1-5 Discussion

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 intrusion of 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. As shown in Chapter II-2-5, 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 is in intermediate sulfidation state.

The results of geophysical survey (IP method) in Phase I and Phase II clarified the strong IP anomalous zones which show a medium to high chargeability values of more than 20 mV/V. The Au, Ag and Cu anomalies of the rock geochemical survey in the center to south part of the area correspond to the medium to high chargeability anomalies of more than 20 mV/V. Some core samples (diorite porphyry with pyrite dissemination and silicification/argillization, sandstone with fracture filling pyrite) from the drill hole MJSI-4 show high chargeability values of over 60 mV/V.

Two strong IP anomalous areas in the survey area are detected. One is located in the center to southeast part of the area, another in the center to south part of the area, mainly along Line-D and Line-E. The former correspond well with distribution of silicification/pyrite dissemination zone near/around intrusive rocks of the diorite porphyry. The strongest IP anomaly is located from center of Line-D to center of Line-F in the silicification/pyrite dissemination zone. According to the results of the drilling survey drilled into the IP anomaly source, pyrite rich zone in mudstone exists from the surface to a few tens meters in the drill hole MJSI-1. The reasons of these strong IP anomalies are related to a pyrite rich zone in the drill hole MJSI-1, and probably to some other pyrite rich zones near the drill site. According to the results of drilling survey at the drill holes MJSI-4 and MJSI-5, there is some mineralization near/around intrusive rocks with sulfide in the former area. The latter in the central to southern part of the area, does not correspondent to distribution of intrusive rocks with pyrite dissemination from the geological map. However, according to the result of an above-mentioned reason and the results of drilling survey at the drill holes MJSI-4 and MJSI-5, it is considered to be some mineralization near/around intrusive rocks with sulfides in the depths in the latter area.

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 extent.

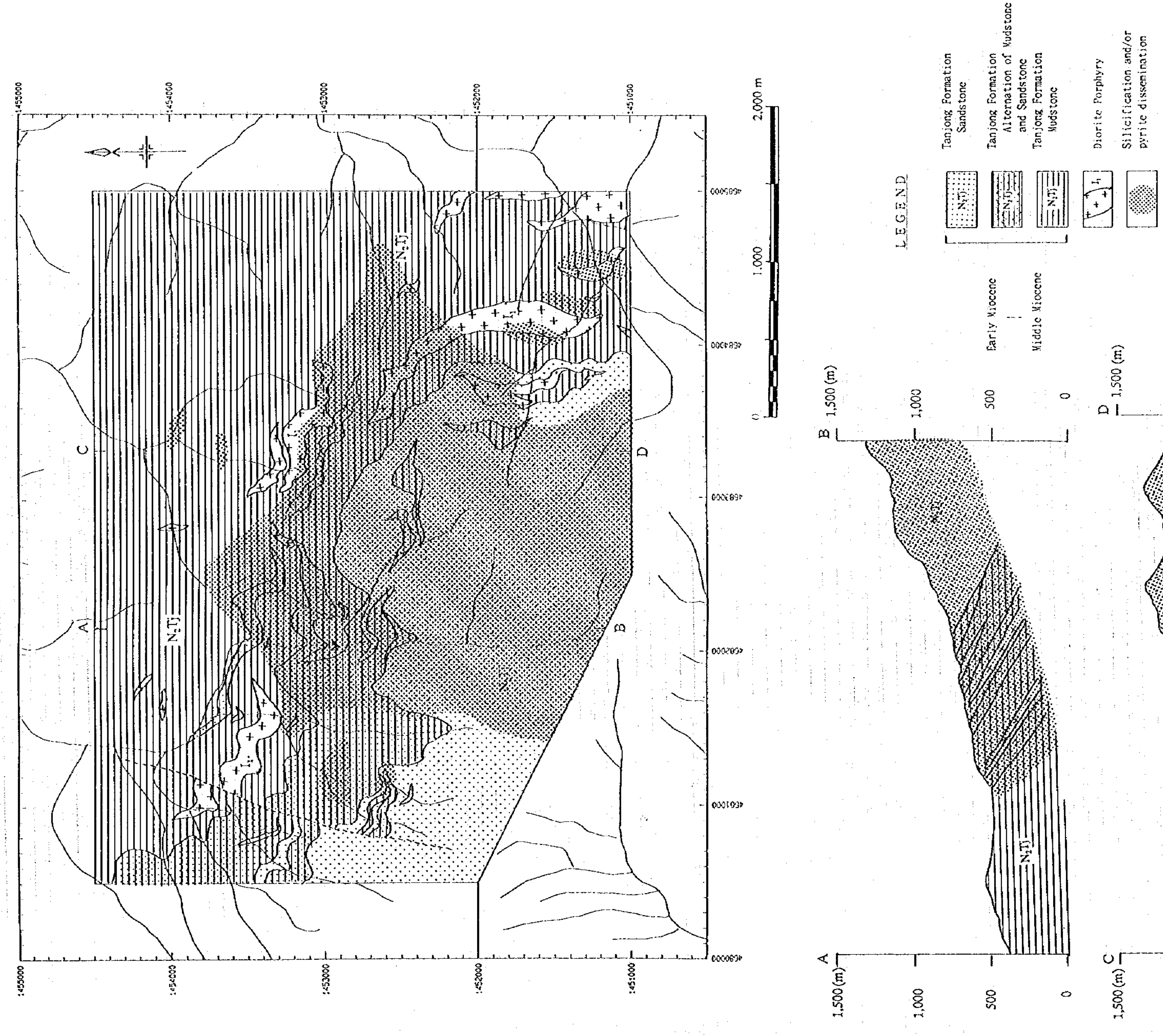


Fig. II-1-1 Geological map and cross sections of S. Imbak Sub-area North

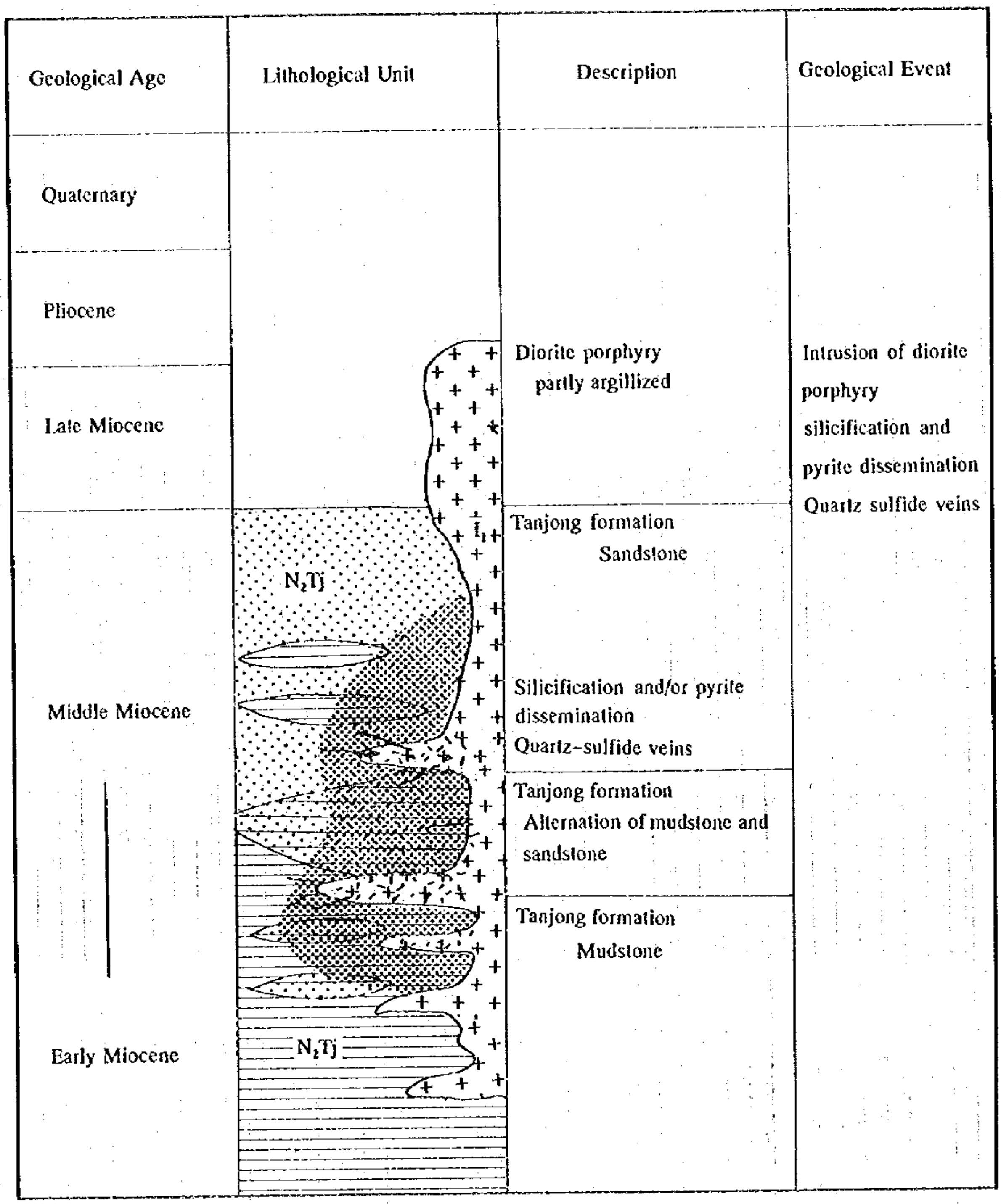


Fig. II-1-2 Schematic lithological succession of S. Imbak Sub-area North

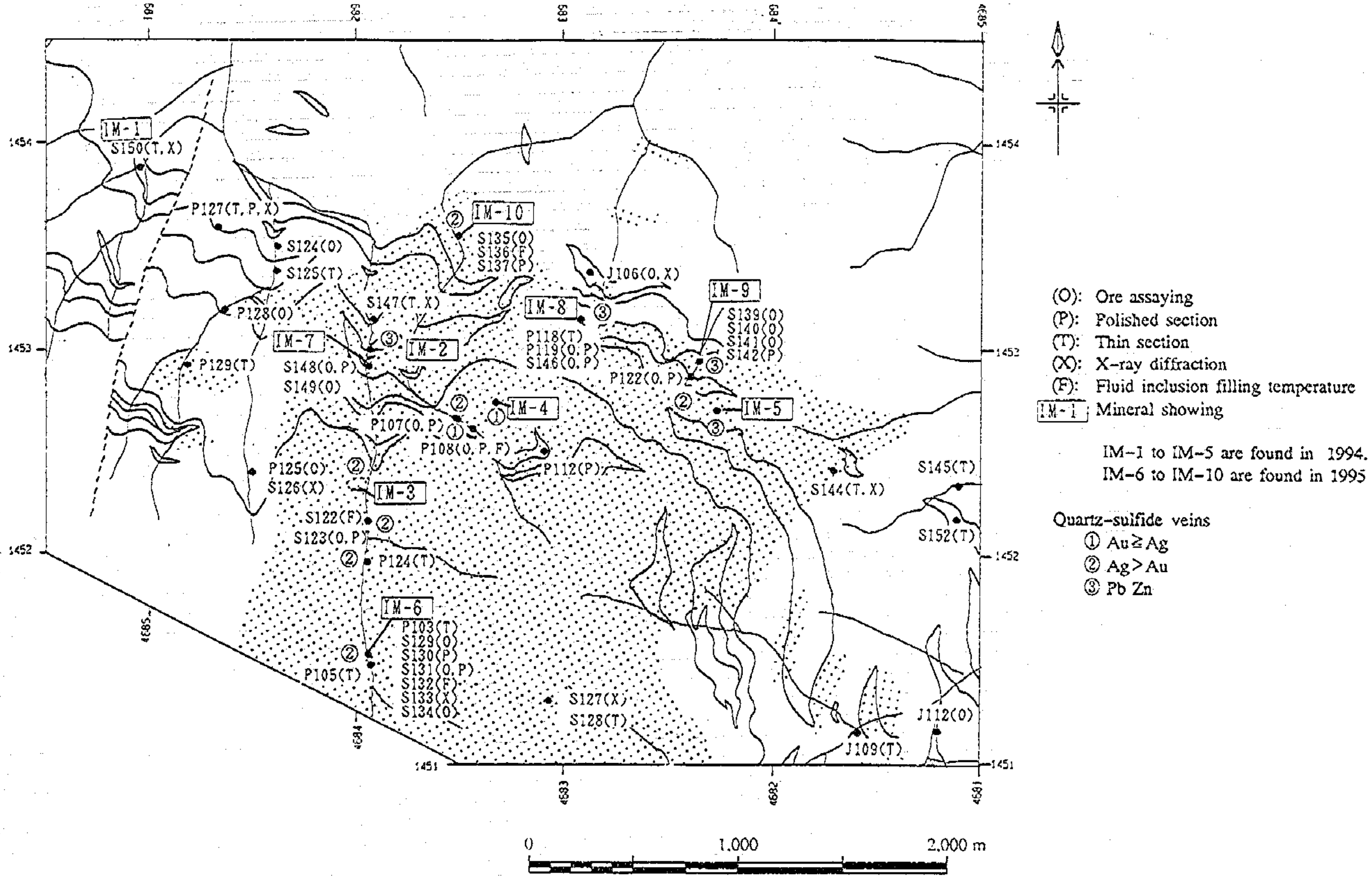
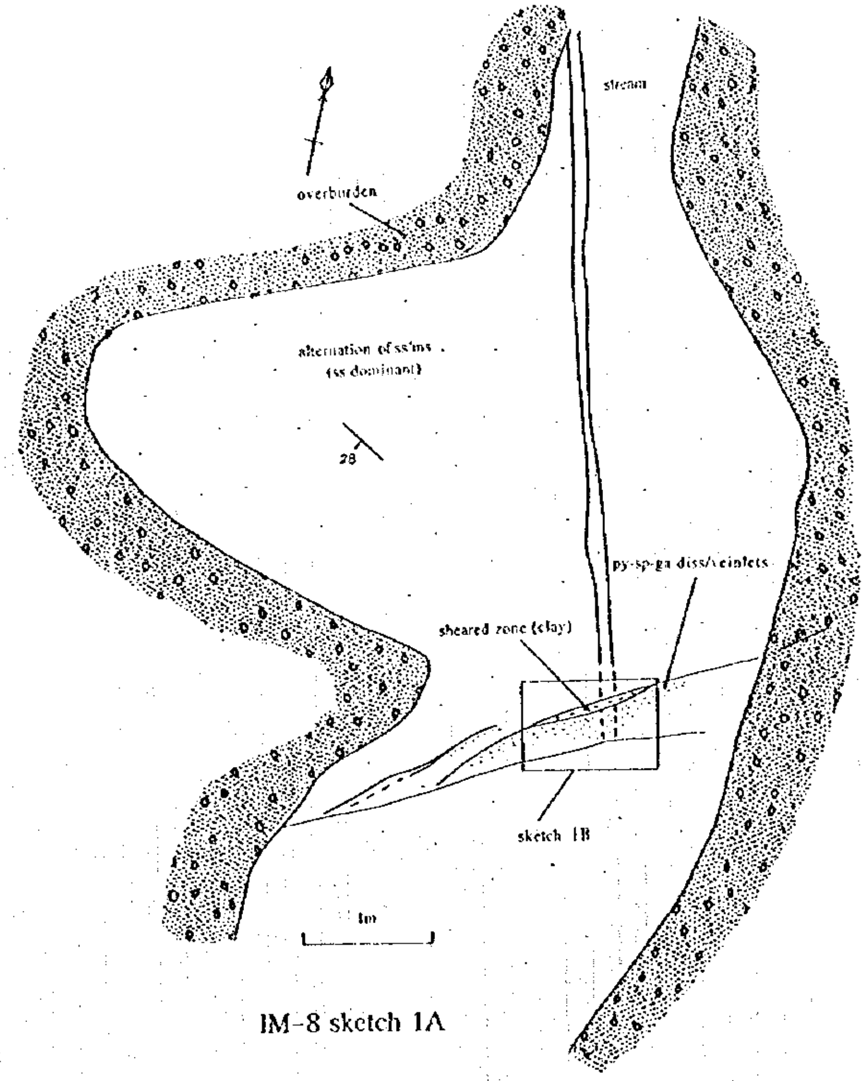
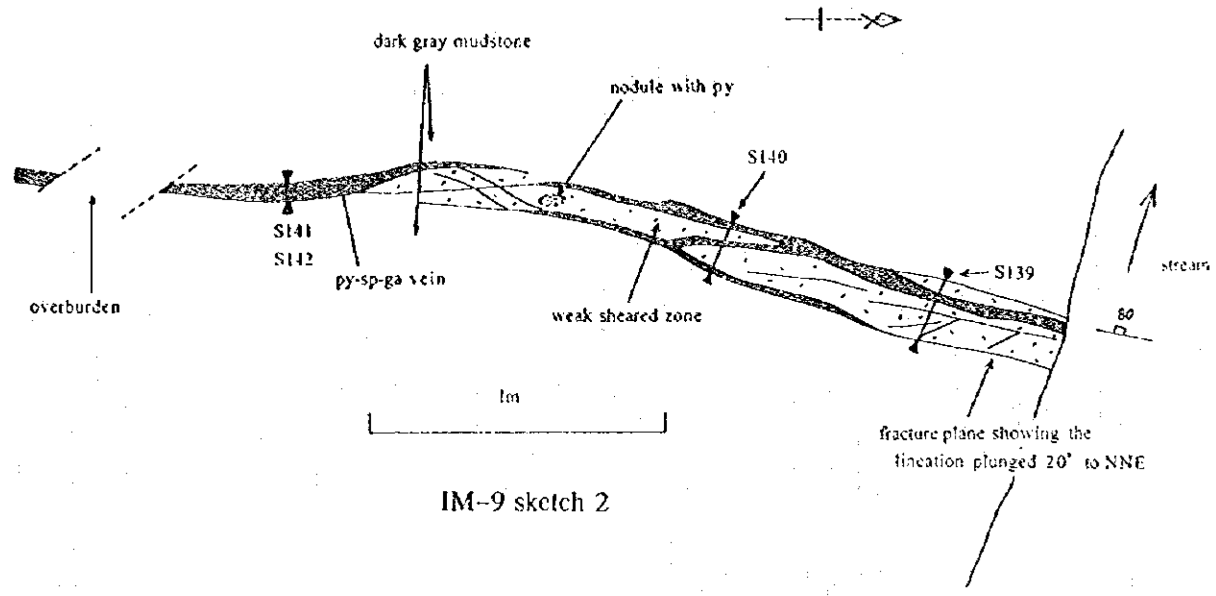


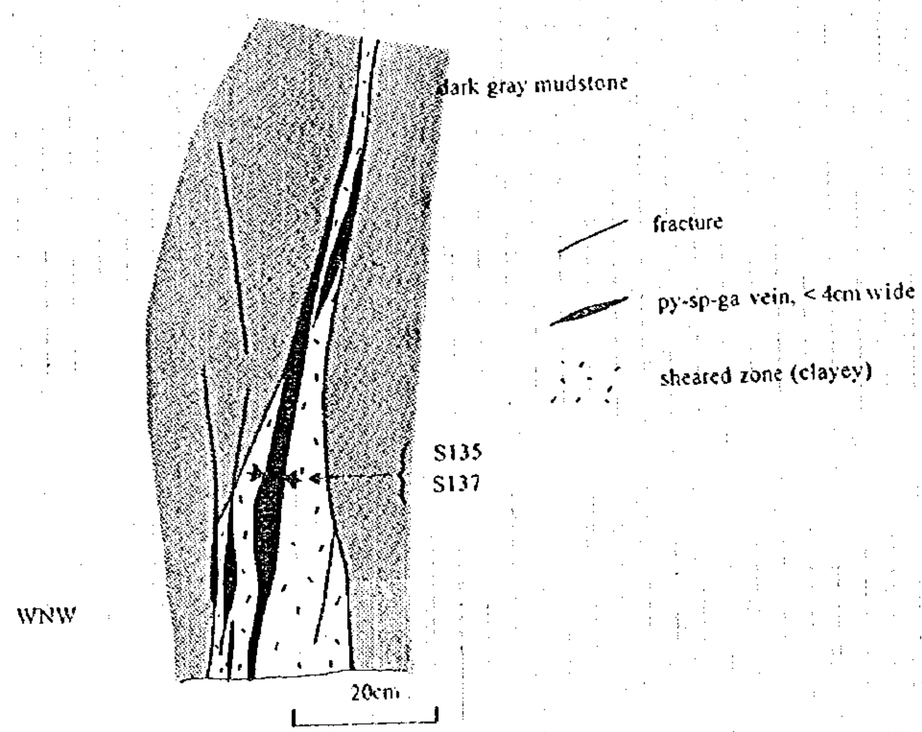
Fig. II-1-3 Location of mineral showings and laboratory work samples



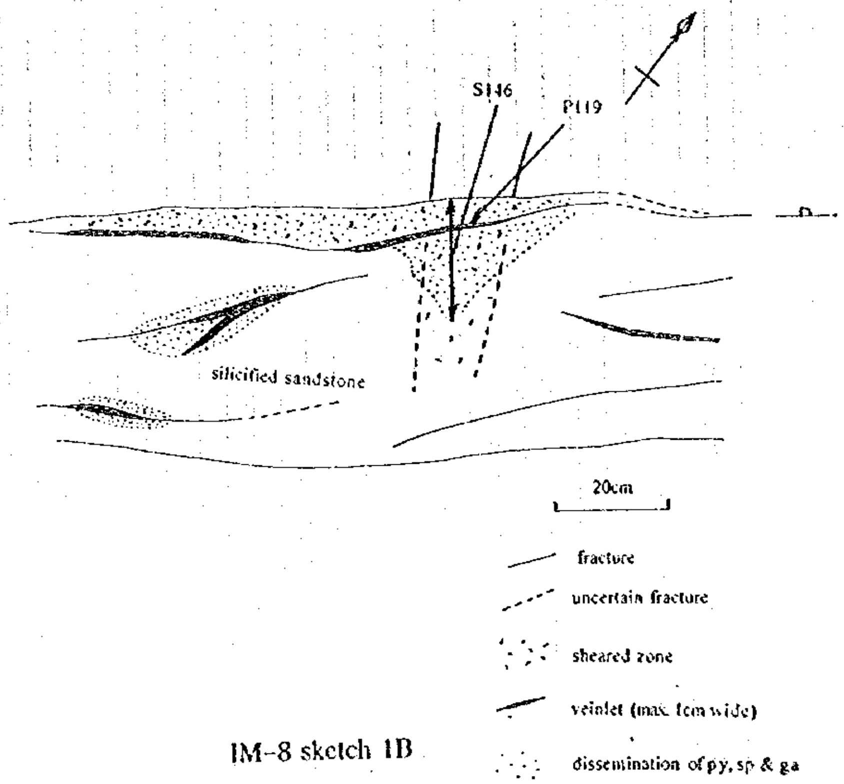
IM-8 sketch 1A



IM-9 sketch 2



IM-10 sketch 3



IM-8 sketch 1B

Fig. II-1-4 Occurrences of mineralization

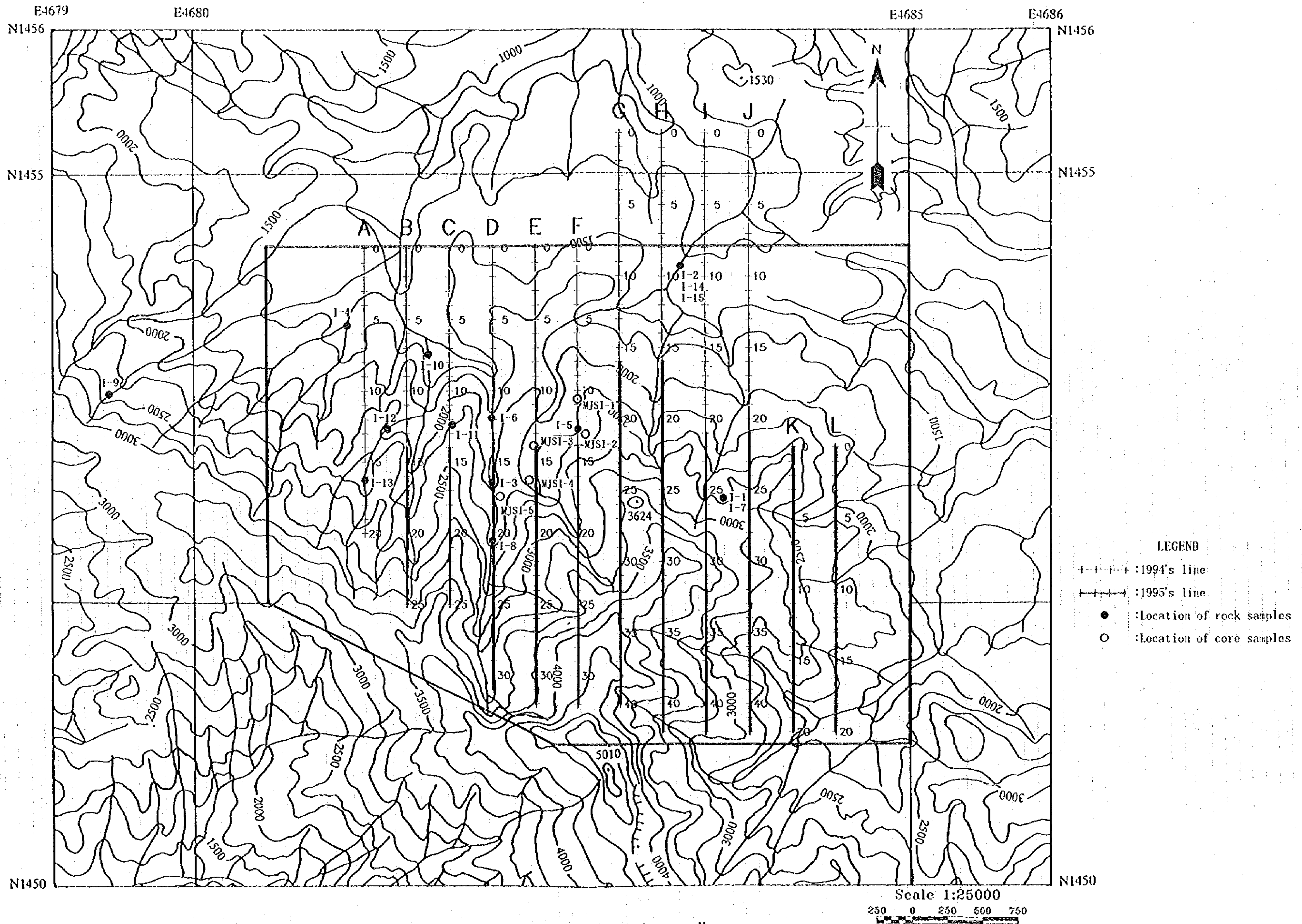


Fig. II-1-5 Location of geophysical survey lines

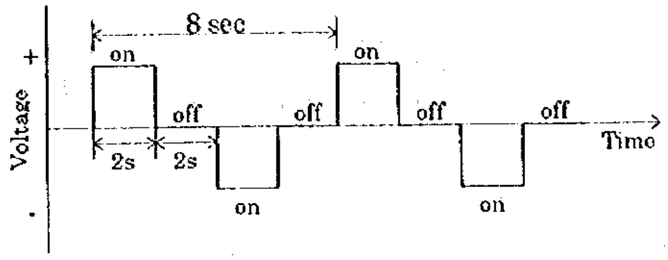


Fig. II -1-6 Wave form produced by the transmitter

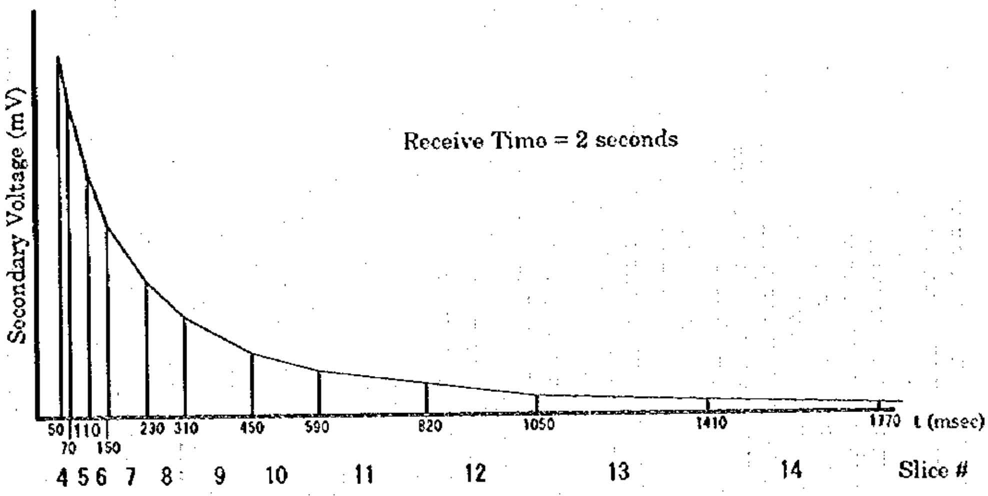


Fig. II -1-7 Sampling interval of IP receiver

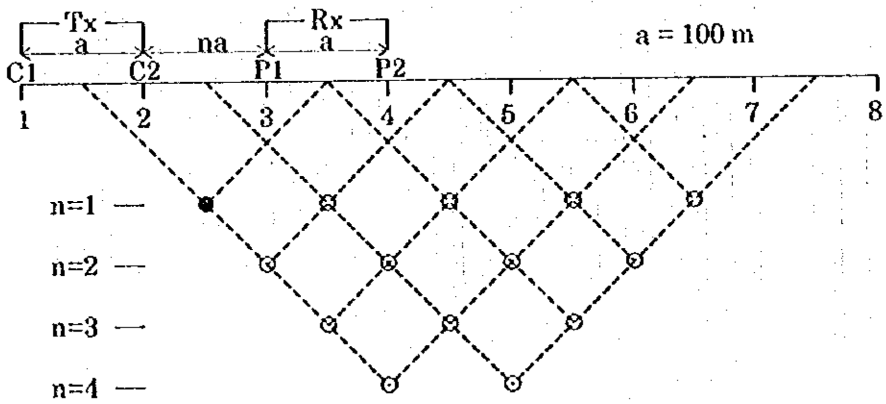


Fig. II -1-8 Dipole-dipole array and plotting procedures

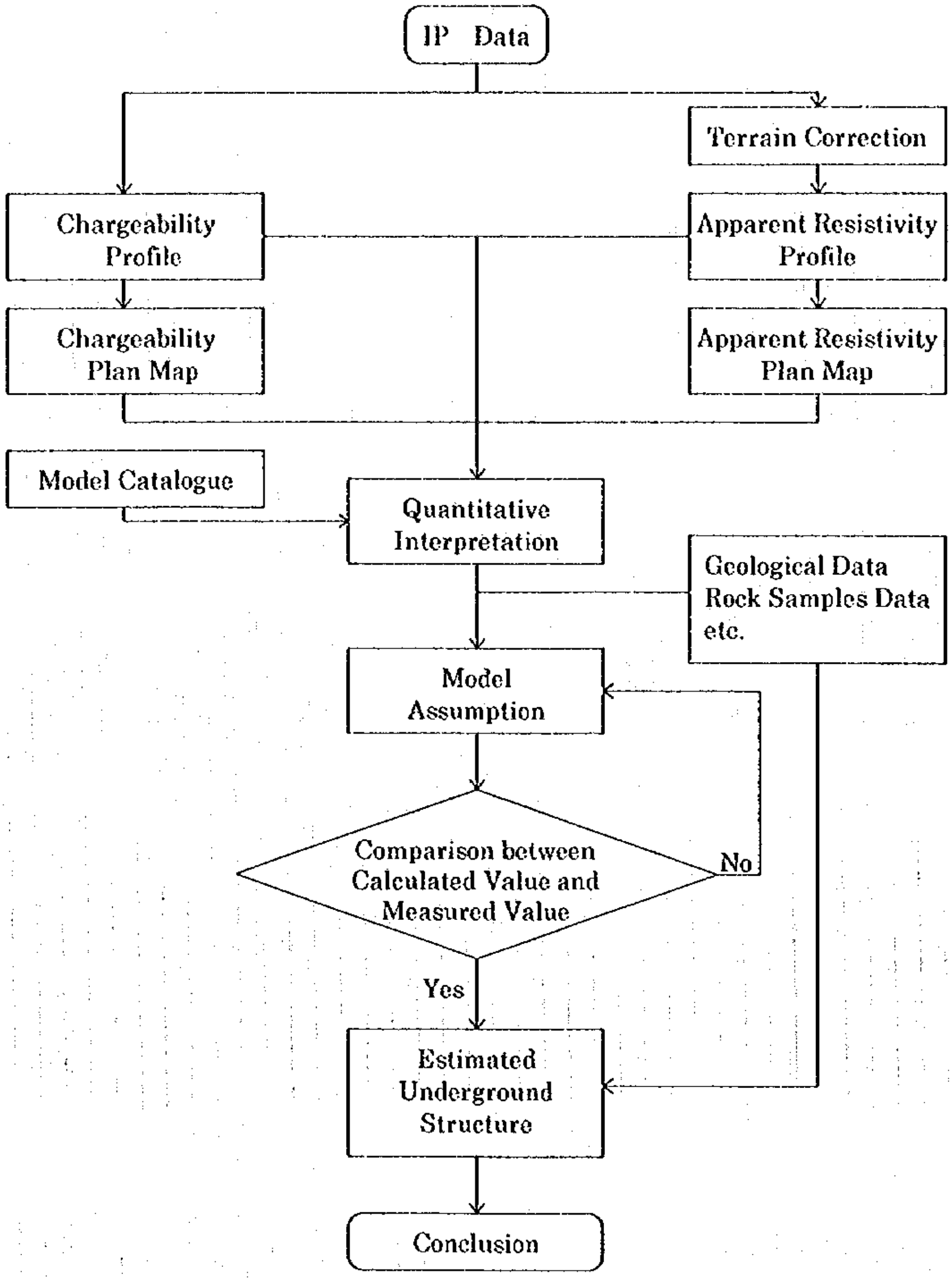


Fig. II-1-9 Flow chart of IP data analysis

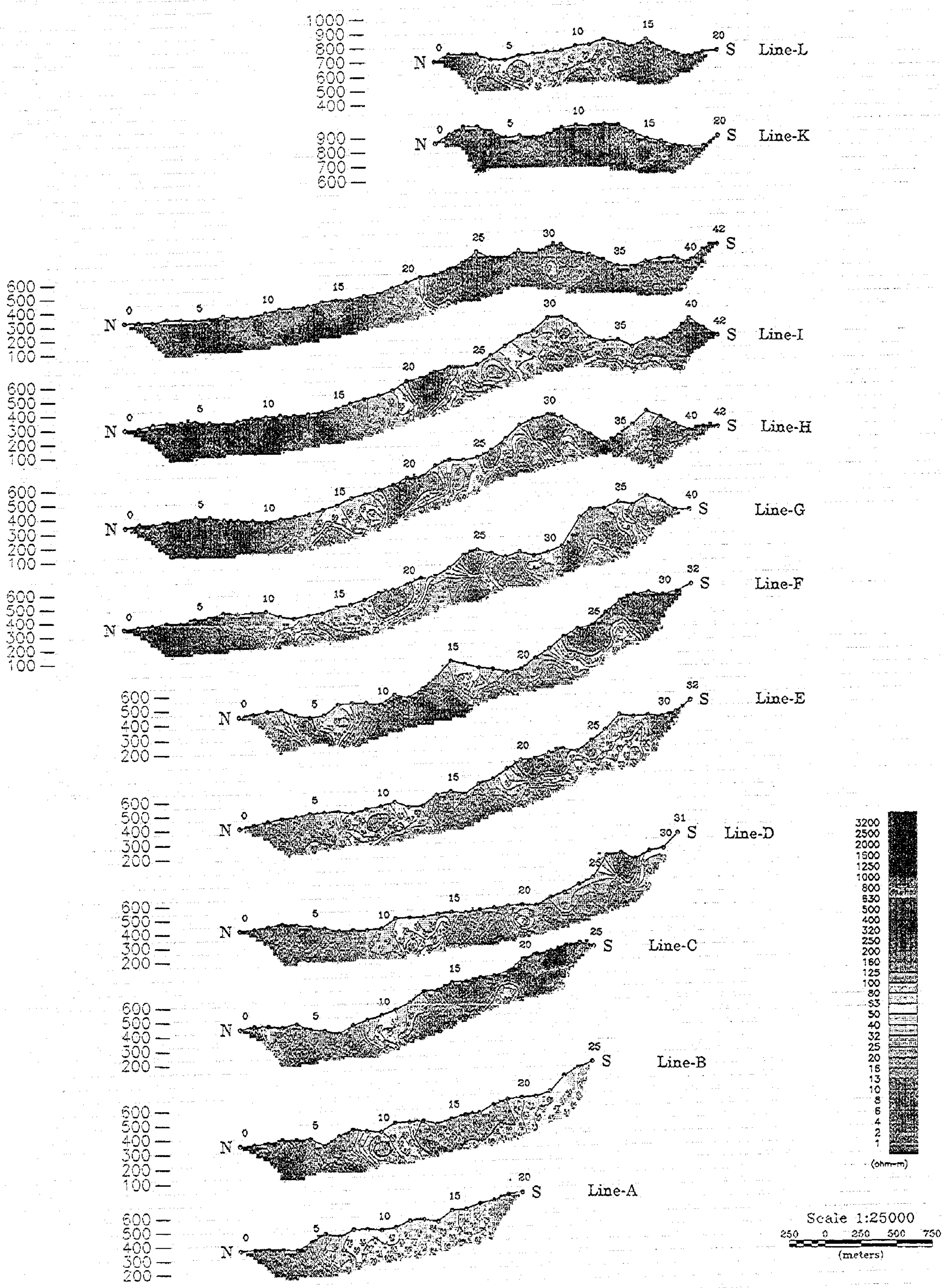


Fig. II-1-10 Pseudo-section of apparent resistivity

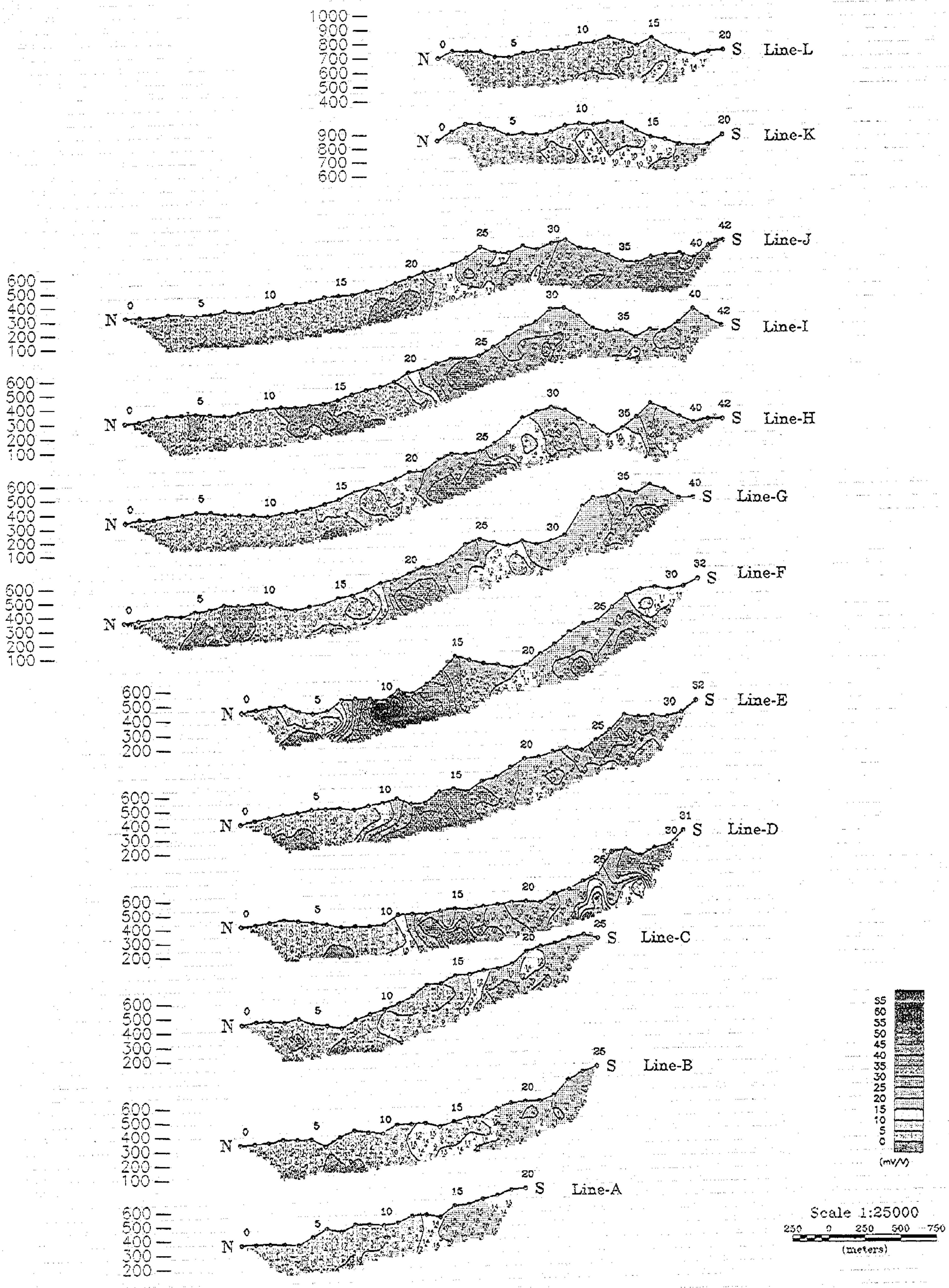


Fig. II-1-11 Pseudo-section of chargeability

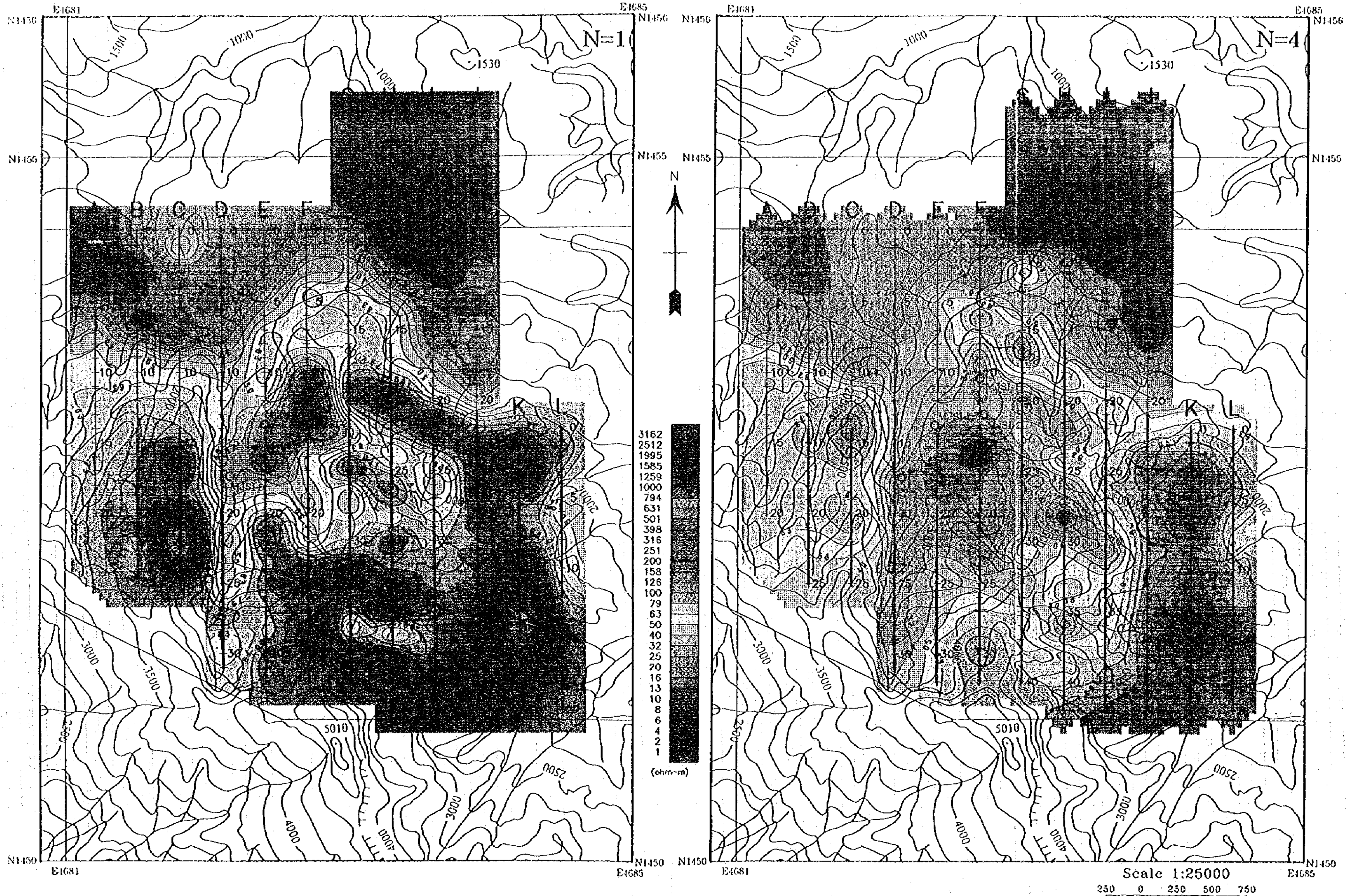


Fig. II-1-12 Plan map of apparent resistivity (n=1 and n=4)

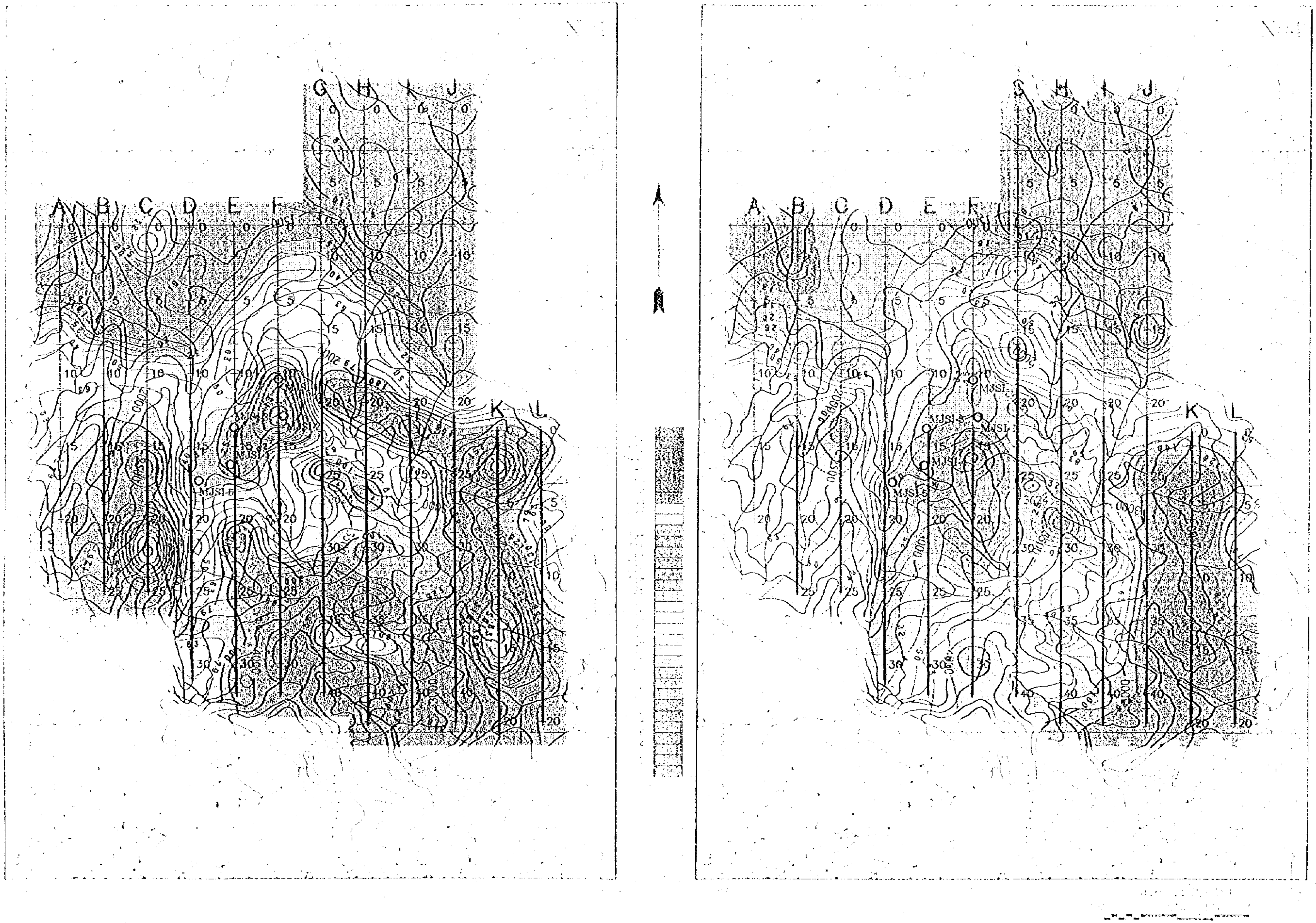


Fig. II-1-12 Plan map of apparent resistivity (n=1 and n=4)

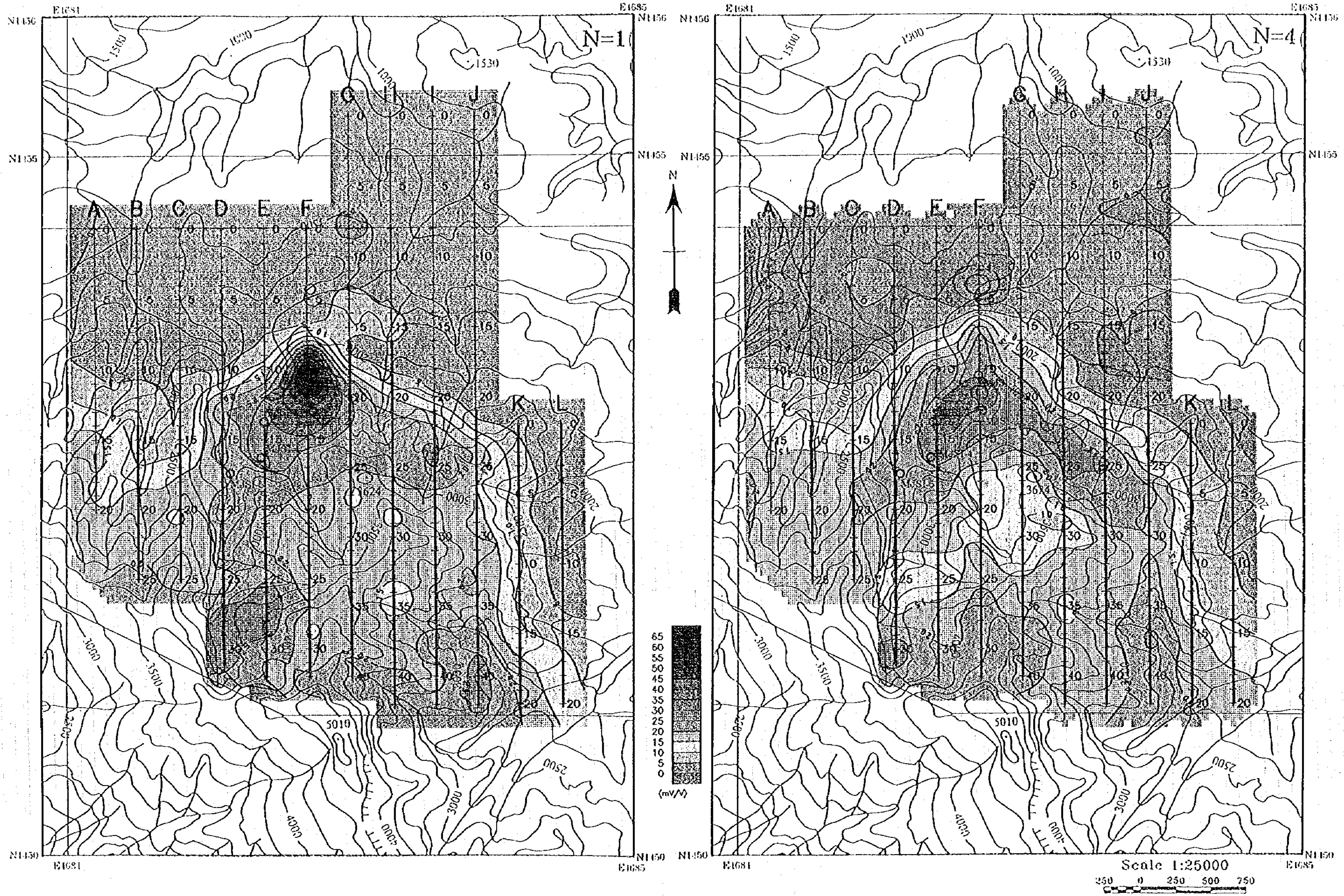


Fig. II-1-13 Plan map of chargeability (n=1 and n=4)

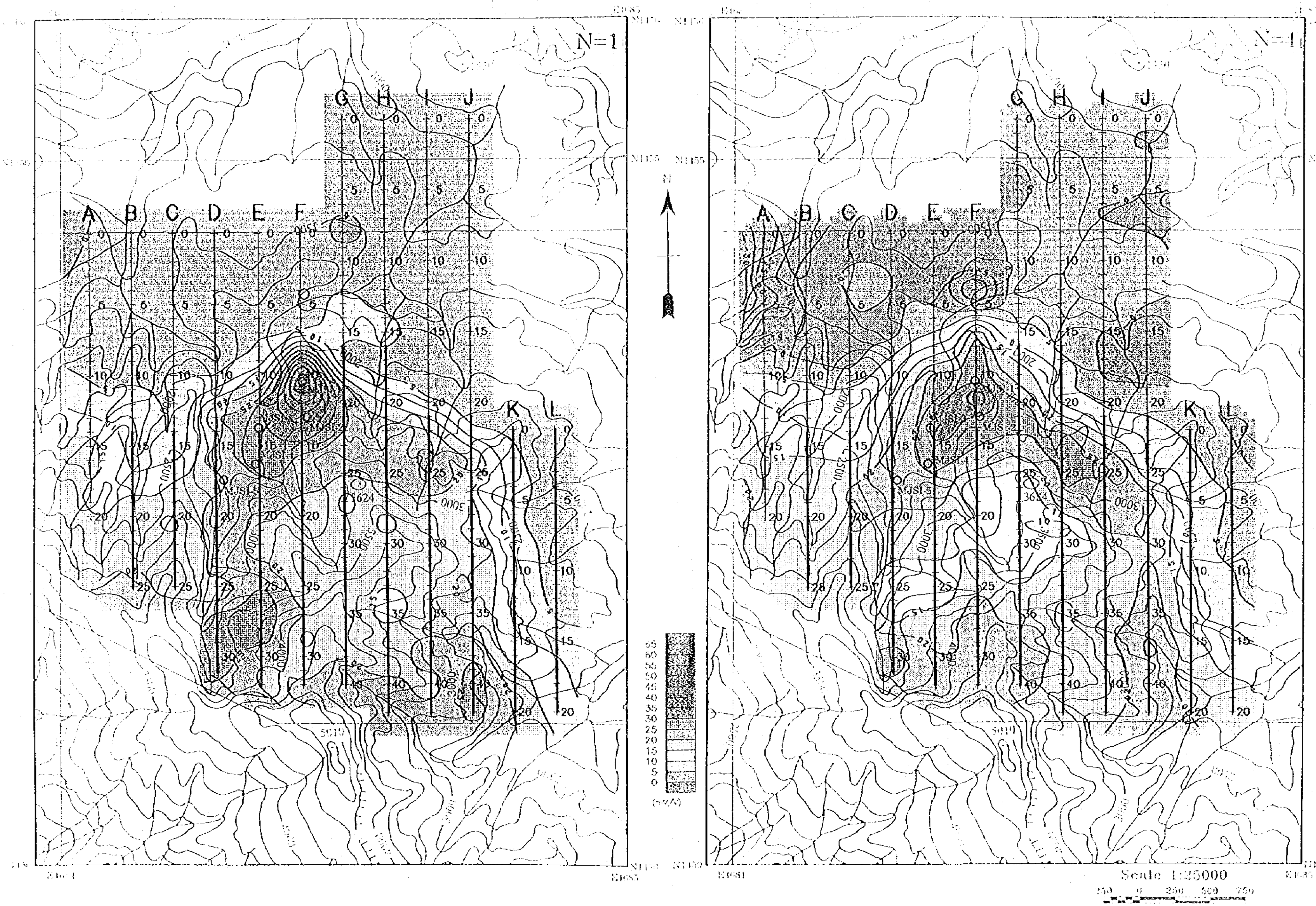


Fig. II-1-13 Plan map of chargeability (n=1 and n=4)

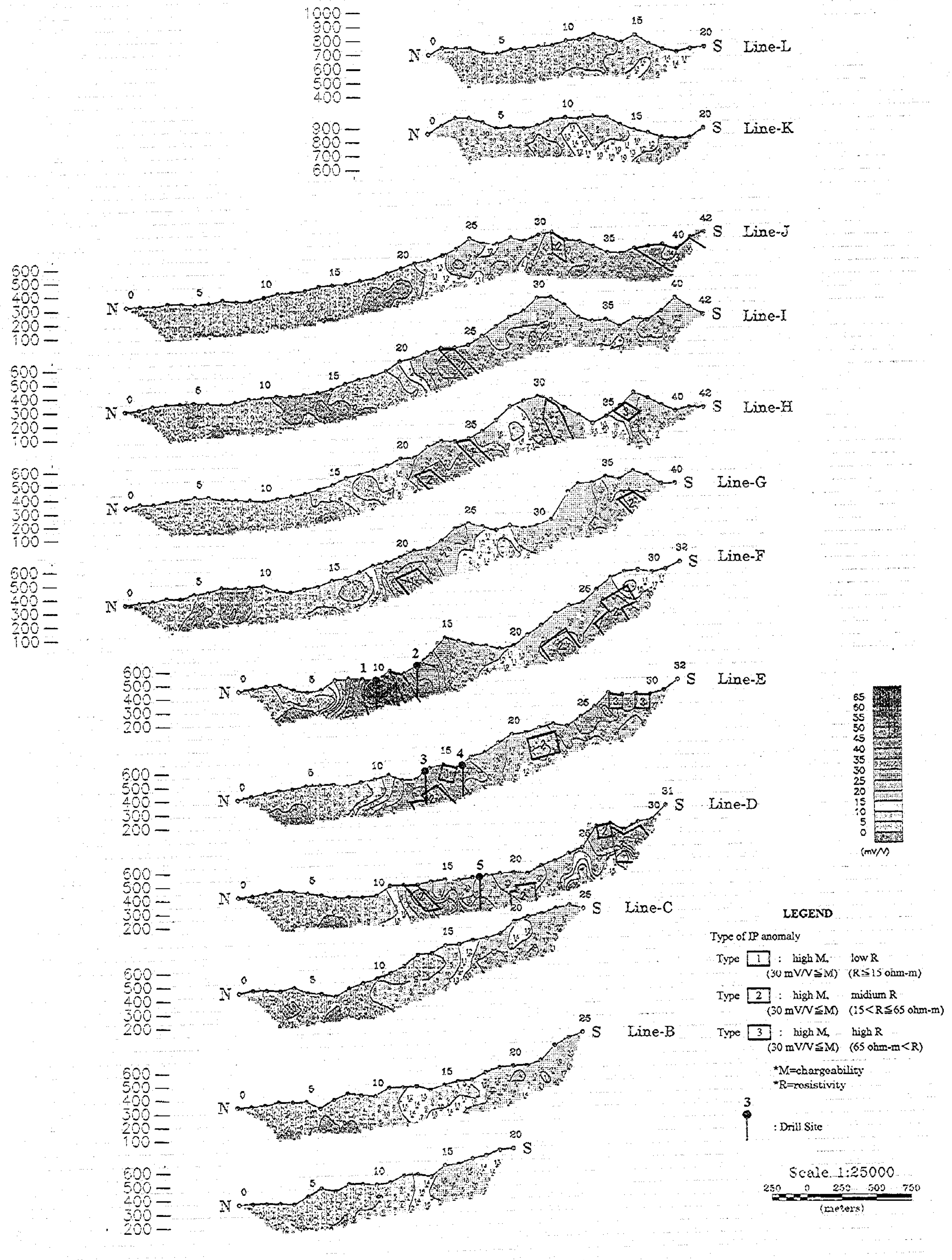


Fig. II-1-14 Results of model simulation

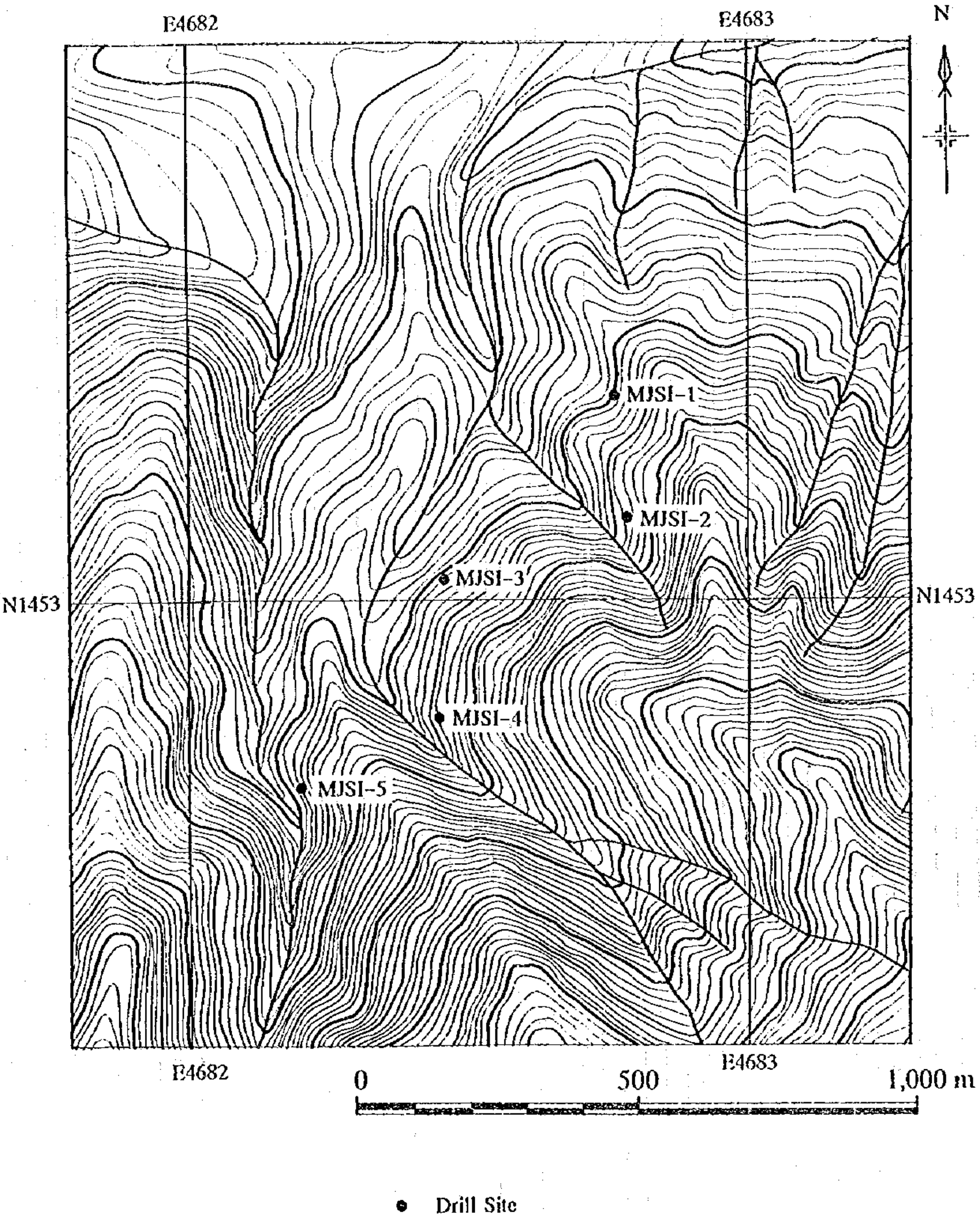


Fig. II-1-15 Location of drill site

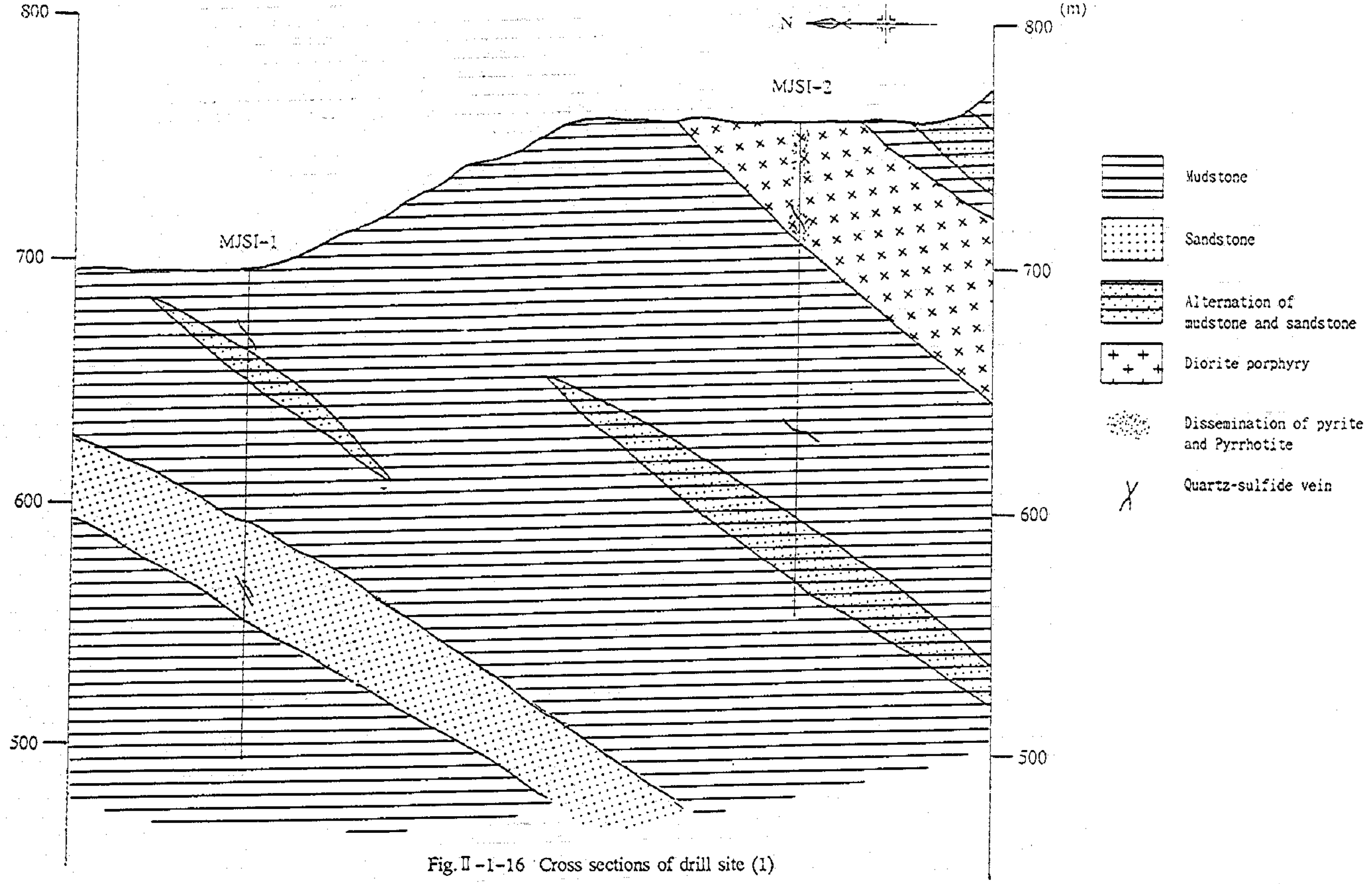


Fig. II-1-16 Cross sections of drill site (1)

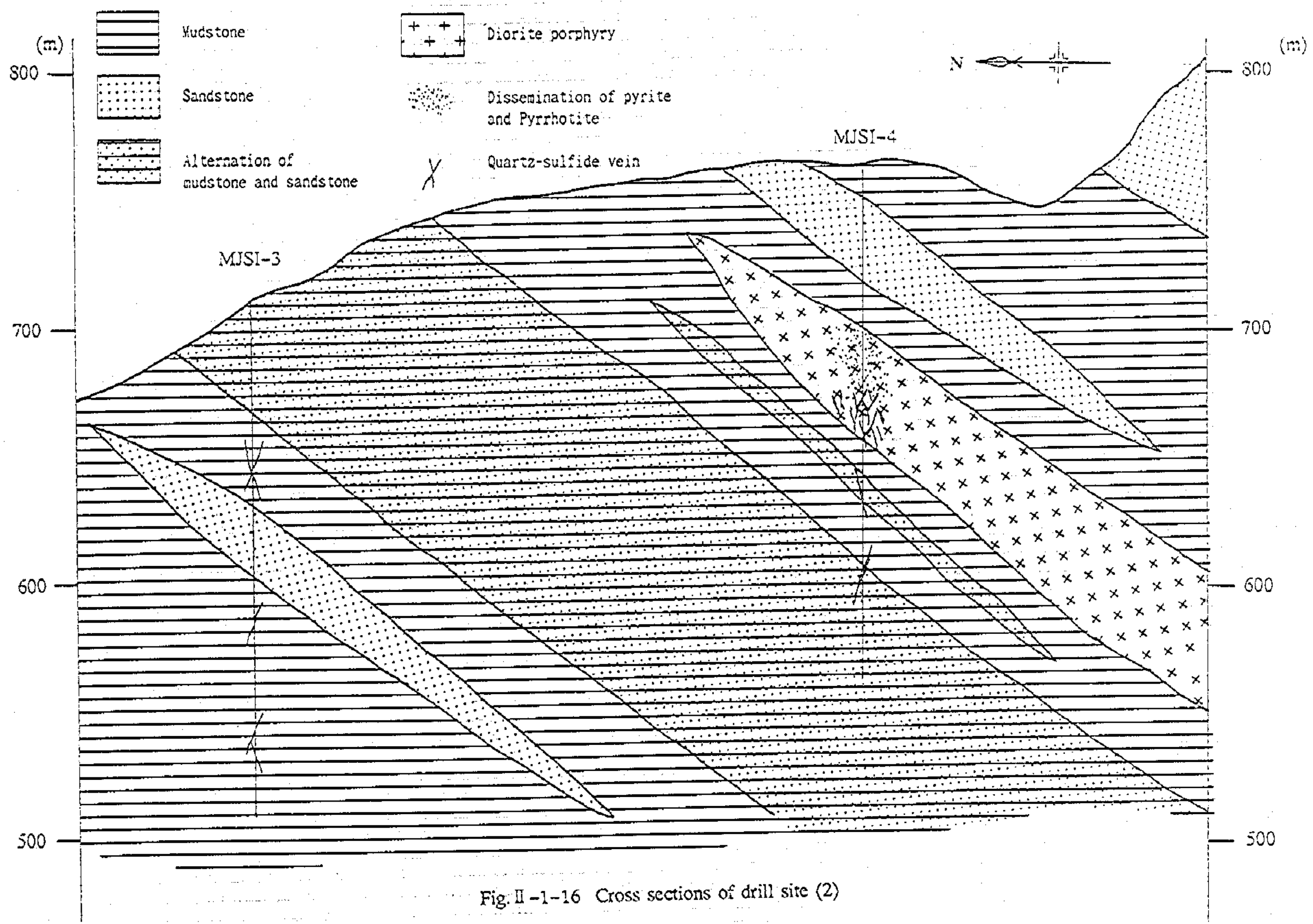


Fig. II-1-16 Cross sections of drill site (2)

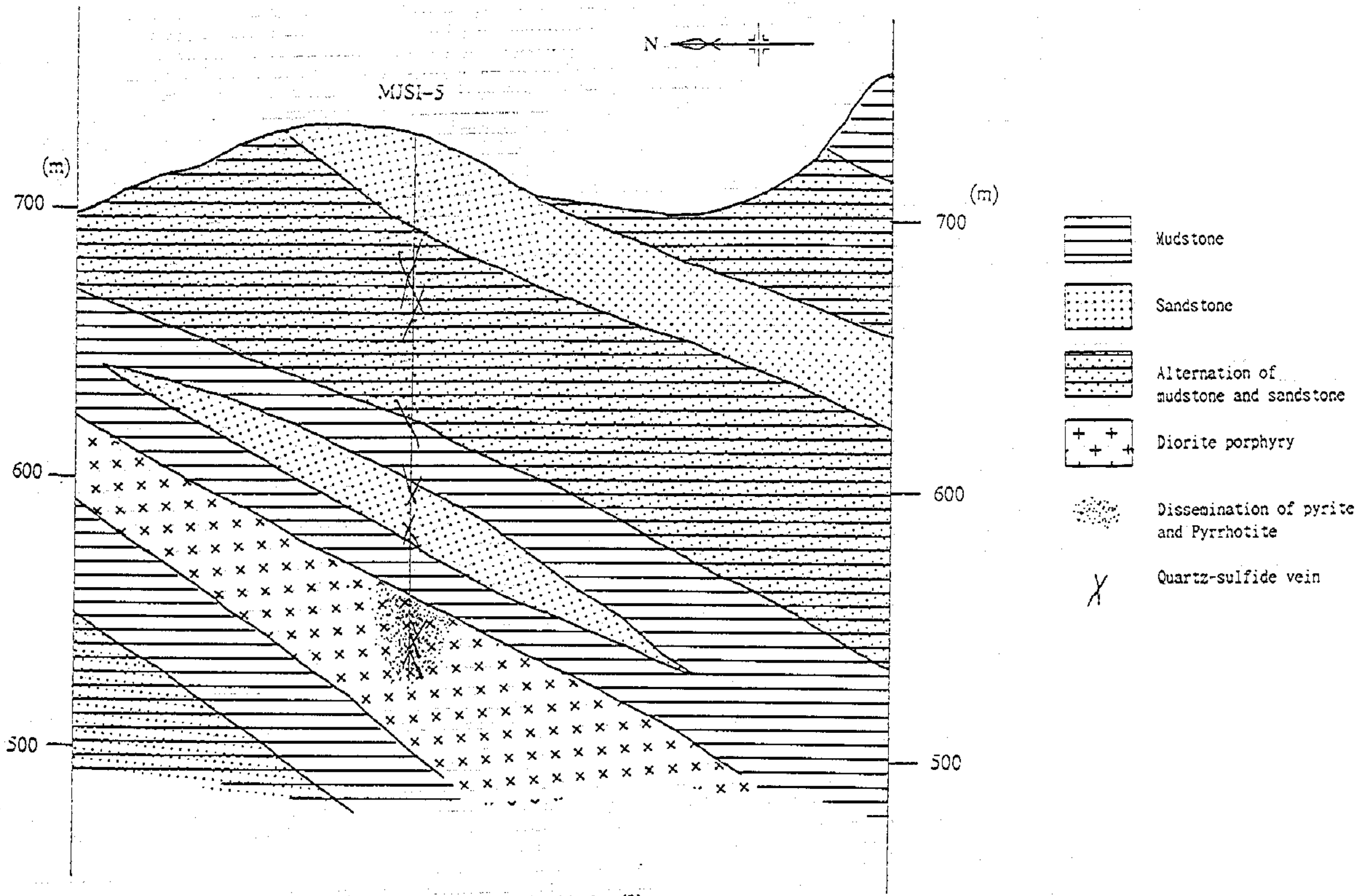


Fig. II -1-16 Cross sections of drill site (3)

Table Ⅱ-1-1 Description of thin section of S. Imbak Sub-area North

Sec. No.	Sample No.	Coordinates N	Coordinates E	Rock Name	Texture	Phenocryst. crystal. & Rock Fragment: Quartz	Plagioclase	Clinopyroxene	Hornblende	Biotite	Rock fragments	Others	Groundmass, matrix, Accessory Minerals: Quartz	Plagioclase	Apatite	Sphene	Zircon	Tourmaline	Opaque minerals	Others	Secondary Minerals: Quartz	Sericite	Calcite	Chlorite	Bioitte	Epidote	Kaolinite	Others	Remarks
1	J109	1451.18	4684.45	Diorite Porphyry	porphyritic intergranular	·	◎		○*	+				◎	·				+		·	○	○	◎					*only pseudomorph remains. altered diorite oirphyry
2	P103	1451.56	4682.05	Sandstone	clastic	◎	·						+					·	+		·	◎							fine sandstone (mudstone) abundant secondary sericite
3	P105	1451.48	4682.07	Sandstone	clastic	◎							+				·	·	+		·	○							fine sandstone with pyrite dissemination. sericitized
4	P118	1453.17	4683.10	Diorite Porphyry	porphyritic intergranular		·		◎					◎	·				+	·*	·	+	○	◎	·				*hornblende. altered fine diorite porphyry
5	P124	1453.48	4681.67	Diorite Porphyry	granoblastic										·				·		◎	◎	+						argillized diorite porphyry no igneous texture remains
6	P127	1453.53	4681.39	Diorite Porphyry	granoblastic										·				·		◎	○	+			·	·		argillized diorite porphyry
7	P129	1452.90	4681.23	Diorite Porphyry	porphyritic granoblastic		○		◎					◎	·				○	·*	·	+	○	○		·			*hornblende. slightly altered diorite porphyry
8	S125	1452.37	4681.56	Mudstone	clastic	◎	·						◎		·			·	·			◎		+	·				sericitized mudstone
9	S128	1451.31	4682.96	Sandstone	clastic	◎					+*		○				+	·	·		+	+							*mudstone>chert. fine sandstone with weak sericitization
10	S144	1452.40	4684.31	Diorite Porphyry	granoblastic									◎	·				·		○	○	◎	·				○*	*albite. strongly altered diorite porphyry
11	S145	1452.35	4684.91	Diorite Porphyry	porphyritic		◎		◎					◎	·				+		+	+	◎	◎					altered diorite porphyry
12	S147	1453.10	4682.14	Diorite Porphyry	granoblastic intergranular									◎	·				·		○	+	◎			·		○*	*albite. strongly altered diorite porphyry
13	S150	1453.79	4681.05	Diorite Porphyry	granoblastic										·				·		◎	◎	◎			·	·	+*	*albite. strongly altered diorite porphyry
14	S152	1452.18	4684.92	Diorite Porphyry	porphyritic. hypidiomorphic granular		◎	+	◎					◎	·				·	+*	·	+	+	·	○				*hornblend. clinopyroxene fresh diorite porphyry

◎: abundant ○: common +: a little ·: rare

Table Ⅱ-1-2 Description of polished sections of S. Imbak Sub-area North

Ser. No.	Sample No.	Coordinates N	Coordinates E	Descriptions	Chalcopyrite	Bornite	Chalcocite	Native gold	Sphalerite	Galena	Pyrite	Powder pyrite	Pyrrhotite	Marcasite	Arsenopyrite	Magnetite	Hematite	Geothite	Gang minerals	Remarks
					Ore minerals															
1	P107	1452.64	4682.56	Qz-Py-Sp-Ga-Cp vein in sandstone	○						+	○			+				+q	massive
2	P108	1452.60	4682.62	Qz-Py-Ap vein in sandstone							+				○				○q	
3	P112	1452.49	4682.98	Py vein in sandsone							◎									massive
4	P119	1453.13	4683.09	Sp-Py-Cp vein in mudstone					○	○				·	○					
5	P122	1452.80	4683.63	Py vein in mudsone					·		◎			+	·	·				sulphide vein
6	S123	1452.13	4682.10	Qz-sulfide vein in sandstone	+						○	+		·	+				◎q	quartz vein
7	S130	1451.55	4682.06	Py-Ap-Sp vein in sandstone	+						○	·			○				+	sulfide band
8	S131	1451.52	4682.07	Py-Qz vein in sandsone	·						◎				+				+q	massive
9	S137	1453.53	4682.53	Py-Sp vein in mudstone	·				+		◎			·					·	massive
10	S142	1452.86	4683.70	Py-Sp vein in mudstone	·				·	+	○	◎		·					·	massive
11	S146	1453.13	4683.09	Py-Sp dism./veinlet in sandstone					○	+		+		+	○				·	vein and Ap dism. in host rock
12	S148	1452.90	4682.12	Py-Ap-Sp vein in Dio. Porp.	·				+	+	◎	·	·	+	+					massive sulfide

◎: abundant ○: common +: a little ·: rare q : Quartz

Table Ⅱ-1-3 Results of X-ray diffraction analyses in S. Imbak Sub-area North

Ser. No.	Sample No.	Coordinates N	Coordinates E	Description	Se/Mo mixed layer	Kaolinite	Chlorite	Sericite	Montmorillonite	Quartz	Plagioclase	K-feldspar	Amphibole	Biotite	Epidote	Pyrite	Remarks
					Identified Minerals												
1	J106	1453.33	4683.15	argi. diorite porphyry with Py dism.		+		+		◎	+			·	·	·	
2	P127	1453.53	4681.39	argillized diorite porphyry		+				◎							
3	S126	1452.37	4681.56	mudstone with py. dism.				·		◎	+	·		·			
4	S127	1451.31	4682.96	silicified sandstone with Py dism.				·	·	◎						·	
5	S133	1451.50	4682.05	sheared mudstone with Py lenses				○		◎				·			
6	S144	1452.40	4684.31	argillized diorite porphyry			·	·		◎	◎						
7	S147	1453.10	4682.14	argi. diorite porphyry with Py dism.				·		◎	◎						
8	S150	1453.79	4681.05	argillized diorite porphyry		+		+		◎	·						

◎: abundant ○: common +: a little ·: rare

Table Ⅱ-1-4 Assay results of S. Imbak Sub-area North

Ser. No.	Sample No.	Coordinates		Descriptions	Assay results							Remarks and sampling width (m)
		N	E		Au (g/t)	Ag (g/t)	Cu (ppm)	Pb ppm)	Zn (ppm)	Mo (ppm)	S (%)	
1	J106	1453.33	4683.15	argil. diorite porphyry with Py. dism.	<0.1	0.9	89	610	163	3	0.74	grab sample
2	J112	1451.26	4684.84	argil. diorite porphyry with Py. dism.	<0.1	0.9	90	71	88	<1	0.69	grab sample
3	P107	1452.64	4682.56	Qz-sulf. vein 1 cm wide and sandstone	0.7	46.3	7464	80	101	<1	7.26	w.0.10
4	P108	1452.60	4682.62	Qz-Py-Ap vein in sandstone, 1.0cm wide	3.8	2.8	183	104	70	1	3.64	grab sample
5	P119	1453.13	4683.09	Ga-Sp-Cp vein mudstone, 1.0 cm wide	0.3	182.6	425	122444	76343	3	9.92	grab sample
6	P122	1452.63	4683.63	Py-rich vein in mudstone, 3.0 cm wide	0.5	32.4	634	4404	909	<1	24.01	grab sample
7	P125	1453.30	4681.65	Py dism. and film in mudstone	<0.1	0.8	26	55	69	2	6.45	w.0.30
8	P128	1453.15	4681.41	Py dism. mudstone	0.2	1.8	23	47	41	<1	5.07	grab sample
9	S123	1452.13	4682.10	Qz-sulfide vein in sandstone, 5cm wide	0.2	29.5	2042	124	194	3	6.15	grab sample
10	S124	1451.96	4682.06	Qz-Lim vein in sandstone, 4 cm wide	1.0	27.7	260	335	323	22	0.53	grab sample
11	S129	1451.55	4682.06	Py-Ap-Sp vein 4 cm wide and sandstone	2.6	52.8	1897	506	667	<1	12.30	w.0.10
12	S131	1451.52	4682.07	Py-Qz vein 7 cm wide in sandstone	2.5	51.3	825	583	703	<1	13.27	w.0.07
13	S134	1451.50	4682.05	Py dism./lens in sheared mudstone	<0.1	3.1	66	67	28	<1	3.59	w.0.15
14	S135	1453.53	4682.53	Py-Sp vein 1.5 cm wide and mudstone	3.5	64.2	356	1251	7701	2	21.60	grab sample
15	S139	1452.86	4683.70	Py-Sp vein 4 cm wide and mudstone	0.1	47.3	405	31490	16683	1	13.66	w.0.20
16	S140	1452.86	4683.70	Py-Sp-Ga vein 4 cm wide and mudstone	<0.1	28.3	258	18908	8744	<1	8.02	w.0.20
17	S141	1452.86	4683.70	Py-Sp-Ga vein 4 cm wide in mudstone	0.3	156.0	957	103213	20213	<1	30.10	w.0.04
18	S146	1453.13	4683.09	Py-Sp dism./veinlet in sandstone	<0.1	21.7	177	9606	10783	3	3.88	w.0.20
19	S148	1452.90	4682.12	Py-Ga-Sp vein 2 cm wide in dio. poph.	2.0	148.2	612	52233	42773	<1	33.23	grab sample
20	S149	1452.83	4682.12	fault clay with Py dism. 15 cm wide	<0.1	3.9	154	395	350	3	2.95	w.0.15

Table II-1-5 Fluid inclusion filling temperature in S. Imbak Sub-area North

Ser. No.	Sample No.	Coordinates		Descriptions	Number of measurement	Temperature range (° C)	Average Temperature (° C)	Remark
		N	E					
1	P108	1452.60	4682.62	Qz-Py-Ap vein. 1.0cm wide in sandstone	34	346 to 393	379.7	
2	S122	1452.13	4682.10	Qz-Ap-Cp vein. 5.0cm wide in sandstone	30	302 to 370	337.3	
3	S132	1451.52	4682.07	Qz-Py-Ap vein. 7.0cm wide in sandstone	31	340 to 404	369.5	
4	S136	1453.53	4682.53	Py-Sp-Qz vein. 1.5cm wide in sandstone	20	153 to 367	318.1	includes secondary inclusion

Table II-1-6 Occurrences of mineralization in 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-6	Quartz - sulfides (pyrite, arseno-pyrite) 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	1897 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	52233 395	42773 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	122444 9606	76343 10783
IM-9	Sulfides (pyrite, galena and sphalerite) veins, max. 4cm wide within the sheared zone in mud-stone, 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	31490 18908 103213	16683 8744 20213

Table II-1-6 Occurrences of mineralization in 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-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	1251	7701

Table Ⅱ-1-7 Survey specification of geophysical survey

Item	Specification
Method	Induced Polarization
Measureing	Time Domain
Configuration	Dipole-Dipole array
n-spread	n=1 to 4
Survey lines	11 lines
Total amount	19.7 line-km
Line spacing	300 m
Samples for IP survey	21 pcs

Table Ⅱ-1-8 Survey equipments of geophysical survey

Equipment	Model	Specification	Quantity
IP transmitter (Scintrex)	TSQ-3	2.0 A, 1500 V	1
Engine generator (Briggs & Stratton)		5 HP	1
IP receiver (Scintrex)	IPR-12	8ch,14 windows Input range: 50 uV to 14 V	2

Table II-1-9 Resistivity and chargeability of rock samples

	Sample No.	Sampling Depth(m)	Resis. (Ω·m)	Charge. (mV/V)	Rock Name	Alt./Mineral.	Remarks
Core samples	GP-1-1	59.55	163	24	Ms	Po-diss.	
	GP-1-2	92.20	186	10	Ms		
	GP-1-3	123.25	2850	12	Ss		
	GP-1-4	147.90	120	67	Ms	few mm wide Py-Cp vein.	
	GP-2-1	44.00	14600	6.2	Dp		relatively fresh, fine
	GP-2-2	47.00	997	7.5	Dp	sili. and chlori.	
	GP-2-3	142.55	978	27	Ss	weak Po-diss.	
	GP-2-4	152.60	288	3.3	Ms		
	GP-3-1	49.50	91.1	54	Ms	chlori.	
	GP-3-2	69.65	360	121	Ss	few mm wide Py-Cp vein.	
	GP-3-3	154.70	257	6.9	Ms		
	GP-3-4	170.50	71.1	29	Ms	fracture filling Pyrite	slightly coarse
	GP-4-1	30.70	651	2.4	Ss		
	GP-4-2	59.25	89.2	22	Ms		
	GP-4-3	74.10	368	183	Dp	Py-diss.	relatively fresh
	GP-4-4	99.35	106	97	Dp	sili. and argilli.	
	GP-4-5	160.25	1010	68	Ss	fracture filling Pyrite	
	GP-5-1	103.20	543	187	Ss	weak Py-diss.	
	GP-5-2	159.55	252	39	Ms	Po nodule	
	GP-5-3	181.80	1060	180	Dp	sili.	
	GP-5-4	193.60	12200	16	Dp		relatively fresh
Rock samples	I-1		90.7	31.9	Ms	Py-diss.	
	I-2		4040	4.7	Dp		
	I-3		10	49	Qv	Qtz,Py,Sulf.	
	I-4		2950	10.5	Dp		
	I-5		592	6.9	Dp		
	I-6		389	6.6	Dp	argilli.	
	I-7		3	124.2	Sulf.V.	Py,Sulf.	
	I-8		1670	11.1	Ss		
	I-9		38.1	1.7	Ms		many crack
	I-10		192	2.9	Ms		
	I-11		120	3.1	Ms		
	I-12		218	4.5	Ss	weak sili.	
	I-13		58.7	3.8	Ms	weak sili.	many crack
	I-14		1280	6.1	Ss	sili., Py-diss.	
	I-15		32.5	7.6	Ss	sili., sullf.spot	

MS : Mudstone
Ss : Sandstone
Qtz : Quartz
chlori. : chloritization
sili. :silicification
Resis. : Resistivity

Dp : Diorite Porphyry
Py : Pyrite
Po : Pyrrhotite
sulf. : sulfidation
Alt. : Alteration
Charge. : Chargeability

Qv : Quartz vein
Cp : Chalcopyrite
diss. : dissemination
argilli. : argilliaztion
Mineral. : Mineralization

Table II-1-10 Specification of drill holes

Hole No.	Coordinates		Elevation	Bearing	Inclination	Depth
	N	E				
MJSI-1	1453.37	4682.75	697 m	-	-90°	201.25 m
MJSI-2	1453.16	4682.77	758 m	-	-90°	200.30 m
MJSI-3	1453.04	4682.46	708 m	-	-90°	200.84 m
MJSI-4	1452.80	4682.45	763 m	-	-90°	202.20 m
MJSI-5	1452.68	4682.20	727 m	-	-90°	200.20 m

Table II-1-11 Description of thin section of drilling core

Sec. No.	Hole No.	Depth (m)	Sample No.	Rock Name	Texture	Phenocryst, crystal & Rock Fragment							Groundmass, matrix, Accessory Minerals								Secondary Minerals								Remarks
						Quartz	Plagioclase	Clinopyroxene	Hornblende	Biotite	Rock fragments	Others	Quartz	Plagioclase	Apatite	Sphene	Zircon	Tourmaline	Opaque minerals	Others	Quartz	Sericite	Calcite	Chlorite	Bioitte	Epidote	Kaolinite	Others	
1	MJSI-1	37.65	T-1-1	Mudstone	clastic	◎	+						◎				·	·	+			◎		·					sericitized mudstone
2	MJSI-2	43.50	T-2-1	Diorite porphyry	porphyritic, hypid-iomorphic granular		+		◎					◎	·				+		+		◎	◎	·				carbonated diorite porphyry
3	MJSI-2	47.20	T-2-2	Diorite Porphyry	porphyritic, hypid-iomorphic granular		+		◎					◎	·				+		○	○	◎	+					carbonated, sericitized diorite porphyry
4	MJSI-3	49.95	T-3-1	Mudstone	clastic	◎	·						◎						·		+	○		+		+			relatively fresh mudstone
5	MJSI-3	91.15	T-3-2	Sandstone	clastic	◎	·						◎				·	·	+			◎	○	·		·			well sorted fine sandstone carbonated, sericitized
6	MJSI-4	62.00	T-4-1	Mudstone	clastic	○							◎					·	○		+	◎	+	+					sericitized mudstone
7	MJSI-4	63.50	T-4-2	Diorite Porphyry	porphyritic granoblastic		◎		◎	+				○	·	·			·		+		○	○					altered diorite porphyry
8	MJSI-4	86.90	T-4-3	Diorite Porphyry	porphyritic granoblastic		◎ *		○ *	+					·				+		◎	◎	·	+		·		+ ·	*only speudomorph remains, **albite, ***siderite
9	MJSI-5	109.50	T-5-1	Mudstone	clastic	◎	·						◎				·	·	+			○		+					relatively fresh mudstone
10	MJSI-5	172.50	T-5-2	Diorite Porphyry	porphyritic granoblastic		◎		○	+				+	·		·		·		○	◎	+	○		·		+ *	*K-feldspar, strongly altered diorite porphyry
11	MJSI-5	191.50	T-5-3	Diorite porphyry	porphyritic granoblastic		◎		◎	+				◎	·	·			+	· *		+	+	+		·			*hornblende, biotite

◎: abundant ○: common +: a little ·: rare

Table II-1-12 Description of polished sections of drilling core

Ser. No.	Sample No.	Bore hole No. and depth: No.	Bore hole No. and depth: Depth(m)	Descriptions	Ore minerals: Chalcopyrite	Bornite	Chalcocite	Native gold	Sphalerite	Galena	Pyrite	Powder pyrite	Pyrrhotite	Marcasite	Arsenopyrite	Magnetite	Hematite	Geothite	Gang minerals	Remarks
1	P-1-1	MJSI-1	37.10	Po patch in sandstone	·				·		○	◎	·	+	○				+	sulfide band
2	P-1-2	MJSI-1	150.10	Cp-Py patch in mudstone	·				+	+	◎	+		+					·	massive
3	P-2-1	MJSI-2	26.10	Po-Cp-Py vein in Dio. Porp.	·				·	·			·	·	○				◎	dissaminated
4	P-3-1	MJSI-3	67.75	Po-Cp patch in mudstone	·						○	○		○						massive
5	P-3-2	MJSI-3	153.45	Py-Po-Cp vein in mudstone	·							◎		+	+				○	
6	P-4-1	MJSI-4	56.60	Qz-Ap-Cp-Sp veinlet in mudstone	·						·		○	+					○°	
7	P-4-2	MJSI-4	89.40	Sp-Cp network in Dio. Porp.	·				·		◎								+	sulfide band
8	P-4-3	MJSI-4	90.65	Qz-Ap-Sp vein in Dio. Porp.	·				·		○	◎	·	+	·					massive
9	P-4-4	MJSI-4	92.45	Qz-Py-Ap-Cp vein Dio. Porp.					·	·	+	+	◎	+					+°	massive
10	P-5-1	MJSI-5	55.60	Qz-Py-Cp-Sp in sandstone	·				·		◎		·	+	+				○°	sulfide band
11	P-5-2	MJSI-5	70.80	Py-Ap-Cp vein in sandstone	·				·	·	·	◎		+	+				+	massive
12	P-5-3	MJSI-5	84.00	Qz-Cp-Py vein in sandstone	·							◎	·	·	·				+°	
13	P-5-4	MJSI-5	123.90	Ap-Cp vein in mudstone	+			·			+		·		◎					three native gold grains in Ap
14	P-5-5	MJSI-5	150.00	Qz-Po-Cp vein sandstone	·						+	·	○	·					◎°	

◎: abundant ○: common +: a little ·: rare °: Quartz

Table II-1-13 Results of X-ray diffraction analyses of drilling core

Ser. No.	Hole No.	Sample No.	Depth	Description	Identified Minerals: Sc/Mo mixed layer	Kaolinite	Chlorite	Sericite	Montmorillonite	Quartz	Plagioclase	K-feldspar	Amphibole	Biotite	Epidote	Pyrite	Remarks
1	MJSI-1	X-1-1	57.65	mudstone			○	○		◎	○						
2	MJSI-2	X-2-1	8.50	argillized diorite porphyry			○	○		◎	○				○		○chl/mont mix. layer
3	MJSI-2	X-2-2	59.70	mudstone			○	○		◎	○		·				
4	MJSI-3	X-3-1	49.95	chloritized mudstone			○	○		◎	○			·			
5	MJSI-4	X-4-1	59.50	mudstone, close to diorite porphyry				○		◎			○				
6	MJSI-4	X-4-2	84.00	argillized diorite porphyry				○		◎			○			○	· hematite
7	MJSI-4	X-4-3	86.90	altered diorite porphyry				○		◎			○		·	·	· calcite
8	MJSI-5	X-5-1	55.60	Qz-Py-Cp-Sp vein 2cm wide, in sandstone	·			·		◎				·	○	○	
9	MJSI-5	X-5-2	76.10	chloritized sandstone				○		◎	·			·			· magnetite
10	MJSI-5	X-5-3	33.20	Qz-Ca-Barite vein 2cm wide				·		◎		·					◎siderite
11	MJSI-5	X-5-4	172.50	chloritized diorite porphyry			○	○		◎		○	○	·	·		
12	MJSI-5	X-5-5	183.50	Qz-Ca-Barite vein			○	○		◎	·		○	·	○		◎calcite · magnetite

◎: abundant ○: common · : rare

Table II-1-14 Assay results of drilling core (1)

Ser. No.	Hole No.	Sample No.	Samplingm)			Descriptions	Assay results						
			From	To	Length		Au (g/t)	Ag (g/t)	Cu (ppm)	Pb ppm)	Zn (ppm)	Mo (ppm)	S (%)
1	MJSI-1	A-1-1	26.55	26.95	0.40	Qz-Py-Cp vein 1 cm wide in mudstone	<0.1	2.9	184	117	177	1	3.54
2	MJSI-1	A-1-2	56.95	57.30	0.35	mudstone with Po dism. and film	<0.1	1.0	105	51	78	2	2.00
3	MJSI-1	A-1-3	139.55	139.70	0.25	mudstone with Py-Cp patches	<0.1	2.4	267	52	1593	<1	9.47
4	MJSI-1	A-1-4	150.00	150.15	0.15	mudstone with Py-Cp patches	<0.1	2.2	235	127	2407	<1	10.73
5	MJSI-2	A-2-1	7.55	8.55	1.00	argillized diorite porphyry	<0.1	4.8	330	331	933	2	5.62
6	MJSI-2	A-2-2	25.60	26.25	0.65	dio. poph. with Po-Cp-Py vein. W. 3cm	<0.1	25.2	662	1355	5152	<1	10.99
7	MJSI-2	A-2-3	27.50	27.60	0.10	dio. poph. with Po-Cp-Py-Ap vein 2cm	<0.1	3.8	498	195	876	2	9.19
8	MJSI-2	A-2-4	34.45	34.80	0.35	dio. poph. with Py-Po-Cp-Ap vein 2.5cm	0.3	9.6	822	233	3187	<1	14.34
9	MJSI-2	A-2-5	40.65	41.55	0.90	dio. poph. with Py-Po-Sp-Cp films	<0.1	2.6	171	61	1799	3	2.57
10	MJSI-2	A-2-6	44.85	45.05	0.20	dio. poph. with Po dism. and veinlet	<0.1	4.7	299	213	17183	4	4.73
11	MJSI-2	A-2-7	54.30	55.20	0.90	mudstone with Qz-Po-Cp-Py veinlets	<0.1	2.7	96	109	1299	3	2.15
12	MJSI-2	A-2-8	130.10	130.70	0.60	mudstone with Po-Py-Cp veinlet, patch	<0.1	1.0	64	61	332	3	1.57
13	MJSI-3	A-3-1	17.40	18.10	0.70	sandstone with Qz-Py veinlets W. few mm	<0.1	4.6	106	300	691	3	2.76
14	MJSI-3	A-3-2	50.10	50.50	0.40	mudstone with Py-Cp veinlet W. ±1mm	<0.1	0.6	32	20	79	2	2.73
15	MJSI-3	A-3-3	67.60	68.35	0.75	mudstone with Qz-Po-Cp veins, patches	<0.1	15.8	841	780	84	<1	15.97
16	MJSI-3	A-3-4	68.35	68.80	0.45	sandstone with Py-Cp veinlets	<0.1	1.1	87	54	306	2	3.06
17	MJSI-3	A-3-5	153.30	150.90	0.60	mudstone with Py-Cp veinlets	<0.1	0.8	71	38	105	3	2.18
18	MJSI-3	A-3-6	168.15	168.70	0.55	mudstone with Py-Cp veinlets	<0.1	11.8	449	1406	4372	<1	6.94
19	MJSI-3	A-3-7	169.20	169.70	0.50	mudstone with Py-Cp veinlets	<0.1	8.4	280	1568	1483	3	7.00
20	MJSI-4	A-4-1	31.25	31.35	0.10	mudstone with Qz-Sp-Py-Cp vein, W. 1cm	0.3	9.9	414	269	11627	<1	7.20

Table II-1-14 Assay results of drilling core (2)

Ser. No.	Hole No.	Sample No.	Sampling(m)			Descriptions	Assay results						
			From	To	Length		Au (g/t)	Ag (g/t)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	S (%)
21	MJSI-4	A-4-2	56.30	56.70	0.40	Qz-Ap-Cp-Sp veinlets in mudstone	<0.1	26.2	481	875	4804	2	6.79
22	MJSI-4	A-4-3	61.50	61.65	0.15	QZ-Ap-Sp-Cp vein. W.1.5cm and mudstone	<0.1	1.3	50	351	756	2	2.11
23	MJSI-4	A-4-4	66.40	67.40	1.00	dio.poph. with Sp-Cp veinlets	<0.1	4.7	291	352	1476	<1	3.92
24	MJSI-4	A-4-5	75.85	76.80	0.95	dio.poph. with Sp-Cp veins	<0.1	43.2	928	17218	22001	1	10.17
25	MJSI-4	A-4-6	79.00	80.00	1.00	argillized diorite porphyry	<0.1	3.2	187	1416	2202	2	6.00
26	MJSI-4	A-4-7	83.60	84.10	0.50	argillized diorite porphyry	<0.1	4.3	218	1084	2103	<1	7.46
27	MJSI-4	A-4-8	87.00	88.00	1.00	diorite porphyry with Sp-Cp veinlets	0.5	37.2	1375	1183	4276	<1	11.86
28	MJSI-4	A-4-9	88.00	89.00	1.00	diorite porphyry with Sp-Cp veinlets	0.2	39.2	1191	1187	4684	<1	11.58
29	MJSI-4	A-4-10	89.00	90.00	1.00	diorite porphyry with Sp-Cp veinlets	0.1	90.5	1216	7963	9112	3	9.85
30	MJSI-4	A-4-11	90.00	90.80	0.80	dio.poph. Qz-Ap-Sp vein/patches	0.8	5.5	985	116	3842	3	14.21
31	MJSI-4	A-4-12	92.00	93.00	1.00	Qz-Ap-Py veins and patche in dio.poph.	0.4	5.9	806	106	453	<1	19.35
32	MJSI-4	A-4-13	93.00	94.00	1.00	diorite porphyry with Sp-Cp veins	0.2	9.0	1108	269	10925	4	8.45
33	MJSI-4	A-4-14	94.00	95.00	1.00	diorite porphyry with Sp-Cp veins	0.3	9.3	813	265	10413	<1	9.28
34	MJSI-4	A-4-15	124.30	124.70	0.40	mudstone with Py films	<0.1	10.6	205	293	377	3	4.97
35	MJSI-4	A-4-16	160.45	160.65	0.20	sandstone with Py-Po-Cp vein. W.1.5cm	1.3	3.3	704	54	123	<1	7.18
36	MJSI-5	A-5-1	54.80	55.80	1.00	sandstone with QZ-Py-Cp-Sp vein/patch	0.3	0.5	93	28	75	<1	3.57
37	MJSI-5	A-5-2	75.60	76.15	0.55	sandstone with Py-Cp dism. and film	<0.1	8.1	638	209	436	3	7.32
38	MJSI-5	A-5-3	83.75	84.30	0.55	sandstone with Qz-Cp-Py vein. W.1.5cm	0.1	4.7	803	160	53	2	8.74
39	MJSI-5	A-5-4	103.60	103.65	0.05	Py-Cp-Ap-Qz vein. W.2.5cm in sandstone	5.7	13.8	3223	113	100	<1	19.26
40	MJSI-5	A-5-5	123.40	124.00	0.60	sandstone with Qz-Ap-Cp-Po vein. W.2cm	12.3	6.9	1713	19	61	<1	5.42

Table Ⅱ-1-14 Assay results of drilling core (3)

Ser. No.	Hole No.	Sample No.	Samplingm)			Descriptions	Assay results						
			From	To	Length		Au (g/t)	Ag (g/t)	Cu (ppm)	Pb ppm)	Zn (ppm)	Mo (ppm)	S (%)
41	MJSI-5	A-5-6	149.85	150.10	0.25	sandstone with Po-Cp-Qz vein, W.4cm	0.2	6.8	784	82	35	<1	6.57
42	MJSI-5	A-5-7	175.10	175.80	0.70	dio.poph. with Po dism. and veinlet	<0.1	4.1	354	105	175	3	3.64
43	MJSI-5	A-5-8	180.00	180.60	0.60	dio.poph. with Qz-Ba-Po-Cp vein/patch	<0.1	3.7	637	95	79	3	5.91
44	MJSI-5	A-5-9	185.10	185.70	0.60	dio.poph. with Po-Cp dism./veinlet	<0.1	0.9	296	36	93	<1	2.62
45	MJSI-5	A-5-10	192.00	193.00	1.00	dio.poph. with Po-Cp dism.	<0.1	0.9	225	37	69	<1	2.23
46	MJSI-5	A-5-11	195.00	195.80	0.80	dio.poph. with Po-Cp dism. and film	0.2	0.4	329	35	58	<1	3.43
47	MJSI-5	A-5-12	196.25	196.85	0.60	dio.poph. with Qz-Po-Cp-Py, W.1cm	0.4	4.7	1417	33	85	3	6.84

Chapter 2 S. Imbak Sub-area South

2-1 Introduction

2-1-1 Survey area

Based on the results of the soil geochemical survey of the Phase I, the survey area of S. Imbak Sub-area South for the Phase II survey was established excluding south part of the Phase I area for 3 km. It has a irregular square shape covering 45.5 km^2(NS 7 km × EW 7 km).

The S. Imbak Sub-area South is located immediate south of the S. Imbak Sub-area North separated by a steep ridge of more than 1,000 m high and no previous detail geological work has been done in the area. The area belongs to drainage system of Sungai Kuli, which is a tributary of Sungai Kuamut. The drainage system of the area is separated by the ridge running in NNW-SSE direction in the center of the area. In the area west of the ridge, streams flow to the southwest, while in the area east of the ridge streams flow to the east. Because of a steep topography, these streams form many water falls in the area close to the ridge.

The topography of the area, consisting of the ridge running in the middle of the area trending in NNW-SSE direction and slopes of both sides of the ridge, is very steep and rugged. The altitude of the ridge is more or less 1,000 m and the maximum elevation reaches to approximately 1,500 m in the north part of the area. The Gunong kuli is located on this ridge in southeast part of the area.

The entire area is covered by primary jungle and there is no trace of human activity in the area. The access to the area is very poor, only a few trails being found in the area. The geological survey was conducted by fly camp and it takes three days to reach the northwest corner of the area.

2-1-2 Background

The S. Imbak Sub-area South, which lacks detail geological information, has been considered to be an area of monotonous Tertiary sedimentary rocks. The soil geochemical survey conducted in Area T, in which S. Imbak Sub-area North is located, during the Supra-regional survey resulted in the finding of Au-Ag mineralization at the south end of the area. It was concluded that the mineralization was continued further south. Based on the results of soil geochemical survey of Area T, the soil geochemical survey of the S. Imbak Sub-area South (NS 10 km × EW 7 km, 70 km^2) was conducted in Phase I to pursue the extension of the mineralization further south and following results were obtained.

Numerous intrusive bodies of diorite porphyry were found along both slopes of the ridge that runs in the center of the area. Dating shows their age of intrusion to be late Miocene to early

Pliocene. The silicification/pyrite dissemination zones occur in the sedimentary rock along the slopes of the ridge, closely associated with intrusion of diorite porphyry. The intensive silicification/pyrite dissemination zones occur in the northwestern part of the area and the central part of the area. The one in the central part of the area shows a chalcopyrite dissemination in the diorite porphyry, in addition to pyrite dissemination of the sedimentary rocks. The polished section of this shows a small grain of native gold surrounded by chalcopyrite. Geochemical survey shows distributions of overlapping Au, Cu, Hg, S anomalies and high value zones over the areas of silicification /pyrite dissemination zones in northwest and center parts of the area. These areas are also covered by high factor score zone of Factor 2 (Au, Cu, Sb, W) and Factor 6 (As, Au, Hg, S). These two zones of above were considered to have high potentiality for the mineralization. The mineralization that occurs in the S. Imbak Sub-area North seem to be continued over the ridge of Gunong Kuli to S. Imbak Sub-area South.

Based on the above results, the S. Imbak Sub-area South of the Phase II was established including the above mentioned two zones of silicification/pyrite dissemination and semi-detail geological survey was conducted.

2-1-3 Survey amount

For purposes of investigating and evaluating the geochemical anomalies of the Phase I survey and pursuing the mineralization zone that found in the S. Imbak Sub-area North to further south, geological survey (semi-detail) was conducted in the S. Imbak Sub-area South (45.5 km^2). The survey consists of a semi-detail geological survey of 77 km long traverse and, in addition to this, 300 rock samples were collected during the geological survey to investigate the geochemical halo related to the mineralization.

2-2 Geological survey

A semi-detail geological survey was conducted in the S. Imbak Sub-area South.

2-2-1 Survey method

1. Geological survey

A geological survey (semi-detail) was conducted along drainage system using 1 : 5,000 scale map produced from an enlargement of 1 : 50,000 topographic sheet. Other than streams, wherever outcrop is expected, ridges and slopes of mountains 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 the fluid inclusion was conducted from the quartz of quartz–sulfide veins.

2. Rock geochemical survey

A total of 300 rock samples were collected during the geological survey for geochemical investigation. At each outcrop, the sample representing the whole outcrop was taken and description was done on sample sheet. After crushing and splitting they were sent for chemical analysis for 15 elements (Ag, As, Au, Ca, Cu, Hg, K, Na, Mg, Pb, Rb, S, Sb, Sr, Zn).

The analytical results of the geochemical samples were input in computer and statistical data treatment, single element and multi–elements analyses were conducted. For the single element analyses, statistic figures such as maximum, minimum, mean values and standard deviation for each element were calculated. A half value of the detection limit was used for the sample with value less than the detection limit. The mean values calculated are geometric means. The correlation matrix among the elements were, also, calculated.

The drainage system of the survey area was input in the computer using digitizer and distribution maps of each element were prepared. Exploratory Data Analysis (EDA) method of Kurzl (1988) was applied to obtain the threshold value (anomalous value) for each element.

As the multi element analyses, factor analysis was applied in this survey. The factor analysis is a method to delineate the factor (group of elements) controlling the chemical character of a group of the samples.

For understanding the chemical halos related to the mineralization of a whole area of the S. Imbak Sub–area, data analysis and interpretation were conducted for a total of 501 samples including the 201 samples collected in the S. Imbak Sub–area North during the Phase I survey.

Among the 300 rock samples of geochemical survey, 55 samples were selected for X–ray diffraction analysis for investigation the alteration halos related to the mineralization.

2–2–2 Geology

The S. Imbak Sub–area South is overlain by the Tanjong Formation (NT_3j) 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. Geological map together with cross sections are given in Plate II–2–1 and Fig. II–2–1 and schematic lithological succession is shown Fig. II–2–2. The sample location of laboratory studies and location of mineralization are given in Fig. II–2–3. The results of laboratory studies are given on Table II–2–1 (thin section), Table II–2–2 (polished section), Table II–2–3 (X–ray diffraction analysis) and Table II–2–4 (ore assaying). The description of mineral showings and results of filling temperature of the fluid inclusion are given in Table II–2–5, Table II–2–6 and Appendix 1.

The area is entirely overlain by the Tanjong Formation and it is divided into three formations. They are, from bottom to top, lower mudstone formation, sandstone formation and upper mudstone formation. All the sedimentary rocks, consistently, dip toward SW direction, consequently, the lower formation is distributed to the east and upper formation is distributed to the west. The mudstone occur on the both side of the ridge, in the areas of relatively lower altitude, while sandstone occur in the area of higher altitude, being distributed along the ridge. The small intrusive bodies of the diorite porphyry are distributed on both sides of the slop close to the ridge.

The lower mudstone formation is distributed on the east facing slop of the ridge at the elevation lower than 900 m in the east part of the area. Dark gray to black, slightly soft mudstone occupies the area from north to south along the east edge of the area. Sandstone layers of few cm to few 10s cm thick are intercalated in the area near the sandstone formation. The amount of the sandstone increase toward boundary, then mudstone formation gradually change to the sandstone formation. The mudstone close to the diorite porphyry is, generally, silicified and pyrite disseminated. Pyrite nodules of few cm across, rarely, occur in the mudstone.

The sandstone formation occupies the area along the ridge in the center of the area and it form steep topography. It predominantly consists of gray to dark gray, fine to medium grained, massive sandstone. The sandstone found at the higher elevation near the ridge is bleached and shows pale gray color, while, the one near the intrusion of the diorite porphyry is silicified and hard rock with pyrite dissemination. The silicified sandstone is typically observed on the western slop of the ridge in northwest and center parts of the area. In central north part of the area, lenses of conglomerate with thickness of few 10s m are intercalated in the sandstone. The conglomerate consists of granule to pebble size sandstone and mudstone. The sandstone occasionally intercalate thin mudstone beds.

The sandstone formation is overlain by the upper mudstone formation, being distributed in southwest part of the area. The upper mudstone layer predominantly consists of mudstone of the same lithological facies as that of the lower mudstone layer with rare intercalation of sandstone beds.

The mudstone in thin section shows that it consists of mainly quartz grains of 0.02mm to 0.03 mm across with occasional association of plagioclase fragments. The matrix is filled by fine quartz and accessary minerals such as zircon and tourmaline. Sericite is most common alteration mineral occur covering detrital grains. Kaolinite and calcite, also, occur as alteration minerals. The sample, taken at the location close to the diorite porphyry, shows a small amount of biotite in sericite network. The sandstone is well sorted, 0.1 mm to 0.3 mm grain size, arkose sandstone consisting of mainly of quartz with subordinate plagioclase, K–feldspar, rock fragments (mudstone, sandstone, tuff, chert). When alteration increases, network of sericite occurs with secondary quartz. Other alteration minerals are chlorite, kaolinite and calcite. The conglomerate is composed of mudstone and chert of pebble size with quartz matrix.

The strike and dip of the Tanjong Formation in the S. Imbak Sub-area South is consistent over the entire area. It shows a monoclinic stricture, striking N-S to WNW-ESE(45° to 70° W) and dipping at 20° to 40° SW. Regardless of the formations, the strikes tend to gradually change following the trend of the ridge. In the south and east part of the area, the sedimentary rocks strike in N-S to NNW-SSE (0° to 30° W), then, they gradually change toward west direction and NW-SW (40° to 60° W) is predominant strike in northwest part of the area. The sedimentary rocks dip consistently 20° to 40° to southwest.

The diorite porphyry is a gray porphyritic rock with plagioclase and hornblende phenocrysts of a few mm across. Numerous small intrusions with widths ranging from few m to 100 m occur along the slops of both side of the ridge and they are concordant to sub-concordant to the sedimentary rocks. The diorite porphyry of small body is dark fine grained rock with fine hornblende phenocryst and it shows similar appearance to andesite. Because of the different degree of alteration observed in the diorite porphyry, the appearance of it varies from gray color rock with clear porphyritic texture to a totally argillized, white color rock consisting of quartz and sericite. There is no clear indication of thermal metamorphism to the sedimentary rocks at the vicinity of the intrusion. The diorite porphyry of the central south of the area is disseminated by pyrite and chalcopyrite. The K-Ar dating, done in Phase I, suggests that intrusion of the diorite porphyry took place in late Miocene to early Pliocene (7.27±0.18 Ma to 10.5±0.27 Ma).

Microscopic observation of the less altered rock shows clear porphyritic texture with plagioclase and hornblende phenocrysts. In addition to them, biotite and clinopyroxene phenocrysts occasionally appear. The groundmass consists of plagioclase and opaque minerals and its texture varies from intergranular texture similar to that of andesite to hypidiomorphic granular texture. The altered rock is totally replaced by alteration minerals such as quartz, sericite, calcite, chlorite and the original texture is completely extinguished. The x-ray diffraction shows alteration minerals of quartz, sericite, chlorite, (kaolinite), (sericite/montmorillonite mixed layer). The fine diorite porphyry similar to andesite seem to be more mafic with predominant hornblende phenocryst compared with other one with predominant plagioclase phenocryst with biotite. The mineralization and alteration seem to occur more intensively to the latter one.

2-2-3 Mineralization

The main mineralization and alteration of the area occur within the area of silicification/pyrite dissemination zones located in the central north of the area(SA), on west slop of the ridge in the center of the area(SB) and east slop of the ridge in the east of the area (SC). The association of many small intrusions of the diorite porphyry in these areas suggests that the mineralization in the area is closely related to intrusion of the diorite porphyry. In these zones, silicification, rarely argillization, and pyrite dissemination with thin pyrite veinlet along fracture occur to the sandstone and mudstone of the Tanjong Formation. Furthermore, quartz-sulfides veins and lenses occur cutting the sedimentary structure.

Three main zones of silicification/pyrite dissemination and mineral showings within them are summarized below and Table II-2-5. Fig. II-2-4 shows sketches of main mineral showings.

1. Mineralization zone of northwest part of the area (SA)

The silicification/pyrite dissemination zone of SA has an extent of approximately NS 1.5 km × EW 2.0 km. This mineralization zone seem to continue northward over the ridge and connected to the silicification/pyrite dissemination zone of the S. Imbak Sub-area North (NA). Pyrite dissemination occurs both in the sedimentary rocks and the diorite porphyry associated by quartz-sulfides veins of few cm wide. These veins occur both in parallel to and oblique to the sedimentary structure and they do not show consistent trend. The vein of the largest size (maximum width: 35 cm) occur at the mineral showings of IMS-1.

IMS-1 (Sketch 1A, 1B, 1C): On a bed of a steep stream, a scattered distribution of quartz-pyrite-chalcopyrite veins is observed in silicified and pyrite disseminated sandstone for an extent of 150 m. The width of the veins is generally few cm, however, the largest one reaches maximum width of 35 cm and it can be traced along the stream bed for 30 m. Microscopic observation suggests that pyrite, chalcopyrite and arsenopyrite are constituents of the sulphide phase of the veins. The assay results of these veins show similar grade with high Cu (2.21 % to 9.37 %) and Ag (61.9 g/t to 509.7 g/t). Au (0.1 g/t to 1.1 g/t), Zn and Pb are low.

Other quartz-sulfides (pyrite) veins of few cm wide in the mineralization zone SA (P152, P154, P157) give Ag grade ranging from 5.1 g/t to 37.8 g/t with Cu±0.1 % and Au, Pb and Zn are low. From the assay results, these veins are similar to Type ② vein of the S. Imbak Sub-area North. The assay result of Ag 14.8 g/t obtained from the pyrite disseminated sandstone suggests some Ag mineralization in the host rock.

2. Mineralization zone of center part of the area (SB)

Silicification and pyrite dissemination of the mineralization zone SB occur in the area of approximately NS 1 km × EW 1.5 km. The dissemination, mainly pyrite and occasionally chalcopyrite and Cu oxides, occur both in the sedimentary rocks and diorite porphyry, however, dissemination seem to be more strong in the diorite porphyry than in the sedimentary rocks. Thin quartz-pyrite veins rarely occur in the mineralization zone. The center of the mineralization is mineral showing IMS-2, located in southwest part of the mineralization zone SB, where pyrite and chalcopyrite disseminated diorite porphyry occur. Few grains of native gold in the chalcopyrite grain were found through microscope in the Phase I from the sample collected from this mineral showing.

IMS-2 (Sketch 2): Pyrite and chalcopyrite disseminated mudstone and diorite porphyry occur along a stream for a distance of approximately 500 m. Strongly silicified, white mudstone is intruded by the diorite porphyry and dissemination of pyrite and chalcopyrite associated by fracture filling films of the same minerals occur in the mudstone. The pyrite and chalcopyrite disseminated diorite porphyry is slightly felsic type with biotite phenocryst in addition to plagioclase and hornblende and it is strongly silicified with abundant secondary quartz and sericite. The dissemination is slightly stronger in the diorite porphyry than in sedimentary rocks. The assay results of the samples collected at 1 m span show Cu ranging from 0.10 % to 0.20 % and Ag ranging from 0.2 g/t to 2.7 g/t in the diorite porphyry. While, 1 m span samples of mudstone show Cu grade of ±0.10 %, slightly lower than that of the diorite porphyry. Au, Pb, Zn grade are low in the both of samples.

Other than IMS-2, any encouraging assay results was obtained from pyrite disseminated sandstone and mudstone samples collected in the mineralization zone SB.

3. Mineralization zone of east part of the area (SC)

The mineralization zone SC occur on the east slop of the ridge. Silicification and pyrite dissemination associated by fracture filling pyrite film in the sandstone and mudstone occur in the zone. The silicification and pyrite dissemination tend to be more intensive at the vicinity of diorite porphyry intrusion. In addition to this, quartz-sulfides (pyrite, arsenopyrite, sphalerite, galena) veins sporadically occur in the sedimentary rocks. One of the quartz-sulfide vein show assay results of Ag 8.8 g/t, Pb 0.37 % and Zn 0.43 % and it seem to belong to the Type ③ vein of the S. Imbak Sub-area North. The assay results of pyrite disseminated mudstone and diorite porphyry do not show any encouraging result.

In summary, the mineralization zone SA is considered to be a southern extension of silicification/pyrite dissemination zone of the S. Imbak Sub-area North (NA) and it is characterized by silicification/pyrite dissemination with quartz-sulfide veins. Cu and Ag enriched veins and Type ② vein of the S. Imbak Sub-area North exist in the zone. Although slightly low Cu grade was obtained, the mineralization zone SB, characterized by pyrite and chalcopyrite disseminated diorite porphyry, shows a similar occurrence of mineralization to that of porphyry copper type. The intensive mineralization and high grade ore were not found in the mineralization zone SC.

2-2-4 Fluid inclusion filling temperature

Filling temperature measurement of six samples collected from quartz-sulfides veins of S. Imbak Sub-area South was conducted. The method of the measurement is given in chapter 1-2-4 and the results is given in Appendix 1 and Table Ⅱ-2-6. All 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 their distribution.

The sample S199 consists of two part, and measurement of temperature was done separately. S199-1 is gray quartz vein and S199-2 is quartz pool with sulfides. Sample S173 and P152 include the inclusions with solid phase in addition to the inclusion consists of only liquid phase. S173Tm and P152Tm are melting temperature of daughter minerals. Among the six samples, P152, S173 and S196 show a wide temperature range, about 200° C. While, the temperature range of S191-1 and S204 is less than 100° C. The average temperatures of the six samples except S199-2 fall in a relatively narrow range of from 319.5C° to 364.3 ° C. and these temperatures are high compared to those of epithermal type mineralization.

Among four samples (P152, S196, S199 and S204) from the mineralization zone SA, two samples (S199 and S204) were collected from quartz-pyrite-chalcopyrite veins of mineral showings IMS-1 and other two samples (P152 and S196) were collected from the quartz-sulfides veins similar to Type ② vein (Ag > Au type) of the S. Imbak Sub-area North. The former shows higher average temperature of 351.5° C and 364.3° C with narrower temperature range compared with the later with average temperature of 333.3° C and 336.4° C. The two samples collected from the quartz veins occurring in the pyrite-chalcopyrite disseminated diorite porphyry of the mineral showing IMS-2 show average temperature of 319.5° C and 355.2 ° C.

2-2-5 Rock geochemical survey and alteration

The rock samples for geochemical survey were collected during the geological survey in the S. Imbak Sub-area South. For obtaining a whole view of geochemical halos related to the mineralization in the entire area of the S. Imbak Sub-area, 201 samples of Phase Ⅰ collected in the S. Imbak Sub-area North were included to the 300 samples collected in the S. Imbak Sub-area South and data analysis were conducted for a total of 501 samples. From the 300 samples of the geochemical survey, 55 samples were selected for X-ray diffraction analysis for investigating the alteration halo related to the mineralization.

1. Sampling

Among the 300 samples collected in the Phase II survey, some of the samples were collected in the S. Imbak Sub-area North to fill the gap between the S. Imbak Sub-area North and South. The location of the samples and description of each sample are, respectively, given in Fig. II-2-5 and Appendix 2.

2. Statistical data treatment

Analytical results are shown in Appendix 3. These analytical results were input to a computer and statistical figures were obtained. Table II-2-7 shows statistical figures both of the 300 samples of the S. Imbak Sub-area South and the 501 samples of a whole area of the S. Imbak Sub-area. Compared to the S. Imbak Sub-area North, concentrations of Ag and As are lower and Cu, Hg and Sb are slightly higher in the S. Imbak Sub-area South.

Among 501 samples from both of the S. Imbak Sub-area North and South, 45 samples are diorite porphyry and the rest of them are sandstone and mudstone. The mudstone and sandstone show similar chemical character, however, there are some chemical differences between the two and diorite porphyry. The diorite porphyry shows following chemical characters compared to sandstone and mudstone.

Clearly high in diorite porphyry: Ca, Sr
Slightly high in diorite porphyry: Cu, Mg, Na
Low in diorite porphyry: As

Compared with fresh diorite porphyry with altered diorite porphyry, the latter shows higher As, K and lower Ca, Na than former.

Ag, As, Au, Hg and S show high maximum values of Ag 17.37 ppm, As 13,675 ppm, Au 6,920 ppb, Hg 2,290 ppb and S 29.355%.

In order to clarify relationships between the elements, correlation coefficients were, also, calculated. The results show following pairs of elements having good (correlation coefficient: more than 0.500) and fairy good (correlation coefficient: more than 0.400) correlations.

good correlation: Au-As, Ca-Mg-Na-Sr-Zn, K-Rb
fairy good correlation: Ag-As, Cu-S-Zn, Pb-Zn

Groups of elements such as Au-As, Ag-As, Cu-S-Zn and Pb-Zn are probably reflecting the chemical nature of mineralization in the area. Ca, Mg, Na, Sr are high in diorite porphyry, especially diorite porphyry of less alteration.

3. Single element analysis

Distribution maps of each element were prepared (Appendix 4) using the values obtained by EDA method. Distributions of each element are summarized as follows;

Ag: Anomalies and high value zones are distributed over the area of north and center part, covering continuously the silicification/pyrite dissemination zone of S. Imbak Sub-area North (NA) and west part of the mineralization zone SA of the S. Imbak Sub-area South. Samples of high values occur in the mineralization zone SB.

As: Similar to Ag distribution, high value and anomalous zones, continuously, occur over the area of silicification/pyrite dissemination zone NA in the S. Imbak Sub-area North and west part of the mineralization zone SA in the S. Imbak Sub-area South. Other than this, high values zone are, sporadically, occur east part of the mineralization zone SB and south part of the mineralization zone SC.

Au: Overlapping the Ag and As distributions, anomaly and high value zone occur covering the area of silicification/pyrite dissemination zone NA in the S. Imbak Sub-area North and west part of the mineralization zone SA in the S. Imbak Sub-area South. The mineral showing IMS-2 of the mineralization zone SB is covered by high value zone and samples of high value are distributed in the mineralization zone SC.

Ca: Samples of high value occur north, southwest and east part of the area where mineralization and alteration are not found. The diorite porphyry of less alteration shows the highest concentration. All the samples, other than diorite porphyry, taken in the mineralization zone show the concentration below background value.

Cu: Anomaly zones occur in west part of the mineralization zone SA, west part of the mineralization zone SB covering the mineral showing IMS-2 and east part of the silicification/pyrite dissemination zone NA.

Hg: Although the samples of high value are scattered over the south part of the silicification/pyrite dissemination zone NA, mineralization zones SB and SC, no clear relation between Hg distribution and mineralization is found.

K: The distribution of high value within the silicification/pyrite dissemination zone NA and its vicinity suggest possible K enrichment in the zone NA by mineralization/alteration. The samples of high K concentration are not found in the mineralization zone SA, SB, SC.

Mg: Diorite porphyry and some of the sedimentary rock outside of the mineralization zones show high value. Within the mineralization zones samples other than diorite porphyry show the concentration below detection limit.

Na: Similar to Mg distribution, diorite porphyry shows high concentration and samples inside the mineralization zones other than diorite porphyry show the concentration below detection limit. Na was possibly depleted through mineralization/alteration episode.

Pb: Anomalies sporadically occur in the area east part of the mineralization zone NA to the mineralization zone SA, the mineralization zones SB and SC.

Rb: No clear distribution tendency was observed, however, samples of mineralization zone NA tend to show high value.

S: The samples of high value are distributed in the mineralization zones. Other than that high value samples occur in the sedimentary rocks of the northeast part of the area.

Sb: Samples of high value is scattered over the area of mineralization zones and, other than that, no clear distribution tendency is observed.

Sr: Similar to Ca distribution, diorite porphyry with less alteration shows high concentration. All the samples, other than diorite porphyry, taken in the mineralization zones show the concentration less than detection limit.

Zn: Samples of high values sporadically occur in the mineralization zones and it does not show clear chemical halos related to mineralization.

The distributions of anomalous zone and high value zone of the elements possibly related to the mineralization of the area are shown in Fig. II-2-6. Anomalies and high value zones of Ag, As, Au, Cu occur closely associated each other in the area silicification/pyrite dissemination zone of S, Imbak Sub-area North (NA) to west part of the mineralization zone SA in the S. Imbak Sub-area South. While, the area of mineral showing IMS-2 in the mineralization zone SB is covered by high value zones of Au and Cu and high value samples of As, Au and Cu are scattered in mineralization zone SC. The mineralization of the area, including the mineralization zone NA (silicification/pyrite dissemination zone) of the S. Imbak Sub-area North and its extension of the mineralization zone SA of the S. Imbak Sub-area South is, characterized by Au, As, Cu and Pb and S associate with them. While, the mineralization of the area including the mineral showing IMS-2 is characterized by Cu, Au and S. Zn does not seem to form clear chemical halo related to the mineralization. The low concentration of Ca, Mg, Na and Sr for the samples collected in the mineralization zones suggest a removal of these elements through the mineralization/alteration. Further, the mineralization zone NA in the S. Imbak Sub-area North is slightly enriched in K and Rb through the mineralization/alteration episode.

4. Multi-element analysis

Factor analysis was conducted as a multi-element analysis in this survey. The results of factor analysis are given in Table II-2-8. Following relationships between elements and factors were extracted by the factor analysis.

Factor 1 : –As, (–Au), Ca, Mg, Na, Sr, Zn
Factor 2 :(Ag),(As), Au, Cu, Pb, S, (Zn)
Factor 3 : –Ag, Sb
Factor 4 : –K, –Rb

Considering the relations between factors, related elements and distributions of each element, Factor 1, Factor 2 and Factor 4 are probably related to the mineralization and alteration of the area.

Distribution map of these factor scores was prepared allocating three different colors for each factor (Fig. II–2–7). For Factor 1 and Factor 4, high factor scores of opposite side (negative side) in relation to Factor 2 were enhanced by colors. Three factors are shown by following colors.

Factor 1 : blue   Factor 2 : red   Factor 4: yellow

Distribution tendencies of these factors are summarized as below;

Factor 1: High factor score zones are distributed covering the area of the mineralization zone (NA) of the North to the mineralization zone SA of the South and they further continues toward south along the ridge.

Factor 2: A high factor score zone clearly occur in the northeast part of the mineralization zone NA. Further, overlapping the high score zone of Factor 1, it occurs in the area covering the mineralization zone NA of the North to the west part of the mineralization zone SA of the South. In the mineralization zone SB, high factor score zone occur around the mineral showing IMS–2 and in the east part.

Factor 4: The high factor score zone occur in the mineralization zone NA of the North, overlapping high factor score zone of Factor 1 and Factor 2 and it does not appear in the mineralization zone SA of the South. It, also, occur in the mineralization zones of SB and SC in the South.

Factor 1 (–As, (–Au), Ca, Mg, Na, Sr, Zn) consists of the elements reflecting the mineralization of the area (As–Au) on the negative side and the elements reflecting the alteration of the area (Ca, Mg, Na, Sr) on the positive side. Factor 2 ((Ag),(As), Au, Cu, Pb, S, (Zn)) consists of the elements reflecting Ag–Au mineralization in addition to base metal (Cu, Pb) mineralization. The Factor 1 and Factor 2 are considered to be reflecting the mineralization of the area. While, Factor 3 (–K, –Rb) seem to reflect an addition of K during the episode of mineralization/alteration in the mineralization zone, especially NA of the North.

5. Alteration

For considering the alteration halos related to the mineralization of the area, 55 samples covering the S. Imbak Sub-area South were selected from the samples of the rock geochemical survey and X-ray diffraction analysis was done (Table II-2-3). For understanding the alteration halos of the entire area of the S. Imbak Sub-area, the investigation was done together with the results of Phase I survey in S. Imbak Sub-area North. Fig. II-2-8 shows the mineral assemblages of alteration minerals in the S. Imbak Sub-area.

The x-ray diffraction analysis of the typical alteration samples, argillized diorite porphyry, silicified and pyrite disseminated sandstone and mudstone at the vicinities of the intrusion of diorite porphyry and quartz-sulfides veins, show following mineral assemblages.

The assemblages of alteration minerals in the diorite porphyry is quartz-sericite-Se/Mo(sericite/montmorillonite)-kaolinite-sericite. Altered sandstone and mudstone has a common mineral assemblage of quartz and sericite and it is associated by chlorite, kaolinite and Se/Mo. A negative relation is observed between plagioclse and sericite. A sample of abundant plagioclase has a small amount of sericite and in sericite rich samples the amount of plagioclase is rare or absent. Therefore, amount of sericite can be used as a indicator of alteration. As an alteration advances, more plagioclse is decomposed to sericite.

Based on the above, alteration mineral assemblages are considered for 106 geochemical samples (55 samples of the S. Imbak Sub-area North and 51 samples of S. Imbak Sub-area South). The common mineral assemblages of geochemical samples is quartz-sericite-kaolinite and, in addition to them, chlorite and Se/Mo appear occasionally. The amount of sericite changes from trace to abundant regardless of lithological facies. Chlorite appears more and Se/Mo and kaolinite appear less in the S. Imbak Sub-area South compared to the North. Using three key minerals characterizing the alteration of the area, Se/Mo, chlorite and appearance of sericite more than trace amount, the alteration of the area is considered.

As shown in Fig. II-2-8, which shows occurrences of abundant quartz and biotite in addition to three key minerals, three zones of alteration minerals are identified in a concentric distribution surrounding the mineralization zone NA at the center. Se/Mo occurs in the outer margin, mainly northwestern part of the area and chlorite occurs in the middle, near the out margin of the mineralization zone NA. The samples with sericite more than trace amount occur only inside the mineralization zone NA. The three zones are considered to be indicators of the intensity of alteration. The alteration increases toward the mineralization zone NA.

The existence of argillized diorite porphyry outside of mineralization zone NA and no strong argillization found at the vicinity of argillized diorite porphyry suggest that argillization of the diorite porphyry is caused by a different episode of alteration from the alteration of the sedimentary rocks.