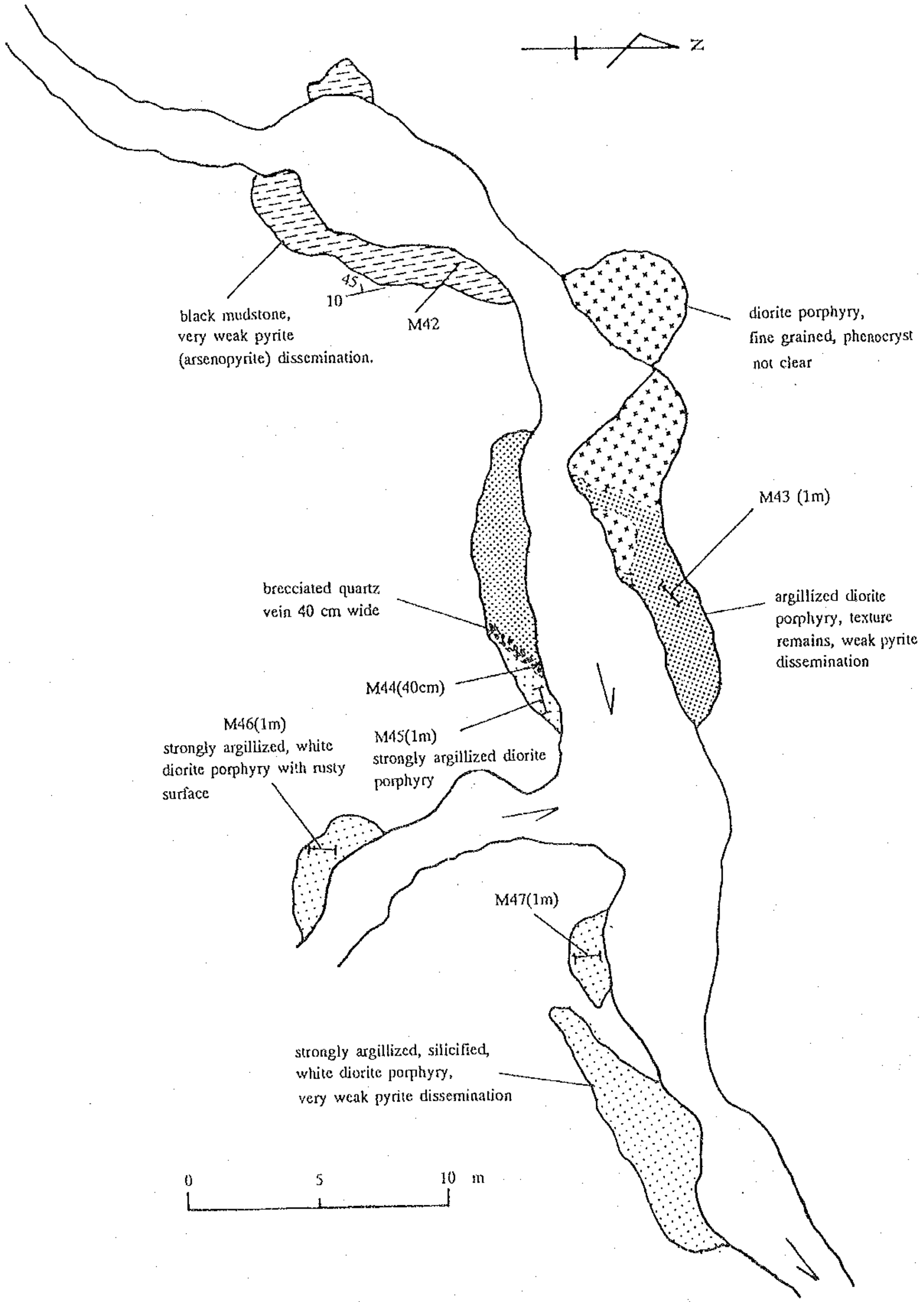
Mineral Showing No.	Descriptions of Mineralization	Host Rock	Alteration	Assay Results						
				Sample No.	Sampling width (m)	Au (g/t)	Ag (g/t)	Cu (ppm)	Pb (ppm)	Zn (ppm)
IM-4	Quartz - sulfides (pyrite, arseno-pyrite) veins, 12cm and 10 cm wide concordant to bedding of mudstone N 30°, 25° W (Sketch 3)	Mudstone	silicified	K20	0.1	17.5	27.6	2,913	13	30
				M31	0.1	72.5	57.6	5,349	56	81
				M32	0.1	29.0	38.1	1,874	180	56
				M33	0.1	7.0	17.5	850	553	79
				M34	0.05	33.3	36.3	2,216	43	33
				M35	2.0	0.3	2.5	310	71	17
				M36	0.12	64.2	25.8	2,396	28	31
				M37	2.0	33.3	64.0	4,560	132	202
				M38	grab	36.2	67.6	5,594	120	128
				M39	0.8	0.4	36.8	2,143	65	49
				M40	0.01	0.3	<0.1	174	30	371
IM-5	Quartz - sulfides (pyrite, galena sphalerite) lens, 25cm × 2m in silicified mudstone, N10° W, 90°	Mudstone	silicification	K34	1.0	<0.1	<0.1	14	72	275
				K36	1.0	<0.1	<0.1	27	50	191
				K37	1.0	<0.1	<0.1	21	101	210
				K38	1.0	<0.1	<0.1	24	25	296
				K40	1.0	<0.1	5.9	62	1,169	180
				K41	1.0	<0.1	<0.1	27	473	213
				K42	1.0	<0.1	<0.1	21	390	155
				K43	1.0	<0.1	<0.1	29	194	96
				K44	1.0	<0.1	<0.1	13	13	193
				W43	0.2	0.4	105.6	1,150	20,331	89,303

Table II-3-1 Mineralization showings of S. Imbak Sub-area North (3)

Mineral Showing No.	Descriptions of Mineralization	Host Rock	Alteration	Assay Results						
				Sample No.	Sampling width (m)	Au (g/t)	Ag (g/t)	Cu (ppm)	Pb (ppm)	Zn (ppm)
IM-6	Quartz - sulfides (pyrite, arsenopyrite) veins, 2.5cm to 7cm wide in silicified sandstone, dominant trend: N-S, dip: 70° W to 90°, cutting structure of sandstone.	sandstone	silicification	S129 S131 S134	0.10 0.07 0.15	2.6 2.5 <0.1	52.8 51.3 3.1	1,897 825 66	506 583 67	667 703 28
IM-7	Sulfides (pyrite, sphalerite and galena) veins, 1cm to 3cm wide in sandstone and diorite porphyry, trend: NNE-SSW to NE-SW, dip: 80° W, cutting structure of sandstone.	Sandstone and diorite porphyry	silicification (sandstone) argillization (diorite porphyry)	S148 S149	grab 0.15	2.0 <0.1	148.2 3.9	612 154	52,233 395	42,773 350
IM-8	Sulfides (pyrite, galena and sphalerite) lenses, 2cm wide in sedimentary rock with pyrite dissemination, trend: N50° E, dip:85° NW, cutting the structure of sediments. (Sketch 1A, 1B)	alternation of sandstone and mudstone	silicification	P119 S146	grab 0.20	0.3 <0.1	182.6 21.7	425 177	122,444 9,606	76,343 10,783
IM-9	Sulfides (pyrite, galena and sphalerite) veins, max.4cm wide within the sheared zone in mudstone, vein trend: N10° E, dip: 80° W, cutting the structure of mudstone. (Sketch 2)	mudstone	—	S139 S140 S141	0.20 0.20 0.04	0.1 <0.1 0.3	47.3 28.3 156.0	405 458 957	31,490 18,908 103,213	16,683 8,744 20,213

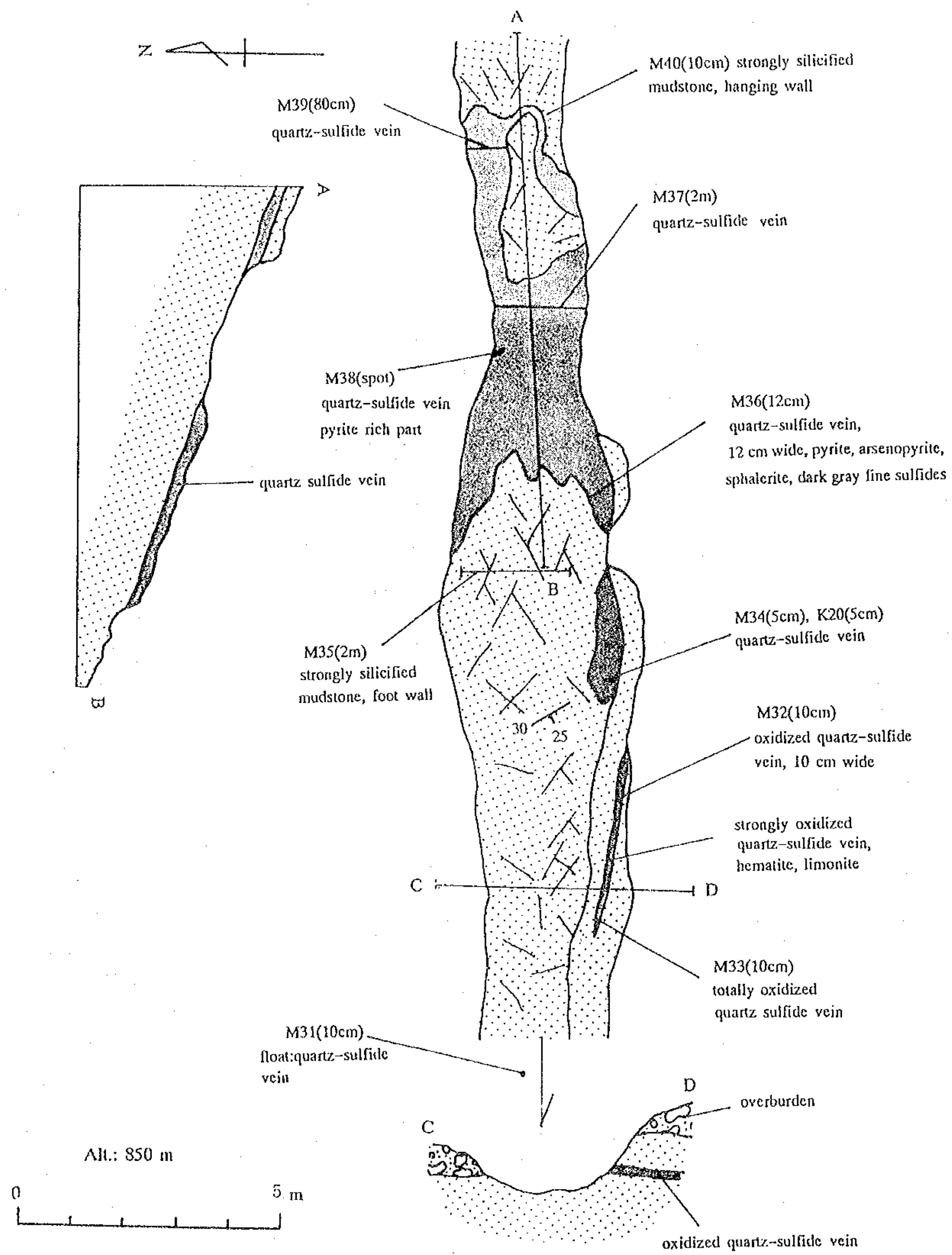
Table II-3-1 Mineralization showings of S. Imbak Sub-area North (4)

Mineral Showing No.	Descriptions of Mineralization	Host Rock	Alteration	Assay Results						
				Sample No.	Sampling width (m)	Au (g/t)	Ag (g/t)	Cu (ppm)	Pb (ppm)	Zn (ppm)
IM-10	Sulfide (pyrite, galena and sphalerite) veins, max.4cm wide along sheared zone in mudstone, vein trend: N25° E, dip: 60° W, cutting the structure of mudstone. (Sketch 3)	mudstone	—	S135	grab	3.5	64.2	356	1,251	7,701



IM-1

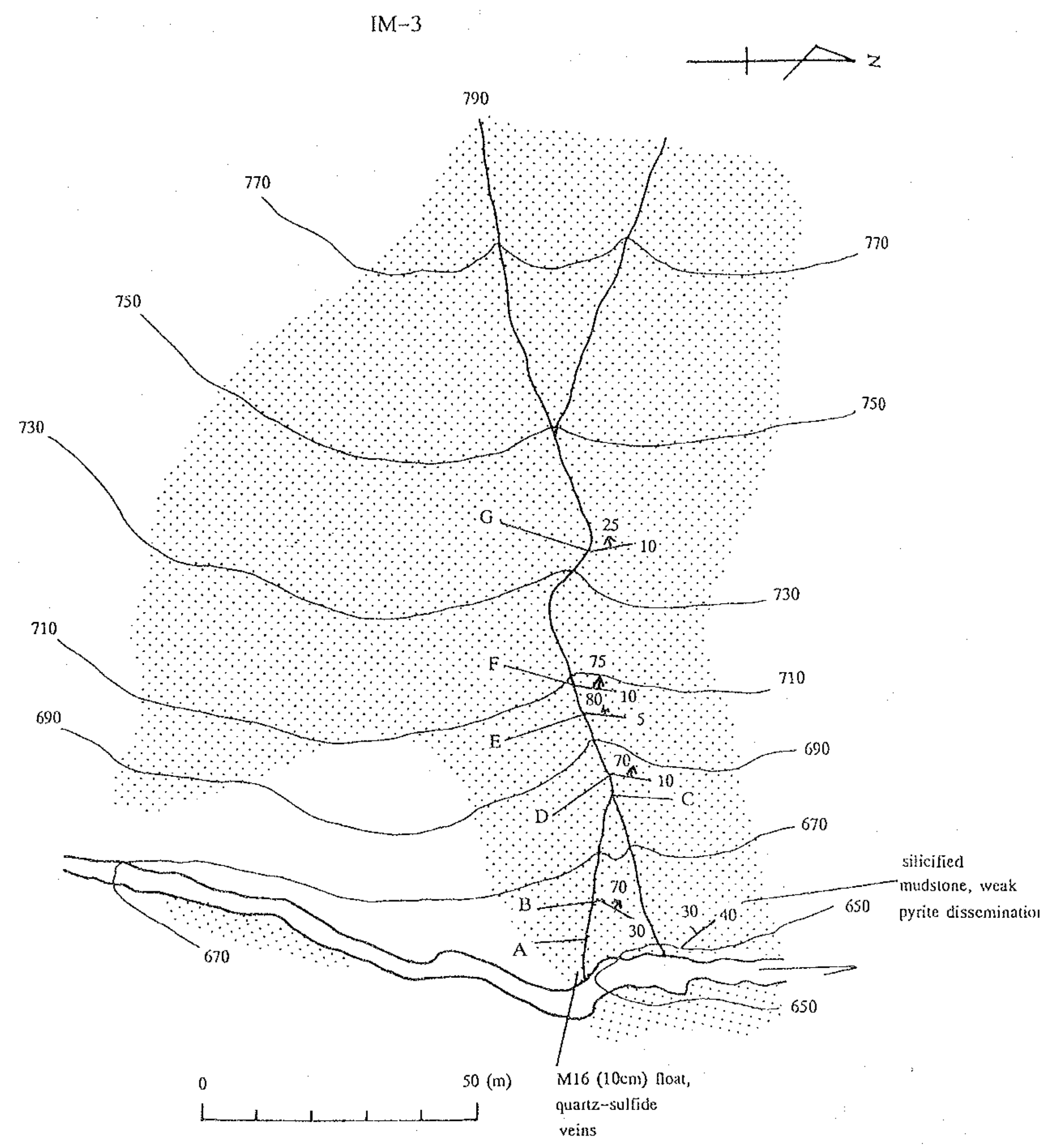
Sketch 1



IM-4

Sketch 3

Fig. II-3-3 Sketch of the mineral showings in S. Imbak Sub-area North (1)



A: 1m across, rusty patch in silicified mudstone
M17 (1m)

B: light gray, argillized zone, 20 cm wide
M18 (20cm)

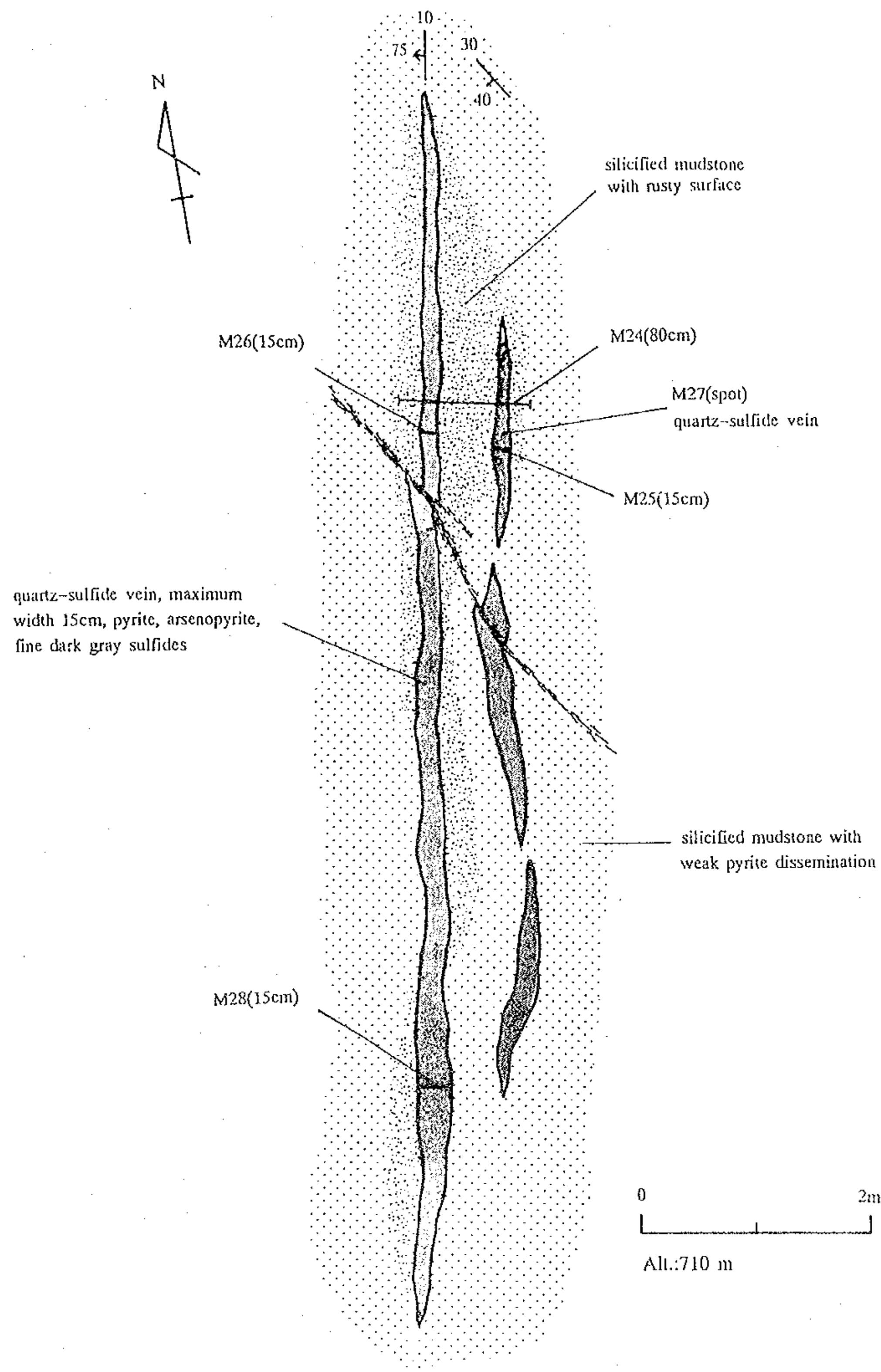
C: float: quartz vein with pyrite and arsenopyrite
M19 (5cm)

D: quartz-sulfide vein filling joint, 1 cm wide
M20 (1cm), M21 (1m, vein and wall rock)

E: quartz-sulfide (pyrite, arsenopyrite, fine dark gray sulfides) lens,
maximum 20cm × 1m, M22 (20cm), M23 (spot)

F: quartz-sulfide vein, 10m × 15 cm × 2,
see sketch IM-3 F

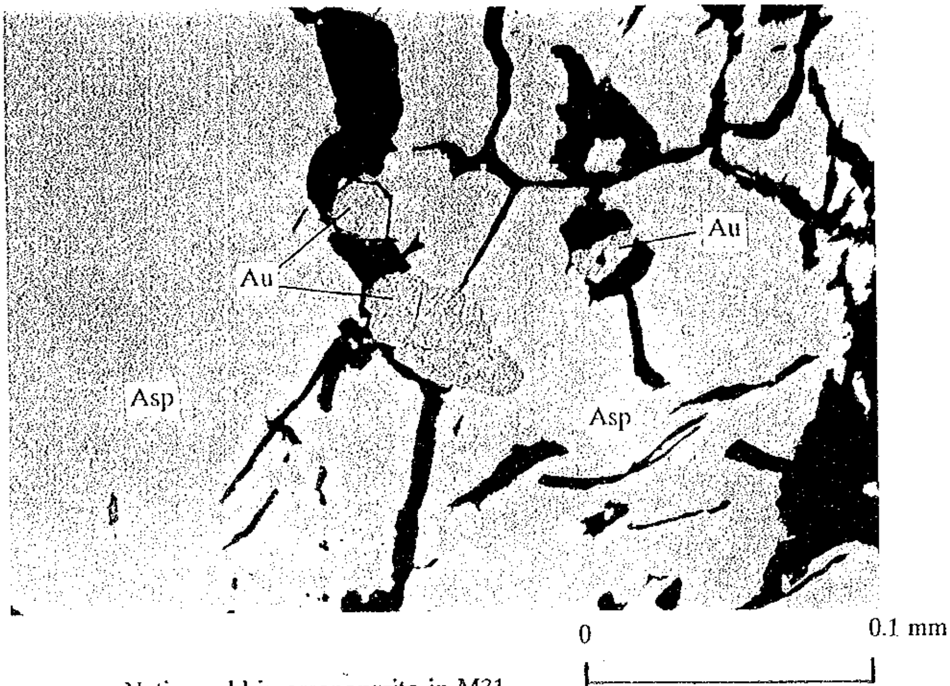
G: quartz-sulfide (pyrite, fine dark gray sulfides) vein, 5 cm wide
M29 (5cm)



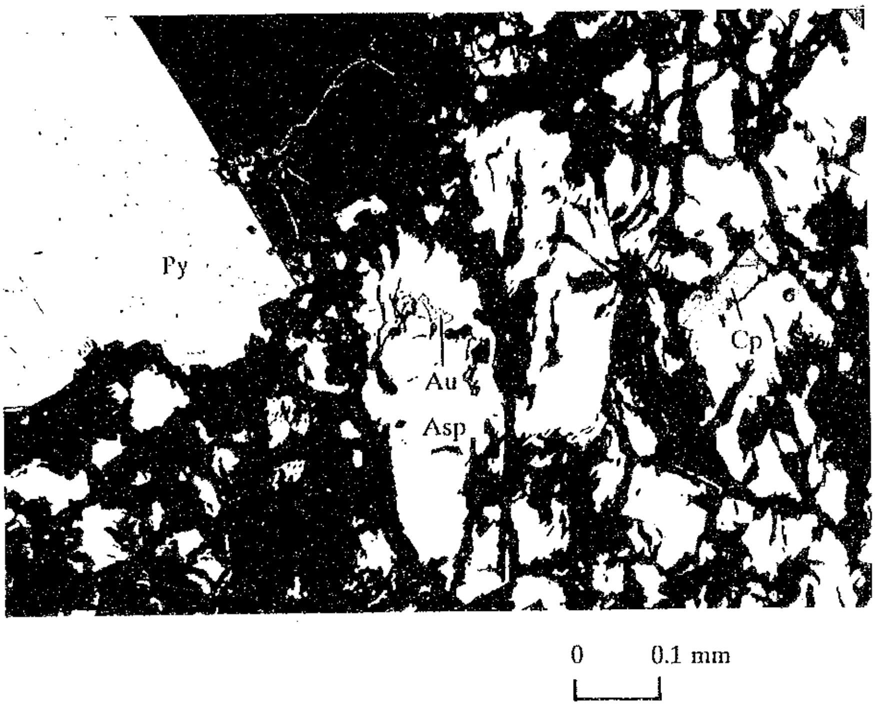
IM-3 F

Sketch 2

Fig. II-3-3 Sketch of the mineral showings in S. Imbak Sub-area North (2)



Native gold in arsenopyrite in M31



Native gold in arsenopyrite in M37

Au: Native gold
Asp: Arsenopyrite
Py: Pyrite
Cp: Calcopyrite

Fig. II -3-4 Occurrence of gold

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 veins are pyrite, arsenopyrite, sphalerite and galena. IM–5, IM–7, IM–8, IM–9 are examples of this type.

As shown in Fig.II –3–2, Type ① and Type ② occur in a relatively restricted area of southwest part of the silicification/pyrite dissemination zone, while Type③ occurs in the northeast part of the silicification/pyrite dissemination zone.

Despite of strong alteration of the 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 over wide extent in the sedimentary rocks.

The filling temperature measurement of four samples collected from quartz sulfide veins of the S. Imbak Sub–area North show a temperature range of 300° C to 400° C, and their average temperature of each sample vary from 318.1° C to 379.7° C. The temperatures obtained are higher compared to those of epithermal type mineralization.

3-2-4 Rock geochemical survey and alteration

(1) Rock geochemical survey

The rock geochemical survey of 201 samples in the S. Imbak Sub-area North shows a good correlation between elements such as Ag, As and Au. The mineralization and anomalies of As, Au, Cu and S are closely associated with the silicification/pyrite dissemination zone (Fig. II -3-5). The samples of silicification/pyirte dissemination zone are lower in Ca, Mg and Na suggesting the removal of these elements during alteration.

The results of factor analysis suggests that the following factors are related to the mineralization of the area.

Factor 1 : -Ag, -As, -Au, Ca, Mg, Na, Sr
Factor 2 : -Cu, -Hg, -Mg, -S, -Zn
Factor 5 : -Pb, -Zn

The distribution of high factor scores are shown by three colors, Factor 1(red), Factor 2 (blue) and Factor 5 (yellow), in Fig. II -3-6. The distribution of high Factor 1 zone occurs over the area of