REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE CHAMBISHI SOUTHEAST AREA
THE REPUBLIC OF ZAMBIA

PHASE III

FEBRUARY 1996

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE CHAMBISHI SOUTHEAST AREA
THE REPUBLIC OF ZAMBIA

PHASE III

FEBRUARY 1996

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

P R E F A C E

In response to the request of the Government of the Republic of Zambia, the Japanese Government decided to conduct a Mineral Exploration Project consisting of drilling exploration, data compilation and other relevant work in the Chambishi Southeast area to clarify the potential of mineral resources, and entrusted the survey to Japan International Cooperation Agency (JICA). The JICA entrusted the survey to Metal Mining Agency of Japan, because contents of the survey belongs to a very specialized field of mineral exploration. The survey conducted during this fiscal year is the third-phase of a three-phase project to be compiled in 1996, MMAJ sent a survey team headed by Mr. Masaaki SUGAWARA to the Republic of Zambia from July 4, 1995 to December 5, 1995.

The field survey was completed on schedule with the cooperation of the Government of Republic of Zambia and Zambia Consolidated Copper Mines Limited.

Results of the third-phase survey are summarized in this report which constitutes a part of the final report.

We wish to express our deep appreciation to the persons concerned of the Government of the Republic of Zambia, the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Embassy of Japan in Zambia and the authorities concerned for the close cooperation extended to the team.

February 1996

Kimio FUJITA
President
Japan International Cooperation Agency

Shozaburo KIYOTAKI
President
Metal Mining Agency of Japan

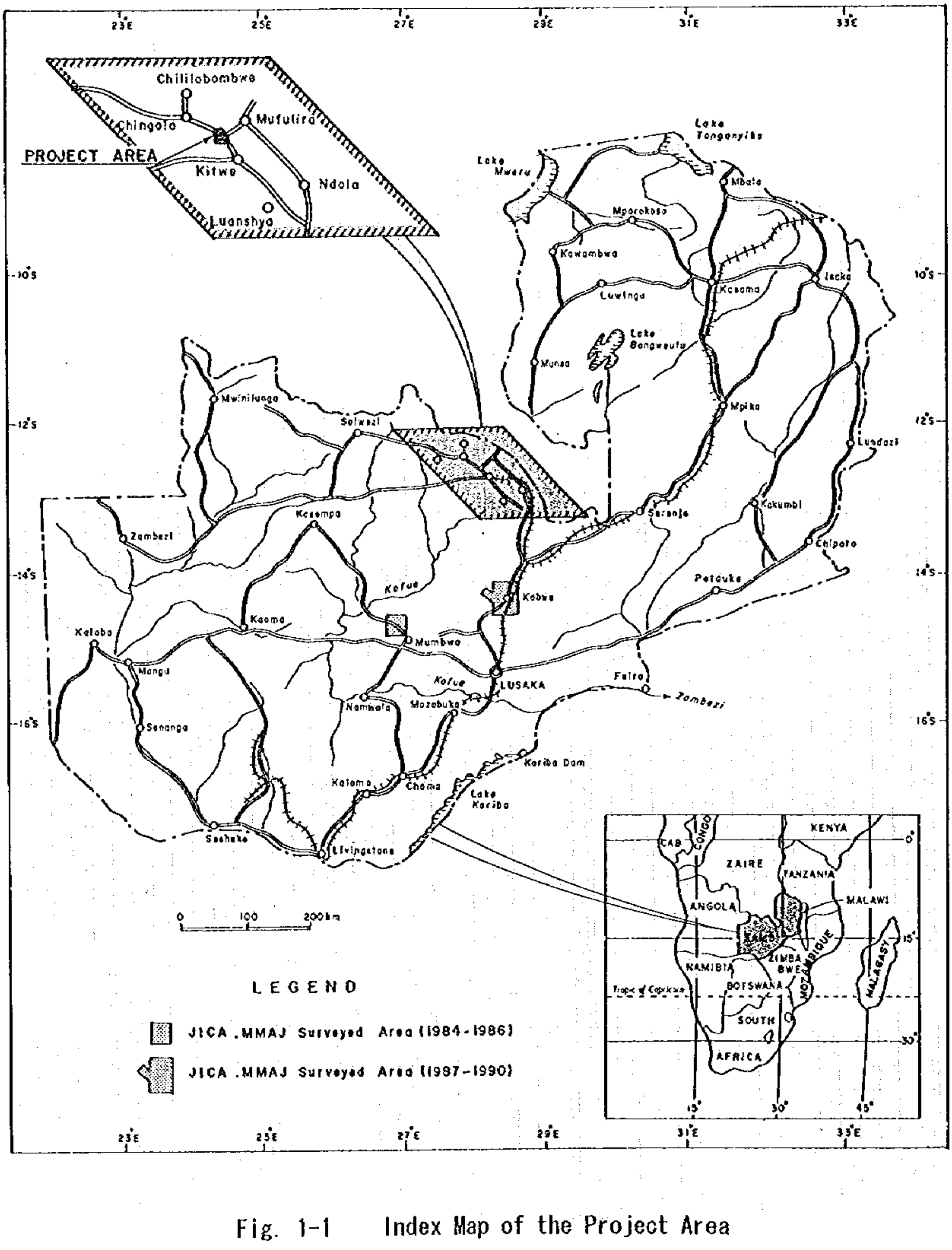


Fig. 1-1 Index Map of the Project Area

S U M M A R Y

Drilling was carried out during the third phase of the Chambishi Southeast survey. All four holes drilled (MJZC-9, -10, -11, -12) this year accomplished their objective by penetrating the ore horizon. Of these four, three reached the basement. The results of these work clarified considerably the geology and mineralization of the western and southern parts of the survey area and the results are summarized below.

MJZC-9 drilled in the western part of the area confirmed the existence of high-grade ores (i. width 5.90m, grade T-Cu 3.12%, T-Co 0.08%; ii. width 2.58m, grade T-Cu 2.29%, T-Co <0.01%). These ores are considered to be continuous to the shoot confirmed to the north of this hole (NN-75). Thus it is now clear that an ore shoot of considerable scale exists in this area. It is inferred that this ore shoot is emplaced over a basement depression which is elongated in the NE-SW direction and it is deemed possible that this shoot is developed further southward or westward.

Relatively low-grade copper ores rich in pyrrhotite were confirmed by MJZC-10 drilled on the eastern side of MJZC-9 and MJZC-11 · -12 drilled in the southern part of the area. In these mineralized zones, the rich ore probably deposited during a relatively short period of time before or after the start of deposition of the "Ore Shale", because Fe/Cu ratio tends to increase upward.

Small scale bornite-chalcopyrite mineralization was confirmed in the basal part of the "Ore Shale" in MJZC-12. It is inferred that this mineralized zone lies over a basement-rise which extends southward. Palaeo-basement highs probably existed in parts of this rise at the time of ore deposition. Therefore, palaeo-basement highs occurred in relatively shallow parts and there are possibilities of ore shoots occurring on their limbs.

A basement depression extending in the NE-SW direction is considered to exist between MJZC-11 and -12. This should be noted as MJZC-2 with relatively high grade ores is located on the northeastern extension of this depression.

Ore reserve calculation was carried out in order to asses the mineral potential of the survey area with the following results.

Northern Area Shoot:	54.79 million tons, 2.70% T-Cu, 0.13% T-Co
Southern Area Shoot:	14.93 million tons, 2.19% T-Cu, 0.13% T-Co
Subeconomic Zone :	107.91 million tons, 1.83% T-Cu, 0.03% T-Co

Significant amounts of ore were confirmed in this survey area by drilling during the period hitherto reported. In order to develop this deposit, however, it is necessary to further increase the ore reserves. The western and southern parts of the survey area have not been explored and the potential is considered to be promising.

CONTENTS

C O N T E N T S

PART II DETAILED DISCUSSIONS

PART III CONCLUSIONS AND RECOMMENDATIONS

FIGURES

TABLES

P H O T O G R A P H S

A P P E N D I C E S

PLATE

PART I OVERVIEW

PART I OVERVIEW

Chapter 1 Introduction

1-1 Background and Objective of the Survey

In response to the request of the Government of the Republic of Zambia, the Government of Japan decided to conduct mineral exploration survey in the Chambishi Southeast area. The survey was entrusted to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ). The Scope of Work was signed by the representatives of JICA, MMAJ and the Zambia Consolidated Copper Mines Limited (ZCCM) on 28 June 1993.

This survey is planned to last three years from 1993 in an area encompassing approximately 60 km^2.

The major objective of the survey is to explore and evaluate the mineral potential of the survey area by study of existing data, drilling and geological assessment of the drilling results.

The first phase of this project was carried out in fiscal 1993. The survey of that phase comprised drilling (3 holes, 2,666m), and compilation of existing data.

The second phase of this project was carried out in fiscal 1994. The survey of that phase comprised drilling (5 holes, 4,241m).

The third phase of this project was carried out in fiscal 1995. The survey of that phase comprised drilling (4 holes, 3,789m), and ore reserve calculation.

1-2 Conclusions of the Second Phase and Recommendations for the Third Phase

1-2-1 Conclusions of the Second Phase

Drilling was carried out during the second-phase of the Chambishi Southeast area mineral exploration. All five boreholes drilled during this phase attained their objectives by penetrating the ore horizon. The four boreholes designed to obtain basement data reached the basement. The geology and mineralization of the vicinity of known deposits were thus clarified and the following conclusions were reached.

1. MJZC-5 drilled in the northwestern part of this area encountered relatively good ore (width 3.10m T-Cu 1.93% T-Co 0.03%, width 2.64m T-Cu 2.32% T-Co 0.03%). This orebody is believed to be the northwestern extension of the Northern Area Shoot which is the major ore shoot of this area. From this, extension of the northern part of the Northern Area Shoot in the west-northwest direction has become a possibility to be considered seriously.

2. MJZC-6 and MJZC-7 drilled to the west-northwest of MJZC-5 encountered relatively low grade ores and they are considered to be located near the palaeo-basement high at the time of ore deposition. The ore shoot confirmed by NN-75 located between these two boreholes is inferred to be developed in the local depression to the south of NN-75, MJZC-6 and MJZC-7, namely on the southern limb of the palaeo-basement high.

3. MJZC-1 drilled in the southern part of the area encountered relatively low-grade ore. This mineralization, however, is developed immediately below the "Ore Shale" and is believed to be of the same type as that of the currently operating Chibuluma mine. To the east of MJZC-1, MJZC-2 confirmed relatively high-grade ore last year. This brings out the possibility that ore shoot may exist in the unexplored areas to the south of the above two boreholes.

4. MJZC-8 drilled in the southeastern part of the Northern Area Shoot encountered only weakly mineralized zone. This is most likely located at the crest of the palaeo-basement high and is considered to be barren.

1-2-2 Recommendations for Third Phase Survey

It is concluded from the results of the drilling reported above that the most promising area for discovering new ore deposits is; the area northwest of the Northern Area Shoot, namely south of NN-75, south of MJZC-6 and south of MJZC-7.

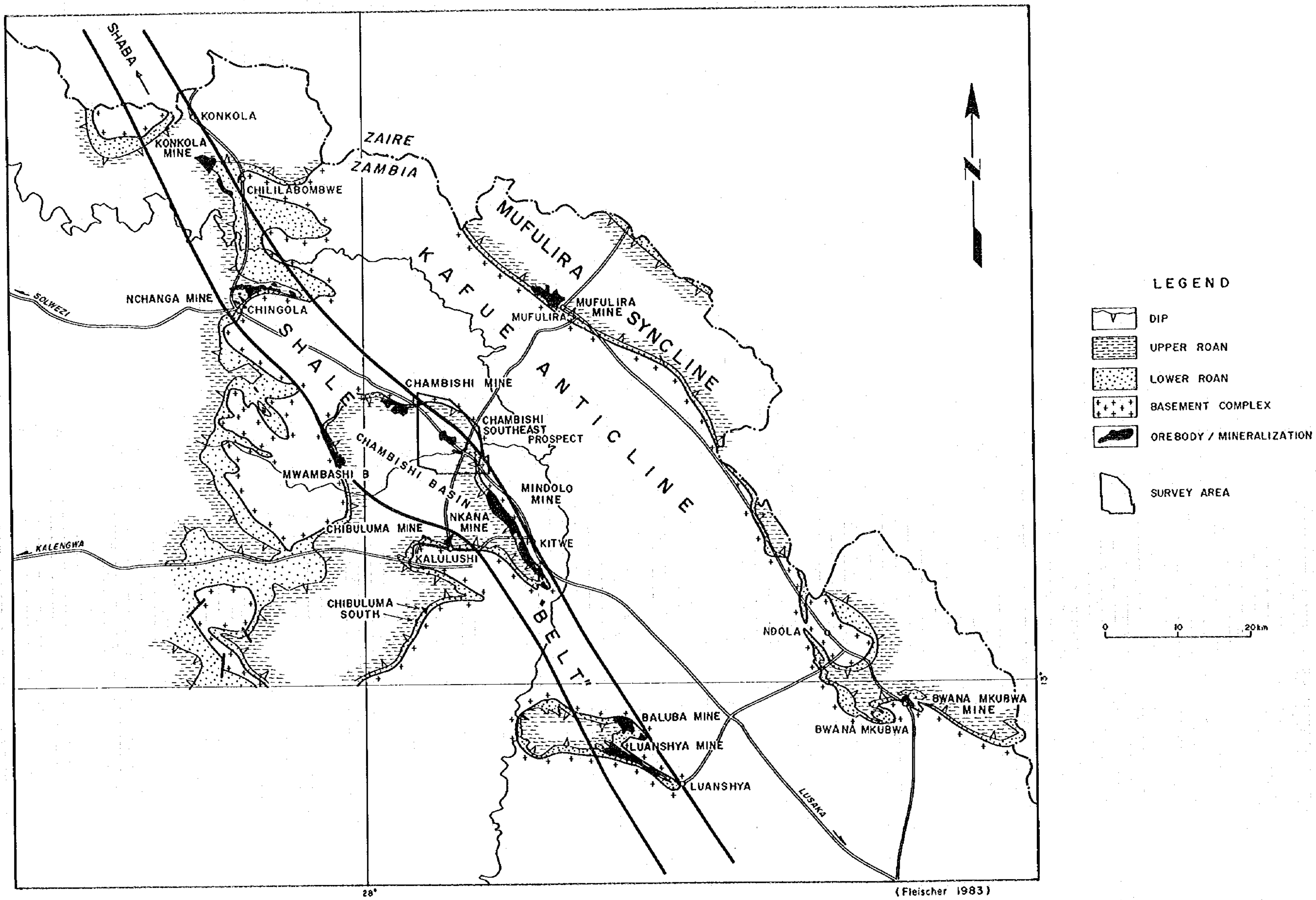


Fig. 1-2 Copperbelt Index Plan

Next in line of prospectivity is the area south of MJZC-1 and MJZC-2.

The Northern Area Shoot, the most important deposit of the project area, however, has not been prospected sufficiently and drilling along the periphery of the deposit is necessary in order to evaluate the ore reserve of this deposit accurately.

With the above consideration, drilling plan has been formulated for the third phase. The planned depth of the drilling is that of the basement for new areas, but for those with known basement depth, the figures are those designed to reach the footwall of the orebodies.

It is thus recommended that drilling be carried out with high priority for the search for new deposits and that the ore reserves of this area be accurately evaluated by integrated study of the drilling results.

1-3 Outline of the Third Phase Survey

1-3-1 Survey Area

There is an arc-shaped zone extending in the NW-SE to E-W (12°15'S to 13°15') direction in south-central Africa which is very rich in copper. It is called the "Copperbelt" and many copper deposits are concentrated in this zone. The survey area (Chambishi Southeast) is located near the centre of the Copperbelt between the Chambishi and Mindola mines and approximately 305 km north of the capital Lusaka as the crow flies (Fig. 1-1).

Kitwe, the third largest city of Zambia, has the Nkana deposit within its jurisdiction and is located about 10 km to the south-southeast of the area; Kalulushi where the Technical Directorate of ZCCM and the Chibuluma mine are located is 10 km to the south; the Chambishi mine (suspended) is 10 km to the northwest; the mining town Chingola where the largest deposit of the Belt, the Nchanga mine, occurs is 30 km to the northwest; and the mining town Mufulira is 20 km to the northeast (Fig. 1-2).

The survey area (60 km2)lies in the vicinity of the main tarmac road, joining Chingola and Kitwe (Fig. 1-3).

It is one hour flight from Lusaka to Kitwe and four hours by car.

1-3-2 Objective of the Survey

The objective of the second-phase survey is to discover new ore deposits through the understanding of the metallic mineralization and the geology of the Chambishi Southeast area, and to pursue technology transfer to the Zambian counterpart personnel. And also, the main objective of drilling is to confirm the extension of known ore deposits, and clarify the state of mineralization, and thereby enlarge the ore reserves in the survey area.

1-3-3 Survey Methods

The method of the second-phase survey is drilling exploration. The contents are as follows.

(1) Localities of Holes and Details

Details of the drill holes shown in Figure 1-3 are as follows.

Hole No.	Hole Length (m)	Inclination (°)	Azimuth
MJZC- 9	1,144.76	-90	-
MJZC-10	1,009.86	-90	-
MJZC-11	852.87	-90	-
MJZC-12	782.28	-90	-
Total	3,789.77		

(2) Methods

Drilling work was done by DRILLING EXPLORATION AND EQUIPMENT LTD., (D.E.E.) incorporated in Zambia. D.E.E. has sister companies in South Africa, Zimbabwe and Botswana.

From the surface to about 180m, non-core drilling was made by 254mm to 139mm percussion bit, and 219mm, 177mm, 114mm and NW casing pipes were inserted. For deeper parts, wire-line method was used with NQ(79mm) and CHD(78mm) bits. The encountered rocks were generally hard, however, soft parts with lost circulation occurred sometimes. Regarding these soft parts, extension of the casing pipe, cementing and injection of Drill-

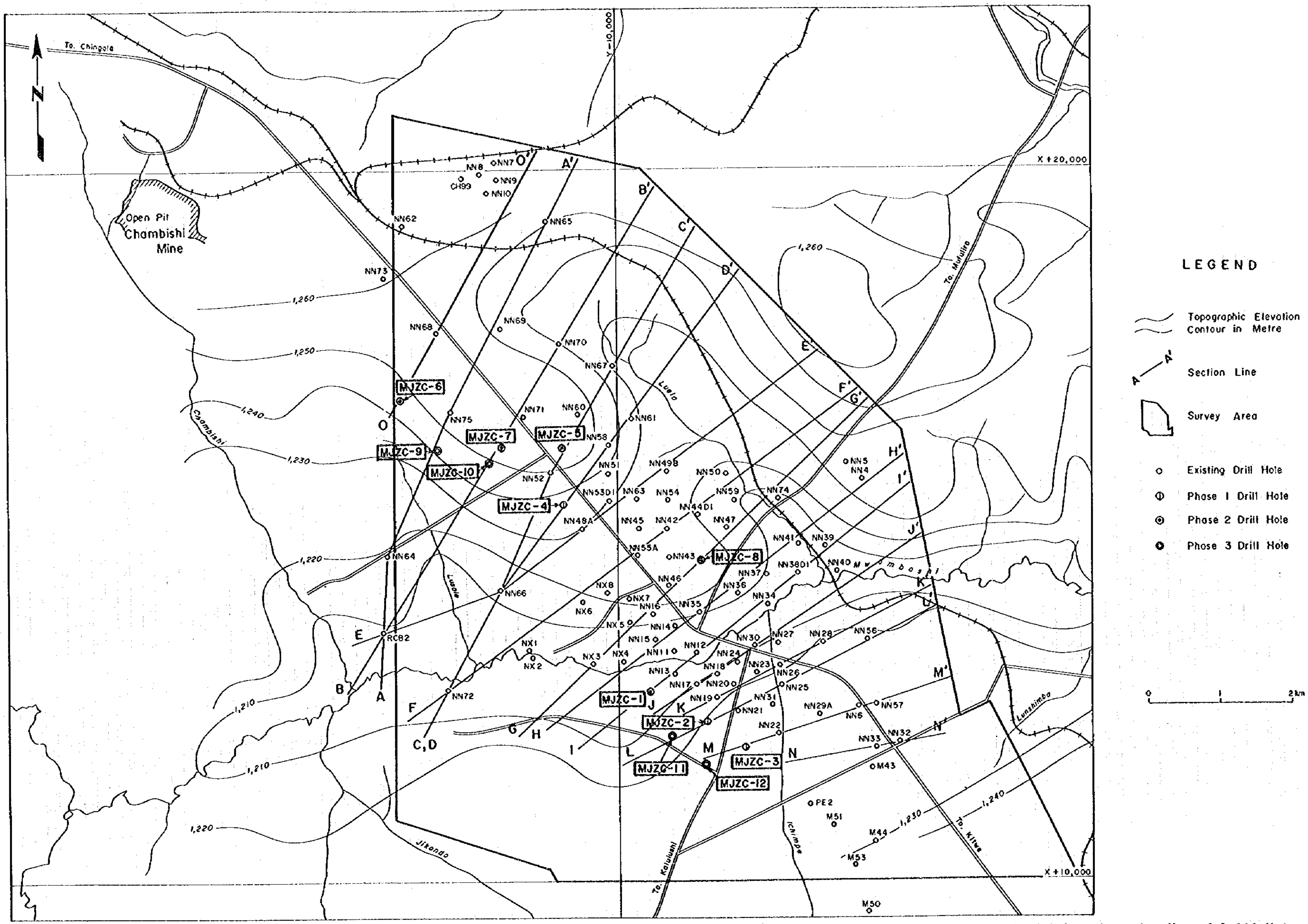


Fig. 1-3 Location Map of Drill Holes with Geological Section Lines

Table 1-1 Drilling Machine and Equipment

Drilling Machine Model	L-44 (2 set)	Strata (1 set)	Sullvin-22 (2 set)
Specifications:			
Capacity	1,500m(BQ-WL)	2,500m(BQ-WL)	800m(BQ-WL)
Dimensions L x W x H	2,375mm×1,500mm×1,750mm	3,000mm×2,000mm×2,500mm	2,500mm×1,500mm×1,500mm
Hoisting capacity	4,500kg	8,250kg	4,000kg
Spindle speed Forward	50～900rpm	500～800rpm	500～800rpm
Engine Model			
"DEUTZ" "FIRD"	6 cylinder-624	6 cylinder	4 cylinder
Drilling Machine Model	Superrockdrill-1000 (1 set)		
Specifications:			
Capacity	400m(percussion drilling)		
Dimensions L x W x H	7m×2.5m×3m		
Hoisting capacity	10,000kg		
Spindle speed	10rpn		
Engine Model	248PERKENS		
Drillind pump Model	BEAN ROYAL-35 (2 set)	BEAN ROYAL-22 (2 set)	
Specifications:			
Piston diameter	40mm	30mm	
Stroke	70mm	70mm	
Capacity	Discharge capacity 210 liter/min	Discharge capacity 150 liter/min	
Dimensions L x W x H	2,500mm×1,200mm×1,500mm	1,500mm×1,000mm×2,000mm	
Engine Model "HATZ"	12.5ps/800rpm (2 cylinder)	12.5ps/800rpm (2 cylinder)	
Wire-line Hoist	L-44 (2 set)	Strata (1 set)	
Specifications:			
Rope Capacity	1,000m	2,500m	
Hoisting speed	8～105rpm/min	80m/mm	
Engine Model "HATZ"	12.5ps/800rpm	Hydraulic	
Generator Model	HONDA (4 set)	BOYD BROWN-LEROY SOMER (2 set)	
Specifications:			
Capacity	2.8kw, 50hz, 220V	10kw, 50hz, 220V	
Water supply pump model	HONDA (2 set)	BRISAN (2 set)	
Specifications:			
Capacity	Discharge capacity 50 liter/min	100 liter/min	
Dimensions L x W x H	500mm×450mm×450mm	100mm	
Engine Model	4.5ps/2,000rpm	3.7kw	
Derrick	L-44 (1 set)	Strata (1 set)	Sullvin-22 (2 set)
Specifications:	(skid)	(trailer mounted)	(tripot)
Capacity	12m-pull	12m-pull	9m-pull
Max load capacity	10,000kg	10,000kg	7,000kg
Tractor Model	188ps (2 set)		
Specifications:			
Water tanker	2 set		
Capacity	4,500 liter		
Drilling tools			
Drilling rod			
NDBR(CHD) 6.0m	623 pcs		
BQ 6.0m	168 pcs		
Casing pipe			
NW 6.0m	122 pcs		
BW 6.0m	105 pcs		

Table 1-2 Drilling Meterage of Diamond Bit Used

Item	Size	Bit No.	Drilling Meterage by Unit				Total(m)
			MJZC-9	MJZC-10	MJZC-11	MJZC-12	
Diamond bit	HQ-WL	B755-2	104.00				104.00
		B4296.8		57.00			57.00
		14296.2		37.91			37.91
		R4296.2		18.99			18.99
		4296.1			6.09		6.09
		A2490.2			41.91		41.91
	NQ-WL	21378.46	53.09				53.09
		21086-41	241.50				241.50
		26688-1	0.43				0.43
		B1301-5	273.51				273.51
		1311-7	24.20				24.20
		5723-13	241.30				241.30
		2134-3	109.70			65.95	175.65
		21373.46		132.30			132.30
		4574.2		9.70			9.70
		4574.4		2.15			2.15
		5728.8		48.35			48.35
		B1301.6		91.16			91.16
		21877-8		145.05			145.05
		18212		0.00			0.00
		5723-4		61.29			61.29
		3767-2		15.75			15.75
		1301		214.03			214.03
		B134-10		174.00			174.00
		2134-7		99.70			99.70
		B3767-2		63.02			63.02
		B2134-7		114.56			114.56
		182102			17.96		17.96
		21377			90.73		90.73
		5723-12			316.36		316.36
		2134-8			142.70		142.70
		2134-2			111.12	36.00	147.12
		17694-10				33.96	33.96
		5723-11				142.62	142.62
		B1301.2				124.60	124.60
		B1301				108.90	108.90
		4574-3				90.24	90.24
	BQ-WL	680240		111.21			111.21
		DG7229		181.08			181.08
		680247		15.87			15.87
		629217-6		52.79			52.79
		25204-6		20.16			20.16
		Total	1,047.73	1,666.07	726.87	602.27	4,042.94
			Drilling length / bit (4,042.94m / 44 pcs)				91.89

Table 1-3 Consumables Used

Description	Specifications	Unit	Quantity				
			MJZC-9	MJZC-10	MJZC-11	MJZC-12	Total
Light oil		liter	6.760	11.150	4.060	3.550	25.520
Hydraulic oil		liter	50	210	60	10	330
Engine oil		liter	108	139	70	64	381
Gear oil		liter	60	78	33	26	197
Grease		liter	9	17	7	9	42
Drillprop		liter	176	242	68	125	611
Rod grease		kg	85	88	65	45	283
Cutting oil		liter	135	550	143	86	914
Cement	50kg/sx	kg	1.190	1.100		1.400	3.690
Bentonite		kg		5.830	40		5.870
Percussion bit	254mm	pc	1	1	1	1	4
Percussion bit	203mm	pc	1	1	1	1	4
Percussion bit	165mm	pc	1				1
Percussion bit	139mm	pc		1		1	2
Percussion bit	114mm	pc			1		1
Diamond bit	HQ	pc	1	3	2		6
Diamond bit	NQ	pc	7	14	5	8	34
Diamond bit	BQ	pc		5			5
Diamond shoe bit	NQ	pc		3			3
Diamond reamer	HQ	pc	1	1	1		3
Diamond reamer	NQ	pc	3	4	1	2	10
Diamond reamer	BQ	pc		2			2
Core barrel Ass'y	HQ-WL	set	1	1	1		3
Core barrel Ass'y	NQ-WL	set	1	2	1	1	5
Core barrel Ass'y	BQ-WL	set		1			1
Inner tube Ass'y	HQ-WL	set	1	1	1		3
Inner tube Ass'y	NQ-WL	set	1	2	1	1	5
Inner tube Ass'y	BQ-WL	set		1			1
Inner tube	HQ-WL	pc	1	1	1		3
Inner tube	NQ-WL	pc	1	1	1	1	4
Inner tube	BQ-WL	pc		1			1
Locking coupling	HQ-WL	pc	1	1	1		3
Locking coupling	NQ-WL	pc	2	3	2	2	9
Locking coupling	BQ-WL	pc		2			2
Adapter coupling	HQ-WL	pc	1	1	1		3
Adapter coupling	NQ-WL	pc	2	3	2	2	9
Adapter coupling	BQ-WL	pc		2			2
Landing ring	HQ-WL	pc	1	1	1		3
Landing ring	NQ-WL	pc	3	4	3	3	13
Landing ring	BQ-WL	pc		2			2
Core lifter case	HQ-WL	pc	1	2	2		5
Core lifter case	NQ-WL	pc	5	7	5	5	22
Core lifter case	BQ-WL	pc		4			4
Core lifter	HQ-WL	pc	1	2	2		5
Core lifter	NQ-WL	pc	5	7	5	5	22
Core lifter	BQ-WL	pc		4			4
Stop ring	HQ-WL	pc	1	1	1		3
Stop ring	NQ-WL	pc	2	3	2	2	9
Stop ring	BQ-WL	pc		2			2
Thrust ball bearing	HQ-WL	pc	1	1	1		3
Thrust ball bearing	NQ-WL	pc	2	3	1	1	7
Thrust ball bearing	BQ-WL	pc		2			2
Hanger bearing	HQ-WL	pc	1	1	1		3
Hanger bearing	NQ-WL	pc	2	3	1	1	7
Hanger bearing	BQ-WL	pc		2			2
Inner tube stabilizer	HQ-WL	pc	1	1	1		3
Inner tube stabilizer	NQ-WL	pc	2	3	2	2	9
Inner tube stabilizer	BQ-WL	pc		3			3
Hoisting wire rope	21mm×35mm	roll	2	2	1	1	6
Wire line rope	6mm×1.500m	roll	1	1	1	1	4
Waste		kg	10	15	6	6	37

Table 1-4 Working Time Analysis of the Drilling Operatio

Hole No	Bit Size	Drilling: Drilling length (m)	Drilling: Core length (m)	Shift: Drilling (shift)	Shift: Total (shift)	Man Working: Engineer (man)	Man Working: Worker (man)	Working Time: Drilling (h)	Other work (h)	Recovering (h)	Sub total (h)	Reassemblage (h)	Dismantlement (h)	Road Construction (h)	Transportation (h)	Water supply (h)	Grand total (h)
MJZC-9	254mm	40.00	N/C	1.50	5.50	15.00	44.00	12.00	4.00	12.00	28.00	8.00	0.00	8.00	12.00	0.00	56.00
	203mm	22.00	N/C	1.00	1.00	2.00	5.00	8.00	6.00	0.00	14.00	0.00	0.00	0.00	0.00	0.00	14.00
	165mm	35.00	N/C	2.50	5.50	13.00	35.00	15.00	15.00	12.00	42.00	24.00	0.00	0.00	12.00	0.00	78.00
	HQ	104.00	98.10	12.00	12.00	25.00	50.00	73.00	59.00	0.00	132.00	0.00	0.00	0.00	0.00	29.00	161.00
	NQ	943.76	933.17	83.00	99.00	231.00	437.00	517.00	466.00	169.00	1152.00	0.00	18.00	0.00	18.00	241.00	1429.00
	BQ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	1144.76	1031.27	100.00	123.00	286.00	571.00	625.00	550.00	193.00	1368.00	32.00	18.00	8.00	42.00	270.00	1738.00
MJZC-10	254mm	24.00	N/C	1.00	5.00	12.00	39.00	9.00	3.00	0.00	12.00	20.00	0.00	8.00	12.00	0.00	52.00
	203mm	8.00	N/C	0.50	0.50	1.00	2.00	2.00	1.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	3.00
	139mm	28.00	N/C	0.50	1.50	7.00	15.00	7.00	2.00	0.00	9.00	12.00	0.00	0.00	0.00	0.00	21.00
	HQ	113.90	110.03	26.00	34.00	87.00	165.00	137.00	128.00	203.00	468.00	0.00	0.00	0.00	0.00	121.50	589.50
	NQ	784.50	763.70	114.00	176.00	407.00	929.00	448.00	392.00	1283.00	2124.00	8.00	4.00	0.00	6.00	462.00	2604.00
	BQ	51.46	50.95	25.00	33.00	88.00	180.00	31.00	62.00	267.00	360.00	0.00	24.00	0.00	12.00	28.50	424.50
	Total	1009.86	924.68	167.00	250.00	602.00	1330.00	634.00	588.00	1753.00	2976.00	40.00	28.00	8.00	30.00	612.00	3694.00
MJZC-11	254mm	36.00	N/C	0.50	2.50	7.00	21.00	5.00	2.00	0.00	7.00	12.00	0.00	0.00	12.00	0.00	31.00
	203mm	59.00	N/C	1.50	1.50	5.00	10.00	11.00	6.00	0.00	17.00	0.00	0.00	0.00	0.00	0.00	17.00
	114mm	31.00	N/C	1.00	8.00	42.00	108.00	7.00	17.00	0.00	24.00	28.00	0.00	0.00	8.00	4.50	64.50
	HQ	48.00	44.39	11.00	13.00	31.00	70.00	56.00	66.00	70.00	192.00	0.00	0.00	0.00	0.00	36.00	228.00
	NQ	678.87	676.24	54.00	69.00	158.00	383.00	412.00	323.00	21.00	756.00	6.00	30.00	0.00	24.00	149.00	965.00
	BQ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	852.87	720.63	68.00	94.00	243.00	592.00	491.00	414.00	91.00	996.00	46.00	30.00	0.00	44.00	189.50	1305.50
MJZC-12	254mm	43.00	N/C	0.50	2.50	8.00	23.00	4.00	3.00	0.00	7.00	6.00	0.00	12.00	6.00	0.00	31.00
	203mm	29.00	N/C	0.50	0.50	2.00	4.00	3.00	2.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	5.00
	139mm	108.00	N/C	3.00	5.00	15.00	36.00	22.00	14.00	0.00	36.00	12.00	0.00	0.00	12.00	0.00	60.00
	HQ	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NQ	602.28	594.05	49.00	60.00	217.00	417.00	311.00	294.00	68.00	673.00	6.00	18.00	0.00	24.00	111.00	832.00
	BQ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	782.28	594.05	53.00	69.00	242.00	480.00	340.00	313.00	68.00	721.00	24.00	18.00	12.00	42.00	111.00	928.00
Grand Total		3789.77	3270.63	388.00	536.00	1373.00	2973.00	2090.00	1865.00	2105.00	6061.00	142.00	94.00	28.00	158.00	1182.50	7665.50

props or bentonite prevented collapses and lost circulation.

(3) Machinery

The specifications for the drilling rig, and other machinery are listed in Table 1-1, the conditions of the diamond bits in Table 1-2 and the used consumables in Table 1-3.

(4) Operations

Construction, moving, and withdrawal were done by single shift per day, while drilling was carried out by two twelve-hour shifts. Each shift consisted of one Zambian or Botswanian or South African drilling operator and five Zambian workers. And one South African superintendent, one South African engineer and two Japanese engineers supervised all work sites. Operators and workers camped by the site, while both South African and Japanese engineers commuted by car from the accommodations in Kitwe. Working time analysis of the drilling operation is shown in Table 1-4.

(5) Transportation of machinery

Machinery and material sent from South Africa and Botswana were stored in the D.E.E. workshop of Kitwe after passing the customs inspection in Livingstone, and were transported from the workshop to each site by a truck with crane.

(6) Drilling water

Water borehole was drilled at each site of MJZC-9 and MJZC-11 to the depth of 52m and 36m, respectively. The borehole water was pumped up and supplied to each drilling. Water for MJZC-10 and MJZC-12 were transported from MJZC-9 and MJZC-11 respectively by tractors after pumping up into tankers from the borehole.

(7) Withdrawal

After the completion of the survey, all equipments were transported to the D.E.E. workshop in Kitwe by truck, and stored.

(8) Measurement of borehole deviation

Borehole deviation was measured every 60 to 100 m for each hole.

(9) Surveying and analysis of cores

a) Cores and cuttings were studied in detail, and geologic logs at scale of 1:200 were made.

b) Microscopic studies of core were made whenever necessary.

c) Each ore and/or mineralized parts of cores were assayed by ZCCM.

d) The numbers of samples studied in the laboratory are as follows.

Laboratory Work	Particulars
Thin section microscopy	10 sections
Polished thin section microscopy	20 sections
Electron probe microanalysis (quantitative)	5 samples
Chemical analysis of ore samples	400 samples

1-3-4 Participants of the Third Phase Survey

Survey Team

Zambian member (Zambia Consolidated Copper Mines Limited)

J. M. D. Patterson	(Technical Director)
C. C. Tomkins	(Consulting Geologist)
A. C. Kaunda	(Project Manager, geological survey)
F. A. Siddiqui	(Head of Geological Services, ore reserve calculation)
W. J. Silondwa	(Senior Geologist, geological survey)
P. N. Mubuyaeta	(Senior Geologist, geological survey)
S. Haabanyama	(Project Geologist, ore reserve calculation)

Japanese member (Nikko Exploration & Development Co.,Ltd.)

Masaaki Sugawara	(Team leader, Geological Survey, Drilling)
Masaya Wakamatsu	(Drilling)

1-3-5 Duration

Field survey (Drilling)
6 July 1995 to 2 December 1995

Laboratory work, report preparation
8 December 1995 to 28 February 1996

Chapter 2 Geography of the Survey Area

2-1 Topography and Drainage

2-1-1 Topography

The topography of the survey area and the vicinity is in a relatively flat plateau of 1,200 to 1,300 m in elevation. In general, the elevation gradually rises toward the Chambishi mine to the northwest of the survey area.

As the topography along rivers is more or less flat, they become swampy (called Dambo) during the rainy season.

2-1-2 Drainage

The drainage of the survey area belongs to the Kafue system which is a tributary of the Zambezi system, the large river flowing into the Indian Ocean. The Kafue river flows southward approximately 8 km northeast of the survey area. The Mwambashi stream, a tributary of Kafue, flows eastward in the southern part of the area. NW-SE trending streams are developed to the north of the Mwambashi stream.

2-2 Climate and Vegetation

2-2-1 Climate

The survey area belongs to the savanna climatic zone. The climate largely comprises cold and dry (April to July), hot and dry (August to mid-November) and rainy (mid-November to March) seasons. It rains only once or twice a month during May to September, but it is very humid during September to October, and it rains several times a month. During January to February, precipitation is the largest, heavy rains with thunder occurs almost every day and cold cloudy days are frequent.

Average annual temperature is about 20°C, the maximum temperature 30 to 35°C and the annual precipitation is 1,000 to 1,500 mm.

The monthly mean precipitation observed at Kalulushi, where the ZCCM Technical Service is located, over 13 years (1981-

1993) are as follows.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
1981	243.8	277.0	253.8	49.0	15.0	-	-	-	2.0	2.0	176.5	168.0	1187.1
1982	463.0	196.5	63.0	92.6	19.0	-	-	-	1.0	83.5	318.5	210.0	1447.1
1983	299.5	190.5	125.5	122.0	2.5	-	-	-	0.0	38.5	124.0	342.5	1245.0
1984	251.0	252.5	175.5	17.5	62.0	-	-	-	2.5	52.5	114.0	495.5	1423.0
1985	304.5	185.5	192.0	51.0	42.0	-	-	-	3.5	34.5	80.5	287.5	1181.0
1986	313.5	253.5	308.0	191.5	0.0	-	-	-	0.0	104.0	355.0	178.5	1734.0
1987	347.0	266.5	100.2	12.0	0.0	-	-	-	4.0	25.0	49.8	218.0	1022.5
1988	475.0	217.5	272.1	10.7	0.0	-	-	-	3.2	75.0	101.2	215.0	1369.7
1989	264.1	202.8	168.7	67.0	8.5	-	-	-	0.0	0.0	57.5	285.5	1054.1
1990	202.0	226.5	178.0	53.5	42.0	-	-	-	0.0	0.0	85.0	296.0	1083.0
1991	569.5	117.5	296.5	36.5	2.5	-	-	-	98.6	100.9	205.0	201.6	1628.6
1992	97.1	300.9	17.9	0.0	0.0	-	-	-	0.0	11.6	92.8	364.9	885.2
1993	285.9	439.8	239.9	101.1	0.0	-	-	-	0.0	0.5	192.8	157.9	1417.9

(mm)

The monthly mean temperature and precipitation observed at Kabwe in central Zambia over 16 years (1961-1976) and 14 years (1962-1975), respectively, are shown in below.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Average (℃) Temperature	21.0	20.7	20.7	19.8	17.5	16.0	15.8	18.2	21.8	24.0	22.6	21.0	19.9
Average (mm) Precipitation	263.9	204.9	108.3	18.4	4.3	0.0	0.0	0.1	1.0	22.6	84.7	259.1	967.3

2-2-2 Vegetation

The vegetation of the area comprises forests with relatively tall trees of 15 m in height within smaller bushes, and savanna with sparsely distributed trees within grass. The forests are in areas of argillite and dolomite where soil is developed into deeper zones, while the savanna occurs in areas of hard rocks such as quartzite and basement complex where the soil is relatively shallow.

Chapter 3 General Geology

3-1 Geology and Mineralization of the Zambian Copperbelt

The present survey area belongs to the so-called Copperbelt of Africa. This belt extends for approximately 500 km in an arc from the border of Zambia and the southern end of Zaire in the east to the border of Zambia and Angola in the west. This constitutes a metallogenic province of about 80 km in width.

The geology of this belt mainly comprises early to middle Precambrian basement complex and late Precambrian Katangan Supergroup.

The basement of the Zambian Copperbelt comprises the early Precambrian Lufubu Supergroup consisting mainly of schist and gneiss, granitic bodies (1975 Ma) intruded into the Lufubu Supergroup, and the middle Precambrian Muva Supergroup consisting mainly of quartzite and quartz mica schist(Figs. 1-2 and 1-4). Widespread low-grade copper mineralization is known to occur in these granitic bodies.

The basement complex is overlain by the Katangan Supergroup with marked unconformity. The Supergroup is divided into the Lower Roan Group consisting mainly of conglomerate, sandstone and mudstone with talus and aeolian deposits at the base, the Upper Roan Group consisting mainly of dolomite and dolomitic mudstone including anhydrite, the Mwashia Group consisting mainly of dolomite and shale, and the Kundelungu Group containing glacier deposits, the every Group being conformable to each other. The ore deposits occur as platy bodies within the mudstone and sandstone near the boundary of Upper and Lower Roan Groups (Fig. 1-4).

The Lower Roan Group is further divided into three formations, namely, the Footwall, Ore and Hangingwall Formations. The Footwall Formation is the basal conglomerate unit, and mainly comprises conglomerate and arkosic sandstone. The Ore Formation consists mainly of shale, siltstone, quartzose sandstone and feldspathic sandstone with intercalations of dolomite and conglomerate. The Hangingwall Formation consists mainly of siltstone, quartzose sandstone and arkosic sandstone with intercalations of dolomite.

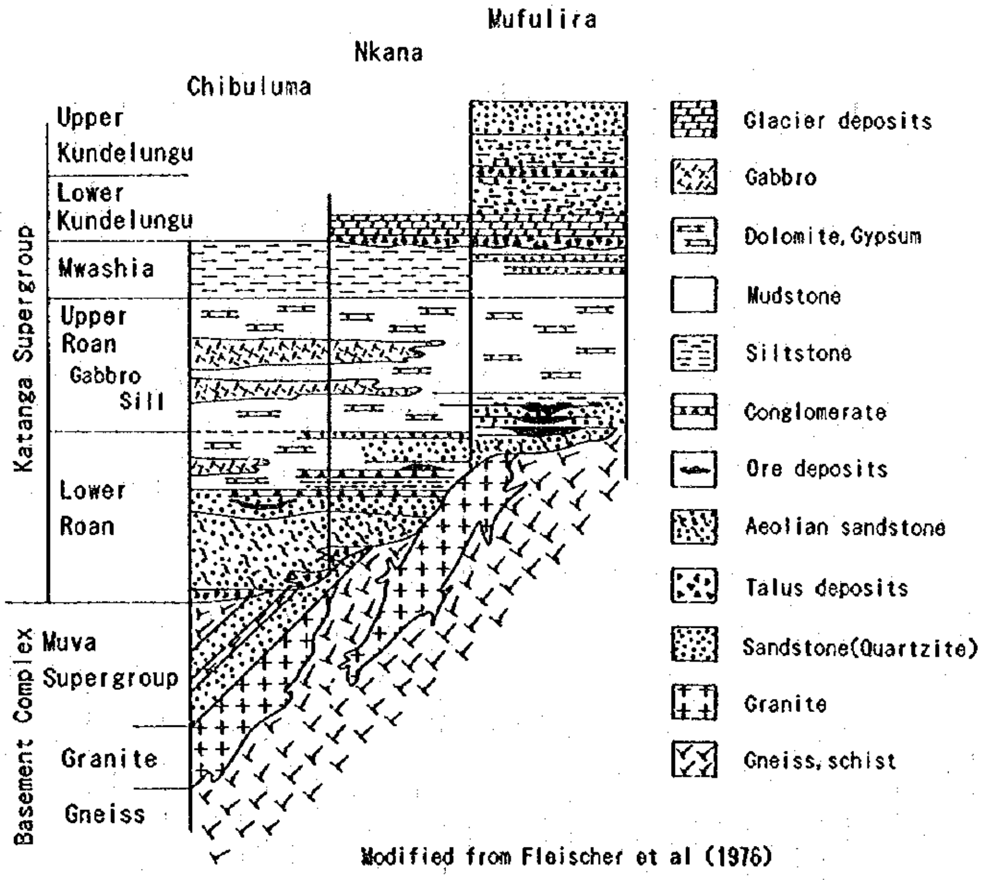


Fig. 1-4 Schematic Stratigraphic Columns of the Zambian Copperbelt

The Katangan Supergroup is distributed in an orogenic zone which is developed in an arc in northwest Zambia and extending into Zaire and Angola. Folds, klippe and thrust faults are developed in this zone, and it is called the Lufilian Arc. The geologic units of the Copperbelt were strongly folded with axis in the E-W to NW-SE direction by the late-middle Kundelungu (840 to 465 Ma) Lufilian Orogeny.

The Kafue Anticline trending in the NW-SE direction occur in the Zambian Copper Belt (Fig. 1-2). On the western side of this anticline, ore deposits such as Luanshya, Baluba, Nkana, Chambishi, Nchanga and Konkola occur in pelitic Ore Formation (Ore Shale), but also in footwall quartzite of the Ore Formation (Chibuluma, Nkana). On the other hand, on the eastern side, ore deposits such as Mufulira and Bwana Mkubwa occur in quartzites of the Mufulira Syncline and the Ore Shale Formation is not recognized. Therefore, the complete stratigraphic correlation of orebodies is not possible. There are two theories regarding the ore-bearing horizon, namely in the Lower Roan Group and in the Upper Roan Group.

Characteristics of ore deposits in the Zambian Copperbelt are summarized as follows.

(1) Ore horizon: Most ore deposits occur in the Ore Formation of the Lower Roan Group, and are clearly stratigraphically controlled.

(2) Shape of ore deposit: Ore deposits including the intensely folded ones in the Chambishi and Roan-Muliashi Basins are stratiform, and conformable with the host rocks. Size of ore deposits is 5 to 55 m in thickness, several kilometers in length and several hundred metres in width. Most of the ore deposits have one ore horizon while those of Nchanga have two and Mufulira and Bwana Mkubwa ore deposits have three ore horizons.

(3) Host rocks: The mineralization in the area west of the Kafue Anticline is hosted in argillite, sandstone or impure dolomite. On the other hand, those in the area east of the Anticline are hosted in sericitic quartzite or graywacke.

(4) Alteration of host rocks: Biotitization, sericitization and

silicification are reported. However, the relation between these alteration and mineralization is not clear.

(5) Ore minerals: Pyrite, chalcopyrite, bornite and chalcocite occur as major primary ore minerals. These are accompanied by minor primary minerals such as pyrrhotite, covelline, digenite, carrollite, linnaeite, cobalt pentlandite, Cu-bearing pyrite, molybdenite, scheelite, wolframite, uraninite. Of these, cobalt minerals occur in the Chambishi, Nchanga, Nkana and Baluba ore deposits, and uraninite in the Nkana-Mindola ore deposit.

Malachite, chrysocolla, azurite, cuprite, tenorite, chalcocite, bornite, covelline, native copper, asbolite and heterogenite are present as secondary ore minerals.

(6) Gangue minerals: Biotite, sericite, quartz, feldspar, dolomite, calcite, scapolite and anhydrite occur as major gangue minerals. Chlorite, carbonaceous material, tourmaline, apatite, rutile, tremolite, talc, sphene, epidote, zircon and hematite occur as subordinate gangue minerals.

(7) Zorning of sulfide minerals: A horizontal zoning is recognized at most of the ore deposits, and have a nearly constant tendency, i.e., ore deposits distributed in the Ore Shale show the zoning of barren zone → chalcocite → bornite → chalcopyrite → pyrite from northeast southwestward (away from the basement areas). Ore deposits in quartzite show a zoning consisting of pyrite at the central part and chalcopyrite and bornite at the periphery. A vertical zoning is also recognized at most of ore deposits.

(8) Occurrence of ore: Depositional structures such as cross-bedding and slumping are observed in ore.

3-2 Geology and Mineralization of the Survey Area

The following discussion is based on Fleischer (1983), ZCCM data and results of this survey.

Geological map, generalized columnar section, geological section line and geological sections are shown in Figures 1-5, 1-6, 1-3 and 1-7, respectively. Geology of the survey area is

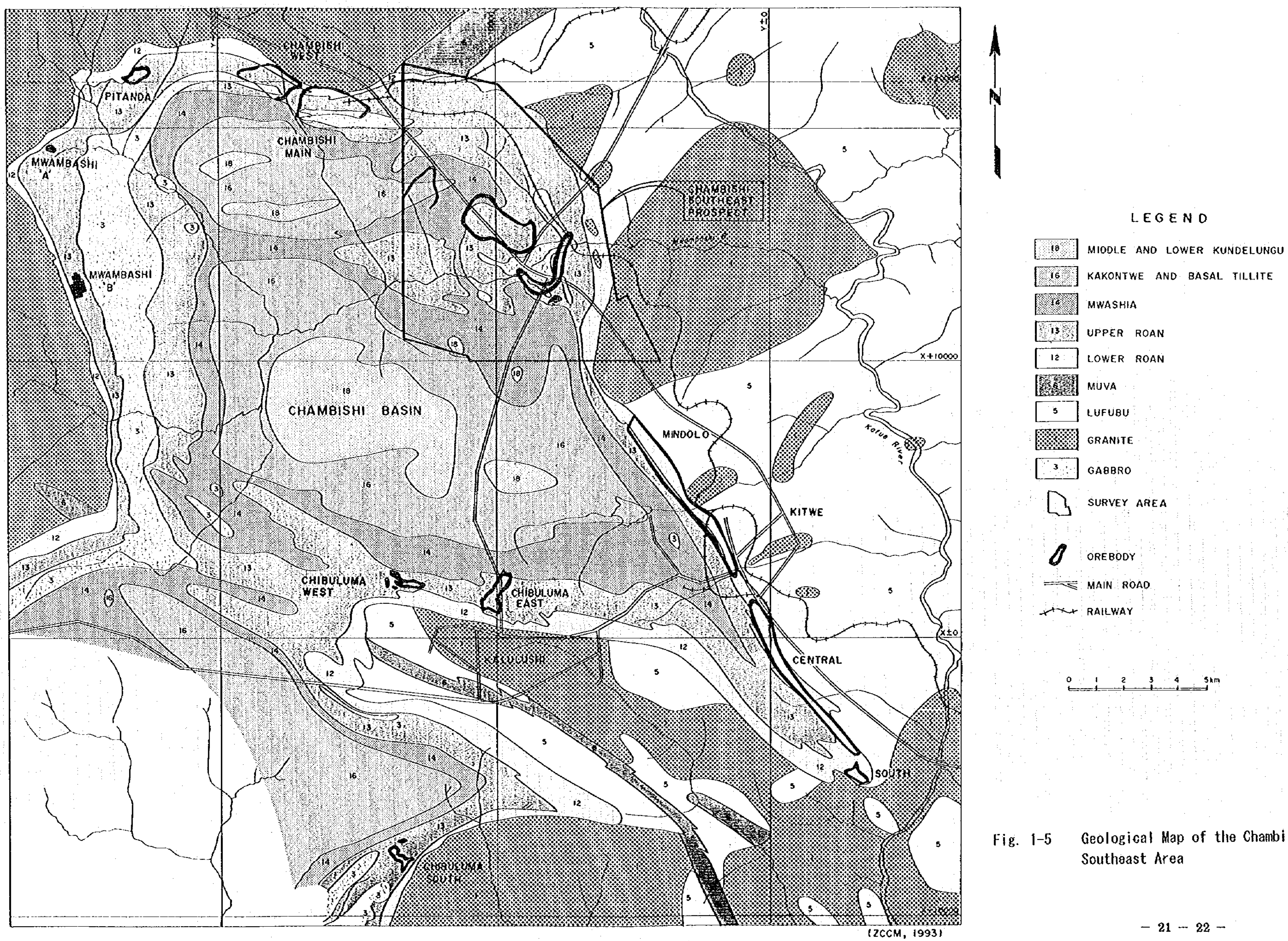


Fig. 1-5 Geological Map of the Chambishi Southeast Area

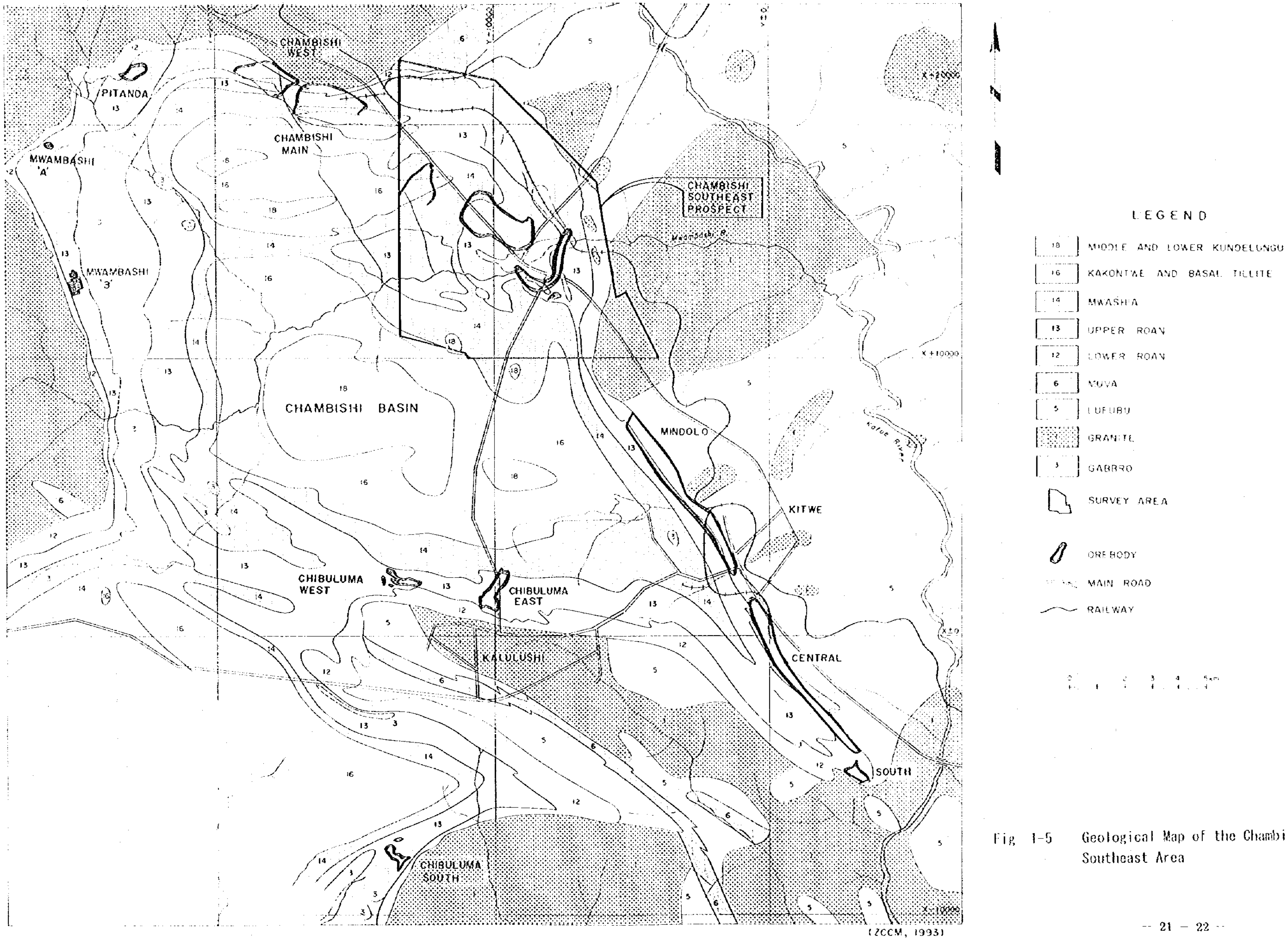


Fig. 1-5 Geological Map of the Chambishi Southeast Area

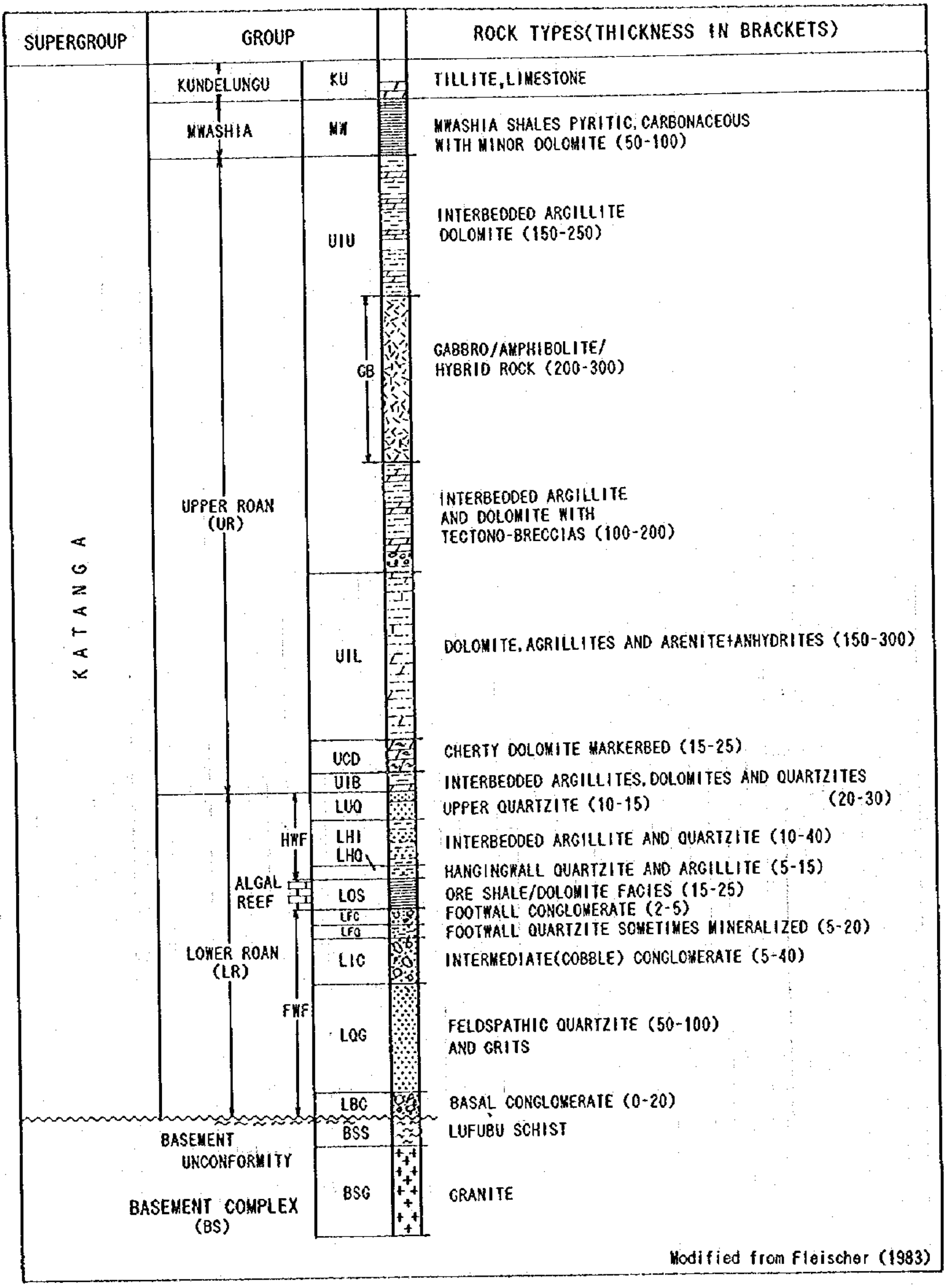


Fig. 1-6 Generalized Stratigraphic Section through Chambishi Southeast

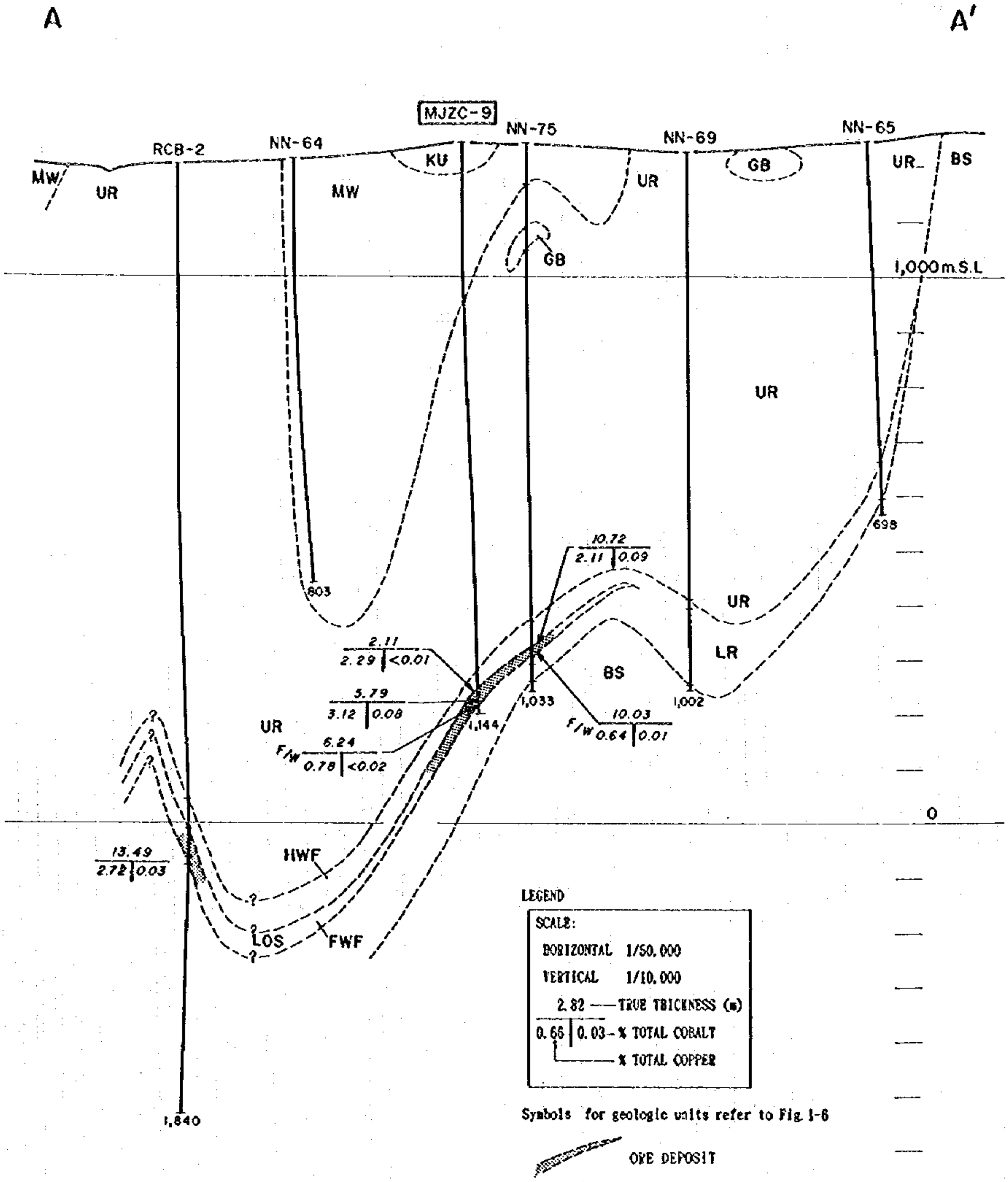


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area (1)

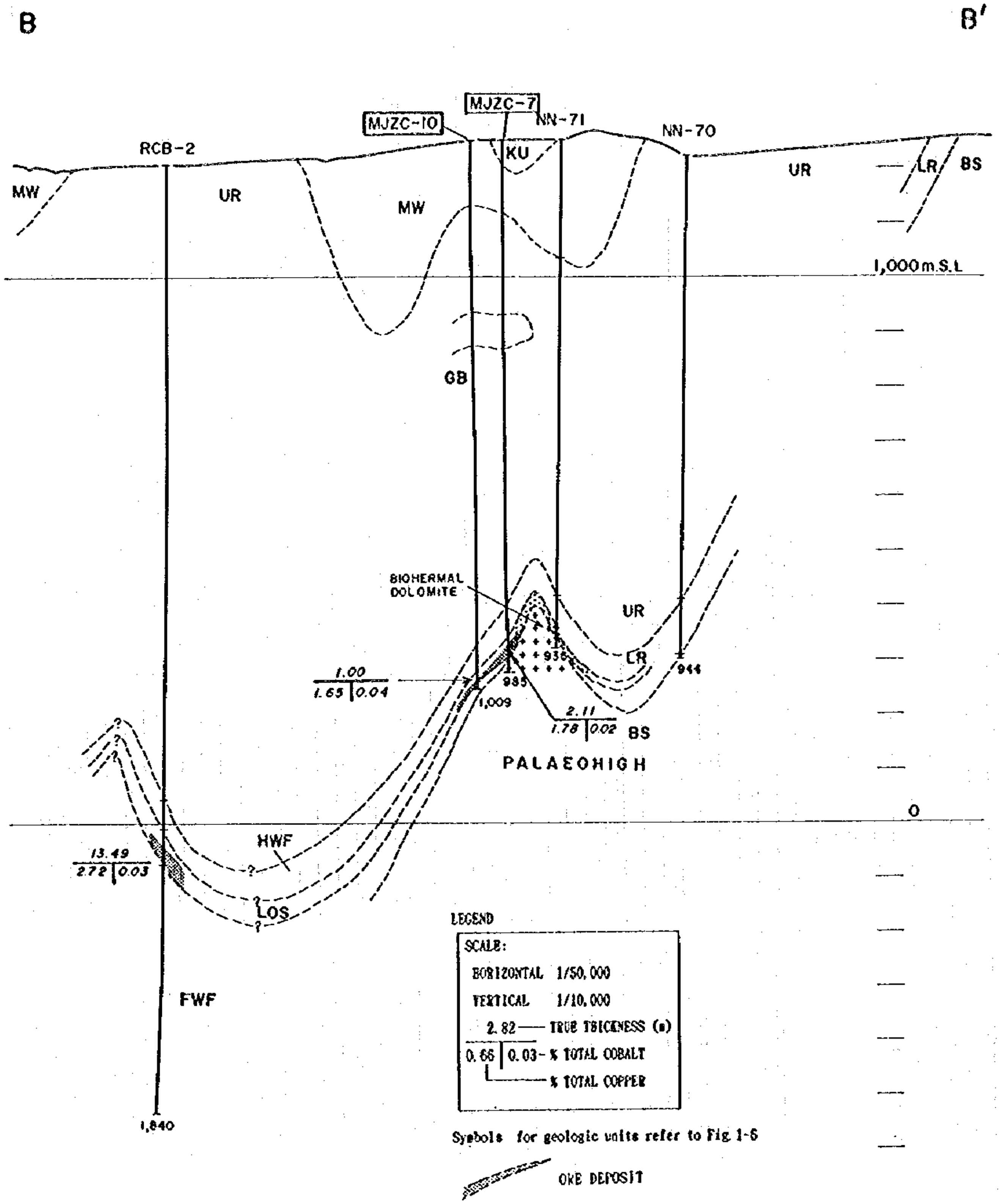


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area (2)

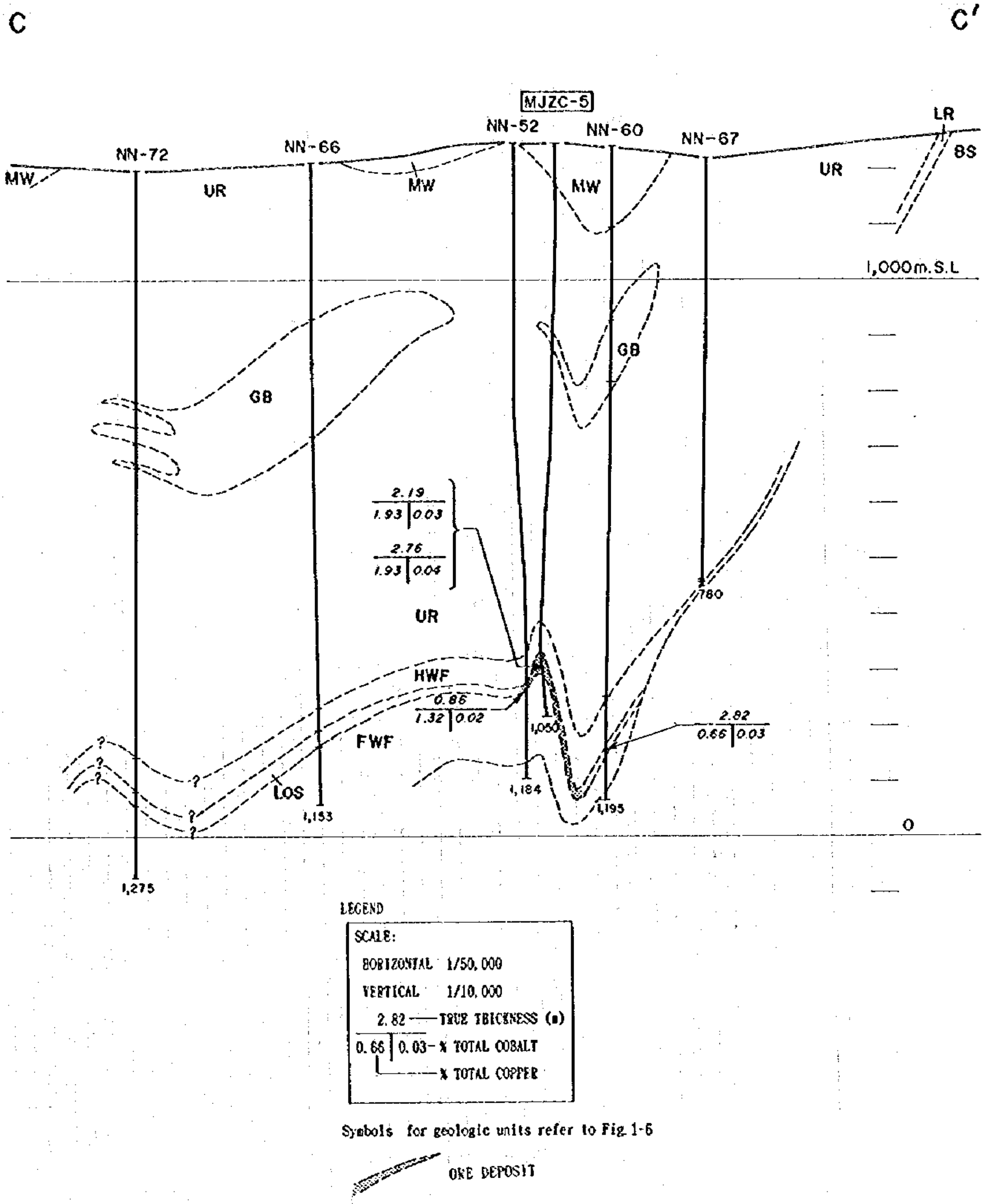
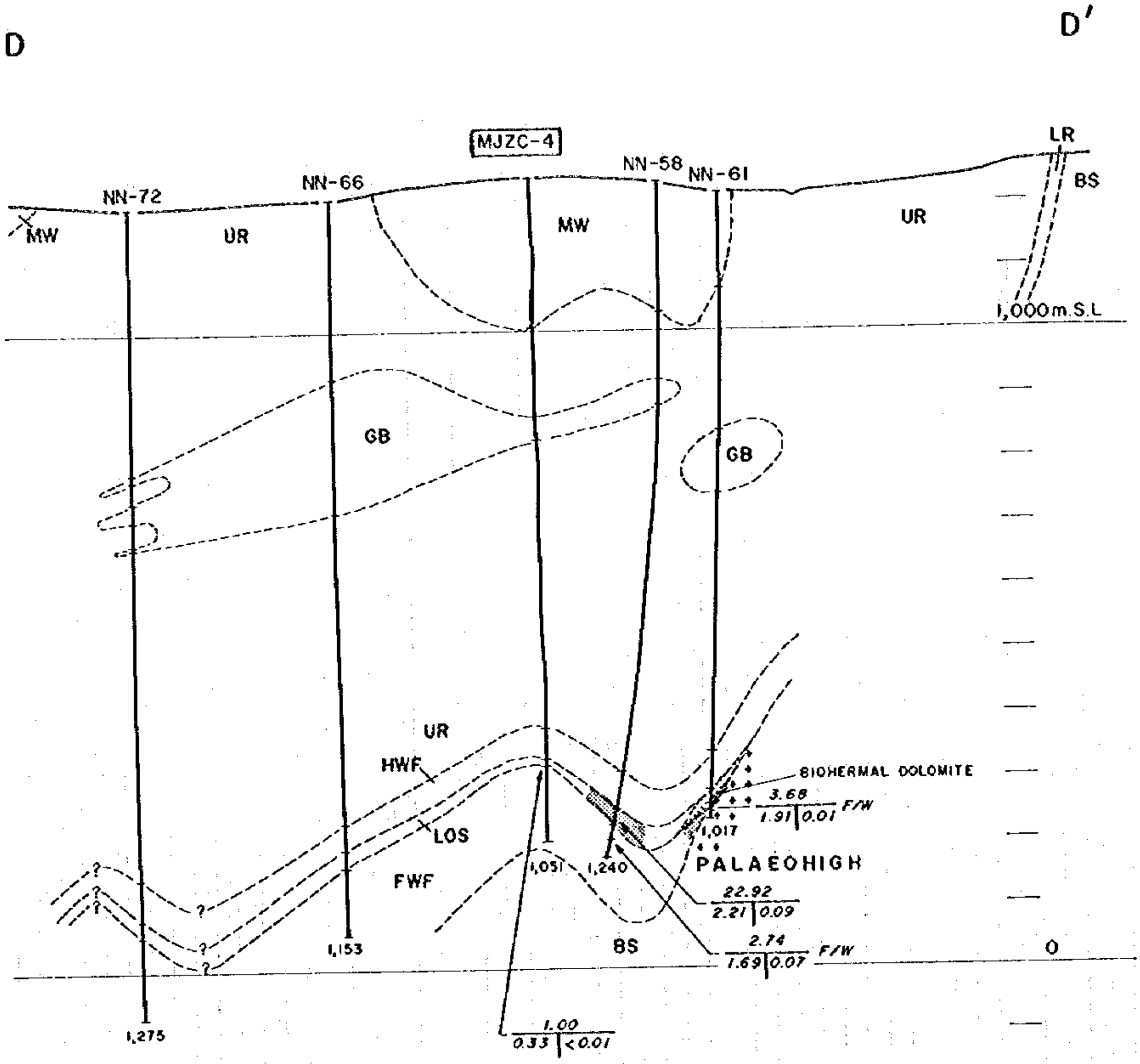


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area(3)



LEGEND

SCALE:

HORIZONTAL 1/50,000

VERTICAL 1/10,000

2.82 —TRUE THICKNESS (m)

0.66 | 0.03 --% TOTAL COBALT

% TOTAL COPPER

Symbols for geologic units refer to Fig. 1-6

ORE DEPOSIT

Fig. 1-7 Geological Profiles of the Chambishi Southeast Area(4)

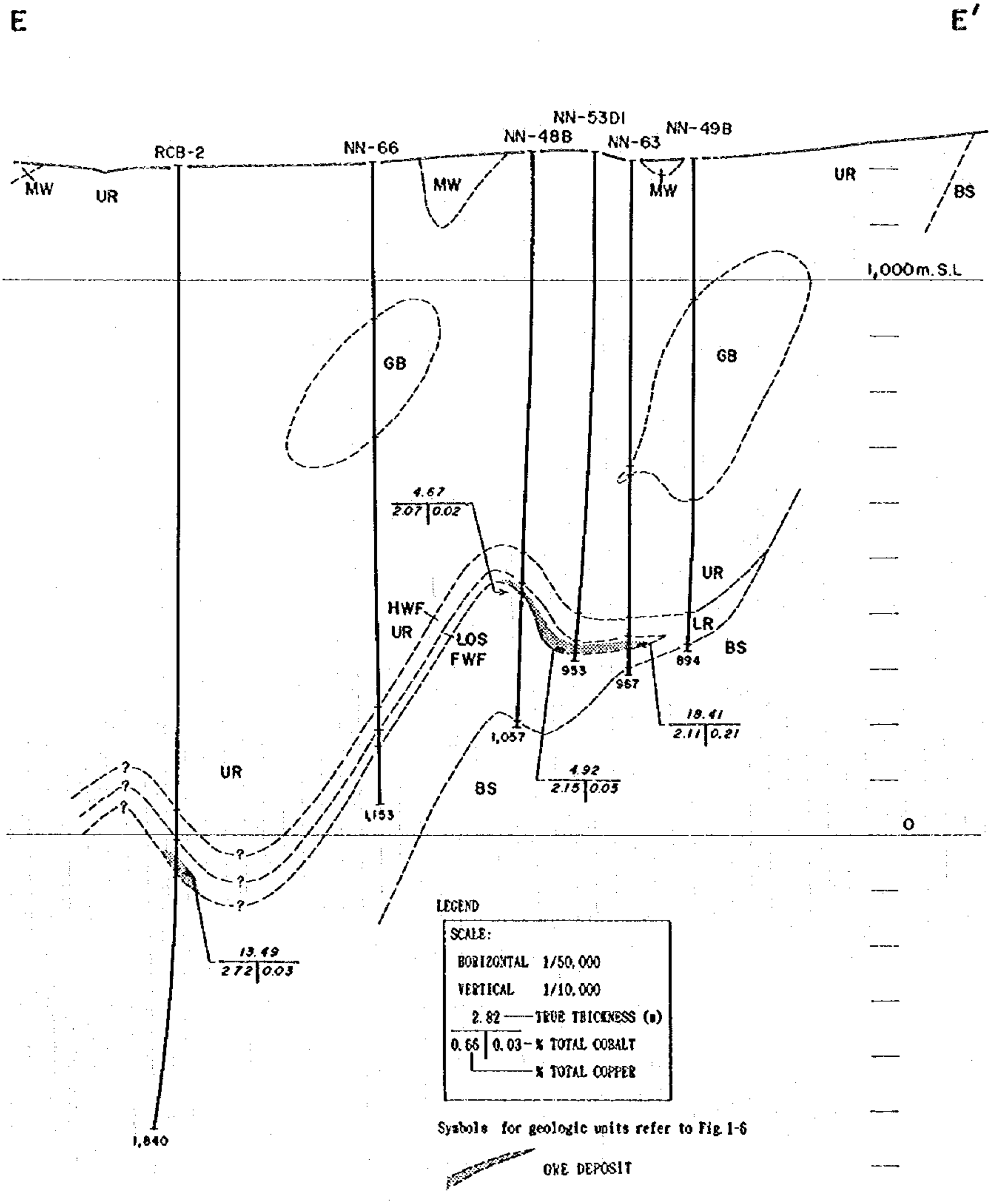


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area(5).

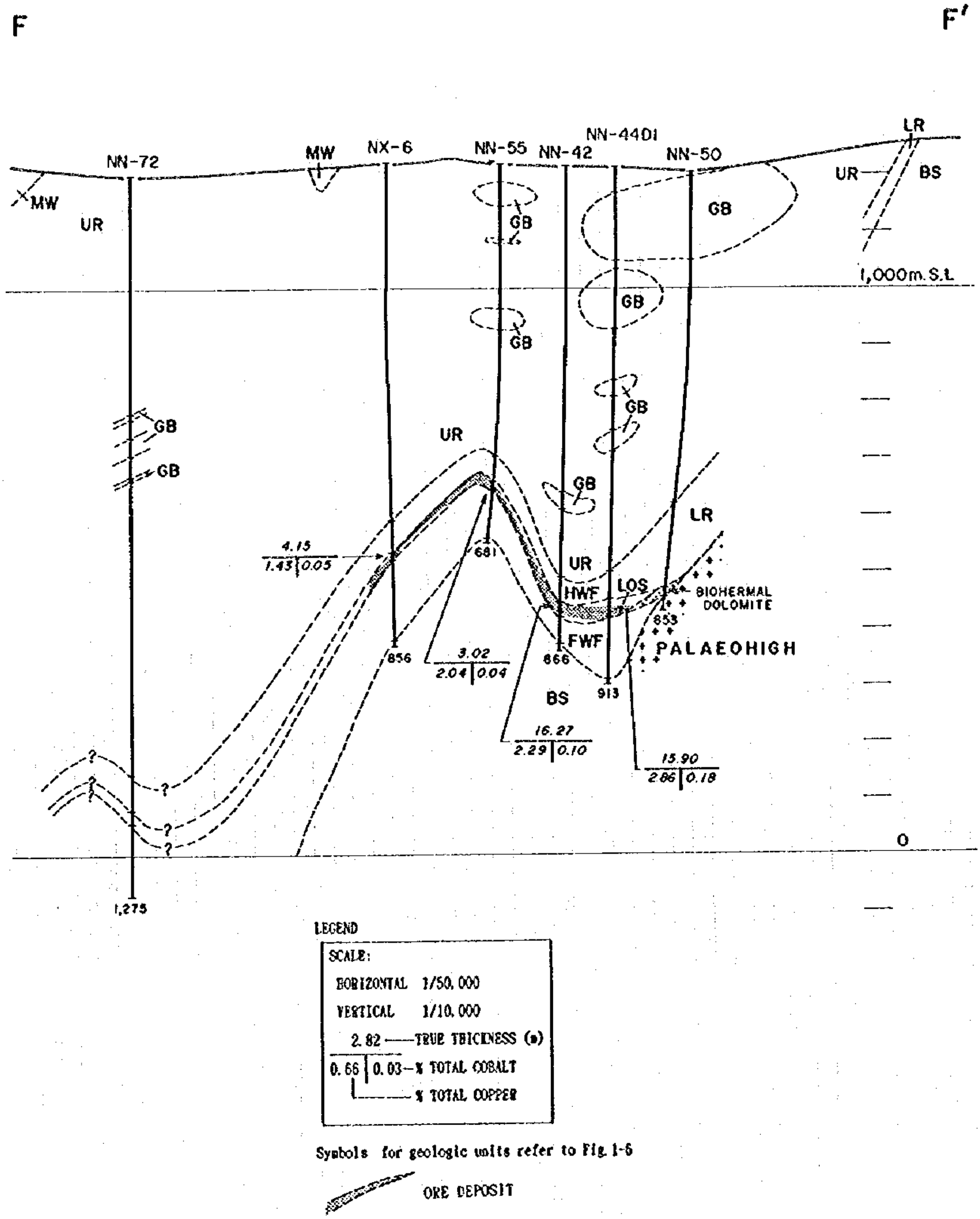


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area (6)

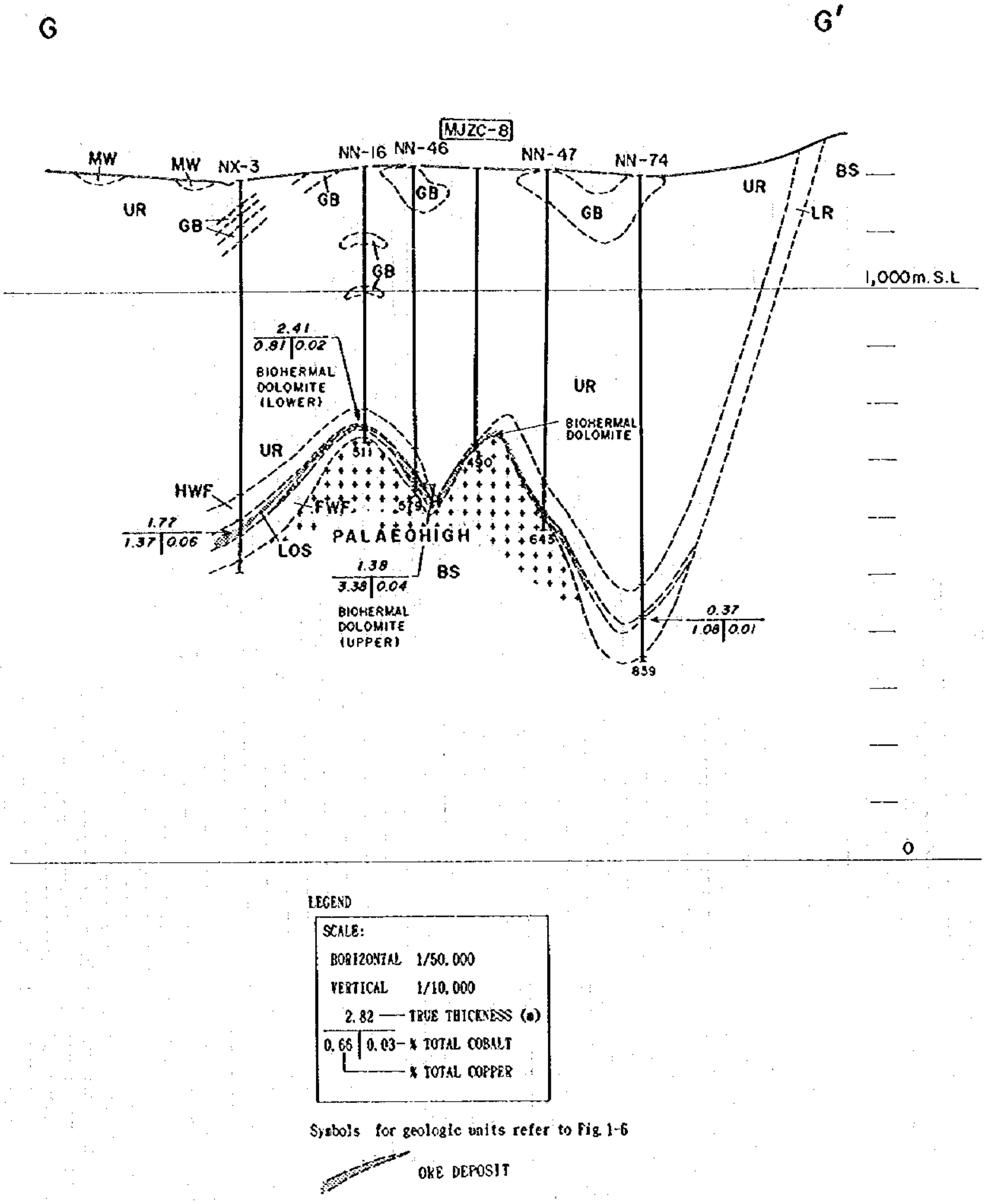


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area(7)

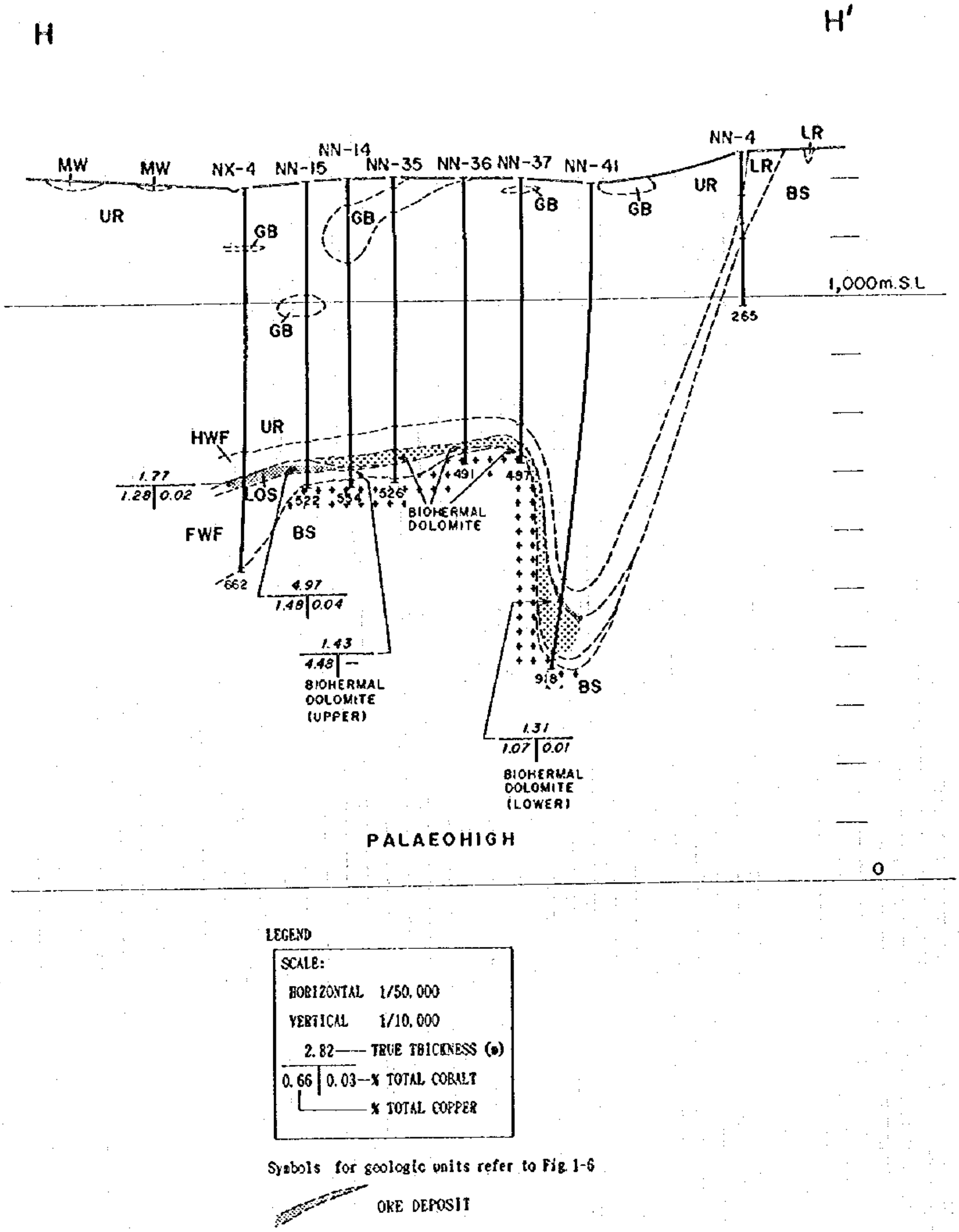
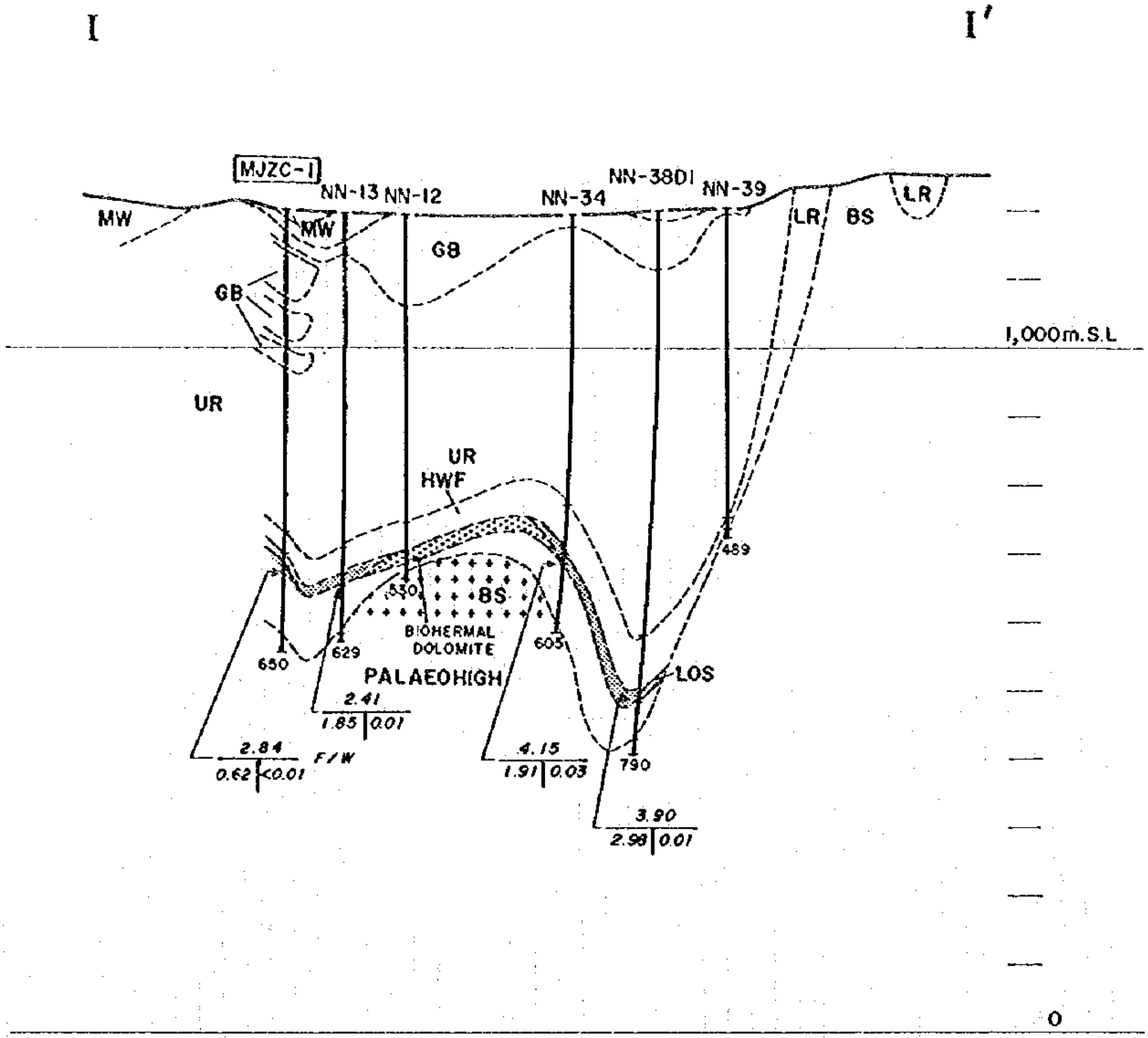


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area (8)



LEGEND

SCALE:

HORIZONTAL 1/50,000

VERTICAL 1/10,000

2.82 — TRUE THICKNESS (m)

0.66 | 0.03 — % TOTAL COBALT

— % TOTAL COPPER

Symbols for geologic units refer to Fig. 1-6

ORE DEPOSIT

Fig. 1-7 Geological Profiles of the Chambishi Southeast Area (9)

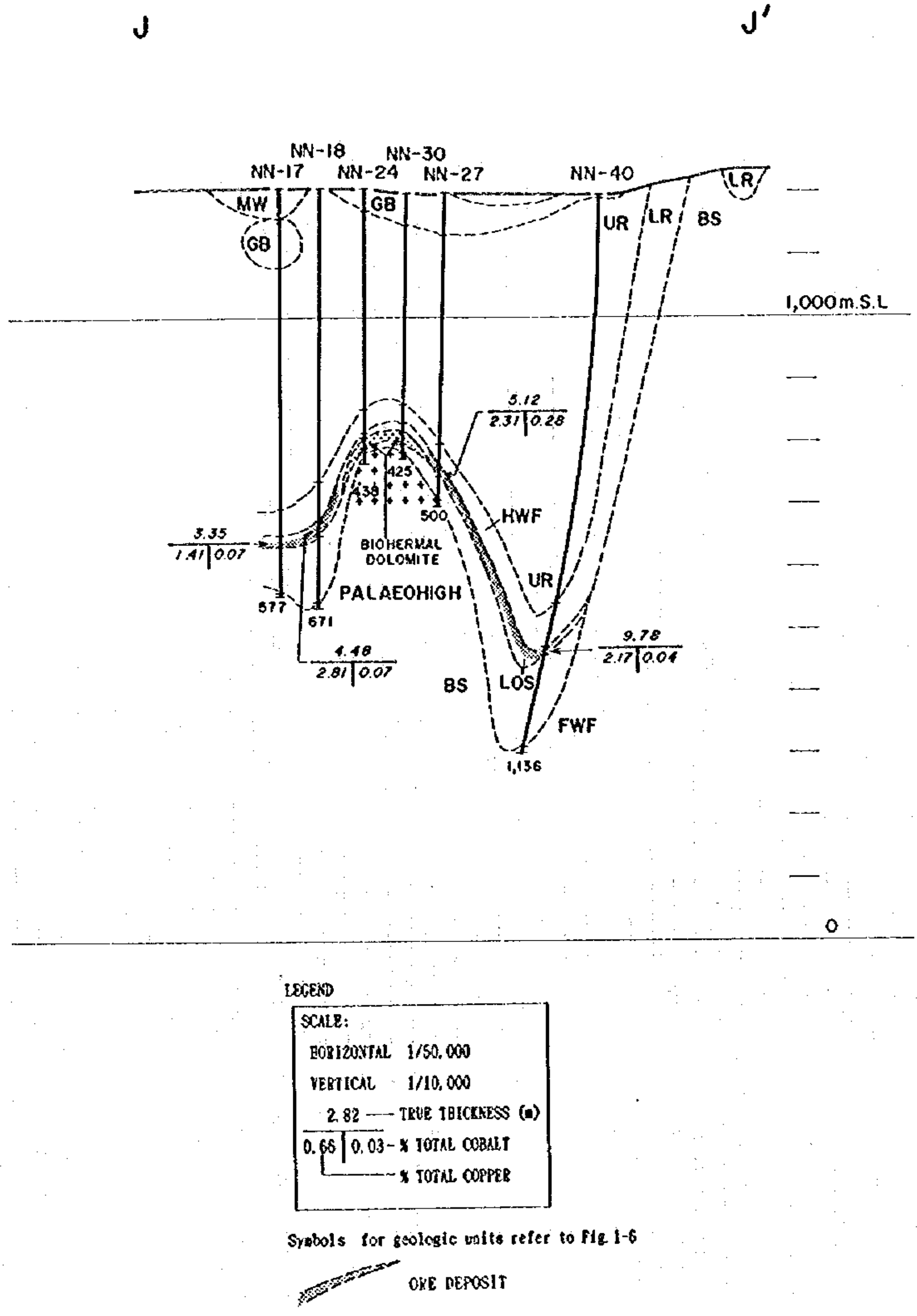
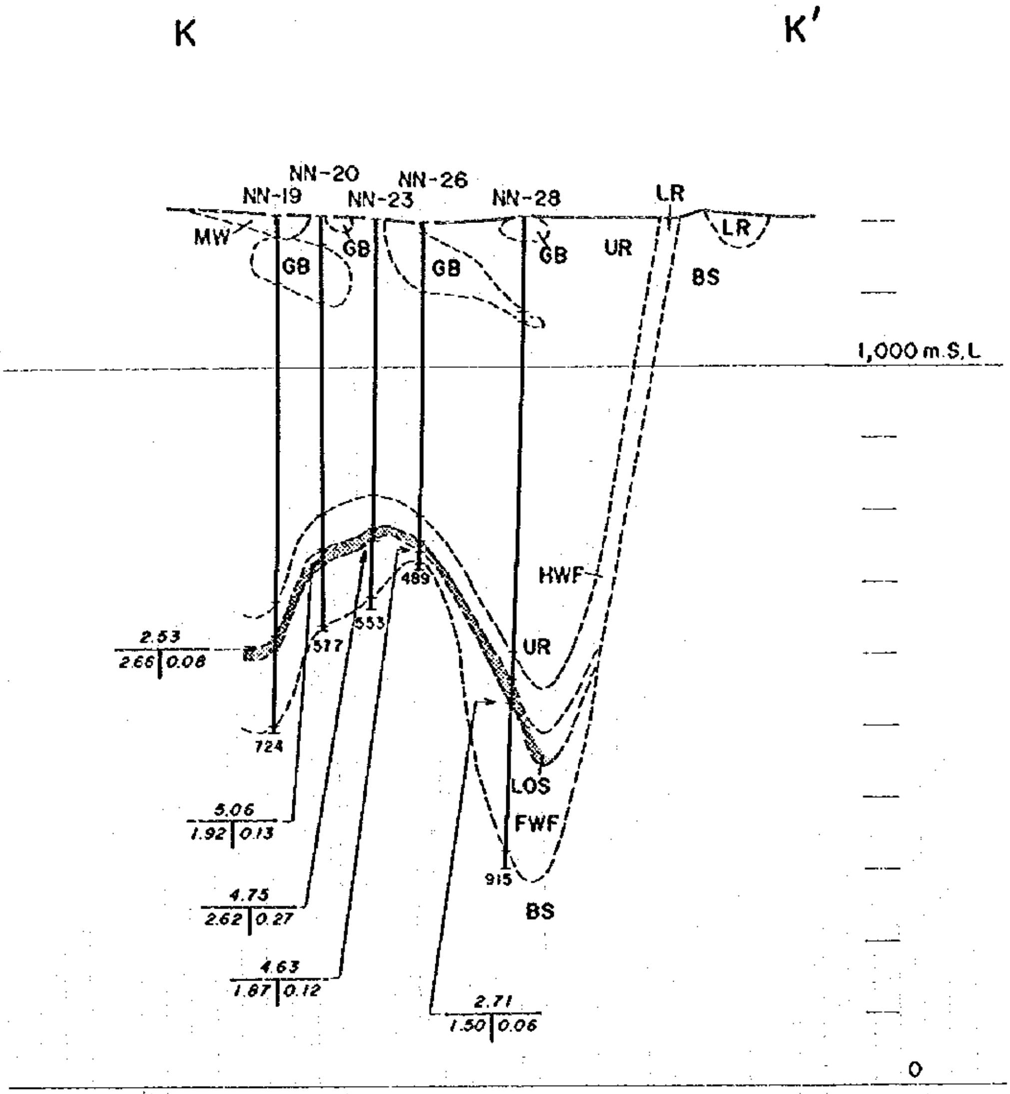


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area(10)



LEGEND

SCALE:
HORIZONTAL 1/50,000
VERTICAL 1/10,000
2.82 —— TRUE THICKNESS (m)
0.65 | 0.03 — % TOTAL COBALT
└—— % TOTAL COPPER

Symbols for geologic units refer to Fig. 1-6

ORE DEPOSIT

Fig. 1-7 Geological Profiles of the Chambishi Southeast Area(11)

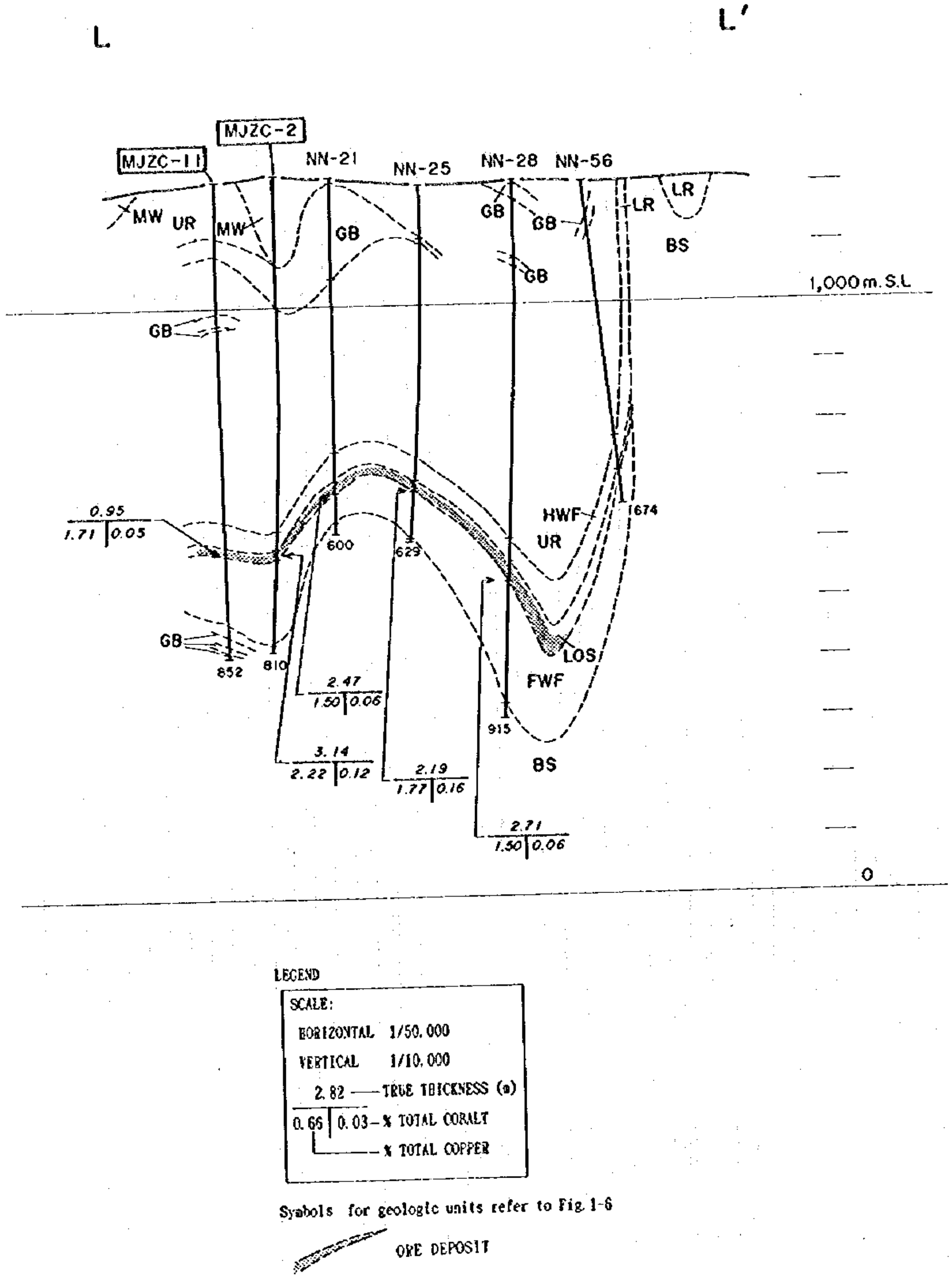


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area(12)

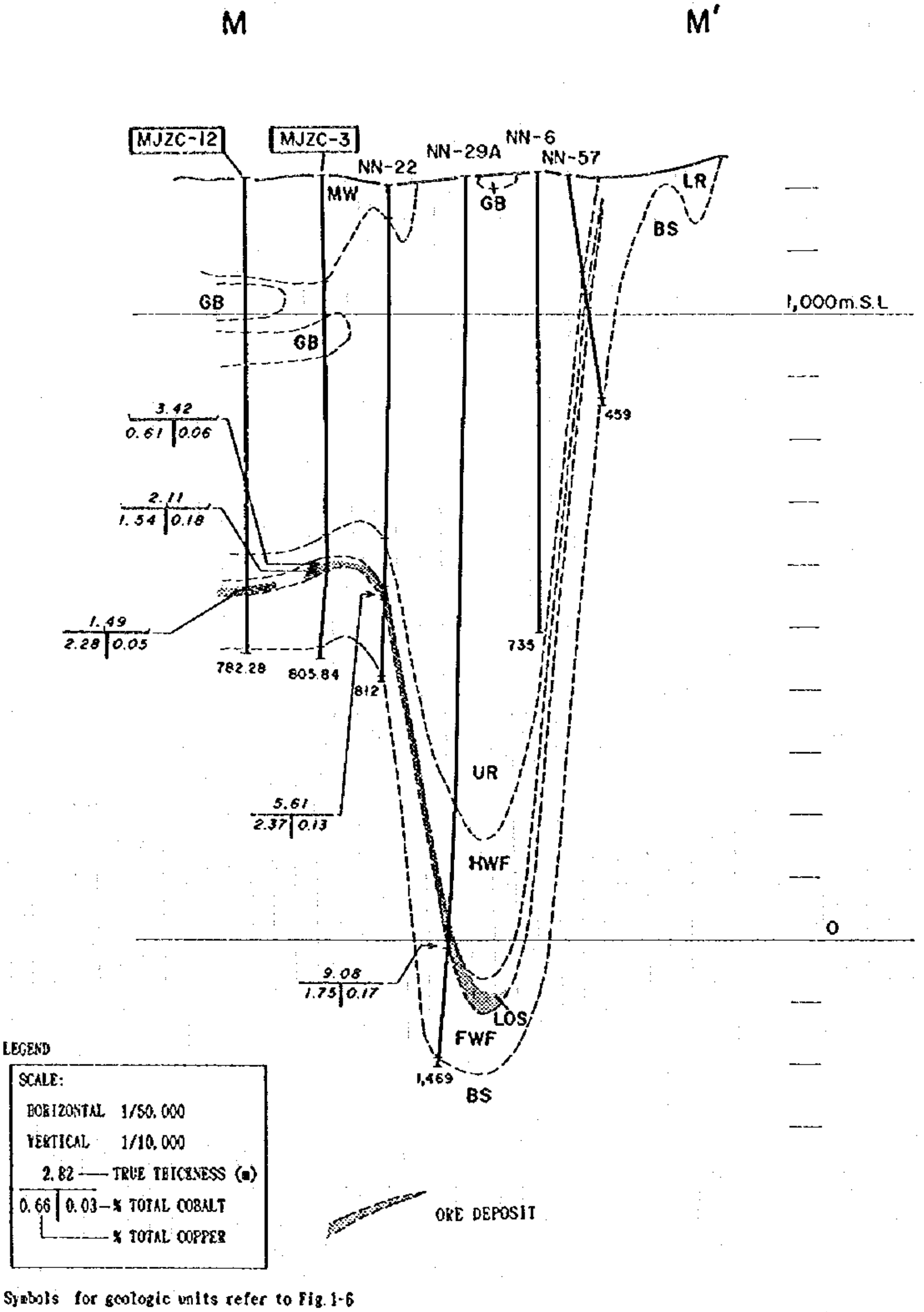


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area(13)

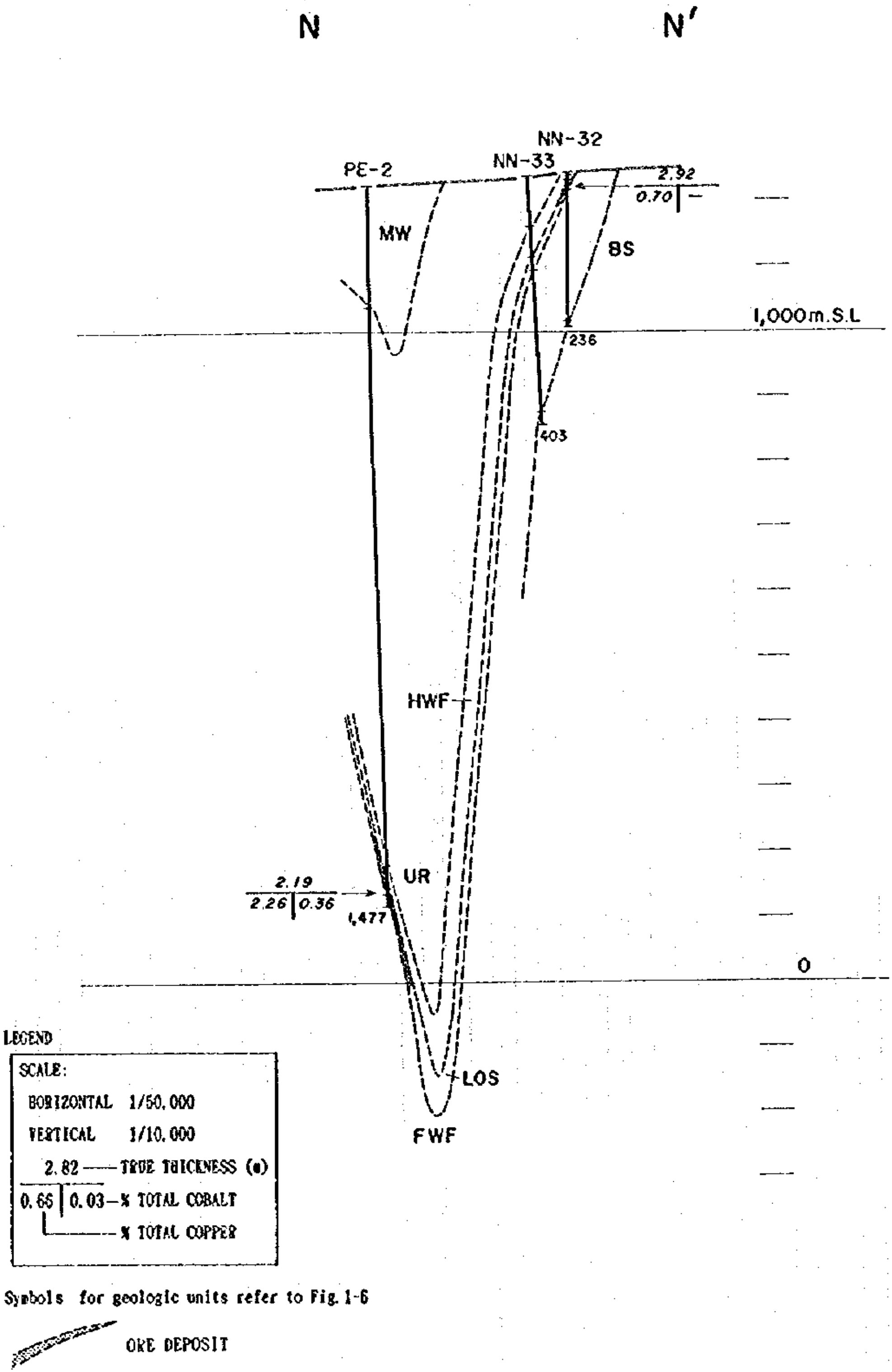


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area(14)

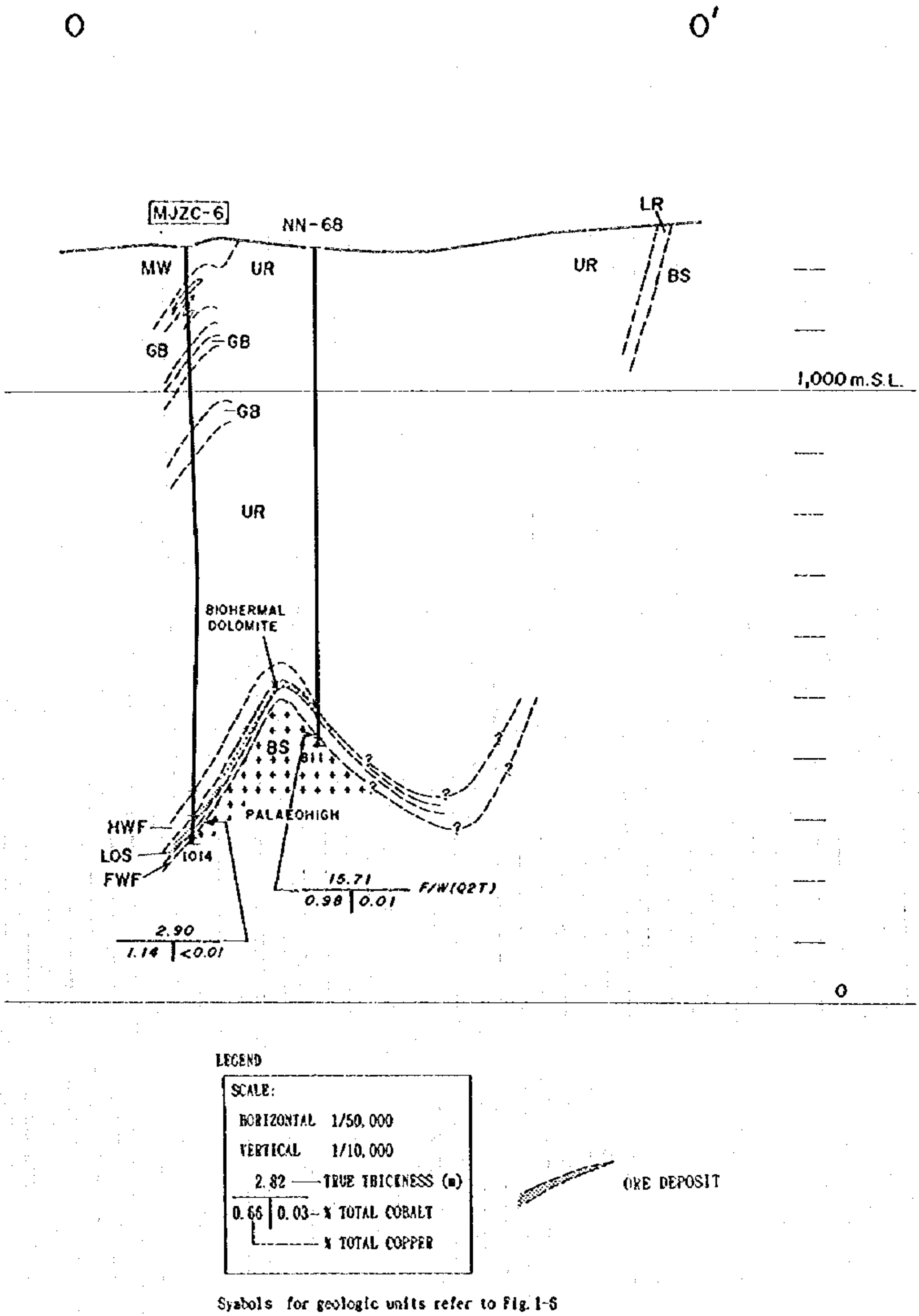


Fig. 1-7 Geological Profiles of the Chambishi Southeast Area(15)

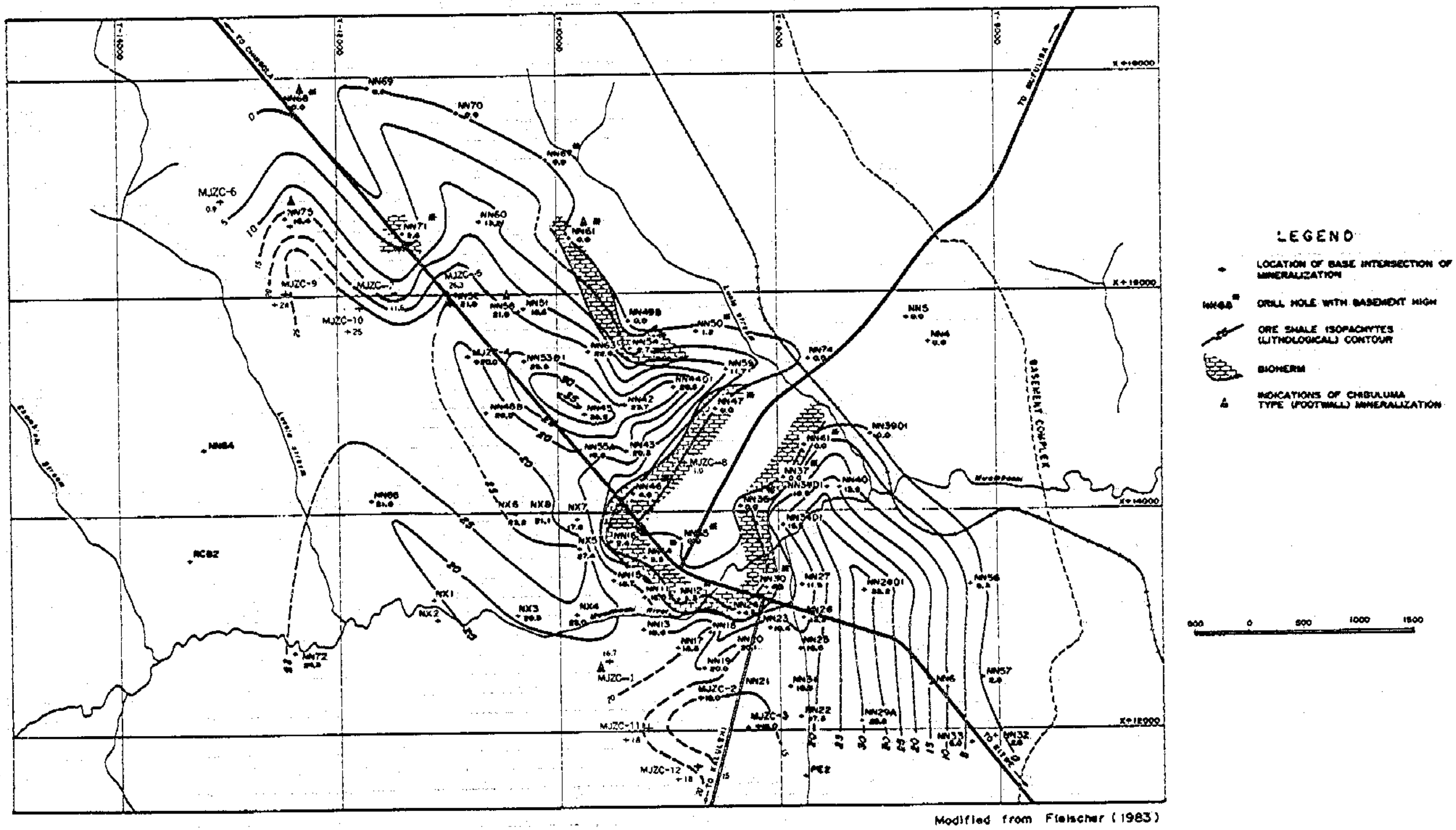


Fig. 1-8 Ore Shale Isopach Map

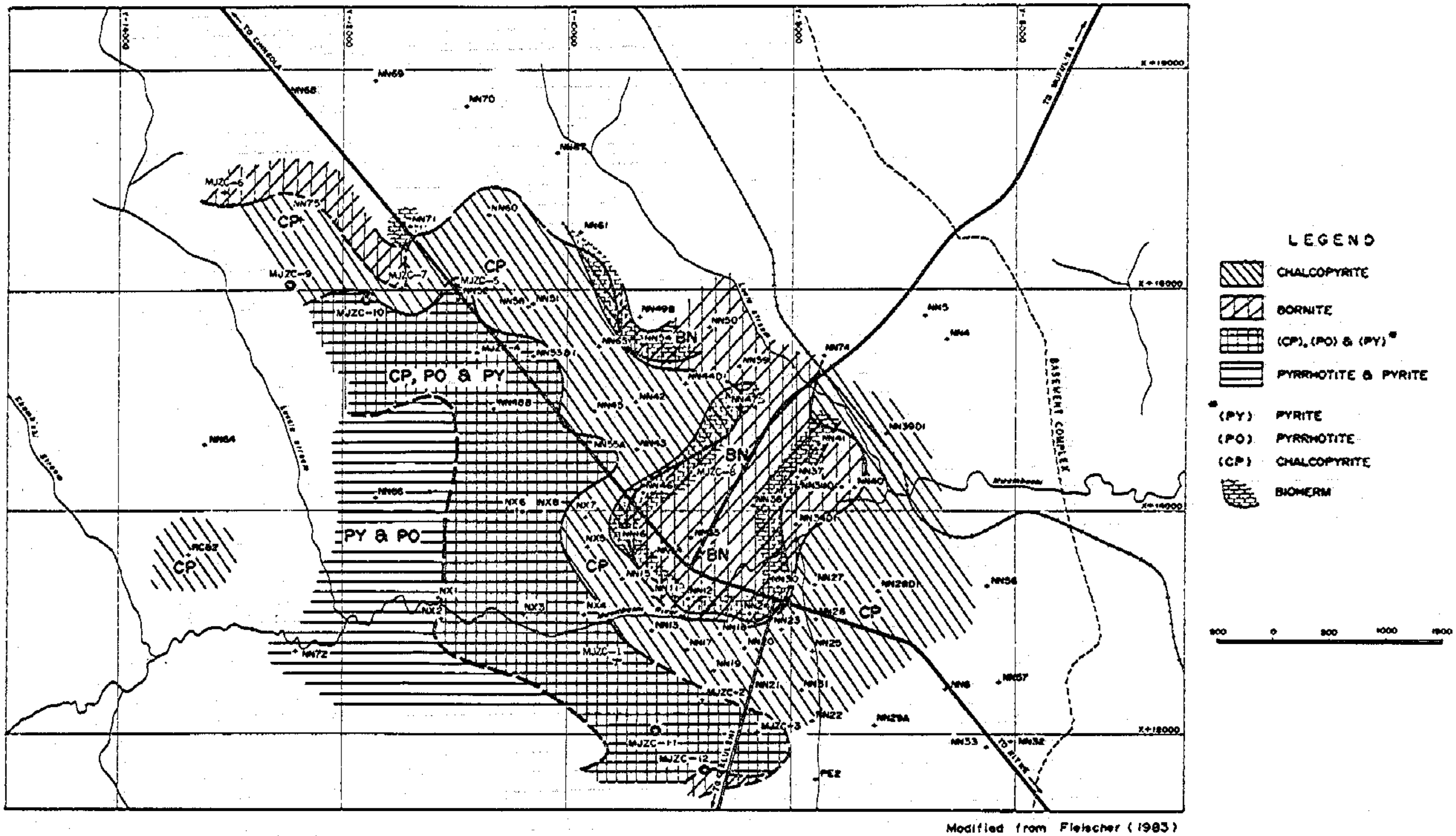


Fig. 1-9 Sulfide Mineral Zoning

composed of the Basement Complex and the Katangan Supergroup.

The Basement Complex consists of the Lufubu Schist consisting of schist and gneiss, granites intruded in the Schist, and quartzite of the Muva Supergroup. Schist, gneiss and quartzite are mainly composed of quartz and biotite with subordinate feldspar and chlorite. The granites are mainly composed of quartz, feldspar and biotite.

The Katangan Supergroup is divided into the Lower Roan, Upper Roan, Mwashia and Kundelungu Groups in ascending order and gabbroic sill, and every Group is conformable to each other.

The Lower Roan Group unconformably overlies the Basement Complex, and comprises "Basal Conglomerate", "Feldspatic Quartzite and Grits", "Intermediate Conglomerate", "Footwall Quartzite", "Footwall Conglomerate", "Ore Shale Horizon", "Hangingwall Quartzite and Argillite", "Interbedded Argillite and Quartzite" and "Upper Quartzite" in ascending order. Of these, units lower than the "Ore Shale Horizon", the Horizon itself and units higher than the Horizon are called the "Footwall", "Ore" and "Hangingwall" Formations, respectively.

"Ore Shale Horizon" is made up of argillite and/or dolomite. Because of the presence of stromatolite in the dolomite, the dolomite-dominated part has been considered to be bioherm.

The Upper Roan Group is divided into "Interbedded Argillite, Dolomite and Quartzite", "Cherty Dolomite", "Arenite, Argillite and Dolomite with Anhydrite" and "Interbedded Argillite and Dolomite with Tectono-Breccias" in ascending order. Of these, "Cherty Dolomite" has an intercalation of argillite (Marker bed), and is treated as a key bed.

The Mwashia Group is mainly composed of black shale, green argillite and dolomite.

The Kundelungu Group consists of tillite comprising many kinds of erratic boulders (mainly argillite, dolomite and quartzite, rarely granite and quartz veins) at the basal part, and the upper limestone. It is correlated to the Lower Kundelungu Group.

Gabbro is usually present as sill in the Upper Roan Group, and is considered to have been intruded at the early stages of the Lufilian Orogeny (Mendelshon, 1961). Most of the gabbroic bodies in this area are called amphibolite because of the lack of pyroxene and olivine, and are mainly composed of plagioclase, hornblende, quartz and scapolite (in part) with subordinate epidote, apatite, sphene, biotite and chlorite. By the intrusion of the gabbro, argillite and dolomite were metamorphosed to hornfels and also to chloritized and silicified rocks (called "Hybrid Rocks"). On the other hand, typical skarn minerals do not occur in the carbonate rocks near the gabbroic bodies.

The Katangan Supergroup and Basement Complex in the survey area were regionally metamorphosed to greenschist facies. The metamorphism is considered to have occurred during the Lufilian Orogeny. The Lufubu Schist of the Basement Complex has been metamorphosed to a higher degree than the Katangan Supergroup, and its major constituents are biotite and sericite. Banded structure has been developed in this unit. Metamorphic minerals generally observed in the Katangan Supergroup are biotite, chlorite, tremolite, talc, sericite and albite.

The survey area is located in the northeastern margin of the Chambishi Basin on the southwestern limb of the Kafue Anticline. The strata of the Basin are folded and, on the whole, they tilt gently toward the centre of the Basin with an overall angle of about 10°. Folded structure with E-W trending axis occurs in the western part of the survey area, and WNW-ESE to NNW-SSE trending folds in the southern part.

In the Basin, the Basement Complex which forms the Kafue Anticline, is generally tilted to the southwestern side. But the Complex is partly undulating, and basement highs occur in the central part (around the junction of the Chingola-Kitwe main road and the Mufulira road) and the northwestern part of the survey area. In parts between these basement highs, local basins extending in the NW-SE direction are formed. A trough extending in an N-S direction is present to the east of the central basement high (Figs. 1-7 and 1-10).

Dolomite-dominated zones (bioherm) in the Ore Shale Horizon occur on the above basement highs and on local basins and troughs formed at the limbs of the basement highs (Fig. 1-7).

The formations of the Lower Roan and Upper Roan Groups above the basement have folded structures harmonious with relief of the basement, but they abut on the basement at the limbs of the Kafue Anticline in the northeastern part of the survey area, and also at the sides of the basement highs in the Chambishi Basin (Fig. 1-7).

The thick parts of argillite in the Ore Shale Horizon coincide with the above local basins and troughs on the basement (Fig. 1-8).

Ore deposits confirmed by drilling in the survey area, are shale-type copper deposits, typical of the Copperbelt. Occurrence of the ore deposits is as follows.

(1) Shape of ore deposit: One deposit (Northern Area Shoot) occurs on the northwestern limb of the basement high located in the central part of the survey area, two deposits (Southern Area Shoot-I and II) are on the southeastern limb, and three holes (NN-75, MJZC-9 and RCB-2) caught high-grade ores in the western part of the survey area (Fig. 1-3). The deposits are bedded and occur in the Ore Shale Horizon. These are folded conformably to the host rocks. Size of the Northern Area Shoot is 5 to 23 m in thickness, over 2.5km along strike and about 1.5 km along dip. Size of the Southern Area Shoot-I is 5 to 10 m in thickness, about 1.5 km along strike and about 0.5 to 1.3 km along dip. Size of the Southern Area Shoot-II is 5 to 9 m in thickness, over 0.5 km along strike and about 1.5 km along dip. These ore deposits have one ore horizon, but chalcopyrite-mineralized zones are present in the Footwall Quartzite at NN-58, NN-61, NN-63 and NN-68 of the Northern Area Shoot and its vicinity, and under the basal part of the Ore Shale at NN-75.

(2) Host rocks: Argillite and dolomite.

(3) Alteration of host rocks: Biotitization, sericitization and silicification are recognized. However, relation between these alteration and mineralization is not clear.

(4) Ore minerals: Pyrite, chalcopyrite, bornite, chalcocite, pyrrhotite, carrollite and cobalt pentlandite occurs as major primary minerals. Cobaltian pyrite, linnaeite and cattierite occurs as rare primary minerals. Most of copper are from

chalcopyrite, but fair amount of bornite also exists. Most of cobalt are from carrollite, but cobalt pentlandite cannot be ignored.

(5) Gangue minerals: Dolomite, calcite, mica, quartz, feldspar and tourmaline are present as gangue minerals. Large amount of tourmaline is characteristic of this belt. The increase of sulfur in "Ore Shale horizon" and the presence of organic carbons after deposition of the Ore Shale are noted.

(6) Zoning of sulfide minerals: The following transition of mineral assemblage can be seen from the northeast to the southwest (away from basement areas); bornite → chalcopyrite → chalcopyrite-pyrrhotite-pyrite → pyrite-pyrrhotite. The occurrence of bornite coincides roughly with that of bioherm (Fig. 1-9).

(7) Occurrence of ore: The ores of the survey area have the typical characteristics of the Zambian Copperbelt deposits. The Fe-Cu-Co sulfide minerals are concentrated along bedding planes. Main occurrences of ore minerals are as follows.

- Thin concretion along bedding plans.
- Segregation parallel to bedding planes.
- Dissemination in host rocks.
- Rim of spotted dolomitic concretions.
- Inclusions in siliceous and dolomitic lenticular concretions.
- Irregular veinlets.

Breccia dike and convoluted lamination formed by liquefaction are observed in these ores, and the former is accompanied by chalcopyrite-spotted ores. Also dolomite, anhydrite, quartz and feldspar veins are present in the orebodies.

In addition to the above main mineralization, the following mineralization is recognized.

- Dissemination of chalcopyrite and pyrite in "Interbedded Argillite and Quartzite" of the Hangingwall Formation.
- Molybdenite at the basal part of "Cherty Dolomite" of the Upper Roan Group (NN-30).
- Micro-spotted chalcopyrite parallel to the bedding planes of "Cherty Dolomite".
- Chalcopyrite-pyrite-mica-dolomite-quartz veinlets and chalcopyrite dissemination developed partly in argillites of "Arenite, Argillite and Dolomite with Anhydrite" of the Upper

Roan Group.

- Pyrrhotite rim of dolomitic lens contained in shales of the Mwashia Group and boudinage or intensely disseminated pyrite in the shales.
- Pyrite-pyrrhotite rim of fragments contained in sedimentary rocks of the Kundelungu Group, and discontinuous thin beds and dissemination of pyrrhotite in the Group.

Chapter 4 Comprehensive Analysis of Survey Results

4-1 Characteristics of Geologic Structure, Mineralization, and Structural Control

As mentioned in the reports of the first and second year surveys, the most important factor which controlled the genesis of the shale-type mineralization of the Copperbelt is the palaeo-topography, namely the depth of the sea at the time of the deposition of the ores. The deposits were formed in the stagnant local marine basins. The grade is generally low or barren over the palaeo-basement highs at the time of the deposition. The results of the drilling which was carried out during the present year attest to the above (Fig. 1-10). Also the sulfide minerals of the mineralized zone show the following zonal distribution from the basement rock area outward; bornite -> chalcopyrite -> chalcopyrite-pyrrhotite-pyrite -> pyrite-pyrrhotite. This is interpreted to be the result of gradual increase of chemically reducing environment towards the off-shore at the time of deposition (Fig. 1-9). Most of the ore shoots of this area belong to the chalcopyrite sulfide zone.

The geological cross sections, contour map of the surface of the basement complex, and the ore shale isopach map and sulfide zonal distribution map (Fleischer, 1983) were revised in accordance with the findings of this year's survey (Figs. 1-7, 1-8, 1-9, 1-10).

The major revisions of the basement upper surface contour map are as follows. i. Existence of a NE-SW trending depression of the basement is inferred in the western part of the survey area. ii. Basement high between the Northern Area Ore Shoot and that of the Southern Area extends further southward than the map prepared last year, and also the existence of a NE-SW trending depression is inferred between MJZC-11 and MJZC-12.

MJZC-9 confirmed a relatively thick strong chalcopyrite mineralization within the "Ore Shale" and the quartzite of the footwall. Similar strong chalcopyrite mineralization is also confirmed in NN-75 to the north. On the other hand, MJZC-6 and MJZC-7 were drilled last year to the northwest and east of MJZC-9 and was concluded that these sites were located near the

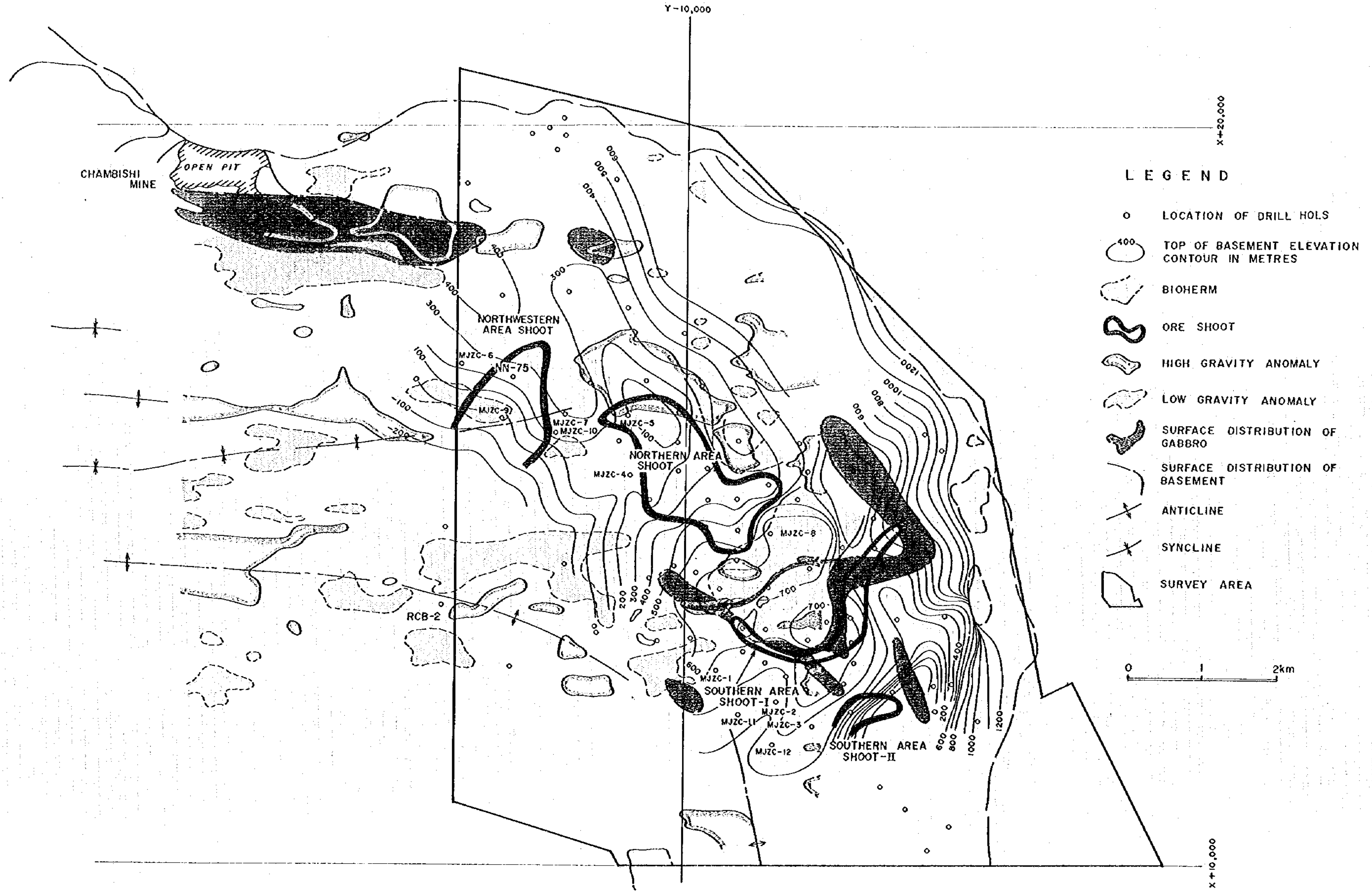


Fig. 1-10 Integrated Interpretation Map

Fig. 1-10 Integrated Interpretation Map

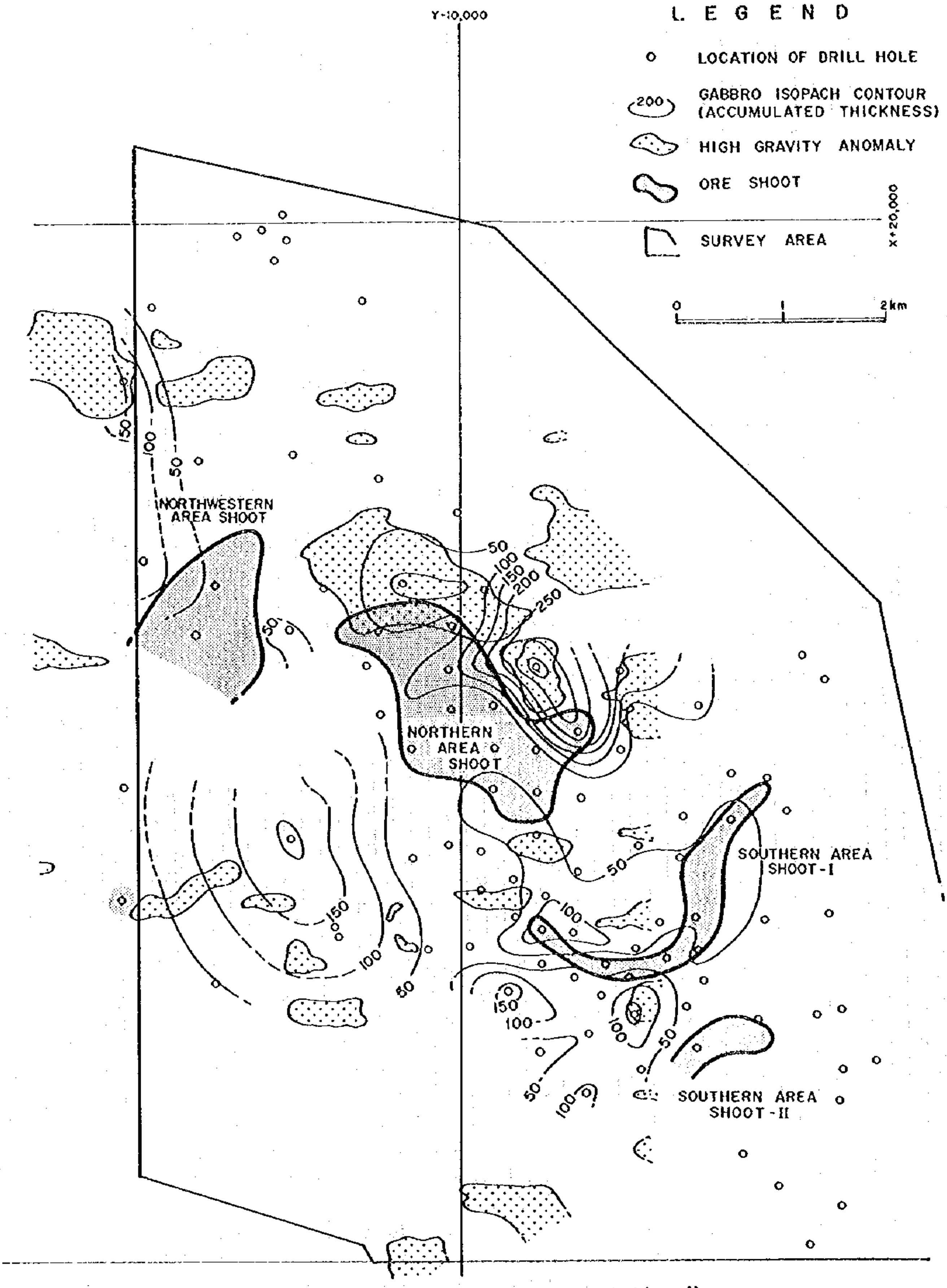


Fig. 1-11 Supplementary Interpretation Map

palaeo-basement high at the time of the deposition of the ore (Report of the Second Phase). Weak chalcopyrite mineralization was discovered within the "Ore Shale" and the footwall quartzite in MJZC-10 drilled to the east of MJZC-9 this year and pyrrhotite is strong in the "Ore Shale". "Footwall Formation" is very thin in MJZC-10. From the above it is concluded that the chalcopyrite shoots confirmed by MJZC-9 and NN-75 are one continuous orebody formed over the basement depression extending in approximately NE-SW direction.

MJZC-11 and MJZC-12 both confirmed the existence of strong pyrrhotite-pyrite mineralization and weak chalcopyrite mineralization within the "Ore Shale". Relatively high-grade bornite mineralization was found towards the bottom of the "Ore Shale" in the MJZC-12 hole. In both boreholes, the relatively copper-rich parts occur in the lower part of the "Ore Shale" whose upper part is rich in pyrrhotite-pyrite. Also the basement is relatively shallow and the "Footwall Formation" thick at both sites. The above type of mineralization and geologic environment have been confirmed by previous surveys and drillings near the sites, and thus it is inferred that; in the southern part of the survey area, environment was favorable for the precipitation of copper minerals at about the start of the deposition of "Ore Shale", but the sea became rapidly deeper and the chemical environment of the sea-floor became reducing.

Isopach contours of the gabbroic bodies and the relationship between the high-gravity anomaly zones and the ore shoots are shown in Figure 1-11. This was prepared by revising, on the basis of the results of the present survey, the map prepared last year. It is seen from these data, as pointed out previously, that ore shoots do not occur in the high-gravity zones nor below the thick gabbroic bodies.

4-2 Mineral Potential

Zones of high potential for shale-type copper mineralization are in the limbs of palaeo-basement highs at the time of ore deposition, particularly in the local depressions parallel to the palaeo-coast lines. Also ore shoots were not formed where thick gabbroic bodies occur and in gravity highs in this area.

It is seen from the results of the surveys carried out that the palaeo-basement highs at the time of ore deposition were distributed to the southeast, north, and northwest of the Northern Area Shoot. Of the above zones, based on the confirmation of ores in boreholes MJZC-9 and NN-75, the occurrence of ore shoots of significant scale was anticipated in the limbs of the northwestern basement high. However, zones to the northwest, north, and east of this ore shoot are considered to be in the vicinity of a palaeo-basement high at the time of the ore deposition, and also the deposits to the southeast of this ore shoot is inferred to consist of low-grade pyrrhotite-pyrite ores, it is difficult to envisage the development of large scale high-grade ore deposits in these parts of the survey area. On the other hand, the zones to the south and west of MJZC-9 are not yet explored and do not contain high gravity anomalies and are in the general direction of the extension of this ore shoot, therefore it is inferred that these zones would have high mineral potential.

The five boreholes drilled in the southern limb of the basement high to the southeast of the Northern Area Shoot are located at a relative basement high and most of the mineralization in the area belong to the pyrrhotite-pyrite-chalcopyrite zone and have low copper grade. Although of small scale, however, bornite zone was located in the lowest part of "Ore Shale" and chalcopyrite zone in the footwall quartzite. The occurrence of shoots are confined to the lowest part of the "Ore Shale" and its vicinity in this area and thus it is inferred that the period of copper precipitation was probably relatively short and thus it is possible that the ore deposits could not grow very large. If there were, however, deep local depressions of the sea floor at the time of ore deposition, it also would be possible to have formed relatively large ore shoots regardless of the length of precipitating time. From the above, the local basement depression inferred to exist to the south-southwest of MJZC-2 which confirmed relatively high-grade copper is noteworthy. Presence of bornite was confirmed at MJZC-12 and the occurrence of palaeo-basement high near this borehole became a possibility. The occurrence of an anticlinal axis extending in approximately north-south direction is anticipated to the south of MJZC-12, and the basement high of this area is inferred to extend further southward. Therefore, the palaeo-basement highs are distributed in relatively shallow parts to the south of MJZC-12 and the occurrence of ore shoots of the chalcopyrite zone is a possibility.

Chapter 5 Conclusions and Recommendations

5-1 Conclusions

Drilling was carried out during the third phase of the Chambishi Southeast survey. All four holes drilled (MJZC-9, -10, -11, -12) this year accomplished their objective by penetrating the ore horizon. Of these four, three reached the basement. The results of these work clarified considerably the geology and mineralization of the western and southern parts of the survey area and the following conclusions were attained.

1. MJZC-9 drilled in the western part of the area confirmed the existence of high-grade ores (i. width 5.90m, grade T-Cu 3.12%, T-Co 0.08%; ii. width 2.58m, grade T-Cu 2.29%, T-Co <0.01%). These ores are considered to be continuous to the shoot confirmed to the north of this hole (NN-75). Thus it is now clear that ore shoot of considerable scale exists in this area. It is inferred that this ore shoot is emplaced over a basement depression which is elongated in the NE-SW direction and it is deemed possible that this shoot is developed further southward or westward.

2. Relatively low-grade copper ores rich in pyrrhotite were confirmed by MJZC-10 drilled on the eastern side of MJZC-9 and MJZC-11 · -12 drilled in the southern part of the area. In these mineralized zones, the rich ore probably deposited during a relatively short period of time before or after the start of deposition of the "Ore Shale", because Fe/Cu ratio tends to increase upward.

3. Small scale bornite-chalcopyrite mineralization was confirmed in the basal part of the "Ore Shale" in MJZC-12. It is inferred that this mineralized zone lies over a basement-rise which extends southward. Palaeo-basement highs probably existed in parts of this rise at the time of ore deposition. Therefore, palaeo-basement highs occurred in relatively shallow parts and there are possibilities of ore shoots occurring on their limbs.

4. A basement depression extending in the NE-SW direction is considered to exist between MJZC-11 and -12. This should be noted as MJZC-2 with relatively high grade ores is located on

the northeastern extension of this depression.

5. Ore reserve estimation was carried out to asses the mineral potential of the survey area with the following results.

POTENTIALLY ECONOMIC MINERALIZATION;
NORTHERN AREA SHOOT: 54,793,000 tons, 2.70% T-Cu, 0.13% T-Co
SOUTHERN AREA SHOOT: 14,934,000 tons, 2.19% T-Cu, 0.13% T-Co
SUBECONOMIC MINERALIZATION (includes isolated patches of 2% Cu and 3m true thickness blocks):
107,909,000 tons, 1.83% T-Cu, 0.03% T-Co

5-2 Recommendations for Future Exploration

Significant amounts of ore were confirmed in this survey area by drilling during this year. The ore deposits of this area, however, occur in relatively deep zones, the major deposits probably occurs at 550 to 1,050m below the surface. Therefore, in order to develop this deposit, it is necessary to further increase the ore reserves. The western and southern parts of the survey area have not been explored and the potential is considered to be promising.

It is now clear, from the results of the present survey, that a deposit which was hitherto unknown occurs in the western part of the area. Also borehole RCB-2 which confirmed ores is located far south of MJZC-9 which also confirmed ores. From the above it is strongly recommended that efforts be concentrated as follows to confirming new ore reserves and to exploring the vicinity. First drill at sites where the depth of the ore deposits can be estimated at shallow depths, namely near the two boreholes which encountered ores (MJZC-9, NN-75), then drill at sites where the depth of the ore is considered to become deeper, namely south and west of MJZC-9.

The possibility of ore shoots still remain in the southern part of the area and thus it is recommended that drilling be carried out in the area to the south of MJZC-12.

Also in order to accurately determine the ore reserves of the Northern Area Shoot, the main deposit, drilling should be carried out near the peripheries of the deposit.