Chapter 3 Bob Zinc Area (Drilling)

1. Outline of Operation

1-1 Drilling sites and Amount of Work

The locations of the drilling sites are shown in Fig. 41, the profile in Fig. 42 and the details of the operation are summarized in Table 5.

Table 5 The List of the Drillings

Drill Hole No.	Depth (m)	Inclination	Bearing (M.N)	Depth of Laterite (m)	Length of Core (m)	Core recovery (%)	Term		Exploration Target
							Starting	Completion	
MJZ-1	201.0	-40°	N50°W	11.5	186.9	98.6	24 Aug.	1 Sep.	East Zinc Geochemical Anomaly
MJZ-2	201.0	-45°	N32°E	14.0	183.0	97.9	5 Sep.	9 Sep.	Ditto
MJZ-3	201.0	-45°	S28°E	27.6	170.6	98.4	16 Sep.	21 Sep.	Ditto
MJZ-4	102.0	-40°	N50°W	14.8	85.9	95.5	8 Oct.	12 Oct.	Ditto
MJZ-5	201.0	-40°	N50°W	23.3	175.6	98.8	15 Oct.	22 Oct.	Ditto
MJZ-6	201.0	-45°	S84°W	20.0	176.3	97.4	27 Sep.	4 Oct.	Ditto

$$\text{Core Recovery} = \frac{\text{Length of Core}}{\text{Depth} - \text{Depth of Laterite}} \times 100$$

1-2 Surface Geology and Geochemical Anomalies

The area from Bob Zinc Deposit to the geochemical anomaly zone in the east where drilling was conducted is covered by thick (10~20m) laterite and the exposure is extremely poor. And it is not possible to obtain necessary data on mineralization from surface geology. Therefore, small scale geochemical prospecting was conducted in order to check the alteration zone found by surface geological investigation.

1-2-1 Surface Geology

The geology of this area consists of massive dolomite~dolomitic limestone belonging to the lower part of the carbonate rocks. These rocks have been recrystallized into marble or saccharoidal limestone in some parts.

The Bob Zinc Deposit and the geochemical anomalies to the east occur in the brecciated and fractured zone of the carbonate rocks. This fractured zone is approximately 900m×400m and brecciation is strong in the central part. Weak sideritization is observed in the vicinity. Strong sideritization is observed both in the Bob Zinc Ore Body and the geological anomalies to the east, and they occur independently. The former siderite zone is not clear because of the very poor exposure, but the size is inferred to be in the order of 300mx 200m while that of the latter zone is approximately 250mx150m. The strongly sideritized zone extends in E-W direction parallel to the strike of the Bob Zinc Ore Body (Fig. 41)

Ore minerals have not been found on the surface of this area. But a total of 18 holes were drilled in 1957 and

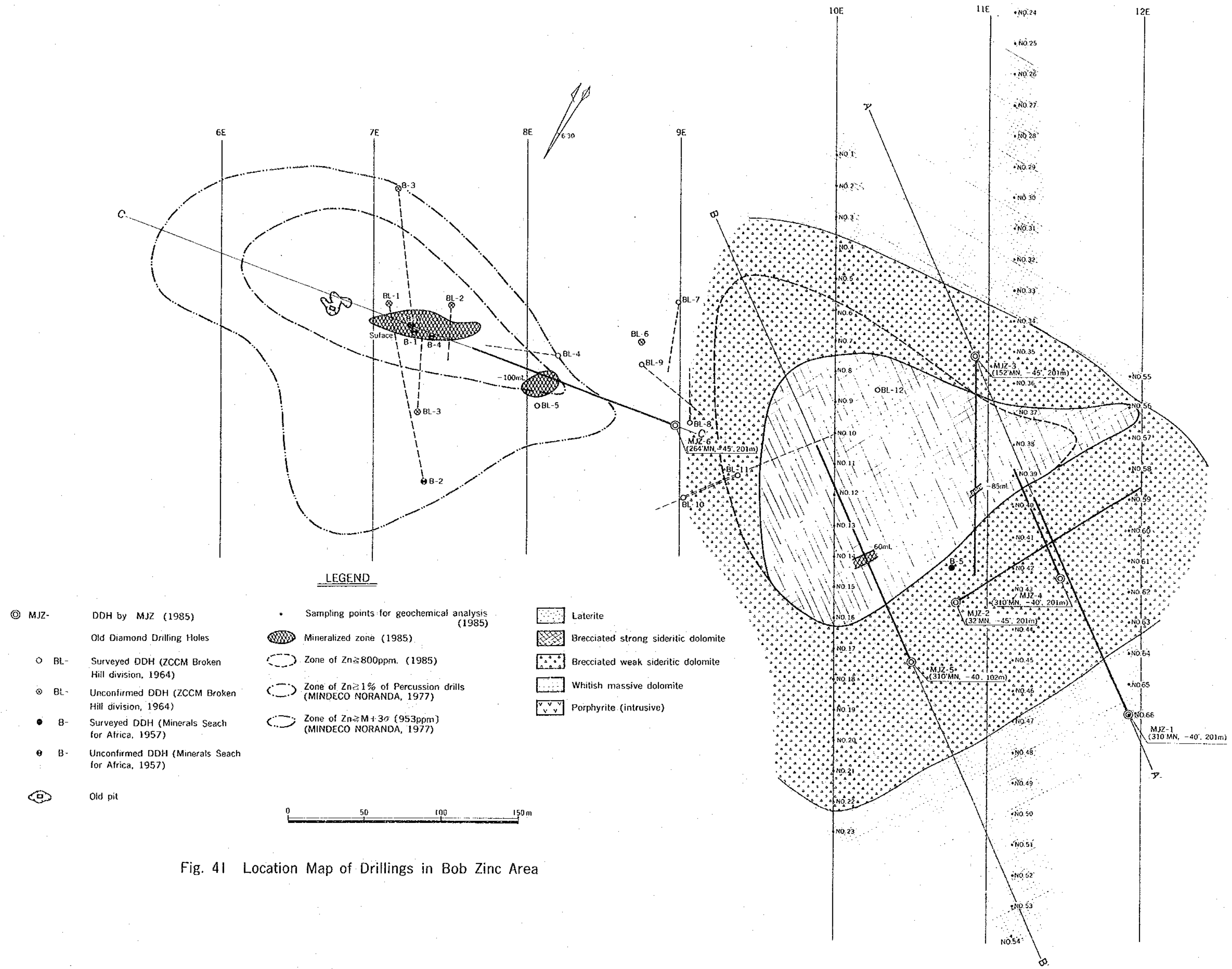


Fig. 41 Location Map of Drillings in Bob Zinc Area

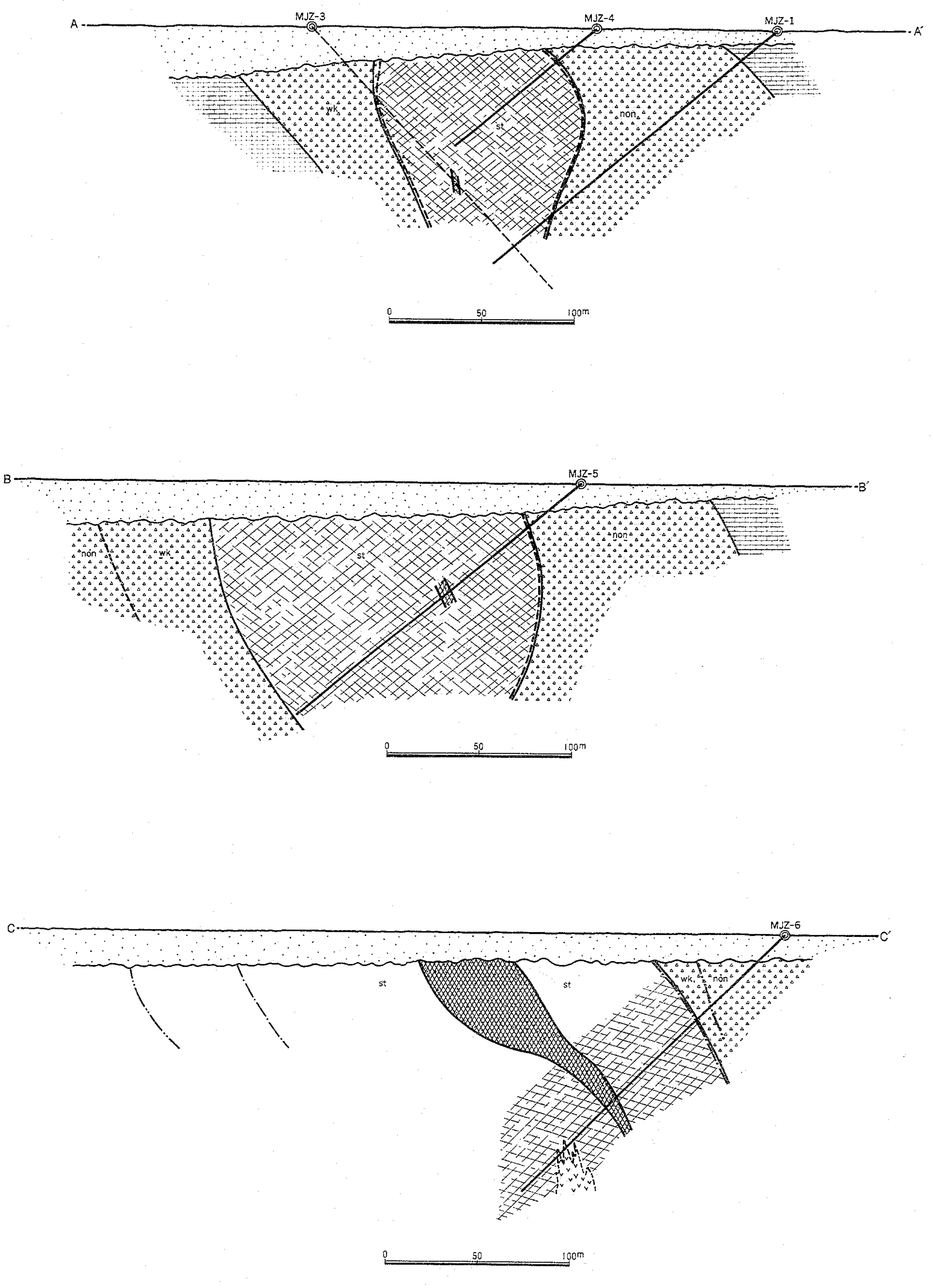


Fig. 42 Geological Section of Drilling Holes in Bob Zinc Area

1964 in the vicinity of the Bob Zinc Ore Body based on the results of geochemical prospecting. Of these drilling, 8 holes have reached the Bob Zinc Ore Body. It was reported on the basis of these work that this was a bedded ore body consisting of zinc silicate ores with strike length of 109m, 12m average thickness and estimated reserves of 305,000t at an average grade of 164 g/t Ag and 11.6% Zn to 106m depth. The high grade portion was reported to be 100,000t with average grade of 96 g/t Ag and 22.77% Zn. The eastern edge of the body was considered to be cut by faults. During the first year of our work, plans and cross sections of the ore body were prepared on the basis of the above drilling data and it is now clear that the nature of the ore body is as follows.
Strike approximately E-W; dip 70°-80°S; strike length at surface 70-80m (at 50m depth 80-100m); width 10-20m with ESE shoot and at 80m depth becomes a pipe with maximum diameter of 30m.

1-2-2 Geochemical Anomalies

The results of the geochemical detailed survey and the shallow percussion drilling conducted by MINDECO-NORANDA in 1977 were analysed and interpreted during the first year.
It was shown that the distribution of high anomaly zones of over $M+3\sigma$ (953 ppm) and more than 1% Zn in the drill cores agree well with the Bob Zinc Deposit and also there is an anomaly zone with similar distribution to the east.

Sixty six geochemical samples were collected from the high Zn zone to the east of Bob Zinc Deposit and the Zn anomalies were checked. The distribution of over 800 ppm anomalies corresponded quite well to the results of the above re-investigation of the MINDECO-NORANDA exploration. Also the maximum Zn content was 1800 ppm, a very high anomaly (Table 6). The distribution of over 800 ppm Zn anomalies also coincided with the strongly sideritized zone. With the above background, the present work was conducted in the area with over 800 ppm Zn and drilling was carried out in the same zone.

Cu, Pb, B, Ni, Zn, Ag, Cr, Co, U, Mn, Ti were detected by spectrometry of the geochemical soil (laterite) samples of this area (Table 7). Of these elements, Cu, Ni, Cr, Co, Mn, Ti were richer in soil than in the drill core samples of the mineralized zone. No difference was detected between the chemical compositions of the soils of the white massive dolomite and the brecciated sideritic dolomite areas. There is a tendency, however, that the Zn content is slightly higher.

2. Drilling

2-1 Method

Pebble-bearing surface soil ranging from 11.5 to 27.6 m thick was penetrated by a non-coring method with a NX single bit and this was followed by NQ coring bit (79mm in diameter) wireline method.

Drilling fluids were mainly bentonite mud water, in which mud oil (lubricant oil) was added to control vibrations arising from loss of circulation.

Table 6 The Results of Geochemical Analysis of Soil Samples in Bob Zimc Area

Sample No.	Zn ppm
1	130
2	160
3	220
4	300
5	520
6	1,000
7	1,000
8	1,800
9	1,400
10	1,100
11	1,000
12	1,000
13	1,000
14	1,000
15	1,000
16	900
17	600
18	500
19	520
20	500
21	500
22	500
23	700

Sample No.	Zn ppm
24	140
25	100
26	90
27	90
28	120
29	120
30	200
31	220
32	220
33	320
34	380
35	400
36	500
37	800
38	800
39	900
40	700
41	600
42	700
43	600
44	580
45	580
46	500
47	600
48	560
49	600
50	580
51	500
52	500
53	380
54	500

Sample No.	Zn ppm
55	440
56	700
57	580
58	500
59	560
60	440
61	480
62	460
63	430
64	440
65	500
66	400

Table 7 The Results of Spectrographic Aralysis

Sample No.	Be	As	Cu	Pb	Sn	Sb	Nb	B	Ni	Bi	Mo	Zn	Ag	Cr	Co	Ta	Au	W	V	Li	Zr	La	Mn	Ba	Ti
Bob Zinc MJZ-6																									
124.6 ∿ 125.5m	<10	nd	<50	80	<10	nd	20	10	<50	nd	<10	6,000	7	60	<20	nd	nd	nd	200	nd	<5,000	nd	50	nd	5.0
125.5 ∿ 127.4	<10	5	100	240	<10	20	<5	10	<50	nd	<10	>10,000	17	50	<20	nd	nd	nd	100	nd	<5,000	nd	300	1,000	0.7
127.4 ∿ 127.7	<10	nd	<50	160	<10	nd	10	10	50	nd	<10	7,500	8	200	<20	nd	nd	nd	400	nd	<5,000	nd	50	1,000	7.0
127.7 ∿ 128.8	<10	30	50	210	<10	40	10	10	<50	nd	35	>10,000	12	60	<20	nd	nd	nd	400	nd	<5,000	nd	1,000	500	1.0
128.8 ∿ 130.4	<10	30	50	130	<10	nd	10	5	50	nd	<10	>10,000	22	<50	20	nd	nd	nd	200	nd	<5,000	nd	200	20	0.6
130.4 ∿ 131.9	<10	nd	<50	110	<10	nd	10	5	<50	nd	10	>10,000	22	<50	<20	nd	nd	nd	200	nd	<5,000	nd	100	20	0.4
131.9 ∿ 133.4	<10	10	<50	150	<10	nd	10	6	<50	nd	<10	>10,000	53	<50	<20	nd	nd	nd	60	nd	<5,000	nd	60	20	0.3
133.4 ∿ 134.3	150	30	50	280	<10	20	10	10	<50	nd	30	>10,000	13	<50	<20	nd	nd	nd	100	nd	<5,000	nd	200	20	0.15
134.3 ∿ 134.9	200	50	<50	260	10	20	10	10	<50	nd	<10	>10,000	22	<50	<20	nd	nd	nd	70	nd	<5,000	nd	200	200	0.1
134.9 ∿ 135.4	<10	150	<50	240	10	nd	10	8	<50	nd	10	>10,000	42	<50	<20	nd	nd	nd	200	nd	<5,000	nd	80	200	0.15
135.4 ∿ 136.4	<10	100	80	250	<10	20	10	10	<50	nd	30	>10,000	7,100	<50	<20	nd	nd	nd	400	nd	<5,000	nd	200	20	0.3
136.4 ∿ 137.3	<10	5	<50	120	10	nd	10	6	<50	nd	<10	5,500	55	<50	<20	nd	nd	nd	200	nd	<5,000	nd	500	1,000	0.5
Bob Zinc Geochemical Soil Samples																									
55	<10	nd	100	80	<10	nd	<5	15	100	nd	10	500	0.5	100	40	nd	nd	nd	200	nd	<5,000	nd	2,000	nd	3.0
56	<10	nd	100	80	<10	nd	<5	15	100	nd	10	500	0.5	100	40	nd	nd	nd	200	nd	<5,000	nd	2,000	nd	2.0
57	<10	nd	100	80	<10	nd	<5	10	100	nd	10	500	0.5	100	50	nd	nd	nd	200	nd	<5,000	nd	2,000	nd	5.0
58	<10	nd	60	80	<10	nd	<5	10	100	nd	<10	300	0.4	100	40	nd	nd	nd	200	nd	<5,000	nd	1,000	nd	5.0
59	<10	nd	100	60	<10	nd	<5	10	100	nd	10	500	0.5	120	40	nd	nd	nd	300	nd	<5,000	nd	2,000	nd	5.0
60	<10	nd	100	100	<10	nd	<5	15	100	nd	<10	500	0.5	120	40	nd	nd	nd	200	nd	<5,000	nd	2,000	nd	6.0
61	<10	nd	100	100	<10	nd	<5	10	100	nd	<10	500	0.6	120	40	nd	nd	nd	300	nd	<5,000	nd	1,500	nd	5.0
62	<10	nd	80	100	<10	nd	<5	10	100	nd	10	500	0.5	150	40	nd	nd	nd	300	nd	<5,000	nd	1,500	nd	7.0
63	<10	nd	100	70	<10	nd	<5	10	100	nd	10	300	0.6	130	35	nd	nd	nd	300	nd	<5,000	nd	1,000	nd	6.0
64	<10	nd	100	100	<10	nd	<5	10	100	nd	<10	200	0.5	100	35	nd	nd	nd	300	nd	<5,000	nd	1,000	nd	5.0
65	<10	nd	100	100	<10	nd	<5	10	100	nd	<10	300	0.5	120	40	nd	nd	nd	300	nd	<5,000	nd	1,000	nd	5.0
66	<10	nd	100	50	<10	nd	<5	10	100	nd	<10	200	0.4	180	30	nd	nd	nd	200	nd	<5,000	nd	500	nd	2.0
Blue Jacket C-13.5 Pit Surface																									
Hem.-Mag.-(Lim.)	<10	5	50	<20	10	nd	<5	200	100	nd	<10	<50	nd	100	30	nd	nd	100	200	nd	nd	nd	500	nd	2.0
"	<10	5	60	<20	10	nd	<5	200	100	nd	<10	<50	nd	100	40	nd	nd	200	200	nd	nd	nd	500	nd	2.0
"	<10	5	50	<20	10	nd	<5	200	100	nd	<10	<50	nd	100	40	nd	nd	200	200	nd	nd	nd	500	nd	2.0

Hem. : Hematite Mag. : Magnetite Lim. Limonite ( ) : Small Amount nd : not detected Unit : ppm except Ti Unit of Ti : %

There were so many druses and cracks developed in rocks that continuous losses of drilling fluids were encountered. Although several substances such as Telstop (squeezed cotton-seeds) and Seacray (asbestos) were added in drilling muds, no effectiveness in preventing loss of circulation was achieved and drilling crews were consistently forced to drill without return water.

As a standard, HX casing strings were inserted to a depth of 20m, NX casing to 50m and BX casing to 120m in drilling of a hole of 200m depth. In case of drilling of a 100 m hole, HX casing to 15m, NX casing to 30m and BX casing to 60m from a mouth were inserted as illustrated in Fig.43.

2-2 Rig and Materials

A rig employed is of a type OE-8BL of Koken Boring Co., Ltd., Japan with a hydraulic chuck. This machine has been designated to a capacity of some 300m depth. Types and specifications of machineries used and details of bits and drilling muds consumed are shown in Tables 8 to 11.

Among used materials, drilling muds were brought from Japan, but diesel fuel, petro, oils and cement were purchased in Lusaka and at Mumbwa.

2-3 Operation

Drilling operation was carried out by 3 shifts a day each of 8 hours. Preparation of drill sites, installation moving,

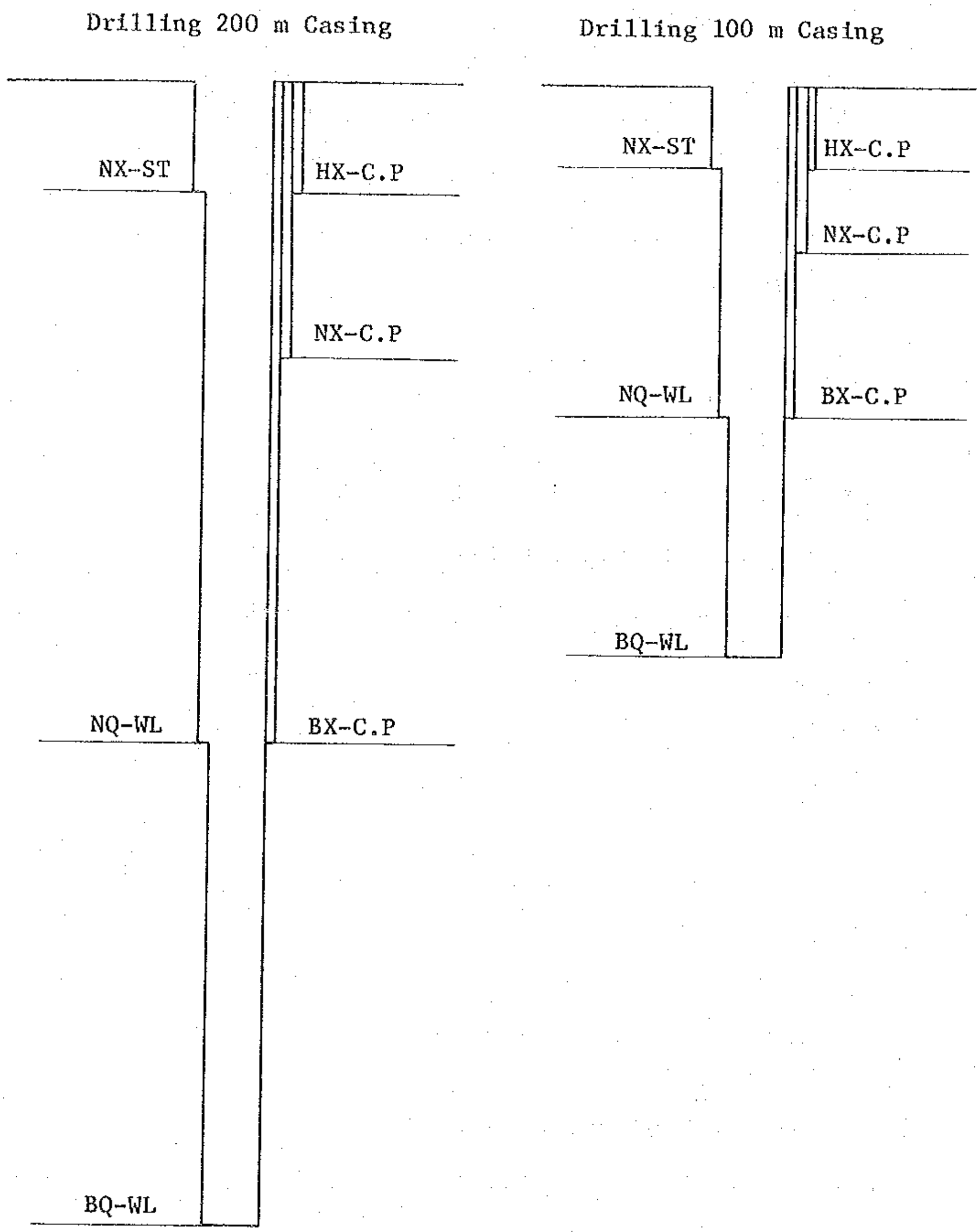


Fig. 43 Profile of Casing in Drilling Holes

Table 8 Drilling Machine and Equipments Used

Drilling Machine Model "OE-8BL"	1 set
Specifications:	
Capacity	300 m (BQ-WL)
Dimensions L × W × H	1,550mm × 700mm × 1,510mm
Hoisting capacity	2,000kg
Spindle speed	forward 100,190,320,530, rpm
Engine Model "F2L912"	25.5 ps/1,800 rpm
Drilling Pump Model "WLMG-10"	1 set
Specifications:	
Piston diameter	68 mm
Stroke	100 mm
Capacity	discharge capacity 144ℓ/min max. pressure 30 kg/cm^2
Dimensions L × W × H	1,460mm × 580mm × 980mm
Engine Model "NF-110K"	11ps/2,200 rpm
Water supply pump Model "U-40KI"	
Specifications:	
Capacity	discharge capacity 300ℓ/min max. pressure 10 kg/cm^2
Wire line hoist Model "WLH-4"	1 set
Specifications:	
Rope capacity	500 m
Hoisting speed	8 ∿ 105 m/min
Engine Model "NF-80K"	8ps/2,200 rpm
Mud mixer Model "HM-250"	1 set
Specifications:	
Capacity	200 ℓ/600 rpm
Engine Model "NF-80K"	8 ps/2,200 rpm
Generator Mode "YSG-2000B"	3 set
Drilling tools	
Drilling rod	NQ-WL 3 m 40 pcs BQ-WL 3 m 67 pcs
Casing pipe	HX 1 m 3 pcs HX 1.5 m 4 pcs NX 1 m 2 pcs NX 3 m 9 pcs BX 1 m 1 pc BX 3 m 40 pcs
Derrick	1 set
Specifications :	
Height	9.5 m
Max.load capacity	4,000 Kg

Table 9 Specification of Diamond Bit Used

Item	Size of bit	Type of bit	Carats of bit	Matrix	Stones per carat	Waterway	Total bit Used
Diamond bit	94 mm	NX - NW	25 ct	E	15	4	2
	79 mm	NQ - WL	30	E	15	4	10
		NQ - WL	30	CE	25	4	7
	62 mm	BQ - WL	22	E	15	4	6
		BQ-WL	22	CE	25	4	4
Total			*780				29

E : for ordinary rock

CE : for ordinary rock

* : total amount of diamond carat

Table 10 Drilling Meterage of Diamond Bit Used

Item	Size	Bit No.	Drilling Meterage by Unit: Meter						Total (m)
			MJZ-1	MJZ-2	MJZ-3	MJZ-4	MJZ-5	MJZ-6	
Diamond bit	NX	185672	14.10	3.10	9.10			6.10	32.40
		185673				6.10	6.10		12.20
		Total	Drilling length/bit (44.60/2)						22.30
	NQ	185654	26.40						26.40
		185655	38.90						38.90
		185656	40.70						40.70
		185657		37.40					37.40
		185658		42.00					42.00
		185659		37.60					37.60
		185660			46.40				46.40
		185661			39.00				39.00
		185662			25.60	16.40			42.00
		185663				39.00			39.00
		185664				40.50			40.50
		185665					34.40		34.40
		185666					45.00		45.00
		185667					35.60		35.60
		185668						40.40	40.40
		185669						36.00	36.00
		185670						37.60	37.60
		Total	106.00	117.00	111.00	95.90	115.00	114.00	658.90
		Total	Drilling length/bit (658.90/17)						38.76
	BQ	175462	43.30						43.30
		175463	37.60						37.60
		175464		37.30					37.30
		175465		43.60					43.60
		175466			46.30				46.30
		175467			34.60				34.60
		175468					48.30		48.30
		175469					31.60		31.60
		175470						43.30	43.30
		175471						37.60	37.60
		Total	80.90	80.90	80.90	-	79.90	80.90	403.50
		Total	Drilling length/bit (403.50/10)						40.35
Grand Total			Drilling length/bit (1,107.00/29)						38.17

Table 11 Consumables Used

Description	Specifications	Unit	Quantity						Total
			MJZ-1	MJZ-2	MJZ-3	MJZ-4	MJZ-5	MJZ-6	
Light oil		ℓ	515	330	345	315	560	555	2,620
Petrol		ℓ	490	160	240	385	400	505	2,180
Hydraulic oil		ℓ	30		8			17	55
Gear oil		ℓ	16		4	2			22
Greas		Kg	4	1	1		1	1	8
Bentonite		Kg	1,475	1,125	925	950	1,250	1,850	7,575
C.M.C		Kg	25	25	13	18	27	40	148
Tel - stop		Kg	35	15	20	20	30	55	175
Sea clay		Kg	10	10	10	20	20	20	90
Cutting oil		ℓ	98	144	126	40	42	90	540
Cement		Kg	20	3	4	3	4	4	38
Diamond bit	NX-ST	Pc	1			1			2
Diamond bit	NQ-WL	Pc	3	3	3	2	3	3	17
Diamond bit	BQ-WL	Pc	2	2	2		2	2	10
Diamond reamer	NQ-WL	Pc	2	1	1	1	1	2	8
Diamond reamer	BQ-WL	Pc	1	1	1		1	1	5
Casing Diamond shoe	NX	Pc	1				1		2
Casing metal shoe	HX	Pc	1		1		1	1	4
Casing metal shoe	BX	Pc	1		1		1	1	4
Tri-cone bit	3 7/8"	Pc	1						1
Core barrel Assy	NQ-WL	set	1					1	2
Core barrel Assy	BQ-WL	set	1					1	2
Inner tube	NQ-WL	Pc			2		1		3
Inner tube	BQ-WL	Pc		1			2		3
Core lifter case	NQ-WL	Pc	4	4	3	2	2	2	17
Core lifter case	BQ-WL	Pc	2	2	2		2	2	10
Core lifter	NQ-WL	Pc	4	4	4	2	4	4	22
Core lifter	BQ-WL	Pc	4	2	4		4	2	16
Thrust ball bearing	NQ-WL	Pc	2		4	4	2	2	14
Thrust ball bearing	BQ-WL	Pc		2			4	4	10
Innertube stabilizer	NQ-WL	Pc	2	1	1	1	1	2	8
Innertube stabilizer	BQ-WL	Pc	1	1	1		1	1	5
Chack piece	NQ	ste	1		1			1	3
Chack piece	BQ	ste	1					1	2
Cylinder liner	MG-10 68 mm	Pc			2				2
Piston rod		Pc			2		2		4
Piston rubber	68 mm	Pc		4			4	4	12
Valve seat		Pc			8				8
Steel ball		Pc			8				8
V - packing		Pc			14		14		28
Waste		Kg	10	8	6	4	6	6	40
Wire rope	6 mm x 300 m	roll	1					1	2
Core box		Pc	23	24	20	16	21	20	124
Core box		Pc	14	14	14		14	14	70
Engine oil		ℓ	12	16	18	6	16	24	92

and dismantling were principally on a basis of one shift a day.

A drilling crew consists a Japanese technician and three local workers per shift. In addition to this, 4 to 6 persons in a morning shift and 2 persons in a second shift were consistently employed for a maintenance of water supply. In case of moving from site to site, local helpers ranged from 15 to 20 peoples.

Operation records are listed in Table 12, drilling records of each holes are given in Tables 13 to 18. The results of drilling performance are shown in Tables 19 to 24, and progress records in Figs. 44 to 49. The average drilling speed over all holes is 9.54m per shift and an overall core recovery stands at 98.2%.

2-4 Mobilization

The machinaries, tools, equipments, drilling muds and other materials were shipped from Yokohama on 9th June, 1985 and landed at Durban, South Africa on 6th July. These were transported by trailor trucks over a distance of some 2,000km from the port to Lusaka via Zimbabwe. After customs clearance in Lusaka on 20th August, all cargos were further transported by trailor trucks for another 200 km more or less to a base camp at Bob Zinc and unloaded by fork-lifts.

Table 12 Working Time Analysis of the Drilling Operation

Hole No.	Bit size	Drilling: Drilling	Drilling: Core length	Shift: Drilling	Shift: Total	Working man: Engineer	Working man: Worker	Working Time: Drilling	Working Time: Other working	Working Time: Recove-ring	Working Time: Total	Working Time: Removing	Working Time: Road con-struction and others	G.Total
		m	m	shift	shift	man	man	h	h	h	h	h	h	h
MJZ-1	NX	14.10	2.50	2	20	56	215	6°00'	9°30'	-	15°30'	25°30'	122°00'	163°00'
	NQ	106.00	103.50	14	15	15	94	56°20'	54°40'	7°50'	118°50'	-	-	118°50'
	BQ	80.90	80.90	10	13	16	84	47°00'	48°40'	1°00'	96°40'	10°00'	-	106°40'
	Total	201.00	186.90	26	48	87	393	109°20'	112°50'	8°50'	231°00'	35°30'	122°00'	388°30'
MJZ-2	NX	3.10	-	0.5	2.5	4	39	1°00'	1°50'	-	2°50'	17°00'	-	19°50'
	NQ	117.00	104.40	9.5	9.5	9	72	54°50'	21°20'	-	76°10'	-	-	76°10'
	BQ	80.90	78.60	5	7	8	58	33°00'	17°30'	-	50°30'	8°00'	-	58°30'
	Total	201.00	183.00	15	19	21	169	88°50'	40°40'	-	129°30'	25°00'	-	154°30'
MJZ-3	NX	9.10	-	1	9	16	113	3°00'	4°20'	-	7°20'	40°00'	24°00'	71°20'
	NQ	111.00	89.70	11	11	11	86	51°40'	37°00'	-	88°40'	-	-	88°40'
	BQ	80.90	80.90	6	8	9	78	36°00'	17°00'	-	53°00'	11°00'	-	64°00'
	Total	201.00	170.60	18	28	36	277	90°40'	58°20'	-	149°00'	51°00'	24°00'	224°30'
MJZ-4	NX	6.10	-	1	4	10	70	2°00'	6°00'	-	8°00'	27°00'	-	35°00'
	NQ	95.90	85.90	12	13	14	95	63°40'	30°50'	2°30'	97°00'	7°00'	-	104°00'
	Total	102.00	85.90	13	17	24	165	65°40'	36°50'	2°30'	105°00'	34°00'	-	139°00'
MJZ-5	NX	6.10	-	1	3	7	44	1°20'	2°40'	-	4°00'	22°00'	-	26°00'
	NQ	115.00	95.70	13	13	13	89	60°20'	40°30'	3°10'	104°00'	-	-	104°00'
	BQ	79.90	79.90	9	13	22	123	40°50'	31°10'	-	72°00'	36°00'	-	108°00'
	Total	201.00	175.60	23	29	42	256	102°30'	74°20'	3°10'	180°00'	58°00'	-	238°00'
MJZ-6	NX	6.10	-	1	5	13	77	2°30'	3°30'	-	6°00'	30°00'	8°00'	44°00'
	NQ	114.00	96.80	12	13	13	97	59°00'	43°30'	1°30'	104°00'	-	-	104°00'
	BQ	80.90	79.50	8	9	10	74	43°10	22°50'	-	66°00'	8°00'	-	74°00'
	Total	201.00	176.30	21	27	36	248	104°40'	69°50'	1°30'	176°00'	38°00'	8°00'	222°00'
Grand Total		1,107.00	978.30	116	168	246	1,508	561°40'	392°50'	16°00'	970°30'	241°30'	154°00'	1,366°00'

Table 13 Record of the Drilling Operation on MJZ-1

	Drilling length			Total		Shift		Working man	
	Shift. 1	Shift. 2	Shift. 3	Drilling	Core length	Drilling	Total	Engineer	Worker
August	m	m	m	m	m	shift	Shift	man	man
4	Pds.								
5	Pds.								
6	Pds.								
7	Pds.								
8	Pds.								
9	Pds.								
10	Pds.						7	21	77
11	Pds.								
12	Pds.								
13	Pds.								
14	Pds.								
15	Pds.								
16	Day off								
17	Pds.						6	18	60
18	Day off								
19	Pds.								
20	Pds.								
21	Reassemb.								
22	Reassemb.								
23	Reassemb.								
24	9.10	7.40	4.80	21.30	8.40	3	8	18	81
25	4.10	6.10	6.00	16.20	15.20				
26	Stop-wat.	8.20	9.80	18.00	18.00				
27	8.50	6.50	8.90	23.90	23.70				
28	9.10	9.00	9.00	27.10	27.10				
29	9.00	4.60	4.30	17.90	17.90				
30	9.00	9.00	9.00	27.00	27.00				
31	6.00	9.00	9.00	24.00	24.00	20	21	21	121
September									
1	9.00	9.00	7.60	25.60	25.60				
2	Out-C.P	Out-C.P Dismant.							
3	Dismant.					3	6	9	54
Total	63.80	68.80	68.40	201.00	186.90	26	48	87	393

Abbreviation

Pds.	Preparation for drilling site	Dismant.	Dismantlement
Transpor.	Transportation	Out-C.P.	Taking out casing pipe
Reassemb.	Reassemblage	Stop-wat.	Stopping water leakage
		Road-con.	Road construction

Table 14 Record of the Drilling Operation on MJZ-2

	Drilling length			Total		Shift		Working man	
	Shift. 1	Shift. 2	Shift. 3	Drilling	Core length	Drilling	Total	Engineer	Worker
September	m	m	m	m	m	shift	shift	man	man
4	Reassemb.	Reassemb.							
5	10.50	12.00	15.00	37.50	21.80				
6	15.00	13.50	13.50	42.00	42.00				
7	12.00	14.50	12.50	39.00	39.00	9	11	12	99
8	4.60	15.00	15.80	35.40	35.40				
9	17.20	15.00	14.90	47.10	44.80				
10	Out-C.P	Dismant.				6	8	9	70
Total	59.30	70.00	71.70	201.00	183.00	15	19	21	169

Table 15 Record of the Drilling Operation on MJZ-3

	Drilling length			Total		Shift		Working man	
	Shift. 1	Shift. 2	Shift. 3	Drilling	Core length	Drilling	Total	Engineer	Worker
September	m	m	m	m	m	shift	shift	man	man
11	Pds.								
12	Pds.								
13	Road-con.	Transpor.							
14	Reassemb.	Reassemb.					6	12	73
15	Reassemb.	Reassemb.							
16	12.50	8.00	6.60	27.10	-				
17	2.00	8.40	15.00	25.40	22.10				
18	9.00	13.50	12.00	34.50	34.50				
19	15.00	10.50	7.60	33.10	33.10				
20	13.30	15.00	15.00	43.30	43.30				
21	13.50	13.50	10.60	37.60	37.60	18	20	21	179
22	Out-C.P	Dismant.					2	3	25
Total	65.30	68.90	66.80	201.00	170.60	18	28	36	277

Table 16 Record of the Drilling Operation on MJZ-4

	Drilling length			Total		Shift		Working man	
	Shift.1	Shift.2	Shift.3	Drilling	Core length	Drilling	Total	Engineer	Worker
October	m	m	m	m	m	shift	shift	man	man
5	Transpor.						1	3	21
6	Reassemb.								
7	Reassemb.								
8	6.10	9.20	4.20	19.50	4.50				
9	9.00	7.50	9.50	26.00	24.90				
10	7.80	7.20	7.50	22.50	22.50				
11	9.00	9.00	8.50	26.50	26.50				
12	7.50	Out-C.P Dismant.		7.50	7.50	13	16	21	144
Total	39.40	32.90	29.70	102.00	85.90	13	17	24	165

Table 17 Record of the Drilling Operation on MJZ-5

	Drilling length			Total		Shift		Working man	
	Shift.1	Shift.2	Shift.3	Drilling	Core length	Drilling	Total	Engineer	Worker
October	m	m	m	m	m	shift	shift	man	man
13	Reassemb.								
14	Reassemb.								
15	6.10	8.90	7.50	22.50	-				
16	6.00	9.00	11.00	26.00	24.70				
17	10.00	9.00	9.50	28.50	28.50				
18	8.50	12.00	9.00	29.50	28.40				
19	6.00	8.60	6.30	20.90	20.40	15	17	21	136
20	12.00	10.50	10.50	33.00	33.00				
21	9.00	11.00	10.50	30.50	30.50				
22	8.50	1.60		10.10	10.10				
23	Dismant.								
24	Transpor.								
25	Transpor.								
26	Transpor.					8	12	21	120
Total	66.10	70.60	64.30	201.00	175.60	23	29	42	256

Table 18 Record of the Drilling Operation on MJZ-6

	Shift.1	Shift.2	Shift.3	Drilling	Core length	Drilling	Total	Engineer	Worker
September	m	m	m	m	m	shift	shift	man	man
23	Pds.								
24	Transpor.								
25	Reassemb.								
26	Reassemb.								
27	10.50	6.50	4.50	21.50	1.50				
28	Reaming	7.00	9.00	16.00	13.40	5	10	18	110
29	9.00	12.00	12.00	33.00	32.80				
30	8.90	9.10	12.00	30.00	29.50				
October									
1	12.00	7.60	4.30	23.90	23.90				
2	11.00	10.00	12.00	33.00	31.60				
3	13.50	13.50	13.00	39.00	39.00				
4	4.60	Dismant.		4.60	4.60	16	17	18	138
Total	69.50	65.70	65.80	201.00	176.30	21	27	36	248

Table 19 Summary of the Drilling Operation on MJZ-1

		Survey Period				Total man day	
		Period	days	work day	off day	Engineer	worker
Operation	Preparation	4.8.1985 ∿ 23.8.1985	20	days 18	days 2	man 54	man 205
	Drilling	24.8.1985 ∿ 1.9.1985	9	drilling 9	0	27	160
				recovering 0	0	0	0
	Removing	2.9.1985∿3.9.1985	2	2	0	6	28
	Total	4.8.1985∿3.9.1985	31	29	2	87	393

Drilling length	Length planned	100.00 m	Surface soil Overburden Quaternary	11.50 m
	Increase or Decrease in length	100.00 m	Core length	186.90 m
	Length drilled	201.00 m	Core recovery	98.6 %

Core recovery of 100 m hole

Depth of hole (m)	core recovery (%)	core recovery cumulated (%)
0 ∿ 100	97.1	
100 ∿ 201	100	98.6

			h	%	%
Wrking hours	Drilling		109°20'	47.3	28.1
	Other working		112°50'	48.9	29.0
	Recovering		8°50'	3.8	2.3
	Total		231°00'	100	59.4
		Reassemblage	25°30'		6.6
		Dismantlement	10°00'		2.6
	Water transportation		(138°00')		
	Road construction and others		122°00'		31.4
	G. Total		388°30'		100

Efficiency of Drilling

Total m/work period(m/day)	201.00m/9 days (22.33 m/day)
Total m/total shift(m/shift)	201.00m/26shifts (7.73m/shift)

Drilling length/bit (each sized bit)

Bit size	NX	NQ	BQ
Drilled length	14.10	106.00	80.90
Core length	2.50	103.50	80.90

	Size	meterage (m)	meterage / drilling length × 100 (%)	Recovery (%)
Casing pipe inserted	HX	9.10	4.5	100
	NX	25.40	12.6	100
	BX	120.10	60.0	100

Table 20 Summary of the Drilling Operation on MJZ-2

		Survey Period				Total man day	
		Period	days	work day	off day	Engineer	worker
Operation	Preparation	4.9.1985 ∿ 4.9.1985	1	days 1	days 0	man 3	man 29
	Drilling	5.9.1985 ∿ 9.9.1985	5	drilling 5	0	15	123
				recovering 0	0	0	0
	Removing	10.9.1985∿10.9.1985	1	1	0	3	18
	Total	4.9.1985∿10.9.1985	7	7	0	21	168

Drilling length				
Length planned	100.00 m	Surface soil Overburden Quaternary	14.00 m
Increase or Decrease in length	100.00 m	Core length	183.00 m
Length drilled	201.00	Core recovery	97.9 %

Core recovery of 100 m hole

Depth of hole (m)	core recovery (%)	core recovery cumulated (%)
0 ∿ 100	98.0	
100 ∿ 201	98.7	97.9

Working hours	h	%	%
Drilling	88°50'	68.6	57.5
Other working	40°40'	31.4	26.3
Recovering	-	-	-
Total	129°30'	100	83.8
Reassemblage	17°00		11.0
Dismantlement	8°00'		5.2
Water transportation	(75°00')		-
Road construction and others	-		-
G. Total	154°30'		100

Efficiency of Drilling

Total m/work period(m/day)	201.00 m/5 days (40.20 m/day)
Total m/total shift(m/shift)	201.00m/15shifts (13.40 m/shift)

Drilling length/bit (each sized bit)

Bit size	NX	NQ	BQ
Drilled length	3.10	117.00	80.90
Core length	-	104.40	78.60

Casing pipe inserted

Size	meterage (m)	meterage / drilling length ×100 (%)	Recovery (%)
HX	1.60	0.8	100
NX	14.10	7.0	100
BX	120.10	60.0	100

Table 21 Summary of the Drilling Operation on MJZ-3

		Survey Period				Total man day	
		Period	days	work day	Off day	Engineer	worker
Operation	Preparation	11.9.1985 ∿ 15.9.1985	5	days 5	days 0	man 15	man 101
	Dilling	16.9.1985 ∿ 21.9.1985	6	drilling 6	0	18	151
				recovering 0	0	0	0
	Removing	22.9.1985 ∿ 22.9.1985	1	1	0	3	25
	Total	11.9.1985 ∿ 22.9.1985	12	12	0	36	277

Drilling length				
	Length planned	100.00 m	Surface soil Overburden Quaternary	27.6 m
	Increase or Decrease in length	100.00 m	Core length	170.60 m
	Length drilled	201.00	Core recovery	98.4 %

Core recovery of 100 m hole

Depth of hole (m)	core recovery (%)	core recovery cumulated (%)
0 ∿ 100	96.1	
100 ∿ 201	100	98.4

Working hours		h	%	%
	Drilling	90°40'	60.9	40.5
	Other working	58°20'	39.1	26.0
	Recovering	-	-	-
	Total	149°00'	100	66.5
	Reassemblage	40°00'		17.9
	Dismantlement	11°00'		4.9
	Water transportation	(87°00')		-
	Road construction and others	24°00'		10.7
	G. Total	224°00'		100

Efficiency of Drilling

Total/work period(m/day)	201.00m/6 days (33.50 m/day)
Total m/total shift(m/shift)	201.00m/18 shifts (11.07m/shift)

Drilling length/bit (each sized bit)

Bit size	NX	NQ	BQ
Drilled length	9.10	111.00	80.90
Core length	-	89.70	80.90

Casing pipe inserted	Size	mterage (m)	meterage / drilling length × 100 (%)	Recovery (%)
	HX	9.10	4.5	100
	NX	29.10	14.5	100
	BX	120.10	60.0	100

Table 22 Summary of the Drilling Operation on MJZ-4

		Survey Period				Ttal man day	
		Period	days	work day	off day	Engineer	worker
Operation	Preparation	5.10.1985∿7.10.1985	3	days 3	days 0	man 9	man 58
	Drilling	8.10.1985∿12.10.1985	4.5	drilling 4.5	0	13	98
				recovering 0	0	0	0
	Removing	12.10.1985∿12.10.1985	0.5	0.5	0	2	9
	Total	5.10.1985∿12.10.1985	8	8	0	24	165

Drilling length	Length planned	m 100.00	Surface soil Overburden Quaternary	m 14.80
	Increase or Decrease in length	m –	Core length	m 85.90
	Length drilled	102.00	Core recovery	% 98.5

Core recovery of 100 m hole		
Depth of hole (m)	core recovery (%)	core recovery cumulated (%)
0 ∿ 102	98.5	98.5
100 ∿ 200		

Working hours	Drilling	h 65°40	% 62.5	% 47.2
	Other working	36°50	35.1	26.5
	Recovering	2°30'	2.4	1.8
	Total	105°00'	100	75.5
	Reassemblage	27°00		19.5
	Dismantlement	7°00		5.0
	Water transportation	(74°00')		–
	Road construction and others	–		–
	G. Total	139°00'		100

Eficiency of Drilling	
Total m/work period(m/day)	102.00m/4.5days (22.67 m/day)
Total m/total shift(m/shift)	102.00m/13shifts (7.85 m/shift)

Drilling length/bit (each sized bit)			
Bit size	NX	NQ	BQ
Drilled length	6.10	95.90	
Core length	–	85.90	

Casing pipe inserted	Size	meterage (m)	$\frac{\text{meterage}}{\text{drilling length}} \times 100$ (%)	Recovery (%)
	HX	6.10	6.0	100
	NX	15.10	14.8	100
	BX			100

Table 23 Summary of the Drilling Operation on MJZ-5

		Survey Period				Total man day	
		Period	days	work day	off day	Engineer	worker
Operation	Preparation	13.10.1985∿14.10.1985	2	days 2	days 0	man 6	man 34
	Drilling	15.10.1985∿22.10.1985	8	drilling 8	0	24	162
				recovering 0	0	0	0
	Removing	23.10.1985∿26.10.1985	4	4	0	12	60
	Total	13.10.1985∿26.10.1985	14	14	0	42	256

Drilling length				
	Length planned	m 100.00	Surface soil Overburden Quaternary	m 23.30
	Increase or Decrease in length	m 100.00	Core length	m 175.60
	Length drilled	201.00	Core recovery	% 98.8

Core recovery of 100 m hole

Depth of hole (m)	core recovery (%)	core recovery (%)
0 ∿ 100	98.0	
100 ∿ 201	99.4	98.8

Working hours		h	%	%
	Drilling	102°30'	56.9	43.1
	Other working	74°20'	41.3	31.2
	Recovering	3°10'	1.8	1.3
	Total	180°00'	100	75.6
	Reassemblage	22°00'		9.3
	Dismantlement	36°00'		15.1
	Water transportation	(135°00')		-
	Road construction and others	-		-
	Total	238°00'		100

Efficiency of Drilling

Total m/work period(m/day)	201.00 m/8 days (25.13 m/day)
Total m/total shift(m/shift)	201.00m/23 shifts (8.74 m/shift)

Drilling length/bit (each sized bit)

Bit size	NX	NQ	BQ
Drilled length	6.10	115.00	79.90
Core length	-	95.70	79.90

Casing pipe inserted	Size	meterage (m)	meterage/drilling length ×100 (%)	Recovery (%)
	HX	6.10	3.0	100
	NX	24.10	12.0	100
	BX	121.10	60.2	100

Table 24 Summary of the Drilling Operation on MJZ-6

		Survey Period				Total man day	
		Period	days	work day	off day	Engineer	worker
Operation	Preparation	23.9.1985∿26.9. 1985	4	days 4	days 0	man 12	man 65
	Drilling	27.9.1985∿4.10.1985	7.5	drilling 7.5	0	22	175
				recovering 0	0	0	0
	Removing	4.10.1985∿4.10.1985	0.5	0.5	0	2	8
	Total	23.9.1985∿4.10.1985	12	12	0	36	248

Drilling length				
Length planned	200.00 m	Surface soil Overburden Quaternary	20.00 m
Increase or Decrease in length	– m	Core length	176.30 m
Length drilled	201.00	Core recovery	97.4 %

Core recovery of 100 m hole		
Depth of hole (m)	core recovery (%)	core recovery cumulated (%)
0 ∿ 100	95.9	
100 ∿ 200	98.6	97.4

Working hours	h	%	%
Drilling	104°40'	59.5	47.1
Other working	69°50'	39.7	31.5
Recovering	1°30'	0.8	0.7
Total	176°00'	100	79.3
Reassemblage	30°00'		13.5
Dismantlement	8°00'		3.6
Water transportation	(133°00')		–
Road construction and others	8°00'		3.6
G. Total	222°00'		100

Efficiency of Drilling	
Total m/work period (m/day)	201.00 m/7.5 days (26.80 m/day)
Total m/total shift (m/shift)	201.00m/21 shifts (9.57 m/shift)

Drilling length/bit (each sized bit)			
Bit size	NX	NQ	BQ
Drilled length	6.10	114.00	80.90
Core length	–	96.80	79.50

Casing pipe inserted			
Size	meterage (m)	meterage / drillikg length × 100 (%)	Recovery (%)
HX	6.10	3.0	100
NX	21.10	10.5	100
BX	120.10	60.0	100

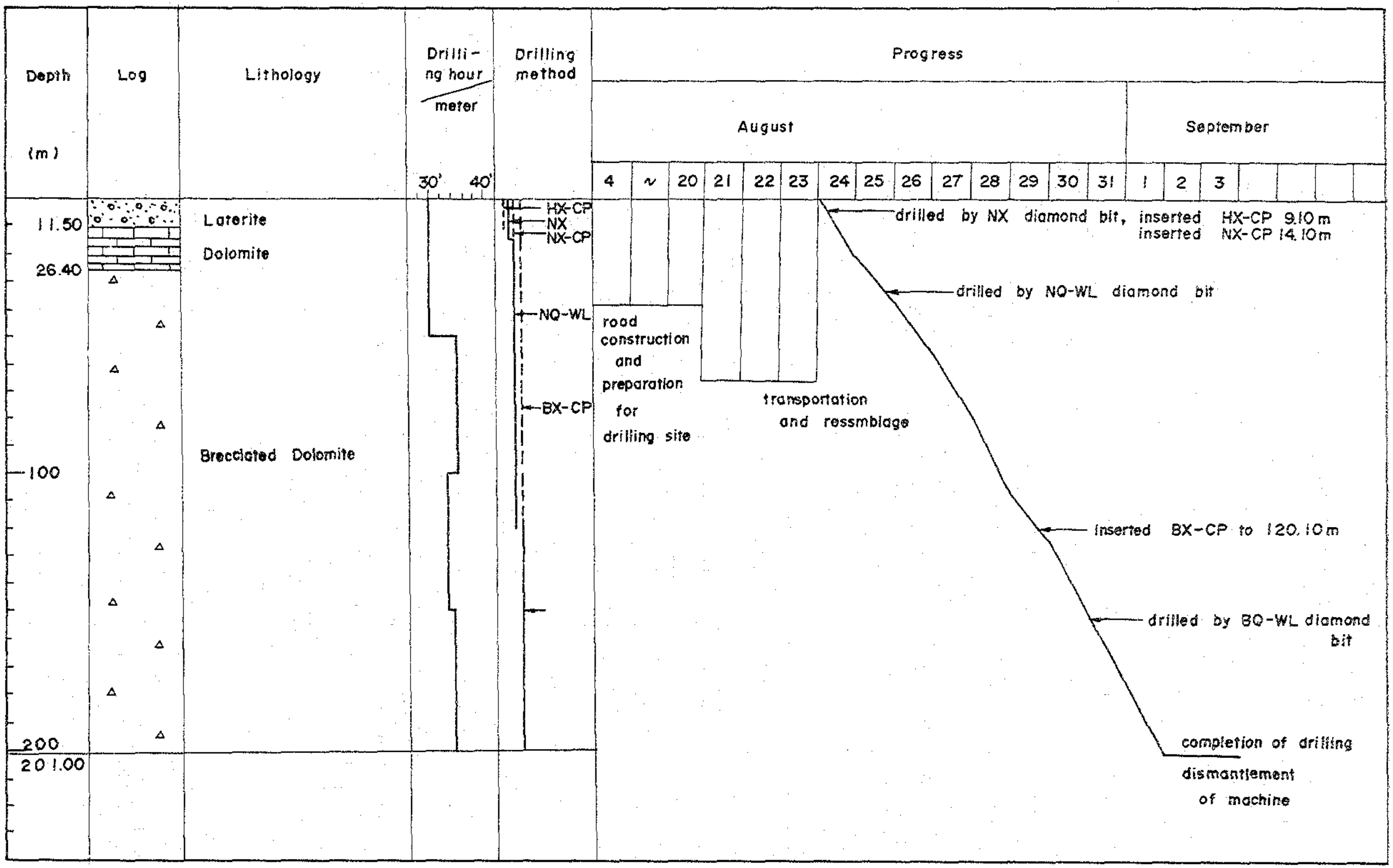


Fig. 44 Drilling Progress on MJZ-1

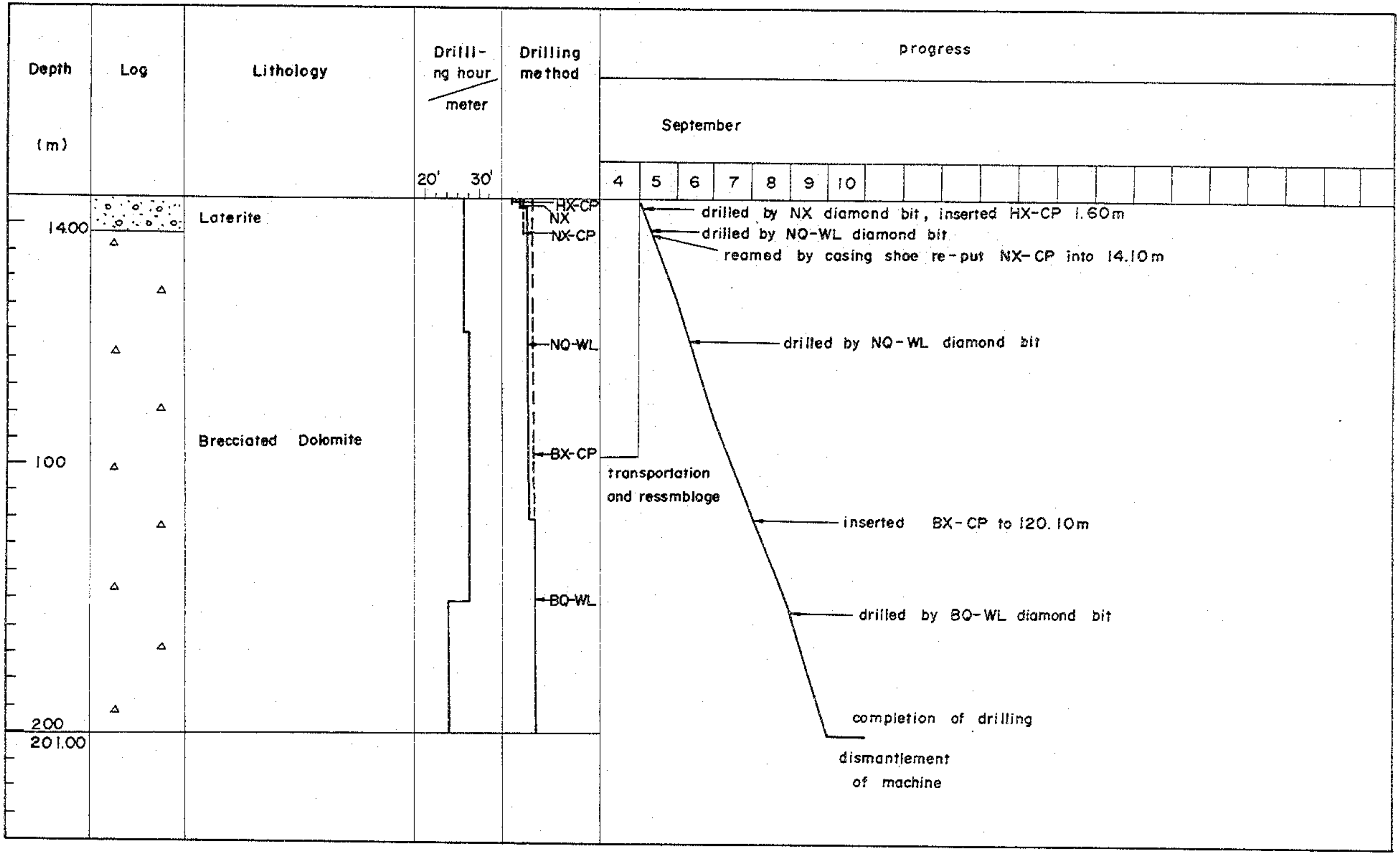


Fig. 45 Drilling Progress on MJZ-2

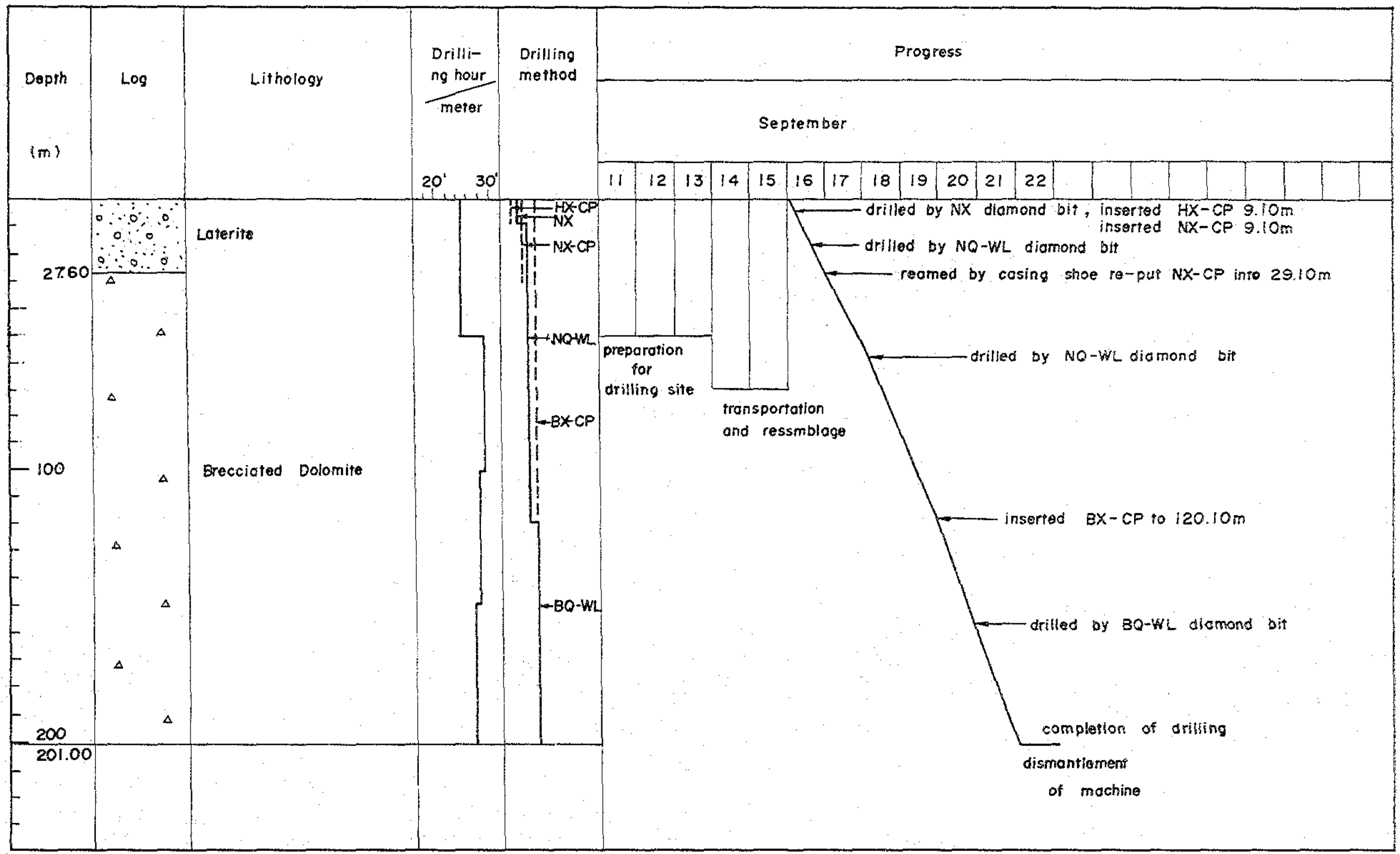


Fig. 46 Drilling Progress on MJZ-3

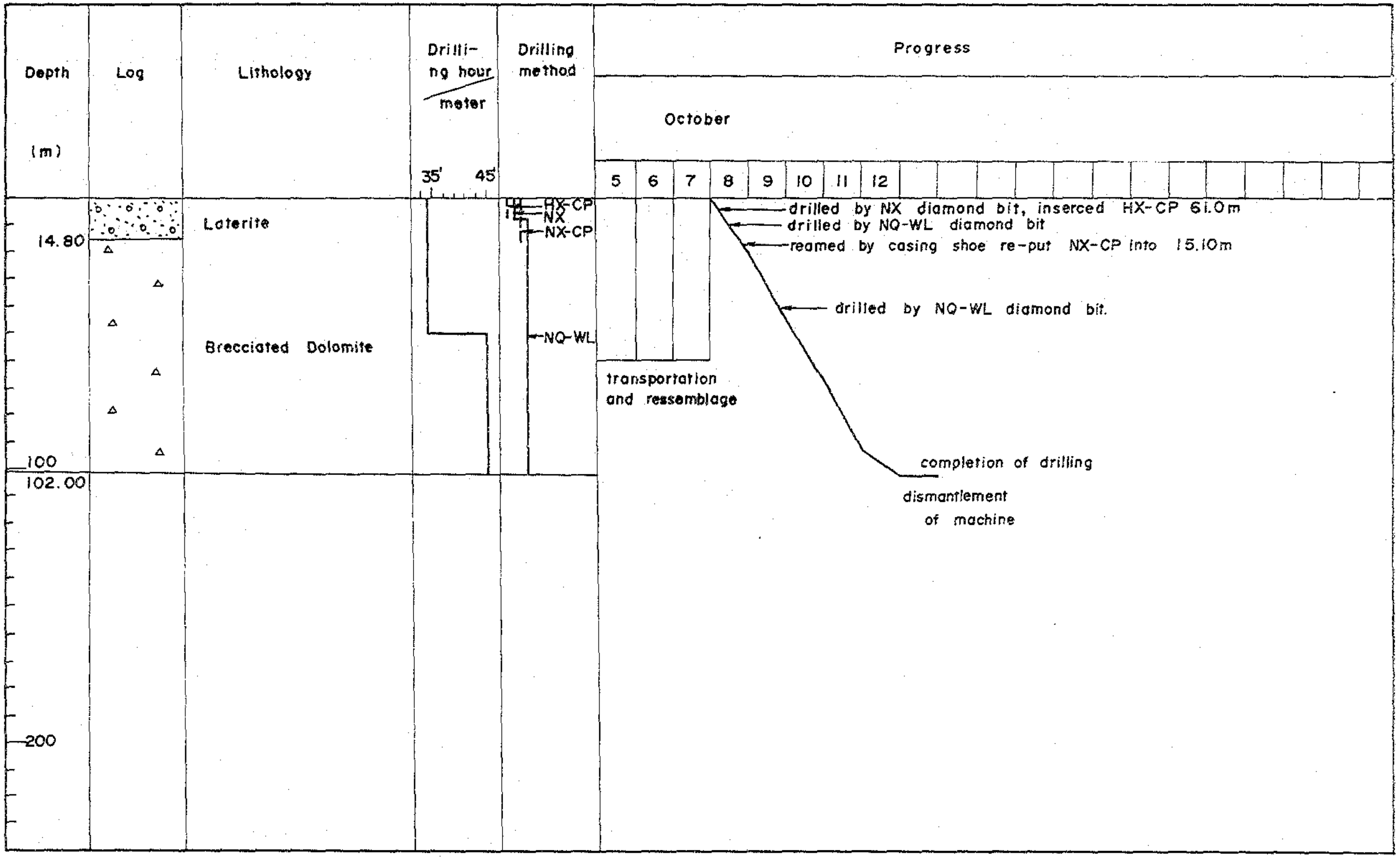


Fig. 47 Drilling Progress on MJZ-4

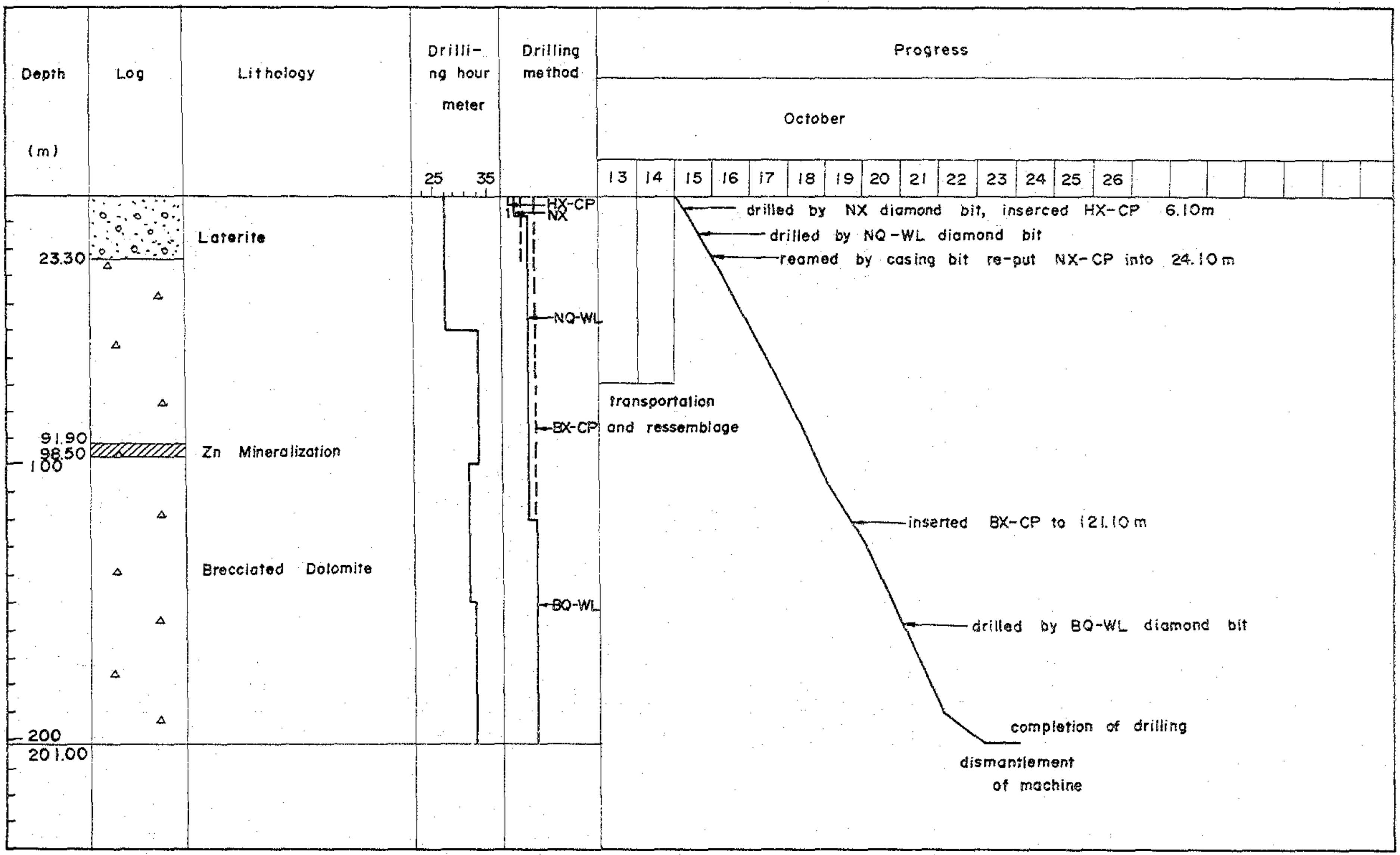


Fig. 48 Drilling Progress on MJZ-5

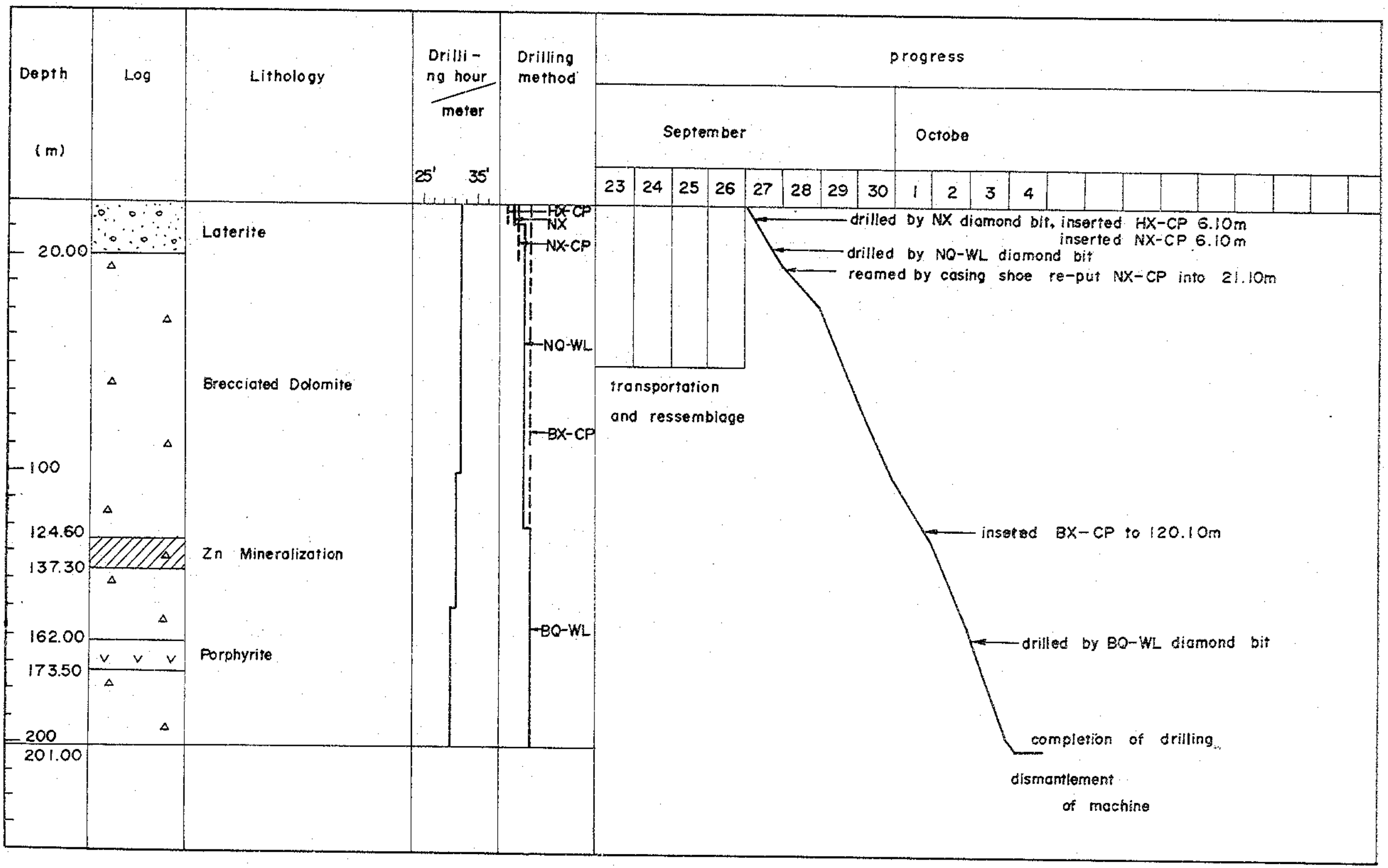


Fig. 49 Drilling Progress on MJZ-6

An access road of a distance of about 1.5km from the Kaindu Road and connecting roads for moving from site to site were provided by clearing trees in the bush. Moving was made by using small trucks and a tractor.

2-5 Drilling Water

Drilling water was pumped up from a water reservoir at the National Service farm near Karenda and moved for a distance of some 17 km to drill sites by two or three small trucks loaded with vinyl tanks of $1.5m^3$ in volume.

2-6 Demobilization

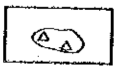
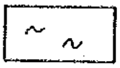
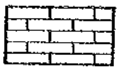
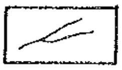
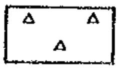
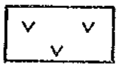
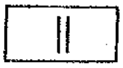
After completion of drilling scheme, a set of equipments and materials was stored in the base camp except specific items such as engines and generators which were carried to Lusaka.

All cores were arranged in a shed at the camp and handed over for care to our counterpart, MINEX.

3. Geology of the Drill Holes and Mineralization

Geological logs of MJZ-1 ∿ MJZ-6 holes are shown in Figs. 50∿55, and the results of chemical analysis of ores, microscopic observation of polished thin sections, EPMA and X-ray diffractive analysis are given in Tables 25∿28.

Legend

	Laterite		Druse
	Dolomite Boulder		Clay
	Massive Dolomite		Veinlet and/or Fracture
	Brecciated Dolomite		Zn Minerals
	Porphyrite		Strong and/or Rich

Abbreviations

Dol	Dolomite	Drs	Druse
Cal	Calcite (Crystal)	Vnt	Veinlet
Cly	Clay	Frc	Fracture
Fe - Ox	Iron Oxides (mainly hematite)	frc	fractured
Lim	Limonite	dec	decomposed
Sid	Siderite (Sideritic Dolomite)	rec	reddish
		grn	greenish
		brw	brownish

R. Q. D   Rock Quality Designation

Drill Hole No.	M J Z − 1	Inclination	−40°
Location	Bob Zinc	Bearing	N 50° W M.N.
Elevation	Approx. 1200 m sl	Term	24 Ang. ~ 1 Sep. '85
Depth	201.0 m	Core Recovery	98.6 %

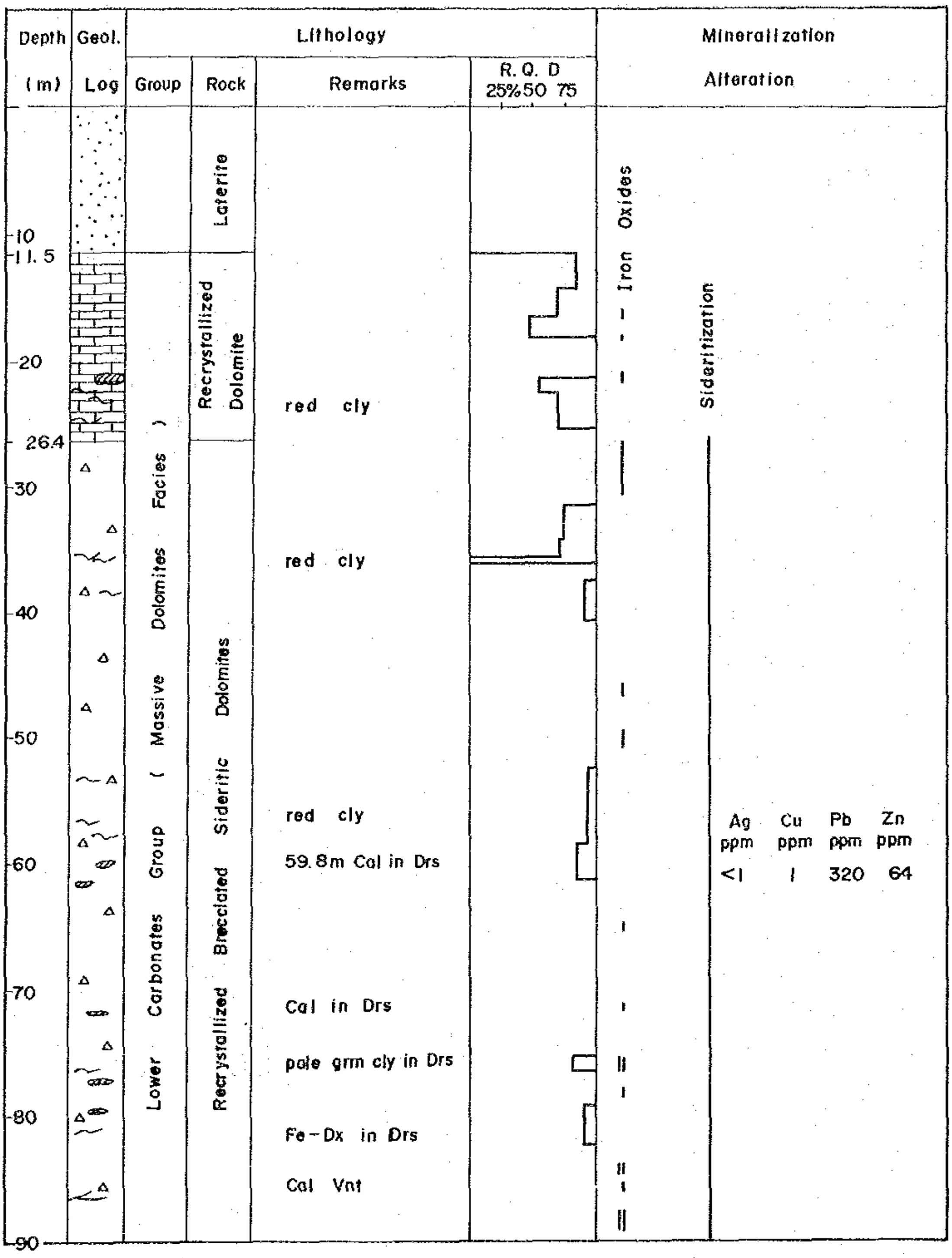


Fig. 50 (a) MJZ-1 Drilling Geological Log

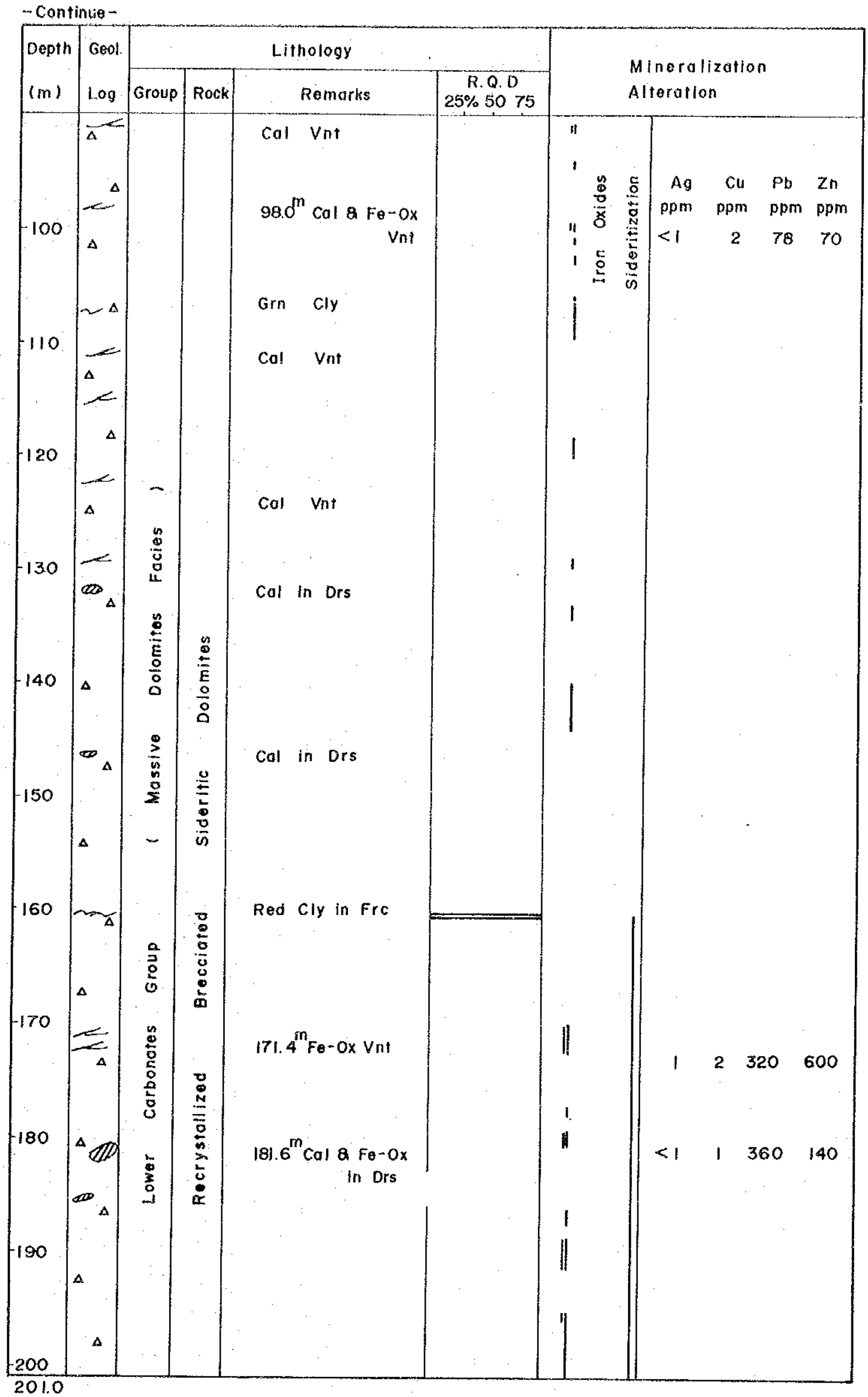


Fig. 50 (b) MJZ-1 Drilling Geological Log

Drill Hole No	MJZ - 2	Inclination	- 45°
Location	Bob Zinc	Bearing	N 32° E M. N.
Elevation	Approx. 1 200m. sl	Term	5 Sep. ~ 9 Sep. '85
Depth	201. 0 m	Core Recovery	97. 9 %

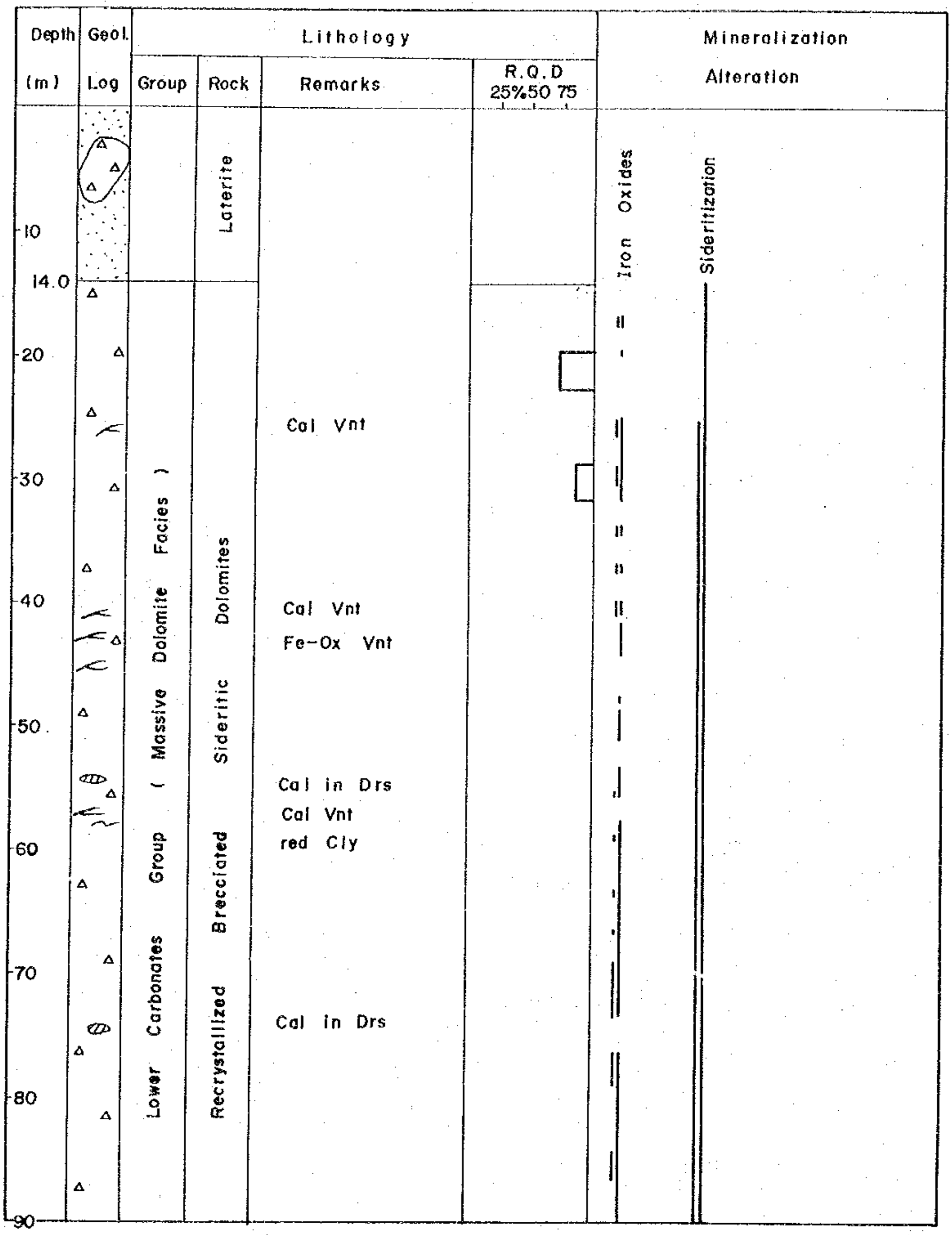


Fig. 51 (a) MJZ-2 Drilling Geological Log

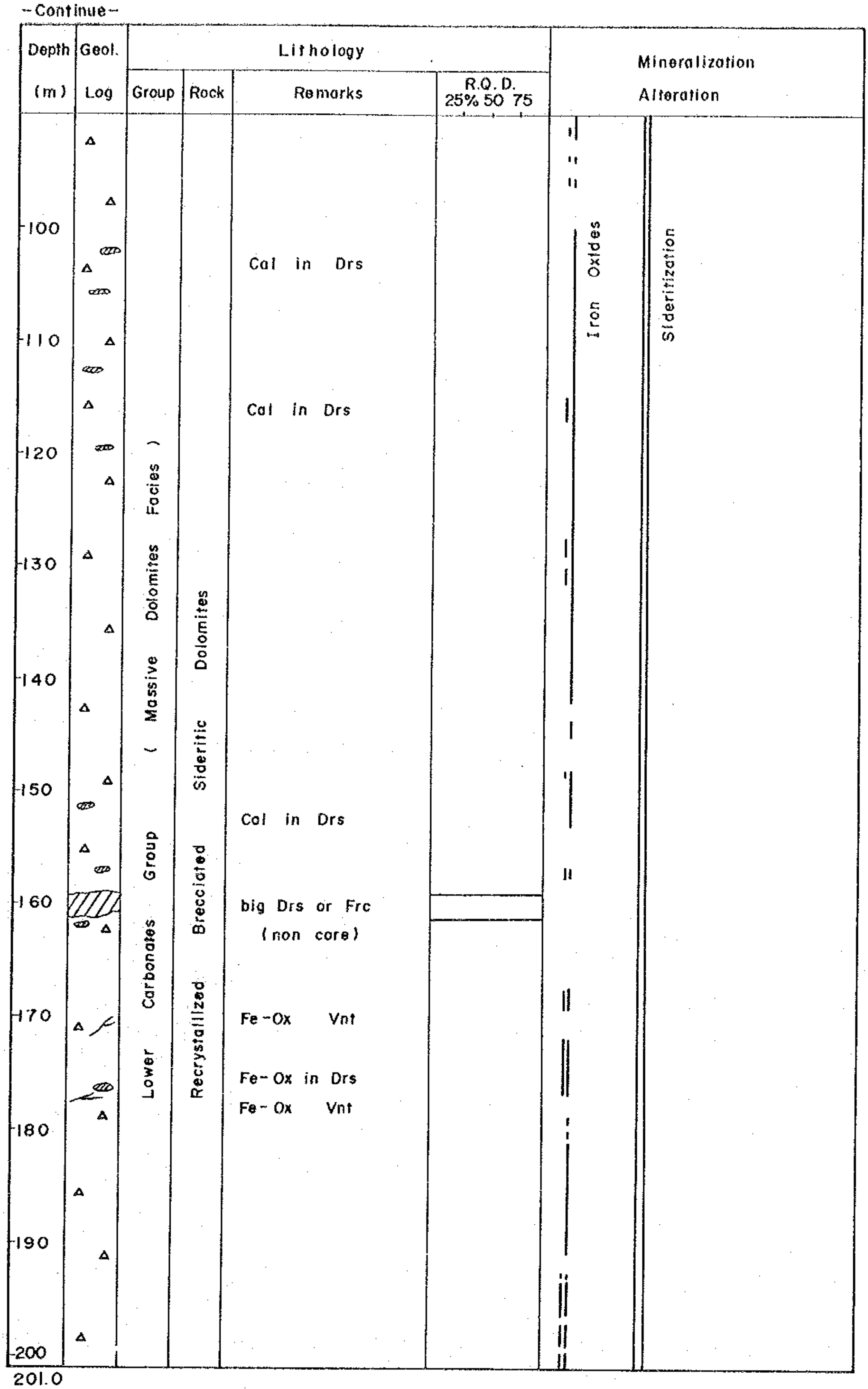


Fig. 51 (b) MJZ-2 Drilling Geological Log

Drill Hole No.	MJZ - 3	Inclination	- 45°
Location	Bob Zinc	Bearing	S 28°E M.N.
Elevation	Approx. 1200 m. sl	Term	16 Sep. ~ 21 Sep. '85
Depth	201.0 m	Core Recovery	98.4 %

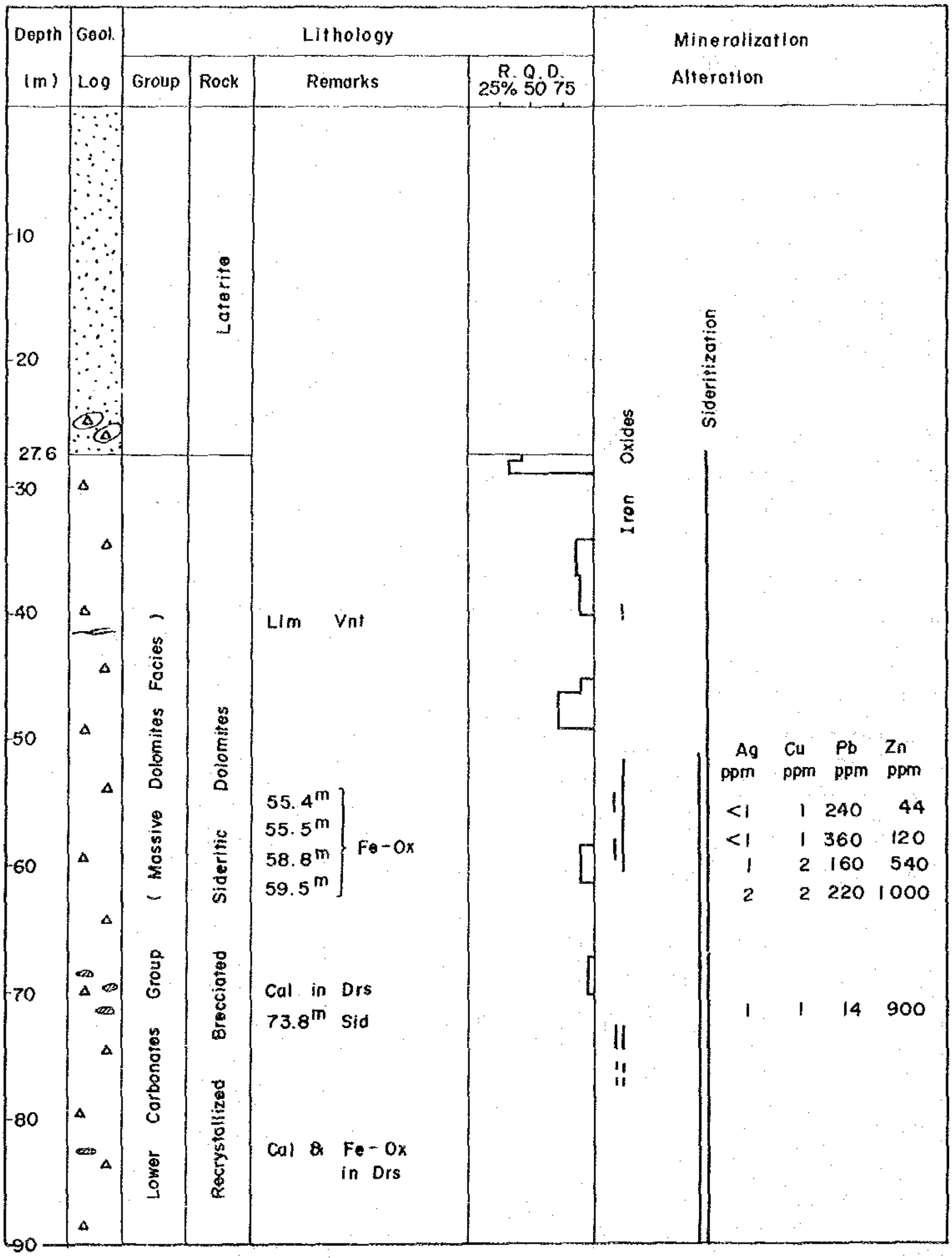


Fig. 52 (a) MJZ-3 Drilling Geological Log

- Continue -

Group: Lower Carbonates Group (Massive Dolomites Facies)

Rock: Recrystallized Brecciated Sideritic Dolomites

Mineralization / Alteration: Iron Oxides, Sideritization

Depth (m)	Remarks	Ag ppm	Cu ppm	Pb ppm	Zn ppm
	Cal in Drs				
	91.8m Fe-Ox	2	2	210	1000
	95.8m Fe-Ox	2	3	60	2000
	95.9m Fe-Ox	2	2	80	2000
100	98.4m Sid	2	20	190	1800
	Cal in Drs				
	109.6m Sid	2	1	76	1000
110	112.3m Fe-Ox	2	1	140	1000
	116.3m Fe Ox & Sid	2	13	40	1200
120	121.3m Sid	1	10	340	7000
	Fe-Ox Vnt				
	Cal in Drs				
130	133.5m Fe-Ox	2	6	240	1400
	Fe-Ox in Frc				
140	142.6m Fe-Ox & Sid	1	2	100	400
	Fe-Ox in Frc				
150	Cal in Drs				
	Cal in Drs	2	48	480	1500
160	160.7m, 160.8m Cal & Fe-Ox in Frc	2	40	340	1000
170	Fe-Ox in Frc				
180	Cly in Frc				
	187.3m Fe-Ox	2	170	440	3400
190	Cal & Fe-Ox in Drs				
	193.7m Sid	1	32	180	500
200					
201.0					

Fig. 52 (b) MJZ-3 Drilling Geological Log

Drill Hole No.	MJZ - 4	Inclination	- 40°
Location	Bob Zinc	Bearing	N 50° W M.N.
Elevation	Approx. 1 200m.sl	Term	8 Oct. ~ 12 Oct. '85
Depth	102.0 m	Core Recovery	98.5 %

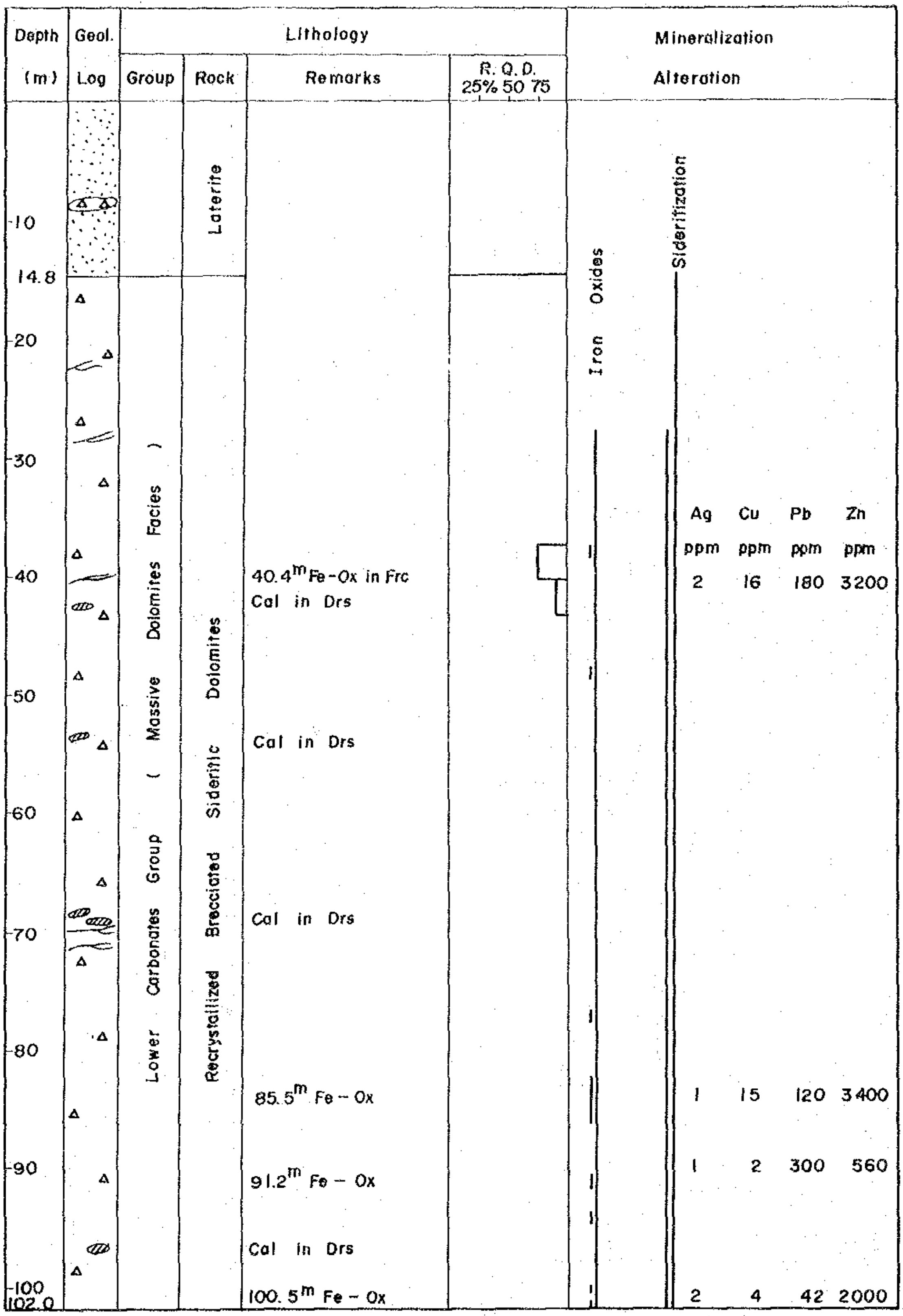


Fig. 53 MJZ-4 Drilling Geological Log

Drill Hole No.	MJZ − 5	Inclination	− 40°
Location	Bob Zinc	Bearing	N 50° W M. N.
Elevation	Approx. 1200m sl	Term	15 Oct. ~ 22 Oct.'85
Depth	201.0 m	Core Recovery	98.8 %

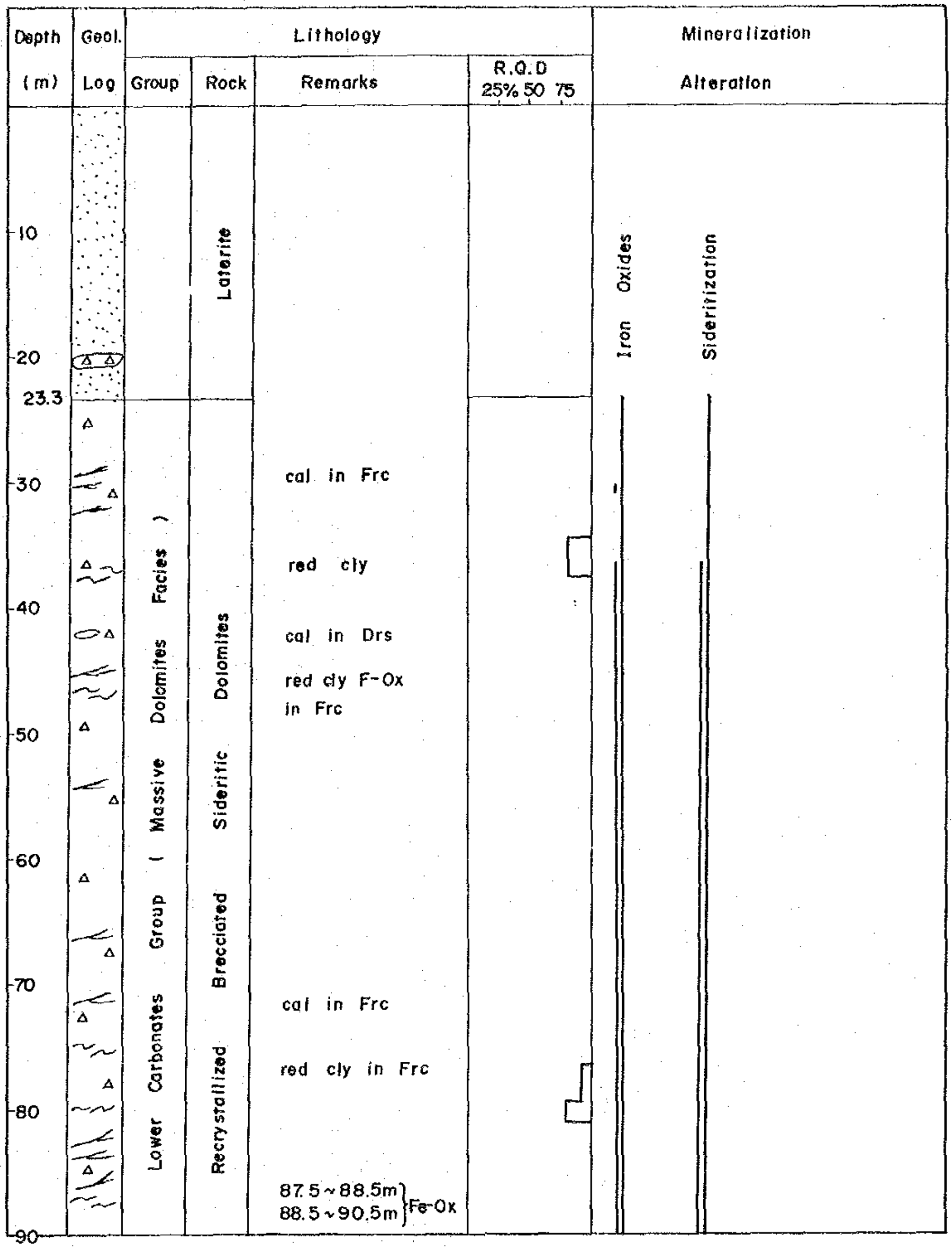
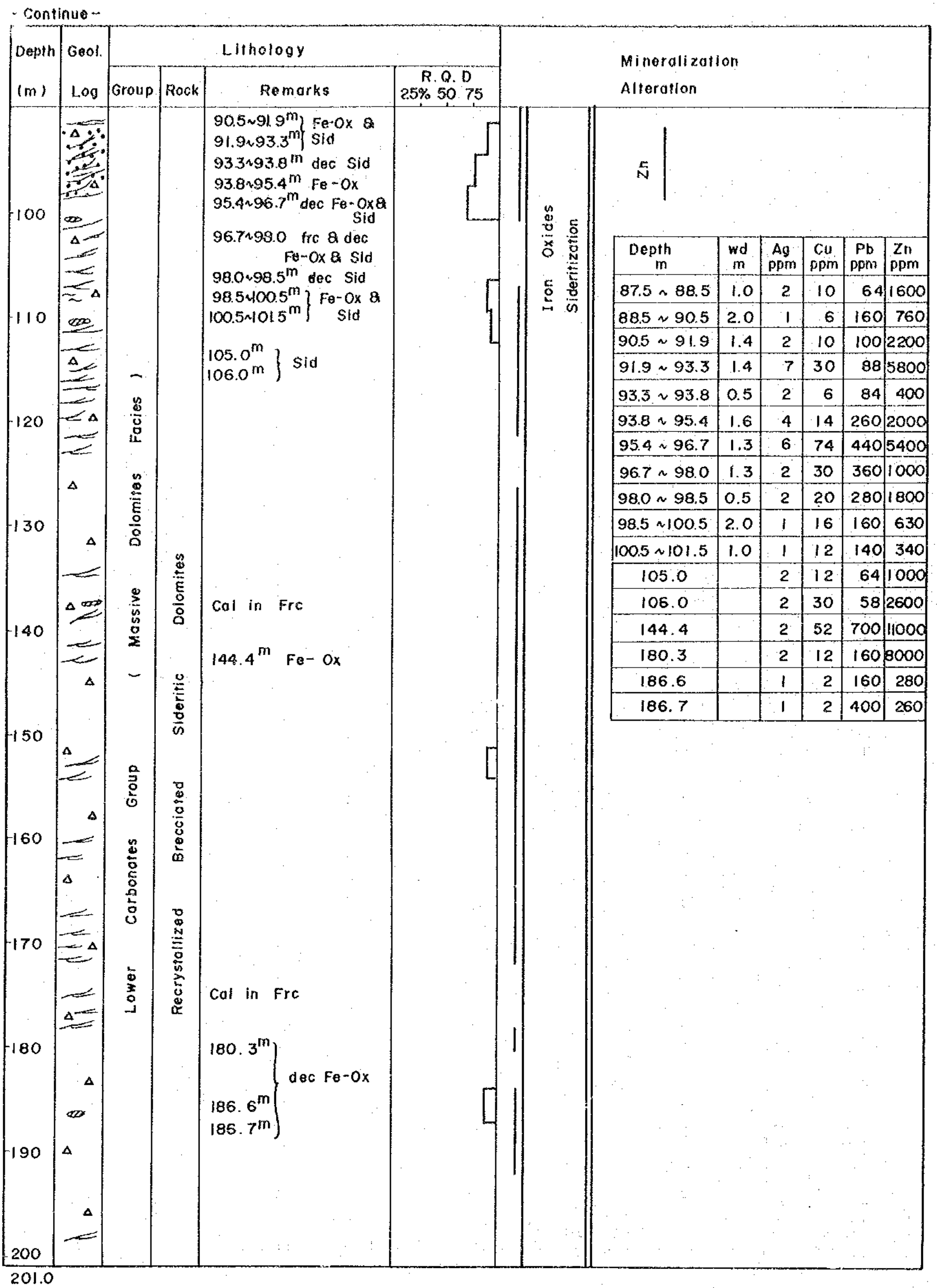


Fig. 54 (a) MJZ-5 Drilling Geological Log



Depth m	wd m	Ag ppm	Cu ppm	Pb ppm	Zn ppm
87.5 ~ 88.5	1.0	2	10	64	1600
88.5 ~ 90.5	2.0	1	6	160	760
90.5 ~ 91.9	1.4	2	10	100	2200
91.9 ~ 93.3	1.4	7	30	88	5800
93.3 ~ 93.8	0.5	2	6	84	400
93.8 ~ 95.4	1.6	4	14	260	2000
95.4 ~ 96.7	1.3	6	74	440	5400
96.7 ~ 98.0	1.3	2	30	360	1000
98.0 ~ 98.5	0.5	2	20	280	1800
98.5 ~100.5	2.0	1	16	160	630
100.5 ~101.5	1.0	1	12	140	340
105.0		2	12	64	1000
106.0		2	30	58	2600
144.4		2	52	700	11000
180.3		2	12	160	8000
186.6		1	2	160	280
186.7		1	2	400	260

Fig. 54 (b) MJZ-5 Drilling Geological Log

Drill Hole No.	M J Z - 6	Inclination	- 45°
Location	Bob Zinc	Bearing	S 84° W M.N.
Elevation	Approx. 1200m sl	Term	27 Sep. ~ 4 Oct.'85
Depth	201.0 m	Core Recovery	97.4 %

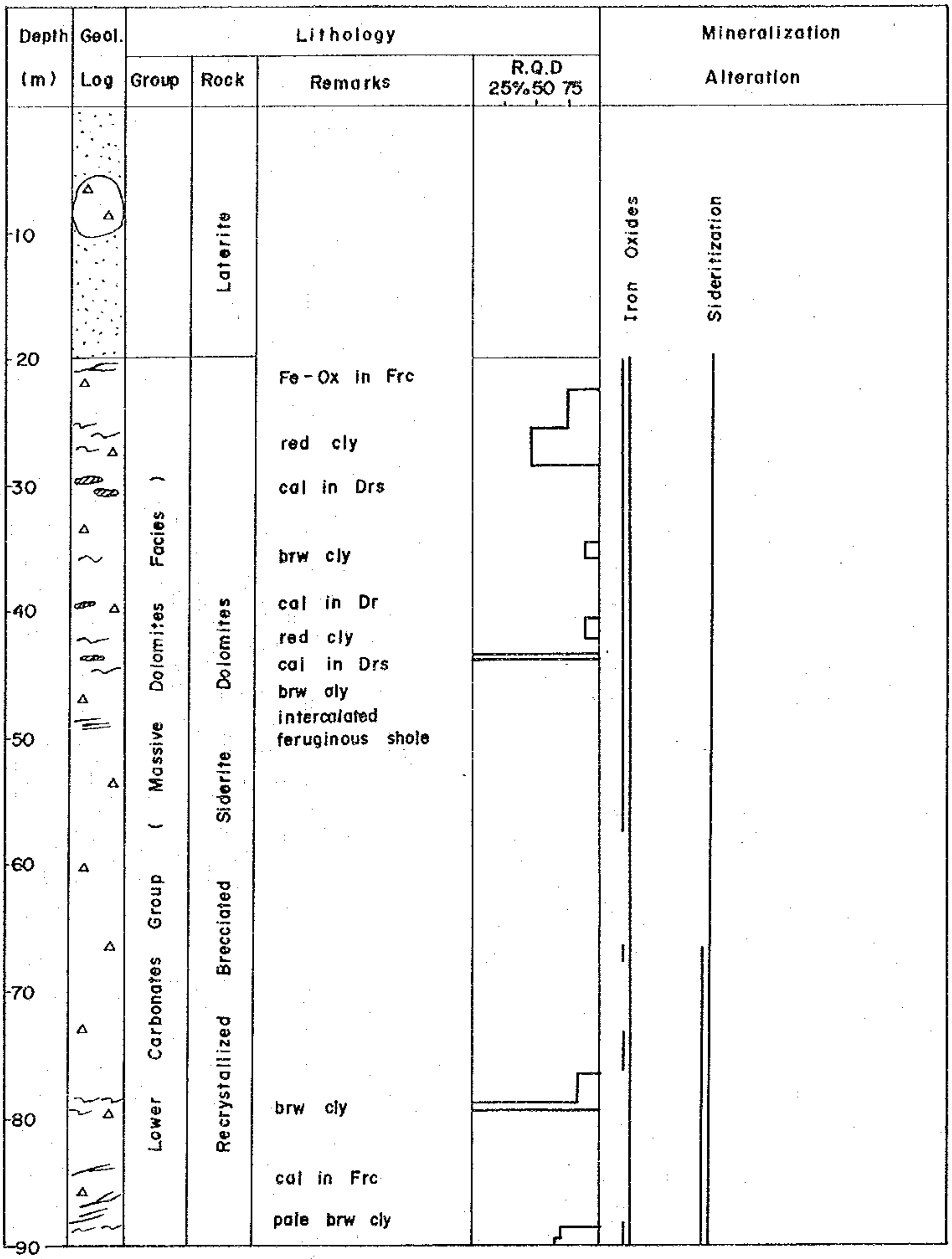
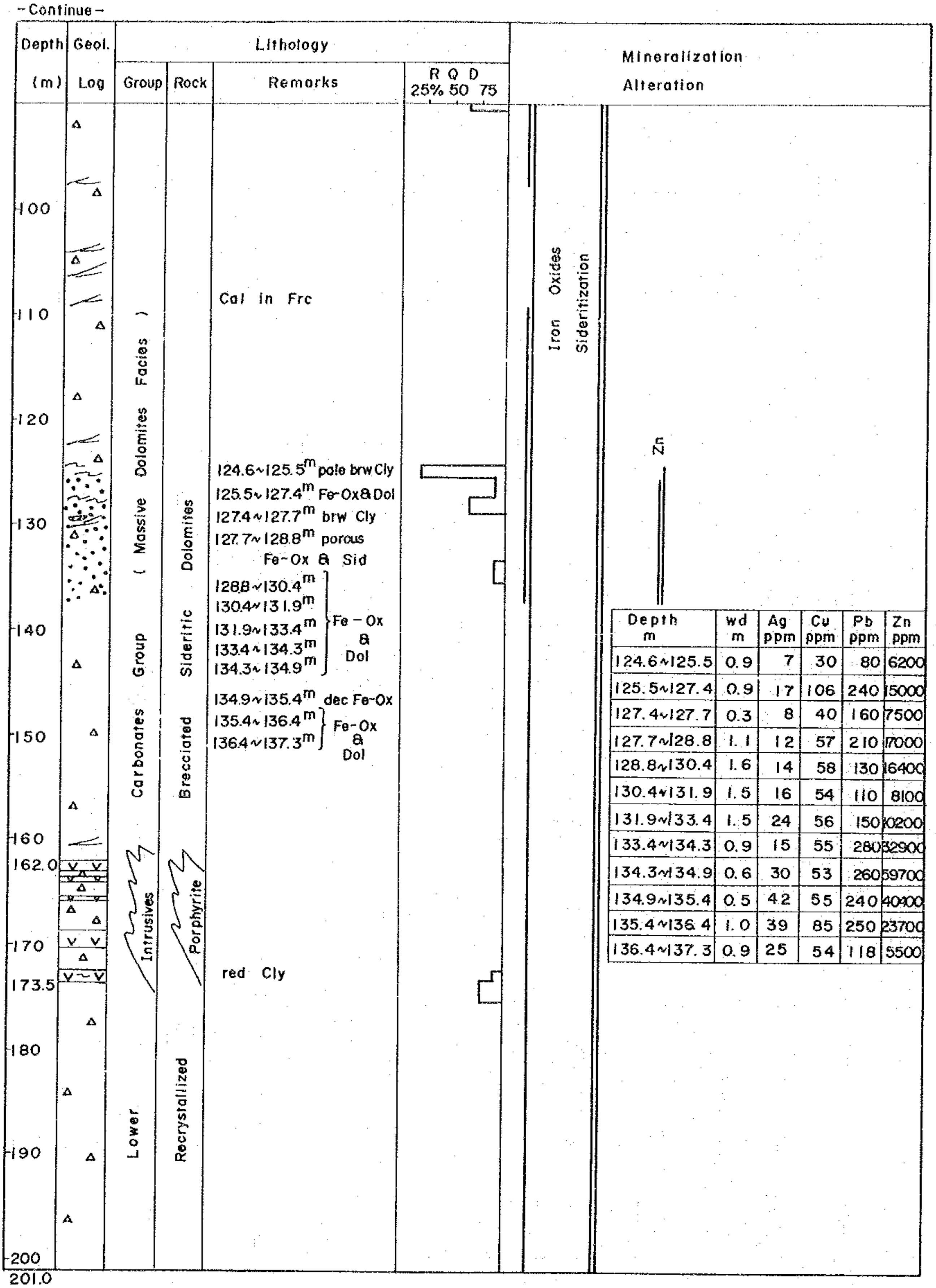


Fig. 55 (a) MJZ-6 Drilling Geological Log



Depth m	wd m	Ag ppm	Cu ppm	Pb ppm	Zn ppm
124.6~125.5	0.9	7	30	80	6200
125.5~127.4	0.9	17	106	240	15000
127.4~127.7	0.3	8	40	160	7500
127.7~128.8	1.1	12	57	210	17000
128.8~130.4	1.6	14	58	130	16400
130.4~131.9	1.5	16	54	110	8100
131.9~133.4	1.5	24	56	150	10200
133.4~134.3	0.9	15	55	280	32900
134.3~134.9	0.6	30	53	260	59700
134.9~135.4	0.5	42	55	240	40400
135.4~136.4	1.0	39	85	250	23700
136.4~137.3	0.9	25	54	118	5500

Fig. 55 (b) MJZ-6 Drilling Geological Log

Table 25 The Results of Chemical Analysis of Ores

No.	Sample Locality	Depth m	Wd m	Ag g/t	Cu ppm	Pb ppm	Zn %	No.	Sample Locality	Depth m	Wd m	Ag g/t	Cu ppm	Pb ppm	Zn %
1	Bob Zinc MJZ-1	59.8		<1	1	320	<0.01	19	Bob Zinc MJZ-3	142.6		1	2	100	0.04
2	"	98.0		<1	1	78	<0.01	20	"	160.7		2	48	480	0.15
3	"	171.4		1	2	320	0.06	21	"	160.8		2	40	340	0.10
4	"	181.6		<1	1	360	0.01	22	"	187.3		2	170	440	0.34
5	Bob Zinc MJZ-3	55.4		<1	1	240	<0.01	23	"	193.7		1	32	180	0.05
6	"	55.5		<1	1	360	0.01	24	Bob Zinc MJZ-4	40.4		2	16	180	0.32
7	"	58.8		1	2	160	0.05	25	"	85.5		1	15	120	0.34
8	"	59.5		2	2	220	0.10	26	"	91.2		1	2	300	0.05
9	"	73.8		1	1	14	0.09	27	"	100.5		2	4	42	0.20
10	"	91.8		2	2	210	0.10	28	Bob Zinc MJZ-5	87.5∿88.5	1.0	2	10	64	0.16
11	"	95.8		2	3	60	0.20	29	"	88.5∿90.5	2.0	1	6	160	0.08
12	"	95.9		2	2	80	0.20	30	"	90.5∿91.9	1.4	2	10	100	0.22
13	"	98.4		2	20	190	0.18	31	"	91.9∿93.3	1.4	7	30	88	0.58
14	"	109.6		2	1	76	0.10	32	"	93.3∿93.8	0.5	2	6	84	0.04
15	"	112.3		2	1	140	0.10	33	"	93.8∿95.4	1.6	4	14	260	0.20
16	"	116.3		2	13	40	0.12	34	"	95.4∿96.7	1.3	6	74	440	0.54
17	"	121.3		1	10	340	0.70	35	"	96.7∿98.0	1.3	2	30	360	0.10
18	"	133.5		2	6	240	0.14	36	"	98.0∿98.5	0.5	2	20	280	0.18

Continue

No.	Sample Locality	Depth m	Wd m	Ag g/t	Cu ppm	Pb ppm	Zn %	No.	Sample Locality	Depth m	Wd m	Ag g/t	Cu ppm	Pb ppm	Zn %
37	Bob Zinc MJZ-5	98.5 100.5	2.0	1	16	160	0.06	56	Bob Zinc MJZ-6	137.2		12	4	72	0.32
38	"	100.5 101.5	1.0	1	12	140	0.03	57	"	124.6~125.5	0.9	7	30	80	0.62
39	"	105.0		2	12	64	0.10	58	"	125.5~127.4	0.9	17	106	240	1.50
40	"	106.0		2	30	58	0.26	59	"	127.4~127.7	0.3	8	40	160	0.75
41	"	144.4		2	52	700	1.10	60	"	127.7~128.8	1.1	12	57	210	1.70
42	"	180.3		2	12	160	0.80	61	"	128.8~130.4	1.6	14	58	130	1.64
43	"	186.6		1	2	160	0.03	62	"	130.4~131.9	1.5	16	54	110	0.81
44	"	186.7		1	2	400	0.03	63	"	131.9~133.4	1.5	24	56	150	1.02
45	Bob Zinc MJZ-6	125.4		7	36	80	0.60	64	"	133.4~134.3	0.9	15	55	280	3.29
46	"	127.3		15	7	180	1.00	65	"	134.3~134.9	0.6	30	53	260	5.97
47	"	127.6		10	46	150	0.64	66	"	134.9~135.4	0.5	42	55	240	4.04
48	"	128.7		22	6	140	8.20	67	"	135.4~136.4	1.0	39	85	250	2.37
49	"	130.3		12	5	90	1.40	68	"	136.4~137.3	0.9	25	54	118	0.55
50	"	131.8		14	4	70	0.90	69	Bob Zinc Surface FB1	Sideritic Dolomite		1	4	420	0.09
51	"	133.3		22	8	130	1.00	70	Kamlyobo Surface FK1	Iron Ore		<1	90	200	<0.01
52	"	134.2		15	4	140	3.00	71	Blue Jacket B-15E Pit	-1.0m Limonitic S.S.		<1	38	6	<0.01
53	"	134.8		30	10	230	5.20	72	Blue Jacket C-13.5 Pit	Surface Iron Ore		<1	240	34	<0.01
54	"	135.3		44	10	230	7.40	73	" " " " "	-1.0m Iron Ore		1	8	16	0.03
55	"	135.8		38	5	140	2.40	74	Sable Antelope C-28.5 Pit	-1.0m Quartz		< 1	10	8	< 0.01

Table 26 The Results of Microscopic Observation of the Polished Thin Sections

No.	Sample	Locality	Kind of Ore (Zn %)	Mineral Constituents: Major and Minor Accessory							Undermined				Remarks
				Ca	Do	He	Go	Qz	Py	Cp	X_1	X_2	X_3	X_4	
1	MJZ-5 92.5 m	Bob Zinc	Zn disseminated Ferrous & Sideritic Dolomite (0.58 %)	◎	◉	++	++	+	+	+	+	+	+	+	1. Relict of "framboidal" pyrite. 2. X_2∿X_4 are included in oolitic clots of dolomite
2	MJZ-5 94.7 m	Ditto	Zn disseminated Ferrous & Calcitic Dolomite (0.20 %)	◉	◎	+++	++	+	+	+	++		+		1. Oolitic clots of dolomite rimmed by iron oxides. 2. X_3 is included in oolitic clots of dolomite. 3. Relict of pyrite framboid.
3	MJZ-5 95.9 m	Ditto	Zn disseminated Ferrous & Sideritic Limestone (0.54 %)	◉	•	+	++	+	+		+			+	1. Oolitic clots of calcite and dolomite rimmed by Fe-oxides. 2. Relict of pyrite framboid.
4	MJZ-5 144.4 m	Ditto	Zn disseminated Ferrous Limestone (1.10 %)	◉	○	++	++	+			+	+			1. Oolitic clots of dolomite rimmed by iron oxides.
5	MJZ-6 128.7 m	Ditto	Zn disseminated Ferrous & Sideritic Limestone (8.20 %)	◉	•	+	++	+	+	+	+	+	+		1. Oolitic clots of calcite and dolomite rimmed by iron oxides. 2. Relict of pyrite framboid
6	MJZ-6 133.3 m	Ditto	Zn disseminated Ferrous Limestone (1.00 %)	◉	•	++	++	+	+	+	+				1. Pelletal∿Oolitic clots of dolomite and calcite rimmed by iron oxides. 2. Relict of pyrite framboid in dolomite clots.
7	MJZ-6 134.2 m	Ditto	Zn disseminated Ferrous Limestone (3.00 %)	◉	○	++	++	+			+	+		+	1. Pelletal∿Oolitic clots of dolomite rimmed by iron oxides.
8	MJZ-6 134.8 m	Ditto	Zn disseminated Ferrous Limestone (5.2 %)	◉	•	+	++	+	+	+	+		+		1. Pelletal∿Oolitic clots of dolomite rimmed by iron oxides. 2. Relict of pyrite framboid.
9	MJZ-6 135.3 m	Ditto	Zn disseminated Ferrous Limestone (7.40 %)	◉	•	+++	++	+	+	+	+		+		1. Pelletal∿Oolitic clots of dolomite rimmed by iron oxides. 2. Relict of pyrite framboid in dolomite clots.
10	MJZ-6 135.8 m	Ditto	Zn disseminated Ferrous Limestone (2.40 %)	◉	•	+	++	+	+		+				1. Oolitic∿Pelletal clots of dolomite rimmed by iron oxides. 2. Relict of pyrite framboid.

Major Essential Components

Ca : Calcite (probably Fe-bearing)
Do : Dolomite (probably Fe-bearing magnesio-dolomite)

◉ ↑ Abundant
◎
○
• ↓ Rare

Minor Accessory Components

He : Hematite
Go : Goethite (including lepidocrocite)
Q : Quartz (including chalcedony)
Py : Pyrite
Cp : Chalco pyrite

+++ ↑ Abundant
++
+ ↓ Rare

Undetermined Minor Phases

X_1 : Clay mineral (probably kaolinite∿illite?, chlorite?)
X_2 : Siderite ?
X_3 : Magnesite (Fe-bearing) ∿ Smithsonite ?
X_4 : Apatite (collophane)?

Table 27 The Results of EPMA (Electron Prove Micro-Analysis)

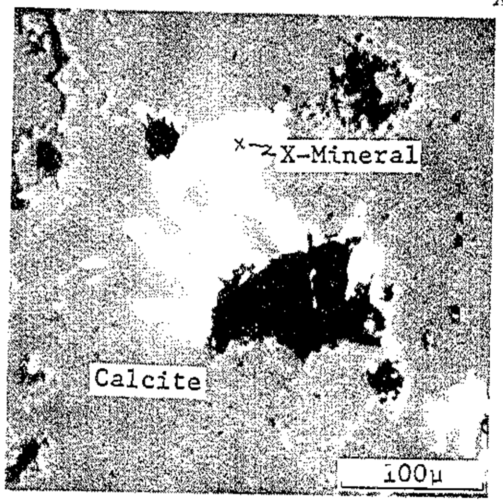
No.	Sample	Kinds of Ore (Zn %)	Analyzed Minerals		
			C	X	Y
1	MJZ-6 128.7 m	Zn disseminated Ferrous & Sideritic Limestone (8.20 %)	o		o
2	MJZ-6 134.8 m	Zn disseminated Ferrous Limestone (5.20 %)	o	o	o
3	MJZ-6 135.3 m	Zn disseminated Ferrous Limestone (7.40 %)	o		o

C : Calcite, (Ca, Fe^{+2}, Mn^{+2}) CO_3

X : Major components ....Zn, Cu
Minor components ....Ca, Fe
Smithsonite (Zn, Cu) CO_3 ?
Rosasite (Zn, $Cu)_2$ $(OH)_2$ CO_3 ?
Aurichalcite(Zn, $Cu)_5$ $(OH)_6$ $(CO_3)_2$?

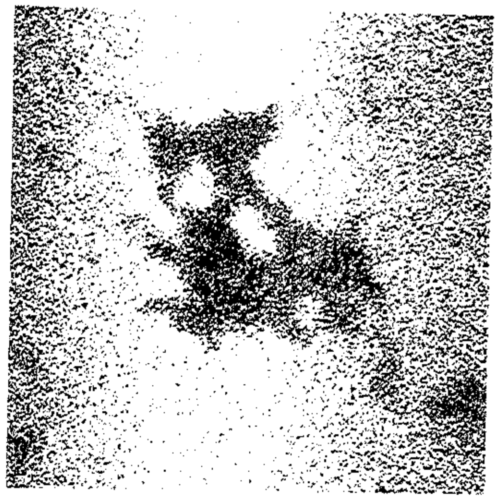
Y : Major components .... Zn, Si
Minor components .... Ca, Fe
Willemite Zn_2SiO_4 ?
Hemimorphite $Zn_4Si_2(OH)_2 \cdot H_2O$?

X - Mineral Image of EPMA



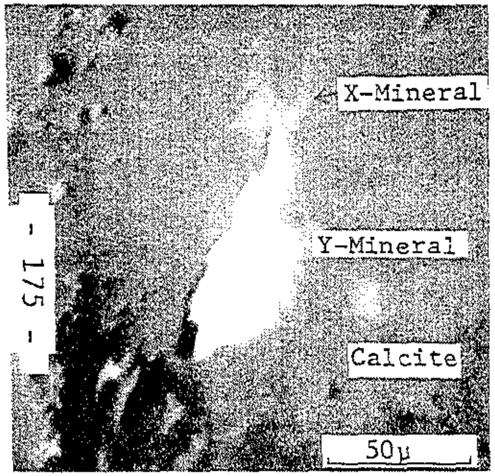
Composition Image


Zn Kα

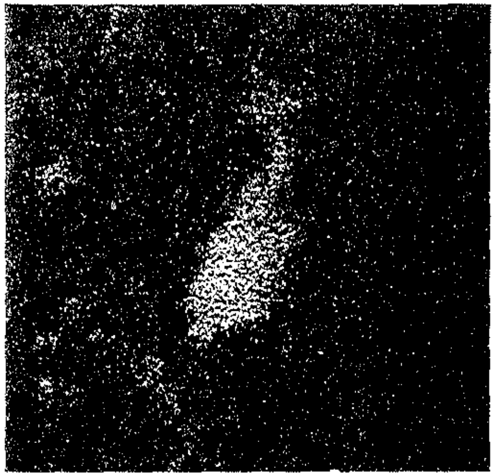

Ca Kα

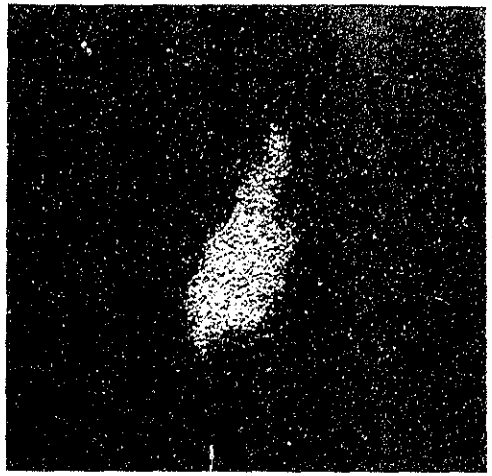
- Continue -

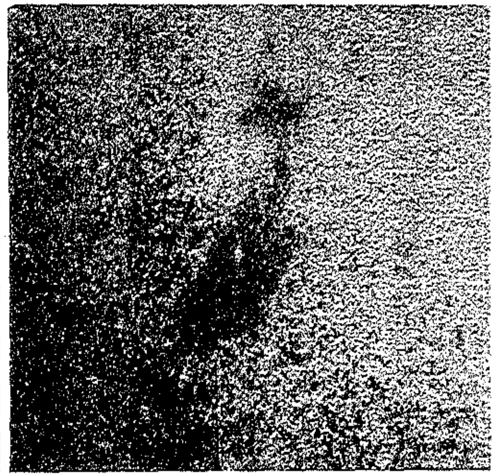
Y - Mineral Image of EPMA



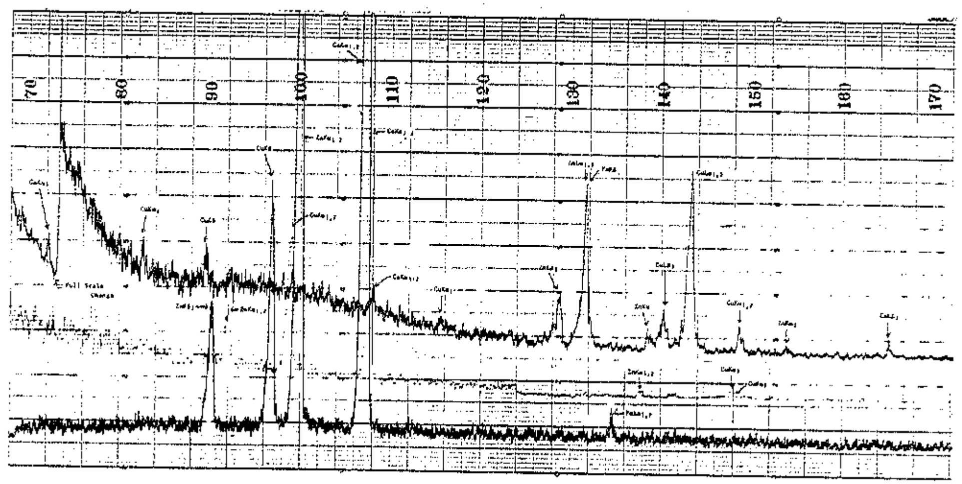
Composition Image


Zn Kα

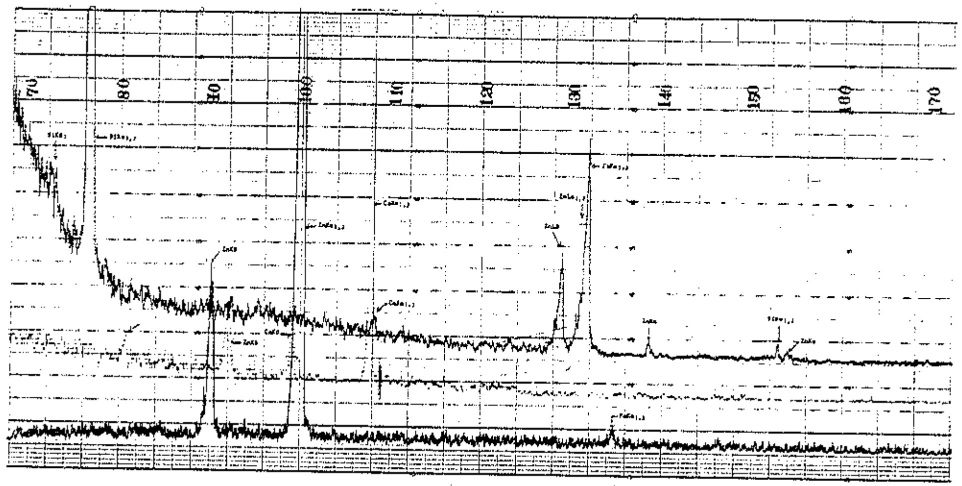

Cu Kα


Ca Kα

- Continue -



X - Mineral



Y - Mineral

Characteristic X-ray Chart

Table 28 The Results of X-ray Diffractive Analysis

No.	Sample	Locality	Kinds of Ore and Rock (Zn %)	Detected Minerals								
				Ca	Do	He	Qz	Chl	Il	K	Sm	Wil
1	MJZ-5 92.5 m	Bob Zinc	Zn disseminated Ferrous & Sideritic Dolomite (0.58 %)	◎	◎	o	o	o	o	•	•?	
2	MJZ-5 94.7 m	Ditto	Zn disseminated Ferrous & Calcitic Dolomite (0.20 %)	◎	◎	o	•				•?	
3	MJZ-5 95.9 m	Ditto	Zn disseminated Ferrous & Sideritic Limestone (0.54 %)	◎		•	•					
4	MJZ-5 144.4 m	Ditto	Zn disseminated Ferrous Limestone (1.10 %)	◎	◎	o						
5	MJZ-6 128.7 m	Ditto	Zn disseminated Ferrous & Sideritic Limestone (8.20 %)	◎			•	o	o	•	•?	◯
6	MJZ-6 130.3 m	Ditto	Zn disseminated Ferrous Limestone (1.40 %)	◎			o	o	o	•	•?	•?
7	MJZ-6 131.8 m	Ditto	Zn disseminated Ferrous Limestone (0.90 %)	◎			o	o	o	•		•?
8	MJZ-6 133.3 m	Ditto	Zn disseminated Ferrous Limestone (1.00 %)	◎		o	o	o	o	•		•?
9	MJZ-6 134.2 m	Ditto	Zn disseminated Ferrous Limestone (3.00 %)	◎	•	o	o	o	o	•		◯
10	MJZ-6 134.8 m	Ditto	Zn disseminated Ferrous Limestone (5.20 %)	◎		•	o	o	o	•	•?	◯
11	MJZ-6 135.3 m	Ditto	Zn disseminated Ferrous Limestone (7.40 %)	◎		o	o	o	•	•		◯
12	MJZ-6 135.8 m	Ditto	Zn disseminated Ferrous Limestone (2.40 %)	◎		•	o	o	o	•		◯

Abbreviation

Ca : Calcite
Do : Dolomite
He : Hematite
Qz : Quartz
Chl: Chlorite
Il : Illite
K : Kaoline mineral
Sm : Smithsonite
Wil: Willemite

◎ Abundant
◯ Common
o Few
• Rare

3-1 MJZ-1 Hole (Fig. 50)

Depth	0-11.50m	Laterite
"	11.50-26.40m	Recrystallized massive dolomite
"	26.40-201.00m	Recrystallized brecciated sideritic dolomite

Sideritization is weak above 116.50m and intense below. The cores at depths of; 75.4-76.4m, 84.1-84.4m, 88.0-89.0m, 90.7-91.0m, 101.0-101.2m, 170.3-172.4m, 179.5-180.8m, 188.7-191.4m and 195.6-195.9m are rich in oxides such as hematite and specularite.

Samples of; calcite crystals from a small druse (15cm) at 59.8m, iron oxide bearing calcite vein (10cm wide) at 98.0m, iron oxide vein (10cm wide) at 171.4m, and iron oxides and calcite crystals from druse (90cm) at 181.6m were analysed, but the contents of Ag, Cu, Pb, Zn were very minor.

The red clay at 160.4-160.5m flowed into the drill hole for approximately 13m length and it is believed that it filled a relatively large fracture.

3-2 MJZ-2 Hole (Fig. 51)

Depth	0-14.00m	Laterite, large boulders of dolomite occur at 2.4-8.0m
"	14.00-201.00m	Recrystallized brecciated sideritic dolomite

Sideritization is weak above 25.00m and intense below. The cores at depths of; 16.8-17.4m, 25.0-26.0m, 28.7-30.2m, 33.7-34.0m, 36.9-37.2m, 39.9-40.7m, 54.2-56.5m, 59.7-59.8m, 64.4-64.5m, 67.2-67.5m, 70.0-74.4m, 77.5-80.0m, 85.4-87.6m, 91.0-91.5m, 93.5-93.7m, 95.7-95.8m, 115.5-117.0m, 127.6-129.3m 130.5-131.5m, 148.3-148.4m, 157.1-157.7m, 167.6-169.6m, 172.4-177.0m, 193.0-193.2m, 193.5-196.4m, 197.4-199.3m, 199.7-200.4m are rich in oxides such as hematite and specularite.

The 159.2-161.3 zone is completely void without any fillings such as clays or crystals.

3-3 MJZ-3 Hole (Fig. 52)

Depth	0-27.60m	Laterite, dolomite boulders 10-50cm in 26.5-27.1m.
"	27.60-201.00m	Recrystallized brecciated sideritic dolomite. Sideritization weak above 51.90m and intense below.

The cores at depths of; 54.5-55.6m, 58.3-59.8m, 73.6-74.6m, 76.0-76.1m, 77.4-77.5m, 90.5-98.5m, 108.9-110.5m, 111.9-113.7m, 115.6-117.5m, 126.8-126.9m, 131.7-135.0m, 136.2-136.3m, 142.5-142.7m, 148.2-148.3m, 155.6-155.9m, 156.4-156.6m, 160.5-160.6m, 185.4-187.7m are rich in oxides such as hematite and specularite.

Analysis of iron oxide samples at 55.4m, 55.5m and 58.8m showed very minor content of Ag, Cu, Pb and Zn, but those from 59.5m, 91.8m, 95.9m, 112.3m, 133.5m and 187.3m resulted in 0.n% Zn. Also similar amount of Zn was detected from sideritic dolomite samples at 98.9m, 109.6m and 121.3m; from iron oxide-bearing sideritic dolomite at 116.3m and from iron oxide-bearing calcite crystals which fill fractures at 160.7m and 160.8m.

The highest content was 0.7% in the sideritic dolomite at 121.3m.

3-4 MJZ-4 Hole (Fig. 53)

Depth	0-14.8m	Laterite, dolomite boulders at 8.1-8.5m
"	14.80-102.00m	Recrystallized brecciated sid sideritic dolomite. Sideritization weak above 27.50m and intense below.

The cores at depths of; 37.6-38.3m, 47.7-48.7m, 77.1-77.8m, 82.6-86.6m, 90.6-91.6m, 94.2-94.7m, 100.0-100.7m and 101.8-102.0m are rich in oxides such as hematite and specularite.

Zn content of 0.n% was detected from iron oxides at 40.4m, 85.5m and 110.5m. The highest value was 0.34% in an iron oxide mineral at 85.5m. The Ag, Cu, Pb contents were very minor in all samples.

3-5 MJZ-5 Hole (Fig. 54)

Depth	0-23.30m	Laterite, dolomite boulders at 20.0-20.4m.
"	23.30-201.00m	Recrystallized brecciated sideritic dolomite. Sideritization weak above 36.50m and intense below.

The cores at depths of; 30.3-30.5m, 36.5-100.7m, 107.3-121.1m, 126.3-172.3m, 178.4-180.5m and 184.4-192.4m are rich in oxides such as hematite and specularite.

Weak Zn mineralization is found at a 6.60m zone between 91.90-98.50m depth. The zone 91.9-93.3m is iron oxide-bearing sideritic dolomite and pale green smithsonite occurs scattered in this rock. The 10cm between 92.4m and 92.5m is relatively rich and is disseminated ore. The lithology at 93.3-93.8m is fractured and weathered sideritic dolomite and small amount of smithsonite is observed, and that of 93.8-95.4m is iron oxide and here smithsonite occurs in scattered mode. The zone 95.4-96.7m consists of strongly weathered iron oxide-bearing sideritic dolomite and smithsonite occurs as scattered dots. The interval 96.7-98.0m consists of completely fractured and strongly weathered iron oxide-bearing sideritic dolomite and small amount of dots of green minerals are observed. Weathered sideritic dolomite comprises 98.0-98.8m and the rock is porous. The pores are filled mainly by iron oxides with some green minerals.

The highest Zn content of this mineralized zone was from a core 1.40m long at 91.90-93.30m depth with 0.58% Zn. The average grade of the total mineralized zone (91.90-98.50m) was detected from a 6.60m thick horizon with 4 g/t Ag, <0.01% Cu, 0.03% Pb and 0.31% Zn.

In the drill core above and below the mineralized zone mentioned above, Zn minerals could not be observed by the unaided eyes, but analytical results of over 0.1% Zn is obtained from samples at 87.5-88.5m and 90.5-91.9m and also those of less than 0.1% Zn from samples below the mineralized zone.

Samples from 92.5m, 94.7m and 95.9m depth were observed microscopically and studied by X-ray diffraction. The results are laid out in Figs. 26, 28. The ore minerals identified are hematite, goethite, phosphoferrite, smithsonite and minute grains (<1μm) of pyrite and chalcopyrite. The pyrite has framboidal texture. The smithsonite occurs in oolitic clots of dolomite.

Aside from the above mineralized zone, 0.n% Zn was detected from sideritic dolomite at 105.0m and 106.0m, iron oxide-bearing limestone at 144.4m and weathered iron oxide-bearing dolomite at 180.3m. Zn minerals could not be observed by the unaided eyes in the iron oxide-bearing limestone at 144.4m although highest Zn content of 1.10% was obtained. Microscopic (x 1000) and X-ray work (Figs 26, 28) also could not identify Zn minerals, hematite, goethite, phosphoferrite and siderite were the only ore minerals found. Therefore, it may be possible that Zn occurs in the carbonate rocks rather than as independent minerals.

3-6 MJZ-6 Hole (Fig. 55)

Depth	0-20.00m	Laterite, large boulders of dolomite at 6.5-10.5m.
"	20.00-201.00m	Recrystallized brecciated sideritic dolomite. Sideritization weak above 66.70m and intense below.

This recrystalized brecciated sideritic dolomite is intruded by porphyrite at 162.00 - 162.90m, 163.50 - 164.00m, 165.40-165.80m, 168.60-170.30m and 172.30-173.50m.

The core at depths of; 20.0-57.5m, 66.7-67.5m, 73.0-76.0m, 88.0-97.7m and 109.3-137.3m is rich in oxides such as hematite and specularite.

Zn mineralization is observed for 12.70m from 124.60 to 137.30m. The interval 124.60-125.5m consists of pale brown clay. 125.5-127.4m consists of iron oxide-bearing dolomite with scattered dots of green smithsonite and brown willemite. 127.4-127.7m consists of brown clay. 127.7-128.8m consists of porous iron oxide-bearing dolomite and minute crystals of willemite occurs in these pores. Also dots of smithsonite are scattered in the samples. 128.8-130.4m and 130.4-131.9m consist of iron oxide-bearing limestone and willemite and smithsonite are disseminated in the carbonate. 131.9-133.4m consists of porous iron oxide-bearing limestone and willemite. occurs in the pores. 133.4-134.3m and 134.3-134.9m consist of iron oxide-bearing limestone and relatively abundant willemite and small amount of smithsonite are disseminated. 134.9-135.4m consists of strongly weathered red iron oxide with dissemination of willemite. 135.4-136.4m and 136.4-137.3m consist of iron oxide-bearing limestone with willemite dissemination.

The highest Zn content, 5.97% of this mineralized zone was detected in a sample from 0.60m thick zone at 134.30-134.90m depth.

The average grade of the total mineralized zone (124.60-137.30m) was from a 12.70m thick horizon with 18 g/t Ag, <0.01% Cu, 0.02% Pb and 1.64% Zn. The relatively high grade part was between 133.40-136.40m in depth, 3.00m thick with 31 g/t Ag, <0.01% Cu, 0.03% Pb and 3.64% Zn. The results of the analyses of relatively intensely mineralized parts are; at 128.7m depth, 8.20% Zn; 135m, 7.40% Zn; 34.8m, 5.20% Zn; 134.2m, 3.00% Zn; 135.8m, 2.40% Zn; 130.3m, 1.40% Zn; 133.3m, 1.00% Zn ; 131.8m, 0.90% Zn (Table 25).

X-ray diffraction studies were made for all the above samples, EPMA analysis was done for the former three samples and microscopic work was carried out for six samples (Tables 26∿28). The results of these laboratory work showed the occurrence of hematite, goethite, phosphoferrite, pyrite, willemite and smithsonite as the ore minerals. Aside from the above, although identification was not possible at x1000 magnification, minute grains with very high reflectivity were observed. These could be silver minerals.

The EPMA method has been applied for three sorts of minerals given in Table 27, of which diameters of particles are larger than that of electronic beams. Among them, a zinc component was detected in two sorts.

One sort comprises mainly zinc and copper and the other consists of mainly zinc and silicon.

Both sorts are accompanied with subordinate amounts of calcium and iron but no sulphur, phosphor or silver components.

PART Ⅲ. CONCLUSIONS AND RECOMMENDATIONS

PART III CONCLUSIONS AND RECOMMENDATIONS

Chapter 1 Conclusions

1-1 Geochemical Anomalies and Mineralized Zones of the Kamiyobo Area

Two geochemical anomaly zones, extending in three directions were delineated by the present geochemical work in the Kamiyobo area. Of these zones, the geochemical anomaly extending in NNE-SSW at the southwestern part was assessed to be promising for future prospecting work. The main reason for this evaluation is, as mentioned in PART II, Chapter 1, that the magnitude, the component, the number and the high values ($\geqq M+3\sigma$) of the geochemical anomalies were most concentrated in this zone.

This anomaly zone extends for more than 1 km and consists of anomalies of all three elements, Cu, Pb and Zn. The central part is approximately 300m long and the number of high anomalies ($\geqq M+3\sigma$) is highest for Zn followed by Pb and then Cu.

This zone is developed in the area of muddy-sandy metasedimentary rocks near the boundary with the bedded limestone. The exposure is extremely poor in this general area and there are no outcrops in the anomaly zone. It is inferred, however, from the following reasons that these anomalies are caused by primary sulfide deposits.

(1) The erosion and the secondary precipitation at the ore deposits and mineralized zones in the northern carbonate

area are less intense in the metasediments area and primary sulfide deposits remain intact in such parts. This is mentioned in section 1 - 3 of this chapter.

(2) The geochemical anomalies of the mineralized zones formed by secondary precipitation after erosion have very high Zn values but very low Pb, Cu anomalies. Also the anomaly zones are distributed in oval shape and are not continuous in vein form.

(3) In areas where weathering was intense and erosion effected the deeper parts of the mineralized zones, iron minerals are all hematite and specularite at the surface, down to 150m below-surface in the Bob Zinc area, and no magnetite is found. In the southeastern part of the area and the Kamiyobo Mineralized Zone 600m to the north, the magnetite has changed partly to hematite and specularite, but a large amount of magnetite still exists.

It is clear from the above, that there is a high possibility of the existence of primary sulfide deposits in this geochemical anomaly zone and it is most desirable to confirm this by drilling.

1-2 Geophysical Anomalies and Mineralization of the Sable Antelope Area

Five IP anomaly zones were discovered by geophysical (IP) prospecting in this area. These anomaly zones were compared with the MINDECO-NORANDA geochemical data which were reanalysed during the first year (Fig. 1). It is apparent that Zone Nos.1 and 2 are located in the Cu and Zn geochemical anomaly zones of the Sable Antelope area and Zone Nos.3 and 4 North and the Zone No.5 are located in the Cu and Zn geochemical anomaly zones of the Blue Jacket area. Also the Sable Antelope Ore Deposit occurs in the Zone No.2 and the Blue Jacket Mineralized Zone in the Zone No.3.

Geologically, Zone Nos.1 and 2 occur in the brecciated fractured zone in the massive carbonate rocks and Zone Nos.3, 4 and 5 in the sandy-muddy metasedimentary area. Mineralization occurs in the vicinity of Zone Nos.1, 2 and 3, but mineralization is not found on the surface near Zone Nos.4 and 5.

Pitting was done in localities where mineralization was confirmed in shallow parts, in order to obtain information regarding the relationship between the geophysical anomalies and the mineralization. Zone No.2 was excluded from this work because the above relationship was clear by the existence of Sable Antelope Deposit. A total of four pits, were sampled; one in Zone No.1, two near the highest anomaly of Zone No.3 and at the hematite-magnetite-limonite outcrop of Zone No.3 (Figs. 40,56).

A very high Zn anomaly was obtained from Zone No.1 and high Cu anomaly in laterite and Zn anomaly in iron oxides from the pits in Zone No 3 (Table 29).

From the above work, it is believed that the IP anomalies

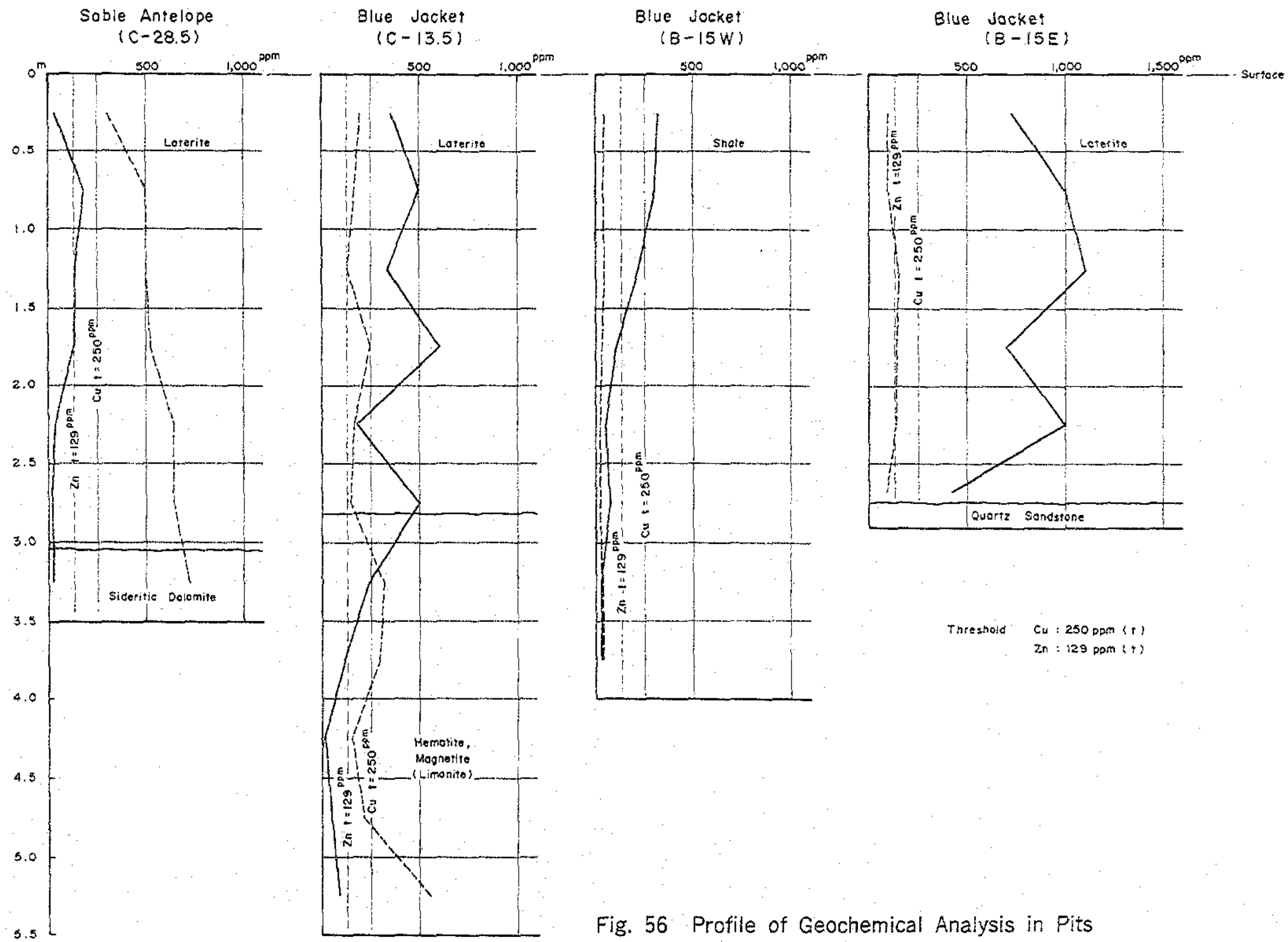


Fig. 56 Profile of Geochemical Analysis in Pits

Table 29 The Results of Geochemical Analysis of Pit Samples

Locality	Depth	Kind of Sample	Cu ppm	Pb ppm	Zn ppm
Blue Jacket C-13.5	0~0.5^m	Laterite	360	28	200
	0.5~1.0	"	500	21	170
	1.0~1.5	"	340	18	130
	1.5~2.0	"	600	22	250
	2.0~2.5	"	180	16	170
	2.5~3.0	"	500	50	150
	3.0~3.5	Iron Ore Hem.Mag.(Lim.)	240	27	320
	3.5~4.0	"	120	20	300
	4.0~4.5	"	15	12	160
	4.5~5.0	"	50	30	220
	5.0~5.5	"	90	20	560
B-15 E	0~0.5	Laterite	720	25	100
	0.5~1.0	"	1,000	20	100
	1.0~1.5	"	1,100	18	150
	1.5~2.0	"	700	14	140
	2.0~2.5	"	1,000	18	140
	2.5~2.9	"	420	18	90
B-15 W	0~0.5	Shale	320	21	45
	0.5~1.0	"	300	22	40
	1.0~1.5	"	220	17	45
	1.5~2.0	"	100	14	30
	2.0~2.5	"	50	10	24
	2.5~3.0	"	70	12	27
	3.0~3.5	"	31	9	35
	3.5~4.0	"	30	9	36
Sable Antelope C-28.5	0~0.5^m	Laterite	32	50	300
	0.5~1.0	"	180	60	500
	1.0~1.5	"	130	50	500
	1.5~2.0	"	130	38	520
	2.0~2.5	"	35	30	640
	2.5~3.0	"	20	24	640
	3.0~3.5	"	24	43	720

Hem. : Hematite
Mag. : Magnetite
Lim. : Limonite
( ) : Small Amount

of Zone Nos.1, 2 and 3 where Cu and Zn are concentrated are most probably caused by mineralization. The Zone Nos.4 North and 5 are also located in Cu and Zn geochemical anomaly zones and it is possible that these are showings of deposits covered by laterite.

Study of data relating to frequency effect, resistivity and phase spectra obtained by geophysical prospecting showed that various data are best concentrated in Zone No.3. In the five parallel geophysical traverses, three IP traverses and two SIP traverses, the anomalies show similar values and distribution pattern. Model constructed by simulation, showed a sulfide concentration in a body 60-70m wide, over 200m long, vertical to steep southward dip at 100m to over 300m below the surface.

The Zone Nos.1 and 2 consist of continuous somewhat high frequency effect in a zone of high apparent resistivity. Zone No.2 cuts accross Sable Antelope Deposit. There is a tendency for the apparent resistivity to rise at frequency effect anomalies. This is interpreted to be caused by silicification such as that in Sable Antelope Deposit. Therefore, it is probable that this anomaly zone shows the existence of mineralized zones of Sable Antelope type.

The frequency effect anomalies tend to continue eastward, and it is necessary to increase the traverses toward the east in order to determine the center of mineralization.

From the distribution of resistivity values, Zone No.4

is divided into the northern and southern parts by E-W lineation and each consists of different geology. The northern anomalies occur along the lineation and the values are similar to those of Zone No.3. Thus it is inferred that these are caused by mineralization. The southern anomalies occur in the very low resistivity zone and is composite with electromagnetic coupling.

Zone No.5 consists of a fairly high frequency effect in somewhat high resistivity zone and it is calculated to be located deeper than 200m below the surface. Although there is no data which directly relates this zone to mineralization, it is possible that this is a manifestation of a blind mineralized zone because the geology of this area consists of muddy-sandy metasedimentary rocks on the surface and bedded carbonate rocks from relatively shallow subsurface zone. Therefore, it should be mentioned that this Zone is noteworthy.

1-3 Interpretation of the Drilling Results of Bob Zinc Area

1-3-1 Geology, Geologic Structure and Mineralization.

The geology of this area consists of massive dolomites which are the lowest formation of the Karenda area. The Bob Zinc Ore Body and the mineralized zone to the east is located at the brecciated fractured zone. This fractured zone is 900m x 400m, with depth of over 150m. The dimensions of the strongly sideritized alteration zone is 250-300m x 150-200m with depth of over 150m. This fractured zone and the strongly altered zone are almost vertical with a slight southward.dip to the depth of 150m (Fig. 42). The mineralization occurs as vein to pipe form which thins downward in a part of the alteration zone. The mineralization is strong in the upper horizons and weakens downward with abrupt deterioration at 50m depth and below.

Zinc mineralization was confirmed at MJZ-5 and MJZ-6 by the drilling conducted during this year. The mineralization at MJZ-5 occurs over a length of 6.60m thick between 91.90-98.50m depth and the average grade is 0.31% Zn with a maximum grade of 0.58% Zn over a length of 1.40m thick between 91.90-93.30m. The mineralization at MJZ-6 occurs over a length of 12.70m thick between 124.60-137.30m depth and the average grade is 1.64% Zn with a maximum content of 5.97% Zn over a length of 0.60m thick between 134.30-134.90m depth. The former mineralized zone is located 60m below the surface and the latter 100m below. The latter mineralization improves in the shallower parts. Thus it is possible that the former mineralization in shallower parts might be better than that of the depth at MJZ-5, but the size of the ore body does not seem promising.

Ore minerals are mainly secondary smithsonite ($ZnCo_3$) and willemite ($Zn\ SiO_4$). And sulfides, iron oxides of sulfide origin and Cu, Pb minerals are not observed by the unaided eyes. Microscopically, however, minute grains of pyrite and chalcopyrite are observed as remnant minerals.

The secondary zinc minerals are concentrated in the weathered parts of the fractured zones and are not associated with iron oxides such as hematite and specularite. Also 0.n% Zn is frequently contained in the host rock, brecciated sideritic dolomite where small fractures are developed.

It is clear from the above, that the Bob Zinc Mineralized Zone was formed along weak lineations, then eroded, and the remaining parts were weathered and formed secondary minerals. This agrees with the geologic structure of the general Karenda area because the Bob Zinc Mineralized zone is located where erosion was deep.

The known mineral deposits and mineralized zones of the Karenda area are mostly located in the northern carbonate area. And most of them occur in the E-W trending zone which is harmonious with the geological structure between the Silver King Deposit and the Sable Antelope Deposit (Fig. 1). The only mineralized zones which occur outside of the above are Bob Zinc and Wonder Rocks Mineralized Zones. It was clarified during the work of the first year that these mineralized zones are located at the intersection of N-S and E-W trending weak lines.

It was clarified during the first year that the Wonder Rocks Mineralized Zone consists of secondary minerals such as malachite and willemite and that the erosion was intense and reached the deeper parts of the mineralized zone.

Only three mineral deposits, Silver King, Crystal Jacket and Sable Antelope were worked in the past. A line joining these deposits is very close to the boundary between the massive dolomites and the bedded limestone. These deposits were explored from the outcrop and Silver King was developed to the depth of 60m and Sable Antelope to 90m. The depth of Crystal Jacket is not clear, but it is inferred to be shallower than the other two from the amount of shipped ore. From our work it is now clear that these deposits have pipe-form, the grade deteriorates rapidly below 30m depth and that the ore minerals are mainly sulfides such as chalcocite, tennantite bornite, chalcopyrite, pyrite and others. Also near the surface, malachite and other oxides are associated.

It is inferred from the above, that the deposits which were worked from the outcrops were considerably eroded and most probably only a small portion of the primary sulfide deposits remained.

The summary of the mineralization of the northern Karenda area is as follows.

(1) The mineralized zones of the Wonder Rocks, Bob Zinc and other mineralized areas in the massive dolomite area in the northern part of north Karenda have been eroded to the deeper parts. Even if a part of the primary ores remained or secondary enrichment took place, these will consist of secondary oxides, silicates and carbonates and they will not continue to the deeper zones.

(2) Sable Antelope, Crystal Jacket, Silver Kind and other primary sulfide mineralization occur near the boundary of massive dolomite and bedded limestone, in the central part of northern Karenda, but they also have been intensely

eroded.

(3) Blue Jacket and other mineralized zones are known to occur in the bedded limestone and sandy to muddy metasediments in the southern part of northern Karenda. The erosion is shallow and primary sulfide deposits can be expected in this area.

1-3-2 Geochemical Anomalies and Mineralization

The geochemical anomalies of the Bob Zinc occur over a wide area (Fig. 1), but the distribution of those higher than M+3σ is limited to the brecciated fractured zone and agrees with the strongly sideritized alteration zone (Fig.41).

The Zn geochemical anomaly zone of the area in the vicinity of Bob Zinc Ore Body has a distribution pattern very similar to that of the ore body. At the geochemical anomaly zone with very similar pattern to the east of Bob Zinc Ore Body, Zn mineralization was observed but ore bodies could not be located.

The cores from the drilling conducted during this year at this geochemical anomaly to the east of the Bob Zinc Ore Body were studied. Several hundred to several thousand ppm Zn was determined from the strongly sideritized brecciated dolomites and several tens to several hundred ppm Zn from the weakly sideritized brecciated dolomites (Table 25). The analysis of soil samples resulted with 200-300ppm Zn for most of those from the massive dolomite area, and those from the weakly sideritized brecciated dolomite area contained mainly 400-600ppm Zn and those from the strongly sideritized brecciated dolomite area had more than 800ppm Zn. The Maximum value was 1800ppm Zn (Table 1). Thus it is concluded that the Zn chemical anomalies of the area to the east of the Bob Zinc Ore Body are caused by the relatively high Zn content of the strongly sideritized brecciated dolomite.

It will be necessary to investigate in detail the relation between the distribution of geochemical anomalies higher than M+3σ and the strongly sideritized brecciated fractured zones in order to analyse and interpret the geochemical anomalies distributed along the boundary of bedded limestone and the muddy-sandy metasedimentary rocks (Fig. 1).

It is concluded from our investigation that the geochemical anomaly zones were formed through the following stages.

(1) Deposition of massive carbonate rocks(mainly dolomite).

(2) Deposition of bedded carbonate rocks (mainly limestone).

(3) Deposition of muddy-sandy sedimentary rocks. (Stages (1) - (3) are conformable)

(4) Folding movement.

(5) Igneous activity.

(6) Sideritization (part of the siderite was deposited during stages (1) - (3), but those forming veins and box-type mineralization in igneous rocks

occured at this stage).

(7) Formation of brecciated fractured zone (igneous activity-tectonic movement).

(8) Sulfide mineralization (Cu, Pb, Zn).

(9) Folding, faulting.

(10) Uplift-erosion.

(11) Formation of secondary minerals and migration and precipitation along weak zones.

(12) Weathering, erosion, dispersion.

1-4 Conclusion

During this year, the following work was conducted in three areas which were delineated by the work of the first year.

(a) Kamiyobo Area: Geological survey, geochemical prospecting

(b) Sable Antelope Area: Geophysical prospecting, IP, SIP methods

(c) Bob Zinc Area: Drilling

As the result of the above work, mineralized zones and anomaly zones laid out in Table 30 were extracted. After detailed study of these zones, we concluded that the following two areas are the most promising.

(1) Geophysical IP Anomaly Zones No.1∿No.3 (Sable Antelope-Blue Jacket Area)

(2) NNW-SSE trending geochemical anomaly zone (Kamiyobo Area)

No.3 IP anomaly zone is the widest and strongest in the

Table 30 The List of Mineralized and/or Anomalous Zones

Zone		Recognized Survey Methods		
		Geological Survey (including Pit)	Geochemical Survey (including Re-analysis of Old Data)	Geophysical Survey
Kamiyobo South West NNW-SSE Geochemical Anomalous Zone		○	◎	—
Kamiyobo South West NE-SW Geochemical Anomalous Zone		○	○	—
Kamiyobo South East NNE-SSW Geochemical Anomalous Zone		○	○	—
Geophysical No.1 IP Anomalous Zone (Sable Antelope Area)		◎	○	◎
Geophysical No.2 IP Anomalous Zone (Sable Antelope Area)		◎	○	◎
Geophysical No.3 IP Anomalous Zone (Blue Jacket Area)		◎	○	◎
Geophysical No.4 IP Anomalous Zone	Northern Part	—	○	○
	Southern Part	—	×	×
Geophysical No.5 IP Anomalous Zone		—	○	○
Bob Zinc Mineralized Area		×	×	—

◎ Very interesting, ○ interesting, × not interesting, – no data.

IP anomaly zones of (1) and is a high frequency effect, low resistivity zone which continues for more than 400m in WNW-ESE direction and it was inferred from simulation study that this anomaly is caused by sulfide concentration in a body 60~70m wide with vertical to steep southward dip continuing in WNW-ESE direction located 100m to over 300m below the surface.

High Cu and Zn anomaly values were obtained by pitting in this zone from the central part (Cu) and the hematite-magnetite-limonite vein in the southern fork of the eastern part.

From the above reasons, there is a very high possibility of the existence of primary sulfide ore deposits in this zone.

The IP anomaly zones of No.1 and No.2 include the Sable Antelope Deposit and Zone No.1 continues for more than 200m in WNW-ESE direction and No.2 more than 400m in E-W direction.

The Sable Antelope Deposit consists of two ore bodies. Copper is the main comodity for both and they are partly massive, disseminated bodies associated with strong silicified zone. Because of this alteration, the resistivity of this zone is high, but the frequency effect is high compared to the vicinity. These values are higher to the east and it is expected that the zone continues eastward.

Very high Zn anomaly was obtained from Zone No.1 by pitting. Therefore, it is possible that Sable Antelope type

Zinc deposit exists in this zone.

As for the geochemical anomaly zone of (2), it consists of high anomalies of Cu, Pb and Zn and it is distributed as a belt extending more than 1 km. The central part ($\geq$M+3σ) is approximately 300m long in the direction of the general trend and is more than comparable to the 75m extension in the strike direction of the Sable Antelope Deposit which is the largest worked mine in this area. Also the effect of weathering is relatively weak because magnetite still remains in the vicinity of the anomaly zone. The possibility of the occurrence of primary sulfide deposits is considered to be high.

Chapter 2 Recommendations

2-1 Recommendations for the third phase

It is recommended that the following work be conducted in the most promising two localities mentioned in the previous chapter (Fig. 57), though a preference is given to the Sable Antelope - Blue Jacket area which is more favorable in these localities.

(1) Sable Antelope - Blue Jacket Area

It is very desirable to clarify the state of mineralization in geophysical IP anomaly zones No.1 ∿ No.3 by drilling, though preference is given to IP anomaly No.3 which is the most promising among them.

(2) Kamiyobo Area

It is very desirable to clarify the state of mineralization of central part in NNW-SSE geochemical anomaly zone by drilling. It will be desirable to plan the drilling operation after determining the depth, the dip and the shoot of the deposit by geophysical survey (IP,SIP).

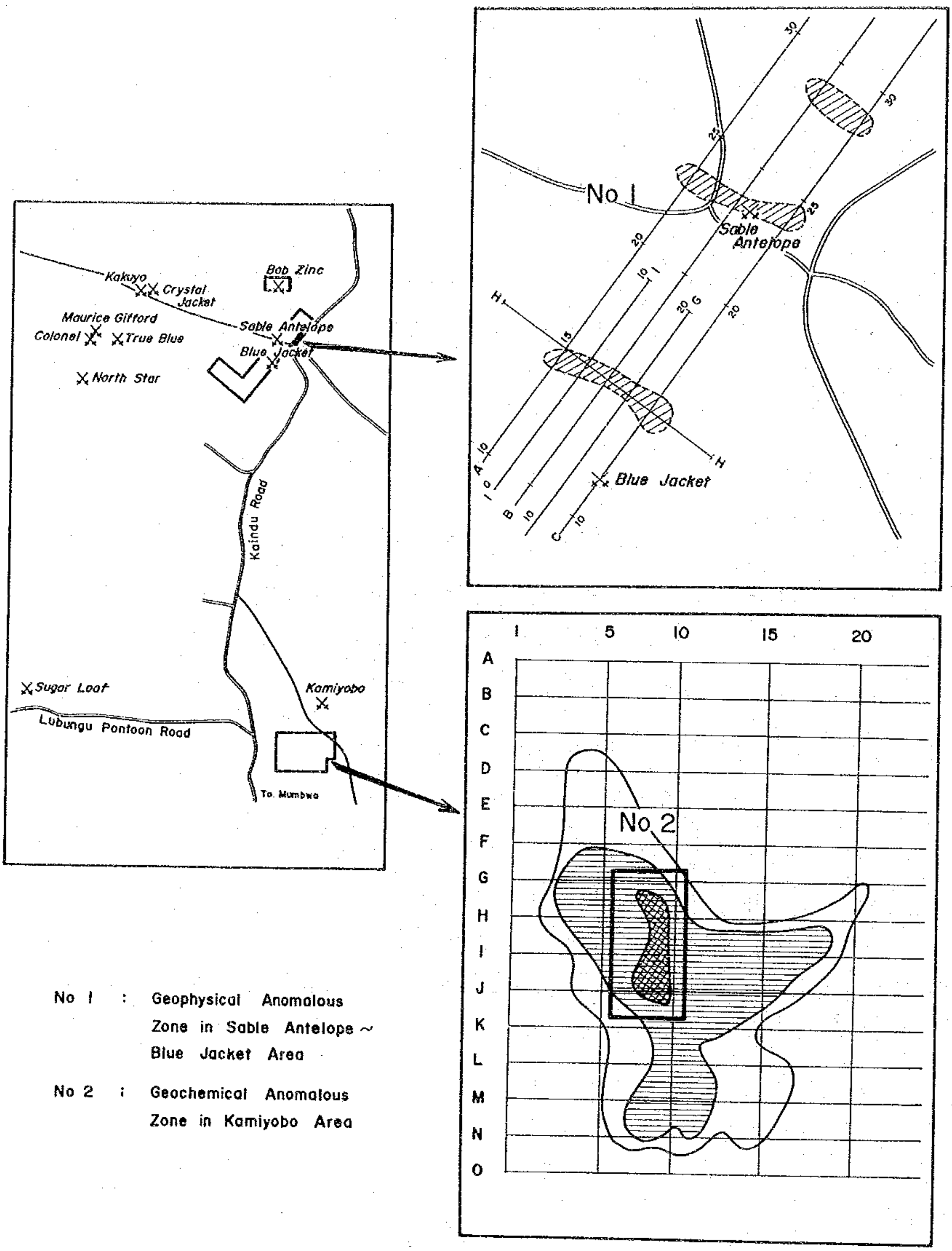


Fig. 57 Recommendation Map for Phase III Survey

Bibliography

Japan International Cooperation Agency and Metal Mining Agency of Japan (1985) : Report on the mineral exploration of Karenda area, the Republic of Zambia.

Metal Mining Agency of Japan (1980, 81 82, 83, 84) : Report on the development of exploration technology of mineral resources (SIP and CSAMT)

Pelton, W.H., Ward, S.H., Hallof, P.G., Sill, W.R. and Nelson, P.H. (1978) : Mineral discrimination and removal of inductive coupling with multifrequency IP, Geophysics, Vol. 43, No. 3.

Hallof, P.G. and Pelton, W.H. (1980) : The removal of inductive coupling effects from spectral IP data, S.E.G. 50th Annual international meeting in Houston.

Hallof, P.G. and Pelton, W.H. (1980) : Spectral IP Survey Elura Deposit (Line 50800N) Cobar, NSW, Bull. Aust. Soc. Explor. Geop-ys., v.11, no.4.

Webster, S.S. (1980) : Implication of a Spectral IP Survey at Elura, Bull. Aust. Soc. Explor. Geophys., v.11, no. 4.

JICA