NO.

REPORT
ON
THE MINERAL EXPLORATION
IN
THE YANQUL-GHUZAYN AREA
SULTANATE OF OMAN

FINAL REPORT

VOLUME I
(SUMMARY)

MARCH 2002

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Sultanate of Oman, the Japanese Government decided to conduct pre-F/S in order to investigate the possibility of mineral resources development in Yanqul and Ghuzayn areas and entrusted the project to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

This investigation was carried out for two years from fiscal year 2000 to 2001.

The survey team exchanged views with the officials concerned of the Government of Oman and conducted a field survey in Yanqul area. After the team returned to Japan, further studies were made and present report was elaborated.

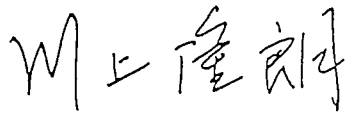
The results of these investigations are presented in a report consisting of 3 volumes: Volume 1: Summary, Volume 2: Exploration Results and Volume 3: Mine Development.

We hope that this report will serve for the development of the mineral resources in Oman and contribute to the promotion of friendly relations between Japan and Oman.

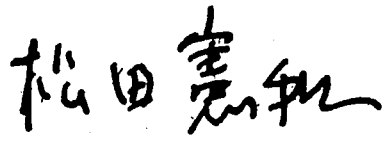
We wish to express our deep appreciation to the officials concerned of the Government of Oman for their close cooperation extended to the team.

March 2002

Takao Kawakami
President
Japan International Cooperation Agency



Norikazu Matsuda
President
Metal Mining Agency of Japan



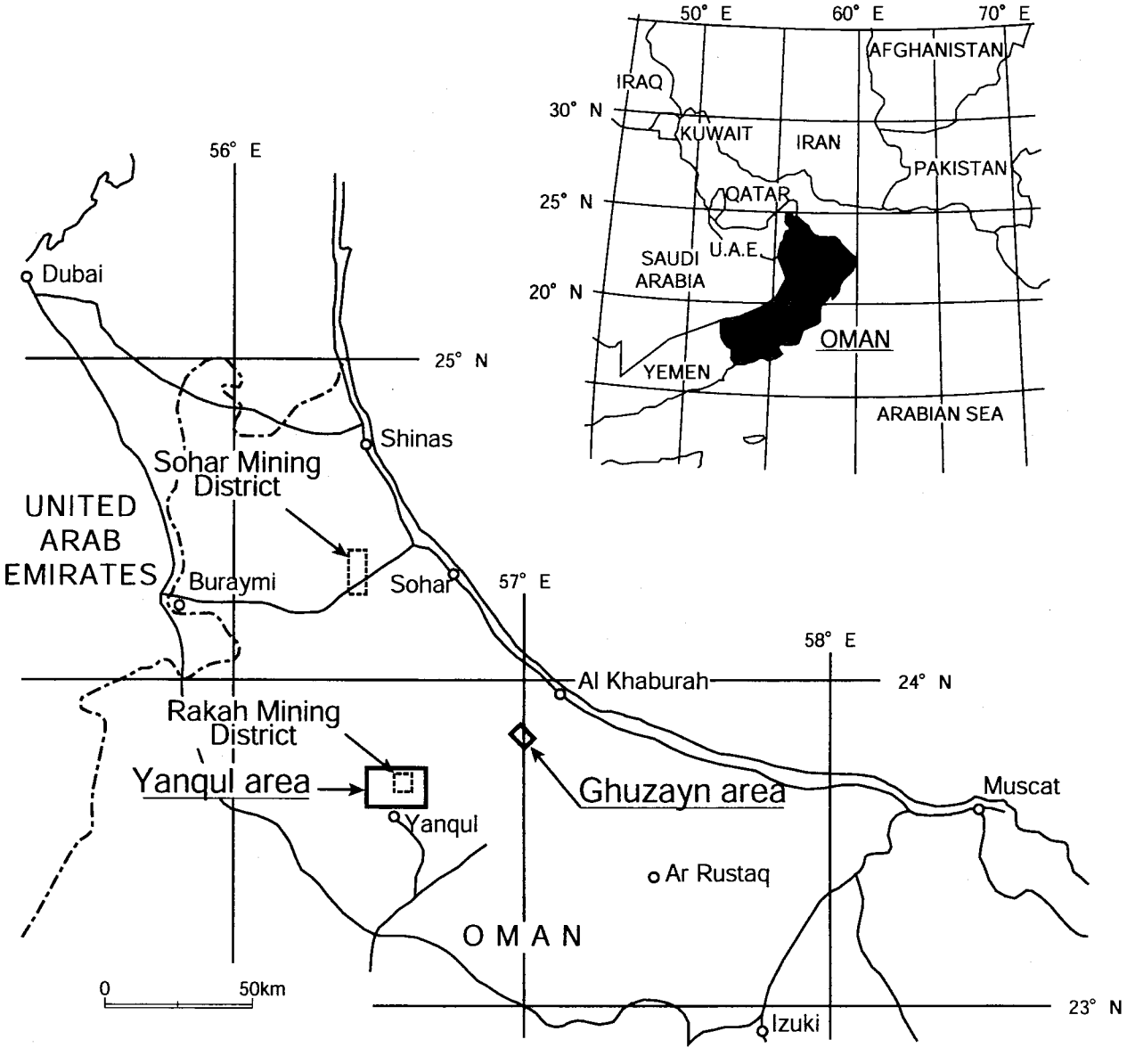


Fig.1 Location map of the surveyed area

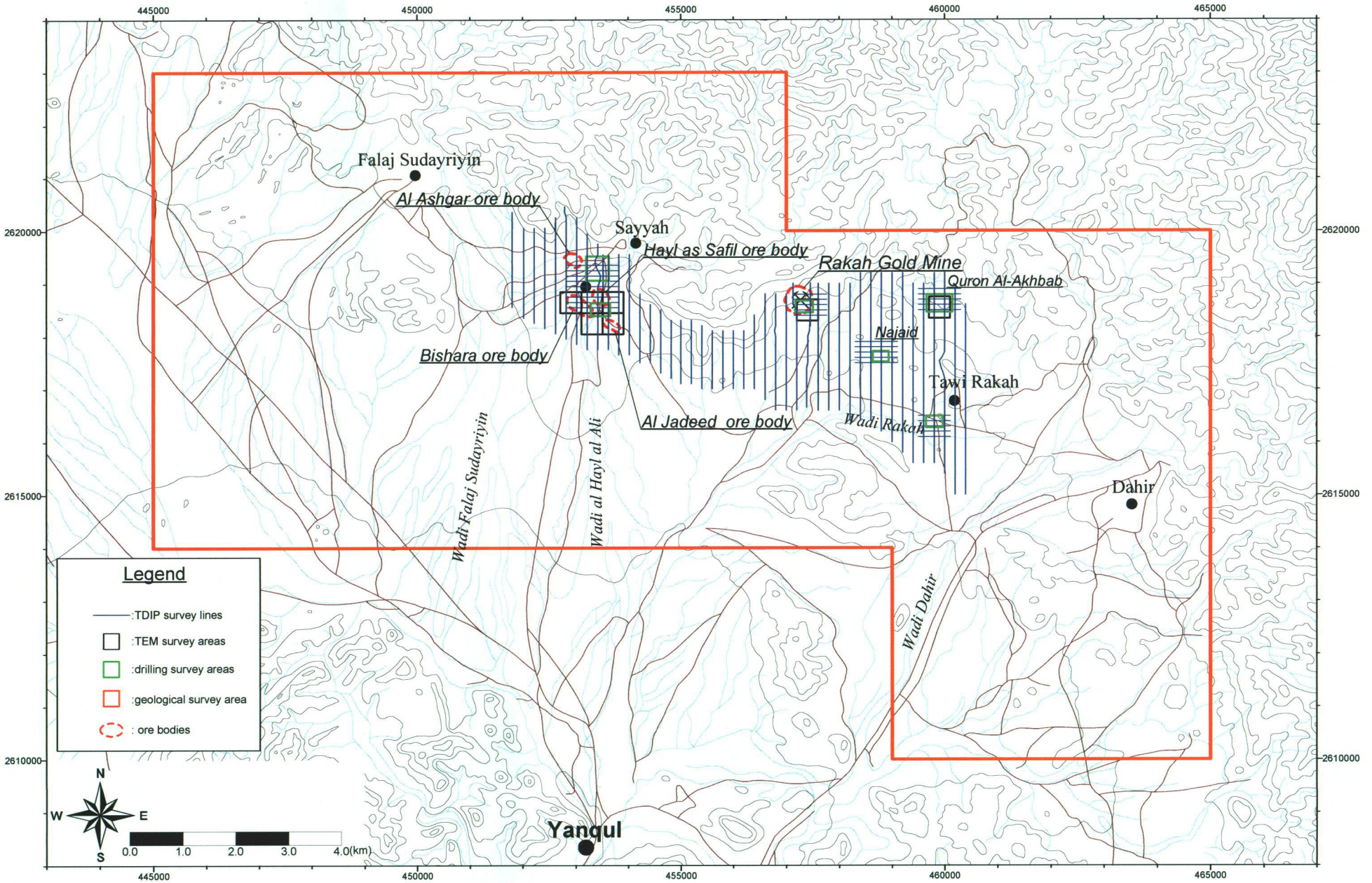


Fig.2 Location map of the surveyed area

ABSTRACT

The Government of Sultanate of Oman and the Government of Japan agreed to conduct a mineral exploration project in Yanqul and Ghuzayn areas. Both governments on 28th June 2000 signed the Scope of Work for this project. The objective of this program is to clarify the possibility of mining development by undertaking Pre-F/S that will evaluate the ore deposits and ore bodies distributed in Ghuzayn and Yanqul areas.

Accordingly, the main task of the study are:

1) to increase gold recovery and grade of copper concentrate,
2) to increase minable ore reserves through exploration activities and
3) to estimate minimum investment costs and operation costs.

Exploration and development plan of the mine can be summarized as follows:

1. Exploration Results

(1) Geophysical survey to find new ore bodies yielded very promising IP anomalies in Quron Al-Akhbab area. Drilling results within these anomalies revealed that dominant mineralization zone extends about 300m in East-West and about 150m in North-South direction. However, a total copper grade is generally low, and gold mineralization is found quite local.

(2) Based on this survey, it is concluded that the potentiality of discovering a new ore body of economical size is very low in this area. On the other hand, in the southwestern part of the open pit in Rakah and in the north of the gossan in Hayl as Safil area, a small scale with conspicuous IP anomalies were detected in places where the drilling exploration have confirmed a stockwork zone. A slight increase of ore reserves can be expected here.

(3) The IP Geophysical method in this survey area detected several new mineralized zones including the known ore deposits. The application of the TEM method indicated the shape of the massive sulfide ore body. However, the massive sulphide ore in this area represents only a small-scale mineralization, and most deposits are in the form of stockwork types, which are also found a good target by IP method.

2. Mining Development Plan

(1) In making ore reserve calculations and taking into consideration the nugget effect, a top cutting method for each deposit were adopted both for copper and gold.

Geological ore reserves at a 0.5%Cu cut off grade are as follows:

Reserves (t)	Cu (%)	Au (g/t)	Contained Cu (t)	Contained Au (t)
15,767,000	1.13	0.62	178,738	9,851

(2) Minable ore reserve from the designed pit with a cut-off grade of 0.5% of Cu is as follows:

Reserves (t)	Cu (%)	Au (g/t)	Contained Cu (t)	Contained Au (t)
8,175,000	1.23	0.68	100,441	5,571

(3) As a result of metallurgical tests, conventional methods are to be applied for crushing and grinding process, and a crusher with a primary ball mill is adopted in order to minimize total construction costs. Estimated metallurgical test results based mainly on a locked cycle test are Cu: 20.0%, Au: 5.13 g/t, and recovery rate resulted in Cu: 85.7% and Au: 39.6%.

(4) Owing to poor precipitations, water resource in this area is very precious so that contamination of ground water should strictly be avoided. Therefore, a filter Press is to be installed to the refinery plant, and dry-type trailing dam is designed which is able to process from 10 to 20% of the dehydrated drainage.

(5) Investment costs with a crude ore production rate of 3,000 tons/day totaled US$29,658,500. The total operation cost resulted in US$89,864,200 but 30% of this costs goes to mining operation costs because the operation is to be done by subcontracts.

(6) Investment costs with a crude ore production rate of 2,000 t/d totaled US$2,278,500, which is little less than 3,000 t/d case, but operation cost of US$102,068,200 exceeds much from the reduced investment, and therefore the case of 3,000 t/d is clearly economical.

(7) As a result of financial evaluation, for the case that all required capital is covered by loan and with a copper price of US100 ¢ /lb, the financial IRR to the plan of the project results in 5.92%. Economical evaluation on this results in IRR of 12.47% in case that all required capital is covered by loan and copper price of US100 ¢ /lb.

(8) If gold production from the gossan is added at Al Bishara ore body, IRR could be increased about 1%, and in case of copper price of 100 ¢ /lb, IRR would be 19.22%, and even in case of copper price of 90 ¢ /lb, it would be 8.83%. Furthermore, it is estimated that IRR could be raised up to 10% depending on smelting cost, even under a copper price of 90 ¢ /lb.

Cyprus type massive sulfide exploration scheme that was established in Batinah Coast can also be successfully adapted to exploration in Yanqul area. Therefore, this exploration methodology can be adapted to other type of mineralization in Oman for more efficient exploration.

It is concluded that under present copper price level (US70 ¢ /lb as of February 2002), mining development of sulfide ore in Yanqul district is negative for a private company, but the possibility of development still remains if copper price increases over 100 ¢ /lb. If the area is developed by a governmental firm, even US 90 ¢ /lb would be feasible.

VOLUME 1

CONTENTS

CHAPTER 1 INTRODUCTION

1-1 Background and Objectives

This survey was carried out as a Cooperative Mineral Exploration program in Yanqul and Ghuzayn areas based on the Scope of Works agreed on 28th June 2000 between the Government of Japan and the Government of the Sultanate of Oman. The objective of this program is to clarify the possibility of mining development by undertaking a Pre-F/S that will evaluate the ore deposits and ore bodies distributed in Ghuzayn and Yanqul areas.

The northern part of Oman is well known as copper production areas since ancient times with Cyprus type copper-gold deposits. Since the modern exploration started in 1960's, large-scale ore deposits were confirmed, and in 1983 the Government of Oman commenced mine operations in Sohar (Lasail, Bayda and Aarja deposits) and then Sohar Smelter in 1983. However in 1993, Sohar mining resources ran out and they imported overseas ores to keep their smelter in operation. The Omani government is vigorously continuing exploration activities and found Rakah and Hayl as Safil deposits in Yanqul areas. Along the same lines, the Japanese government, upon the request of the Omani government, conducted a mineral exploration project in Rakah area (1988-1989), Central Batinah Coast area (1995 to 1996) and South Batinah Coast area(1997 to 1998). As a result, additional reserves with high Au grade were confirmed as an extension of known deposits of Rakah in Yanqul, and also high-grade stockwork type deposits of around 5 million tons at Hayl as Safil deposit. Furthermore, in Ghuzayn area of Batinah Coast area, 3 new massive sulphide ore bodies, with a total estimated ore reserve of 14 million tons were newly discovered.

In this regards, the Omani government requested the Japanese government to conduct 2 years Pre-F/S survey to evaluate in an integrated manner, the ore deposits already confirmed.

1-2 Coverage and Outline of Works

The Yanqul and Ghuzayn areas, the objective area of this survey, are located to the west of Muscat, the capital of the country. The distance between the two areas is about 50 km in straight line and separated by the Oman Mountains, Ghuzayn to the north and Yanqul to the south. The survey areas, shown in Fig.1, are 20km^2 in Ghuzayn and 180km^2 in Yanqul. Fig.2 shows the location map of Yanqul region.

The works during Phase I included metallurgical tests, existing data analysis, and environmental, geological, geophysical and drilling surveys. During Phase II, the works consisted of mine development and exploration. Mine development studies consisted of ore resources evaluation, mining plan and process plant plan, whereas exploration survey consisted of geology, geophysical and

drilling surveys. The content and amount of these works are indicated in Tables 1-1-1 to 1-1-5.

1-3 Members of the Project

The members of the project were as follows:

1-3-1 Phase I

(1) Project planning and negotiation

Japanese Counterpart

Kenji Sawada	Metal Mining Agency of Japan
Noboru Fujii	Metal Mining Agency of Japan
Hisamitsu Moriwaki	Metal Mining Agency of Japan
Kiyoto Kurokawa	Japan International Cooperation Agency

Omani Counterpart

Hilal Mohamed Sultan Al Azri	Ministry of Commerce and Industry
Salim Omer Abdullah Ibrahim	Ministry of Commerce and Industry
Saif Ali Al Rashidi	Ministry of Commerce and Industry

(2) Inspection of field work

Toshio Sakasegawa	Metal Mining Agency of Japan
Shigeo Wada	Metal Mining Agency of Japan
Noboru Fujii	Metal Mining Agency of Japan

(3) Field work

Japanese Counterpart

Yoshiaki Shibata	Team Coordinator	Mitsubishi Materials Natural Resources Dev. Corp.
Hiroshi Kawakami	Metallurgical Tests	Mitsubishi Materials Natural Resources Dev. Corp.
Hisashi Ogawa	Environmental Survey	Mitsubishi Materials Natural Resources Dev. Corp.
David Escobar	Geophysical Survey	Mitsubishi Materials Natural Resources Dev. Corp.
Yoshimitsu Negishi	Geophysical Survey	Mitsubishi Materials Natural Resources Dev. Corp.
Susumu Endo	Geophysical Survey	Mitsubishi Materials Natural Resources Dev. Corp.

Omani Counterpart

Salim Omer Abdullah Ibrahim	Ministry of Commerce and Industry
Ahmed Nasser Al Towaya	Ministry of Commerce and Industry
Florentino Alba Carulla	Oman Mining Company
Perfecto Cuevas Lagapa	Oman Mining Company

Table Ⅰ-1-1 Content and amount of the survey(1)

・Drilling survey

Area		No.	Length	Dip	Direction
Yanqul Area	Phase I (2000)	MJOY-1	251.10m	-90°	
		MJOY-2	200.35m	-90°	
		MJOY-3	251.10m	-90°	
		MJOY-4	200.10m	-90°	
		MJOY-5	250.10m	-90°	
		MJOY-6	250.65m	-90°	
		MJOY-7	250.60m	-90°	
		MJOY-8	250.25m	-90°	
		Total length	1904.25m		
	Phase II (2001)	MJOY-9	150.00m	-90°	
		MJOY-10	150.35m	-90°	
		MJOY-11	150.30m	-90°	
		MJOY-12	150.35m	-80°	45°
		MJOY-13	150.05m	-90°	
		MJOY-14	150.20m	-80°	90°
		MJOY-15	150.35m	-90°	
		MJOY-16	150.40m	-90°	
		MJOY-17	150.35m	-90°	
		MJOY-18	150.35m	-90°	
		MJOY-19	150.35m	-90°	
		MJOY-20	150.35m	-90°	
		MJOY-21	150.05m	-90°	
		MJOY-22	150.35m	-90°	
		MJOY-23	150.35m	-70°	270°
		MJOY-24	150.35m	-70°	90°
		MJOY-25	153.40m	-70°	270°
		MJOY-26	150.35m	-90°	
		MJOY-27	150.35m	-90°	
		Total length	2858.60m		
	Grand total of length		4762.85m		
	Related work(Phase II: 2001)		Road construction: 1,100m(length) x 3m(width Site preparation: 13 sites		

Table I -1-2 Content and amount of the survey(2)

· Drilling for metallurgical test (Phase I: 2000)

Area	No.	Length	Dip	Direcion
Yanqul Area	MJOY-P1	125.65m	-90°	
	MJOY-P2	125.80m	-90°	
	MJOY-P3	125.65m	-75°	270°
	MJOY-P4	137.55m	-90°	
	MJOY-P5	126.00m	-90°	
Grand total of length		640.65m		

· Drilling for environmental survey (Phase I: 2000)

Area	No.	Length	Dip	Direcion
Yanqul Area	MJOY-W1	75.00m	-90°	
	MJOY-W2	75.00m	-90°	
	MJOY-W3	75.00m	-90°	
	MJOY-W4	75.00m	-90°	
	MJOY-W5	75.00m	-90°	
Ground total of length		375.00m		

· Drilling for geotechnical test in planned tailing dam area (Phase II: 2001)

Area	No.	Length	Dip	Direcion
Yanqul Area	MJOY-T1	25.10m	-90°	
	MJOY-T2	25.25m	-90°	
	MJOY-T3	25.35m	-90°	
	MJOY-T4	25.15m	-90°	
	MJOY-T5	25.25m	-90°	
Ground total of length		126.10m		

Table Ⅰ-1-3 Content and amount of the survey(3)

· Geological survey

	Area coverage	Scale	Length of Survey route
Phase I (2000)	60km^2	1/25,000	74.3km
Phase II (2001)	2km^2	1/25,000	27.8km
Total	62km^2		102.1km

· Geophysical survey(1)

	Area name	Method	Length of measurement
Phase I (2000)	Yanqul Area	IP method	95.9km
Phase II (2001)	Yanqul Area	IP method	31.0km
Total length of measurement		126.9km	
Number of measurement point		5,580 points	

· Geophysical survey(2)

	Area name	Method	Number of loop
Phase I (2000)	Yanqul Area	TEM method	7 loops
Total number of loop		7 loops	
Number of measurement point		567 points	
Total length of loop		16.8km	

Table Ⅰ-1-4 Content and amount of laboratory work

Survey	Laboratory work	Phase I	Phase II	Total amount
Geophysical survey (IP method)	Resistivity and polarizability measurement	41 samples	20 samples	61 samples
Geological survey	Thin sections	22 samples		22 samples
	X-ray difractive analysis	21 samples		21 samples
	Chemical analysis of ore (Au,Ag,Cu,Pb, Zn,Fe)	17 samples		17 samples
Drilling survey	Thin sections	10 samples	10 samples	20 samples
	Polished sections	20 samples	10 samples	30 samples
	X-ray difractive analysis	10 samples		10 samples
	Chemical analysis of ore (Au,Ag,Cu,Pb, Zn,Fe)	275 samples	300 samples	575 samples
	Chemical analysis of ore (Au,Ag,Cu)		388 samples	388 samples
Mine development	Geotechnical test		15 samples	15 samples
Environmental survey	pH, conductivity, groundwater temperature	5 samples		5 samples
	Chemical analysis of groundwater (Cu,Zn, Pb,Ni,Cr,Fe,Mn,Hg,SO4)	5 samples		5 samples

Table I -1-5 Content and amount of metallurgical test

Test Item		Details	Amount
1. Sampling	Phase I	Drilling, core logging and core sampling	Number of Samples: 4 (massive ore of Rakah, stockwork ore of Rakah, stockwork ore of Hayl as Safil, breccia ore of Bishara) Total weight of samples: 1,000kg
2. Sample preparation	Phase I, II	Weighting, crushing and blending	4 sets of ore samples, 1,000kg in total
3. Characreristics of feed ore	Phase I	Chemical analysis (Cu, Au, Ag, Pb, Zn, Fe, As, Sb, S, S^{2-}, Bi, Cd, Co, Cs, Ga, In, Mo, Ni, Rb, Se, Te, Th, Tl, U, Y,)	4 samples × 25 elements
		Mineralogical test for gold	4 samples
		Measurement of work index for ball mill	4 samples
4. Flotation	Phase I	To produce concentrates, middlings, and tailing by establishment of process flow through each batch test of roughing and cleaning.	23 tests (17 batch rougher flotation tests and 6 batch cleaner flotation tests)
		Chemical analysis of rugher, cleaner and tailing (Cu, Au, Ag, Fe, S,)	Rakah stockwork ore: 57 products, Hayl as Safil stockwork ore: 22 products, Rakah massive ore: 24 products: Bishara breccia ore: 27 products Total: 130 products × 5 elements
		Chemical analysis of flotation concentrates (As, Ba, Ce, Cd, Co, La, Mo, Nb, Sn, Sr, Ta, V, Y, Zr, Al2O3, CaO, Fe2O3, K2O, MgO, MnO, Ma2O, P2O5, SiO2, TiO2, Hg, F)	3 products × 26 elements
		Mineralogical test for flotation products	12 products
	Phase II	To confirm griding size, then to conduct a locked cycle test.	4 samples (1 sample each from 4 types of ore) 1 locked cycle test
		Chemical analysis (Cu, Au, Ag, Fe, S)	5 elements x (2 cleaner, 1 tailing) x 4 type of samples
5.Settling and filtering tests	Phase I	Settling and filtering tests Settling tests	each 1 set of copper concentrates for 4 samples each 1 set of copper tailings for 4 samples
	Phase II	Settling and filtering tests	1 set of composit samples of copper tailings
6. Leaching	Phase I	Sample preparation (pyrite concentrate)	Pyrite concentrate obtained from 2 samples (Rakah massive ore and Bishara breccia ore)
		Leaching tests	2 kinds (original , regrinding) × 2 samples
		Leaching tests after roasting	3 temperature conditions × 2 samples
		Chemical analysis (Au, Ag)	2 elements × 7 kinds (1 feed, 1 residue, 4 activated carbon, 1 leached liquid) × 2 times

1-3-2 Phase II

(1) Inspection of field work

Toshio Sakasegawa	Metal Mining Agency of Japan
Takeshi Sakata	Metal Mining Agency of Japan
Noboru Fujii	Metal Mining Agency of Japan
Yasunori Nuibe	Metal Mining Agency of Japan

(2) Field work

Japanese Counterpart

Yoshiaki Shibata	Team Coordinator	Mitsubishi Materials Natural Resources Dev. Corp.
Masahiro Watanabe	Process Plant	Mitsubishi Materials Natural Resources Dev. Corp.
Masato Kusaka	Mining Plan	Mitsubishi Materials Natural Resources Dev. Corp.
Mikio Kajima	Environmental Survey	Mitsubishi Materials Natural Resources Dev. Corp.
Masayuki Saito	Infrastructure	Mitsubishi Materials Natural Resources Dev. Corp.
David Escobar	Geophysical Survey	Mitsubishi Materials Natural Resources Dev. Corp.
Susumu Endo	Geophysical Survey	Mitsubishi Materials Natural Resources Dev. Corp.
Yoshimitsu Negishi	Geophysical Survey	Mitsubishi Materials Natural Resources Dev. Corp

Omani Counterpart

Ahmed Nasser Al Towaya	Ministry of Commerce and Industry
Ali Salim Al-Rajhi	Ministry of Commerce and Industry
Florentino Alba Carulla	Oman Mining Company

1-4 Survey Period

The negotiation and field works were conducted in Oman during the following period:

1-4-1 Phase I

(1) Project planning and negotiation	June 23, 2000 to June 29, 2000
(2) Inspection of field work	October 10, 2000 to October 15, 2000
	January 12, 2001 to January 18, 2001
(3) Existing data analysis	September 3, 2000 to September 6, 2000
(4) Metallurgical tests	September 9, 2000 to October 28, 2000
(5) Geological survey	September 9, 2000 to October 28, 2000
(6) Geophysical survey	October 1, 2000 to January 29, 2001
(7) Drilling survey	November 24, 2000 to February 12, 2001
(8) Environmental survey	December 16, 2000 to January 12, 2001

1-4-1 Phase II

(1) Inspection of field work	June 19, 2001 to June 29, 2001
	September 29, 2001 to October 7, 2001
(2) Mine development	September 29, 2001 to November 18, 2001
(3) Geological survey	October 7, 2001 to October 20, 2001
(4) Geophysical survey	June 24, 2001 to August 27, 2001
(5) Drilling survey	June 23, 2001 to September 28, 2001

CHAPTER 2 GEOGRAPHY OF THE SURVEY AREA

2-1 Location and Access

The Sultanate of Oman is situated in the southeast corner of the Arabian Peninsula with an area of about 300,000km^2. The population is approximately 2 millions and the capital city is Muscat. In the northern part of Oman, the Oman Mountains, with elevations higher than 2,500m, run NE to SW parallel to the Coast of the Oman gulf. Yanqul and Ghuzayn, which are the objects of this study, are located to the west of Muscat, being Yanqul located at the foot of the southwest part of the North Oman Mountains while Ghuzayn is in its northeast part.

The transportation from Muscat to Yanqul is very convenient because it takes about 4 hrs by driving about 370km on a national road passing through Nizwa and Ibri. On the other hand, it is possible to go to Ghuzayn by driving about 2 hrs in a distance of about 190km.

2-2 Topography and Drainage System

Yanqul is located between the mountain lands and a hilly terrain at the foot of the southwest part of Oman Mountains within altitudes between 600m and 1000m of elevations. The drainage of this zone corresponds to Wadi Dank and its upstream distributes to Wadi Rakah and Wadi Al Hayl al Ali.

Ghuzayn area consists of a hilly land between an altitude of about 150m and 250m at northeast part of the Oman Mountains. On the center of this area, Wadi Hawasinah runs from east to west.

2-3 Climate and Vegetation

Al-Dhahirah, where Yanqul belongs, is dry but with slight rains only in winter. Along the Wadi, dates, limes, mangos, and tobacco can be cultivated by the irrigation of aqueducts and water wells.

The climate of the Batinah Coast Plain, where Ghuzayn area belongs, is semi-dry type, though it presents high temperature and high humidity because it is separated from the desert region by the Oman Mountains. As the humidity coming from the sea is stopped by the Oman Mountains, the rain falls usually in the mountain region in winter season. The infiltrated water from the rain is supplied to coastal plain, so that many kinds of vegetables are cultivated there in addition to the representative agricultural products of Oman such as dates, lime, mango, tobacco, etc. However, except for the cultivated land, vegetation is very scarce and the vegetation of acacia, etc. is observed only in and around the wadis.