(3) Results of Simulation

Two dimensional computer simulation was carried out for the survey lines that low AR and high PFE values were measured.

As the results, following analytical values were obtained:

Area	Line	Depth(m)	Resist.(Ωm)	PFE (%)
Hajar Area	HJ - 1	-200	12	20
	E - 14	-200	12	20
Lamrah Area	LM - 2	-200	10	15
	E - 2	-100	15	5
Frizem Area	W - 1	-100	20	10
	FZ - 1	-200	20	25
	W - 2	-100	20	10
	W - 3	-100	20	10
	FZ - 2	-200	50	20

(4) Extraction of IP Anomaly Zone

The remarkable IP anomaly zones that suggest of the existence of ore deposit were extracted as follows:

Area	Measured V.		Analyzed V.		Magnetic	Geological
	PFE(%)	AR(Ωm)	PFE(%)	ρ(Ωm)	Anomaly	Structure
Hajar S-W	3-4	30-50	20	12	Medium	Southwest of Hajar m.
Lamrah Area	3-5	20-40	5-15	15-20	Weak	West of Hajar horizon
Frizem Area	5-6	20-40	10-25	10-20	Strong	Frizem West min. zone

2-3 Gravity Method

By the gravity survey, several high gravity anomaly zones such as the Hajar area, the Okhribane area, the Akhlij area, and the Amzourh area were detected.

These gravity high zones are corresponding to the exposed area of the basement rocks, the area covered with thin Quaternary sediments, and the uplift area of the basement.

These areas suggest a possibility of ore deposit occuring comparatively in the shallow place, although they do not always indicate the existence of orebody.

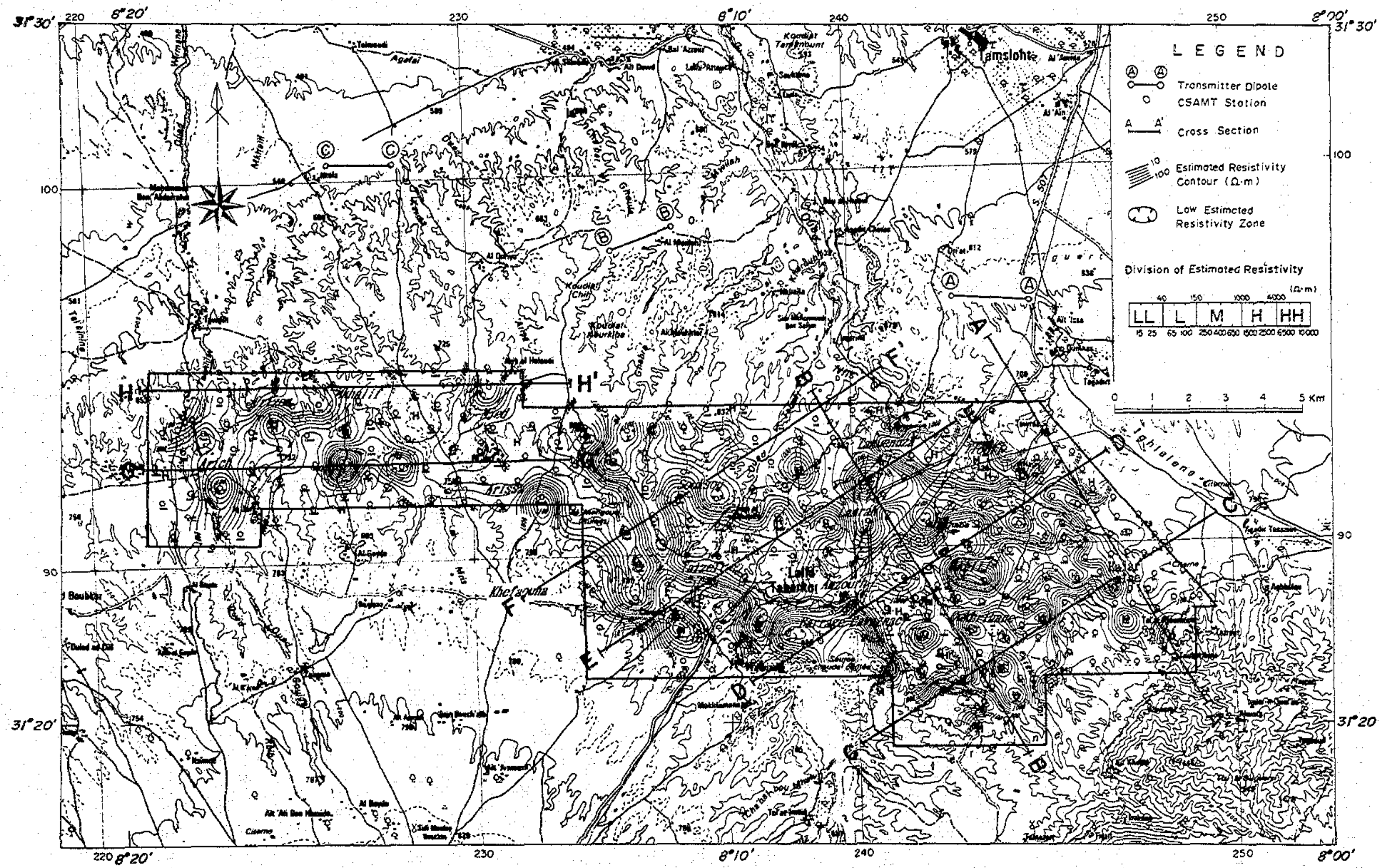


Fig. 17 Resistivity Structure Deduced by CSAMT Method (100m Depth)

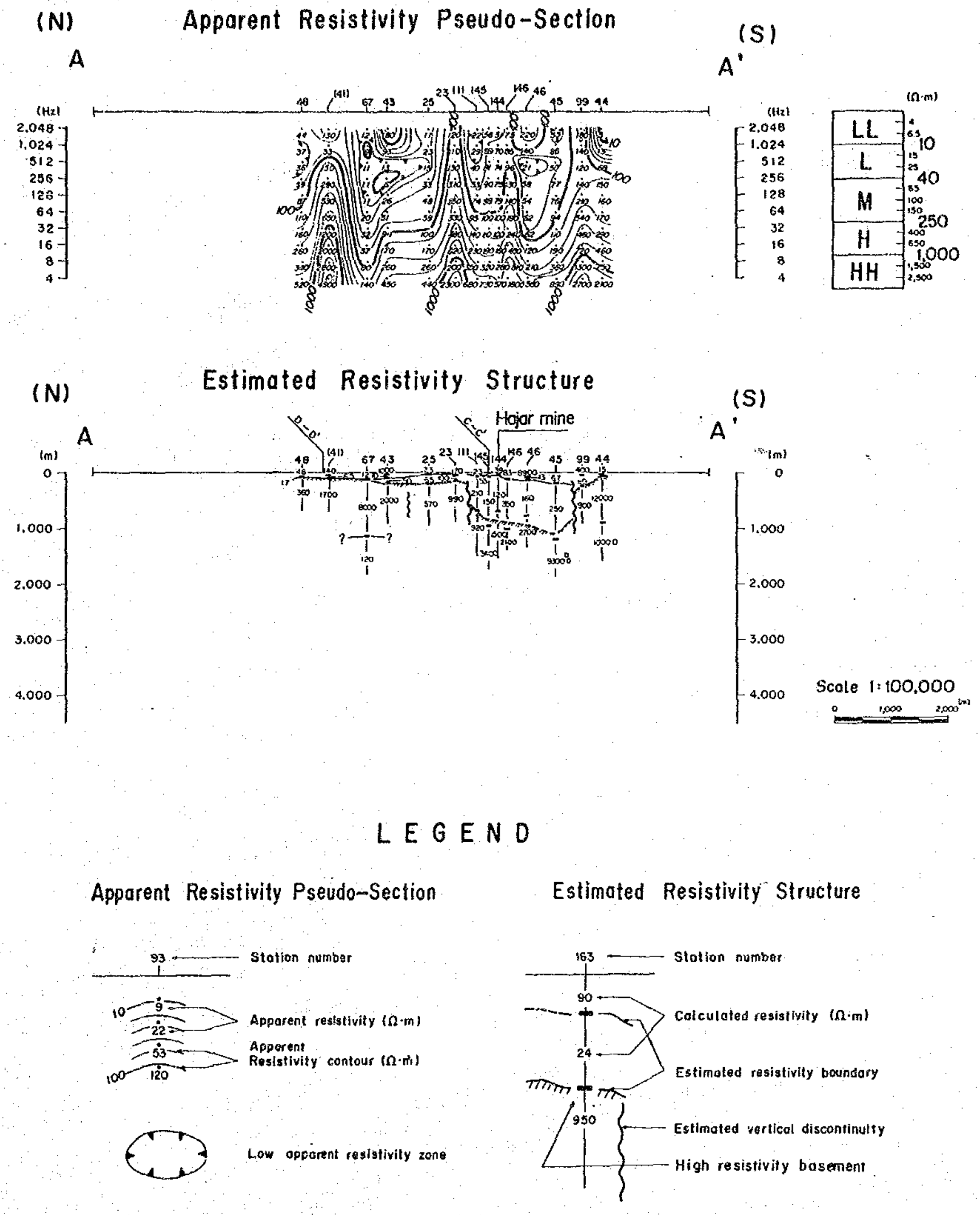


Fig. 18 Resistivity Structure Deduced by CSAMT Method (A-A' Section)

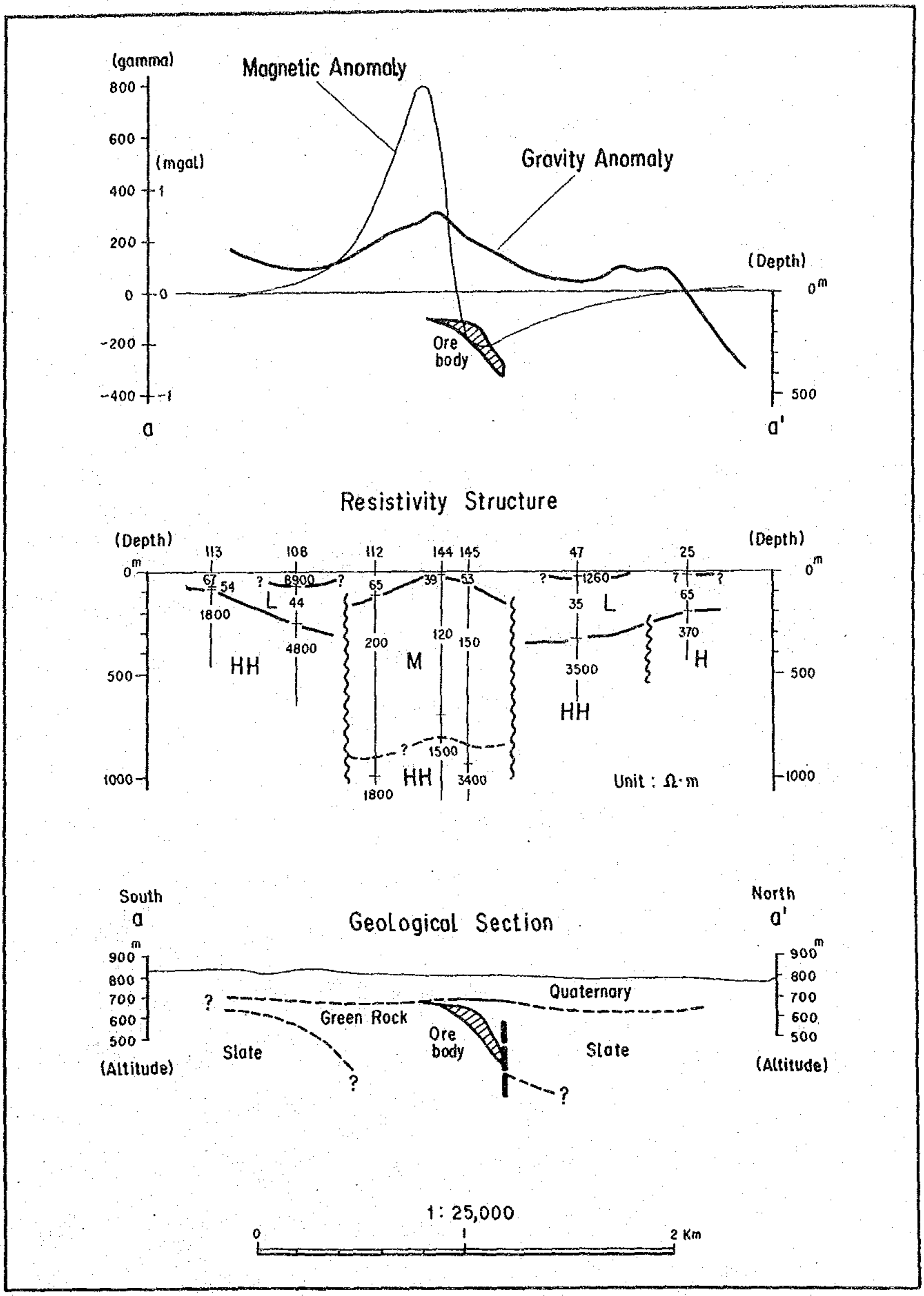


Fig. 19 Relation of Geophysical Survey Results by Different Methods over the Haiar Mine

Tab.4 Measured Values of Rock Property

No.	Formation	Rock Name	Resistivity (Ω・m)	mean	mean	P F E (%)	mean	Density (g/cc)	mean	Susceptibility (10^{-5}cgs/emu)	mean
1		Sand	61			2.3		2.27		3	
2		〃	53			1.7		2.30		2	
3		〃	27			2.1		2.16		-	
4	Quaternary	〃	89		73	0.9	1.1	2.44	2.21	-	2
5		Tuff	150			0.3		2.01		-	
6		〃	76			0.8		1.86		-	
7		Mud	120			1.3		2.48		-	
8		Mudstone	240	330		1.9		2.70		2	
9		〃	460			1.5		2.73		3	
10		Siltstone	1000	880		0.2		2.68		2	
11		〃	730			0.9		2.67		2	
12		Carbonatic Schist	710			0.7		2.71		-	
13		〃	550			0.2		2.73		2	
14		〃	520			1.4		2.67		2	
15	Permian	〃	670			0.2		2.78		2	
16		〃	650			0.1		2.64		-	
17	|	Pelitic Schist	480	520	510	4.3	0.8	2.76	2.70	3	2
18		〃	500			0.6		2.70		2	
19	Carboni-	〃	420			0.2		2.79		3	
20	ferous	〃	290			0.6		2.65		2	
21		〃	510			0.9		2.74		3	
22		Dacite	230			1.1		2.73		2	
23		〃	700	340		3.0		2.70		1	
24		〃	250			2.1		2.61		3	
25		Quartz Vein	1100			1.5		2.61		1	
26		Pb-Zn-Pyrr. ore	21			29.5		4.32		260	
27		〃	15			15.4		4.49		500	
28		〃	14			13.7		4.34		1300	
29	Ore of	〃	11			11.9		3.95		480	
30	Hajar mine	〃	23		18	13.8	15.4	3.89	4.25	—	530
31		〃	35			8.5		3.74		—	
32		〃	17			13.2		4.56		—	
33		〃	20			19.8		4.83		—	
	Mean				150		1.7		2.89		5

※ mean … Geometrical Average

Sample No.	Location & Depth	Resistivity (Ω・m)	mean	P F E (%)	mean	Rock Name
1	MJMH-1 101 m	1,400		2.6		Pelitic Schist Intc.Silts.
2	〃 201 m	230		5.6		Pelitic Schist (Py Diss.)
3	〃 255 m	550	760	1.0	2.7	Pelitic Schist
4	〃 301 m	2,200		4.3		Pelitic Schist Intc.Silts.
5	〃 400 m	670		2.3		Pelitic Schist
6	MJMH-2 141 m	98		17.4		Py-Po Network Ore
7	〃 183 m	1,700		0.3		Psammitic Schist
8	〃 220 m	920	560	1.2	2.3	Pelitic Schist
9	〃 247 m	300		11.4		Py Network Ore
10	〃 317 m	1,200		0.9		Pelitic Schist
11	MJMH-3 92 m	110		0.9		Pelitic Schist
12	〃 126 m	12	51	12.0	4.0	Py-Po Massive Ore
13	〃 141 m	100		5.8		Py Veinlet Ore
Mean		360		2.8		

Tab.5 Mean Values of Apparent Resistivity

(Phase II)

Line	Apparent Resistivity (Ω·m)								Standard
	n=1	n=2	n=3	n=4	n=5	Ave.	Max.	Min.	Dev. σ
HJ-1	40	41	49	57	68	50	160	19	27
2	57	61	68	85	95	72	180	27	37
TF-1	36	50	66	76	90	61	230	15	45
2	30	45	57	76	93	58	220	20	38
3	24	28	37	45	55	37	99	17	15
AK-1	60	92	130	160	200	130	960	26	130
2	39	46	64	69	80	58	150	22	35
LH-1	30	39	50	58	61	46	99	22	19
2	40	58	71	88	86	67	260	19	49
3	26	34	43	49	56	41	91	14	19
4	17	23	32	40	47	30	61	11	13
FZ-1	120	130	110	110	130	120	360	24	74
2	190	250	270	290	280	250	980	48	180
Ave.	55	69	80	92	100	78			

(Phase III)

Line	Apparent Resistivity (Ω·m)								Standard
	n=1	n=2	n=3	n=4	n=5	Ave.	Max.	Min.	Dev. σ
E-1	28	37	47	58	79	47	130	17	26
E-2	35	50	61	71	69	56	180	14	32
E-3	32	43	56	69	93	57	310	20	44
E-4	30	41	50	63	75	51	110	21	18
E-5	53	74	94	100	130	90	210	22	49
E-6	64	100	120	120	140	110	310	22	80
E-7	120	140	150	150	160	150	340	20	83
E-8	58	110	120	140	160	120	250	10	68
E-9	29	47	64	81	100	63	230	18	37
E-10	19	30	43	56	71	42	94	14	19
E-11	25	40	53	62	71	49	110	13	20
E-12	23	31	40	54	61	41	110	13	18
E-13	25	34	45	50	60	42	93	17	17
E-14	33	40	43	45	46	41	73	22	11
W-1	120	130	120	120	120	120	280	20	61
W-2	110	120	140	180	180	140	490	32	88
W-3	130	180	210	230	230	190	700	32	150
Ave.	55	73	86	96	110	83			

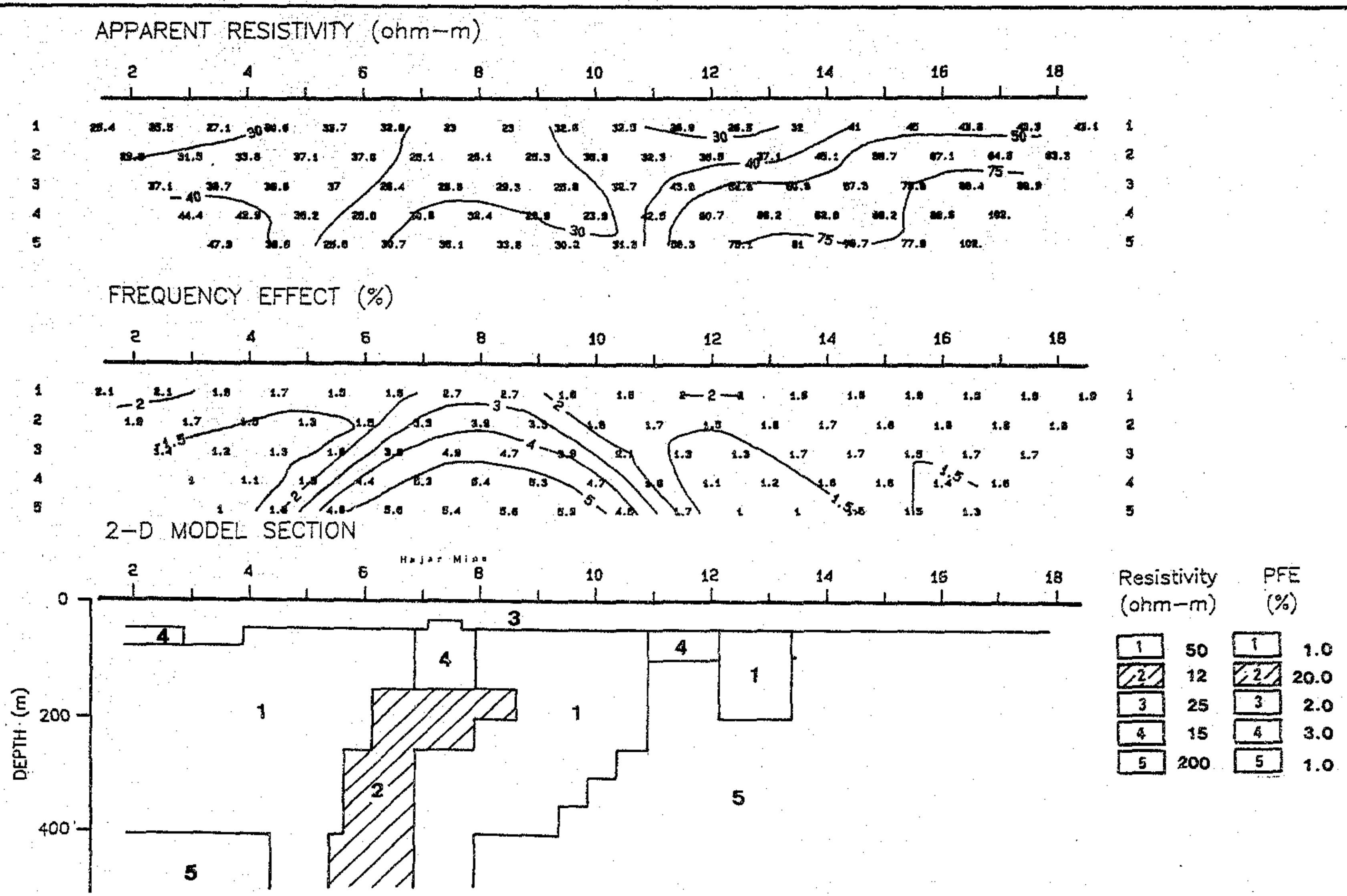
Tab.6 Mean Values of PFE

(Phase II)

Line	PFE (%)								Standard
	n=1	n=2	n=3	n=4	n=5	Ave.	Max.	Min.	Dev. σ
HJ-1	2.0	2.0	2.4	2.9	3.4	2.5	6.6	0.6	1.4
2	1.4	1.4	1.4	1.7	1.7	1.5	2.6	0.8	0.3
TF-1	1.2	1.3	1.5	1.7	1.9	1.5	2.4	0.6	0.4
2	1.1	1.4	1.5	1.6	1.7	1.4	2.8	0.3	0.5
3	1.1	1.3	1.3	1.4	1.8	1.4	2.3	0.6	0.5
AK-1	1.3	1.4	1.5	1.5	1.7	1.5	3.3	0.0	0.8
2	1.4	1.5	1.6	1.6	1.6	1.5	2.5	0.6	0.5
LH-1	1.7	1.7	2.0	2.2	2.6	2.0	3.4	1.3	0.5
2	1.6	1.7	2.2	2.5	2.4	2.0	4.9	0.9	0.7
3	1.2	1.4	1.5	1.7	2.0	1.5	3.0	0.7	0.5
4	1.0	1.2	1.5	1.6	1.7	1.4	2.3	0.4	0.4
FZ-1	2.7	3.4	3.9	4.4	4.3	3.7	6.0	1.3	1.0
2	2.0	2.2	2.3	2.6	2.9	2.4	5.0	0.8	1.0
Ave.	1.5	1.7	1.9	2.1	2.3	1.9			

(Phase III)

Line	PFE (%)								Standard
	n=1	n=2	n=3	n=4	n=5	Ave.	Max.	Min.	Dev. σ
E-1	0.7	1.0	1.2	1.7	2.2	1.3	3.0	0.4	0.6
E-2	1.2	1.7	2.2	2.7	3.7	2.2	5.1	0.3	1.0
E-3	1.1	1.3	1.7	2.1	2.6	1.7	4.2	0.6	0.7
E-4	0.9	0.8	1.0	1.3	1.6	1.1	2.1	0.4	0.4
E-5	0.8	1.2	1.3	1.5	1.9	1.3	2.5	0.3	0.5
E-6	0.7	0.9	1.0	1.4	1.5	1.1	2.8	0.4	0.5
E-7	1.0	1.2	1.6	1.8	1.9	1.5	3.1	0.0	0.9
E-8	1.0	1.1	1.3	1.5	2.2	1.4	3.1	0.0	0.8
E-9	0.5	0.7	0.6	0.9	1.2	0.8	2.0	0.1	0.4
E-10	0.5	0.5	0.6	0.8	1.0	0.7	1.5	0.2	0.3
E-11	0.6	0.7	0.8	1.1	1.2	0.9	2.0	0.3	0.4
E-12	0.6	0.8	0.9	1.1	1.3	0.9	2.2	0.3	0.4
E-13	0.9	1.1	1.3	1.6	2.0	1.4	2.7	0.5	0.5
E-14	0.8	1.0	1.4	2.3	2.8	1.6	4.2	0.2	0.9
W-1	2.8	3.5	3.9	4.2	4.8	3.7	6.8	1.5	1.0
W-2	2.1	2.9	3.1	3.4	3.8	3.0	5.4	0.2	1.3
W-3	2.2	2.5	2.8	3.1	3.2	2.8	5.5	0.0	1.3
Ave.	1.1	1.3	1.6	1.9	2.3	1.6			



DIPOLE LENGTH: 100 m

Fig. 20 Results of IP Modeling (Line HJ-1)

SCALE = 1: 10000

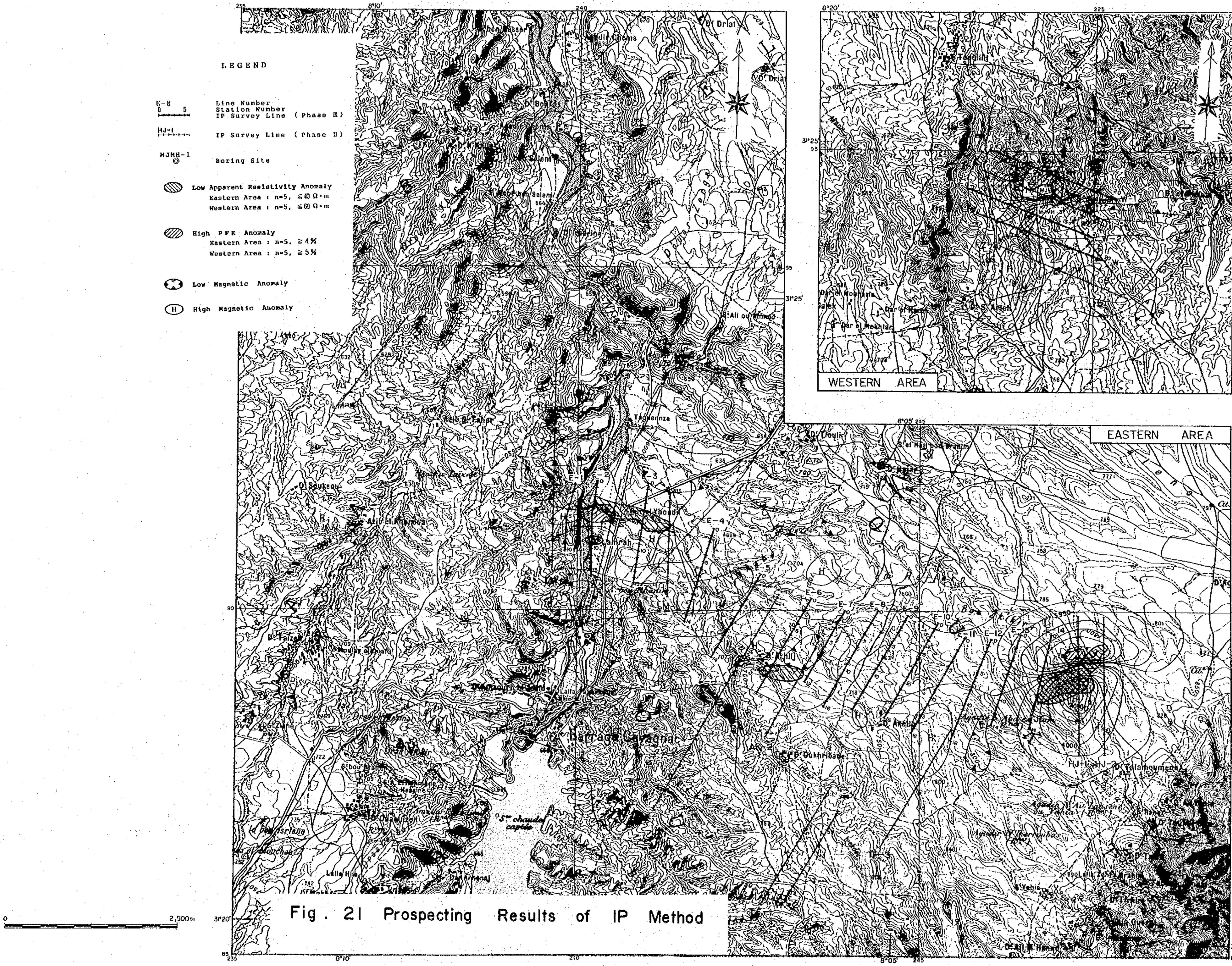


Fig. 21 Prospecting Results of IP Method

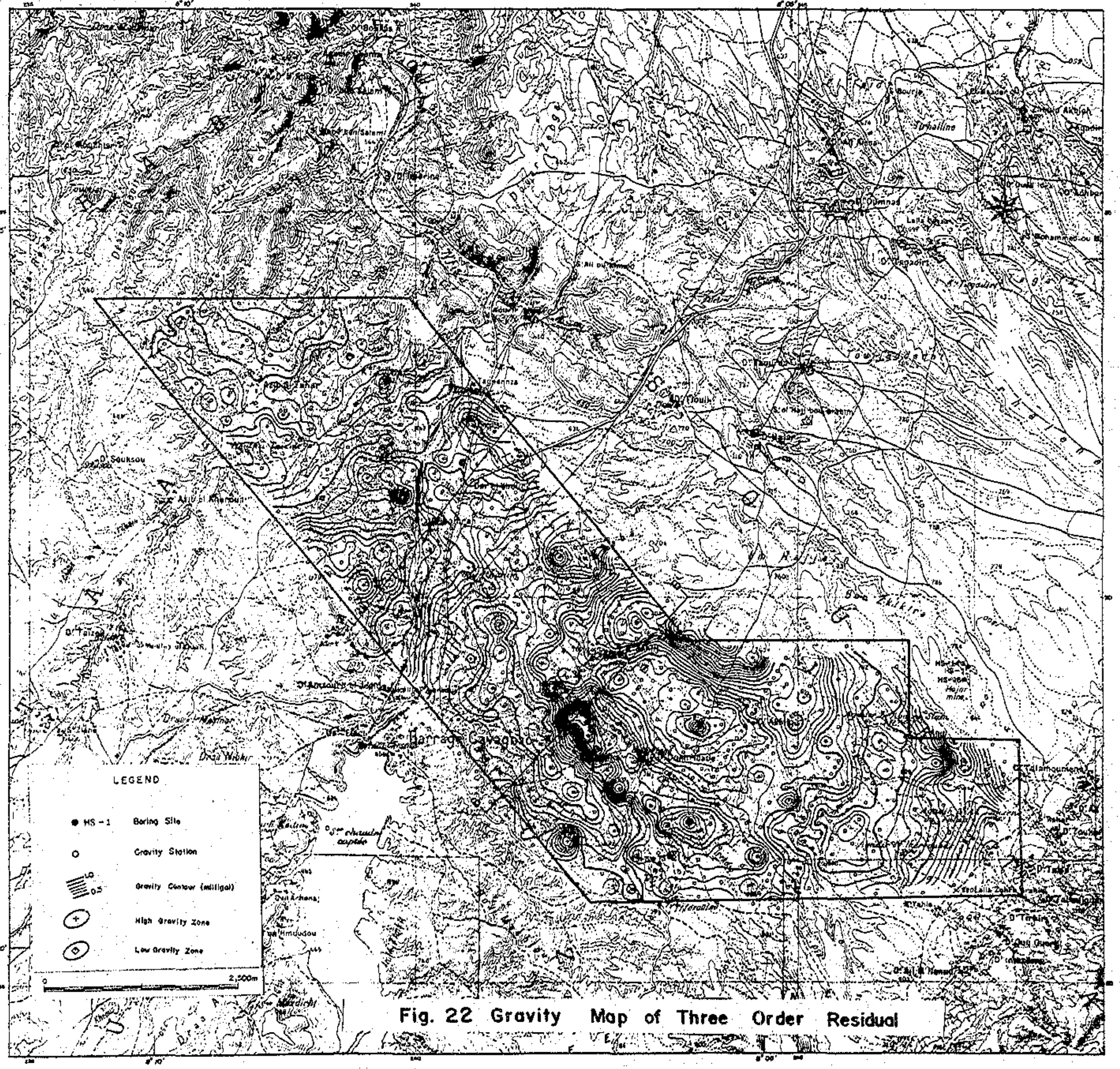


Fig. 22 Gravity Map of Three Order Residual

CHAPTER 3 DRILLING EXPLORATION

(1) The Eastern Area

Drilling, MJMH-1 was performed on the concealed IP anomaly zone (PFE = 3-5%, AR = 20-40 m) in the Lamrah area.

As the drilling result, slate and siltstone belonging to a part of the Hajar horizon were confirmed, in which dissemination of pyrite was found widely and veinlets of lead and zinc were confirmed between the depth of 346 m and 354 m.

Average grade of the 4 veinlets is Ag 8 g/t, Cu 0.05%, Pb 6.39%, and Zn 6.91% in average width 15 cm.

(2) The Western Area

3 drillings, MJMH-2, MJMH-3, and MJMH-4 were performed on the IP and magnetic anomaly zones in the Frizem west area.

As the drilling results, phyllite and siltstone forming a fine alternation were caught in every holes, in which remarkable mineralization of copper, lead and zinc was observed. The ores occur in vein, veinlet, network and dissemination with transitional relation to the host rock.

Ore minerals are mainly chalcopyrite, galena, sphalerite, pyrrhotite and pyrite. Gangue minerals are quartz, dolomite, siderite and calcite.

Siltstone, which forms a fine alternation with phyllite, is inferred to be originated in tuffaceous rock, judging from the mineral composition and texture.

The alternation is corresponded to the uppermost horizon in the pelitic and psammitic schist located at the lower part of the acidic volcanic and pyroclastic rocks.

The assay results of the main ore parts are shown below.

DH No.	No. of Sample	Av. Width(m)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
MJMH-2	4	1.2	10	0.23	0.91	1.44
MJMH-3	5	1.3	6	0.17	0.99	1.62
MJMH-4	4	0.3	8	0.11	0.88	1.82

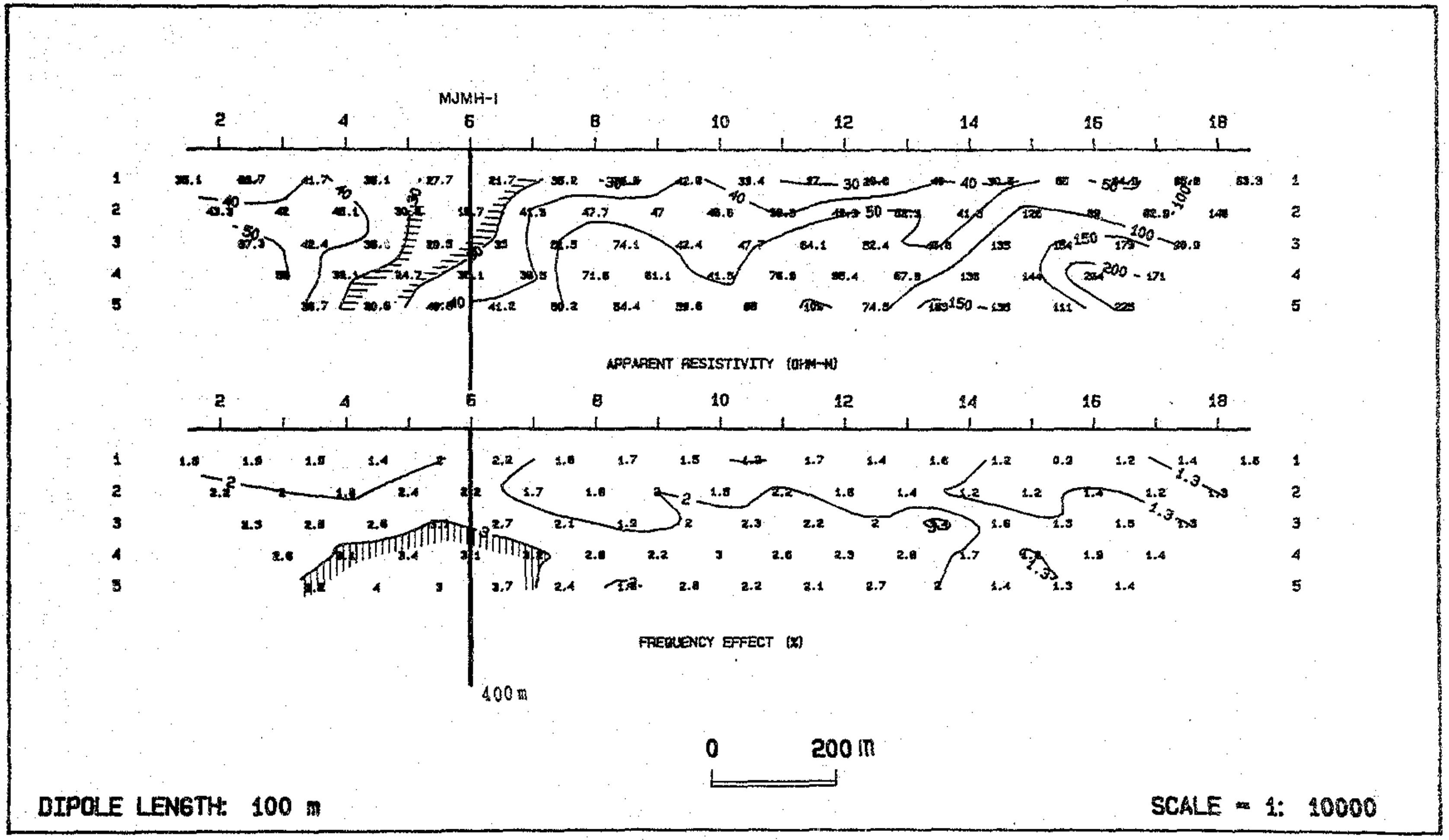


Fig. 23 Relation of Drilling Site and IP Survey Section (I) MJMH-I

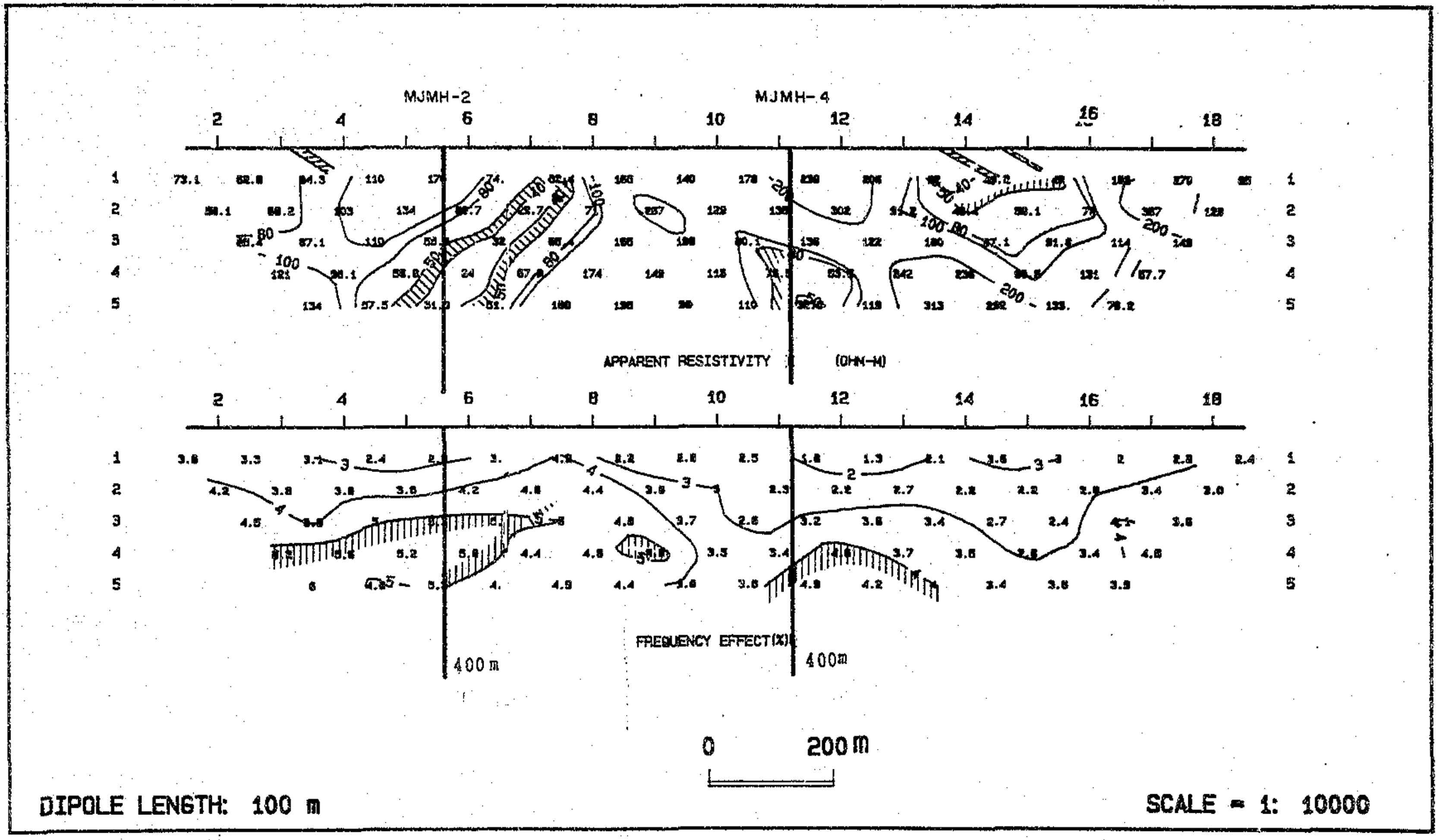


Fig. 24 Relation of Drilling Site and IP Survey Section (2) MJMH-2 and MJMH-4

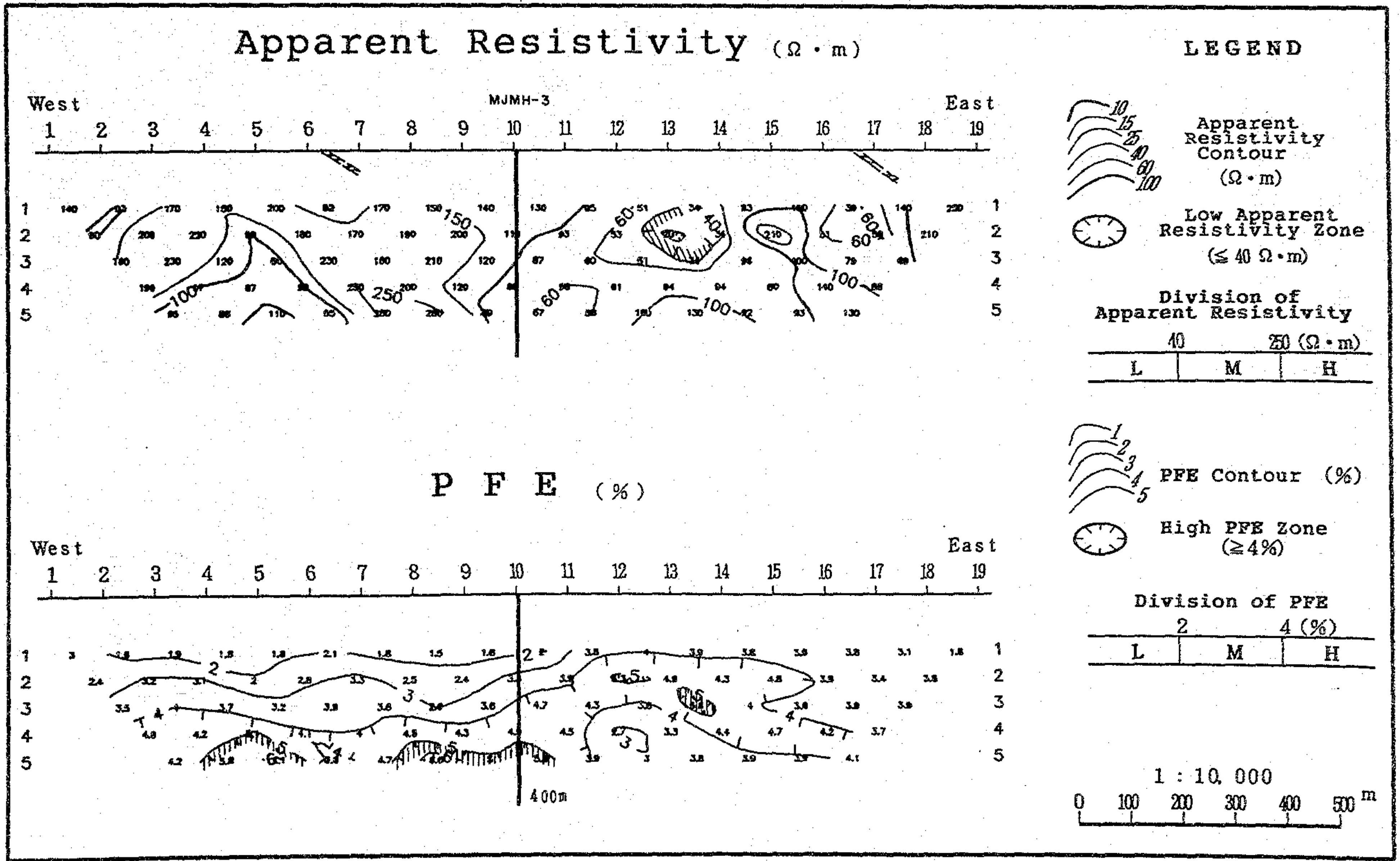


Fig. 25 Relation of Drilling Site and IP Survey Section (3) MJMH-3

	Intv(m)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
1	0.2	5	0.11	6.36	0.96
2	0.2	16	0.01	0.01	7.05
3	0.1	3	0.03	6.12	16.00
4	0.1	3	0.02	9.58	9.58

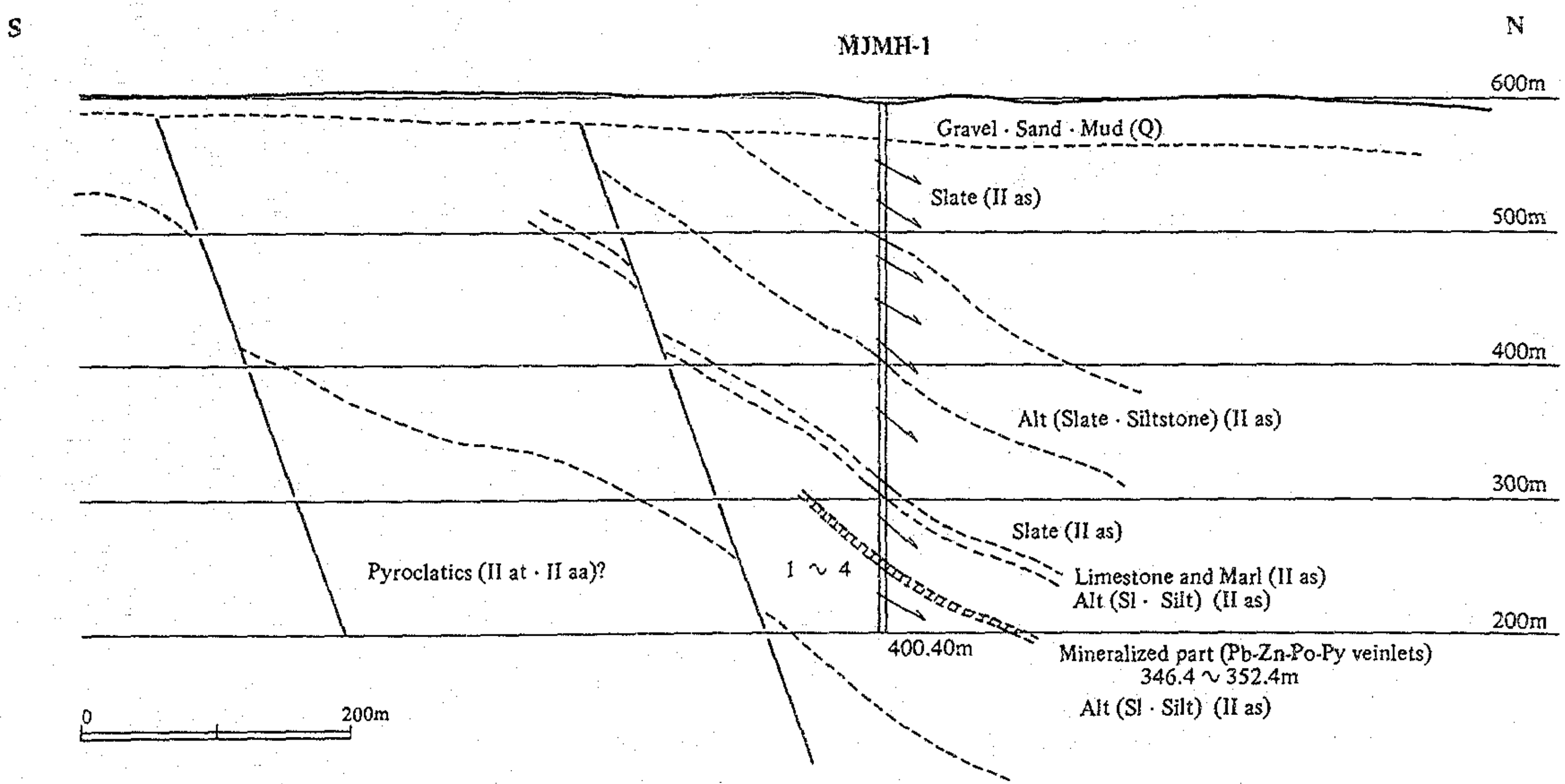


Fig. 26 Geological Section of Drilling Result (1) MJMH-1

	Intv(m)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
1	1.3	8	0.01	2.31	1.86
2	1.0	9	1.07	0.02	0.17
3	1.6	4	0.05	0.33	1.59
4	1.0	23	0.02	0.91	1.92

	Intv(m)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
6	0.6	5	0.01	1.14	1.34
7	0.2	16	0.19	0.48	2.57
8	0.1	3	0.92	0.04	0.28
9	0.4	11	0.03	0.91	2.64

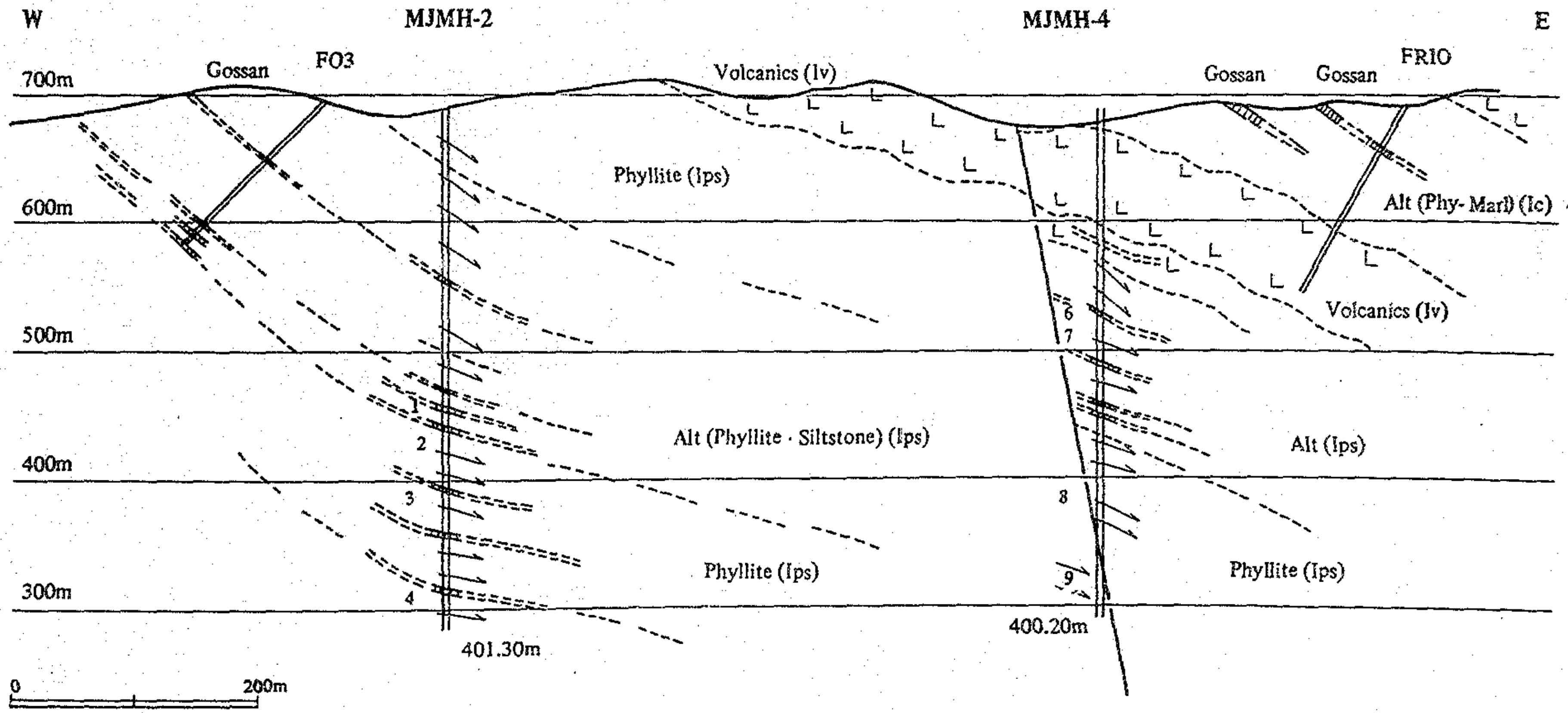


Fig. 27 Geological Section of Drilling Result (2) MJMH-2 MJMH-4

	Intv(m)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
1	1.0	8	0.61	0.10	0.66
2	1.0	3	0.11	0.79	0.95
3	1.9	3	0.11	0.28	2.06
4	1.3	11	0.09	3.08	2.87
5	1.3	5	0.04	0.76	0.97

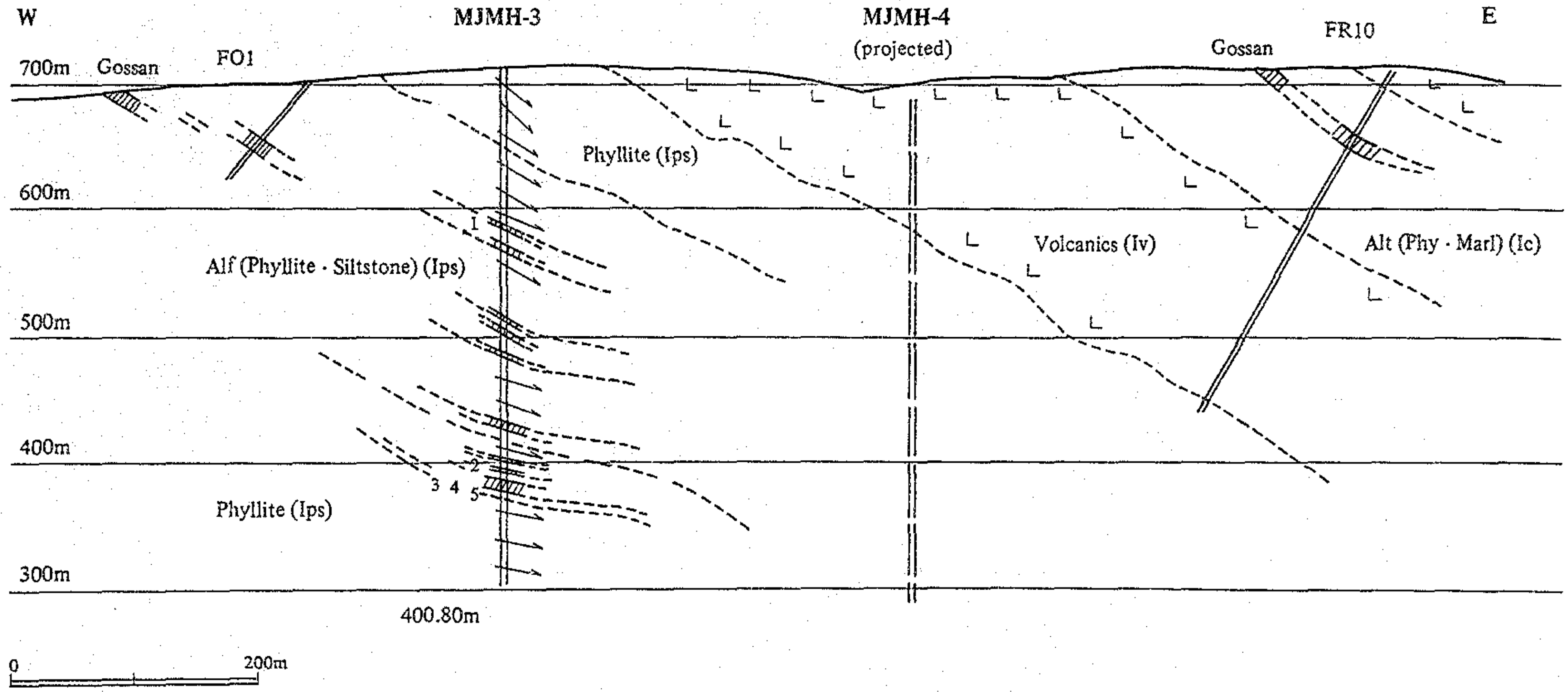


Fig. 28 Geological Section of Drilling Resalt (3) MJMH-3

CHAPTER 4 SYNTHETIC INTERPRETATION

4-1 Age Determination of the Acidic Volcanic Rocks

Age determination was applied by K-Ar method on the acidic volcanic rocks and related pyroclastic rock collected in the Frizem Area and in the Hajar-Amzourh Area, to confirm the period of the volcanic activity and the relation to the Pb-Zn-Cu mineralization.

The detemination result is as follows (Tab. 7).

Sample No.	Rock Type	Area	Isotopic Age (Ma)
801	Rhyolite	Frizem area	328 ± 16
802	Rhyolite	Amzourh area	303 ± 15
803	Rhyolite	Akhlij area	294 ± 15
804	Green Tuff	Oukhribane area	297 ± 15

According to the isotopic age by K-Ar method, the rhyolite in the Frizem Area is corresponding to the lower part of the Carboniferous while the rhyolite and pyroclastic rock in the Hajar-Amzourh Area are corresponding to the upper part of the Carboniferous.

The dating results are coincided with the biostratigraphical age estimated by fossils. According to P. Huvalin (1973), the schist in the area is correlated to the lower and middle parts of the Carboniferous of the Paleozoic Era, as Entroques is found in the limestone.

These volcanic rocks are foliated and schistose due to dynamic metamorphism. However, by the microscopic observation, they preserve mineral assemblage and texture of the original rock comparatively well, having quartz phenocysts and bearing sericite. It is thought that little dispersion of argon gas by heating would have occurred through the period of the metamorphism. If we would take a hypothesis that argon gas had been dispersed, we would have much younger isotopic age than the true value, that means the activity of the volcanic rock is strangely older than the formation of the sedimentary rocks and the result would be entirely inconsistent with the result suggested from the biostratigraphy.

The results of the age determination and geological survey are thought to support the following estimation.

1) The period of the volcanic activity is before the Carboniferous and could not be after the Permian age, which is in good coincidence with the period of the sedimentation of the sedimentary rocks.
2) By the result of the geological survey including stratigraphical and tectonic studies, the volcanic activity is assumed to have been two different successive periods. It has been re-confirmed that the volcanic activity recognized in the Frizem Area is older than that found in the Hajar-Amzourh Area.
3) The volcanic rocks are thought to have been derived from submarine volcanic activities. The period of the mineralization brought about by these volcanisms is coincident with the period of the sedimentation.

4-2 Characteristics of the Hajar Ore Deposit

An outline of the Hajar orebody on -235m level is shown in Fig. 29. Neglecting small-scale dislocation and deformation caused by schistosity faults and drag folds, general stratigraphical structure on this level is the strike of N45°W dipping 40° or 50° to NE.

Because the orebody has been inclined about 45° to the direction of N45°E after the formation, a converted section of showing the original figure is prepared by means of the reverse rotation, 45° to the direction of S45°W.

This section is thought to represent the genetic model of the ore deposit. The form of the ore deposit is like a mushroom, the lamp-shade of which is representing the bedded orebody while the trunk is corresponding to the stockwork orebody with ore veins in the surrounding area.

The bedded orebody is composed of the repetition of several layers containing abundant pyrrhotite. In the uppermost portion of the orebody, lead-zinc-silver concentration is recognized, where the ore grade is up to 10% in Pb, 20% in Zn, and 200 g/t in Ag, though more or less 0.2% in Cu.

In the lower part of the orebody, lead and zinc contents are decreasing while the copper grade is comparatively increasing. The stockworks and veins are composed of pyrite-pyrrhotite-quartz veinlets and veins that are comparatively rich in zinc and copper.

The assay results of the samples collected continuously from the wall of tunnel -235m level is shown below:

Type of Ore	Distance fm Shaft (m)	Width (m)	Pb (%)	Zn (%)	Cu (%)	Ag (%)	Fe (%)
Bedded Ore	212 - 222	10	4.50	8.25	0.14	112	11.5
Bedded Ore	192 - 212	20	9.83	19.39	0.23	209	35.3
Dissem Ore	177 - 192	15	1.78	3.10	0.13	29	7.8
Bedded Ore	145 - 177	32	2.31	8.33	0.58	36	31.9
Network	121 - 131	10	0.15	0.08	0.53	4	8.6
Vein	67 - 73	6	0.58	4.12	0.40	6	28.8

(by BRPM, 1988)

The Hajar ore deposit has the following characteristics and similarity to the Kuroko ore deposit in Japan and the Noranda type ore deposit in Canada (Fig. 30).

1) The host rock of the ore deposit is acidic pyroclastic and tuffaceous rocks.
2) Main part of the ore deposit is bedded ore bodies concentrating in lead and zinc, at the bottom of which networks and veins rich in copper are accompanied.
3) The alteration zone characterized by silicification and argillization is developed around the network and vein type orebodies.
4) The pelitic rocks overlying the ore deposit have not been influenced by the mineralization.
5) Gypsum bodies used to appear to the Kuroko ore deposit are not found around the Hajar orebody and the iron sulfide minerals are mainly pyrrhotite. On these two points, the Hajar ore deposit is more similar to the Noranda type ore deposit than the Kuroka type ore deposit.

4-3 Comparison of the Geophysical Survey Results

The anomalies indicating the possibility of occurrence of ore deposit extracted by several different survey methods are shown below:

Area	Magnetic Anomaly	AR Value	IP Anomaly	Gravity Value	Geoch. Anomaly	Type of Ore
Hajar Ore Dep.	SSS	L	SSS	M	-	mass (Po-Pb-Zn)
Hajar SW Area	SS	L	SS	H	-	
Akhlig Area	W	M	W	M	-	diss (Po-Zn)
Akhlij Area	W	L	W	H	-	
Lamrah Area	W	L	SS	M	-	
Tiferouine Area	SSS	M	W	H	-	diss (Po-Py-Mg)
Oukhribane Area	W	M	W	H	SS	diss (Py-Cu)
Amazourh Area	SS	-	-	-	SS	vein (Py-Zn-Cu)
Frizem East Area	SSS	L	SS	-	SSS	mass (Py-Po-Zn-Pb)
Frizem West Area	SSS	L	SSS	-	SSS	

SSS = very strong H = high
SS = strong L = low
W = weak M = medium

Magnetic anomaly is principally caused by pyrrhotite and magnetite and IP anomaly is chiefly caused by sulfide minerals. Accordingly, the magnetic survey is thought to be very effective for the exploration for the Hajar type ore deposit, although the IP prospecting is considered to be more effective for the exploration for the ore deposit that is rich in pyrite instead of pyrrhotite.

4-4 Interpretation of the Drilling Results

(1) Lamrah Area

1) The Quaternary covering sediment is 34m in thickness at the drilling site.
2) The basement rock is composed mainly of phyllite and siltstone. Siltstone is forming a fine alternation with phyllite. Siltstone is probably originated from tuffeceous sediment. The alternation will be corresponded to a part of the Hajar mineralized horizon.
3) The alternation is disseminated widely with pyrite, and lead and zinc veinlets are found in some places.
4) The mineralization in this area is inferred to be formed in the peripheral zone of the sedimentary massive orebody related to the latest stage of volcanic activity in the Hajar horizon.

(2) Frizem West Area

1) The basement rock of this area is composed mainly of phyllite and siltstone. Siltstone is forming a fine alternation with phyllite and probably originated from tuffaceous sediment.
2) The alternation are mineralized widely. Ore minerals are pyrite, pyrrhotite, chalcopyrite, galena and sphalerite. Gangue minerals are calcite, dolomite siderite and quartz.

3) The types of ore are veinlet, vein, network and dissemination and the parts of ore are transitional to the host rock. The veinlets and veins are usually parallel to the schistosity and foliation structure. Every mineralized part is small-sacale or low-grade.

4) Some parts are seemed to continue to the gossan on the surface. Although, the continuities are not simple because they have been dislocated by numerous schistosity plane faults and the perpendicular direction faults. They have suffered probably secondary deformation and metamorphism.

5) The mineralization in this area is inferred to be formed in a peripheral zone and the lower part of the massive orebody formed in connection with the activity of acidic volcanic rock in the upper part.

4-5 Compariton of the Survey Results of Drilling and Geophysical Survey

Remarkable indications of mineralization have been confirmed widely in all the drilling, total 4 holes carried out in the Lamrah and Frizem areas. However, every mineralized parts encountered by drill holes is low-grade or small-scale dissemination ore, network ore and vein-type ore, which are seemed to be difficult to develop economically for mining.

The comparison table of the drilling results and the geophysical data is shown below:

DH No.	Rock Type	No. of Sample	Mineralization				IP Anomaly	
			Type	Ore Min.	Width(m)	Grade	PFE(%)	AR(m)
MJMH-1	Sl-St	4	vlts	Py-Zn-Pb	0.1	Pb6%, Zn7%	3-4	20-40
MJMH-2	Ph-St	4	netw	Py-Po-Zn-Cu	1.2	Pb1%, Zn2%	5-6	30-40
MJMH-3	Ph-St	5	netw	Py-PO-Zn-Cu	1.3	Pb1%, Zn2%	4-6	50-90
MJMH-4	Ph-St	4	vlts	Py-Po-Zn	0.3	Pb1%, Zn2%	4-5	30-60

Sl: Slate St: Siltstone Ph: Phyllite
Py: Pyrite Po: Pyrrhotite

Then, several measured values concerning to the physical properties of the rock and ore samples collected from the drilling core are shown in the following table:

Area	Type (Ore Mineral)	No. of Sample	Resistivity (Ω m)	PFE (%)
Lamrah Area	Host Rock	4	1205 (550-2200)	2.6 (1.0-4.3)
	Diss Ore (Py)	1	230	5.6
Frizem Area	Host Rock	4	983 (110-1700)	0.8 (0.3- 1.2)
	Netw Ore (Py-Po-Zn-Cu)	3	166 (98-300)	11.5 (5.8-17.4)
	Vein Ore (Py-Po-Zn-Cu)	1	12	12.0

( ): range

Based on the above 2 tables and the measured data shown in the Tab. 4, the following inference on the relationship between physical properties and mode of mineralization is induced.

1) Pyrite dissemination ore and pyrite - pyrrhotite network ore show extraordinally high PFE value nearly equal to the pyrrhotite - pyrite vein-type and massive ores.
2) The reason why IP anomaly in the Lamrah area is not associated with strong magnetic anomaly is depended on it's mineral assemblage composed mainly of pyrite.
3) The strong IP and magnetic anomalies in the Frizem West area are caused by pyrite - pyrrhotite network ore. Accordingly, it is considered to be difficult to expect the existence of high-grade massive orebody comparatively in the shallow place.

Tab. 7 Dating Result by K-Ar method

Sample No.	Rock Type (Formation)*	Area	Material Analyzed	Isotopic Age (Ma)	$^{40}Ar^*$ ($scc/gm \times 10^{-5}$)	$\%^{40}Ar^*$	%K
801	Ryolite (Ivv)	Frizem	Whole rock	328. ± 16.	3.63 3.61	97.5 98.3	2.58 2.59
802	Ryolite (IIav2)	Amzourh	Whole rock	303. ± 15.	.858 .850	91.7 91.6	.67 .66
803	Ryolite (IIav2)	Akhlij	Whole rock	294. ± 15.	2.80 2.99	96.5 98.0	2.33 2.33
804	Green Tuff (IIat)	Oukhribane	Whole rock	297. ± 15.	3.91 4.00	97.9 98.0	3.14 3.16

(by Teledyne Isotopes, USA)

$$T = 1804.08 \times \log_e \{(^{40}Ar^* \div K \times 0.1426) + 1\}$$

T = age in million years
K in weight percent natural potassium
$^{40}Ar^*$ in $scc/gm \times 10^{-5}$

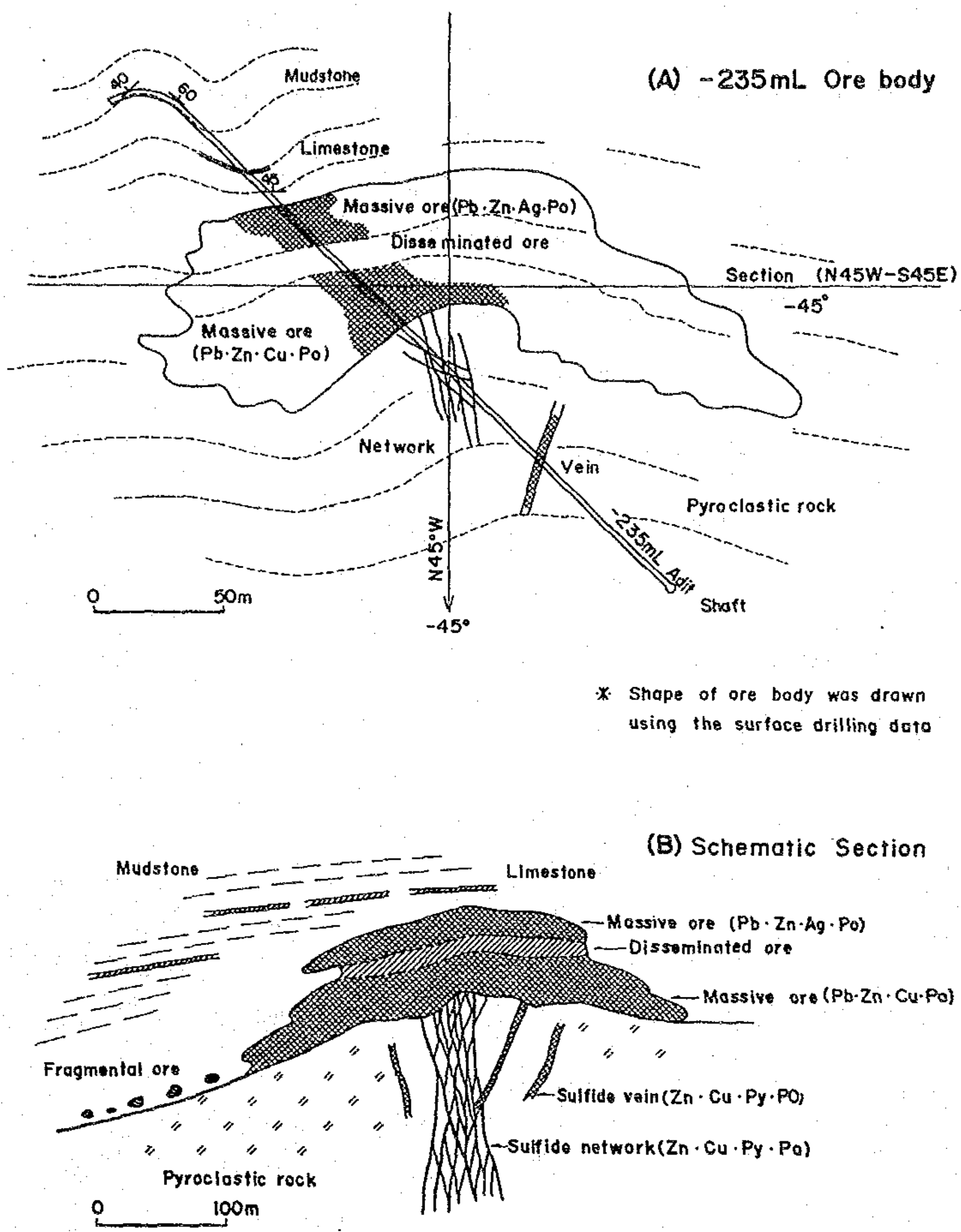
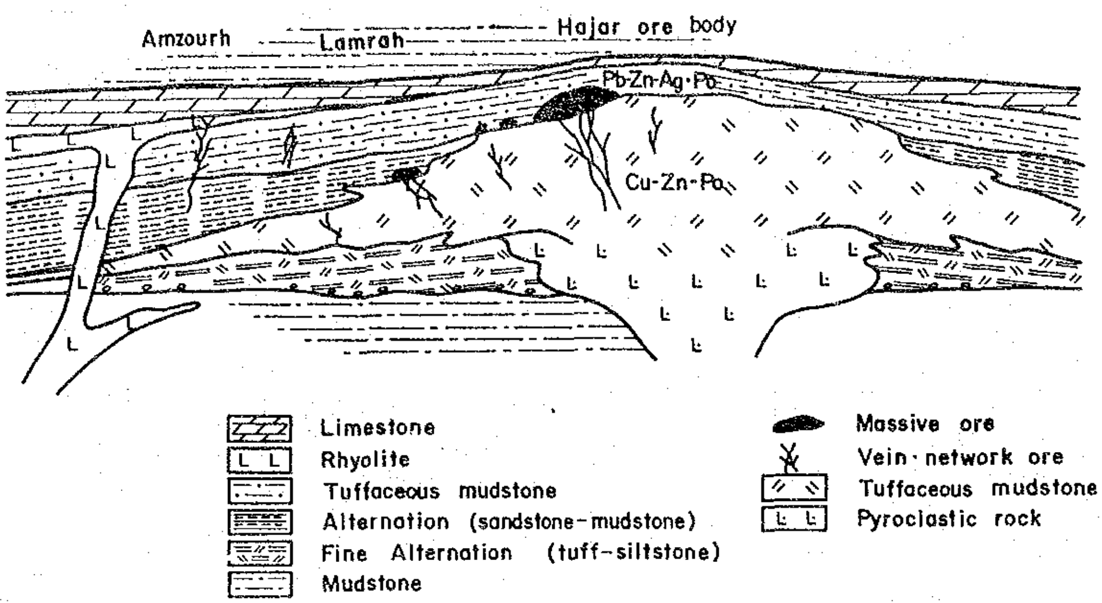


Fig 29 Genetic Model of the Hajar Ore Deposit

(A) Hajar Ore Deposit



(B) Frizem Mineralized Zone

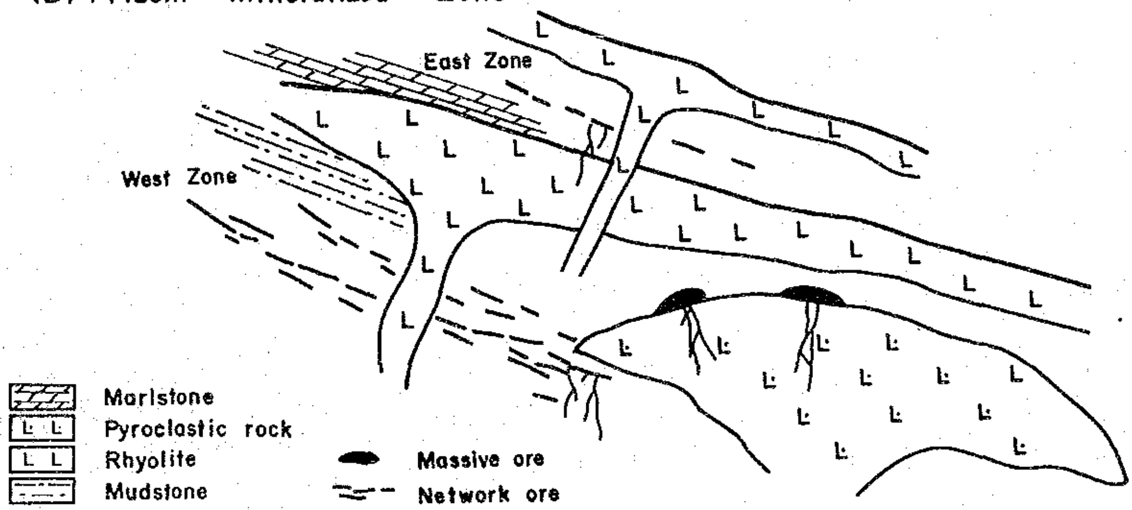


Fig. 30 Schematic Cross Section of Ore Deposit

PART Ⅲ

CONCLUSION AND RCOMMENDATION

CHAPTER 1 CONCLUSION

(1) Geology and Ore Deposit

The basement rocks in the Haouz Central Area is belonging to the Carboniferous and Permian Systems composed mainly of pelitic and marly schist and semischist.

The ore deposit is sedimentary-type, volcano-genetic massive sulfide ore deposit that is formed in the basement rocks in relation to a submarine volcanism and occurs in the specific formation characterized by acidic volcanic and pyroclastic rocks.

(2) Ore Deposit and Geophysical Anomaly

The Hajar ore deposit contains abundant pyrrhotite and concentrates silver, copper, lead and zinc.

The physical property of the ore is high magnetic susceptibility, low electric resistivity, strong IP anomaly (strong frequency effect), and high density.

Accordingly, the magnetic survey and IP survey are considered to be the most effective geophysical methods for the exploration of the Hajar type ore deposit.

(3) Extraction of Anomaly Zones

The following areas have been extracted as the promising target areas, that have a possibility of massive sulfide ore deposit, by a series of several different methods of survey carried out in the area.

Area	Measured Value		Analyzed Value		Magnetic Anomaly	Geological Structure
	PFE(%)	AR(Ωm)	PFE(%)	σ (Ωm)		
Hajar SW Area	3-4	30-50	20	12	Medium	Southwest of Hajar orebody
Lamrah Area	3-5	20-40	5-15	15-20	Weak	West of Hajar horizon
Frizem Area	5-6	20-4	10-25	10-20	Strong	Frizem West mineral zone

(4) Drilling Result

Remarkable mineralization zones concentrating cupper, lead and zinc associated with pyrrhotite and pyrite have been encountered by all of the 4 drilling holes carried out in the Lamrah area and in the Frizem West area. The ores are dissemination-type, network-type, and vein-type and distributed widely in the drill holes. However, all of the ores are low-grade or small-scale and it is difficult to develop economically.

They are estimated to correspond to the mineralization of the lower parts and the peripheral zones of the massive orebody.

(5) Assessment of Prospecting Method

According to the measured results of rock and ore samples collected from the drilling core, the pyrite network ore shows extraordinally high PFE value nearly equal to the massive pyrrhotite ore that is the typical ore of the Hajar ore deposit.

Magnetic anomaly is principally caused by pyrrhotite and magnetite and IP anomaly is chiefly caused by sulfide minerals such as pyrite. Strong magnetic and IP anomalies will indicate a possibility of the existence of mineralized zone. However, they do not always indicate the existence of large-scale high-grade massive orebody, because each orebody has different constitution of ore minerals, different contents and different mode of occurrence. Therefore, it will be necessary to employ a systematic exploration activity adopting several different prospecting methods.

CHAPTER 2 RECOMMENDATION FOR THE FUTURE

(1) To the southwest of the Hajar ore deposit, a weak to medium IP anomaly has been confirmed. It is desirable to clarify the cause of the IP anomaly whether it depends on the occurrence of a concealed orebody or another reasons.

(2) In the Frizem area, it is difficult to expect a large-scale and high-grade massive orebody comparatively in the shallow underground. However, it is recommended to continue the study and survey concerning a possibility of orebody in the deeper place, judging from the increasing trend of IP anomaly to the deeper place.

APPENDICES

Ap. 1 Geologic Drill Log (1) MJMH-1

GEOLOGIC DRILL LOG

HAOUZ PROJECT, MOROCCO (LAMRAH AREA)

Coordinate N 91,250 E 240,540

Elevation 600m

DDH No. MJMH-1

Direction

Inclination -90°

Total Depth 400.40m

Columns: Assays – 1 Leng (m), 2 Cu (%), 3 Pb (%), 4 Zn (%), 5 Ag (g/t); Depth-Symbol – 6 Dep (m), 7 Core Rec, 8 Sym, 9 Str.; Occurrence – 10 Rock, 11 Fac, 12 Altr, 13 Min, 14 Color, 15 Fract; 16 Observations

Dep (m)	Leng	Cu	Pb	Zn	Ag	Str.	Rock	Fac	Altr	Min	Color	Fract	Observations
0											p-brn		Gravel (Covering sediments)
							Sed				brn-gry		Sand Mud Gravel (Covering sediments)
10													
20													
30													
							Sl				p-brn		Sl wtd
40													
													Non-core down to 50m
50						30°	Sl		oxd cly Lim	Lim	p-brn		Wtd Sl : p-brn, Soft
						25°							
						30°							
60						35°							
63.6						25°	Sl		oxd	Py	p-gry		65.6-65.8 : Cly
65.8						10°	Sl			Py	d-gry blk		Sl intercalated with fine alt of Silts, Intv of 1mm~20cm
70						25°							73.1 : Cal v, 75°, 2mm w
						35°							78.5~79.8 : Wtd, p-gry-brn 79.5 : Cal v, 40°, 2cm w
80						60°							
						45°							88.2 : Po diss
90						20°~35°							
						15°~40°							Micro folding is characteristic in fine Alt of Sl and Silts
						10°~25°							96.6 : Po film-like diss along frc
						30°							

Dep (m)	Leng	Cu	Pb	Zn	Ag	Str.	Rock	Fac	Altr	Min	Color	Fract	Observations
100	1.0	tr	tr	0.01	tr	40°							100.7 : Py Cal v 80°, 2mm w
102.8						40°	Alt Sl-Silt			Py	blk wht		Alt of Sl - Silts Intv : 1mm~10cm~1m Silts is calc and ± Microfolding dev.
						35°~10°							
110						±40°							
						30°~40°							
						30°							117.3 ~ 131.0m : Py-Po diss is remarkable
120						25°~35°							120.9 : Py diss in frc
						±25°							Py-Po diss is strong
126.3							Sl				blk		
130													
131.3						±35°	Alt Sl-Silt			Py	blk wht		132.2 : Py diss in J 133.6 : Phyllitic
						45°							
140						±40°							139.5 : Py diss
						45°							
150	1.0	tr	tr	0.01	tr	40°							
						50°							
160						45°							
						40°							164.1~134.2 : Brc cemented by Cal 165.5 : Cal v, 25° 1cm
170						30°~50°	Alt			Py	d-gry p-gry		173.6 : Cal brc 5cm
						50°							175.6 : Py film diss 176.0 : Py film diss 176.4 : Cal v 75°, 2mm w
180						40°							Alt (blk Sl - wht Silt) Intv : 1mm~10cm~1m
						40°							183.7~184.1 : F cly-chl
190						40°							188.2 : Ql v 65° 0.8cm w 189.4 : Py-Cal v 75°, 1cm w 200.4 : Py-Cal v 50°, 1cm w
						55°							195.0 : J - Cal vlts 65°
197.7							Sl			Py	d-gry		199.7~200.0 : Ql-Cal v - brc

Dep (m)	Leng	Cu	Pb	Zn	Ag	Str.	Rock	Fac	Altr	Min	Color	Fract	Observations
200	1.0	tr	tr	tr	tr		Sl	mas		Py	d-gry		
203.3							Sl				gry	F	
204.2						40°	Sl		sil-cal	Py	d-gry		205.4 : Py-Cal v 65°, 4mm w 207.0~207.5 wht porphy Calc Tf 207.6 : Py film along frc
210						40°							Sl intercalated with Silt beds: Silt intv : 1mm~10cm~1m 212.0 : Py-Ql-Cal- v 75°, 1cm w 213.1~213.2 : Calc Tf
						20°							216.8 : F cly 10cm 65° 218.4 : Ql-Cal v 70°, 1cm w
219.1						40°							
220						40°	Sl			Py	d-gry		Sl intercalated with Silt beds (1mm~10cm) 222.4~223.0 : frc 223.3~224.0 : Js 65° 224.8~225.0 : Calc Tf 226.0~226.4 : F frc 228.0~228.7 : Js Py diss
						50°							
230						45°, 40°, 40°							
231.7							Sl	mas		Py	d-gry		Sl massive 235.5 : Cal v 60°, 1cm w
240						30°	Sl	mas		Py	d-gry blk		239.9~240.2 : frc 240.6 : cos-gd 3cm Sl intercalated with Silt thin beds Silt : 1mm~4cm 242.7~242.9 : J
						35°							246.2 : Pb vlt 0.5cm (1-246) (Gl · Py · Cal · Ql · Chl · Xco · Mus · Pl)
						40°							
250						40°							255m : Py-Po cloudy diss
256.3										Cly	Po	F	
257.1						30°	Sl	mas		Py	d-gry blk		Sl intercalated with thin Silt beds Silt : 1mm~4cm
260						25°							263.4 : Py-Cal-Ql v 2mm w, 70° 264.0 : Py-Cal-Ql v 265.9 : J 70° cutting bed 266.3 : J 70° 265~269 : Py-Po cloudy diss 268.5 : Py diss along J
	1.0	0.01	tr	0.01	tr	20°							
270							Sl	mas		Py	blk d-gry		Sl, massive 272.4 : Cal v 4mm w, 75°
280													282.3 : Js 283.3 : Js
						40°							
287.7						40°	Ml				p-gry		287.7~288.6 : Cal netw
290													
291.2						40°	Alt Ls-Ml	mas band			p-gry		292.3
						35°							297.0 : Cal · Mn-Cal v 10cm, 60°
297.1							Sl	mas	cal		blk		297.1~297.3 Cal vlts

Dep (m)	Leng	Cu	Pb	Zn	Ag	Str.	Rock	Fac	Altr	Min	Color	Fract	Observations
300	1.0	tr	tr	0.01	tr	45°							Sl intc with Silt Intv of 1mm~10cm~1m
						40°							302.0~307.2 : Cal brc v
310						40°							
311.5													311.5~312.3 : Cal v 60°
312.3						50°							
319.3						45°, 10°							
320							Alt Silt-Sl			Py	gry		Alt (Silt-Sl) Intv : 1mm~4cm~1m 321.4 : Py Cal v 4m, 70°
						45°							325.3 : Cal v 0.8cm 40°
330						35°			cly			F	330.8~332.5 : F cly
332.5						45°	Alt Silt-Sl			Py	gry		
						55°							
340						45°							
343.5						40°	Alt Silt-Sl	vlts		Cu-Zn Py-Po	gry		345.4~345.6 : F blk cly 346.4 : Po Cal v, 0.6cm 65° 346.8~347.5 : Crsh 345.3~346.8 : Pb-Zn vlts 0.6cm 75° 349.1~349.5 : Zn-Py diss 30cm 349.5 : F graphyle 2cm w 70°
346.4	0.2	0.11	3.34	0.96	5								
349.2	0.2	0.01	0.01	7.65	16	25°	Ore	vlts		Pb-Zn			
350													350.8~352.1 : F, blk cly
350.7	0.1	0.05	0.01	16.00	5	45°	Ore	vlts		Pb-Zn			350.6~350.9 : Zn-Py-Po vlts 10cm
352.3	0.1	0.02	0.01	6.34	5		Ore	vlts		Pb-Zn			352.3~352.4 : Zn vlts, diss 10cm (1-350) : (Sp · Py · Gl · Qt · Mus · Chl · Kao · Pl) Alt Intv : 1mm~2cm~10cm
						15°							
						35°							
360						35°							
						25°							
						30°							
370						30°						frc	372.2~375.2 : frc, phy
						35°	Alt Sl-Silt			Py	gry		375.1~375.2 : F, blk cly Alt intv : 1mm~2cm~30cm
						40°							
380						40°							385.5~386.9 : frc
						35°							388.2~389.2 : Silts
390						35°							
393.7						30°	Sl			Py	blk		394.9~395.3 : frc Sl intc with Silt band (1mm~1cm)
						30°							
	1.0	tr	0.01	0.01	tr								400.40m end

Ap. 2 Geologic Drill Log (2) MJMH-2

GEOLOGIC DRILL LOG

HAOUZ PROJECT, MOROCCO
(FRIZEM AREA)

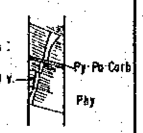
Coordinate N 94.470 E 223.830
Elevation 690m

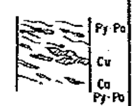
DDH No. MJMH-2
Direction –
Inclination -90
Total Depth 401.30m

Columns: Assays — 1 Leng (m), 2 Cu (%), 3 Pb (%), 4 Zn (%), 5 Ag (g/t); Depth·Symbol — 6 Dep (m), 7 Core Rec, 8 Sym, 9 Str.; Occurrence — 10 Rock, 11 Fac, 12 Altr, 13 Min, 14 Color, 15 Fract; 16 Observations

Dep (m)	Leng	Cu	Pb	Zn	Ag	Str.	Rock	Fac	Altr	Min	Color	Fract	Observations
3.0 – 25.8						30°, 30°, 35°, 30°	f-Alt		whd oxd cly	Lim	p-brn p-gry		f-Alt (Phy-Tf-Silt) 12.2 : Lim network in Qt v 5cm30°
25.8 – 29.5						35°	f-Alt		whd oxd cly	Lim	p-gry		
29.5 – 40.9						30°, 35°	Phy	band	bt-ser		d-gry		Phy : intc with Silt thin bed of 1mm~10cm thickness
40.9 – 41.9							Qt Cal						40.9 ~ 41.9 : Qt Carb v 35° Po diss
41.9 – 46.5						35°	Phy				blk		43.3 : Cal-Carb v 5cm 35° 45.8 : Carb v 10cm 35°
46.5 – 100						35°, 30°, 25°, 40°, 20°, 30°, 40°, 35°, 35°, 35°, 35°	f-Alt	band	bt-ser sch		d-gry l-gry		f-Alt (Phy-Silt) Intv : 1mm~1cm~10cm 57.0 ~ 58.6 : Carb network Po stringer 68.0 ~ 69.7 : Carb network 76.9 : Carb v 3cm 40° 85.3 : Cal v 1cm 80° 86.3 ~ 86.5 : Cal-Carb v 20cm30° Po diss 96.0 : Cal-Carb patch 97.7 : Po-Qt-Carb v 0.7cm 30°

Dep (m)	Leng	Cu	Pb	Zn	Ag	Str.	Rock	Fac	Altr	Min	Color	Fract	Observations
100 – 132.1						30°, 20°, 25°, 35°, 25°, 25°, 40°, 35°	Alt				d-gry l-gry		f-Alt (Phy-Silt) Intv of 1mm~1cm~10cm 111.3 : Cly 5cm 111.3 ~ 112.1 : Qt v with Carb netw 115.4 ~ 116.1 : Qt v partly Carb 116.1 ~ 116.2 : Cly 118.7 ~ 118.9 : Cly 121.7 : Cly 5cm Microfolding 129.7 ~ 130.1 : Carb netw
132.1	0.5	0.05	0.02	0.02	2	25°	Alt	vs	Sid	Cu-Zn	gry		132.1 ~ 132.3 : Cu-Zn-Po-Py Carb-Qt 132.3 ~ 132.6 : Carb-Qt brc Diss ore along bedding and in Qt-Carb v
134.6 – 135.6	0.9	0.03	tr	0.07	tr	30°, 30°, 50°		vs	Qt	Py-Po Mt			134.6 ~ 134.7 : Carb-Qt v 135.0 ~ 135.3 : Carb-Qt v 136.6 ~ 136.9 : Cu-Zn-Po-Py Mt 1cm 138.0 : Cu-Zn Po-Py v 10cm 138.3 ~ 140.0 : Carb-Qt v 141.1 : Cu-Py-Po-Mt 5cm 142.1 ~ 143.2 : Carb-Qt netw
143.2 – 181.7						40°, 30°, 15°, 30°, 20°, 35°, 30°, 30°, 30°, 25°	Alt	band	sil carb		d-gry l-gry		144.8 ~ 145.4 : Carb-Qt brc Alt (Phy-Silt) Intv of 1mm~1cm~10cm 150.3 ~ 150.55 : Carb-Qt v 157.35 ~ 157.5 : Carb-Qt v 176.4 : Qt-Carb v 3cm 176.4 ~ 176.6 : Zn-Po diss 178.05 : Carb-Qt v 2cm 25°
181.7 – 189.0						20°, 20°	Alt				gry		Alt (Phy-Silt) Silts is calc and tfc
189.0 – 200						20°, 20°	Phy				d-gry		

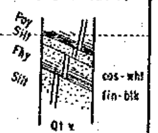
Dep (m)	Leng	Cu	Pb	Zn	Ag	Str.	Rock	Fac	Altr	Min	Color	Fract	Observations
200 – 208.1						30°, 20°	Phy				d-gry blk		
208.1 – 211.7						20°, 25°	Phy				d-gry	frc	
211.7 – 219.3						25°, 15°	Phy		carb sil	Cu-Pb Zn-Py Po	p-gry		
219.3 – 220	0.6	0.16	0.04	0.13	1	15°		vlts					219.3 ~ 220.1 : Cu-Pb-Zn-Po-Py diss in vlts 221.3 ~ 222.3 : Shd
225.7	0.6	0.01	0.02	0.24	tr	10°, 15°		vlts					225.7 ~ 228.3 : Cu-Zn-Pb-Py in Sid druses
232.9 – 234.7	1.3	0.01	2.31	1.86	8	10°	Ore	vlts vs	sil carb	Cu-Pb Zn-Py			232.9 ~ 235.1 : Cu-Zn-Pb-Po-Py
	1.4	0.04	0.10	0.42	1								234.6 ~ 234.7 : Carb-Qt patch Cu-Pb-Zn = 5%
234.7 – 246.8						15°, 20°							246.8 ~ 247.8
246.8 – 247.8	1.0	1.07	0.02	0.17	9		Ore	diss	carb	Cu-Pb-Zn			246.8 ~ 247.8 : Cu-Pb-Zn Ore (2-247) : (Lez-Py-Sp-Qt-Cal-Dol-Sid-Mus-Chl Kao)
247.8 – 293.4						15°	Phy	vs	carb sil sil	Py-Po	d-gry		
250.7	0.2	0.07	0.09	0.08	3	15°, 25°, 20°, 20°, 20°, 5°, 25°, 15°, 15°, 20°							250.1 ~ 250.55 : Carb-Qt v Cu-Pb Zn 5% 251.6 : Cu-Pb-Zn druses 2cm 254.4 : Py-vlts-netw 259.0 : Cly 5cm 20° 260.1 : Cly 5cm 20° 257.3 : Carb v 4cm 20° 261.0 ~ 262.3 : Shd 263.2 : Carb Qt v 2cm 272.8 : Carb v 2cm 70° Stepped dislocation :  291 : Qt v 0.5cm 80°
293.4 – 295.0	1.6	0.05	0.33	1.59	4		Ore	vs	sil carb	Pb-Zn Py-Po	p-gry		293.4 ~ 295.0 : Pb-Zn-Po-Py-Vs-diss 293.4 ~ 293.53 : Pb-Zn = 5%
295.0 – 300							Phy		sil carb	Py-Po	p-gry		Carb vs parallel to bed

Dep (m)	Leng	Cu	Pb	Zn	Ag	Str.	Rock	Fac	Altr	Min	Color	Fract	Observations
300 – 330						20°, 15°, 10°, 10°, 10°	Phy		Carb	Po-Py	gry		314.2 : Zn-Po-Py Carb v 8cm 317.6 : Zn-Po-Py diss 6cm
330 – 334.5	1.5	0.12	0.08	0.20	3		Ore	vlts	cal sil	Pb-Zn			330.0 ~ 333.0 : Pb-Zn-Po-Py diss in Cal vlts
	1.5	0.05	0.03	0.02	2								333.0 ~ 333.4 : Cal v Cu-Pb-Zn
	1.5	0.03	0.06	0.66	2								333.55 ~ 333.63 : Cal v Cu-Pb-Zn
334.5 – 365.9						10°, 10°, 10°, 10°, 10°	Phy		carb sil		gry		352.8 ~ 353.3 : Cal patch, Py-Po diss 366.3 m : Stratiform diss ore 
365.9 – 366.7	0.8	tr	0.14	0.04	1		Ore	diss vlts vs	cal sil	Cu-Pb Zn-Py Po			365.9 ~ 366.7 : Cu-Pb-Zn-Py Po diss 367.2 ~ 367.6 : Qt v
371.5 – 372.1	0.8	0.07	0.04	0.47	1								370.9 : Cu-Zn-Po diss 5cm
372.1 – 373.1	1.0	0.02	0.91	1.92	23	15°							372.1 ~ 373.1 : Cu-Pb-Zn diss in Cal 374.0 ~ 374.5 : F brc, cly 30° (2-373) : (Sp-Py-Cal-Qt-Sid-Chl-Mus-Kao)
373.1 – 401.3						10°, 10°, 10°	Phy		cal sil		gry		391.0 ~ 391.25 : Qt-Carb v 393.1 ~ 393.2 : F cly 10cm 40° 401.3m end

GEOLOGIC DRILL LOG

HAOUZ PROJECT, MOROCCO
(FRIZEM AREA)

Coordinate	N 94.050	DDH No.	MJMH-3
	E 224.120	Direction	
Elevation	712 m	Inclination	-90
		Total Depth	400.80m

Len (m) 1	Cu (%) 2	Pb (%) 3	Zn (%) 4	Ag (g/t) 5	Dep (m) 6	Str. 9	Rock 10	Fac 11	Altr 12	Min 13	Color 14	Fract 15	Observations 16
					8^{0}		Phy		oxd cly	Lim	brn-gry		Phyllite intercalated with Silt thin bed
					10	40°							
						40°							
						50°							
					20								
					21^{8}	40°	Phy		oxd cly	Lim	gry		
					27^{5}	55°	Alt		oxd cly	Lim	brn-gry		30^{0}~30^{4} : Cly
					30, 30^{4}		Alt		Qt-carb (vs)		gry		31^{1}~31^{7} : Qt v 3cm 60° Alt (Phy-Silt) Intv : 1mm 1cm 50cm Phy is blk~d-gry Silts is wht~p-gry, and tuffaceous
						55°							
						45°							
					40	45°							
					44^{0}	15°							
						25°	Phy		sid	Cu-Py	blk		Sid vs diss with Cu-Py 48^{6} : Cu-Py Carb vs parallel to bed 0.5cm 30°
					50	25°							
					51^{0}		Phy		cly		gry	crsh	
					56^{5}	30°	Phy				gry		
					60	45°							
					63^{0}	30°	Alt				gry		Alt (Phy-Silt) 67^{6}~68^{0} : Carb-Qt v 4mm 70°
					70	25°							$68.^{9}$: 
						30°							$75.^{8}$: Py-Po Carb v 0.5cm 30°
						30°							$78.^{0}$: Qt v. 2cm 70°
					80	35°							
						30°							$85.^{0}$: Qt Carb v parallel to str 2cm 35°
					90	40°							
						30°							$93.^{8}$: Carb v 2cm
					94^{8}		Phy		cly carb		gry	crsh	

Len (m) 1	Cu (%) 2	Pb (%) 3	Zn (%) 4	Ag (g/t) 5	Dep (m) 6	Str. 9	Rock 10	Fac 11	Altr 12	Min 13	Color 14	Fract 15	Observations 16
					102^{0}	30°	Alt		sil	Py-Po	l-gry d-gry		Alt (Phy-Silt) Intv : 1mm~1cm~10cm Phy : d-gry Silts : l-gry, tuffaceous
						30°							
					110	40°							$111.^{3}$m :  J 30°
						10°							$117.^{0}$~$117.^{2}$: Carb-Qt patch
					120	10°							
					125^{0}	25°							$125.^{0}$~$125.^{3}$: Cu diss in mass Po
0.9	0.01	0.01	0.01	1	125^{9}		Ore	vs	sil carb	Cu-Pb Zn-Py Po	d-gry		
1.0	0.61	0.10	0.66	8	$126.^{8}$								
0.6	0.02	0.01	0.01	tr	127^{5}								$128.^{3}$~$128.^{4}$: Carb Qt Brc
					129^{4}								$129.^{2}$~$129.^{4}$: Carb Qt Brc
					130		Alt		cly	Py-Zn	gry	shd	
					$131.^{8}$	20°	Alt		sil carb	Py-Po	gry		Carb vlts parallel to str Po-Py diss
						25°							
					138^{4}, 139^{0}								$138.^{4}$~$140.^{0}$: Qt v Cu-Po-Py diss
					140	30°							
2.5	0.02	tr	0.01	tr			Ore	vlts vs	sil carb	Py-Po	d-gry		Py-Po-Carb network low-grad
2.5	0.28	0.09	0.41	7									$142.^{5}$: Cu-Zn-Py-Po Carb v 5cm Cp = 2cm x 1cm
					144^{0}							F	144^{0}~146^{0} : F Cly 65°
							Alt				d-gry		
					$148.^{6}$							F	$148.^{6}$~$150.^{0}$: F 60° cly brc
					150	25°	Alt		carb sil	Py-Po	gry		Alt (Phy-Silt) Intv : 1mm 1cm 10cm
						20°							
					160	25°							$163.^{6}$: F 50° 10cm cly
													$168.^{7}$: Py-Po vlts $169.^{2}$~$169.^{7}$: Carb-Qt v, Cu-Py-Po diss $169.^{7}$~$169.^{9}$: Po-Py druse v 1cm
					170	20°							$172.^{8}$: Py-Po v 2cm
						30°							$176.^{4}$~$176.^{6}$: Carb-Qt v Py-Po diss $179.^{0}$: Cu-Py-Po Carb v 2cm
					180	25°							
					$183.^{6}$								$183.^{5}$~$185.^{1}$: shd $185.^{7}$: F 25°
						25°							$188.^{6}$~$189.^{2}$: F
					190	20°							$190.^{3}$~$191.^{4}$: F $192.^{7}$~$192.^{9}$: Qt-Carb v
					$193.^{7}$								$193.^{7}$~$197.^{2}$: Cu-Py-Po diss
1.8	0.05	0.21	0.03	tr		20°	Ore	diss vs		Cu-Zn Py-Po			$194.^{3}$~$194.^{9}$: Carb-Qt v
1.7	0.05	tr	0.01	tr	$196.^{0}$								
1.8	0.12	0.04	0.23	3	$197.^{2}$								$197.^{2}$~$199.^{0}$: Cu-Zn-Py-Po diss in Carb-Qt
					$199.^{0}$								

Len (m) 1	Cu (%) 2	Pb (%) 3	Zn (%) 4	Ag (g/t) 5	Dep (m) 6	Str. 9	Rock 10	Fac 11	Altr 12	Min 13	Color 14	Fract 15	Observations 16
					200	30°	f-Alt		carb sil		gry		Intv : 1mm~1cm~10cm
1.0	tr	tr	0.01	tr	$203.^{2}$								$203.^{2}$~$204.^{2}$: Cu-Zn-Py-Po diss $203.^{9}$~$204.^{2}$: Carb-Qt v
						20°							$209.^{2}$~$209.^{6}$: shd
					210	25°							$210.^{3}$~$210.^{7}$: Carb Qt v $210.^{7}$~242. : Shd $214.^{5}$~$214.^{6}$: Shd
						30°							$219.^{4}$~$219.^{5}$: Qt v
					220								
0.3	0.02	3.62	4.79	26	$222.^{0}$	25°							$222.^{0}$~$222.^{3}$: Carv Cu-Pb-Zn-Py
					$223.^{4}$		Ore	vlts vs		Zn-Cu Py-Po			$223.^{4}$: Zn-Py-Po v 1~2cm $224.^{2}$: Cu-Zn-Py v 1cm
1.7	0.01	0.01	0.02	tr	$225.^{1}$								$225.^{1}$~$227.^{1}$: Pb-Cu-Zn-Py-Po vlts~netw
2.0	0.02	0.06	0.02	1	$227.^{1}$	20°	f-Alt				blk wht		(3-225) : (Py-Sp-Cp-Qt-Sid-Ser-Chl-Kao-Pl-Bt)
					230	10°							$233.^{4}$~$233.^{8}$: F shd 50° cly
						30°							Bedding 30°, Joint 25° (3-238) (Siltstone) : (Qt-Dol-Chl Kao-Ser)
					240	20°							(3-239) (Phyllite) : Qt-Chl-Ser-(Kao-Pl-Sid)
						25°							
					$247.^{9}$		f-Alt				blk wht		f-Alt : Intv : 1mm~1cm~10cm
					250	25°							
						20°							
						25°							
					260	45°~30°							
						25°							
					270	20°							
					$278.^{1}$	15°							$278.^{1}$~$278.^{35}$: Carb Qt v
3.1	0.04	0.06	0.34	tr	280		Ore	diss vlts	carb sil	Zn Py-Po	gry wht		Carb drusy vs parallel to bed 1mm~2mm
						15°							
3.1	tr	0.01	0.03	tr		15°							
3.0	0.01	0.02	0.02	tr									
					$287.^{3}$	15°	Alt				d-gry		
					290, $290.^{8}$								$290.^{9}$~$292.^{0}$: Shd
							Phy		cly		d-gry	frc	
						15°	Phy				d-gry		
						15°							

Len (m) 1	Cu (%) 2	Pb (%) 3	Zn (%) 4	Ag (g/t) 5	Dep (m) 6	Str. 9	Rock 10	Fac 11	Altr 12	Min 13	Color 14	Fract 15	Observations 16
					300	10°	f-Alt (Phy-Silt)		carb sil	Cu-Pb Zn-Po Py	gry wht		$300.^{4}$ $303.^{0}$: Cu-Zn-Py-Po Carb v 1cm x 2, 5cm = 5%
1.3	0.03	0.02	0.25		$307.^{0}$	10°	Ore	vlts		Cu-Zn			$307.^{05}$~$308.^{3}$: Cu-Zn-Po-Py diss in vlts
					310		f-Alt		carb sil	Cu-Pb Zn-Po Py	gry wht		f-Alt : Intv : 1mm~1cm~4cm $312.^{6}$~$313.^{0}$: Pb-Cu-Po-Py diss in Carb vs
					$312.^{6}$	10°							(3-308) : (Gl-Sp-Py-Qt-Sid-Ser-Chl-Pl-Bt)
1.0	0.12	0.79	0.95	3	$316.^{4}$	10°							$316.^{4}$~$317.^{4}$: Pb-Cu-Zn-Po-Py diss in vlts $318.^{7}$: Cu-Py-Po vlts 0.5cm
					320	10°							
1.9	0.11	0.28	2.06	3	$324.^{6}$		Ore	vs		Zn-Cu			$324.^{6}$~$326.^{5}$: Pb-Zn-Cu-Py-Po diss asc. Carb vs
					$326.^{5}$		f-Alt						$329.^{0}$~$329.^{3}$: Frc cly 60°
1.3	0.09	3.08	2.87	41	$329.^{3}$, 330	15°							$329.^{3}$~$331.^{9}$: Cu-Zn-Py-Po diss
1.3	0.04	0.76	0.97	5			Ore	diss vlts		Cu-Zn			
						10°	f-Alt						$334.^{2}$: Py druse 2cm
					$335.^{5}$		Phy		carb	Cu-Zn Py	blk		
					340	10°							
						25° 10°							$349.^{85}$~$349.^{95}$: Carb v 10cm
					350	20°~10°	Phy		carb		d-gry		$350.^{2}$: Cu-Pb diss
					360	20°							$369.^{2}$~$369.^{9}$: Carb-Qt netw Cu-Py
					370	5°							$372.^{1}$~$372.^{4}$: Zn-Cu-Py diss along f $373.^{5}$~$374.^{3}$: Qt-Carb v. Cu-Py
						5°							
					380	5°							$384.^{6}$: Cu-Py-Po-Carb v 5cm $385.^{4}$: F cly 5cm 20°
					390	5°							
						10°							$395.^{2}$: Carb v 10cm 20°
													$399.^{0}$: Stepped dislocation of Qt v. 400.80m end

Ap. 4 Geologic Drill Log (4) MJMH-4

GEOLOGIC DRILL LOG

HAOUZ PROJECT, MOROCCO
(FRIZEM AREA)

Coordinate	N 94.330	DDH No.	MJMH-4
	E 224.410	Direction	
Elevation	692 m	Inclination	-90°
		Total Depth	400.20m

Columns: Assays — 1 Leng (m), 2 Cu (%), 3 Pb (%), 4 Zn (%), 5 Ag (g/t); Depth·Symbol — 6 Dep (m), 7 Core Rec, 8 Sym, 9 Str.; Occurrence — 10 Rock, 11 Fac, 12 Altr, 13 Min, 14 Color, 15 Fract; 16 Observations

0 – 100 m

Assays

Dep (m)	Leng (m)	Cu (%)	Pb (%)	Zn (%)	Ag (g/t)
33.7–35.2	1.0	tr	0.01	0.01	tr
~57	1.0	tr	0.01	0.02	tr
~75	1.0	tr	tr	0.01	tr

Occurrence

Dep (m)	Rock	Fac	Altr	Min	Color	Fract
7.5–13.9	Phy	mas	Lim cly sil	Lim	p-brn gry	
15.1–18.6	Ry	mas	Lim sil	Lim	l-gry	
18.6–20	Phy	mas	oxd cly sil	Lim	p-gry	
22.0–33.7	Ry	mas	oxd sil	Lim	l-gry	
33.7–35.2	Ry-Phy		oxd	Lim	brn	
35.2–41.2	Sil-r (Phy)	mas	sil oxd	Lim	d-gry brn	
41.2–51.8	Ry-Tf		sil	Py-Po	l-gry	
51.8–75.8	Ry-Tf		carb sil	Py-Po	l-gry	
75.8–77.2	Phy				blk	
77.2–80	Phy		sil carb		p-gry	
80–87.1	Ry-Tf	mas	sil carb		l-gry	
87.1–88	Ry-Tf		ser-dy		p-gry	shd
88–89	Ry-Tf		carb		p-gry	
89–91	Phy					
91–92	Phy					shd
92–100	f-Alt (Phy-Silt)			Py	gry	

Observations

- 6.5 ~ 7.5 : Qt patch·Phy
- 13.9 ~ 15.1 : Qt v
- 33.7 ~ 35. : Ry (tuff-Phy)
- Lim-Cal-Qt vs
- Ry-Tf : acid gry pumice patch compacted, elongated
- 45.6 : Carb v 5cm 40°
- Lamina str
- (4-056) (Rhyolite) : (Qt · Dol · Pl ·
- 51.6 : Py diss in Carb v, 2cm
- 55.0 : Py diss along lamina, 10cm
- 56.4 : Py diss alg lamina, 3cm
- 56.8 : Py diss
- 59.3 : Cal-Carb vlts, drussy
- 59.7 : Py diss, 15cm
- 65.6 : Pb(?) Qt v 1cm 30°
- 67.8 : Py diss alg lamina, 2cm
- 68.7 ~ 69.1 : Py diss with Qt
- 69.1 ~ 69.8 : Frc
- 71.2 ~ 71.3 : Py diss
- 74.0 ~ 74.3 : Py diss alg lamina
- 75.4 ~ 75.8 : brc, cly, Carb·Qt
- 80.3
- 81.3 : Py diss
- 84.7 : Py diss
- 89.1 : Carb v 5cm, drussy
- 90.5 ~ 91.1 : Ry·Tf
- 91.1 92.0 : shd
- f-Alt (Phy·Tf·Silt), 1mm~1cm~4cm
- 94.2 : Py diss alg lamina, 1cm
- 97.5 : Py·Carb vlts, 2mm

100 – 200 m

Assays

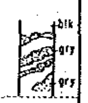
Dep (m)	Leng (m)	Cu (%)	Pb (%)	Zn (%)	Ag (g/t)
158.0	1.8	0.01	0.02	0.05	tr
160	0.6	0.01	1.14	1.34	9
171.5	0.2	0.19	0.48	2.57	16
193.2	1.2	0.02	0.02	0.03	1
	1.2	0.03	0.05	0.18	1
195.6	0.8	tr	tr	0.05	tr
196.4	1.0	0.17	0.08	0.13	11

Occurrence

Dep (m)	Rock	Fac	Altr	Min	Color	Fract
102.2–105.3	Ry	mas	sil	Py-Zn	l-gry	
105.3–110.3	Alt				gry	
110.3–114.9	Phy				blk	
114.9–116.3	Qt			Py	wht	
116.3–158.0	Alt				gry	
158.0–159.8	Alt	brc diss	cly	Cu-Zn Py	d-gry	shd
159.8–160.4				Zn-Py	gry	
160.4–161.8	Alt	brc diss	carb	Py	d-gry	
161.8–171.5	Alt		carb	Py-Po	gry	
171.5–175.8	Alt					
175.8–181.8	Phy		carb	Py-Po	d-gry	
181.8–182.6	Qt					
182.6–193.2	f-Alt		carb	Py-Po	gry	
193.2–195.6	Ore	diss vs	sil carb	Cu-Zn Py-Po	gry	
195.6–196.4	Ry		carb sil	Py-Po	p-grn	
196.4–197.4	Ore	vs		Cu-Po		
197.4–200	Alt				gry	

Observations

- 102.0 ~ 102.9 : Zn·Py vs. 1cm
- Phy with Tf-Silt brc
- Disturbation in Alt is observed



- 110.3
- 114.9 ~ 116.3 : Qt v, Py patches
- Alt (Phy·Tf·Silt) Intv : 1cm~10cm
- 117.9 : Py·Carb·Qt vlts, 1cm
- 120.4 : Py·Cal v 0.5~2cm
- Lamina : 45°~55°
- Joint : 35 ~ 45°
- 134.9 : Py·Carb vlts 1mm
- 137.7 : Py·Carb vlts 2mm~1cm
- Lamina : 40°
- Joint : 30°~40°
- 155.9 : Cross lamina (40° : bedding, 20° : joint)
- 158.0 ~ 159.8 : Brc, Cu·Zn·Py diss
- 159.8 ~ 160.4 : Zn·Py·Ore netw ~ diss
- Alt (Phy·Tf·Silt) blk and wht Intv : 1cm~10cm
- Cross lamina is devloped
- (4-160) : (Sp·Gl·Py·Po·Cp·Qt·Dol)
- 169.0 : Cu·Py·Po·Carb·Qt v.5cm
- 171.5 ~ 171.7 : Cu·Zn·Po·Py Ore asoc. drussy Carb
- 175.2 : Zn·Po·Py·Carb·Qt v 5cm
- 177.7 : Py·Po·Carb vs 1cm
- 179.2 : Cu·Zn·Po·Py Ore 5cm
- 181.6 ~ 182.6 : Carb·Qt v
- f-Alt : Intv : 1mm~1cm~10cm
- 185.1 ~ 185.4 : Brc
- 191.2 : Cu diss in Carb v. 2cm
- 193.2 : Cu·Po diss 5cm
- 194.7 : Cu·Py·Po diss 3cm
- 195.4 Sp diss
- 195.4 ~ 195.6 : Massive Po
- 196.6 : Cp diss
- 197.1 ~ 197.4 : Massive Po

200 – 300 m

Assays

Dep (m)	Leng (m)	Cu (%)	Pb (%)	Zn (%)	Ag (g/t)
225.0	1.2	0.02	0.14	0.14	1
230	0.5	0.18	0.01	0.01	1
231.8	0.8	0.06	0.01	0.01	tr
234.0	0.6	0.04	tr	tr	1

Occurrence

Dep (m)	Rock	Fac	Altr	Min	Color	Fract
200–202.0	Alt					
202.0–209.8	Phy	mas			d-gry	
209.8–225.0	Alt		sil carb		gry	
225.0–226.2	Ore	brc diss	sil carb	Cu-Py-Po	l-gry	brc
226.2–230	f-Alt		sil carb	Py-Po	gry	
230–249.1	Alt	vs vlts	sil carb	Po-Py	gry	
249.1–253.1	Phy		cly		d-gry	shd
253.1–274.5	Phy		cal carb	Py-Po, Zn-Cu	d-gry blk	
274.5–279.5	Phy			Py	d-gry	crsh
279.5–282.9	Phy		carb cal	Py-Po	gry	
282.9–300	Alt		carb	Py-Po Cu-Zn	gry	

Observations

- Intv : 1cm ~ 20cm
- 218.5 ~ 218.6 : Carb·Qt v. Cu·Po diss
- 218.6 ~ 219.0 : Py·Po diss
- 219.0 ~ 219.2 : Cu·Py·Po diss Carb·Qt v.
- 228.8 ~ 228.9 : Zn·Py diss Qt v.
- 230.3 ~ 230.8 : Cu·Po diss with Carb drussy vs
- 231.8 ~ 232.3 : Cu·Po diss
- 234.0 ~ 234.6 : Pb·Py diss
- Intv : 1mm~1cm~10cm~40cm
- 253.5 : Py·Po v 1cm
- Phy intc with Silt thin bed (Qt~1cm)
- 259.6 : Py diss in vlts
- 260.4 : Po v 1cm
- 261.2 : Py·Po diss 1.5cm
- 262.2 : Py diss
- 263.7 : Py vs 3mm
- 267.7 : Zn·Py v 2cm
- 268.2 ~ 269.2 : Py diss in Carb vs
- ~~279.9 : Cu·Py diss in Cal v 1cm~~
- 272.4 ~ 273.9 : Py netw
- 280.2 : Cu·Py diss in vlt 3mm
- Phy : tuffaceous intc with Silt thin bed, 1cm
- 283.2 : Po·Py diss in vlt 3mm
- Intv. 2mm~1cm~20cm
- 287.6 ~ 287.7 : Zn·Py diss
- 287.7 ~ 288.7 : Py·Po diss in vlts
- 290.0 ~ 290.2 : Cal·Qt v.

300 – 400.20 m

Assays

Dep (m)	Leng (m)	Cu (%)	Pb (%)	Zn (%)	Ag (g/t)
304.6	0.1	0.12	0.04	0.23	3
~344.5	0.8	0.01	tr	0.01	1
~362.5	0.4	0.03	0.91	2.64	11

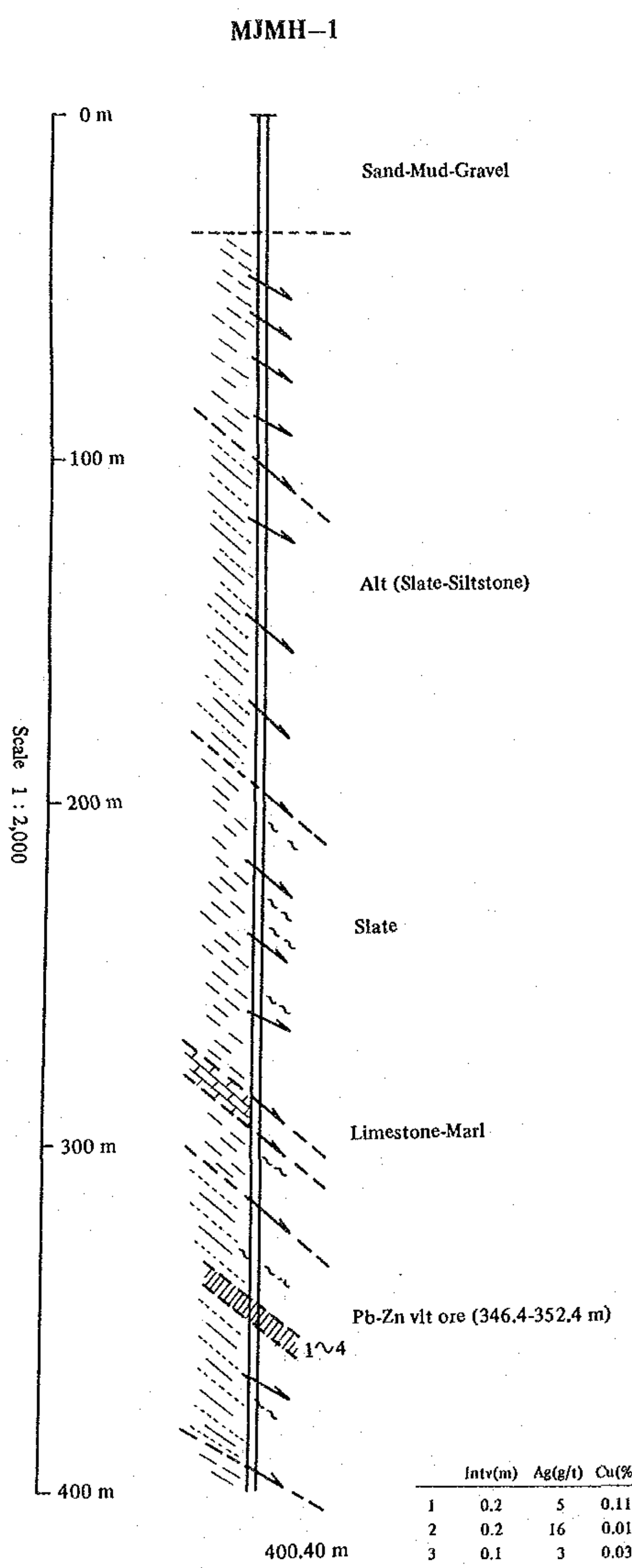
Occurrence

Dep (m)	Rock	Fac	Altr	Min	Color	Fract
300–316.4	Alt		carb sil	Py	l-gry	
316.4–333.4	Phy				d-gry blk	
333.4–340.5	Phy		carb sil	Py	d-gry blk	shd
340.5–357.0	Phy			Py	d-gry blk	
357.0–400.20	Alt			Py	gry l-gry	

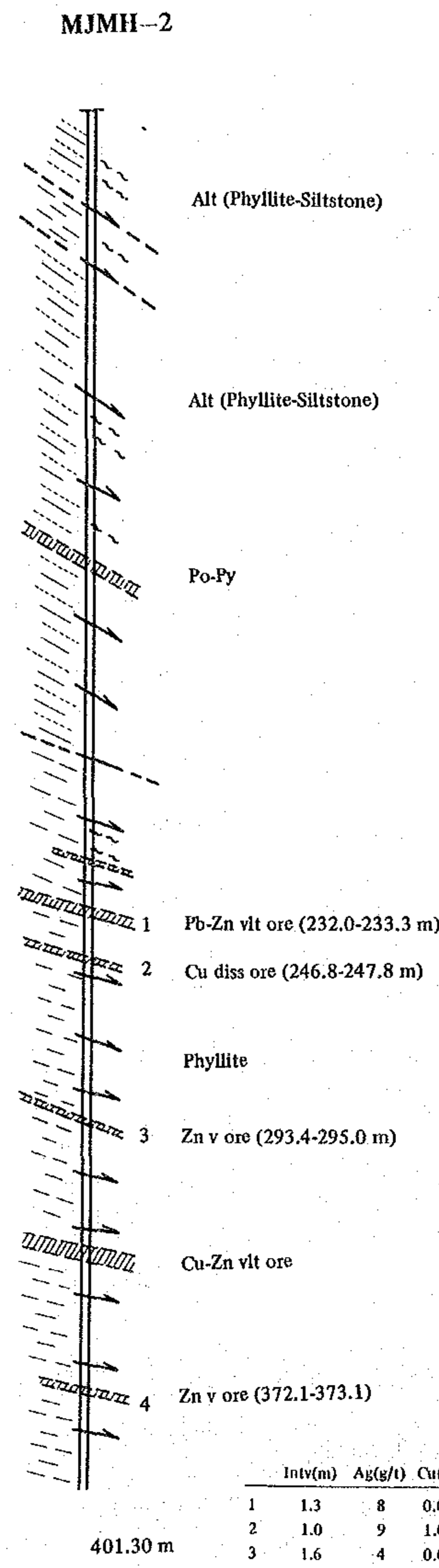
Observations

- 301.8 ~ 303.8 : Frc
- 304.6 : Cu diss, 5cm
- 308.6 : Py diss in patches
- Alt (Phy·Tf·Silt) Intv : 1mm~1cm~20cm
- Phy intc with Silt thin bed (1mm ~ 1cm)
- 323.1 ~ 324.1 : Shd
- 337.0 ~ 337.5 : Qt·Carb v. Cu·Zn·Py·diss
- 341.7 ~ 341.9 : Carb·Qt v
- 344.4 ~ 345.2 : Carb·Qt v, Pb·Cu·Py·diss
- 345.5 ~ 346.5 : Brc intc with Qt v
- Alt (Phy·Tf·Silt) Intv : 2mm~1cm~20cm
- 362.5 ~ 362.9 : Carb·Qt v Zn·Py diss
- 366.5 ~ 367.5 : Shd
- Siltstone is a little calc.
- 393.3 ~ 393.4 : Qt·Carb v Py diss
- 400.20 m end

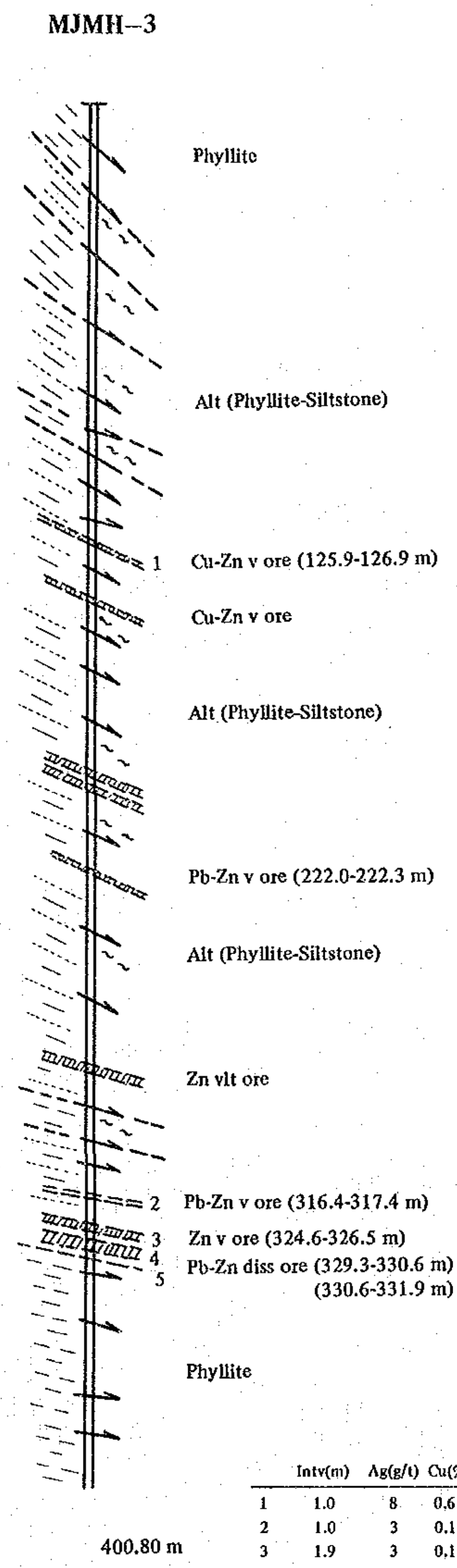
Geologic Drill Section



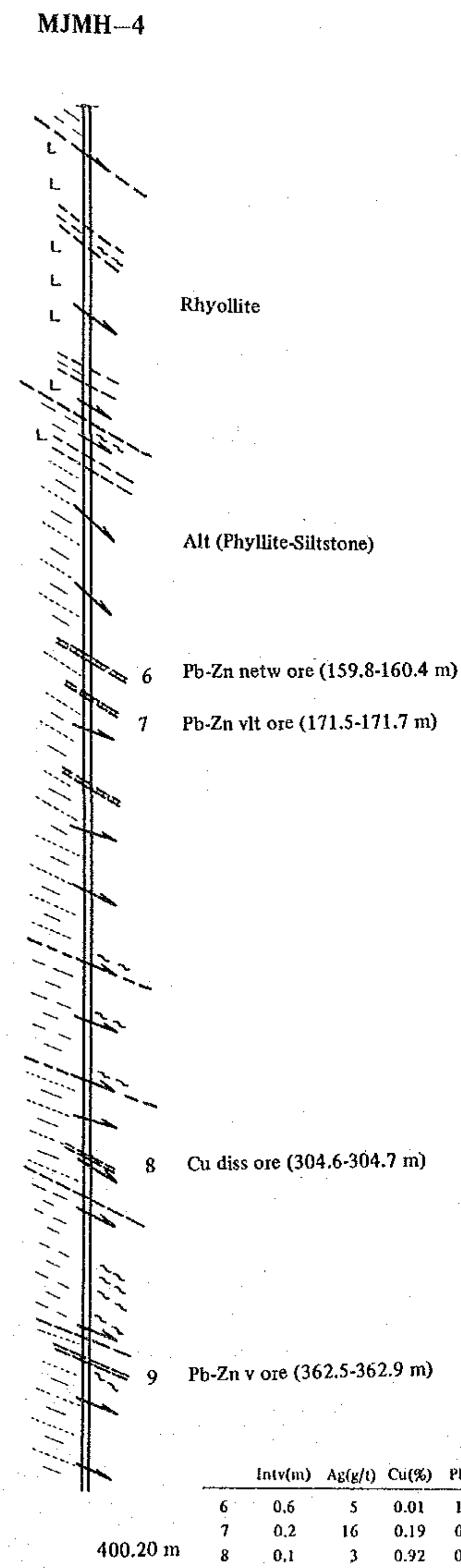
	Intv(m)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
1	0.2	5	0.11	6.36	0.96
2	0.2	16	0.01	0.01	7.05
3	0.1	3	0.03	6.12	16.00
4	0.1	3	0.02	9.58	9.58



	Intv(m)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
1	1.3	8	0.01	2.31	1.86
2	1.0	9	1.07	0.02	0.17
3	1.6	4	0.05	0.33	1.59
4	1.0	23	0.02	0.91	1.92



	Intv(m)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
1	1.0	8	0.61	0.10	0.66
2	1.0	3	0.11	0.79	0.95
3	1.9	3	0.11	0.28	2.06
4	1.3	11	0.09	3.08	2.87
5	1.3	5	0.04	0.76	0.97



	Intv(m)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
6	0.6	5	0.01	1.14	1.34
7	0.2	16	0.19	0.48	2.57
8	0.1	3	0.92	0.04	0.28
9	0.4	11	0.03	0.91	2.64

vlt : veinlet
v : vein
diss: dissemination