PART II DETAILED DISCUSSIONS

PART II DETAILED DISCUSSIONS

CHAPTER 1 ANALYSIS OF EXISTING DATA

1-1 Survey Area

1-1-1 Past exploration

Three known prospects, namely Umm ad Damar North, Umm ad Damar South, and 4/6 Gossan, occur in the survey area.

The exploration history of the North and South Prospects was summarized by Ransom (1982). Ancient workings are concentrated in these two prospects. Particularly in the North Prospect, a large amount of copper smelting slag is accumulated, and it is inferred to amount to 108,000 t containing 0.91 % of Cu. During the past several decades, airborne geophysical survey, surface geophysical survey, geologic survey, and drilling were carried out on both prospects by DGMR (1936-1965), BRGM (1966-1971), SEREM /US Steel (1976-1977), and Riofinex (1981-1983).

Gossan was discovered in the 4/6 Gossan around 1980 to 1981, and trenching, geochemical prospecting, and IP geophysical survey were carried out from 1982 to 1983. Drilling was done in 1983 (BRGM-OF-07-6).

1-1-2 Mineralization

Regarding the mineralization of the above three prospects, various theories were proposed on the basis of drill core investigation and other studies. The mineralized zones of the prospects can be summarized from mode of occurrence, form, and major elements of ores as follows.

(1) North and South Prospects

Disseminated to network pyrite-chalcopyrite mineralized zone forms intermittently continuous lenses in shear zones.

In the past, the ores of these prospects were believed to be parts of stockwork of stratabound massive sulfide deposits, and the mineralization was considered to be of syngenetic nature. In 1984, it was maintained by Howes (1984) that the mineralization, which formed these prospects, had epigenetic characteristics.

(2) 4/6 Gossan

Cu-Au-Ag-Pb-Zn mineralized zone forms intermittently continuous lenses in shear zones. The attitude of these sheared zones is oblique to bedding planes. The mineralization of this prospect has been considered to be epigenetic (Howes, 1984).

1-1-3 Results of geophysical survey

Ground geophysical survey was carried out intermittently in the present survey area including the above three prospects from 1961 to 1983. But the areas of these surveys are not clear except for the work done by Riofinex from 1982 to 1983.

Riofinex carried out geophysical survey (IP and magnetic prospecting) in areas including the North Prospect, the South Prospect, and the 4/6 Gossan. The distribution of chargeability anomalies exceeding 12.5 mV/V coincides with that of the mineralized zones.

1-1-4 Results of drilling exploration

The results of drilling in the three mineral prospects are shown in Table 2-1-1. A total of 27 holes were drilled by DGMR, BRGM, SEREM/US Steel, and Riofinex during the period from 1964 to 1983, and the total length of drilling attained 4,821 m. These holes are; 12 in the North Prospect, 11 in the South Prospect, and 2 in the 4/6 Gossan. It is seen that drilling was concentrated in the first two prospects.

Also of the 27 holes drilled, 15 encountered mineralized zones, but none exceeds 10 m in width with Cu grade exceeding 1 %.

As results of the past drilling exploration, ore reserves of the North Prospect and the 4/6 Gossan were estimated as follows.

Prospect	Length (m)	Width (m)	Depth (m)	Reserve (t)	Grade	Data
Umm ad Damar South	Unknown	Unknown	Unknown	1,000,000	Cu 2 % Zn 1-2.5%	SEREM/US Steel
4/6 Gossan	700	2	45	160,000	Au<15g/t Ag<450g/t	BRGM-OF-07-6

Table 2-1-1 Results of Drilling Exploration

Umm ad Damar North

	Drill Hole	Azimuth (degree)	Inclination (degree)	Drilled Length (m)	Intersection (m)		True Width (m)	Assay Results				
								Cu(%)	Au(g/t)	Ag(g/t)	Zn(%)	Pb(%)
West Hill	DDH-6	270	-43	300.00	151.0	154.0	2.4	0.95				
	DDH-7	240	-35	222.00	39.0	42.0	2.9	1.00				
					119.0	119.7	0.6	5.00				
	DA-3	-	-90	164.30	32.0	40.0	2.5	0.90				
	DA-4	259	-36.5	282.20	87.0	92.0	4.8	1.03				
					137.0	141.0	3.8	1.17				
					183.0	184.0	1.0	2.40				
	DA-5	257.8	-38	257.30	102.7	106.3	3.2	1.40				
					120.0	123.0	2.6	2.17				
					203.9	205.0	1.0	5.10				
	UAD-8	-	-	240.25	-	-	-	Negligible Cu grades				
Southeast Hill	DDH-4	90	-43.5	150.90	108.0	109.0	-	1.26		-	low	
	DDH-5	270	-40	300.00	167.0	170.0	-	2.25		-	low	
	UAD-6	45	-50	270.40	98.0	100.0	-	2.05		-	0.02	
	UAD-11	223	-50	150.00	68.0	88.0	18.0	0.66		12.9	0.12	
					68.0	71.5	3.1	1.87		25.8	0.48	
	UAD-7	-	-90?	140.00	84.5	87.1	-	Very rich pyrite, negligible Cu grades				
	UAD-10	-	-90	96.66	-	-	-	Negligible Mineralization				

Umm ad Damar South

	Drill Hole	Azimuth (degree)	Inclination (degree)	Drilled Length (m)	Intersection (m)		True Width (m)	Cu(%)	Au(g/t)	Ag(g/t)	Zn(%)	Pb(%)
	DDH-1	300	-45	51.80	31.2	31.5	0.3	2.28				
	DDH-2	300	-45	106.70	30.0	100.0	-	Traces diss. pyrite and chalcopyrite				
	DDH-3	300	-64	91.40	67.0	71.0	2.1	2.93				
	DDH-3A	295	-61	125.00	-	-	-	Traces disseminated pyrite at 56 and 96m				
	DA-1	0	-90	181.00	-	-	-	Intercalations of black graphite schist, pyrite throughout.				
	DA-2	0	-90	150.40	-	-	-	As DA-1				
	UAD-1	135	-61	188.35	-	-	-	No mineralization				
	UAD-2	133	-55	222.60	73.0	78.0	2.6	0.56				
					78.0	91.0	6.9	1.99				
					91.0	98.0	3.7	0.62				
	UAD-3	120	-70	237.60	50.8	116.1	-	5 to 15% pyrite				
	UAD-4	138	-55	136.45	106.0	115.0	3.1	2.3		27.5		
					111.0	115.0	1.4				2.36	
	UAD-5	134	-70	230.15	-	-	-	Negligible Cu grades				

4/6 Gossan

	Drill Hole	Azimuth (degree)	Inclination (degree)	Drilled Length (m)	Intersection (m)		True Width (m)	Cu(%)	Au(g/t)	Ag(g/t)	Zn(%)	Pb(%)
	UAD-13	243	-60	84.00	24.0	27.0	1.5	0.13	<0.1	1.1	0.49	-
					40.0	54.0	7.0	0.05	0.1	0.6	0.14	-
					67.0	70.0	1.5	0.91	0.7	8.2	0.75	0.002
					71.0	76.0	2.5	1.01	0.6	7.7	2.75	0.005
					76.0	84.0	4.0	0.22	0.1	3.2	0.54	0.001
	UAD-14	243	-60	90.00	8.0	18.0	5.0	0.04	<0.1	0.5	0.99	-
					20.0	36.0	8.0	0.41	<0.1	2.1	1.05	-
					52.0	56.2	2.1	1.15	16.1	449.8	0.25	1.02

Others

	Drill Hole	Azimuth (degree)	Inclination (degree)	Drilled Length (m)	Intersection (m)		True Width (m)	Assay Results
	UAD-9	-	?	258.45	53.0	84.0	-	Cu and Zn <0.3%
					157.5	158.7	-	90%pyrite
	UD SE-2	-	-55	93.15	-	-	-	-

1-2 Ore Deposits in the Vicinity of the Survey Area

Jabal Sayid deposit occurs about 20-km northwest of the survey area, and Mahd adh Dhahab mine is located 25-km southwest of the present area. The outline of the above deposits is reported below.

1-2-1 Mahd adh Dhahab mine

The geology of the Mahd adh Dhahab mine has been reported by Bowen and Smith (1981), Kemp et al. (1982), and DGMR (1994).

(1) History

The operations of this mine dates back to 3,000 BP. Since then, it has been a very important source of gold and silver for Saudi Arabia.

Saudi Arabian Mining Syndicate operated the mine from 1939 to 1954, and 22 t of gold and 28 t of silver were produced during this period.

USGS began survey of this mine and the neighboring areas in 1972, and discovered 1.7 million tons of ore (Au 27 g/t, Ag 73 g/t) at 700 m south of the then known deposit.

The production of this mine in 1992 was 162,404 t (Au 24.2 g/t) of ore by underground mining, and 158,484 t (Au 50.1 g/t) by open pit mining. Although open pit mining has ceased recently, underground mining continues to the present.

(2) Mineralization

The ore deposits of this mine were formed by vein-type Au-Ag-Cu-Zn mineralization, which occurred 649 Ma (DGMR, 1994). Many quartz veins with N-S strike occur within an area of 900 m × 900 m.

(3) Ore minerals and gangue minerals

The main ore minerals are; chalcopyrite, galena and sphalerite. About 70 % of the precious metals occur as telluride minerals, namely hessite, petzite, and sylvanite (DGMR, 1994). The main gangue minerals are quartz and chlorite.

(4) Host rocks and alteration

The ore deposits of this mine occur in the Haf Formation of the Mahd Group, and the host rocks are; andesitic tuff, andesite, agglomerate, sandstone, and other rocks (Fig. 1-6).

Regarding alteration, silicification , propylitization, pyritization and potassium metasomatism are reported.

(5) Ore reserves

The mineable ore reserves of this mine were calculated to be 1.14 million tons (Au 31.8 g/t, Ag 167 g/t, Cu 0.87 %, and Zn 3.24 %) as of 1992.

(6) Results of the present survey

During the first phase of this project, we surveyed the East and West Veins in the southern part of the mine area.

East Vein occurs in the host rock containing large crystals of potash feldspar. The main ore minerals are sphalerite and galena, and there is a chalcopyrite vein in the central part of this vein. The main gangue mineral is quartz, but the amount is small. The vein is 1-2.5 m wide but changes significantly. The West Vein is also a sphalerite - galena vein and has a quartz veinlet in the central part.

Polished section microscopy revealed that the ore samples consist mainly of chalcopyrite and sphalerite, and unlike the ore minerals of the Jabal Sayid deposit, pyrrhotite and magnetite were not observed.

X-ray diffraction studies were carried out on the host rock of the quartz veinlet and the host rock of the ore vein. Large amounts of chlorite and quartz were detected. These rocks are andesitic agglomerate and thus silicification are inferred to have been strong.

The homogenization temperature and salinity were measured for the two samples collected during the present survey. The average homogenization temperature for one sample is 221° C. But this temperature fluctuates between 140° C and 270° C and the averaged value is not reliable. Also that of another sample is 198° C. The dispersion of this temperature is small. The average salinity of these inclusions is low at 0.2 - 0.9 wt % NaCl for the two samples.

1-2-2 Jabal Sayid ore deposit

The details of this deposit has been reported by Sabir (1981), Bowen and Smith (1981), and Kemp et al. (1982).

(1) History

Gossan (No.1 orebody) was found in 1965. In 1974, a joint venture of SEREM and US Steel obtained exploration rights, and surveyed the area in detail for a period of two years.

(2) Mineralization

The Jabal Sayid deposit is a stratabound massive sulfide deposit accompanied by stockwork orebody in the lower zones. The deposit consists of four orebodies, namely No.1, No.2, No.3, and No.4 orebodies (Fig. 1-5).

(3) Ore minerals

The massive orebodies consist mainly of pyrite, pyrrhotite, sphalerite, and chalcopyrite. The stockwork orebody consists mainly of pyrite and chalcopyrite, and the content of sphalerite is lower. Also, both types of ores contain small amount of gold and silver as follows.

Type of orebody	Au (g/t)	Ag (g/t)
massive	0.5	30-50
stockwork	0.1	10

(4) Host rocks and alteration

The footwall of the orebodies consists of crystal tuff and pyroclastic flows of the upper felsic rocks of the Sayid Formation, and the hanging wall consists of fine- to coarse-grained rhyolitic rocks and quartz phenocryst rhyodacitic pyroclastic rocks. Chemically precipitated chert and carbonates occur intermittently between the hanging and foot walls, and overlie the orebodies. The pyroclastic rocks, which are the host to the stockwork orebody, are chloritized.

(5) Ore reserves

The total ore reserves of No.1 and No.2 orebodies have been assessed to be 19.93 million tons with grade of Cu 2.68 %, according to the feasibility study carried out by BRGM in 1985.

(6) Results of the present survey

During the first phase of this project, we surveyed the gossan and its vicinity of No. 1 orebody. Also we collected samples from the stockpile.

The results of polished section microscopy show the existence of pyrite, chalcopyrite, sphalerite, and small amount of pyrrhotite and magnetite.

X-ray diffraction results revealed the occurrence of large amounts of chlorite, and the chloritization of the host rocks is very strong.

The silicified ore, collected during the course of the first phase, contains pyrite-chalcopyrite bearing quartz vein. The fluid inclusions in this quartz were analyzed and average homogenization temperature of 260 $^{\circ}$C was obtained. However, the homogenization temperature is scattered within the range of 210 $^{\circ}$ to 310 $^{\circ}$C, and thus the averaged value is not reliable. The average salinity of these inclusions is high at 8.3 wt % NaCl.

CHAPTER 2 PHOTOGEOLOGY

2-1 Analytical Methods

An area extending about 90 km^2 including the survey area was analyzed photogeologically (Fig. 2-2-1). Aerial photographs were viewed stereoscopically and geological units (henceforth units) were separated by "tone of photographs", "texture of photographs", "drainage pattern", "drainage density", "resistance of rocks", and "existence of bedding". And further fold structures were extracted from the dips of the bedding, and lineaments were extracted from linear topography.

2-2 Results of Analysis

2-2-1 Geologic units

The area shown in Figure 2-2-1 was divided into 15 units by analysis of aerial photographs. The characteristics of each unit are reported below.

(1) Volcanic and sedimentary rocks

Units "asa" and "ajz"

These two units occur within the survey area and in the vicinity. Bedding is hardly observed in these units, and they are clearly distinguished from Units "mh1-3", which have clear bedding. Units "asa" and "ajz" are distinguished by the tone and the difference in resistance. It is concluded from correlation with previous data that Unit "asa" corresponds to Sayid Formation of the Arj Group, and Unit "ajz" to Jabal Azlam Formation of the same Group.

Units "mh1-3"

Units "mh1", "mh2", and "mh3" are distributed to the west of the survey area. Bedding is observed in many of these units, and is inferred to consist of volcaniclastic rocks. The dips of the bedding indicate the existence of anticlinal structure with NNW-SSE elongation and SSE plunge. These units are divided, from lower horizon upward into "mh_1", "mh_2", and "mh_3". These are distinguished by the difference in texture, resistance, and other characteristics. From comparison with the existing data, these units are concluded to correspond to the Zur Member of the Haf Formation of the Mahd Group.

Unit “mh”

This unit is distributed at the extensional part of the anticlinal structure formed by Units “mh1-3”. This unit differs from Units “mh1-3” by the absence of bedding. From comparison with existing data, this unit is concluded to correspond to the volcaniclastic unit of the Tulaymisah Formation of the Mahd Group.

Unit “gk”

This unit occurs in the southwest corner of the area covered by photogeologic investigation. This unit has bedding, and correlation with existing data of this area indicates that this unit corresponds to the mafic unit of Khazrah Formation of the Ghamr Group.

Units “t”, “a”, and “w”

These units consist of Quaternary sand and gravel. Unit “t” consists of talus deposits near the Unit “gk”. Unit “a” occupies most of the flat land of this photogeologic area, and is correlated to old wadi deposits of the existing data. Unit “w” corresponds to the present wadi deposits.

Unit “gy”

This unit is distributed in small patches to the southwest of the survey area. It is white and occurs within the Unit “a”, which consists old wadi deposits. Thus it is believed to be gypsum-type sediments.

Unit “s”

This unit is observed only in the North Prospect. It is dark gray, and has the appearance of basalt, but ground-truth survey showed that the distribution almost agrees with that of slag.

(2) Intrusive bodies

Unit “dt”

This unit is distributed to the northeast of the survey area. It is distinguished from Units “ht” and “ht-h”, which will be mentioned later, by the tone and resistance. This is concluded to correspond to Dhukhr Tonalite from study of existing data.

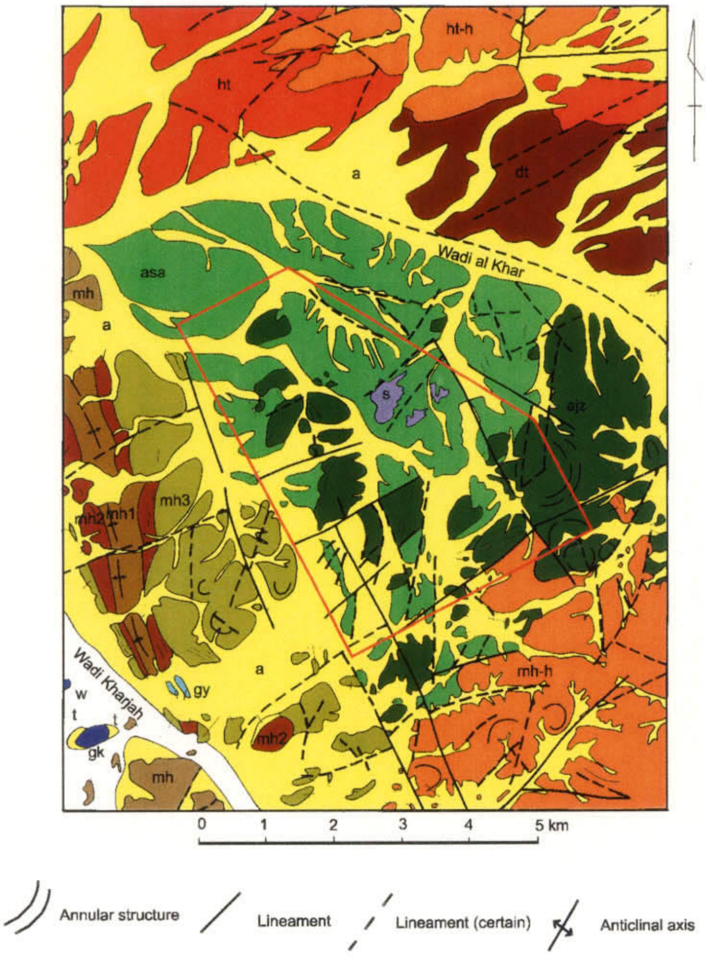
Units "ht" and "ht-h"

Unit "ht" occurs in the northern edge of the photogeologic area, while Unit "ht-h" is distributed in the northern edge and southeastern part of the above area. The two units are distinguished by the difference in resistance and "ht-h" has higher resistance. Existing data indicate these units to be Hufayria Tonalite.

2-2-2 Geologic structure

Only NW-SE trending fault in Wadi al Khar is shown in the regional geological map laid out in Figure 1-2. As a result of these photogeologic studies, however, many lineaments in the NE-SW and NW-SE direction were extracted from the survey area and the vicinity. It is inferred that faults in these directions exist in the area.

Bedding is dominant and anticlinal structure is extracted in Units "mh1-3", which correspond to the Mahd Group, while such structure is not extracted in Units "asa" and "ajz", which correspond to the Arj Group.



Photogeologic Units				Photo Characteristics		Geomorphological Features				Correlation with Geology in the Existing Data
Sedimentary and Volcanic Rocks		Intrusive Rocks				Drainage		Rock Property		
	Possible Lithology		Possible Lithology	Tone	Texture	Pattern	Density	Resistance	Bedding	
s	Slag			dark gray	rough	dendritic	low	high	none	not correlated
gy	Gypsiferous deposits			white	smooth	none	none	very low	none	not correlated
W	Wadi deposits			whitish	smooth	dendritic	low	very low	none	Wadi alluvium
a	Alluvium, gravel			light gray	smooth	dendritic	low	very low	none	Older wadi deposits
t	Talus deposits			light gray	fine	sub-parallel	low	low	none	
gk	Sedimentary and pyroclastic rocks			gray	fine	parallel	medium	medium	often	Mafic units of Kharzah Formation of Ghamr Group
		ht	Granitic rocks	gray	medium	trellis	medium	low-medium	none	Hufayriya Tonalite
		ht-h	Granitic rocks	dark gray	rough	trellis	high	high	none	
mh	Lava, pyroclastic rocks			gray	medium	sub-dendritic	low-medium	low-medium	none	Volcanic rocks of Tulaymisah Formation of Mahd Group
mh3	Mainly pyroclastic rocks			gray	rough	parallel	high	medium	pqrtly	Zur member of Haf Formation of Mahd Group
mh2	Lava, pyroclastic rocks			dark gray	medium	parallel	medium	high-medium	often	
mh1	Lava, pyroclastic rocks			dark gray	fine	parallel	medium	high	often	
		dt	Granitic rocks	gray	rough	trellis	high	medium	none	Dhukhr Tonalite
ajz	Andesitic volcanic rocks			gray	medium	dendritic	medium	medium	partly	Jabal Azlam Formation of Arj Group
asa	Acidic volcanic rocks			light gray	rough	dendritic	high	low-medium	partly	Sayid Formation of Arj Group

Fig.2-2-1 Photogeological Interpretation Map

CHAPTER 3 GEOLOGICAL SURVEY

The geological survey was carried out during the first phase, and the supplemental survey was carried out during the second phase.

3-1 Outline of Geology

The geology of the survey area consists mainly of; lavas and volcaniclastic rocks of Late Proterozoic rhyodacite, andesite, and dacite, belonging to the Arj Group. This group is intruded by diorite, quartz diorite, tonalite, andesite, dacite, rhyodacite, and basalt bodies.

These units are covered unconformably by Late Proterozoic andesitic lava and volcaniclastic rocks of the Mahd Group in the western edge of the survey area.

Jasper and dacitic breccia of the Arj group are distributed around Jabal Sujarah, northwestern part of the survey area. Granitic rocks occur widely, but concentrate from the Umm ad Damar North Prospect to the Umm ad Damar South Prospect.

A geological map of the survey area is shown in Figure 1-7.

3-2 Stratigraphy

3-2-1 Arj Group

Kemp et al. (1982), in their 1:250,000 scale geological map, divided the Arj Group into; the Sayid Formation consisting of felsic volcanic rocks, and the Jabal Azlam Formation consisting of andesitic volcanic and sedimentary rocks and overlying the Sayid Formation. In the present survey area, however, felsic and andesitic volcanic rocks occur alternately and the boundary of the two formations is not clear. Therefore, we divided the Arj Group into units by rock types; rhyodacite and rhyodacitic volcaniclastic rocks (Ar), dacite and dacitic volcaniclastic (Ad; dacitic breccia: Adb), andesite and andesitic volcaniclastics (Aa), and jasper (Aj).

(1) Rhyodacite and rhyodacitic volcaniclastic rocks (Ar)

This unit is mainly distributed near the North Prospect and the 4/6 Gossan.

Rhyodacite is generally white and often shows flow structure. Some have small quartz phenocrysts. Also, some are totally vitreous. The rhyodacitic volcaniclastic rocks are vitreous and in some places they contain augen quartz grains, lapilli size rock fragments, and glass shards. The rock is partly disseminated by hematite.

Many of these rocks are massive, but those to the west and south of the 4/6 Gossan have strongly developed schistosity.

(2) Dacite and dacitic volcaniclastic rocks (Ad)

This unit is distributed mainly to the east of Jabal Sujarah, near the 4/6 Gossan and to the north, and to the east of the South Prospect.

Dacite is dark green and contains small quartz phenocrysts. Dacitic volcaniclastics consist of tuff, lapilli tuff, tuff breccia, sandstone, and conglomerate, and they partly contain augen quartz and feldspar grains. Most of these rocks are massive, but sandstone, conglomerate, and some of the tuff contains clear bedding.

Of these dacite and dacitic volcaniclastics, dacite and tuff are dominant near the 4/6 Gossan and northward, while lapilli tuff and tuff breccia are dominant to the east of Jabal Sujarah and in the eastern part of the survey area. Dacite, sandstone, and conglomerate are predominant to the east of the South Prospect.

Dacitic breccia (Adb) consisting lapili tuff and volcanic breccia is separable from the Ad unit. It concentrates around the Jabal Sujarah.

(3) Andesite and andesitic volcaniclastic rocks (Aa)

This unit is distributed mainly near Jabal Sujarah and southward, and to the west and northeast of the South Prospect.

Andesite is dark green to purplish dark gray to dark gray. And phenocrysts are not observed by unaided eyes. Andesite is generally epidotized. Andesitic volcaniclastics consist of agglomerate, volcanic breccia, tuff breccia, lapilli tuff, and tuff.

Lithologically, many kinds of tuff occur near Jabal Sujarah while lapilli tuff is dominant to the north, and lava is dominant to the south of Jabal Sujarah, west and northeast of the South Prospect. It is also noted that agglomerate and tuff breccia occur in large amount in the northeastern part of the survey area.

(4) Jasper (Aj)

This rock occurs mostly at Jabal Sujarah and to its west. It is generally white, and is intercalated in rhyodacitic to andesitic volcaniclastic rocks. Those containing large amount of hematite is red.

3-2-2 Mahd Group

The andesite and andesitic volcaniclastics, which occur in the western edge of the survey area, correspond to the Zur Member of Haf Formation of the Mahd Group of Kemp et al. (1982, geological map 1:250,000). According to Kemp et al. (1982), the Zur Member consists of rhyolite and sedimentary rocks, but it consists of andesitic rocks in the present survey area.

(1) Andesite and andesitic volcaniclastic rocks (Ha)

These rocks occur in the western end of the survey area.

Andesite is purplish-greenish gray. Volcaniclastic rocks consist of tuff, lapilli tuff, and tuff breccia with intercalations of conglomerate and sandstone.

The relation with underlying Arj Group cannot be observed directly, but the Arj Group strata have steep dip exceeding 60°, while the present unit have low dip of 20 - 40°. It is believed that this unit overlies the Arj Group unconformably.

3-3 Intrusive Rocks

(1) Tonalite (T)

This rock is distributed near the South Prospect. It is medium to fine-grained, equigranular, and holocrystalline rock. It is observed microscopically that the mafic minerals are all decomposed to chlorite and epidote.

(2) Diorite, quartz diorite (D)

These rocks are distributed in the North Prospect and the vicinity. They are dark green and fine-grained. Microscopically they have porphyritic to sub-ophitic texture, and some of the diorite shows myrmekitic texture.

(3) Andesite (a)

Andesite is dark green and show porphyritic texture with large phenocrysts. Microscopically all mafic minerals are decomposed to chlorite and epidote.

(4) Dacite (d)

This rock occurs mostly intruding into dacite and dacitic volcaniclastics of the Arj Group. It contains quartz phenocrysts of about 5mm in size. Microscopically, mafic minerals are almost all decomposed to chlorite and carbonate minerals.

(5) Rhyodacite (r)

This rock has intruded into the andesite and andesitic volcaniclastics of the Arj Group to the northwest of the South Prospect. It has flow structure and similar characteristics as the rhyodacite of the Arj Group.

(6) Basalt (b)

This rock is dark green and occurs generally in small bodies intruding into the Arj Group. Basalt is also observed within tonalite at south of the South Prospect. Microscopically, it shows porphyritic texture and almost all mafic minerals are decomposed to chlorite.

3-4 Geologic Structure

The rocks of the Arj Group of the survey area are regionally chloritized and epidotized, and schistosity is developed in the volcaniclastic rocks. The strike and dip of the volcaniclastics can be measured only at few places. The Arj Group rocks have steep dip of more than 60° at places where bedding could be confirmed. On the other hand, Mahd Group units have low dip of 20 - 40° W.

The strike of the Arj Group is NE at the South Prospect and the eastward, but it is NW - N in other parts of the survey area.

The faults of NE-SW system are dominant. The existence of a NW-SE trending fault parallel to Wadi al Aqiq Fault is inferred in the northeastern edge of the survey area.

3-5 Mineralization

From results of the first-phase geological survey, the past drilling exploration, and the second-phase drilling exploration, the existence of mineralization was confirmed in the four areas: Jabal Sujarah, the North Prospect, the South Prospect, and the 4/6 Gossan (Fig. 1-8).

Volcanogenic massive sulfide-type Cu-Zn mineralization exists in Jabal Sujarah, the 4/6 Gossan, and a part of the North Prospect. On the other hand, vein-type Cu mineralization is confirmed in the North Prospect, and vein-type Cu-Zn mineralization is in the South Prospect.

The ore minerals of these prospects are oxidized to depths of 30 - 40 m and thus only gossan containing oxidized copper minerals, limonite, and hematite occur on the surface.

Mineralization at each areas is as follows.

(1) Jabal Sujarah

The major geologic units near this prospect are jaspar, dacitic breccia, and dacite. These rocks were intruded by rhyodacite, dacite, andesite, and basalt. As feature of mineralization and alteration at the surface of this district, strongly carbonatized silicic breccia only crops out at the southwestern part of Jabal Sujarah, and ancient pits or gossans are not observed.

The mineralization in this area is volcanogenic massive sulfide-type Cu-Zn mineralization. The ore are separated three types; massive ore, brecciated ore, and disseminated ore.

(2) North Prospect

A large amount of slag occurs at the North Prospect, and many ancient pits are distributed in the small hills to the west and southeast of this slag zone. The southeast hill is called "Southeast Hill" and the west hill was named "West Hill" during the present survey. Ancient workings are also distributed in the hills to the southeast of the Southeast Hill. The major geologic units near this prospect are rhyodacite and dacite of the Arj Group, and are elongated in the NW-SE direction. Diorite bodies have intruded into the Arj Group in the northeastern part of this prospect. Mineralization occurs only in the Arj Group and is not observed in the diorite bodies.

A total of five main mineralized zones are inferred to exist from the following observations; namely, the distribution of the ancient pits and gossan in trenches, and the results of drilling carried out in the past. The inferred five mineralized zones are; one in West Hill, another under the slag zone, one in Southeast Hill, and two in Southeast Extension. In this report, these zones will be numbered serially from No.1 to No.5 Mineralized Zones.

Of the 12 holes drilled in this prospect, 9 encountered mineralized zones(Table 2-1-1).

The downward extension of the No.1 Mineralized Zone was penetrated by the following five drill holes.

Drill hole	Depth (below surface) of ore (m)	True width (m)	Cu grade (%)
DDH-7	68.3 - 68.6	0.6	5.0
DA-5	73.9 - 75.7	2.6	2.17
DA-4	51.7 - 54.7	4.8	1.03
DA-3	32.0 - 40.0	2.5	0.90
DDH-6	103.0 - 105.0	2.4	0.95

No.2 Mineralized Zone was not drilled, and thus the downward extension of the mineralization is totally unknown.

No.3 Mineralized Zone was explored by drill holes DDH-4, DDH-5, UAD-6, and UAD-11. The DDH-4 and DDH-5 were drilled in the strike direction. Therefore, it is not possible to measure the width of the mineralized zone by these holes. The following data, however, have been acquired by UAD-11 and UAD-6 holes.

Drill hole	Depth (below surface) of ore (m)	True width (m)	Cu grade (%)
UAD-11	52.1 - 54.8	3.1	1.87
UAD-6	175 - 178 ?	2 ?	0.35

No.4 and No.5 Mineralized Zones were not drilled and thus the downward extensions of these zones are not known.

(3) South Prospect

The major geologic units near this prospect are rhyodacite, andesite, andesitic tuff, and dacitic tuff of the Arj Group, and are elongated in the NE-SW direction.

Seventeen ancient workings have been confirmed in this prospect. The number of major mineralized zone is inferred to be one on the basis of the distribution of ancient workings with oxidized copper minerals and the gossan in the trenches. This mineralized zone is slightly oblique to the strike direction of the country rocks, and occurs mainly in tuff. The zone has a maximum width of 30 m and the extension in the strike direction is 400 m on the surface.

Eleven holes have been drilled for this mineralized zone, and ore zone is 2.1 - 6.9 m wide and Cu 1.99 - 2.93 %. This mineralized zone consists of chalcopyrite-pyrite-quartz veinlets group and pyrite-chalcopyrite-sphalerite dissmination.

Two grab samples collected at the surface during the first-phase survey contain Au 6.2 g/t and Au 3.0 g/t.

(4) 4/6 Gossan

The geology of this prospect is composed mainly of rhyodacitic pyroclastic rocks with intercalation of basaltic tuff. The grab samples collected in the trenches during the first-phase survey have high Au and Ag content, showing Au 1.6 - 3.7 g/t and Ag 287 g/t.

During the first phase of this project, the mineralization of the 4/6 Gossan was thought to be, from study of existing data and surface survey, only one epigenetic dissemination or network in the shear zones of Arj Group. But it is evident that it is volcanogenic massive sulfide and is syngenetic. This mineralization consists of massive ores, siliceous ores and pebly ores, containing chalcopyrite, sphalerite and pyrite.

3-6 Mineralization in the Survey Area and Ore Deposits in the Vicinity

The type, host rocks, age, alteration, and results of fluid inclusion studies of the mineralization of the North Prospect, the South Prospect, and the 4/6 Gossan in the survey area and Jabal Sayid deposit and Mahd adh Dhahab mine in the neighboring areas were compared, based on the existing data (Table 2-3-1).

(1) Mineralization type

The mineralization of the three known prospects in the survey area is disseminated to network-type copper mineralization.

The Jabal Sayid deposit consists of stratabound massive copper sulfide mineralization with stockwork in the lower parts. The Mahd adh Dhahab mine was formed by vein-type Au-Ag-Cu-Zn mineralization.

(2) Host rocks

The ores of the three known prospects in the survey area are hosted by felsic rocks of the Arj Group. The host rocks of the Jabal Sayid deposit is felsic rocks of the Sayid Formation of the Arj Group. The deposits of the Mahd adh Dhahab mine occur in andesite and andesitic volcaniclastics of the Haf Formation of the Mahd Group.

(3) Age of mineralization

Mineralized zones of the three prospects lie in the shear zones within rhyodacite, dacite, and their volcaniclastic rocks, and the mineralization is not confirmed in andesite and its volcaniclastic rocks of the Arj Group, and intrusive bodies. Therefore, the mineralization is considered to have occurred after deposition of silicic rocks and before intrusion of diorite and tonalite.

The mineralization of the Jabal Sayid deposit occurred at the time of the deposition of the Sayid Formation. On the other hand, the age of the mineralization of the Mahd adh Dhahab mine has been determined to be 649 Ma (DGMR, 1994). Probably, this corresponds to the time of deposition of the Ghamr Group overlying the Mahd Group.

(4) Ore minerals

High temperature sulfides such as pyrrhotite, magnetite, and cubanite are observed in the North Prospect and the Jabal Sayid deposit, but these minerals have not been reported from the Mahd adh Dhahab mine.

(5) Alteration

The host rocks of the three prospects, the Jabal Sayid deposit, and the Mahd adh Dhahab mine have been silicified, chloritized and pyritized. The major difference in alteration is that potassium feldspar replacement is observed at Mahd adh Dhahab mine and large crystals of potassium feldspars, several centimeters in size, occur in the andesitic host rock, but these do not occur in the three prospects and the Jabal Sayid deposit.

(6) Fluid inclusions

The fluid inclusion study of the Mahd adh Dhahab mine has been reported by Luce et al. (1979), Rye et al. (1982), Hakim and Chinkul (1989) , and Afifi (1992). Luce et al. (1979) reported that the homogenization temperature of primary and pseudosecondary fluid inclusions in many kinds of quartz veins was 142° - 278° C, and the salinity was 0 - 0.1 wt % NaCl. And the homogenization temperature of fluid inclusions in quartz has been reported to be 110° - 238° C by Rye et al. (1982). Hakim and Chinkul (1989) stated that the homogenization temperature of fluid inclusions in mineralized quartz veins was 100° - 380° C, and the salinity was 1-4 wt % NaCl, on the other hand, that of fluid inclusions in barren quartz veins was 130° - 200° C, and the salinity was 0.6 - 3 wt % NaCl. Afifi (1992) determined that the temperature during hydrothermal activity at the Mahd adh Dhahab mine was 180° - 270° C.

The fluid inclusion study of the Jabal Sayid deposit has been reported by Chinkul (1983). Chinkul (1983) indicated that the homogenization temerature of fluid inclusions in mineralized quartz veins and sphalerites was 300° - 400° C, and the salinity was high as 6.7 - 7.4 wt % NaCl.

During the present survey, homogenization temperature and salinity of 14 quartz samples were measured. The samples are; 1 from the Jabal Sayid deposit, 2 from the Mahd adh Dhahab mine, 5 from the North Prospect, 3 from the South Prospect, 2 from Southeast Extension located southwest of the South Prospect, and 1 from north of the South Prospect. The homogenization temperature is normally measured on primary fluid inclusions. But the inclusions measured during this work were very small, and distinction of primary and secondary inclusions was not possible. Therefore, the reliability of the homogenization temperature and salinity measured during this phase is not high.

The average homogenization temperature of the silicified ore sample collected from the stockpile of the Jabal Sayid deposits was 260° C, and the average salinity was 8.3 wt % NaCl. This temperature was slightly lower than that of Chinkul (1983), and the salinity is almost the same with that of Chinkul (1983).

The average homogenization temperature and salinity of the two samples collected from the Mahd adh Dhahab mine were 192 - 210° C and 0.2 - 0.9 wt % NaCl. These data are almost similar to those of Luce et al. (1979), and Hakim and Chinkul (1989).

The average homogenization temperature of the three samples collected from the South Prospect was 148° - 164° C, and the average salinity was 3.2 - 5.0 wt % NaCl. The temperature is resemble to that of the Mahd adh Dhahab mine more than that of the Jabal Sayid deposit, but the salinity is relatively high. Of five samples collected from the North Prospect, the homogenization temperature and salinity could be measured for the three samples. The average salinities are higher than that of the South Prospect, and the average homogenization temperature is low contrary to the Jabal Sayid deposits.

Table 2-3-1 Correlation of Mineral Prospects

	Umm ad Damar North Prospect	Umm ad Damar South Prospect	4/6 Gossan Prospect	Jabal Sayid deposit	Mahd adh Dhahab mine
Mineralization type	Disseminated and network-type Cu mineralization in shear zone	Disseminated and network-type Cu-(Zn) mineralization in shear zone	Disseminated and network-type Cu-Zn-(Au?) mineralization in shear zone	Volcanogenic massive sulfide deposits	Vein type Au-Ag-Cu-Zn mineralization
Host rocks	Rhyodacite and dacite of Arj Group	Rhyodacite, andesite, andesitic tuff and dacitic tuff of Arj Group	Rhyodacitic tuff and rhyodacite of Arj Group	Sayid Formation, Arj Group	Haf Formation, Mahd Group
Mineralization age	After deposition of silicic rocks and before intrusion diorite and tonalite			Sayid Formation deposition time	649 Ma (DGMR, 1994)
Alteration	Quartz-chlorite-pyrite	Quartz-chlorite-pyrite	Quartz-chlorite-pyrite	Quartz-chlorite-pyrite	Quartz-pyrite-chlorite-potassium feldspar
Fluid inclusion study	This study: 193°C, 6.2wt%, 161°C, 13.4wt%, 164°C, 14.7wt%	This study: 160°C, 3.2wt%, 164°C, 4.4wt%, 148°C, 5.0wt%	Unknown	This study: 260°C, 8.3wt% Chinkul(1983): 300-400°C, 6.7-7.4wt%	This study: 221°C, 0.9wt% 198°C, 0.2wt% Luce et al., (1979): 142-278°C, 0-0.1wt% Hakim and Chinkul(1989): 100-380°C, 1-4wt%

CHAPTER 4 REGIONAL GEOPHYSICAL SURVEY

4-1 Survey Method

The objectives of the geophysical survey using time domain IP method are to extract IP anomalies related to mineralization in the Umm ad Damar area.

The survey lines (300m interval) are laid out as shown in Figure 2-4-1. Amounts of geophysical survey are as follows; Survey lines: 17 lines, Total length of lines: 55 km, Measuring points: 1,962 points. Resistivity and chargeability of thirty six rock samples in the survey areas were measured in laboratory.

The specifications of measurement are as follows.

Electrode configuration	:	Dipole-dipole array
Interval of measuring points	:	100 m
Electrode separation index	:	1 to 4
Electrode spacing	:	100 m
Observed quantity	:	Electric potential and chargeability
ON / OFF time	:	2 s
Time at the beginning of Vs measurement	:	450 ms
Time at the end of Vs measurement	:	1,100 ms

4-2 Analytic Results (2-D Inversion)

The resistivity maps of 2 levels (SL 900 m and SL 800 m) are shown in Figures 2-4-2 and 2-4-3. The high resistivity zones more than 1,000 ohm-m are distributed throughout the survey area, except in the shallow zone. The low resistivity zones of less than 100 ohm-m in the shallow zone are distributed in the flat parts and have the largest thickness of about 50m. In the map of SL 900m (the depth of about 50m below the surface), relatively lower resistivity zones correspond to the flat parts, as a whole. In the map of SL 800m (the depth of about 150m below the surface), the high resistivity zones of more than 1,000 ohm-m are distributed in almost all of the survey area. While, low resistivity areas in the deeper zone were detected at station B-1, station B-8, station H-22, station J-22, station J-14 and station Q-35.

The chargeability maps of 2 levels (SL 900 m and SL 800 m) are shown in Figures 2-4-4 to 2-4-5. In the shallow zone, the background value covers, except for the weak chargeability anomaly detected in the vicinity of the North Prospect on lines G to I. In the deeper level of SL 800m, the strong chargeability anomalies of more than 24 mV/V were extracted in the three zones around station B-12, station J-25 and station M-27.

The anomaly zone around station B-12 exceeding 50 mV/V is the strongest in this area and tends to extend to line A. The anomaly zone around station J-25 has a NW-SE direction and continues to line K. The anomaly zone around station M-27 exhibits a N-S direction and tends to continue up to line P. All of these anomaly zones show vertical structure.

The laboratory test results and geologic information led to the following resistivity and chargeability features regarding the rocks and geologic structure in this area.

The resistivity of the rocks in this area is high on the whole, judging from the laboratory test. In this area, gravel on the surface and weathered zone under gravel are mainly assumed to form low resistivity. In addition, graphite and fracture zone might cause low resistivity. The laboratory test results for gossan shows that relatively low resistivity is distributed in the shallow and oxidized mineralization zone. However, the laboratory test results show that high resistivity is distributed in deeper mineralization zone containing a large amount of network-like sulfide minerals (mainly pyrite).

The laboratory test results show that the background value of chargeability of this area is low. The sulfide minerals (mainly pyrite) are firstly assumed to cause strong chargeability anomaly. However, the laboratory test results for the gossan show that weak chargeability anomaly is detected where pyrite was oxidized in the shallow zone. A layer containing a large mount of graphite seems to cause strong chargeability anomaly, but it is inferred that lower resistivity is detected, as anomaly becomes stronger.

The above strong chargeability anomalies in the deeper zone reflect the distribution of steep-dipping mineralized zone containing network-like sulfide minerals (mainly pyrite), since they are high in resistivity and vertical in structure. Both anomalous zones of the B-12 and M-27 are expected to be covered by thick gravel and weathered zone under gravel, since low resistivity is distributed in the shallow zone.

In the shallow zone, the weak anomaly zone extracted on lines G to J seems to be attributed to mineralization zone containing oxidized sulfide minerals, since it is relatively low in resistivity and is located in the North Prospect.

Table 2-4-1 Results of the Laboratory Tests in the First Phase

Sample No.	Rock Name	Resistivity (ohm-m)	Chargeability (mV/V)	Remarks
1	Altered andesitic tuff	7,139	8.93	Epidotization
2	Andesite	37,186	3.32	brecciated
3	Andesitic arenite conglomerate	28,073	3.48	conglomeratic
4	Andesitic tuff	61,765	2.06	with dotted epidote
5	Andesitic tuff	33,484	1.47	
6	Andesitic tuff	24,642	3.32	
7	Dacite	35,685	1.81	qtz-feldsparphenocryst, glassy
8	Dacitic crystal tuff	24,208	4.85	Matrix glassy
9	Dacitic crystal tuff	21,823	6.21	yellow epidote veinlets
10	Dacitic crystal tuff	15,106	3.79	qtz-feldspar big crystal
11	Dacitic crystal tuff	6,566	7.56	sheared, glassy
12	Dacitic tuff	9,719	5.53	glassy, hematite weal stain, w/qtz
13	Dacitic tuff	44,731	0.91	
14	Dacitic vitric tuff	22,429	3.11	
15	Rhyodacite	27,956	2.21	qtz phenocryst, groundmass glassy
16	Rhyodacite	4,052	6.05	groundmass glassy
17	Rhyodacitic tuff breccia	18,351	3.81	
18	Grennschist	4,257	3.92	with Ox-Cu stain, qtz veinlet
19	Grennschist	4,491	3.42	with Ox-Cu stain
20	Jasper	58,490	3.18	with specularite veinlets
21	Jasper (chert)	39,583	2.03	
22	Diorite	34,628	1.94	Microdiorite
23	Diorite	40,338	1.41	Microdiorite
24	Diorite	16,969	3.00	Microdiorite
25	Diorite	11,540	7.26	Microdiorite
26	Diorite	23,455	2.96	Microdiorite, w/epidote, qtz veinlet
27	Diorite	64,956	3.24	with epidote, porphyritic
28	Quartz diorite (Tonalite?)	26,194	4.00	
29	Quartz diorite (Tonalite?)	21,016	4.10	
30	Epidote-carbonate rock	11,409	6.79	Andesite?
31	Gossan	62	14.80	4/6 Gossan, brecciated
32	Gossan	3,560	2.89	UAD South, silicified
33	Gossan	722	9.75	UAD South
34	Gossan	256	5.67	UAD North, silicified
35	Silicified ore	9,594	115.24	UAD-6 core, Pyrite 20%
36	Slag	50,850	1.17	UAD North

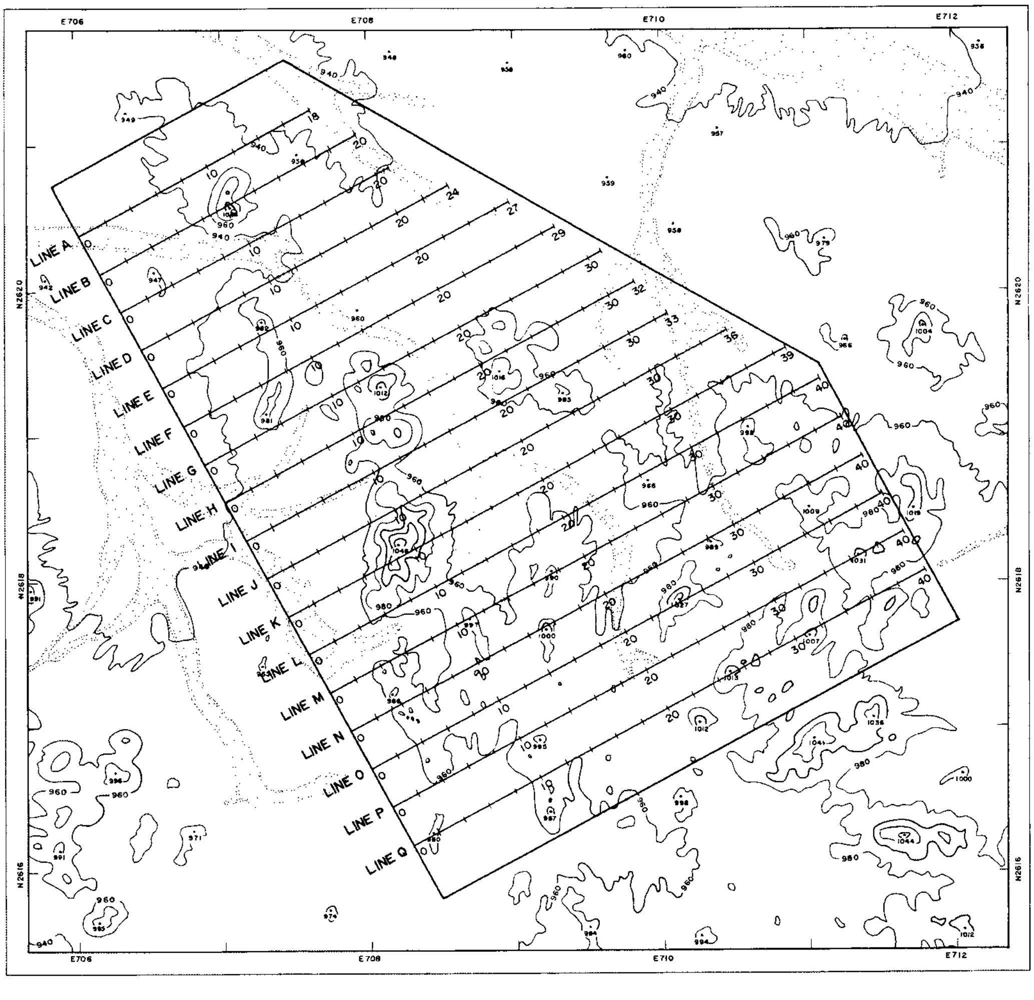


Fig.2-4-1 Location Map of IP Survey Lines in the First Phase

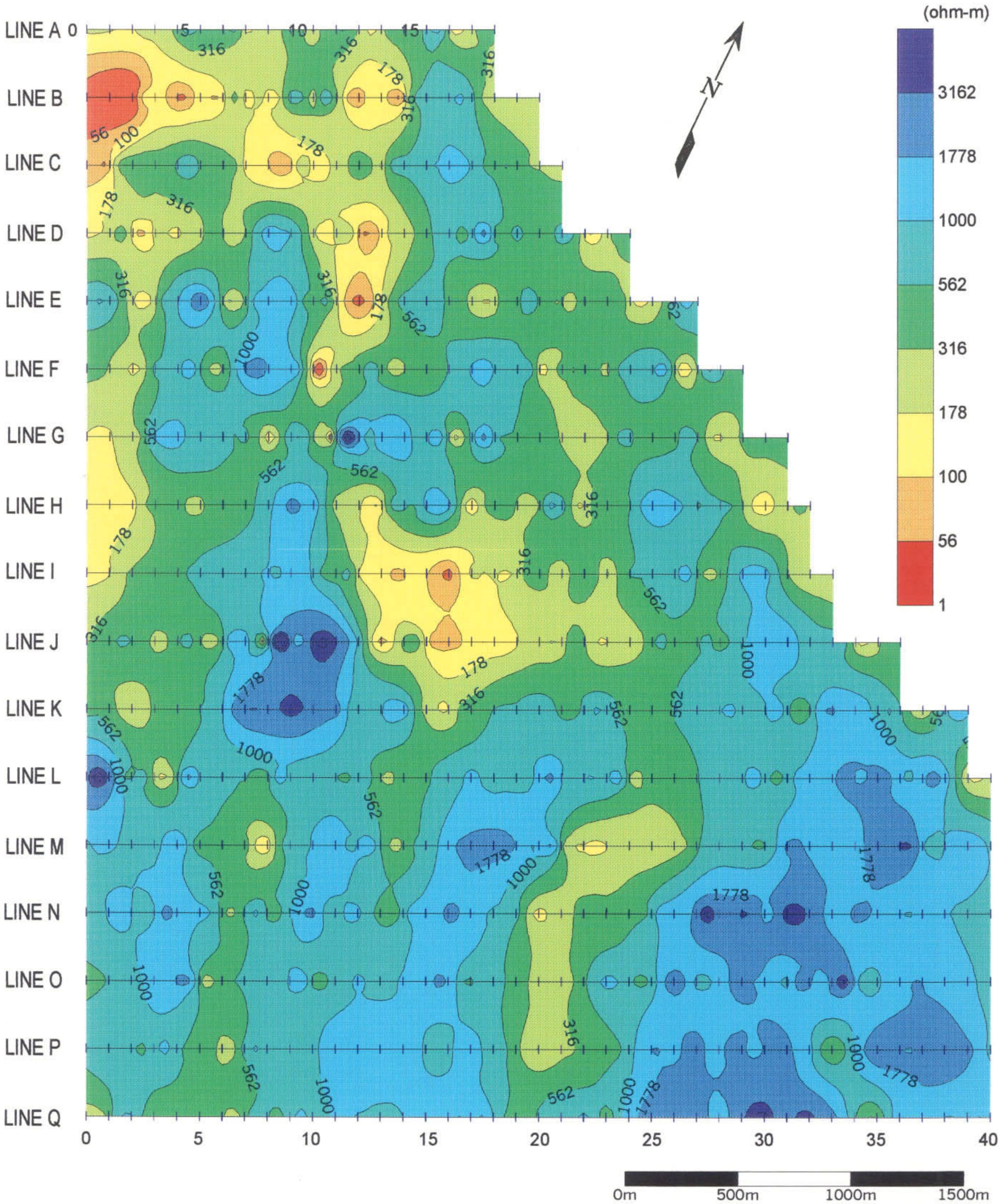


Fig. 2-4-2 Resistivity Map (SL 900m)

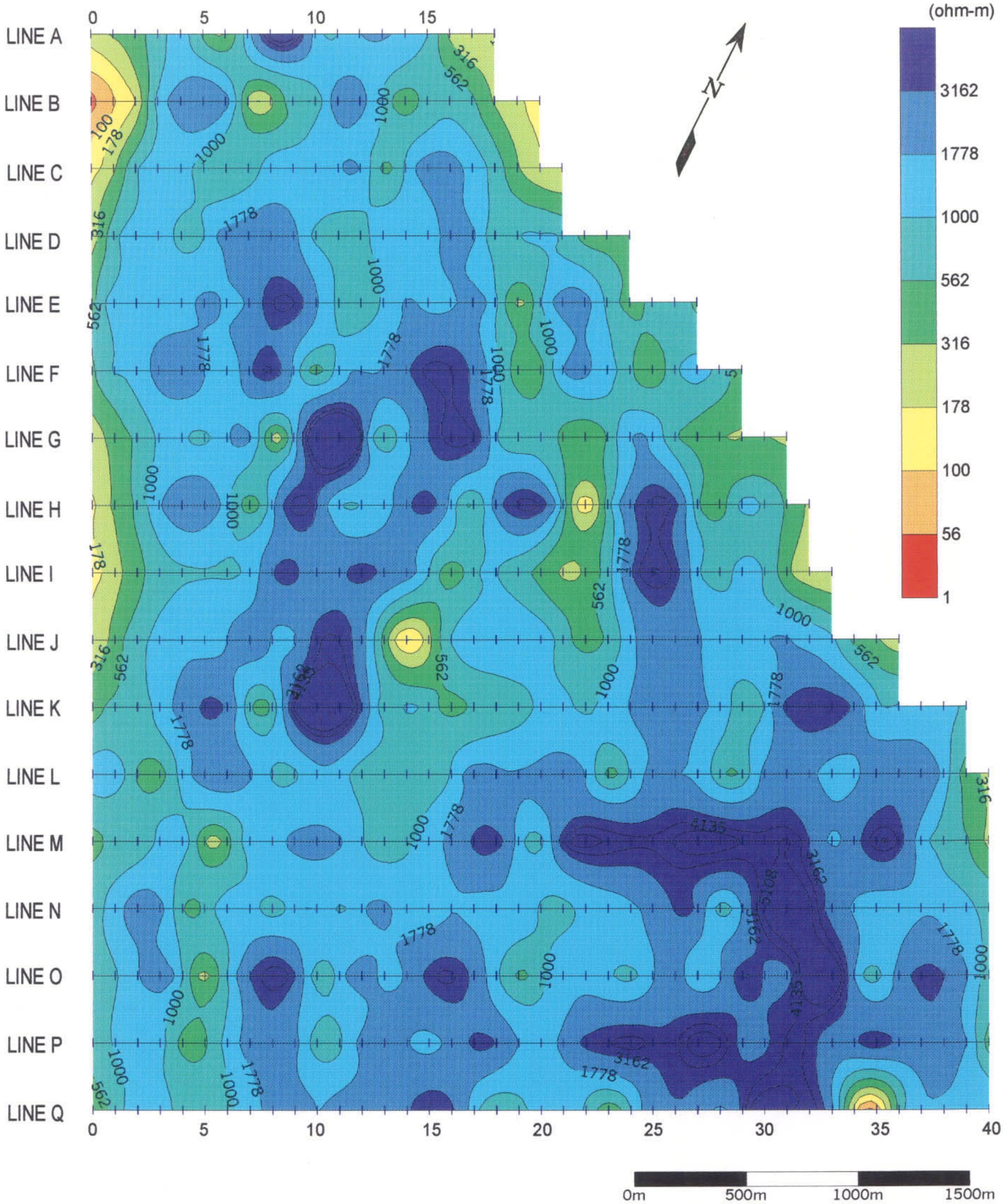


Fig. 2-4-3 Resistivity Map (SL 800m)

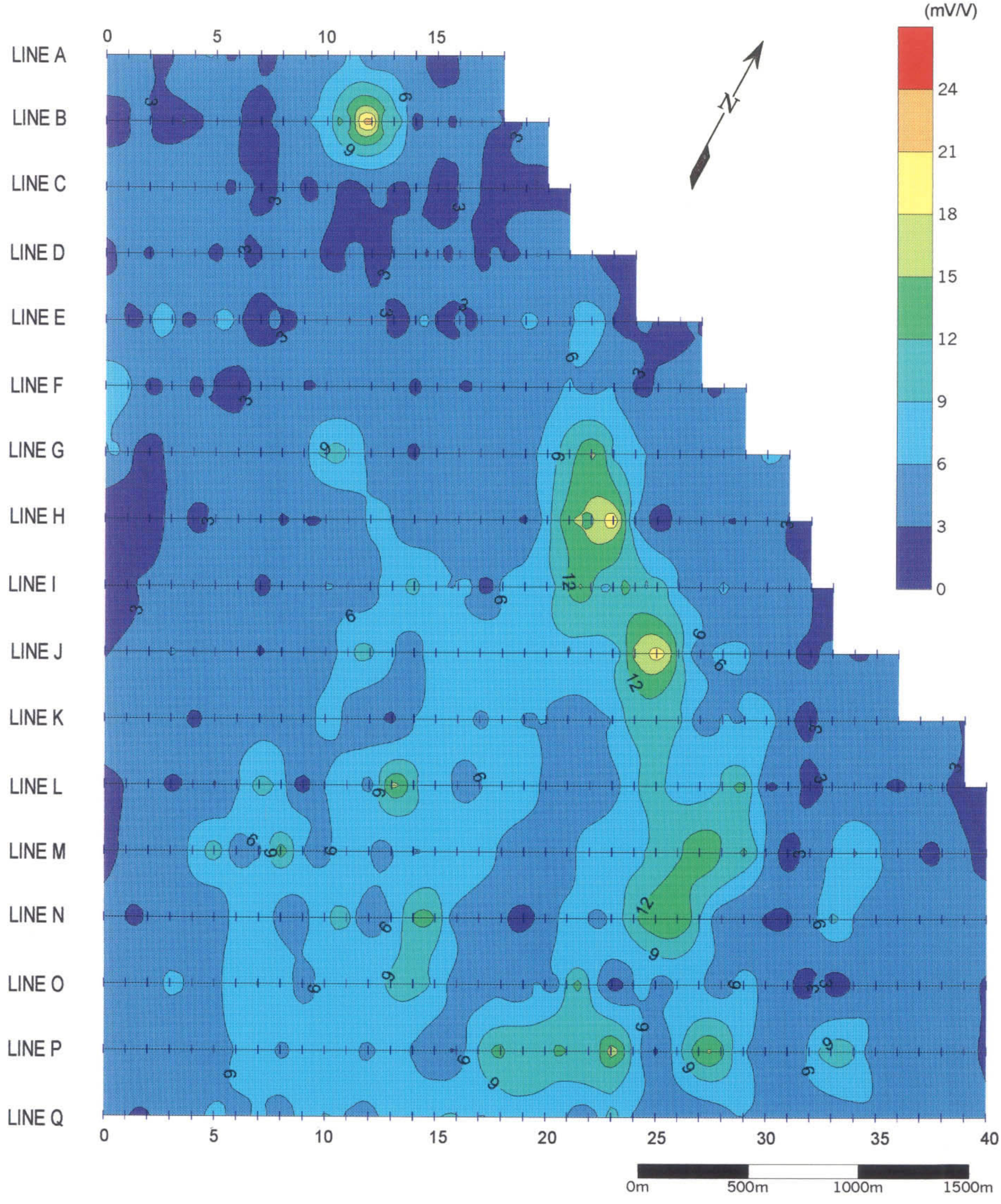


Fig. 2-4-4 Chargeability Map (SL 900m)

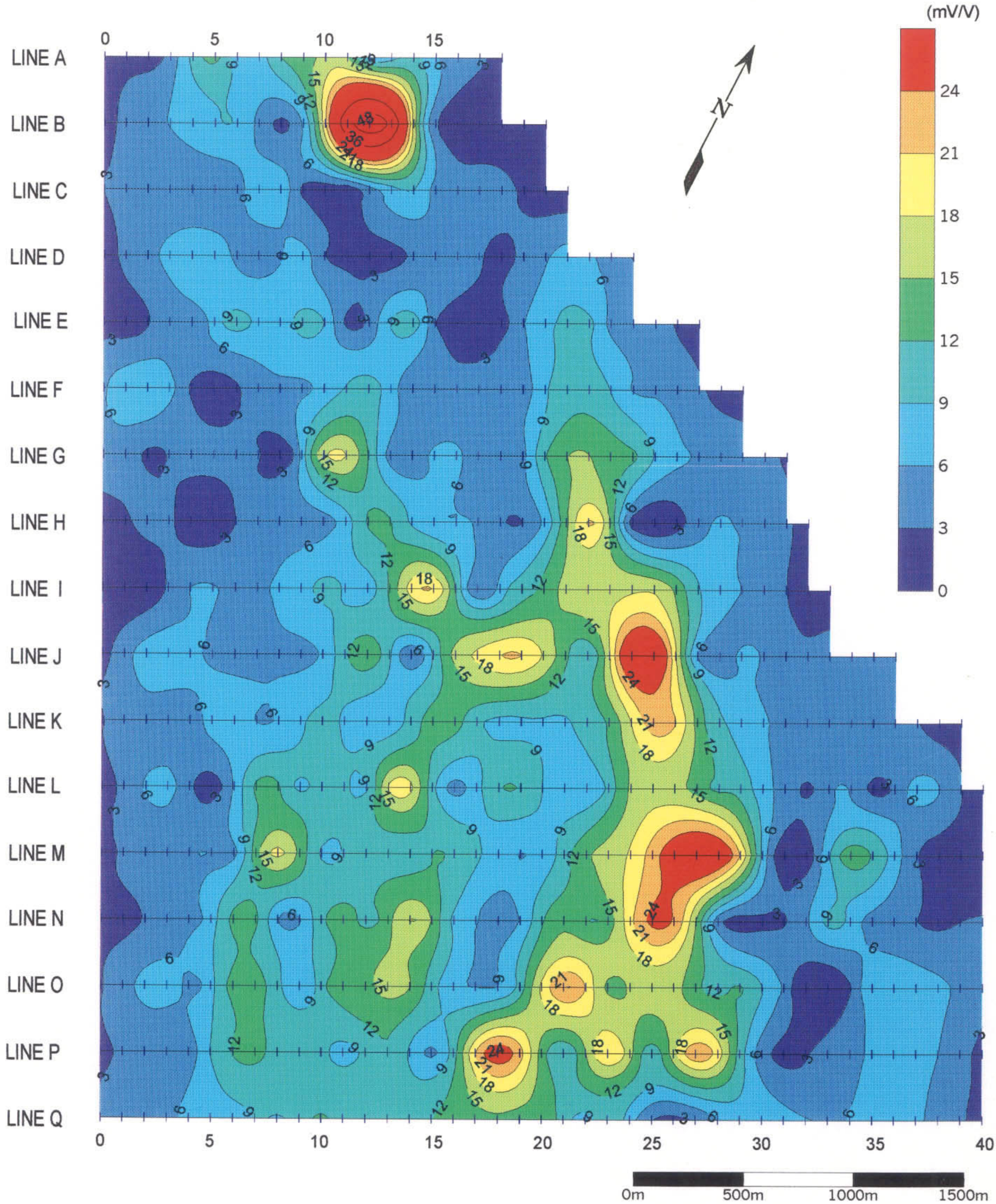


Fig. 2-4-5 Chargeability Map (SL 800m)

CHAPTER 5 DETAILED IP SURVEY

5-1 Exploration Method

The objective of detailed IP survey is to clarify the continuity and the center of chargeability anomalies for the three anomalous zones (B-12, M-27, and P-18) extracted by the regional IP survey.

The survey lines are laid out in high chargeability anomalous areas (around B-12, M-27 and P-18) as shown in Figure 2-5-1. Amounts of IP survey are as follows; Survey lines: 10 lines, Total length of lines: 10 km, Measuring points: 260 points. Resistivity and chargeability of thirty-seven rock samples in the survey area were measured in laboratory.

The interval of the survey lines is 100 m. The other specifications of the measurement are same as the regional IP survey.

5-2 Survey Results

The high resistivity zones of more than 500 ohm-m are distributed throughout the whole survey area, except in the shallow zone. The low resistivity zones of less than 100 ohm-m are distributed partly in the shallow. In the deep zone, low resistivity is detected only at station 98B-8.

The chargeability maps of 2 levels (SL 900 m and SL 800 m) are shown in Figures 2-5-2 and 2-5-3. The results of the regional geophysical survey in the first phase are also shown in these figures.

The extension and location of high chargeability anomalies in the three areas is summarized as followings.

(1) B-12

The large and high chargeability anomaly detected in line-98B is also detected in line-99A and line-99B. The anomaly trends to extend in the WNW-ESE direction. The chargeability in the central part of the anomaly exceeds 50 mV/V.

(2) M-27

The high chargeability anomaly extending in the N-S direction detected in line-98M and line-98N forms two anomalies of northern and southern parts. The northern anomaly around station M-27 occurs in oval-shape extending in the NE-SW direction.

(3) P-18

The high chargeability anomaly detected around station P-18 extends northward and continues to station O-21.

The result of the laboratory tests is shown in Table 2-5-1. The ore sampled from the drilling core (MJSU-2) have low resistivity of 25 ohm-m and high chargeability exceeding 500 mV/V. The host rocks in this area have high resistivity of more than 2,000 ohm-m and low chargeability of less than of 10 mV/V. However breccia containing pyrite and tuff have relatively high chargeability (mean value of 23 mV/V).

The laboratory test results show that rocks in this area generally have high resistivity and low chargeability, while the ore has low resistivity and high chargeability. Consequently the target for the geophysical survey in this area is low resistivity and high chargeability zone within high resistivity and low chargeability environment.

Table 2-5-1 Results of Laboratory Test in the Second Phase

Drill Hole No.	Sample No.	Depth From [m]	Depth To [m]	Rock Name	Resistivity [Ω－m]	Chargeability [mV/V]
MJSU-2	202G	122.40	122.45	Breccia ore	41	459.3
MJSU-2	204G-1	131.10	131.15	Massive ore	21	619.0
MJSU-2	204G-2	ditto	ditto	ditto	26	656.3
MJSU-2	205G-1	141.20	141.25	Massive ore	16	505.8
MJSU-2	205G-2	ditto	ditto	ditto	19	555.9
MJSU-2	201G	116.95	117.05	Basaltic tuff	1,503	5.6
MJSU-2	203G	129.00	129.10	Rhyodacitic lapilli tuff	221	2.5
MJSU-2	206G	144.50	144.60	Rhyodacitic lapilli tuff	2,515	4.1
MJSU-3	204C	204.00	204.10	Porphyritic dacite (intrusive)	3,952	9.1
MJSU-3	232C	232.55	232.65	Dacite	2,785	4.5
MJSU-3	241C	241.40	241.50	Porphyritic dacite (intrusive)	10,710	33.0
MJSU-7	40C	40.15	40.25	Rhyodacitic lapilli tuff	1,437	16.5
MJSU-7	56C	56.65	56.75	Rhyodacitic lapilli tuff	1,600	7.1
MJSU-7	74C	74.85	74.95	Basaltic fine tuff, with pyrite veinlets, pyrite 20%	40	63.7
MJSU-7	81C	81.45	81.55	Rhyodacitic coarse tuff	1,487	7.8
MJSU-7	149C	149.45	149.55	Rhyodacitic lapilli tuff	852	4.5
MJSU-8	16C	16.65	16.70	Porphyritic basalt (intrusive)	2,361	3.5
MJSU-8	28C	28.50	28.55	Porphyritic basalt (intrusive)	1,662	3.1
MJSU-8	38C	38.35	38.40	Silicified rock, rhyodacitic tuff?, pyrite 10%	3,423	19.6
MJSU-8	58C	58.40	58.50	Rhyodacitic coarse tuff	8,364	6.7
MJSU-8	95C	95.80	95.85	Volcanic breccia, pyrite 10%	1,440	11.4
MJSU-8	124C	124.00	124.10	Pumiceous breccia, pyrite 10%	802	8.9
MJSU-8	143C	143.35	143.40	Pumiceous breccia, pyrite 10%	2,055	35.9
MJSU-8	167C	167.15	167.20	Pumiceous breccia, pyrite 10%	111	138.2
MJSU-8	181C	181.75	181.85	Pumiceous breccia, pyrite 5%	1,732	7.7
MJSU-8	193C	193.00	193.10	Porphyritic andesite (intrusive)	12,043	4.9
MJSU-8	206C	206.50	206.55	Pumiceous breccia, pyrite 5%	13,747	18.5
MJSU-8	218C	218.80	218.90	Andesite (intrusive)	2,038	2.2
MJSU-8	236C	236.30	236.40	Breccia, pyrite 5%, oxidized	1,417	8.4
MJSU-8	239C	239.40	239.50	Breccia	6,447	42.4

No. of Samples	Localities	Rock Name	Resistivity [Ω－m]	Chargeability [mV/V]
K0021406	Northeast of MJSU-7	Rhyodacite, glomeroporphyritic	31,691	2.6
K0021407	ditto	Porphyritic dacite	16,475	2.2
K0021408	East of MJSU-7	Rhyodacite, porphyritic	12,324	2.9
K0022401	M-27 chargeability Anomaly	Strongly silicified rock, w/hematite	482	1.7
K0022402	ditto	Porphyritic andesite	23,576	1.0
K0022404	ditto	Porphyritic dacite	26,451	2.5
K0022405	Umm ad Damar South Prospect	Epidotized andesite	47,839	0.8
K0022406	ditto	Andesitic pyroclastic rock	26,554	2.6
K0022407	ditto	Microdiorite	33,264	3.4

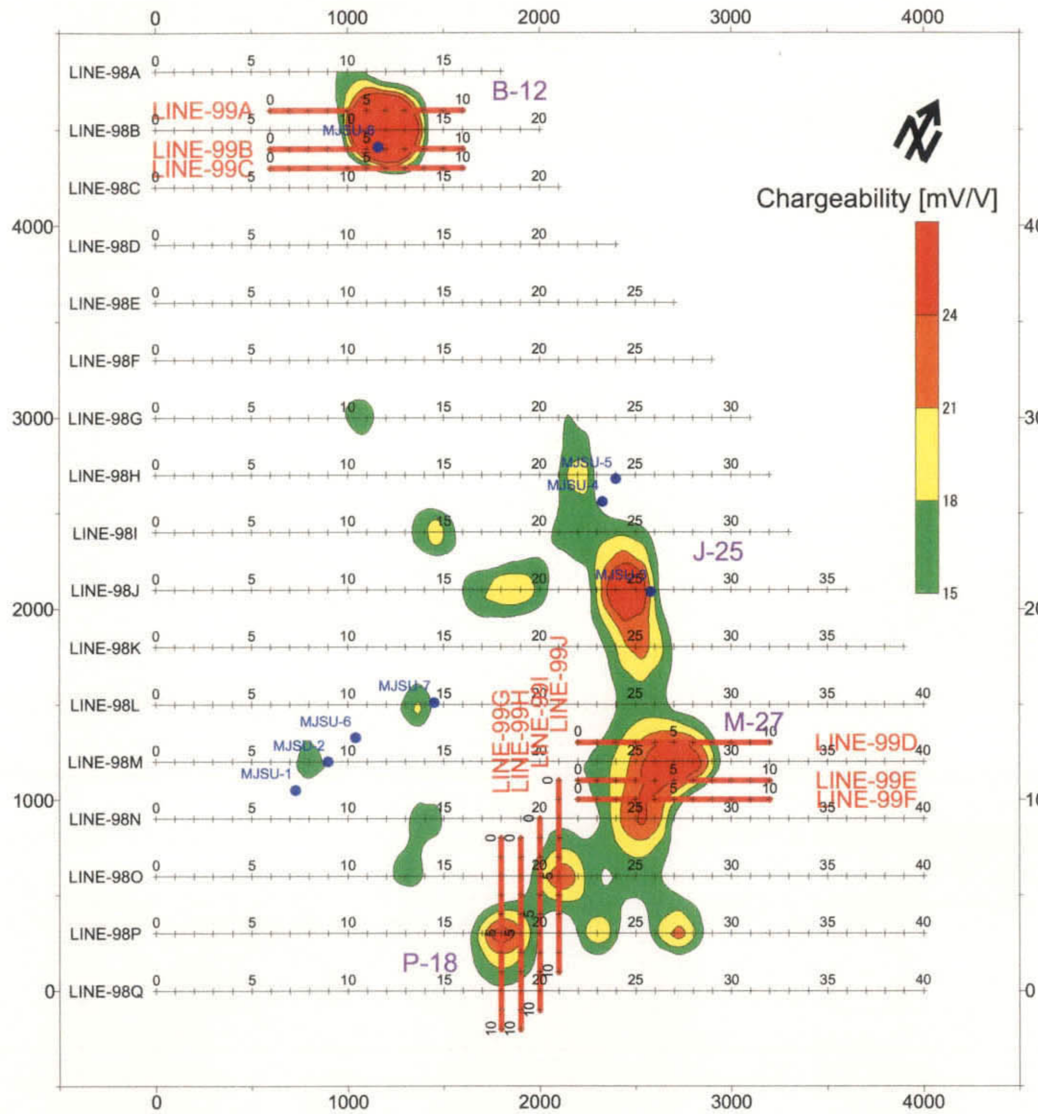


Fig.2-5-1 Location Map of IP Survey Lines in the Second Phase

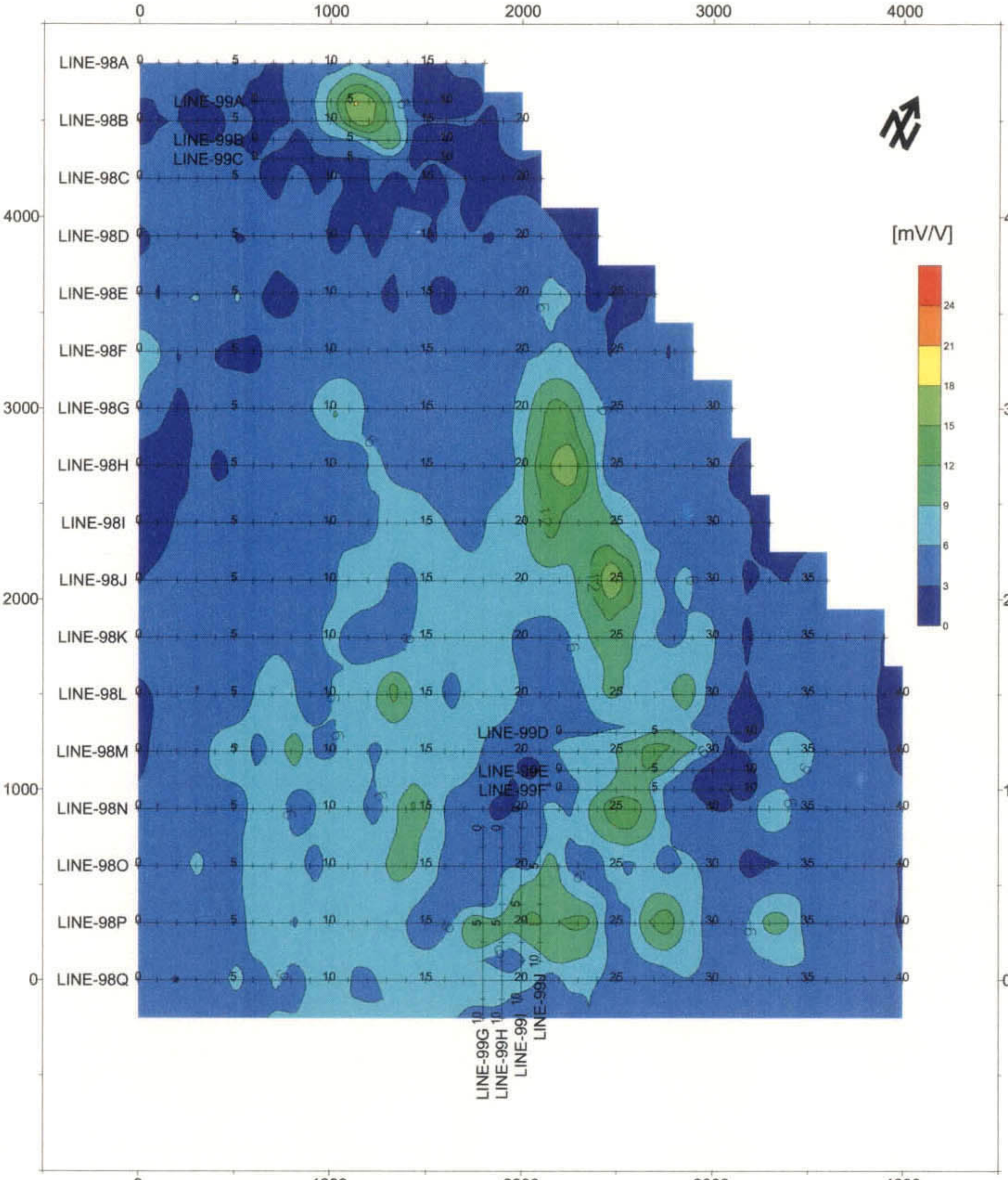


Fig.2-5-2 Chargeability Map (SL:900m)

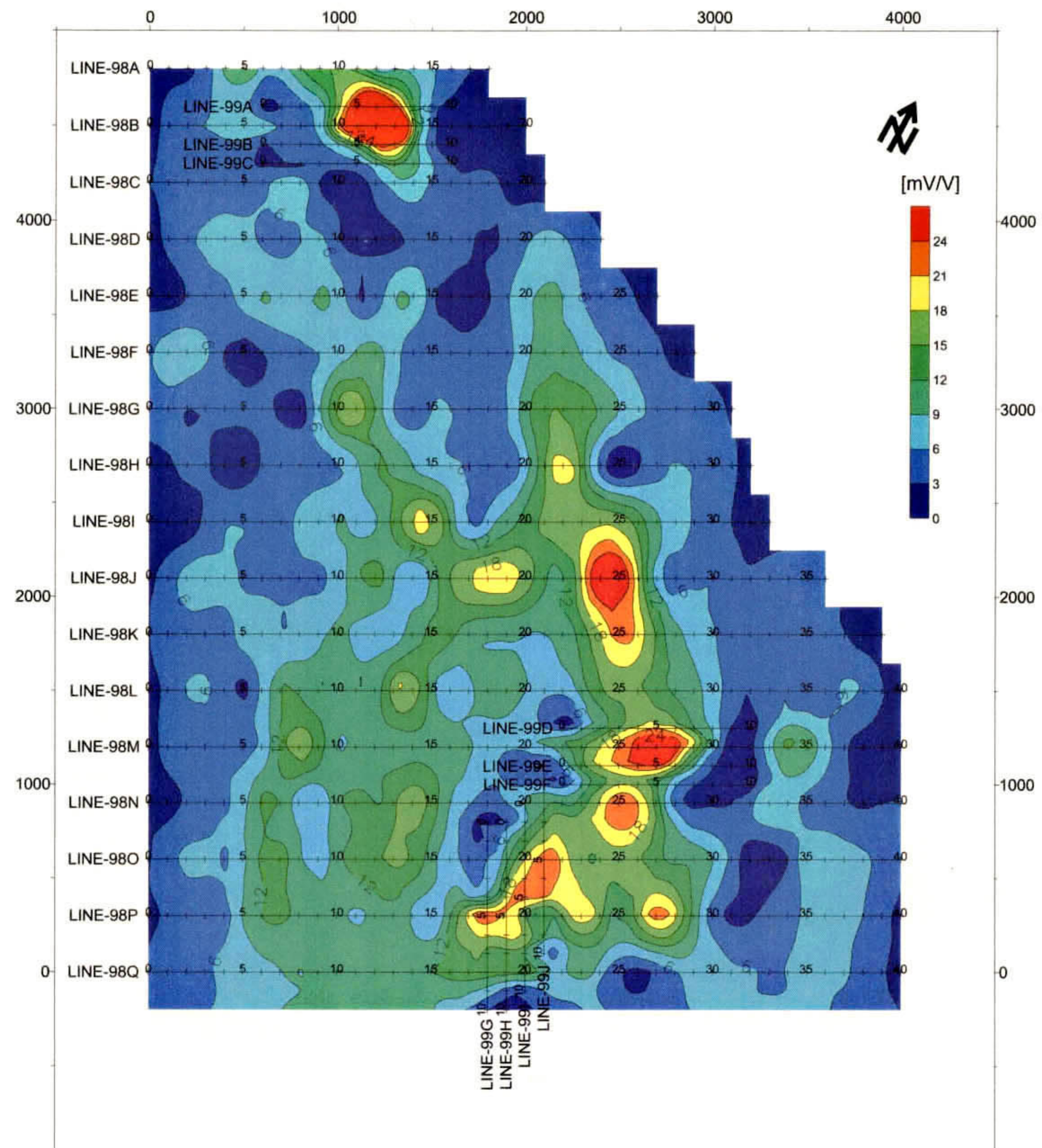


Fig.2-5-3 Chargeability Map (SL:800m)

CHAPTER 6 TEM SURVEY

6-1 Exploration Method

The objective of TEM survey is to clarify the presence of massive sulfide deposits or vein type deposits and to estimate the sizes and the localities of the deposits. TEM survey was carried out in IP anomalous zones extracted by previous IP survey. Five areas were selected as TEM survey areas on the basis of the results of the IP survey and detailed geological survey. The areas were named TB-12, TJ-18, TM-27, TO-21 and TP-18 (Fig. 2-6-1).

Amounts of TEM survey are as follows; Survey Line: 31 lines, Amount of Measuring - Points Fixed Loop: 319 points, Central Induction: 164 points - .

The specifications of the configuration are as follows.

Transmitter loop size	: 200m×400m
Interval of measurement line	: 50m (across the estimated deposit)
Interval of measurement point	: 25 m
Transmitter current	: 4.1 amperes
Measurement frequency	: 30 Hz
Sampling time	: 86.7 μ sec to 7.03 msec.
Sampling component	: x, y, z

The central induction measurement was also carried out in order to obtain resistivity values. The interval of measurement points was 50 m.

6-2 Analytic Results

The results of one-dimensional inversion and two-dimensional plate modeling are the follows.

(1) TB-12

The resistivity structure has three layers. The resistivity of the second layer is less than several hundreds ohm-m and those of the other layers are more than several thousands ohm-m. The depth of the second layer is 10-100 m and its thickness is several tens of meters (Fig. 2-6-2).

One plate is estimated to extend in the NE-SW direction. The conductance is 1.1 to 2.0 s and the dip of the plate is 80° to the south. The depth of the plate is 300 m from Line+150 to Line+50 and steadily decreases from Line0. At Line-150, the depth is 100 m (Fig. 2-6-3).

(2) TJ-18

The resistivity structure has two layers. The resistivity of the upper layer is less than 100 ohm-m and that of the lower layer is more than 1,000 ohm-m. The depths of both layers are constant at several tens meters. The upper layer probably shows a weathered zone and the lower layer shows a fresh rock zone (Fig. 2-6-4).

Three plates are estimated to be almost parallel to NE-SW. The conductance is 2.0 to 2.9 s and the dip of the plates is 90° . The depth of the central plate is 200～270 m. The depth of NW plate is 150～200 m while the SE plate is constant at 140 m (Fig. 2-6-5).

(3) TM-27

The resistivity structure section by the one-dimensional inversion is shown in Fig.2-6-6. The resistivity structure has two layers. The resistivity of the upper layer is less than 100 ohm-m and that of the lower layer is more than 1,000 ohm-m. The depths of both layers are constant at several tens meters except for Line+100. The upper layer probably shows a weathered zone and the lower layer shows a fresh rock zone (Fig. 2-6-6).

The estimated plate from two-dimensional plate modeling is shown in. Two plates are estimated to extend northeastward. The conductance of the central plate is 2.0 to 2.5 s, the dip is 90° , and the depth is constant at 200 m. The conductance of the southern plate is 3.0 s, the dip is 90° , and the depth is constant at 150 m (Fig. 2-6-7).

(4) TO-21

The resistivity structure has two layers. The resistivity of the upper layer is less than 100 ohm-m and that of the lower layer is more than 1,000 ohm-m. The depths of both layers gradually change from 10 to 40 m with a tendency at station No.75 to be the deepest. The upper layer probably shows a weathered zone and the lower layer shows a fresh rock zone. There is a discontinuous boundary at station No.250 between Line+150 and Line-50 (Fig. 2-6-8).

One plate is estimated to pass station No.175 of all survey lines. The conductance of the plate is 1.2 to 1.5 s, the dip of the plate is 90° , and the depth is constant at 270 m (Fig. 2-6-9).

(5) TP-18

The resistivity structure has two layers. The resistivity of the upper layer is less than 500 ohm-m and that of the lower layer is more than 1,000 ohm-m. The depths of both layers gradually change from 30 to 100 m with a tendency at station No.225 to be the deepest. The upper layer probably shows a weathered zone and the lower layer shows a fresh rock zone (Fig. 2-6-10).

Two plates are estimated to extend SW-NE, and merge at around station No.50 of Line+50. The conductance of the plates is 1.3 to 2.9 s, the dip is 90° , and the depth is constant at 120 m (Fig. 2-6-11).

TEM survey was carried out on the five IP anomalous zones. Several conductive plates were estimated in each area. The depths of the conductive plates are several hundred meters, the conductance of the plates are from 1 to 3 s and the dips are almost 90° .

In general, a conductive plate shows a fault, groundwater, an alteration zone or a mineralized zone. There are several faults confirmed or estimated in the survey area. These faults were closed and could not contain groundwater because they are Precambrian in age. There is less alteration around mineralized zones according to the drilling survey. Therefore, the conductive plates estimated in this analysis could be mineralized zones.

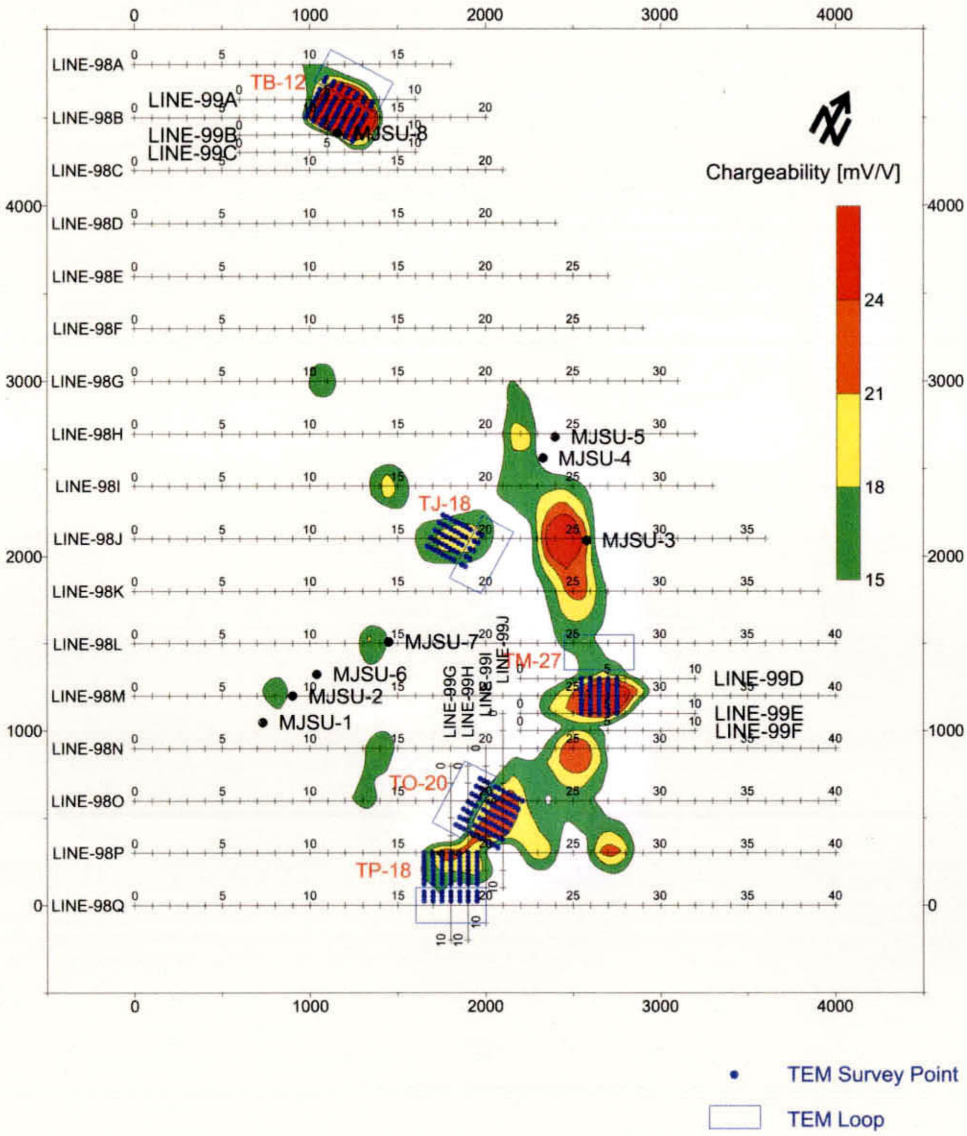


Fig.2-6-1 Location Map of TEM Survey

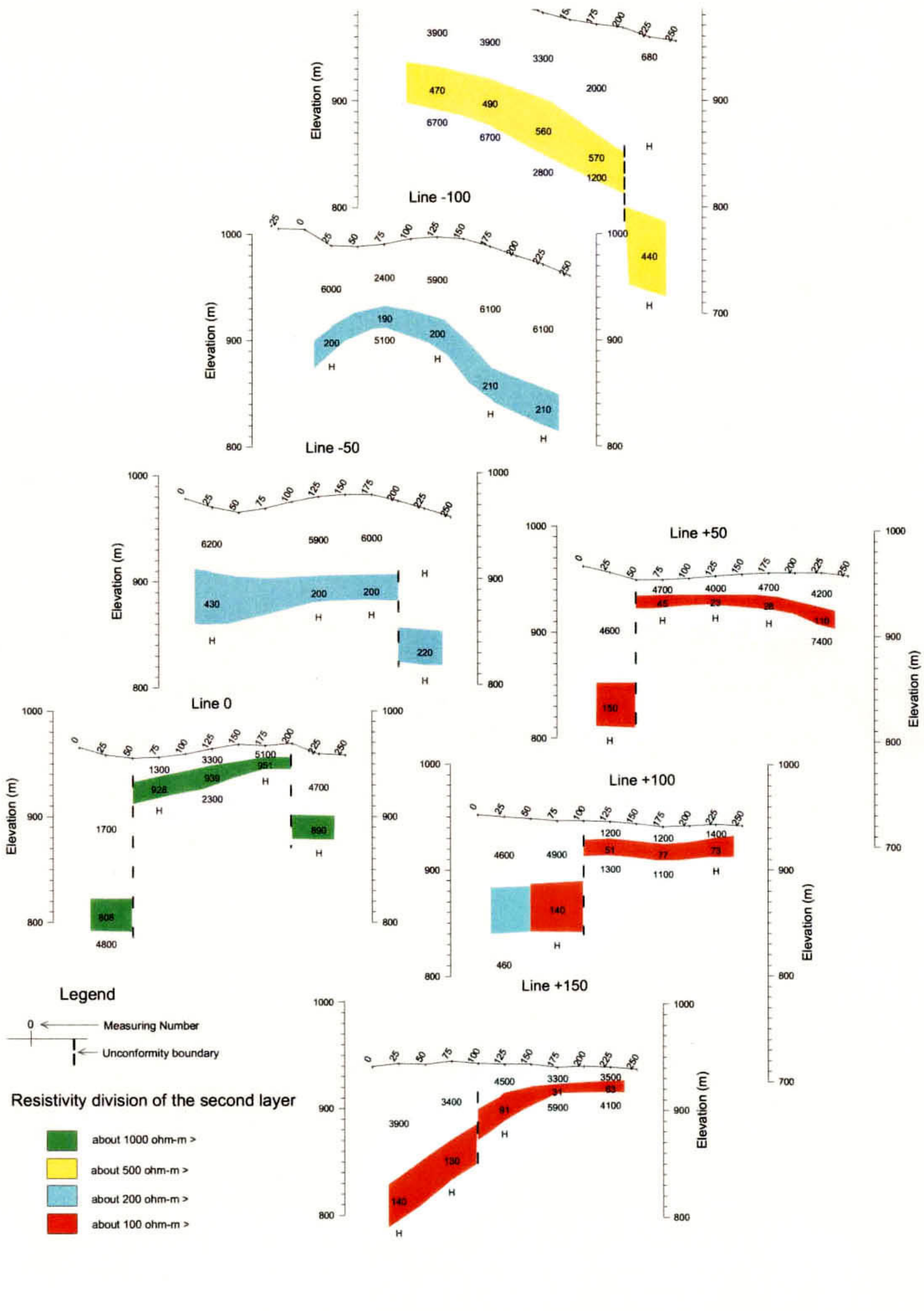


Fig.2-6-2 Resistivity Structure Section (TB-12)

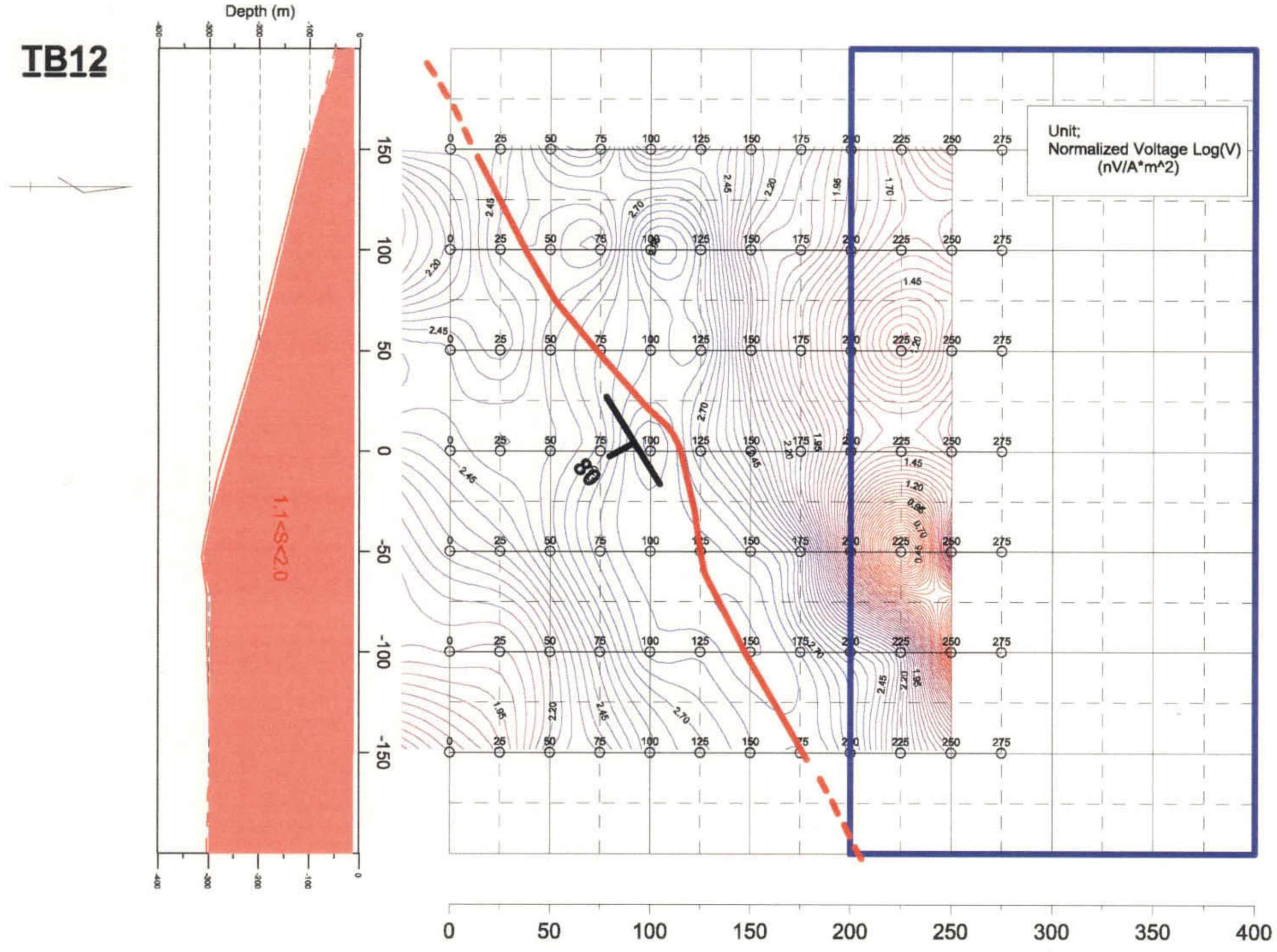


Fig.2-6-3 Estimated Plate from 2-D Plate Modelling (TB-12)

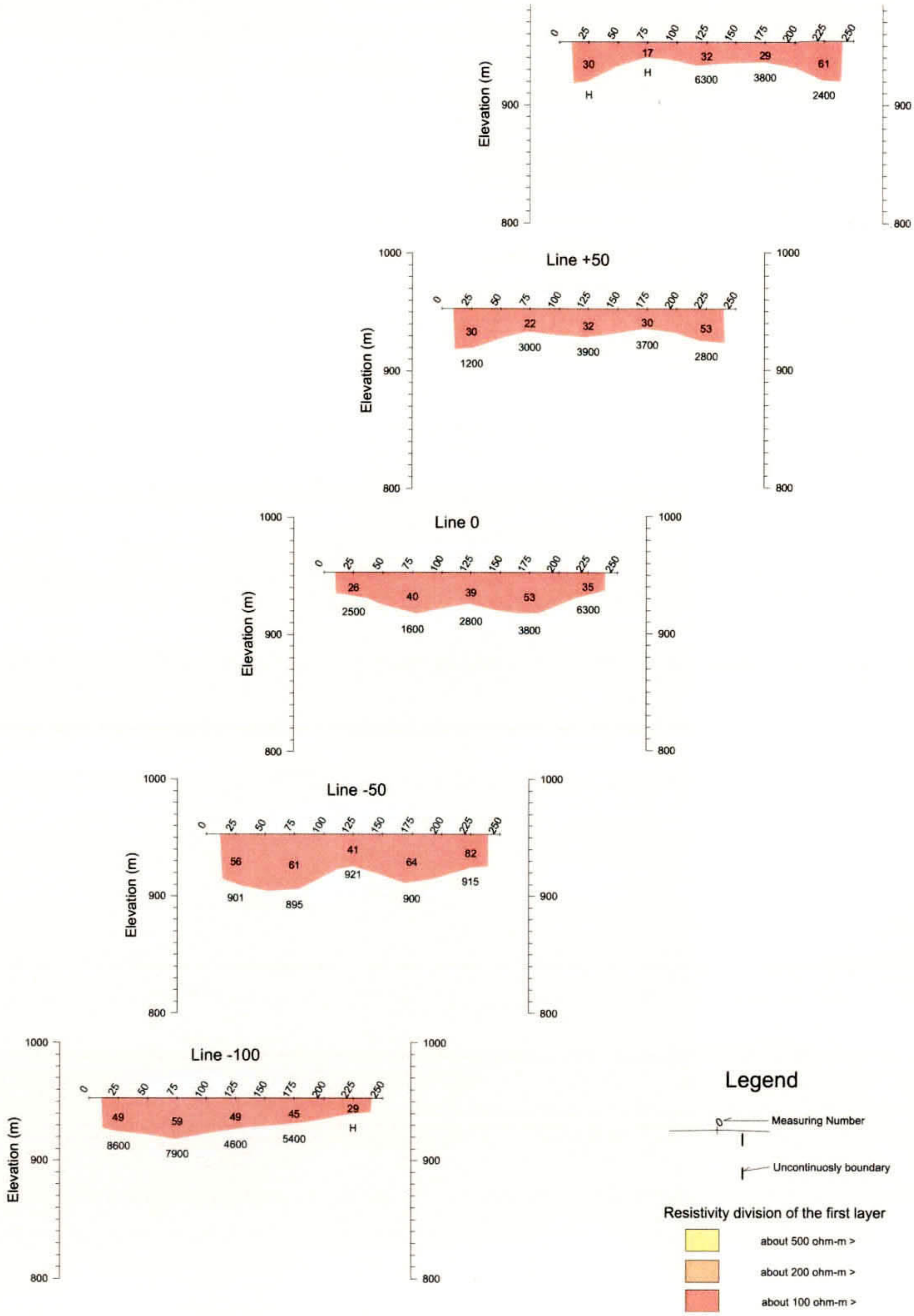


Fig.2-6-4　Resistivity Structure Section (TJ-18)

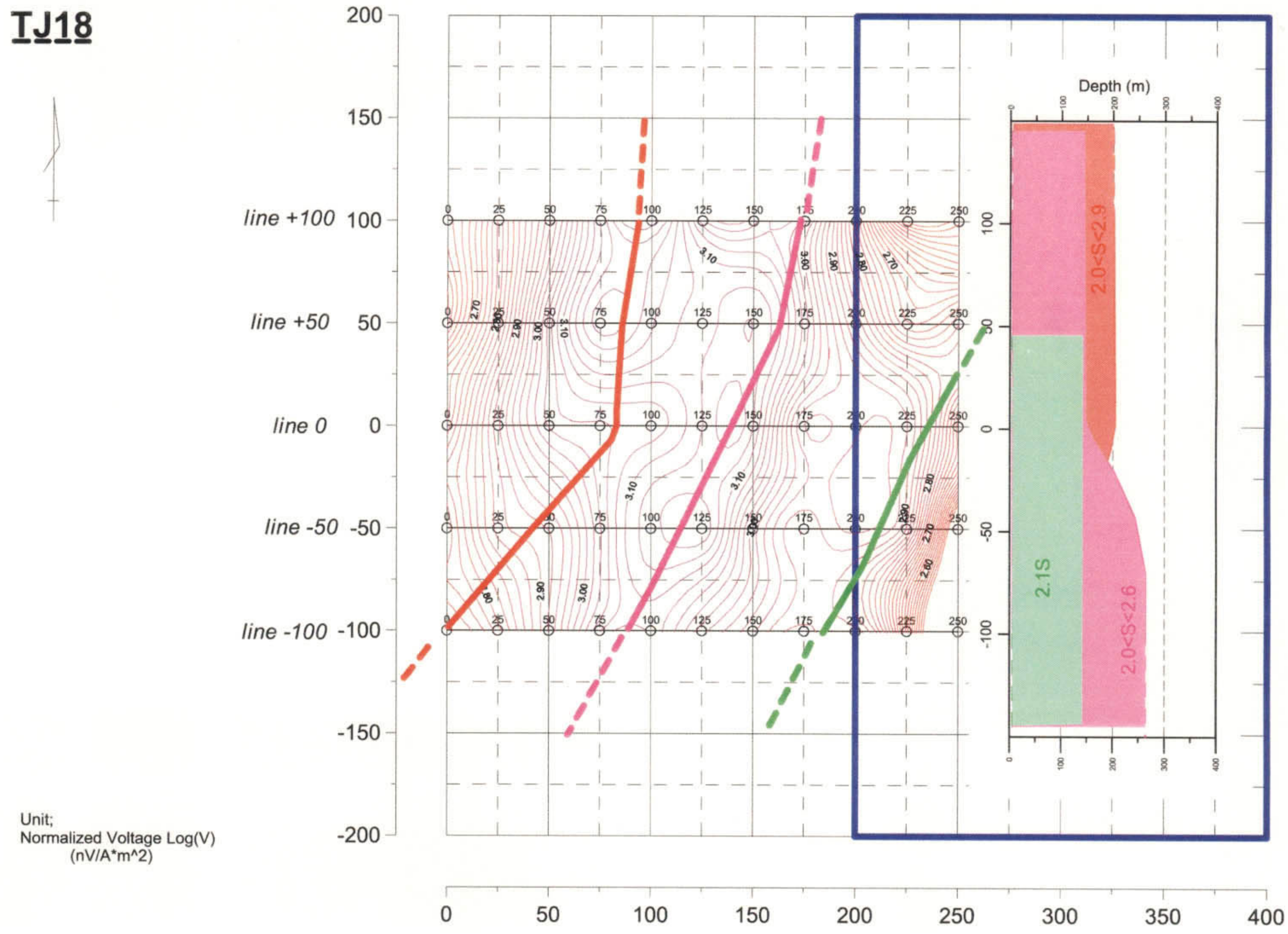


Fig.2-6-5 Estimated Plate from 2-D Plate Modelling (TJ18)

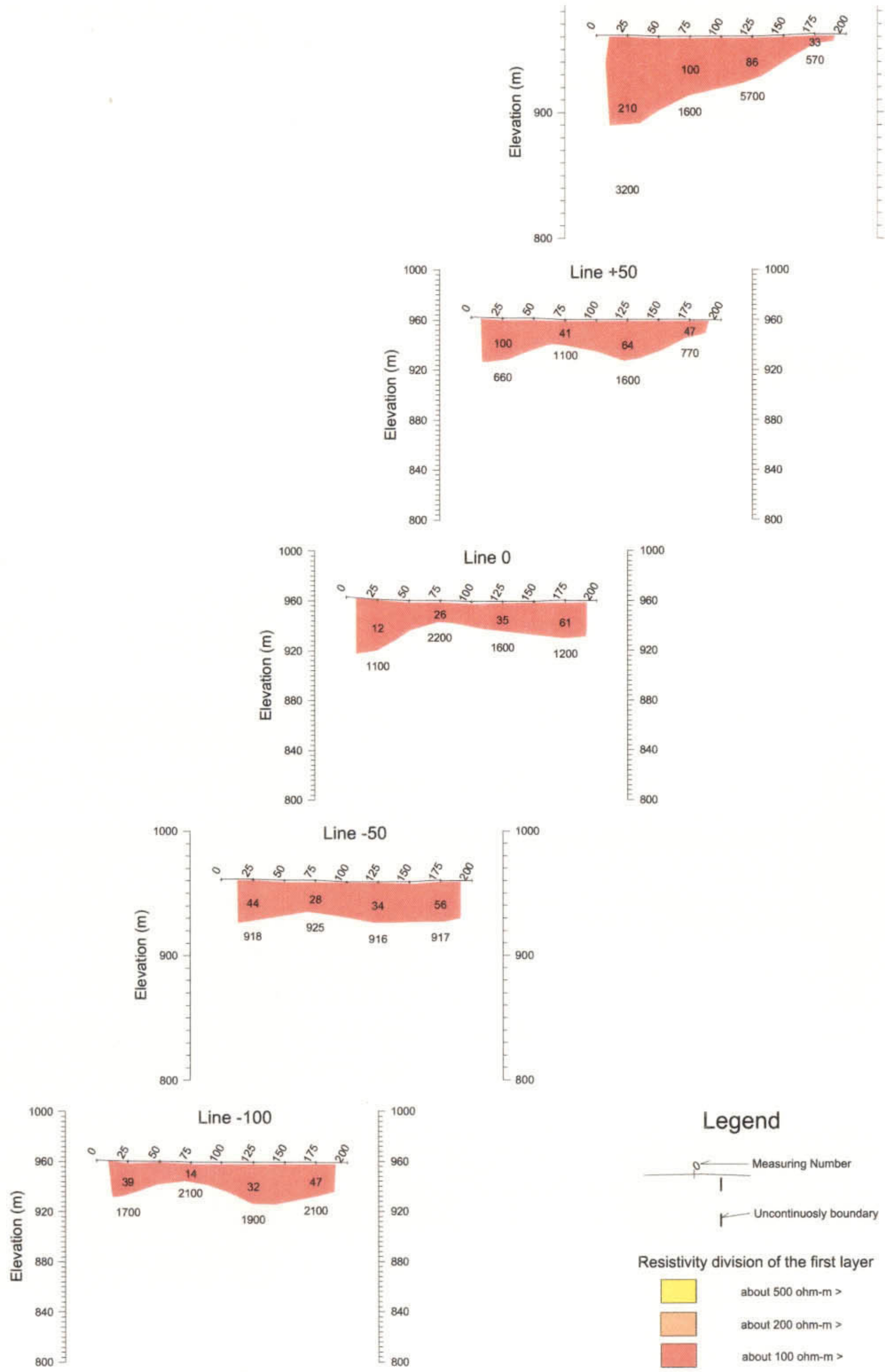


Fig.2-6-6 Resistivity Structure Section (TM-27)

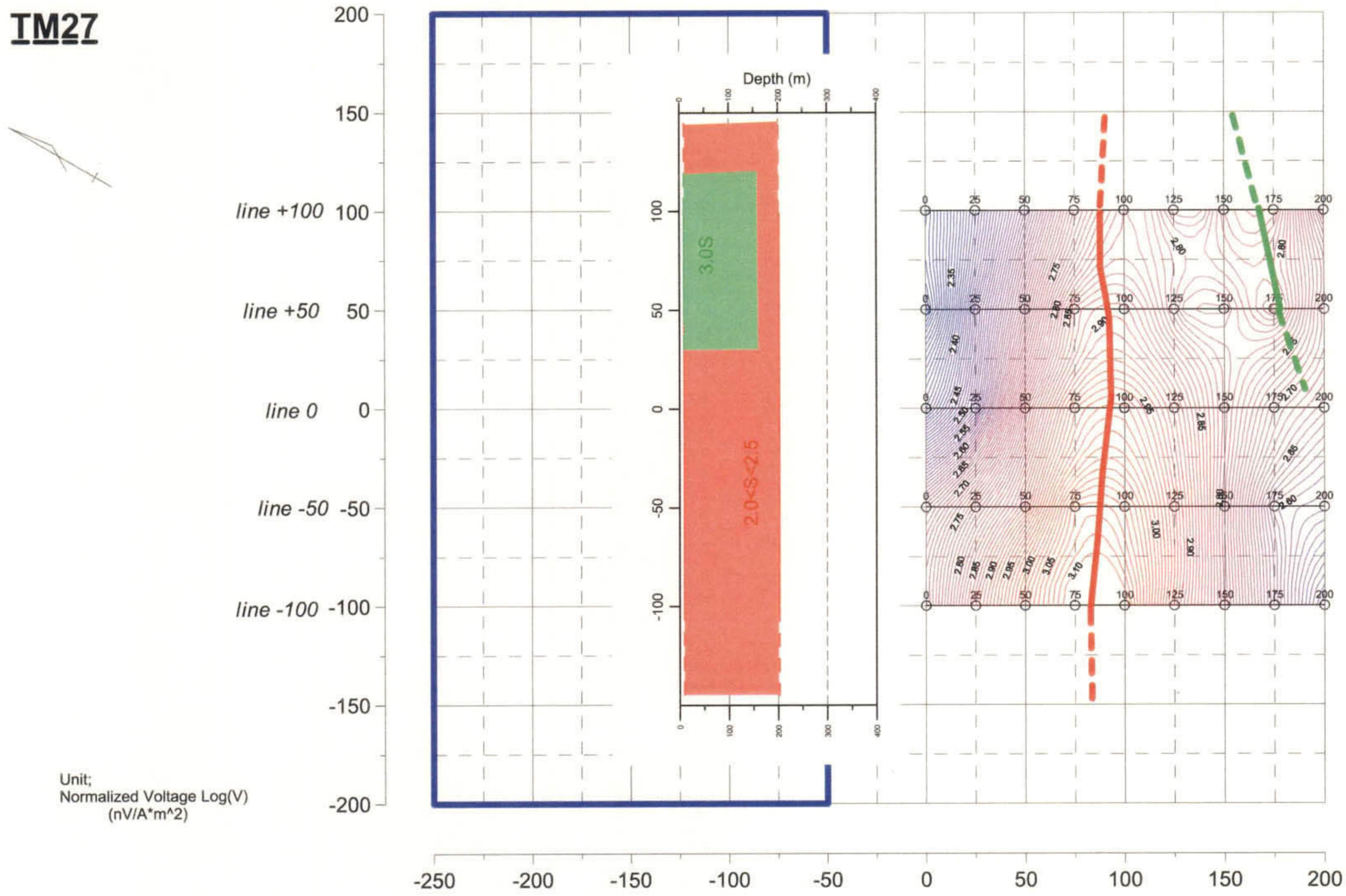


Fig.2-6-7 Estimated Plate from 2-D Plate Modelling (TM-27)

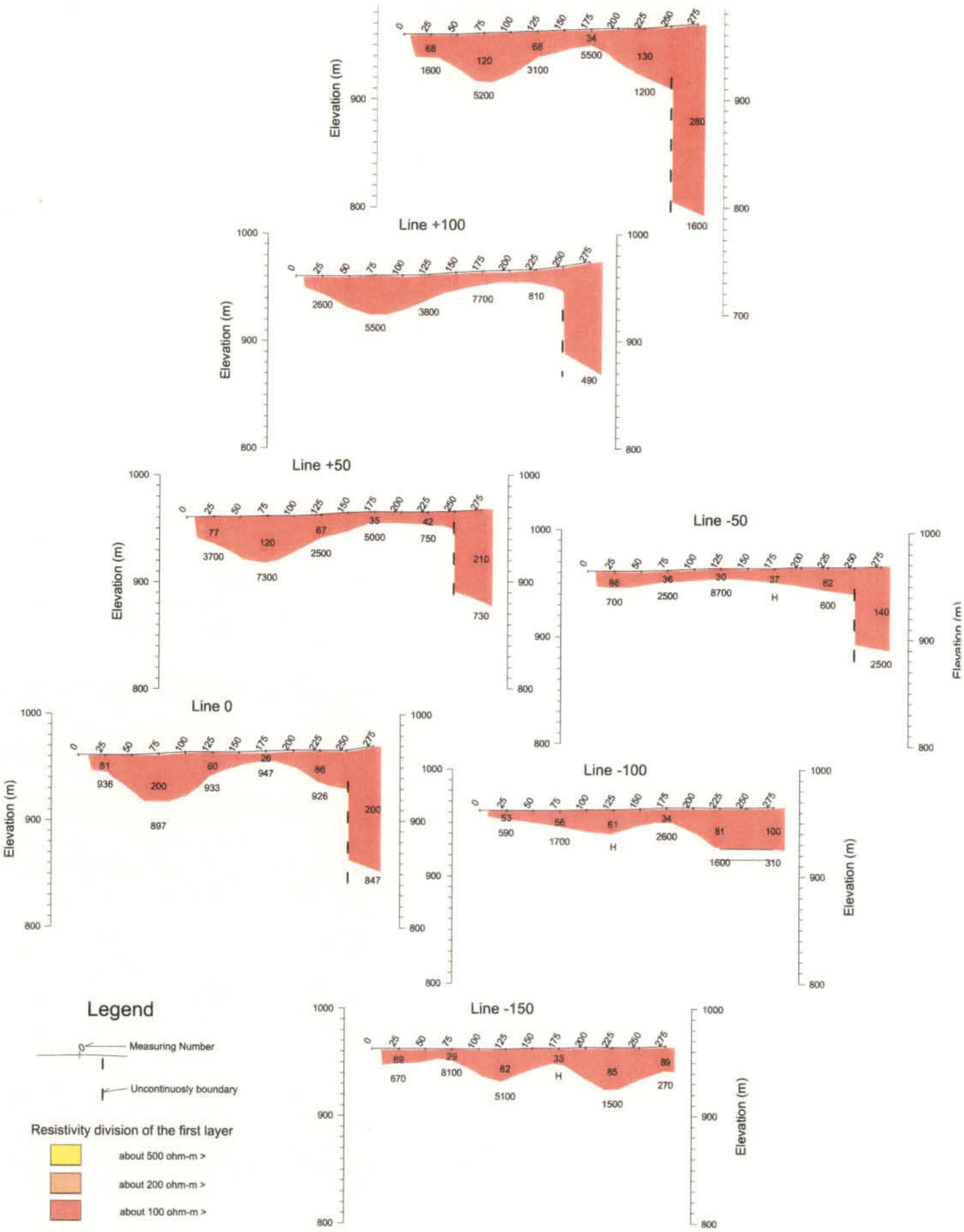


Fig.2-6-8 Resistivity Structure Section (TO-21)

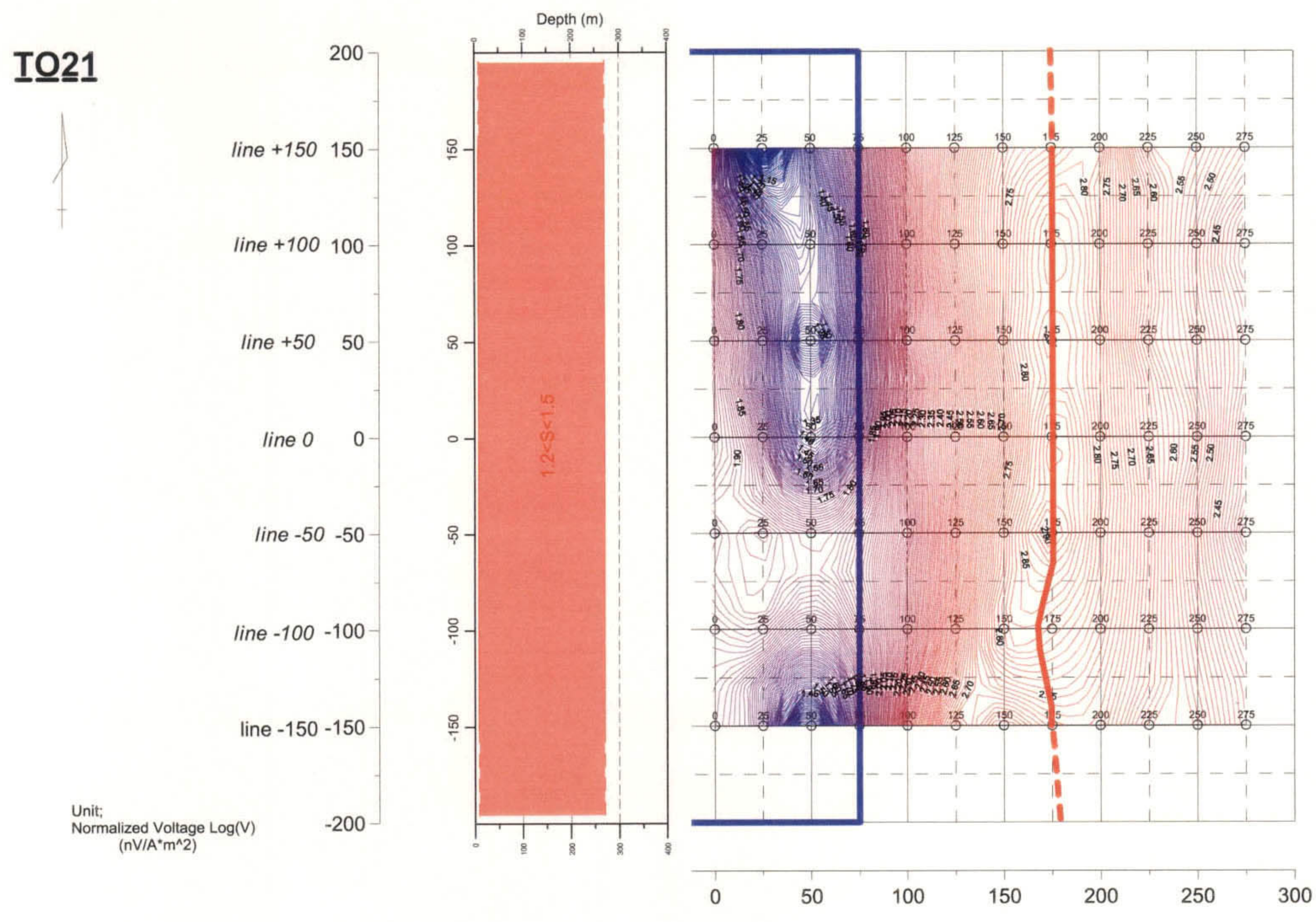


Fig.2-6-9 Estimated Plate from 2-D Plate Modelling (TO-21)

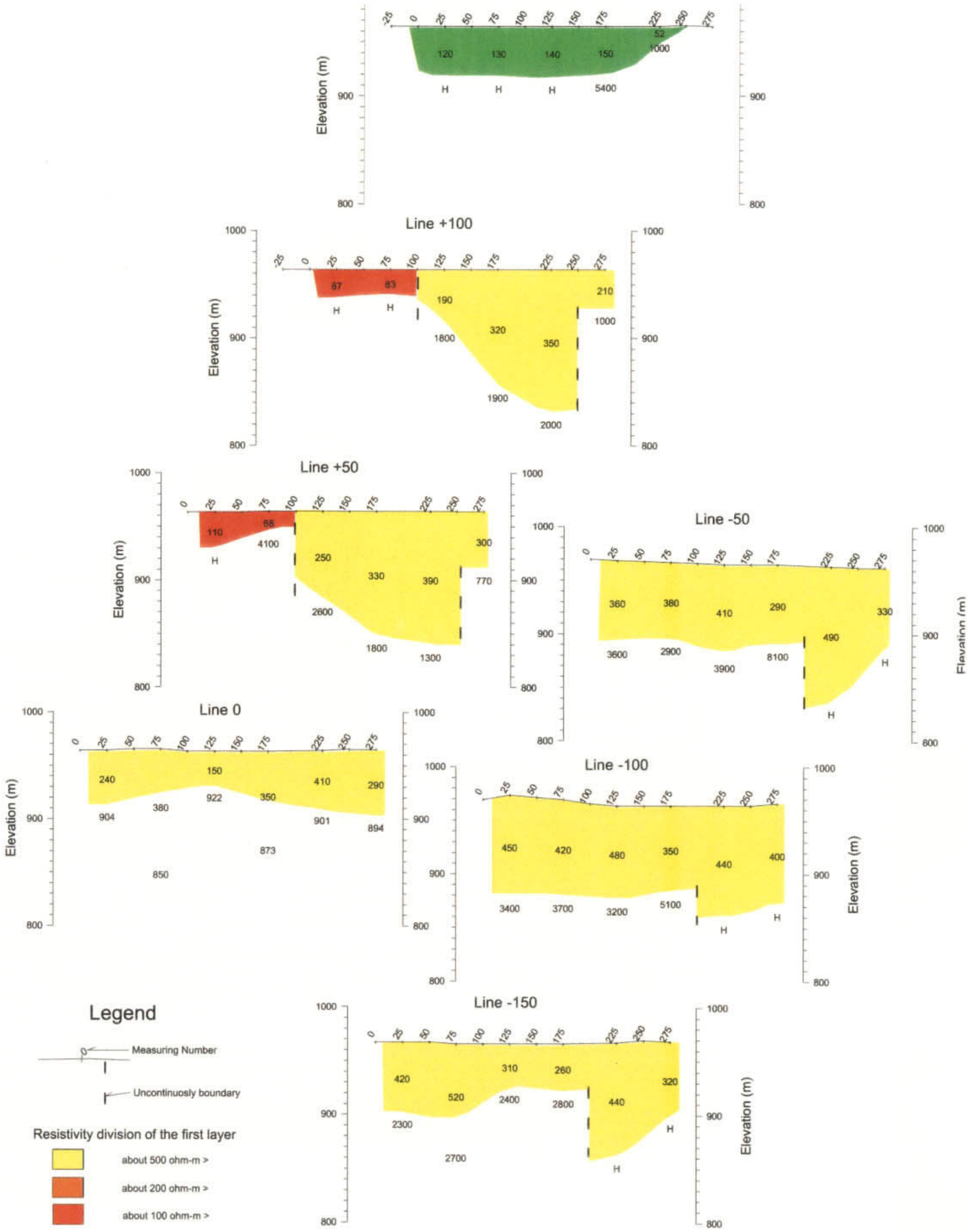


Fig.2-6-10 Resistivity Structure Section (TP-18)

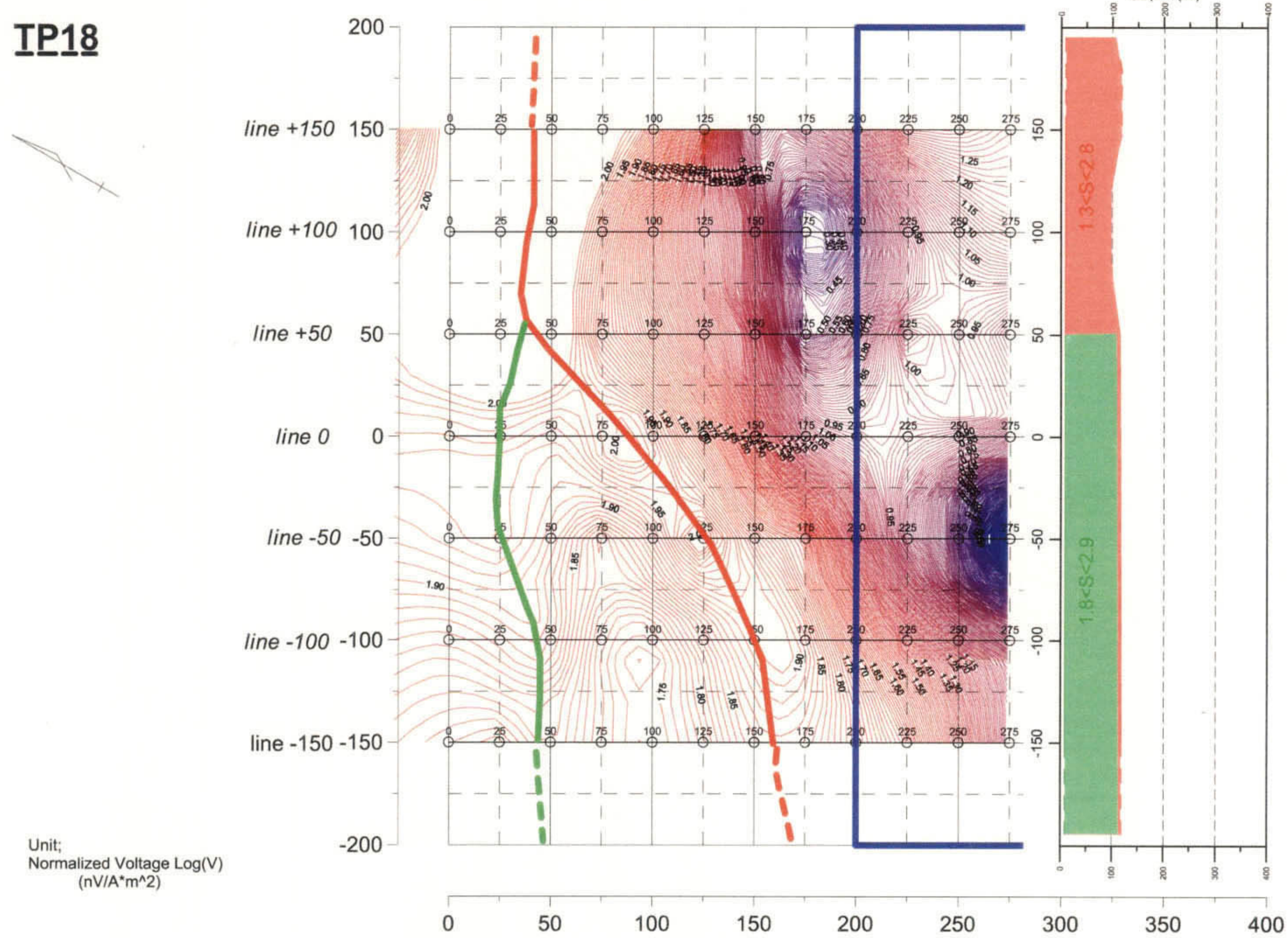


Fig.2-6-11 Estimated Plate from 2-D Plate Modelling

CHAPTER 7 DRILLING EXPLORATION

7-1 Results of Drilling Exploration of Jabal Sujarah

7-1-1 Objectives and locations

A strong chargeability anomaly exceeding 50 mV/V was detected by IP survey during the first year. The anomaly occurred around station 12 of IP traverse B at altitude of 800m (150m below surface). A hole was drilled this second phase to clarify the mineralization of the above anomaly. The results of the detailed IP survey indicate that the extension of higher chargeability anomaly than 20mV/V at altitude of 800m has an area of 400×350 m.

As feature of mineralization and alteration at the surface of this district, strongly carbonatized silicic breccia only crops out at the southwestern part of Jabal Sujarah. Jasper overlies this breccia.

A massive sulfide ore deposit is inferred to occur in this district, as high chargeability anomaly was detected below jasper, and therefore three drill holes, namely MJSU-8, MJSU-9 and MJSU-15, were conducted.

The location, elevation and azimuth of drill holes in this district are shown in Fig.2-7-1 and Appendix 6.

7-1-2 Geology and mineralization of drill hole

Geological sections along each drill hole are shown in Fig.2-7-2～Fig.2-7-4. Results of ore assay, microscopic observation of thin sections and polished sections, and X-ray diffraction analysis of core samples obtained from MJSU-8, MJSU-9, and MJSU-15 are shown in Appendices 1～3 and 5.

(1) MJSU-8

<u>Geology</u>

The geology of this drill hole consists mainly of rhyodacitic lapilli tuff, dacitic lapilli tuff・tuff breccia and intrusive rocks. Porphyritic basalt, porphyritic andesite and andesite constitute the intrusive rocks. Thin shale layers are intercalated between rhyodacitic tuff and dacitic pyroclastic rocks.

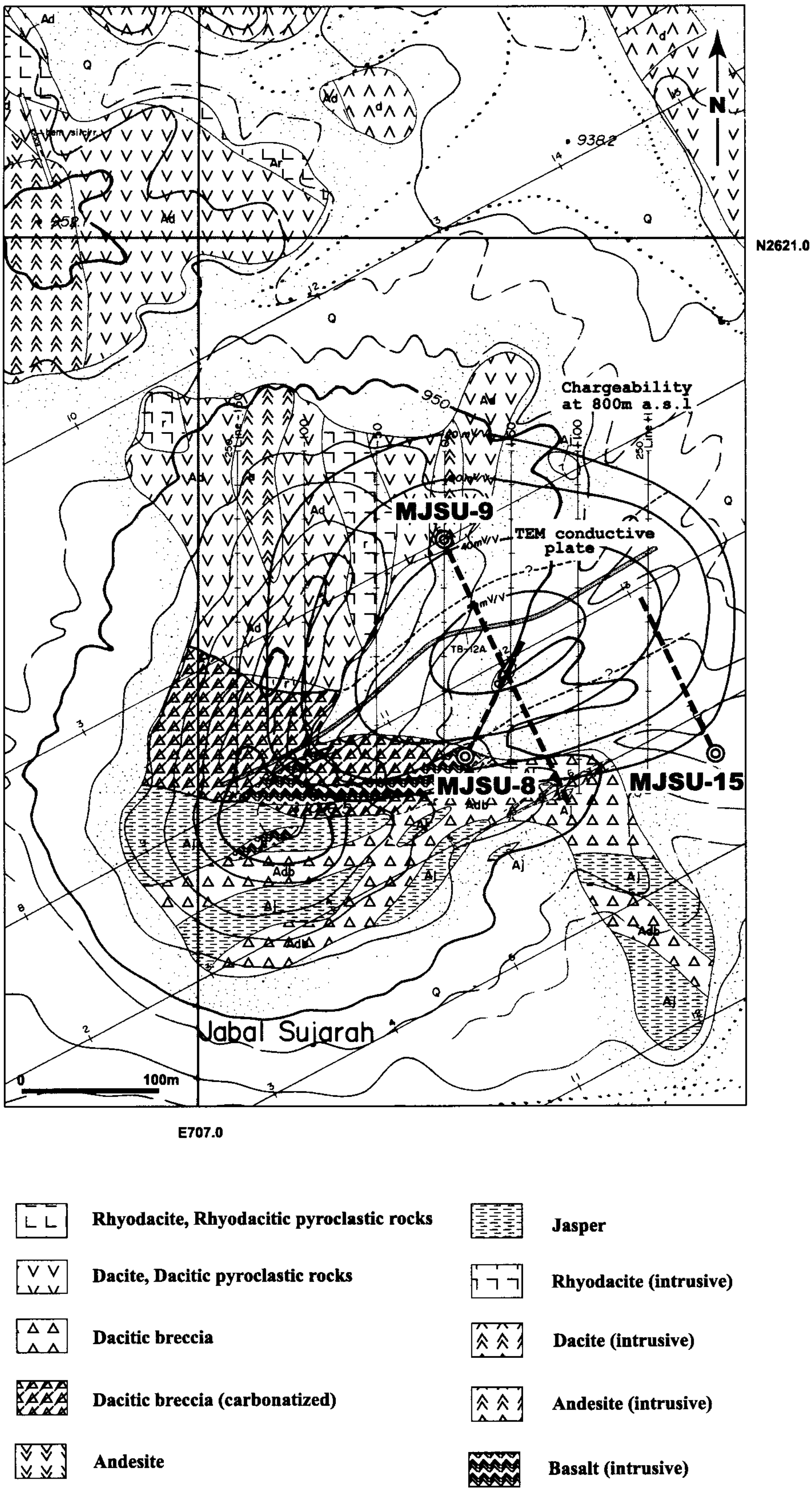
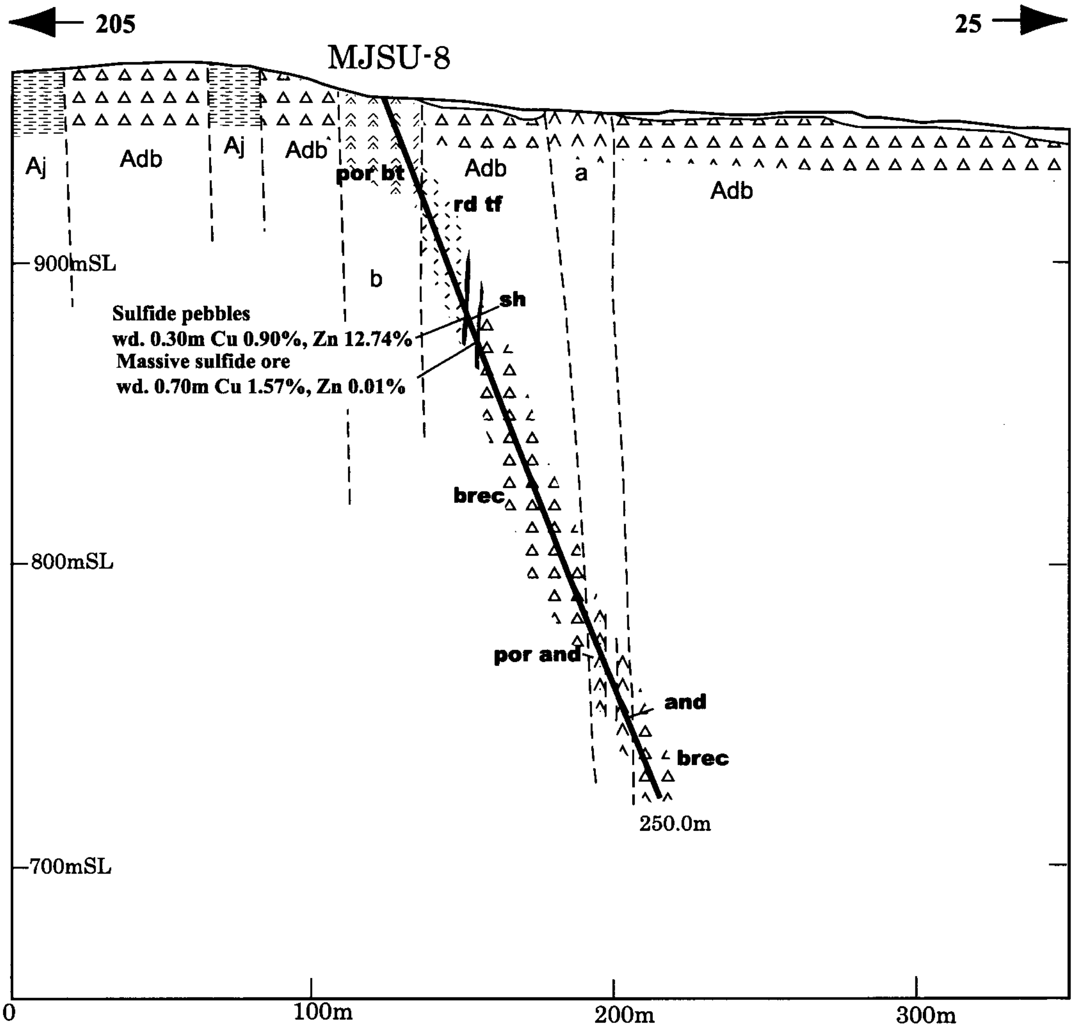


Fig.2-7-1 Detailed Geological Map of Jabal Sujarah

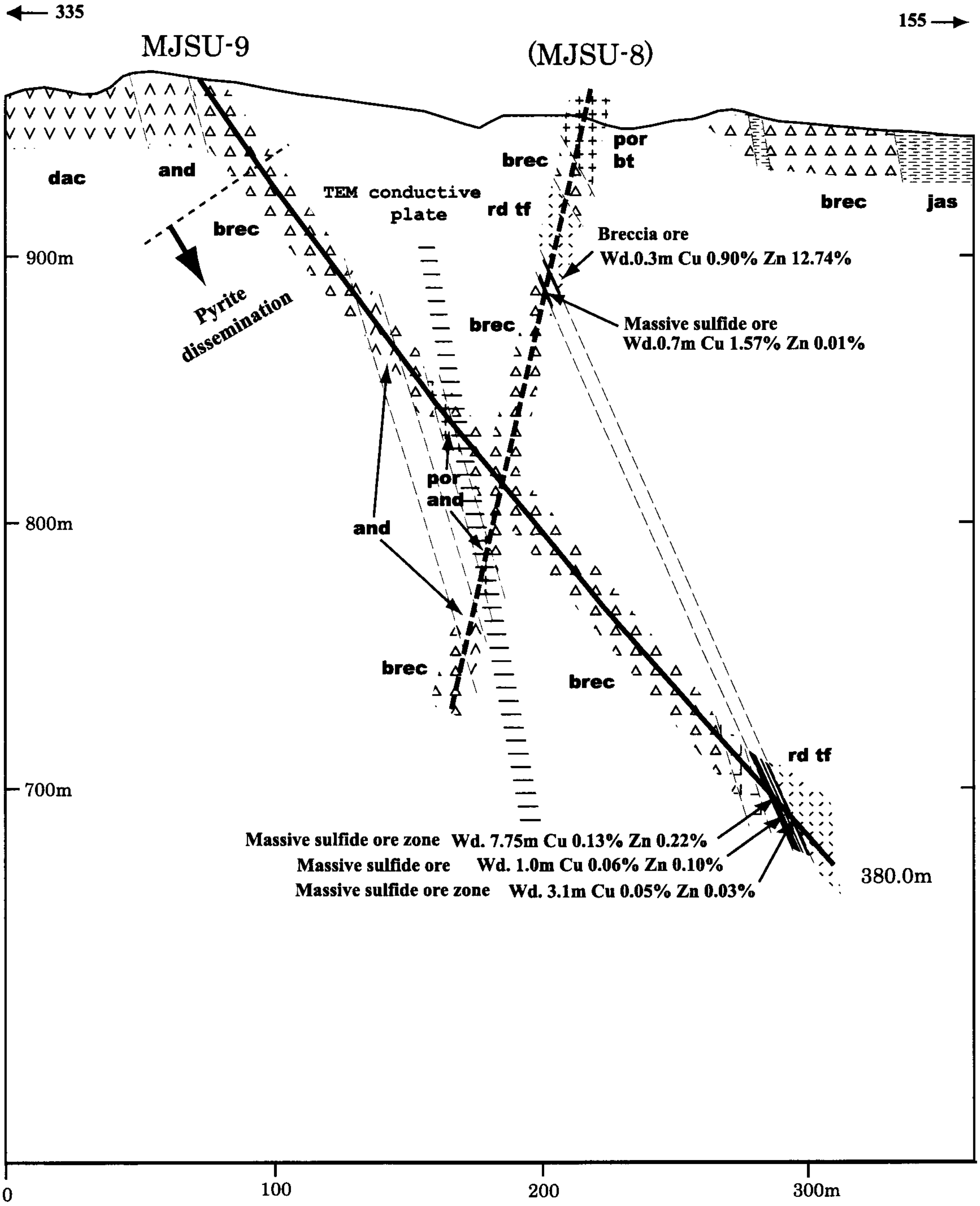


Abbreviation:

Ad : Dacite, Dacitic pyroclastic rocks (Arj Group)
(Adb : Breccia)
Aj : Jasper (Arj Group)
b : Basalt, Porphyritic basalt
a : Andesite, Porphyritic andesite

and : Andesite
brec: Breccia
por and : Porphyritic andesite
por bt : porphyritic basalt
rd tf : rhyodacitic tuff
sh : shale

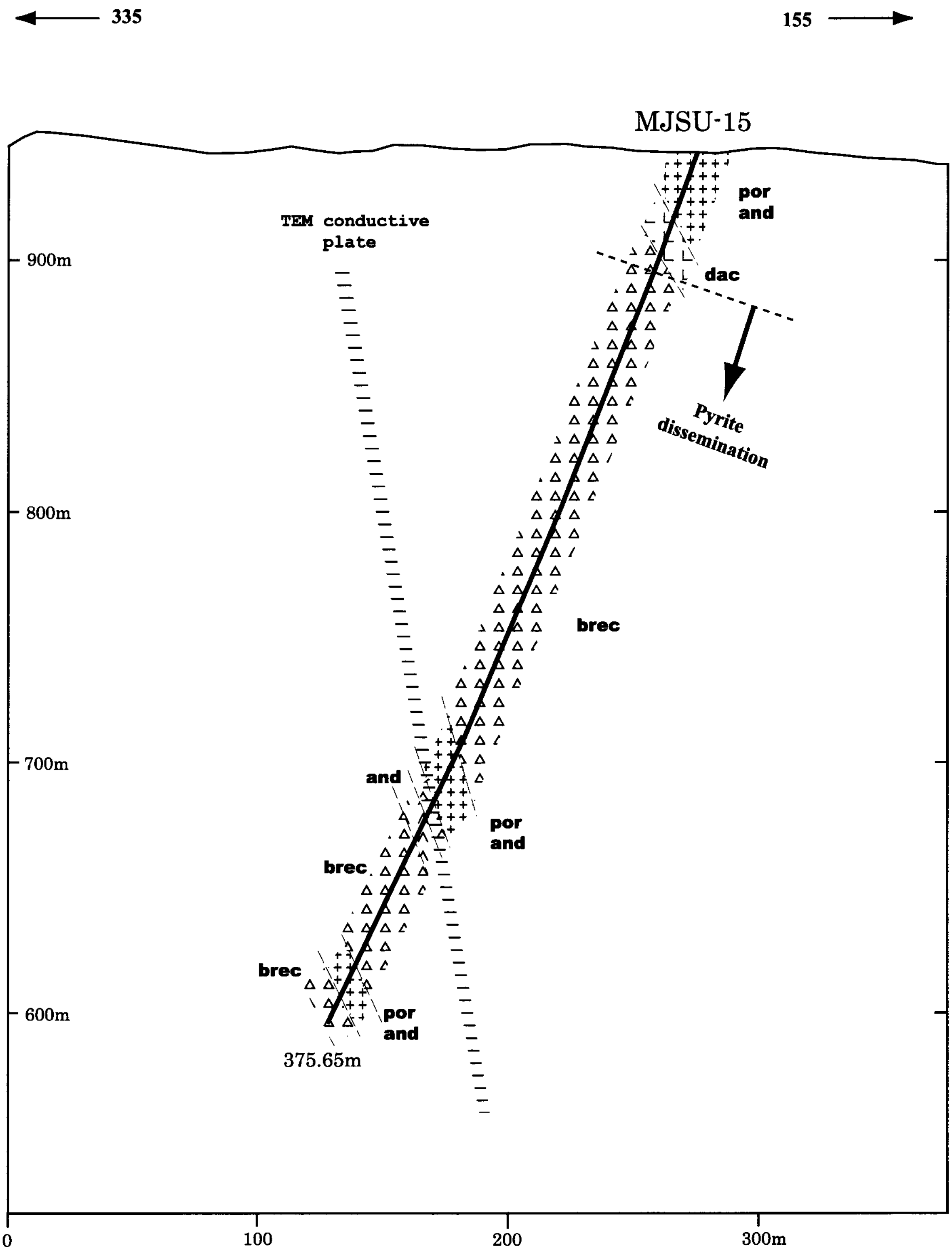
Fig.2-7-2 Geological Section along MJSU-8



Abbreviation :

brec : volcanic breccia, lapilli tuff, lapillistone
rd tf : rhyodacitic tuff
dac : dacite
jas : jasper
por bt : porphyritic basalt
por and : porphyritic andesite
and : andesite

Fig.2-7-3 Geological Section along MJSU-9



Abbreviation :
dac: dacite
brec : volcanic breccia, lapilli tuff
rd tf : rhyodacitic tuff
por and : porphyritic andesite
and : andesite

Fig.2-7-4 Geological Section along MJSU-15

Mineralization and Alteration

Volcanogenic massive sulfide-type mineralizations occur at 73.25～73.55 m and 82.65～83.35 m intervals.

Interval 73.25～73.55m: A 4×4 cm-chalcopyrite rich breccia ore occurs at 73.27m depth and a 7×7cm-sphalerite rich breccia ore at 73.55 cm. Microscopic examination of the former ore showed small amount of sphalerite and clausthalite together with pyrite and chalcopyrite. Also microscopic study of the latter ore showed it to consist of pyrite, chalcopyrite, and sphalerite.

Interval 82.65～83.35m: Massive ore consisting of pyrite and chalcopyrite occurs at this interval. Microscopic study of the ore showed the existence of small amount of chalcopyrite with abundant pyrite.

The rocks encountered in this hole are all silicified and pyritized with the exception of intrusive rocks (Fig. 2-7-5). Particularly, sericitization are notable at 73.25～85.85m interval where the above breccia and massive ores occur and pyrite is dominant (about 20%).

(2) MJSU-9

Geology

The rocks in this hole are mainly rhyodacitic lapilli tuff, dacitic lapillistone, dacitic tuff breccia and intrusive rocks. Thin muddy tuff layers are intercalated in rhyodacitic tuff.

Mineralization and Alteration

Five massive sulfide-type mineralized parts are penetrated by this hole.

Depth interval 341.25～343.4m consists of massive sulfide ores with banded texture and the ore minerals are large amount of pyrite with very minor content of chalcopyrite and sphalerite.

Depth intervals 343.9～345.0m and 347.30～349.0 m consist of siliceous banded sulfide ores with banded texture. The ore minerals are large amount of pyrite with minor amounts of chalcopyrite and sphalerite.

These massive sulfide ores and banded sulfide ores contain intercalation of chloritized rocks, and pyrite lenses and dissemination occur within these chloritized rocks. The grade of all of the massive ores is low with Au less than 1g/t, Cu less than 0.3%, Zn less than 0.5%. The grade of the intercalated chloritized rocks is also low.

Depth interval 350.8～351.8m consists of siliceous banded sulfide ores. It contains large amount of pyrite and the Au, Cu, and Zn grades are low.

Depth interval 356.9～357.7m consists of massive sulfide ores with weakly banded texture. It consists mainly of pyrite with minor content of chalcopyrite and sphalerite. The Au, Cu, and Zn grades are low.

The hanging wall and footwall of the above massive sulfide ores and banded sulfide ores are mainly chloritized rocks containing many lenses, dissemination and veinlets of pyrite. X-ray diffraction studies show that the chloritized rocks consist of large amounts of chlorite and smaller content of pyrite.

Alteration minerals observed in other parts of this hole are quartz-sericite-chlorite combination. The amount of sericite tends to be larger than chlorite in the hanging wall of the massive sulfide ores while chlorite is richer in the hanging wall side.

Strong pyrite dissemination is observed in the footwall side, with the exception of intrusive bodies, of the above massive sulfide ores and banded sulfide ores. These are seen between 40 and 341.25m depth interval and the pyrite tends to increase with depth (Fig. 2-7-5). Ore minerals in the dissemination are large amount of pyrite with minor amount of chalcopyrite and sphalerite.

(3) MJSU-15

Geology

The geology of this hole is composed of dacite, dacitic lapillistone and intrusive porphyritic andesite and andesite.

Mineralization and Alteration

Massive sulfide ores were not encountered in this hole, but as in the case of MJSU-9, pyrite dissemination

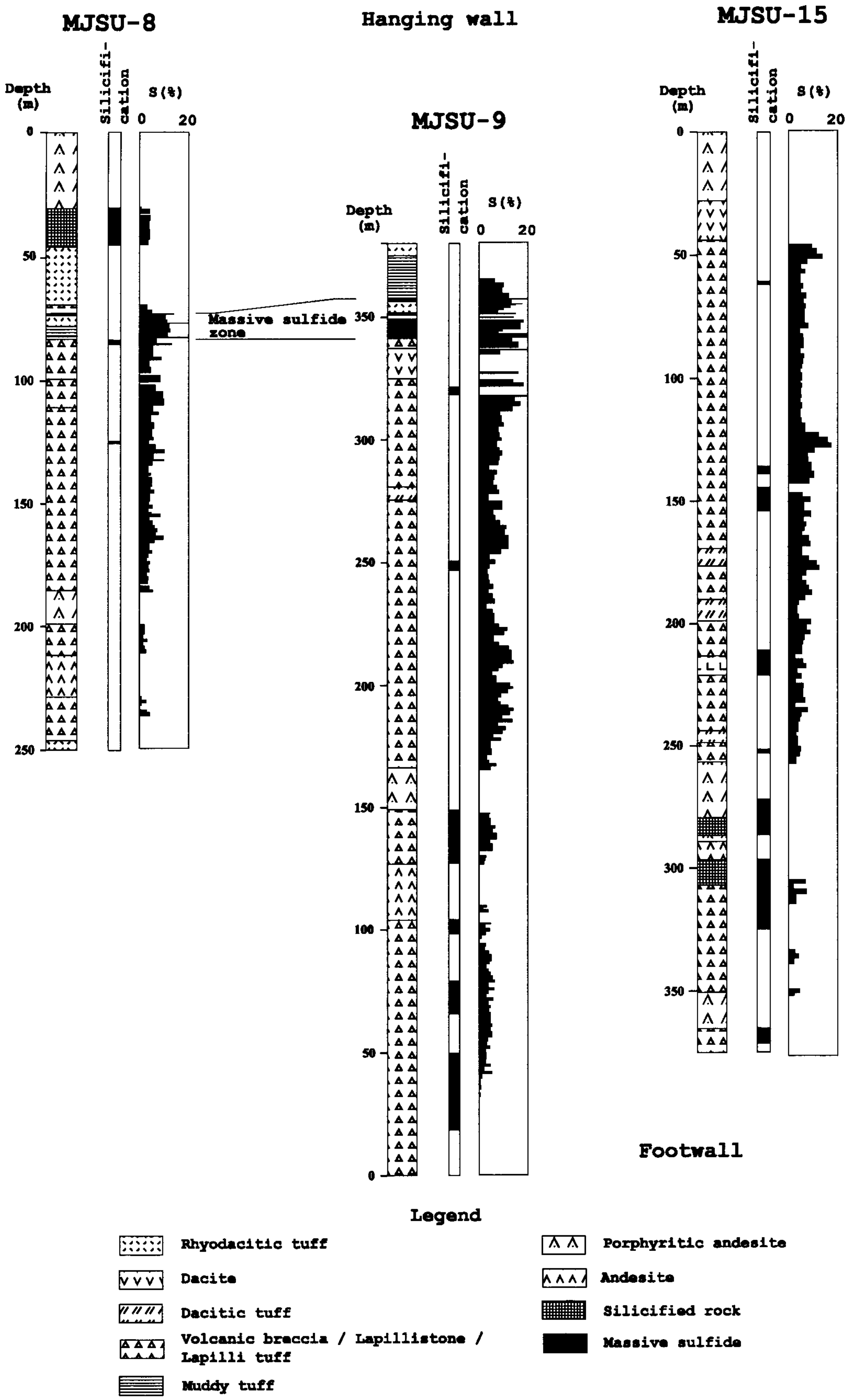


Fig.2-7-5 Correlation of Sulfur Contents of Drill Holes in Jabal Sujarah

was observed in breccia. The amount of pyrite is larger in the shallower parts and smaller in the deeper zones. Namely the tendency of decreasing pyrite from the hanging wall to the footwall side is similar to MJSU-8 and MJSU-9.

7-1-3 Discussions

The drilling carried out to date in the Jabal Sujarah area is; two drilled third phase and another second phase. The geology and mineralization of the area including these three drill holes (henceforth, this area) are summarized as follows.

The rocks, which occur in this area, are; rhyodacitic tuff, muddy tuff, shale, dacite, and dacitic breccia. These rocks are intruded by andesite, porphyritic andesite, porphyritic basalt, and dacite. Dacitic breccia consists mainly of volcanic breccia, lapillistone, volcanic tuff, and coarse tuff. These rocks are believed to strike in approximately E-W direction with dip vertical to 60° S. The rocks of this area are, from the bottom upward, dacitic breccia or dacite, muddy tuff, rhyodacitic tuff.

The mineralization of this area is volcanogenic massive sulfide type and consists of massive ores, pebbly ores and pyrite dissemination.

Several bodies of massive and pebbly ores occur in proximity, and shale, muddy tuff, rhyodacitic tuff, and chloritized rocks are observed in between. The massive and pebbly ores contain; in some cases large amount of sphalerite, and small amount of chalcopyrite, but mostly pyrite and the Au, Cu, and Zn grades are low. The penetrated thickness of the individual massive and pebbly ore parts is 0.3 - 2.15m but the true thickness is probably less than 0.8m. There are several layers of massive and pebbly ores and the thickness of the mineralized zone including the intercalated pyrite dissemination is about 6m. The MJSU-15 drilled in the eastern part of the area have not encountered massive or pebbly ores, and thus these ores probably occur within around 200m in the E-W direction.

There are strongly pyrite disseminated thick breccias on the footwall side of the mineralized zone containing massive and pebbly ores, with thickness exceeding 100m. A large amount of pyrite and small amounts of chalcopyrite and sphalerite occur in the pyrite dissemination zone.

Massive and pebbly ores occur macroscopically between dacitic breccias and rhyodacitic tuff. Dacitic breccia occurs stratigraphically lower than rhyodacitic tuff and jasper overlies both.

The massive and pebbly ores are accompanied by shale and muddy tuff and this is similar to the massive ores of 4/6 Gossan Prospect. However, thick dacitic breccia occurs on the footwall side of the massive sulfide, and this is different from the massive ores of the 4/6 Gossan Prospect. Also the occurrence of strong pyrite dissemination among massive sulfide ores, between massive and pebbly ores, and in the dacitic breccia of the footwall is a feature different from the mineralized zones of the 4/6 Gossan Prospect.

There are two types of alteration mineral combination, which occur among massive ores or between massive and pebbly ores in the mineralized zone of volcanogenic massive sulfide type. One is mainly chlorite and pyrite, and the other sericite and pyrite.

The Jabal Sayid Deposit located 20km north-northwest of this area is a stratabound massive sulfide deposit accompanied by stockwork ore body in the lower part. The Cu grade is around 2.7%. The footwall consists of crystalline tuff and pyroclastic flow deposit of the upper part of the felsic rocks of the Sayid Formation. The hanging wall is composed of fine to coarse rhyolitic rocks and rhyodacite containing quartz. And chert-carbonate rocks or jasper formed by chemical deposition overlie the orebody. Pyroclastic rock, which is the host rock of the stockwork orebody below the massive sulfide deposit, is chloritized. The sulfide minerals of the massive sulfide orebody are mainly pyrite, pyrrhotite, sphalerite, and chalcopyrite. The sulfide minerals of the stockwork body are mainly pyrite and chalcopyrite with smaller amount of sphalerite.

The following similarities and differences between the mineralization of this area and the Jabal Sayid Deposit are noted.

They are both volcanogenic massive sulfide deposits with felsic host rocks, and the occurrence of chert or jasper above the ore horizon is similar.

Strong pyrite dissemination is developed in the footwall of the massive sulfide body of this area while stockwork ores are associated below the deposit of the Jabal Sayid.

Pyrrhotite does not occur with the sulfide minerals in this area. Also the grades of Cu and Zn is lower in this area relative to the Jabal Sayid deposit.

7-2 Results of Drilling Exploration of Umm ad Damar North

7-2-1 Objectives

A wide chargeability anomaly was detected by IP survey during the first year. The anomaly occurred around J-25. A hole (MJSU-3) was drilled the second phase to clarify the mineralization of the above anomaly. Also the surface survey of the first year indicated the existence of a mineralized zone (No. 2 Mineralized Zone) below the slag zone of this area. Two holes, MJSU-4 and MJSU-5 were drilled the second phase to clarify the above mineralization.

The location, elevation and azimuth of drill holes are shown in Fig.2-7-6, Fig.2-7-7 and Appendix 6.

7-2-2 Geology and mineralization of drill hole

Three geological sections along each drill hole are shown in Fig.2-7-8～Fig.2-7-10. Results of ore assay, microscopic observation of thin sections and polished sections, and X-ray diffraction analysis of core samples obtained from MJSU-3, MJSU-4, and MJSU-5 are shown in Appendices 1～3 and 5.

(1) MJSU-3

Geology

The geology of this hole consists of dacite, dacitic tuff, rhyodacite, rhyodacitic tuff and intrusive rocks. The intrusive rocks are porphyritic dacite, fine-grained diorite and dolerite.

Mineralization and Alteration

In this hole, mineralization was observed at the following three depth intervals.

Interval 188.20～188.75m: This depth interval is a chloritized zone within a porphyritic dacite dyke and contains many chalcopyrite-pyrite veinlets.

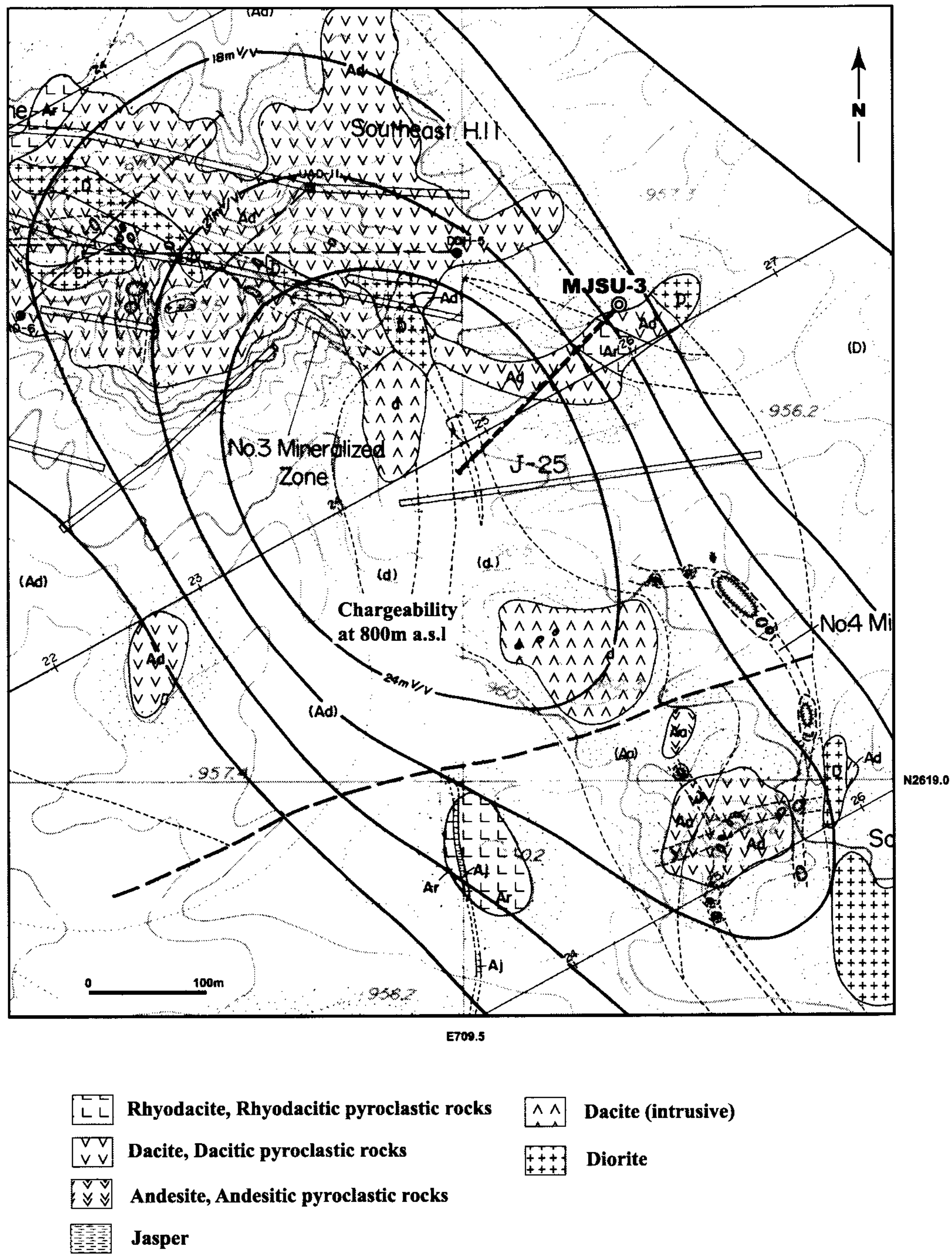


Fig.2-7-6 Detailed Geological Map around MJSU-3

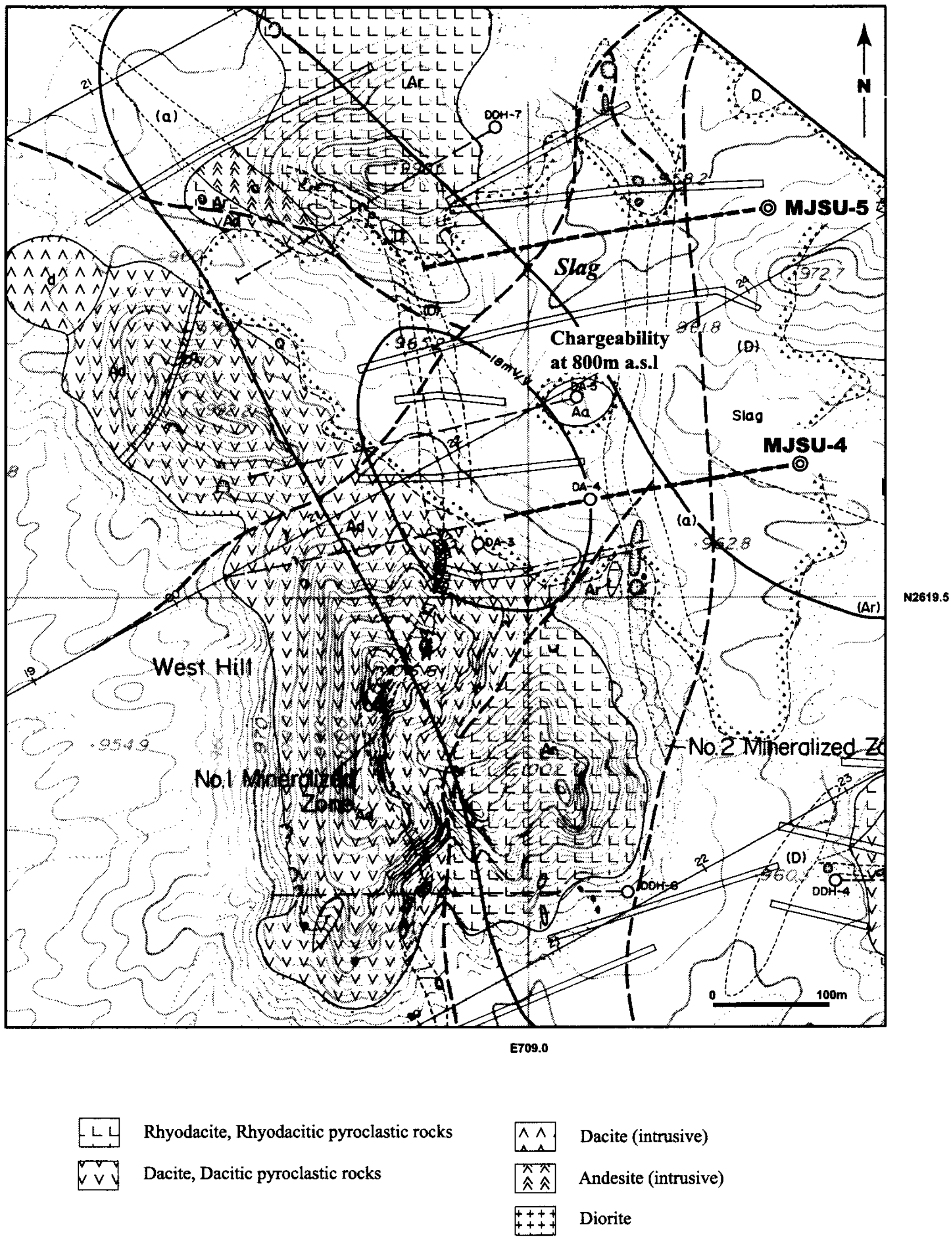
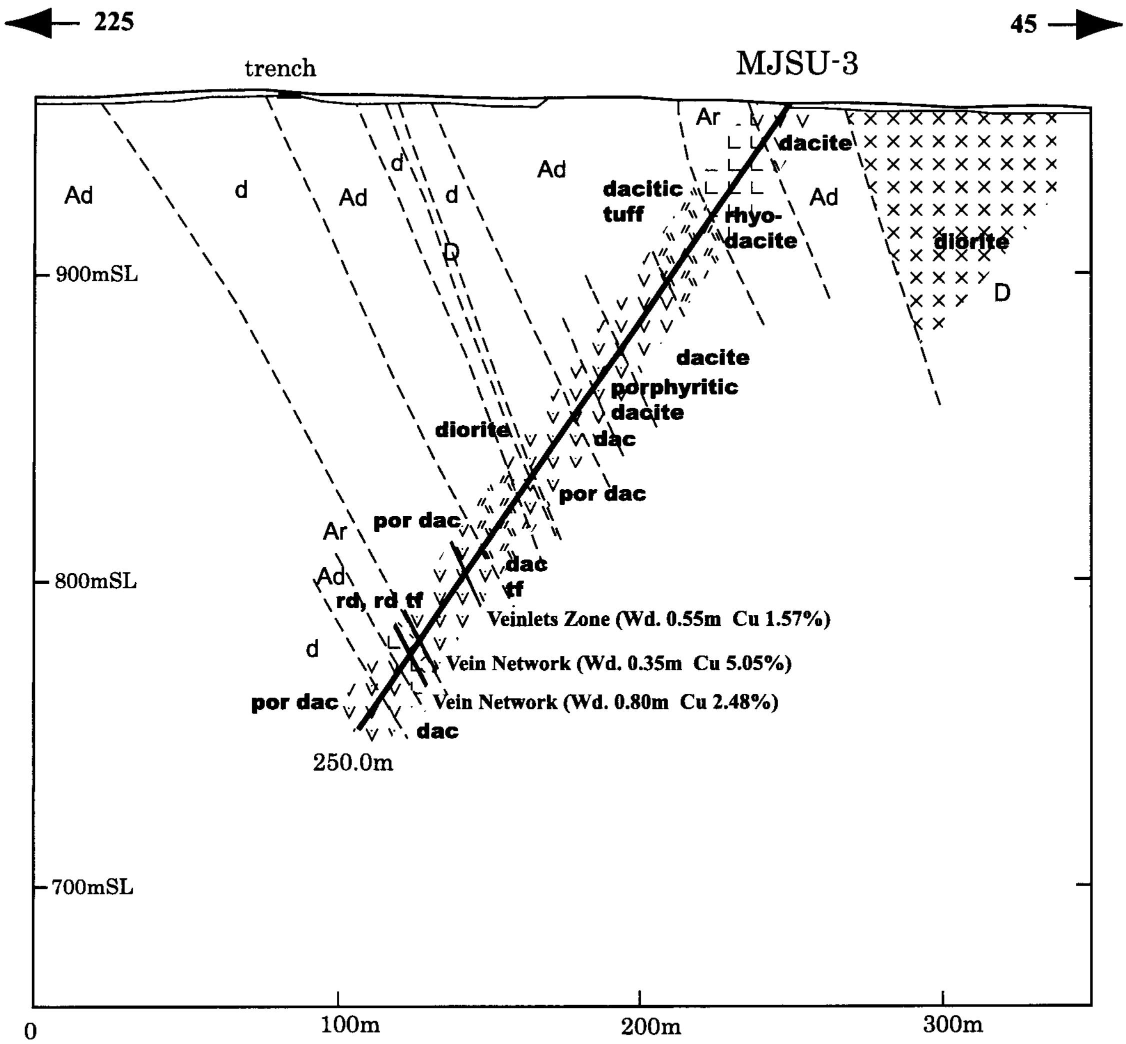


Fig.2-7-7 Detailed Geological Map around MJSU-4 and MJSU-5

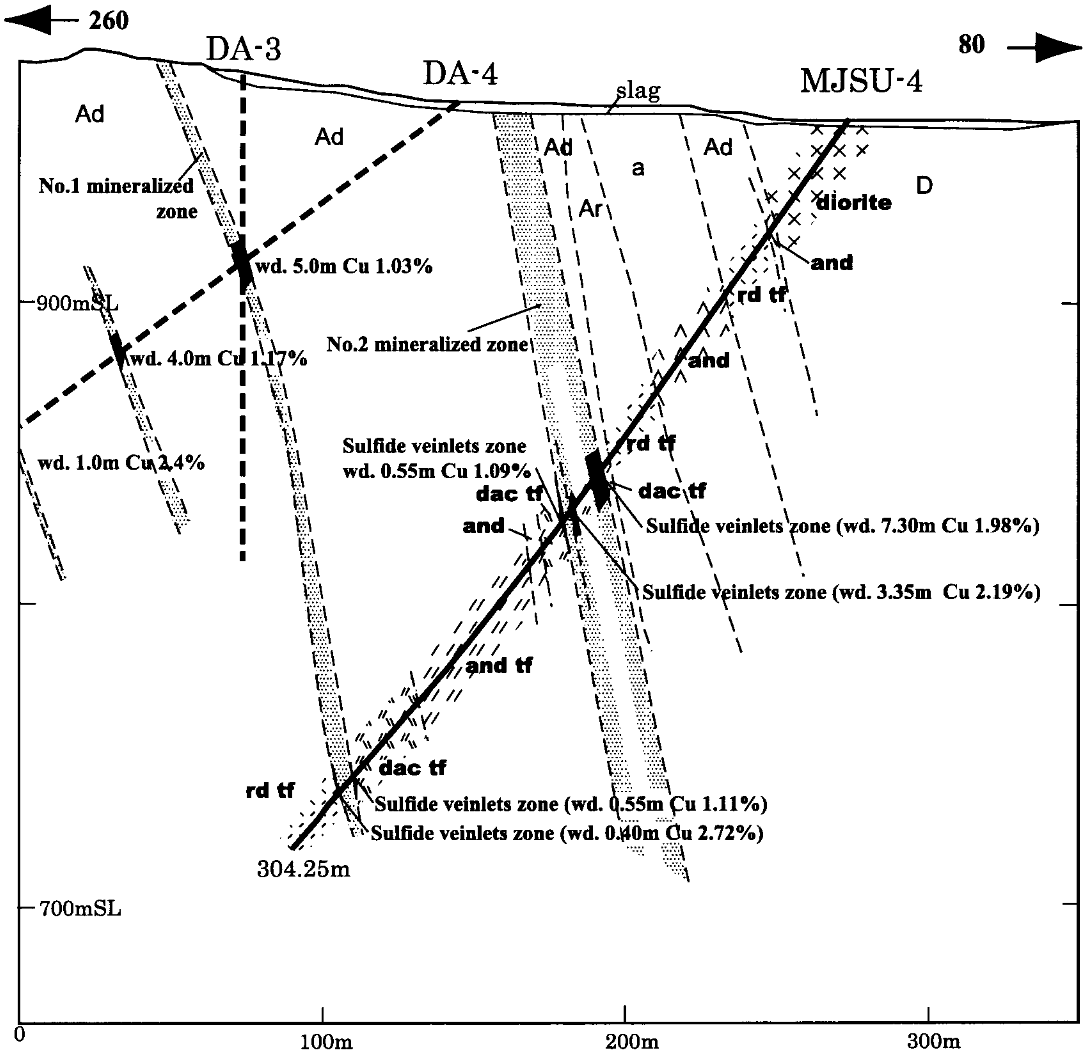


Abbreviation:

Ad : Dacite, Dacitic pyroclastic rocks (Arj Group)
Ar : Rhyodacite, Rhyodacitic pyroclastic rocks (Arj Group)
d : Dacite, Porphyritic dacite
D : Quartz diorite, Diorite

dac : dacite
dac tf : dacitic tuff
por dac : porphyritic dacite
rd : rhyodacite
rd tf : rhyodacitic tuff

Fig.2-7-8 Geological Section along MJSU-3

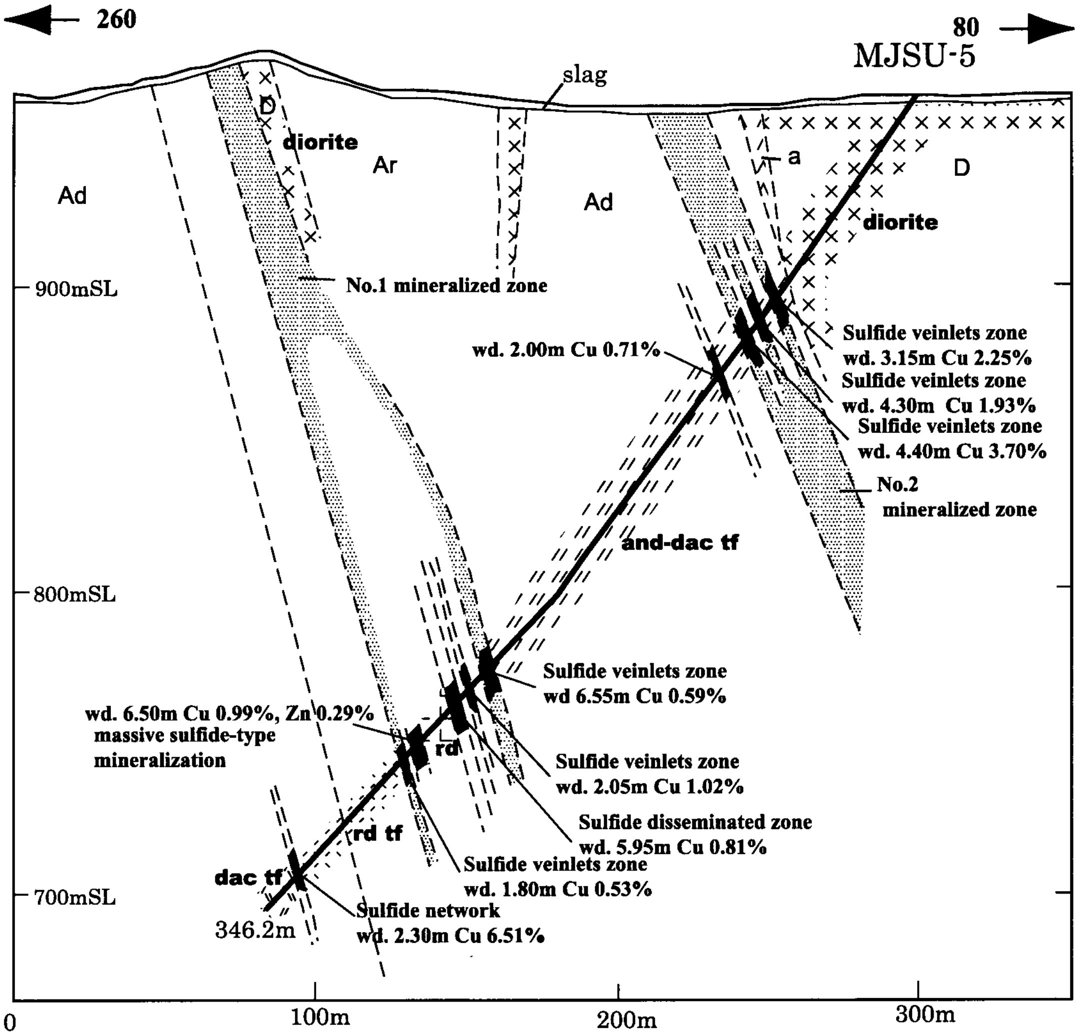


Abbreviation:

Ad : Dacite, Dacitic pyroclastic rocks (Arj Group)
Ar : Rhyodacite, Rhyodacitic pyroclastic rocks (Arj Group)
D : Quartz diorite, Diorite
a : Andesite, Porphyritic andesite

and : Andesite
dac tf : dacitic tuff
rd tf : rhyodacitic tuff

Fig.2-7-9 Geological Section along MJSU-4



Abbreviation:

Ad : Dacite, Dacitic pyroclastic rocks (Arj Group)
Ar : Rhyodacite, Rhyodacitic pyroclastic rocks (Arj Group)
D : Quartz diorite, Diorite
a : Andesite, Porphyritic andesite

and-dac tuff : Andesitic-dacitic tuff
dac tf : dacitic tuff
rd : rhyodacite
rd tf : rhyodacitic tuff

Fig.2-7-10 Geological Section along MJSU-5

Interval 214.70～215.05m: This depth interval consists of chalcopyrite-pyrite network in the shear zone at the border of porphyritic dacite dyke and rhyodacitic coarse tuff. It is accompanied by chloritization. Microscopic study indicated the occurrence of sphalerite aside from pyrite and chalcopyrite.

Interval 220.10～220.90m: This depth interval is a chalcopyrite-pyrite network zone within a shear zone at the border between rhyodacitic coarse-grained tuff and fractured rhyodacite. Magnetite and hematite, aside from pyrite and chalcopyrite, were observed microscopically in a sample.

(2) MJSU-4

__Geology__

The geology of this hole consists of rhyodactic tuff to lapilli tuff, dacitic lapilli tuff to tuff, andesitic lapilli tuff and intrusive rocks. The intrusives are andesite, porphyritic andesite and basalt.

__**Mineralization and Alteration**__

Mineralization was observed at the following five intervals.

Interval 140.50～147.80m: In this depth interval, concentration of pyrite-chalcopyrite veinlets and chalcopyrite veins are observed at six localities within dacitic coarse-grained tuff. The veinlets are less than 1cm wide. In the above veinlets and veins, oxide and silicate minerals are very scarce and the grain size of the sulfide minerals is very small. Sphalerite is observed to occur together with pyrite and chalcopyrite in a sample.

Interval 155.50～158.85m: In this depth interval, concentration of pyrite-chalcopyrite veinlets and chalcopyrite vein are observed at three localities within dacitic lapilli tuff～coarse-grained tuff. Sphalerite, galena, and clausthalite (PbSe) are observed microscopically aside from pyrite and chalcopyrite.

Interval 162.85～163.40m: In this depth interval, host rock is dacitic lapilli tuff and many pyrite-chalcopyrite veinlets occur at 162.85～163.00m depth and one chalcopyrite-bearing quartz vein at 163.30～163.40m depth.

Interval 272.70～273.25m: This depth interval corresponds to the chloritized zone within dacitic coarse-grained tuff, and contains many pyrite-chalcopyrite veinlets.

Interval 278.95～279.35m: In this depth interval, many pyrite-chalcopyrite veinlets occur in rhyodacitic coarse-grained tuff. Microscopic study shows the occurrence of small amount of sphalerite aside from pyrite and chalcopyrite.

(3) MJSU-5

Geology

The geology of this hole consists of dacitic lapilli tuff to coarse tuff, rhyodacite, rhyodacitic lapilli tuff and andesitic lapilli tuff.

Mineralization and Alteration

Vein-type mineralization was observed at the following five intervals and also volcanogenic massive sulfide-type mineralization was penetrated at one interval.

Interval 79.40～82.55m: In this depth interval, concentration of chalcopyrite-pyrite veinlets and dissemination with small amount of oxide and silicate minerals occur at three depths in dacitic tuff. Microscopic study of a sample shows pyrite, chalcopyrite, and small amount of sphalerite.

Interval 88.90～93.20m: This interval consists of pyrite-chalcopyrite dissemination and veinlets in dacitic lapilli tuff.

Interval 95.50～99.90m: This interval consists of concentration of pyrite-chalcopyrite veinlets in dacitic lapilli tuff. Microscopic study of a sample shows the occurrence of small amount of sphalerite together with pyrite and chalcopyrite.

Interval 112.50～114.50m: In this interval, two less than 1cm-thick chalcopyrite-pyrite veins occur in dacitic coarse-grained tuff. They occur at, 112.60～112.70m and 114.35～114.50m depth intervals.

Interval 233.90～240.45m: In this interval, seven concentration of chalcopyrite-pyrite veinlets and chalcopyrite-pyrite dissemination occur in rhyodacitic tuff and dacitic lapilli tuff.

Interval 245.65～247.70m: This interval consists of pyrite-chalcopyrite network in rhyodacitic lapilli tuff.

Interval 250.35～256.30m: In this interval, chalcopyrite is rich at two parts in rhyodacitic lapilli tuff～tuff. They are pyrite-chalcopyrite dissemination at the depth of 250.35～257.10m, and several chalcopyrite veins which cut the tuff containing 2 - 3mm-thick pyrite layers at the depth of 253.90～256.30m.

Interval 276.35～278.15m: In this interval, two concentration of 1 - 3cm-thick chalcopyrite veins occur in dacitic coarse-grained tuff.

Interval 328.90～331.20m: This interval consists of chalcopyrite network in dacitic coarse-grained tuff to dacitic lapilli tuff. Microscopic study of a sample shows chalcopyrite, pyrite, and small amount of clausthalite (PbSe).

The following volcanogenic massive sulfide-type mineralization was observed at depth interval 268.9～275.4m, besides above vein-type mineralization.

Interval 268.90～275.40m: A geologic column is, from footwall rock side to hanging wall rock side;

268.90～271.10m:	Banded ore consisting of thin beds of pyrite-chalcopyrite, chlorite, and siliceous rock
271.10～271.55m:	Massive ore consisting of pyrite and chalcopyrite
271.55～271.85m:	Jasper
271.85～274.20m:	Banded ore consisting of thin beds of pyrite-chalcopyrite, chlorite, and siliceous rock
274.20～275.40m:	Banded ore consisting of thin beds of pyrite-sphalerite, chlorite, and siliceous rock

Also dacitic tuff is intercalated at 272.55～273.00m and 273.45～273.80m in the banded ore of 271.85～275.40m depth interval. Microscopic study of a sample of massive ore from 271.2m shows a small content of sphalerite aside from pyrite and chalcopyrite. And microscopy of a banded ore sample from 273.1m also shows chalcopyrite, sphalerite and pyrite.

The alteration associated with vein-type mineralization is silicification and chloritization. The host rock of volcanogenic massive sulfide-type mineralization consists mainly of quartz and chlorite, and this associated alteration is not different from that of vein-type mineralization.

7-2-3 Discussions

Mineralization confirmed at MJSU-3, MJSU-4, and MJSU-5 is mainly hydrothermal Cu veins and it occurs in the shear zone of dacitic pyroclastic rocks and rhyodacitic pyroclastic rocks. But the mineralization confirmed at 268.90～275.40m of MJSU-5 is different, the ores are mainly banded and contain massive ores and jasper, the host rocks are rhyodacitic pyroclastic rocks as in the case of the 4/6 Gossan. And thus it is believed to be volcanogenic massive sulfide mineralization.

At MJSU-4, it is believed that the mineralized zone confirmed at three locations in interval 140.50～160.40m is the lower extension of No.2 Mineralized zone, and that at two places in interval 272.70～279.35m is the lower extension of No.1 Mineralized Zone.

At MJSU-5, the three mineralized parts at interval 79.40～99.90m correspond to No.2 Mineralized Zone. In this hole, however, it is not clear whether the three mineralized parts in 233.90～256.30m interval or that at 276.35～278.15m interval correspond to No.1 Mineralized Zone.

The chargeability anomaly around regional IP survey point J-25 is large, and existence of large-scale mineralization was anticipated. But only a small Cu vein mineralization was observed at 188.20～220.90m depth interval in MJSU-3 which was drilled toward the center of this anomaly. Many porphyritic dacite intrusions are observed at 97.75m depth downward. The lateral distribution of these intrusive bodies is harmonious with that of the chargeability anomaly, and it is possible that the anomaly was a reflection of weak pyrite dissemination in these intrusive rocks.

7-3 Results of Drilling Exploration of 4/6 Gossan Prospect

7-3-1 Objectives

Occurrence of high grade Au, Ag, Cu and Zn mineralization was anticipated from existing data analysis and geological survey in the first phase in this prospect. Six drill holes, namely MJSU-1, 2, 6, 7, 14 and 16, was conducted with the purpose of clarifying the geologic conditions and mineralization in this prospect.

The location, elevation and azimuth of drill holes are shown in Fig.2-7-11 and Appendix 6.

7-3-2 Geology and mineralization of drill hole

Geological sections along each drill hole are shown in Fig.2-7-12～16. Results of ore assay, microscopic observation of thin sections and polished sections, and X-ray diffraction analysis of core samples obtained from six holes are shown in Appendices 1～3 and 5.

(1) MJSU-1

Geology

The geology of this hole consists mainly of rhyodacite and rhyodacitic tuff.

Mineralization and Alteration

Following mineralization is observed in this hole.

Interval 91.05～92.20m: This interval consists of siliceous rock containing dissemination and thin beds of pyrite. The content of pyrite is about 20%.

Interval 122.50～123.10m: In this interval, silicified zone containing many chalcopyrite veinlets (less than 1cm wide) occur at 122.50～123.00m, and 123.00～123.10m consists of chalcopyrite-bearing 1cm thick quartz vein in rhyodacitic tuff.

Two chalcopyrite-pyrite-sphalerite veinlets were confirmed at 215.45～215.60m interval and a small amount of galena and hessite was found microscopically in a sample from 215.5m depth. The silver content of 215.45～215.60m depth is high at 150.0g/t and the source is probably hessite. Chalcopyrite veins (4cm wide) are observed at 212.75～212.85m depth interval and the Ag grade is 213.0g/t.

Notable alteration was not observed in this hole and X-ray studies have not been carried out.

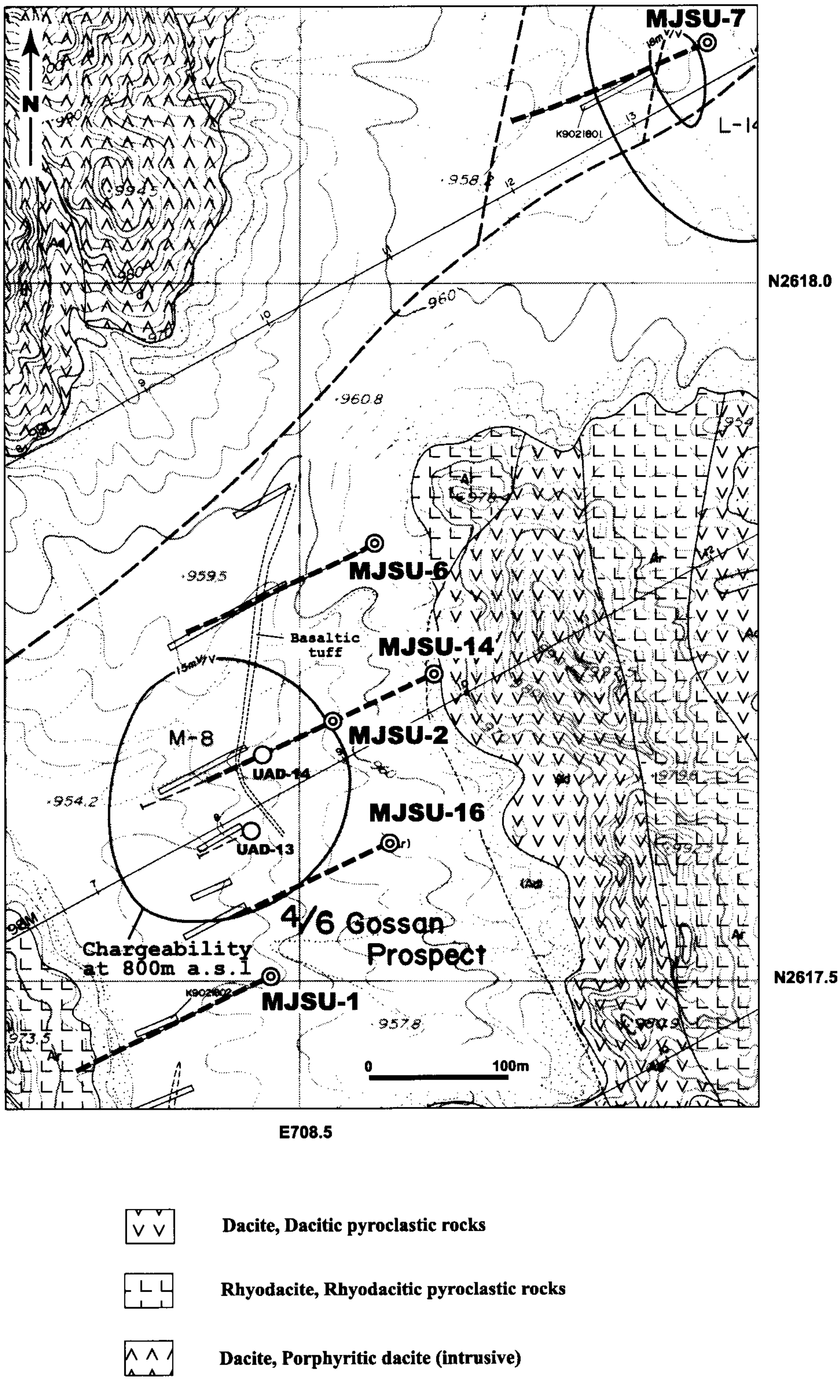
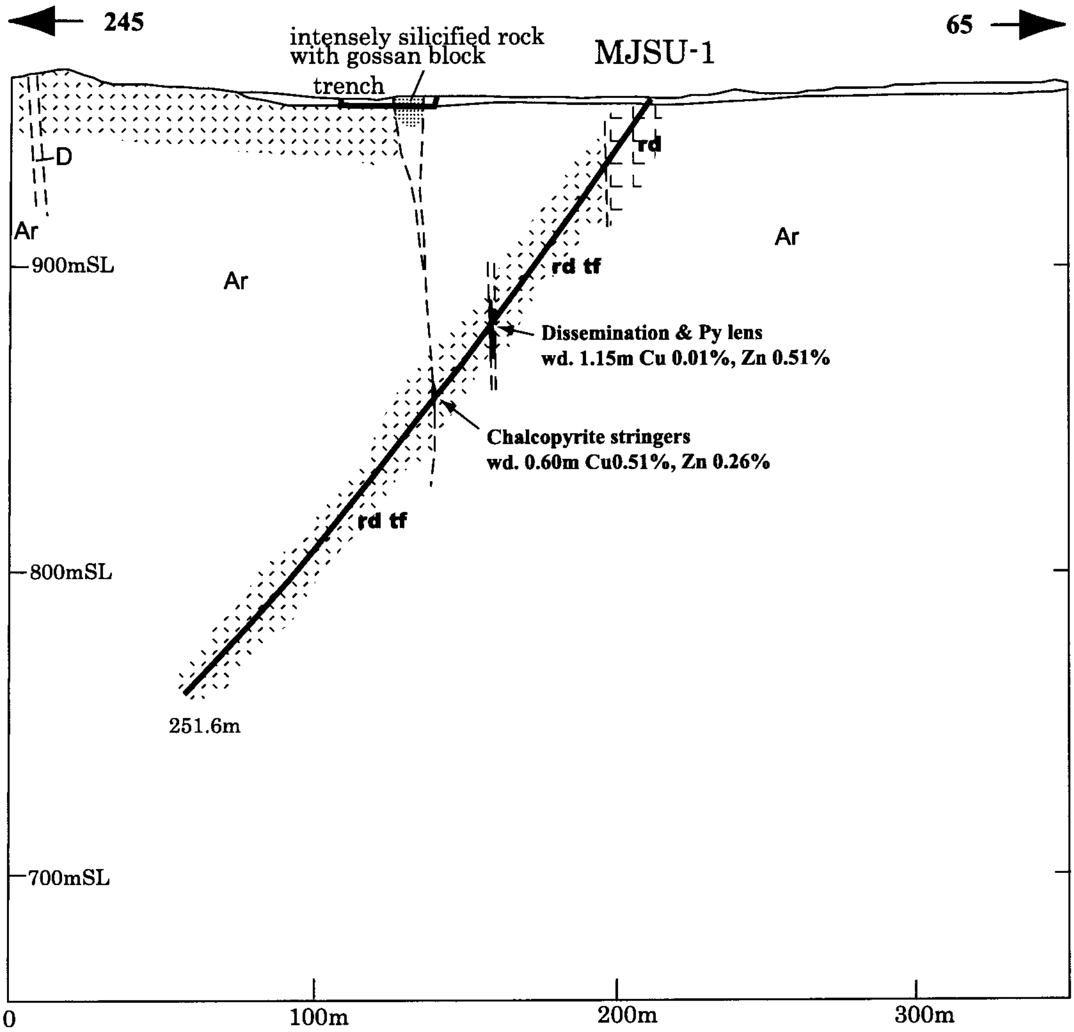


Fig.2-7-11 Detailed Geological Map of 4/6 Gossan Prospect

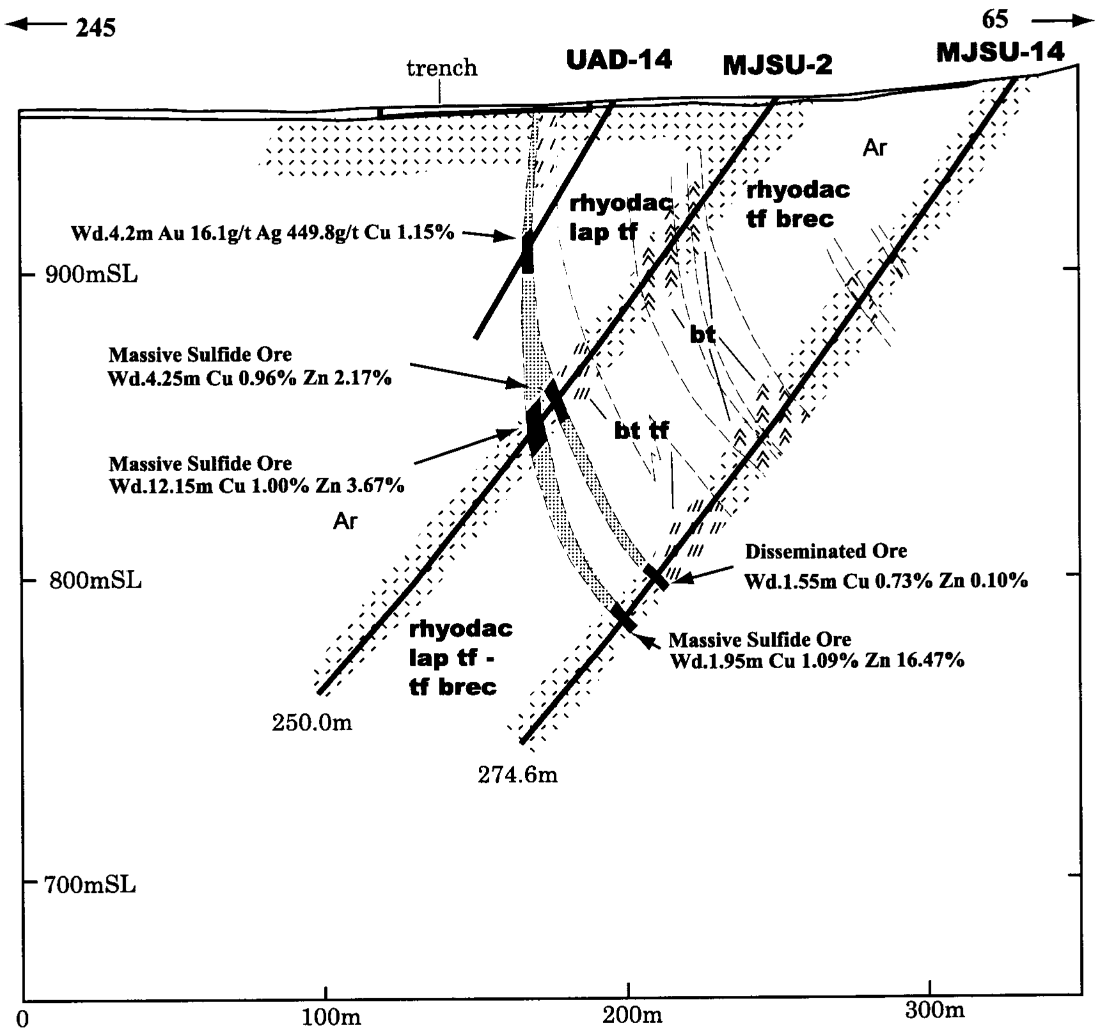


Abbreviation:

Ar : Rhyodacite, Rhyodacitic pyroclastic rocks (Arj Group)
D : Quartz diorite, Diorite

rd : rhyodacite
rd tf : rhyodacitic tuff

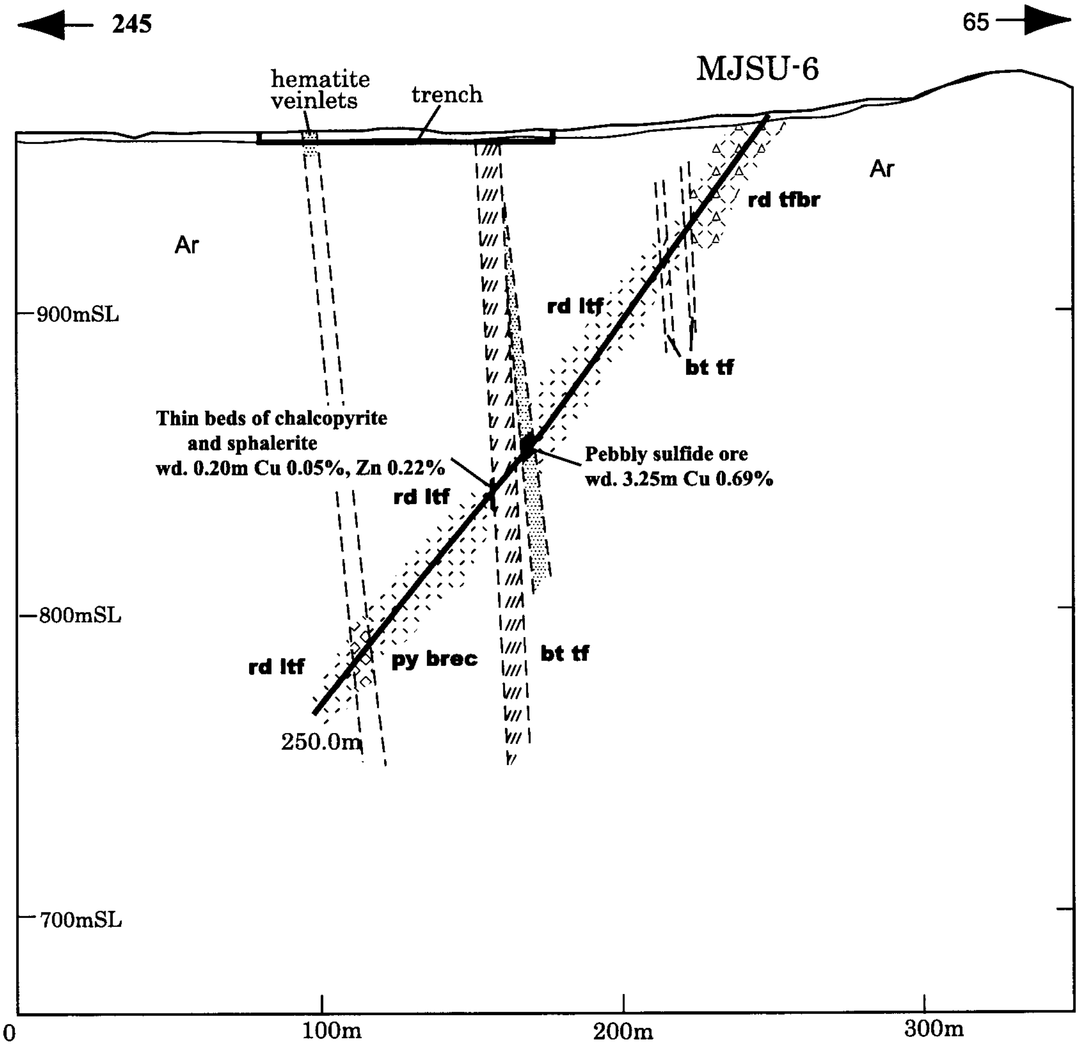
Fig.2-7-12 Geological Section along MJSU-1



Abbreviation:

Ar : Rhyodacite, Rhyodacitic pyroclastic rocks (Arj Group)
rhyodac lap tf : rhyodacitic lapilli tuff
rhyodac tf brec : rhyodacitic tuff breccia
bt tf : basaltic tuff
bt : basalt

Fig.2-7-13 Geological Section along MJSU-2 and MJSU-14

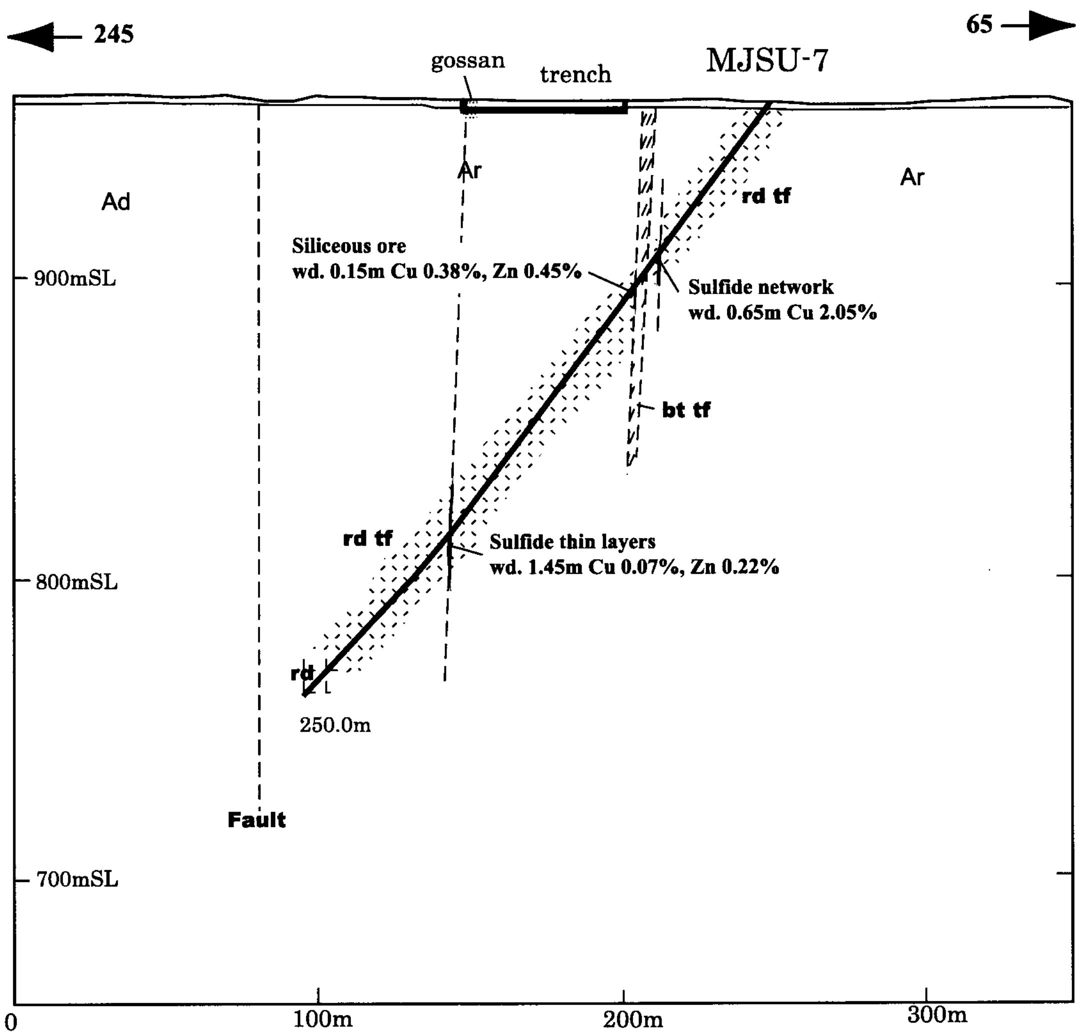


Abbreviation:

Ar : Rhyodacite, Rhyodacitic pyroclastic rocks (Arj Group)

bt tf : basaltic tuff
py brec : pyrite breccia
rd ltf : rhyodacitic lapilli tuff
rd tfbr : rhyodacitic tuff breccia

Fig.2-7-14 Geological Section along MJSU-6



Abbreviation:

Ad : Dacite, Dacitic pyroclastic rocks (Arj Group)

Ar : Rhyodacite, Rhyodacitic pyroclastic rocks (Arj Group)

bt tf : basaltic tuff

rd : rhyodacite

rd tf : rhyodacitic tuff

Fig.2-7-15 Geological Section along MJSU-7

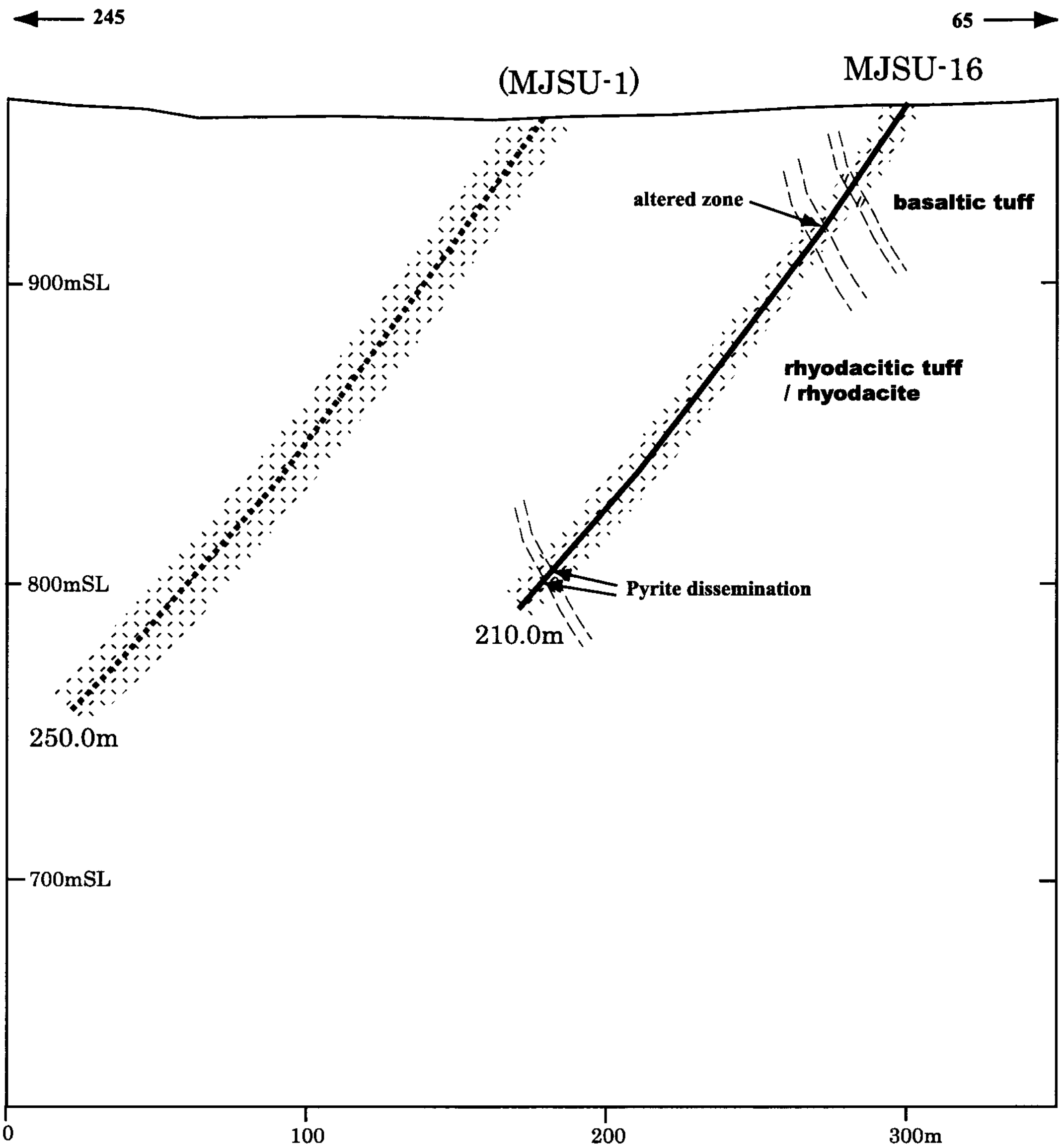


Fig.2-7-16 Geological Section along MJSU-16

(2) **MJSU-2**

Geology

The geology of this hole consists mainly of rhyodacitic tuff, basaltic tuff and basaltic dike.

Mineralization and Alteration

In MJSU-2, Volcanogenic massive sulfide-type Cu-Zn mineralization is observed at 121.15～125.40m and 130.10～142.25m.

The ores are divided into the following four types.

- Massive ores: Massive ores consisting of fine-grained sulfides such as pyrite, sphalerite, and chalcopyrite. Oxide and silicate minerals are almost non-existent.
- Breccia ores: Ores consisting of angular pebbles of fine-grained sulfide minerals. Pebbles are 10cm maximum and mostly less than 1cm. The matrices consist mainly of quartz and chlorite.
- Siliceous ores: Siliceous host rocks disseminated by sulfide minerals.
- Banded ores: Ores consisting of several-centimeters wide bands of fine-grained sulfide minerals and chlorite.

Depth interval 121.15～125.40m consists following mineralized parts and rocks from shallower part.

- Massive ore rich in pyrite (Length of cores 0.45m, Au 0.12g/t, Cu 1.70%, Zn 0.18%)
- Shale (Length 0.70m)
- Pebbly ore (Length 0.60m, Au 0.28g/t, Cu 2.71%, Zn 0.08%)
- Shale (Length 1.35m)
- Pebbly ore (Length 0.50m, Au 0.65g/t, Cu 1.66%, Zn 9.81%)
- Siliceous ore (Length 0.35m, Au 1.00g/t, Cu 1.03%, Zn 5.90%)
- Pebbly ore (Length 0.30m, Au 1.40g/t, Cu 0.99%, Zn 6.81%)

Average grade of above mineralized zone including intercalated shale is Au 0.37g/t, Cu 0.96% and Zn 2.17%, and whole thickness of the mineralized zone is inferred to be about 3.7m.

Depth interval 130.10～142.25m consists following mineralized parts and rocks from shallower part.

- Pebbly ore (Length of cores 0.30m, Au 0.56g/t, Cu 0.89%, Zn 3.65%)
- Conglomerate (Length 0.10m)
- Pebbly ore (Length 0.65m, Au 0.67g/t, Cu 0.68%, Zn 9.55%)
- Massive ore rich in sphalerite (Length 0.95m, Au 0.13g/t, Cu 1.46%, Zn 24.68%)
- Siliceous ore (Length 1.80m, Au 0.21g/t, Cu 1.54%, Zn 4.21%)
- Pebbly ore (Length 0.25m, Au<0.05g/t, Cu 0.48%, Zn 1.97%)
- Siliceous ore (Length 0.75m, Au 0.18g/t, Cu 0.29%, Zn 4.13%)
- Pebbly ore (Length 1.30m, Au<0.05g/t, Cu 0.67%, Zn 0.81%)
- Tuff (Length 1.00m)
- Massive ore rich in chalcopyrite (Length 0.20m, Au 0.70g/t, Cu 4.79%, Zn 0.24%)
- Conglomerate (Length 0.60m)
- Banded ore (Length 0.90m, Au 0.14g/t, Cu 0.50%, Zn 0.22%)
- Quartz vein (Length 0.20m)
- Banded ore (Length 1.20m, Au 0.19g/t, Cu 1.17%, Zn 0.50%)
- Banded ore rich in pyrite (Length 0.85m, Au 0.35g/t, Cu 0.32%, Zn 0.55%)
- Massive ore rich in chalcopyrite (Length 0.40m, Au 5.83g/t, Cu 4.58%, Zn 0.08%)
- Banded ore (Length 0.70m, Au<0.05g/t, Cu 1.05%, Zn 0.12%)

Average grade of whole mineralized part including conglomerate and tuff is Au 0.37g/t, Cu 1.00% and Zn 3.67%. Thickness of this mineralized part is inferred to be about 9.3m.

These ores generally consist of chalcopyrite-sphalerite-pyrite and small amount of galena, and altaite (PbTe) was found only in a sample.

Alteration within the mineralized zones and the vicinity consists mainly of silicification and chloritization, and sericitization is weak.

(3) MJSU-6

Geology

The geology of this hole consists mainly of rhyodacitic tuff, basaltic tuff and black shale.

Mineralization and Alteration

Mineralization was confirmed at the following two depth intervals in this hole.

In the depth interval 133.20～138.00m black organic shale containing large amount of pyrite pebbles and pyrite beds occurs. Breccia ore of 0.60m in length and siliceous ore of 0.80m are intercalated in this shale. Quartz-calcite veins constitute network containing small amount of pyrite. The veins occur intersecting the pyrite-bearing black shale and breccia ore. Average grade of drilled length 3.25m containing breccia ore and siliceous ore is less than 0.05g/t of Au, 0.69% of Cu, and 3.84% of Zn. The thickness of the above is estimated to be about 2m. The pebbles (less than 1cm) of breccia ore consists of combination of sphalerite-pyrite-chalcopyrite and silicic rock fragments. Matrix is quartz and chlorite.

In 154.05～154.25m depth interval, thin beds of pyrite-sphalerite are intercalated in chloritized black lapilli tuff. The amount of pyrite in this depth interval is about 10%.

Aside from the above, pyrite pebbles and thin bed are intercalated in rhyodacitic tuff－lapilli tuff at 220.70～228.90m depth interval. The amount of pyrite attains 20 %.

(4) MJSU-7

Geology

The geology of the hole consists of rhyodacite, rhyodacitic tuff and basaltic tuff.

Mineralization and Alteration

Mineralization was observed at the following three depth intervals.

Depth interval 62.85～63.50m consists of network of chalcopyrite-bearing 1 - 2cm wide quartz veins. Microscopic observation shows the occurrence of a large amount of pyrite, chalcopyrite, and small amount of sphalerite, clausthalite (PbSe), and naumanite (Ag_2Se).

Depth interval 76.55～76.70m consists of siliceous rock containing fine-grained pyrite and the amount of pyrite is about 35%. Microscopic examination shows the occurrence of large amount of pyrite and minor content of chalcopyrite, sphalerite, and clausthalite.

Depth interval 174.55～176.00m consists of rhyodacitic tuff breccia containing pyrite-chalcopyrite-sphalerite thin layers.

Notable alteration was not observed and X-ray diffraction studies were not carried out.

(5) MJSU-14

Geology

The geology of this hole consists mainly of rhyodacite, rhyodacitic tuff and basaltic tuff.

Mineralization and Alteration

Notable mineralization was observed at depth intervals of 202.90～204.45m and 219.80～221.75m. The above-mineralized zones are summarized below.

202.90～204.45m: Mineralized zone consists of silicified zone 30cm wide, argillized tuff 90cm, and tuffaceous mudstone 35cm. Thin layers to lenses of sulfide minerals and sulfide dissemination occur in these host rocks. The ore minerals are mainly pyrite with smaller amounts of chalcopyrite and sphalerite. Average grade of this mineralized part is Au below 0.05g/t, Cu 0.73% and Zn 0.10%. The thickness of this mineralized part is inferred to be 1.4m.

219.80～221.75m: Mineralized zones consist of pyrite and chalcopyrite dissemination in 30cm-wide black mudstone, 10cm-wide quartz veins, 70cm-wide sphalerite-rich massive sulfide ore, 10cm-wide mudstone, 20cm-wide pelitic tuff, and 55cm-wide massive sulfide ore. Average grade of this mineralized part is Au 0.19g/t, Cu 1.09% and Zn 16.47%. The thickness of this part is estimated to be 1.8m.

Aside from the above, pyrite-chalcopyrite lenses occur in rhyodacitic tuff at 195.7～196.3m depth interval, and their Cu grade is 0.53%.

Alteration minerals in the cores of this hole are quartz, chlorite, sericite, and calcite.

Regarding rock-forming minerals, plagioclase occur throughout the core except in the argillized tuff of the mineralized zone, muddy tuff, and rhyodacitic tuff of the apparent footwall of the mineralize zone. These plagioclase-deficient parts often contain large amounts of chlorite. Thus deficiency of plagioclase and large amounts of chlorite characterize the alteration near the above-mineralized zones.

Chlorite is dominant in the shallow zones (apparent hanging wall of the mineralized zone) while sericite is the dominant alteration mineral in the deeper zones (apparent footwall of the mineralized zone). This tendency is also observed in MJSU-2 drilled the second year.

(6) MJSU-16

Geology

The geology of this hole consists mainly of rhyodacite, rhyodacitic tuff and basaltic tuff.

Mineralization and Alteration

Notable mineralization was not observed in this MJSU-16 except for pyrite dissemination with sulfur grade of S 9.8% and 8.9% at 193.8～194.3m depth interval and 198.2～199.2m interval respectively.

Alteration was also not noteworthy.

7–3–3 Discussions

Geologic columns of the six holes drilled in this area, namely MJSU-1, 2, 6, 7, 14, and 16 are laid out in Figure 2-7-17. Basaltic tuff is the key bed for correlating the stratigraphy of this area. Basaltic tuff occurs in five holes of this area with the exception of MJSU-1. Mineralization is observed immediately above, below or within this basaltic tuff.

Rhyodacite and rhyodacitic tuff occurs immediately above or below the basaltic tuff. There is intercalation of sedimentary rocks such as shale in parts of the mineralized zone.

The mineralization in this area is volcanogenic massive sulfide Cu-Zn mineralization. This mineralization was confirmed in four holes MJSU-2, 6, 7, and 14 (Fig. 2-7-18).

The ore found in the four holes are separated four types; massive ore, pebbly ore, siliceous ore, and banded ore.

The massive ores are divided into those with very high Zn grade (Zn 11.0～35.0%) and those with extremely low Zn grade. Pb content is low in both types. Cu grade is relatively high (average 2.11%). Au grade is generally low (less than Au 0.7g/t) with one part containing Au 8.5g/t.

Pebbly and siliceous ores have relatively high Zn content (Zn 0.8 - 9.8%), and the Pb grade is also relatively high in some parts (Pb 0.4 - 1.3%). Cu grade (average Cu 1.24%) of these ores is somewhat lower than the massive ore. Au grade is less than 1.5g/t.

Banded ores have low Zn and Pb grades, and Cu grade is lower than pebbly and siliceous ores. Au grade is less than 0.5g/t.

Dissemination ores have low Au, Cu, and Zn grades and none are worth consideration. Slightly high-grade Cu is observed in a part of MJSU-14.

Massive and banded ores occur only below (henceforth above or below will indicate apparent above or below) basaltic tuffs.

The mineralized zones that occur below basaltic tuffs can be divided largely into two parts, namely BF-1 in the upper part and BF-2 in the lower part.

BF-1 occurs immediately below the basaltic tuff. At MJSU-2, BF-1 consists of massive, pebbly and siliceous ores and is accompanied by shale and tuffaceous shale. At MJSU-14, BF-1 consists of siliceous and disseminated ores. At MJSU-6 it corresponds to disseminated zone, and to siliceous rocks at MJSU-7. BF-1 is inferred to be about 3.7m thick at MJSU-2, and it is thickest at this part. The grade of BF-1 at MJSU-2 is Au 0.4g/t, Cu 0.96%, and Zn 2.17% while at MJSU-14 the grade is Au less than 0.1g/t, Cu 0.73%, and Zn 0.03%.

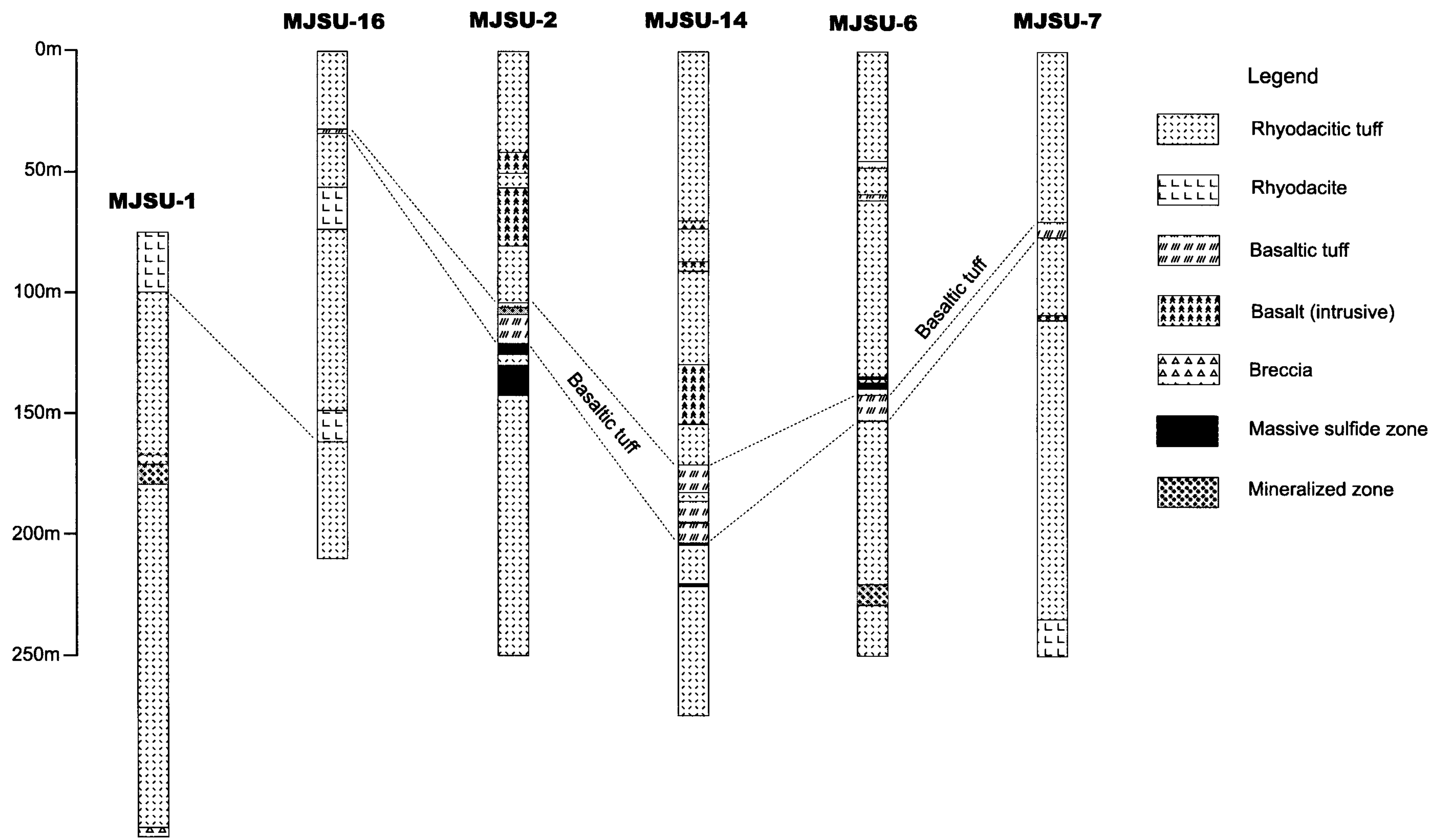


Fig.2-7-17 Comparison of Geologic Columns of Drill Holes in 4/6 Gossan Prospect

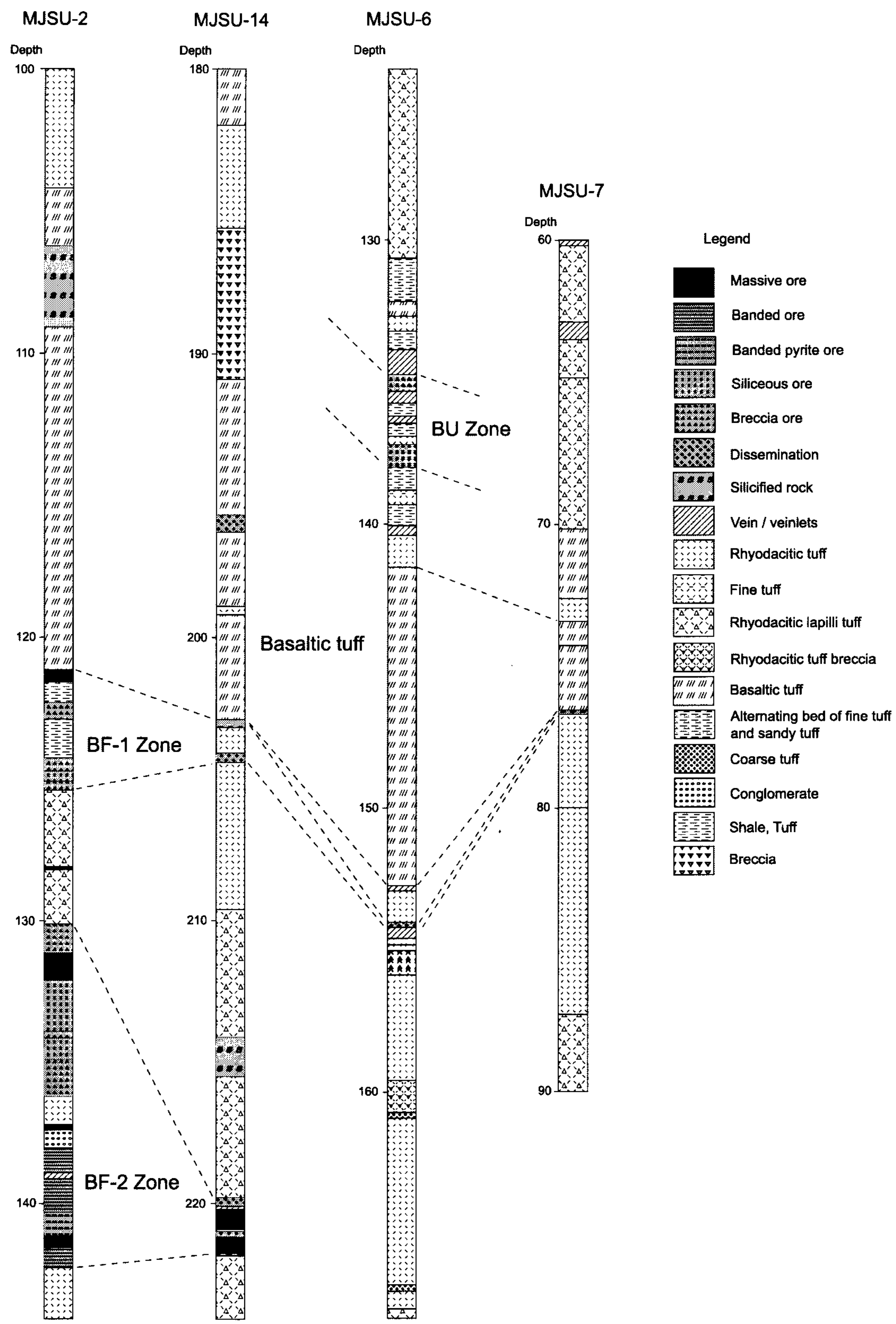


Fig.2-7-18 Geologic Columns of Mineralized Part of 4/6 Gossan Prospect

BF-2 occurs below BF-1 with rhyodacitic tuff between the two mineralized zones. BF-2 consists of massive ore, pebbly ore, siliceous ore, and banded ore with intercalation of tuff and conglomerate at MJSU-2. At MJSU-14, it contains massive ore and disseminated ore with intercalation of muddy tuff and mudstone. Mineralized zone corresponding to BF-2 does not occur in MJSU-6 and 7. BF-2 is about 9.3m thick at MJSU-2 and is thickest in this hole. It is believed to be about 1.8m thick at MJSU-14, thus the thickness of BF-2 varies considerably. At UAD-14 drilled in the past, high-grade mineralized zone (Au 16.1g/t, Cu 1.15%, Zn 0.25%) is confirmed at 52.0~56.2m depth interval. From correlation with surface geology, it is inferred that joining of BF-1 and 2 formed this zone.

The grade of BF-2 is Au 0.4g/t, Cu 1.00%, and Zn 3.67% at MJSU-2, and Au 0.2g/t, Cu 1.09%, and Zn 16.47% at MJSU-14.

A mineralized zone also occurs in horizon higher than basaltic tuff (henceforth BU). BU is only found at MJSU-6 and shale and fine tuff occurs between the lower basaltic tuff. BU consists of pebbly ore and siliceous ore with intercalation of shale and fine tuff at MJSU-6. The average grade of BU at MJSU-6 is Au less than 0.1g/t, Cu 0.69%, and Zn 3.99%, and is believed to be about 2.5m thick.

The higher-grade part of BF-1 occur dipping eastward from UAD-14 to MJSU-2 (extension along the dip projected on map exceeds 60m). The extension of BF-1 in the N-S direction is inferred to be, at the most, about 100m. The higher-grade part of BF-2 occurs from UAD-1 to MJSU14 (extension along dip projected on map exceeds 120m, average dip about 75°). The N-S extension is believed to be at most 100m because it is not found in MJSU-6 and 16. BU is confirmed at MJSU-6, but not in MJSU-14 to the south and its size is probably similar to that of BF-1 and 2.

Strong alteration zones are found only in the vicinity of massive ores of this area (MJSU-2 and 14). These zones are characterized by large amount of chlorite.

7-4 Results of Drilling Exploration in Geophysical Anomaly Zones

7-4-1 Objectives and location of drill holes

Four high chargeability zones were confirmed by IP surveys during the first and second years in localities other than the known prospects. The existence of a number of conductive plates was inferred from the results of the TEM survey in these zones.

Four holes, MJSU-10, MJSU-11, MJSU12, and MJSU-13 were drilled in these geophysical anomaly zones with the objective of clarifying the geology and the details of the copper, zinc, and gold mineralization

The location, elevation and azimuth of each drill hole are shown in Fig.2-7-19～Fig.2-7-21 and Appendix 6.

7-4-2 Geology and mineralization of drill hole

Geological sections of 4 holes are laid out in Fig.2-7-22～Fig.2-7-25. Results of ore assay, microscopic observation of thin sections and polished sections, and X-ray diffraction analysis of core samples obtained from four holes are shown in Appendices 1～3 and 5.

(1) MJSU-10

Geology

Rhyodacite, rhyodacitic tuff, dacite, dacitic tuff and basaltic dyke occur in this hole.

Mineralization and Alteration

Mineralization confirmed in this hole is pyrite veinlets and pyrite dissemination.

Pyrite veinlets are observed intermittently at 121.6～165.4m and 214.7～302.4m intervals. The thickness of the veinlets is 0.3 - 5mm containing large amount of pyrite and minor amounts of chalcopyrite and sphalerite. Those in 137.9～162.9m interval occur densely and veinlet network is observed at five points.

Pyrite dissemination is observed in 42.9～216.6m interval with the exception of intrusive bodies. Small-scale dissemination is also observed below 223.4m.

The maximum S content of these pyrite veinlets and disseminated parts is 18.9% at 158.6～159.6m depth interval. But the Au, Cu, and Zn grades are low in all of these high-pyrite zones. Alteration minerals of these high-sulfur zones are large amount of sericite and small amount of chlorite and quartz, while those of other zones are large amount of quartz and smaller amount of sericite and chlorite.

Pyrite dissemination is observed in the silicified zone at 67.5～85.1m depth interval and chalcopyrite and sphalerite are associated (Cu 0.02%, Zn 0.11%). This silicified zone contains large amount of quartz and small amount of sericite and chlorite.

(2) MJSU-11

Geology

Geology of this hole consists of dacite.

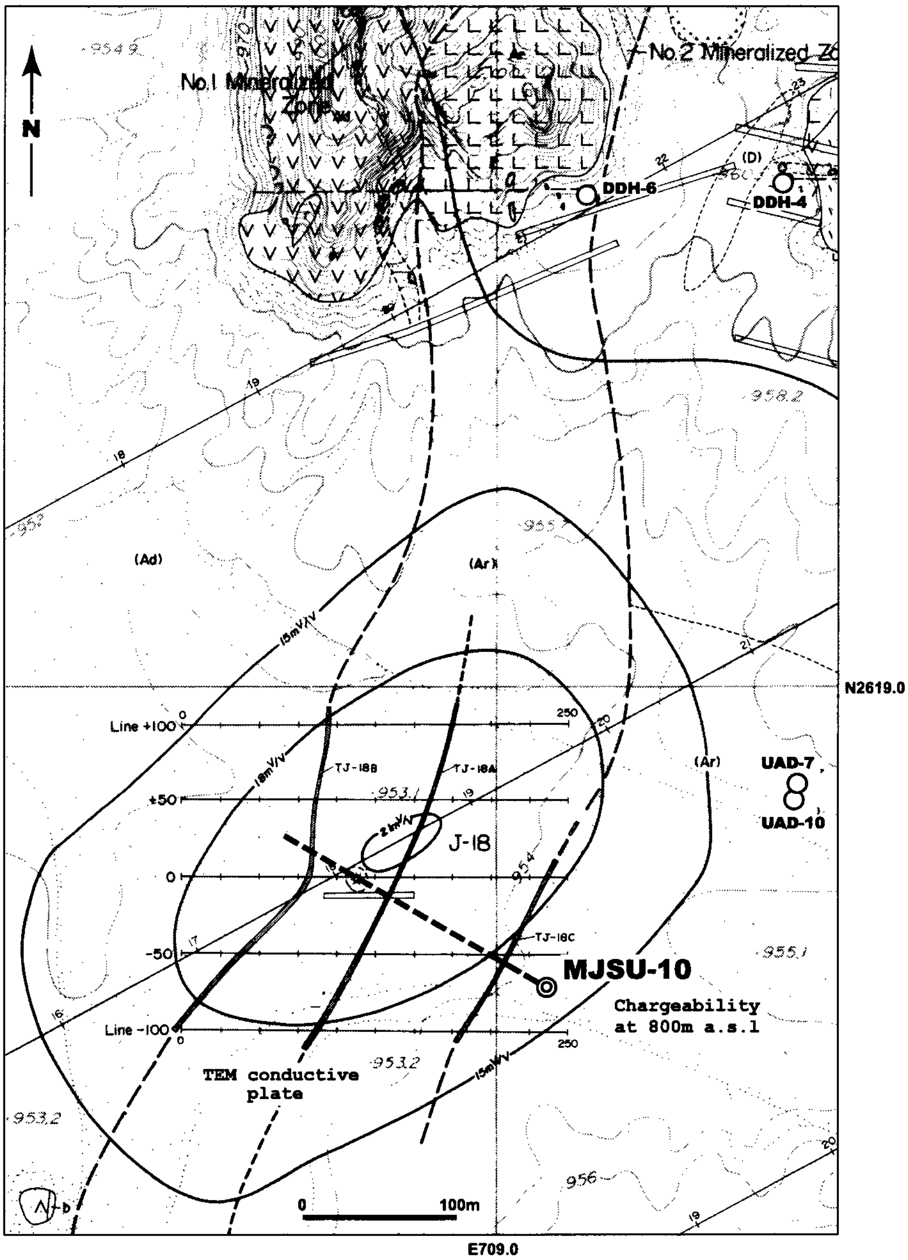
Mineralization and Alteration

Mineralization confirmed in this hole is quartz-pyrite veinlets and pyrite dissemination.

The quartz-pyrite veinlets are less than 2cm wide. The ore minerals are mainly pyrite with small amount of sphalerite. Chalcopyrite occurs rarely. Parts with dense occurrence of veinlets (veinlet groups) are found at 6 points between 132.4 and 182.4m depth and each group is 0.4 - 7.6m thick in this hole. The very densely concentrated parts occur at 132.4～140.0m (S 9.6%) and 161.7～165.8m (S 9.2%) depth intervals. The grade of these veinlet groups is less than Au 0.1g/t, Cu 0.05%, and Zn 0.01%.

Although weak, pyrite dissemination is observed throughout the length from 29.8m to the bottom of the hole. Pyrite is slightly more densely disseminated in the veinlet groups between 132.4 to 182.4m depth interval.

Alteration minerals within the veinlet groups are large amount of quartz and small amount of sericite and minor amount of chlorite. Those in parts without veinlets are large amount of quartz, small amount of chlorite and minor amount of sericite. Plagioclase is not observed in the veinlet group zone, and the large amount of sericite and the disappearance of plagioclase characterizes the alteration of the veinlet groups.



Dacite, Dacitic pyroclastic rocks

Rhyodacite, Rhyodacitic pyroclastic rocks

Dacite, Porphyritic dacite (intrusive)

Fig.2-7-19 Detailed Geological Map around MJSU-10

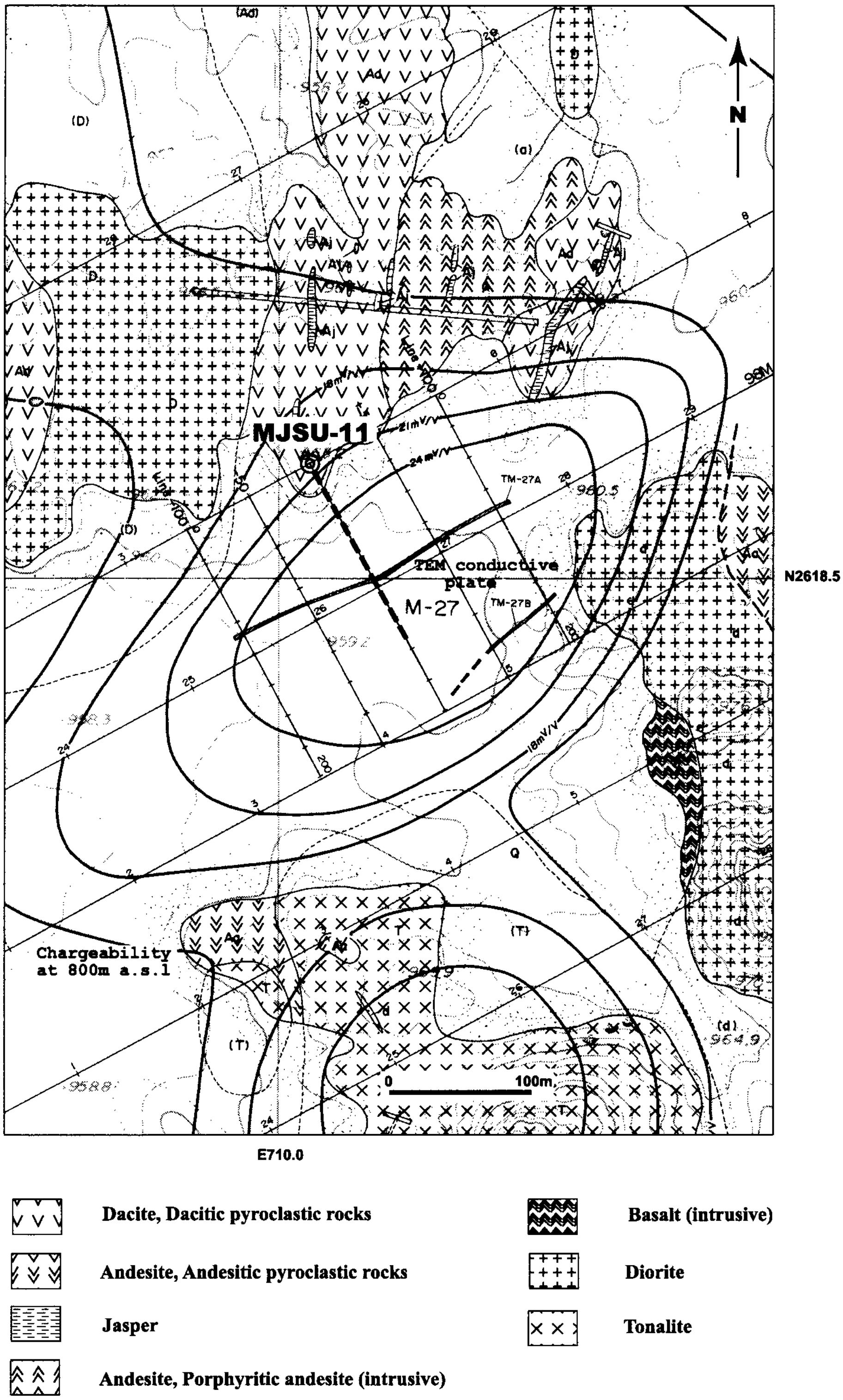
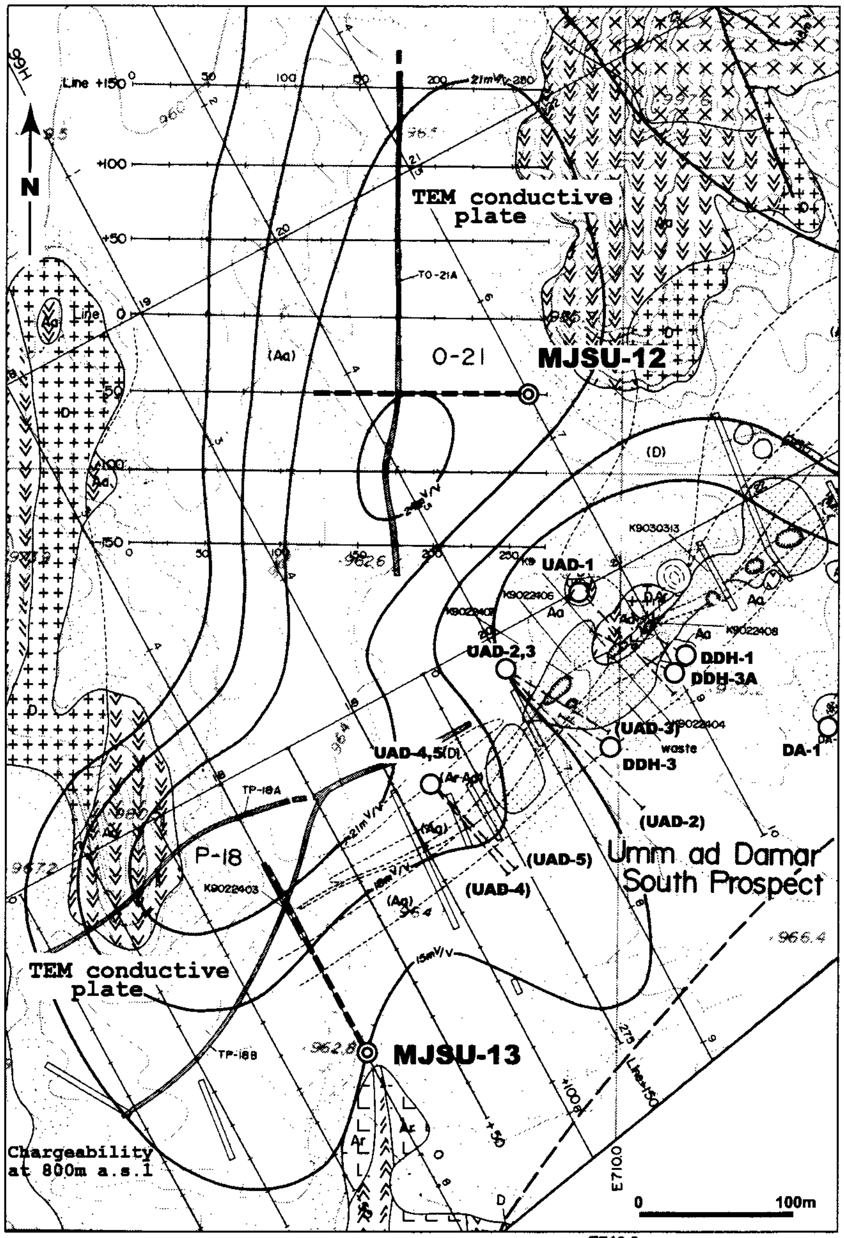


Fig.2-7-20 Detailed Geological Map around MJSU-11



E710.0

Rhyodacite, Rhyodacitic pyroclastic rocks

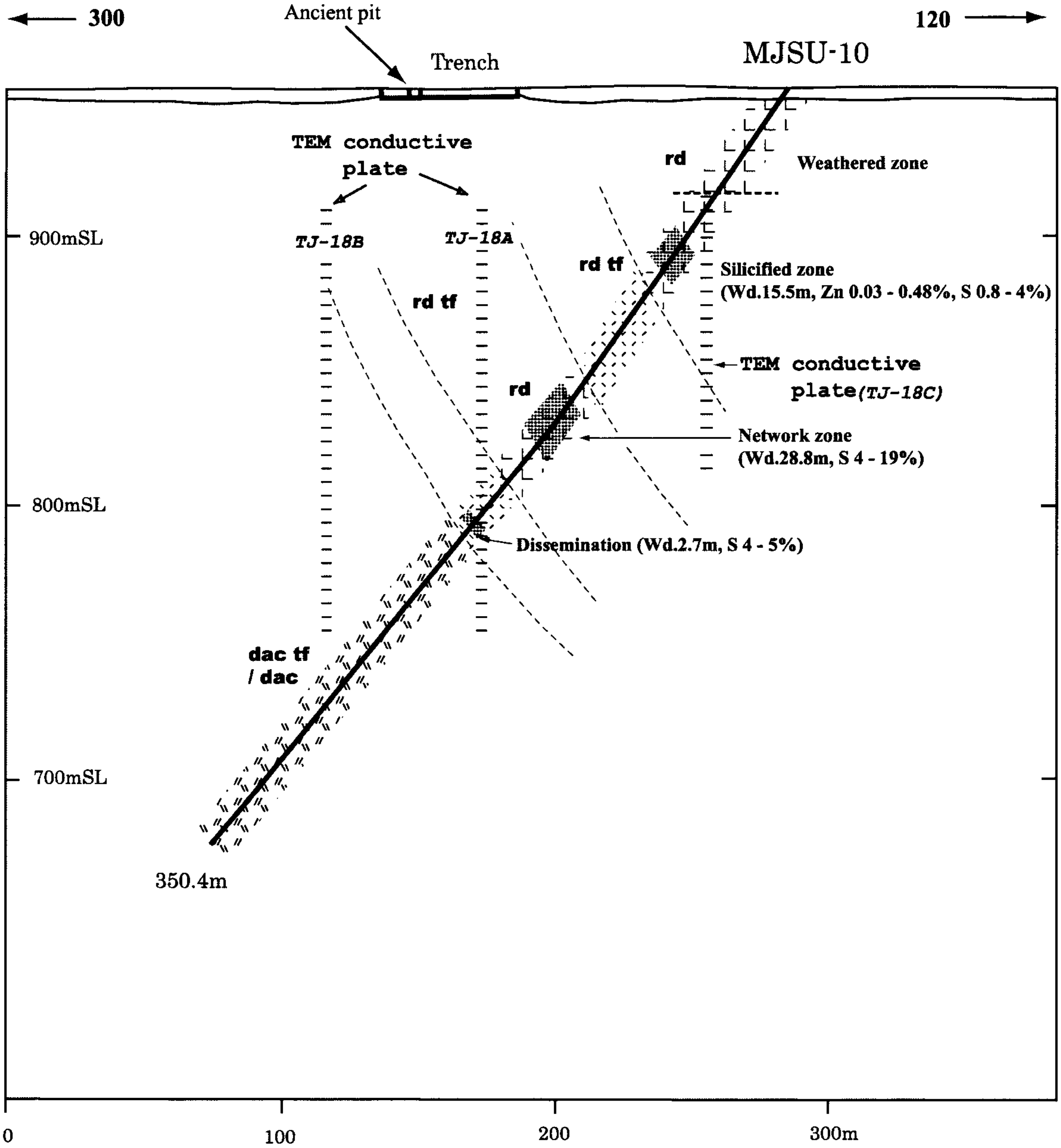
Andesite, Andesitic pyroclastic rocks

Andesite, Porphyritic andesite (intrusive)

Diorite

Tonalite

Fig.2-7-21 Detailed Geological Map around MJSU-12 and MJSU-13



Abbreviation:

rd : rhyodacite
rd tf : rhyodacitic tuff
dac tf / dac : dacitic tuff or dacite

Fig.2-7-22 Geological Section along MJSU-10

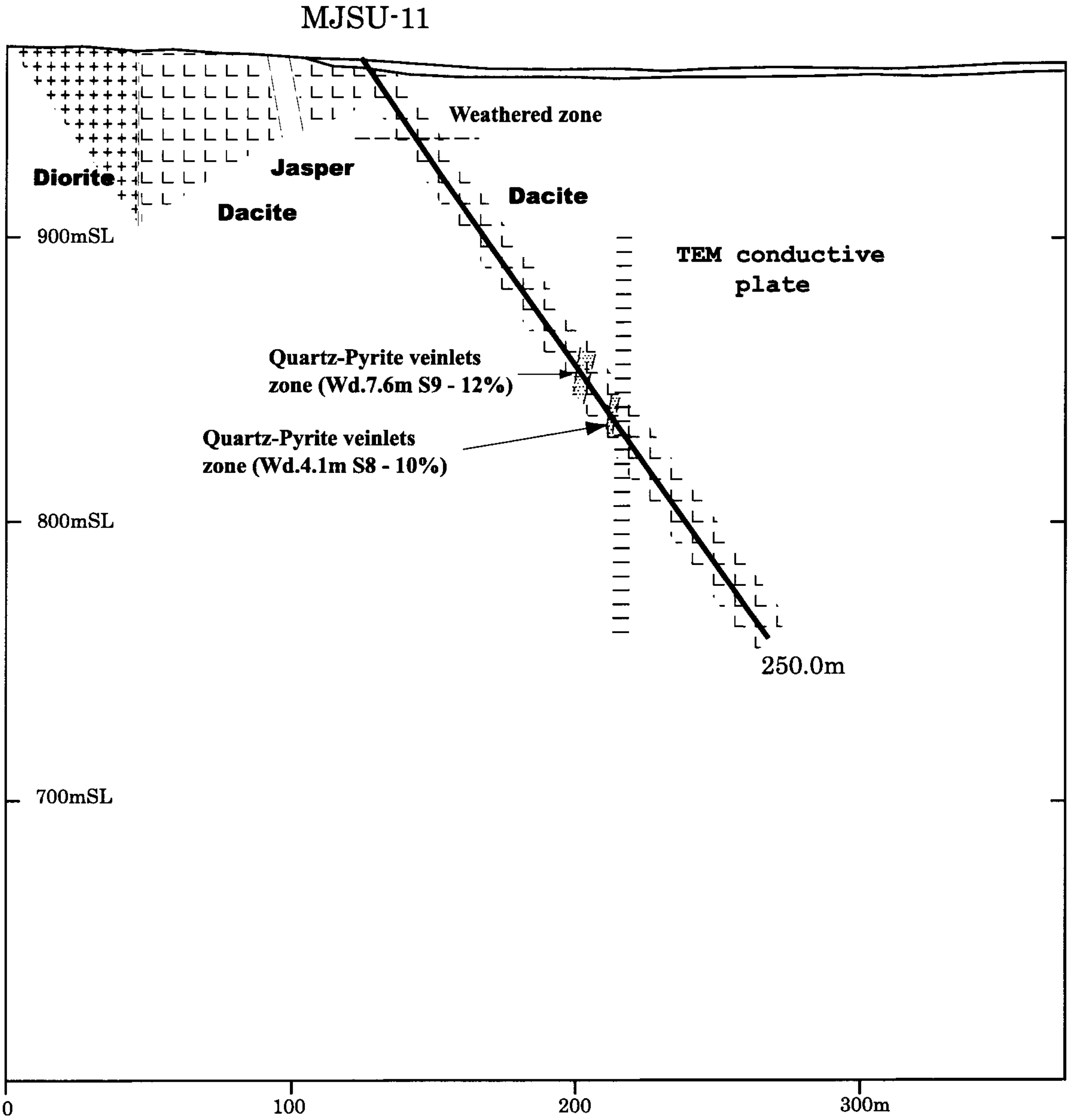
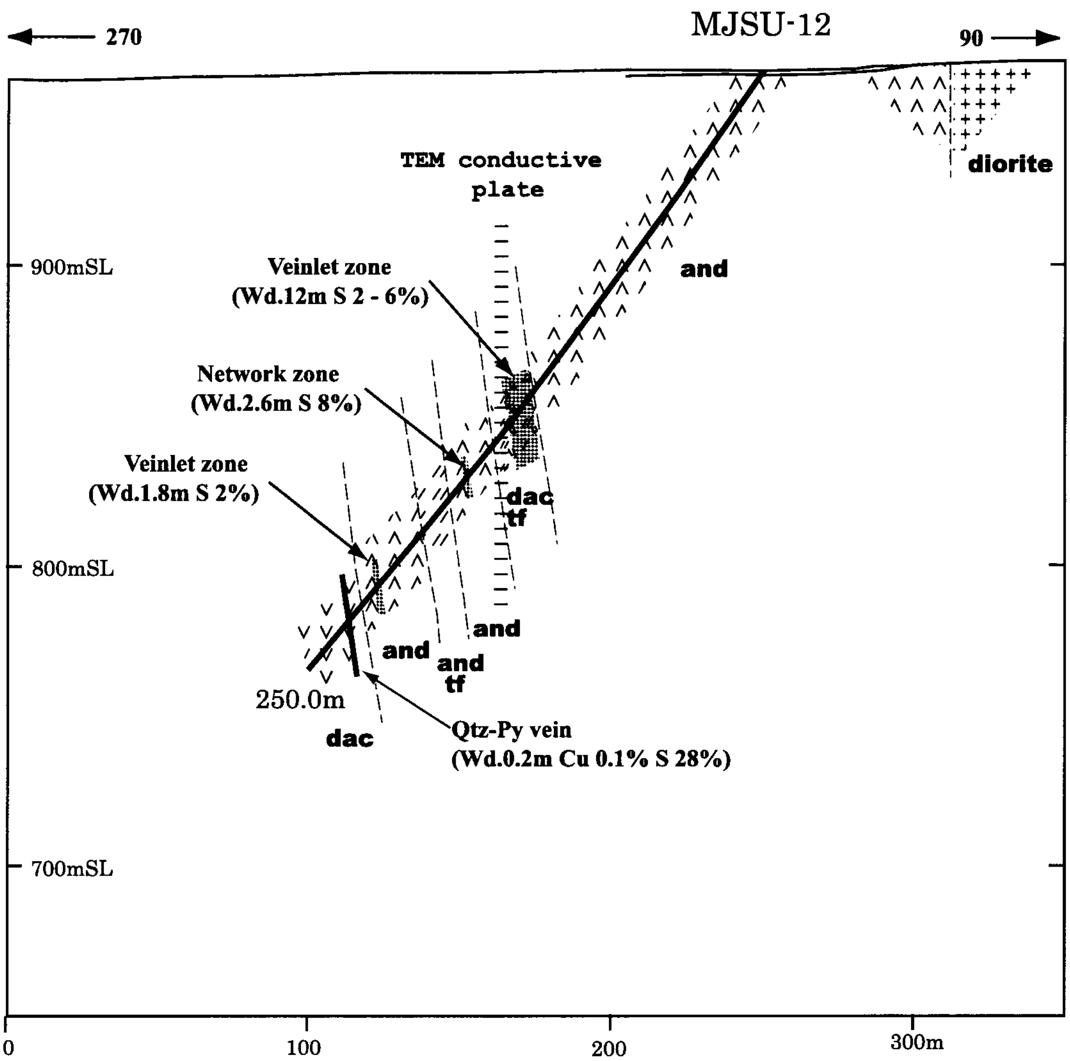


Fig.2-7-23 Geological Section along MJSU-11



Abbreviation:

dac : dacite
dac tf : dacitic tuff
and : andesite
and tf : andesitic tuff

Fig.2-7-24 Geological Section along MJSU-12

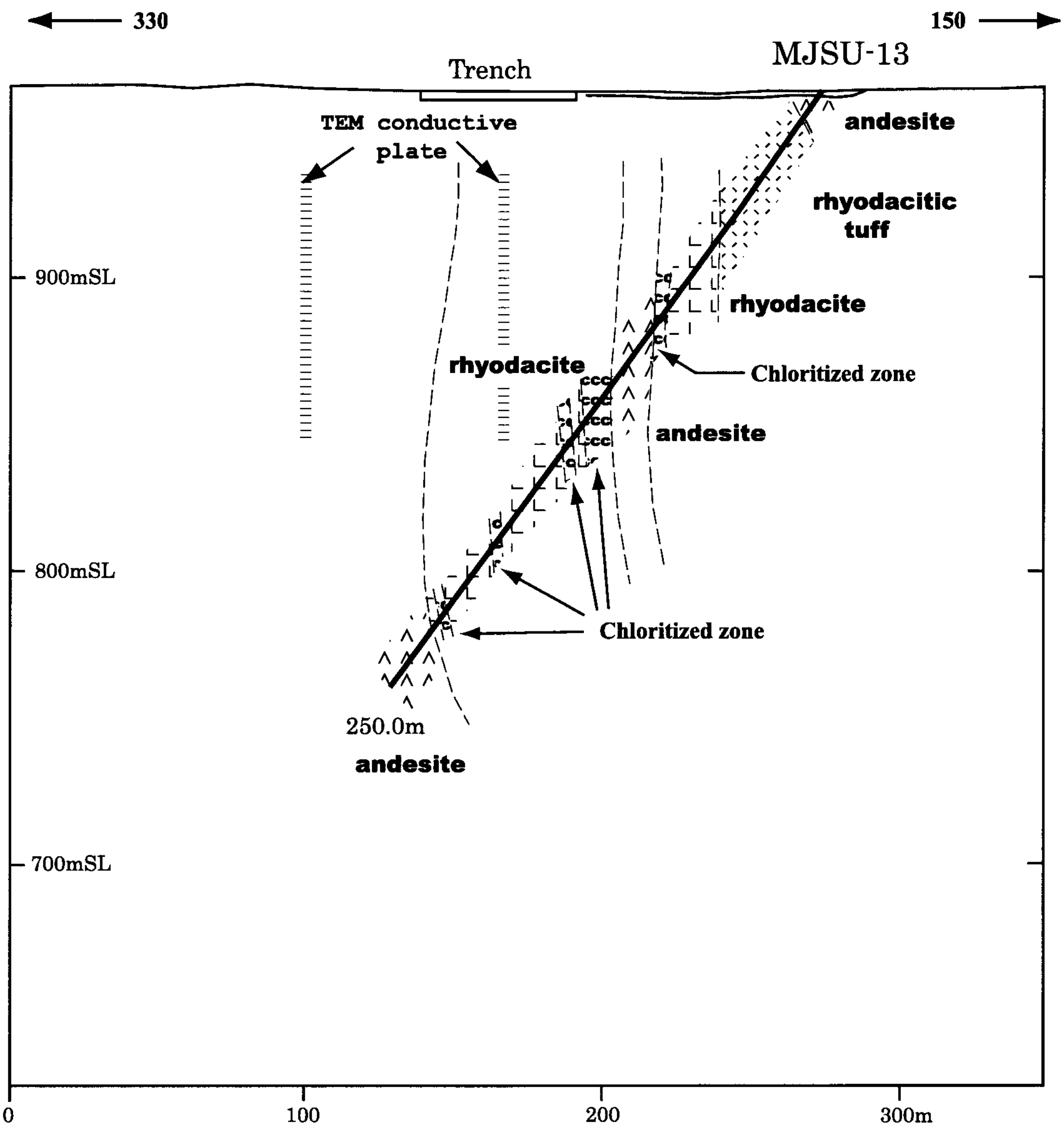


Fig.2-7-25 Geological Section along MJSU-13

(3) MJSU-12

Geology

Geology of this hole consists of dacite, dacitic tuff, andesite, andesitic tuff and intrusive porphyritic andesite.

Mineralization and Alteration

Mineralization observed in this hole is pyrite veinlets, pyrite network veins, quartz-pyrite veins, and pyrite dissemination.

The pyrite network veins occur at 163.3～165.8m depth interval and the ore minerals are mainly pyrite associated with minor amount of chalcopyrite and sphalerite. Assay results of this part are less than, 0.1g/t Au, 0.01% Cu, and 0.01% Zn.

Quartz-pyrite veins occur at 227.75～227.95m depth interval and the S content is high as 28.3%, but the Au, Cu, and Zn grades are low.

Pyrite dissemination is found at 231.6～232.0m depth interval, but the Au, Cu, and Zn grades are low.

Alteration minerals of the host rock associated with the pyrite veinlet groups (142m depth) and pyrite veins (164.7m depth) is, varying amounts of chlorite and small amount of quartz. These alteration minerals are observed in parts where veinlets are not developed, and thus the mineralization confirmed in this drill hole is not accompanied by characteristic alteration.

(4) MJSU-13

Geology

Geology of this hole consists of andesite, chloritized rock and intrusive rocks. The intrusives are porphyritic andesite and andesite.

Mineralization and Alteration

Mineralization observed in MJSU-13 is pyrite veinlets and dissemination.

Pyrite veinlets occur throughout the hole with the exception of the weathered zone from the surface to 43.4m depth and andesite at 225.1～244.6m depth interval. The density of veinlet occurrence is less than 5 veinlets per meter and densely packed zones are not observed with the exception of the chloritized rocks mentioned later. The constituent sulfide minerals of the veinlets are mainly pyrite with minor amount of associated chalcopyrite.

Although weak, pyrite dissemination has almost the same distribution as the veinlets.

Chloritized rocks occur at nine points within 89.5～188.4m depth interval. The individual thickness of these rocks are 1.0 - 8.6m. Pyrite veinlets occur more densely (S 3 - 7%) in these chloritized rocks than in the rocks of the vicinity. The Au, Cu, and Zn grades of these chloritized rocks are generally low, but the Cu grade of these rocks in 129.0～143.7m depth interval are slightly higher (about Cu 0.1%) than that in the surrounding rocks (Cu<0.04%).

Alteration minerals in the chloritized rocks are large amount of chlorite and small amount of quartz, and weakly chloritized rhyodacite contain large amount of quartz and small amounts of sericite and chlorite.

7-4-4 Discussions

Chargeability anomaly exceeding 15mV/V continues from Umm ad Damar (UAD) North Prospect to UAD South Prospect. The anomaly changes its elongation from NW-SE (UAD North Prospect) through N-S to NE-SW (UAD South Prospect).

Whole UAD North Prospect is included in this chargeability anomaly zone (more than 15mV/V) while a part of the UAD South Prospect is in the anomaly zone.

Three holes MJSU-11, MJSU-12, and MJSU-13 were drilled where the chargeability is high. The rocks of the above three high chargeability anomalies were expected to be dacites or andesites and together with the above conditions, mineralization of these localities was inferred to be of vein type.

The results of the above drilling confirmed the mineralization to be veinlets, network, and dissemination.

These are associated with vein-type mineralization and the results were as expected. But the Au, Cu, and Zn grades were low.

There is an isolated chargeability anomaly (over 15mV/V) approximately 500m west of the anomaly continuous from UAD North Prospect to UAD South Prospect. Three plates are inferred to exist in this anomaly and also rhyodacite is inferred to occur. Thus mineralization in the nature of the volcanogenic massive sulfide in the 4/6 Gossan Prospect was anticipated. The rhyodacite body expected in this anomaly extends in the N-S direction from UAD North Prospect to the 4/6 Gossan Prospect. Volcanogenic massive sulfide mineralization is observed in a part of the UAD North Prospect and in 4/6 Gossan Prospect.

MJSU-10 in this anomaly zone confirmed the occurrence of rhyodacite but volcanogenic massive sulfide mineralization could not be found. Mineralization found in this hole is pyrite veinlets and dissemination, namely vein-type mineralization.

Next, the relation between chargeability and mineralization and alteration will be considered. MJSU-10, 11, 12, and 13 were all drilled in the chargeability anomaly zones. With the exception of MJSU-13, pyrite dissemination and veinlets occurred in large amount in all the three holes. Thus the anomaly is believed to be closely associated the dissemination and veinlets. Evidences for the increase of chargeability cannot be found in MJSU-13.

CHAPTER 8 INTEGRATED ANALYSIS OF THE SURVEY RESULTS

8-1 Geologic Characteristics and Mineralization

Volcanogenic massive sulfide-type Cu-Zn mineralization, vein-type Cu mineralization, and vein-type Au-Cu-Zn mineralization occur in this area.

Volcanogenic massive sulfide Cu-Zn mineralization occurs in the 4/6 Gossan Prospect, the Jabal Sujarah district, and a part of the Umm ad Damar North Prospect.

The host rocks of the mineralized zone in the Jabal Sujarah district are breccia consisting of dacitic tuff breccia, dacitic lapillistone, and other rocks. Shale, muddy tuff and chloritized rocks are associated with parts of the mineralized zone. Also thick jasper occurs above the dacitic breccia.

On the other hand in 4/6 Gossan Prospect, mineralization is observed within rhyodacitic tuff and both the hanging wall and footwall of the mineralized zone are basaltic tuff, shale, or conglomerate.

The mineralized zone of the Jabal Sujarah district consists of massive and pebbly ores, and thick pyrite dissemination zone occurs in the footwall. That of the 4/6 Gossan Prospect consists of massive, pebbly, and siliceous ores and is not accompanied by thick pyrite mineralization. Thus although the nature of mineralization of the two prospects is similar in some aspects, but it differs in the host rocks and the occurrence and absence of thick pyrite dissemination.

Diorite occurs to the west of Umm ad Damar South Prospect, and also near and to the west of Umm ad Damar North Prospect. The diorite body near the Umm ad Damar North Prospect is the largest and occupies an area of about 500×1,500m. Tonalite occurs only near Umm ad Damar South Prospect. These plutonic bodies are concentrated in a N-S-trending belt joining the Umm ad Damar North Prospect and the Umm ad Damar South Prospect.

The vein-type mineralization is distributed in the Umm ad Damar North Prospect and Umm ad Damar South Prospect.

The vein-type mineralization in the Umm ad Damar North occurs as chalcopyrite-pyrite network veins in the fractured zones of dacitic pyroclastic rocks, porphyritic dacite (intrusive), and rhyodacitic pyroclastic rocks at the western periphery of the diorite body. The network veins have nearly parallel strike with the western margin of the diorite body.

The vein-type mineralization in the Umm ad Damar South Prospect occurs as chalcopyrite-pyrite-quartz veins and as chalcopyrite-pyrite-sphalerite dissemination in rhyodacitic pyroclastic rocks at the southwestern periphery of a tonalite-diorite body. This mineralized zone strikes in the NE-SW direction similar to the distribution of diorite and tonalite.

Since both vein-type mineralized zones occur near the plutonic bodies and strike in the direction of the elongation of the rock bodies, it is believed that the mineralization was related to the intrusive activities of tonalite and diorite.

8-2 Results of Geophysical Survey and Mineralization

IP survey was carried out with the objective of extracting IP anomalies associated with mineralization and geologic structure. Also TEM survey was carried out in the IP anomalies which indicate mineralization. And the objective was to determine the occurrence or absence of volcanogenic massive sulfide-type orebodies and vein-type orebodies, and to estimate the location and shape of the orebodies where they occur.

8-2-1 Chargeability anomalies and mineralization

Eight chargeability anomaly zones exceeding 15mV/V at 800m elevation were extracted by regional IP survey. Of these, high chargeability anomalies were obtained at many stations continuously at four localities. These are in Jabal Sujarah district, intermediate location between 4/6 Gossan Prospect and Umm ad Damar South Prospect, west of Umm ad Damar North Prospect, the zone extending from Umm ad Damar North Prospect to Umm ad Damar South Prospect.

A total of eight holes were drilled in the above anomaly localities. The localities are; 3 drill holes in Jabal Sujarah district, 1 hole to the west of Umm ad Damar North Prospect, and 4 holes in the zone between Umm ad Damar North Prospect to Umm ad Damar South Prospect.

(1) Jabal Sujarah district

Volcanogenic massive sulfide mineralized zones occur in this district. The orebodies consist of massive and pebbly ores and 100m-thick pyrite disseminated zones occur in the footwall. The average grade of these pyrite disseminated zones is 5.8 - 8.2% S.

Chargeability measurements of the drill cores in the laboratory indicate values of 8 - 180mV/V (average of 12 samples, 42mV/V). Massive ore samples show very high values of 625mV/V.

On the other hand, detailed IP survey results show that the high chargeability anomaly zone at 800m elevation (40mV/V) in this district extends 240m in the NE-SW direction and 140m in the NW-SE direction.

The attitude of the pyrite dissemination zone is inferred to be strike E-W and dip vertical to 60° S. And the distribution largely coincides with that of the above chargeability anomaly zone. Thus the chargeability anomalies of this prospect can be said to represent the pyrite disseminated zone. Also the thickness of the massive and pebbly ores is at the most about 6m and the contribution of these orebodies to the chargeability anomalies is considered to be not large.

(2) West of Umm ad Damar North Prospect

MJSU-10 was drilled in this anomaly zone. The chargeability of the MJSU-10 drill core was measured to be 5 - 170mV/V (average of 9 samples; 29mV/V). The highest chargeability was measured on pyrite network veinlet sample, and that of other pyrite dissemination and veinlet samples range from 5 to 29mV/V (average 12mV/V).

The zone with more than 15mV/V chargeability in this locality delineated by regional IP survey extends for about 400m in the E-W direction and 250m in the N-S direction at 800m elevation.

In MJSU-10 drill hole, pyrite dissemination partly associated with network and veinlets occurs at 42.9～216.6m depth interval with the exception of oxidation leached zone and intrusive bodies.

From the above it is concluded that the chargeability anomalies of this locality reflects the pyrite dissemination, network and veinlets.

(3) Between Umm ad Damar North Prospect to Umm ad Damar South Prospect

Within this subarea, high chargeability anomaly zones occur in four localities. The chargeability values are; over 24mV/V, over 24mV/V, over 21mV/V, and over 21mV/V at 800m elevation. Four holes, namely MJSU-3, MJSU-11, MJSU-12, and MJSU-13 were drilled in these anomaly zones.

MJSU-3 was designed to reach the center of the chargeability anomaly that extends 350m in the NW-SE direction and 250m in the NE-SW direction at 800m elevation. Small vein-type Cu mineralization was observed at 188.20～220.90m interval and many porphyritic dacite intrusive bodies associated with pyrite dissemination occur below 97.75m depth. Chargeability of the pyrite disseminated part of the drill core was measured to be 9 - 33mV/V. The lateral distribution of these intrusive bodies is harmonious with the chargeability anomalies and thus it is highly possible that the weak pyrite dissemination of the intrusive bodies is the cause of the anomaly.

Although weak, pyrite dissemination is observed throughout the length from 29.8m to the bottom of the hole. Pyrite is slightly more densely disseminated in the veinlet groups between 132.4 to 182.4m depth interval. There are some possibilities that the above conditions caused the chargeability anomaly exceeding 24mV/V, but the measured chargeability values of the drill cores are within the range of 7 - 13mV/V, and evidences for the high anomalies could not be found in this drill hole.

Pyrite-bearing veinlets and network are observed and pyrite dissemination also occurs in MJSU-12. The higher chargeability values measured on the drill core are 26 - 72mV/V. Thus the existence of the above veinlets and network is interpreted to have raised the chargeability values.

Pyrite-bearing veinlets and pyrite dissemination are observed in MJSU-13, but the veinlets are less dense than in the above two drill holes. The chargeability values of the drill core measured in the laboratory are 5 - 18mV/V for the veinlets and disseminated parts and 2 - 3mV/V for parts without pyrite. This hole was drilled outside this anomaly zone (within 15 - 21mV/V range) and the value exceeding 21mV/V is inferred to reflect the occurrence of more dense veinlets and dissemination.

(4) 4/6 Gossan Prospect

Although not in a large scale as the above anomaly zones, there are chargeability anomaly zones in 4/6 Gossan Prospect. Many holes have been drilled in the vicinity of these anomaly zones, and the results will be discussed in the following sections.

There is a zone with 200×160m extension in the central part of this prospect where chargeability exceeds 15mV/V at 800m elevation. MJSU-2 and MJSU-14 were drilled in this chargeability anomaly zone and both have confirmed the occurrence of volcanogenic sulfide-type mineralization. The laboratory chargeability measurement of the drill cores of both holes indicate over 450mV/V for massive and pebbly ores, 8 - 15mV/V for rocks with somewhat strong pyrite dissemination, and 2.5 - 4mV/V for other rocks.

The total thickness of the massive and pebbly ores in MJSU-2 and MJSU-14 is at the most 6m excluding the intercalated mudstone and tuff.

Strong volcanogenic massive sulfide-type mineralization has not been encountered in MJSU-6 and MJSU-16 drilled outside this anomaly zone. Thus considering the above phenomena, it is inferred that this anomaly zone reflects the occurrence of massive and pebbly ores.

8-2-2 Conductive plates and mineralization

The mineralized zones in this area are inferred to be platy and vertical from geological survey and the results of the past drilling. Thus plate analysis was applied to the obtained TEM data because it can best extract the shape of the mineralized zones.

Drilling was carried out this year with the purpose of confirming the structure of the resistivity and high chargeability extracted from geophysical prospecting. The conductivity plates coincided with the disseminated zones and ore veinlets in almost all of the drill holes. However the expected platy resistivity structure was not obtained and evidences for platy shape of the mineralized zones could not be found from the geology of the vicinity.

The location of the conductive plates reasonably coincides with dissemination and network mineralized zones and thus the plates are considered to reflect the mineralized zones. In these cases the conductance of the plates are 1 - 3 S, and thus, if the width of the mineralized zones is less than several tens of meters, their resistivity will be less than 30ohm-m. This value is close to the resistivity of massive ore obtained by laboratory tests (about 20ohm-m), but differs from that of the disseminated and network rocks (40 - 100ohm-m). The following is considered to be the reason for the disagreement of the values.

① The low resistivity anomalies detected by TEM are dependent on the conductance, which is the product of conductivity (inverse number of resistivity) and the thickness. Bodies with the same conductance, for example, 50m thick plate with 50ohm-m resistivity and 10m thick plate with 10ohm-m, are equivalent electro-magnetically and cannot be distinguished. In the present survey, existence of thin plate was surmised as a result of model simulation on the basis of 20ohm-m resistivity, which was measured during the second year on massive ore samples. It is, however, interpreted that electro-magnetically-equivalent thick disseminated mineralized zones occur.

② The resistivity of rock samples measured in the laboratory is generally higher than the values measured in the field. This discrepancy is believed to be caused by the difference of environment of measurement. Namely the resistivity is measured in air in laboratories, while in the field, average values of large rock bodies including fissures with groundwater are obtained.

③ The resistivity of conductive plates has homogeneous platy structure in 2-dimensional analysis, but in actual structure the resistivity is uneven and the product of thickness and resistivity varies significantly.

The above is believed to be the cause of the discrepancy between the results of electro-magnetic modeling and drilling.

8-3 Mineral Potential

The following is the mineral potential of the surveyed areas judged from the results of exploration carried out.

(1) Jabal Sujarah

The mineralization of this district is volcanogenic massive sulfide-type Cu-Zn mineralization. The mineralized zones consist of massive and pebbly ores and are accompanied by pyrite dissemination. The highest chargeability anomaly (exceeds 30mV/V at 800m elevation) in the entire survey area occurs over a range of 200×200m in this district. These anomalies are caused by strong and thick pyrite dissemination zone in the footwall of the massive and pebbly ores. These dissemination zones consist only of pyrite and Au, Cu, and Zn contents are negligible.

There are several layers of massive and pebbly ores and the thickness of the mineralized zone including the intercalated pyrite dissemination is about 6m. The extent of the mineralized zone is about 200m in the strike direction and over 250m in the dip direction. The massive and pebbly ores are partly rich in Cu and Zn, but their grade is generally low consisting mostly of pyrite.

From the above, the potential of this prospect for mineral development is concluded to be low.

(2) Umm ad Damar North Prospect

Existence of five rows of vein-type Cu mineralized zones is inferred in this prospect (these zones are numbered from Mineralized Zone No.1 to No.5).

Five holes have been drilled in Mineralized Zone No.1 and the average thickness of this orebody is 4.8m and the grade Cu 1.40%. Two holes were drilled in Zone No.2, and two to three veinlet groups and dissemination have been confirmed. The average thickness is 3.5m and the grade Cu 2.38%. In Zone No.3, four holes were drilled and the orebody is 3.1m thick and the grade Cu 1.87% at drill hole UAD-11. The Nos. 1 and 2 mineralized zones are expected to extend 400 - 500m in strike direction, and about 300m for the Zone No.3. Grades of metals other than Cu such as Au and Zn are low.

Aside from Cu veins, volcanogenic massive sulfide mineralization was confirmed by MJSU-5 in this prospect, but drilling in the vicinity has not encountered such mineralized zones and this is considered to be of small scale.

From the above, the potential of this prospect for mineral development is concluded to be low.

(3) Umm ad Damar South Prospect

There is one row of vein Cu-Zn mineralized zones in Umm ad Damar South.

Eleven holes were drilled in this mineralized zone in the past and ores were confirmed in four holes. The hole drilled in a location southwest of this mineralized zone this year did not encounter vein-type mineralization. From the above data, this mineralized zone is inferred to be 2.1 - 6.9m thick and 130m long in the dip direction. The Cu grade is 1.99 - 2.93%. Au and Zn has been found in some drill holes and the grade is Au 0.3 - 1.1g/t and Zn 0.2 - 3.1%.

As mentioned above, the data lead us to conclude that this prospect has low potential for mineral development.

(4) 4/6 Gossan Prospect

The mineralization that occur in this prospect is volcanogenic massive sulfide-type Cu-Zn mineralization.

The mineralized zone consists of massive, siliceous, and pebbly ores and contains chalcopyrite, sphalerite, pyrite, and other ore minerals.

Three mineralized layers are observed above and below (apparent) the basaltic tuff. The zone below the basaltic tuff can be divided into two parts. The zone immediately below the basaltic tuff is most thick in MJSU-2 with estimated thickness of 3.7m. The grade here is Au 0.4g/t, Cu 0.96%, and Zn 2.17%.

The mineralized zone further below is 9.3m thick in MJSU-2 which is also the most thick part encountered. The grade is Au 0.4g/t, Cu 1.00%, and Zn 3.67%.

There is a mineralized zone above the basaltic tuff. This is also confirmed in MJSU-6. Here the zone is about 2.5m thick and the grade is Au less than 0.1g/t, Cu 0.69%, and Zn 3.99%.

The two mineralized zones below the basaltic tuff is estimated to be about 100m long in the strike direction and more than 60m and more than 120m respectively in the dip direction. The zone above the basaltic tuff was confirmed only in one hole and is at most 100m long in the strike direction. Therefore, this prospect is considered to have low potential for mineral development.

(5) Other chargeability anomaly zones

The known mineralized zones in Umm ad Damar Prospect and others are all within the IP chargeability anomaly zones (over 15mV/V, at 800m elevation). Therefore, it was hoped that similar mineralized zones would also occur in high chargeability anomaly zones other than the above known mineralized bodies. Drilling was carried out to ascertain this inference. The results, however, clarified that these anomalies were caused by pyrite veinlets and dissemination, but the Au, Cu, and Zn contents were low.

In the Jabal Sujarah area, the highest chargeability anomaly (over 30mV/V, 800m elevation) in the whole survey area occurs extensively. This chargeability anomaly, however, was formed by the pyrite dissemination in the footwall associated with volcanogenic massive sulfide mineralization. Since chargeability anomaly exceeding 30mV/V does not occur in other prospects of the survey area, mineralization with characteristics of this prospect probably do not occur elsewhere.