REPORT ON THE MINERAL EXPLORATION IN THE RAKAH AREA, SULTANATE OF OMAN FINAL REPORT FEBRUARY 1990

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JAPAN INTERNATIONAL COOPERATIONAL AGENCY
METAL MINING AGENCY OF JAPAN

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VOLUME I
(SUMMARY)

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PREFACE

In response to the Government of the Sultanate of Oman, the Japanese Government decided to conduct a Preliminary Feasibility Study for Mine Development Project in Rakah Area and entrusted the survey to Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Sultanate of Oman a survey team for two field seasons from 1988 to 1989, headed by Mr. Takehiko Nagamatsu. The team exchanged views with the officials concerned of the Govenment of the Sultanate of Oman and conducted a field survey in the Rakah area. After the field survey, further studies were made and present reports have been prepared.

The reports consist of three volumes. The summary of the work, exploration results and the preliminary feasbility study for mine development are given in Volume I, II and III respectively.

We hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

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

February, 1990

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

Gen-ichi Fukuhara
President
Metal Mining Agency of Japan

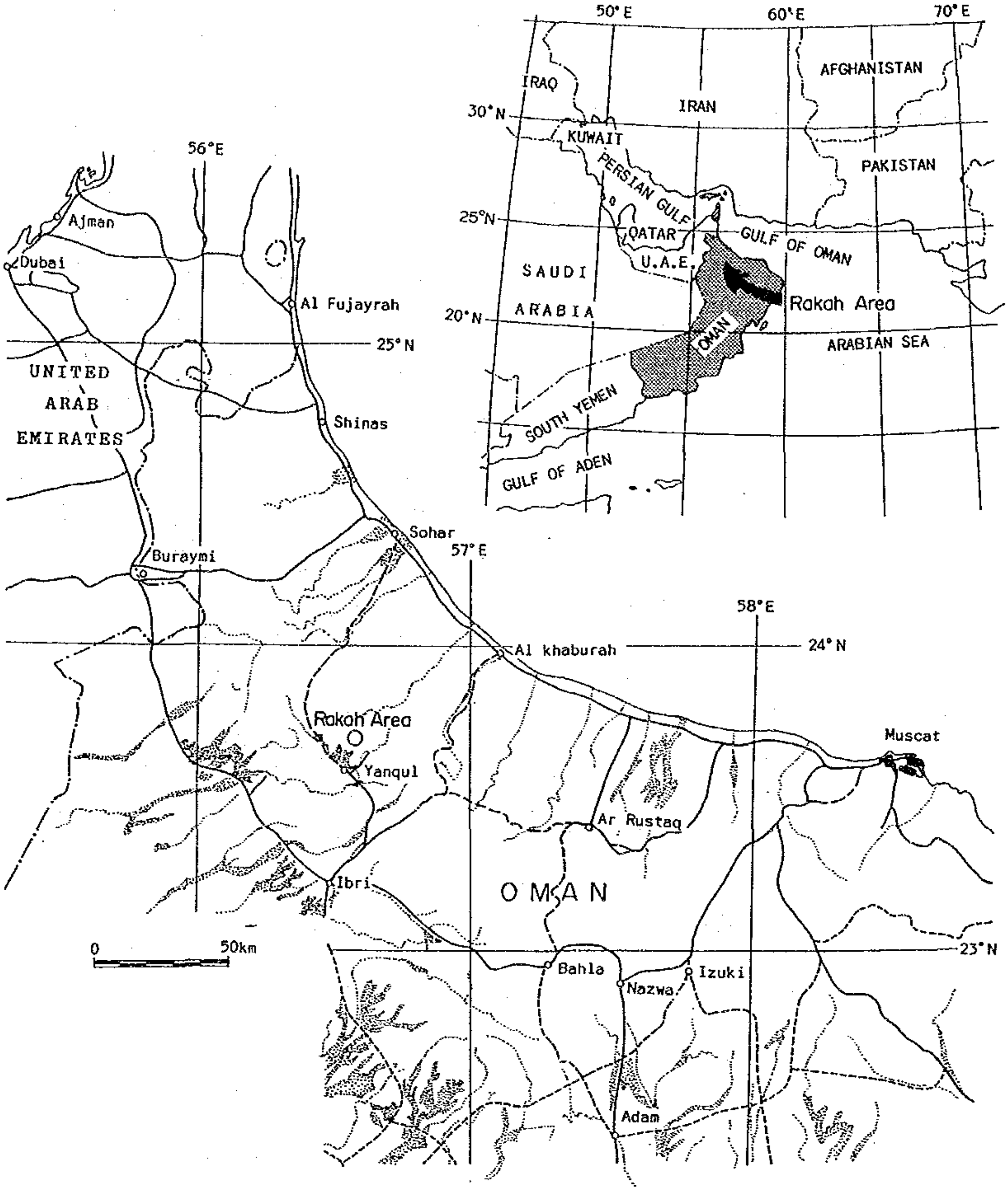

Fig. 1 Location map of the Rakah area

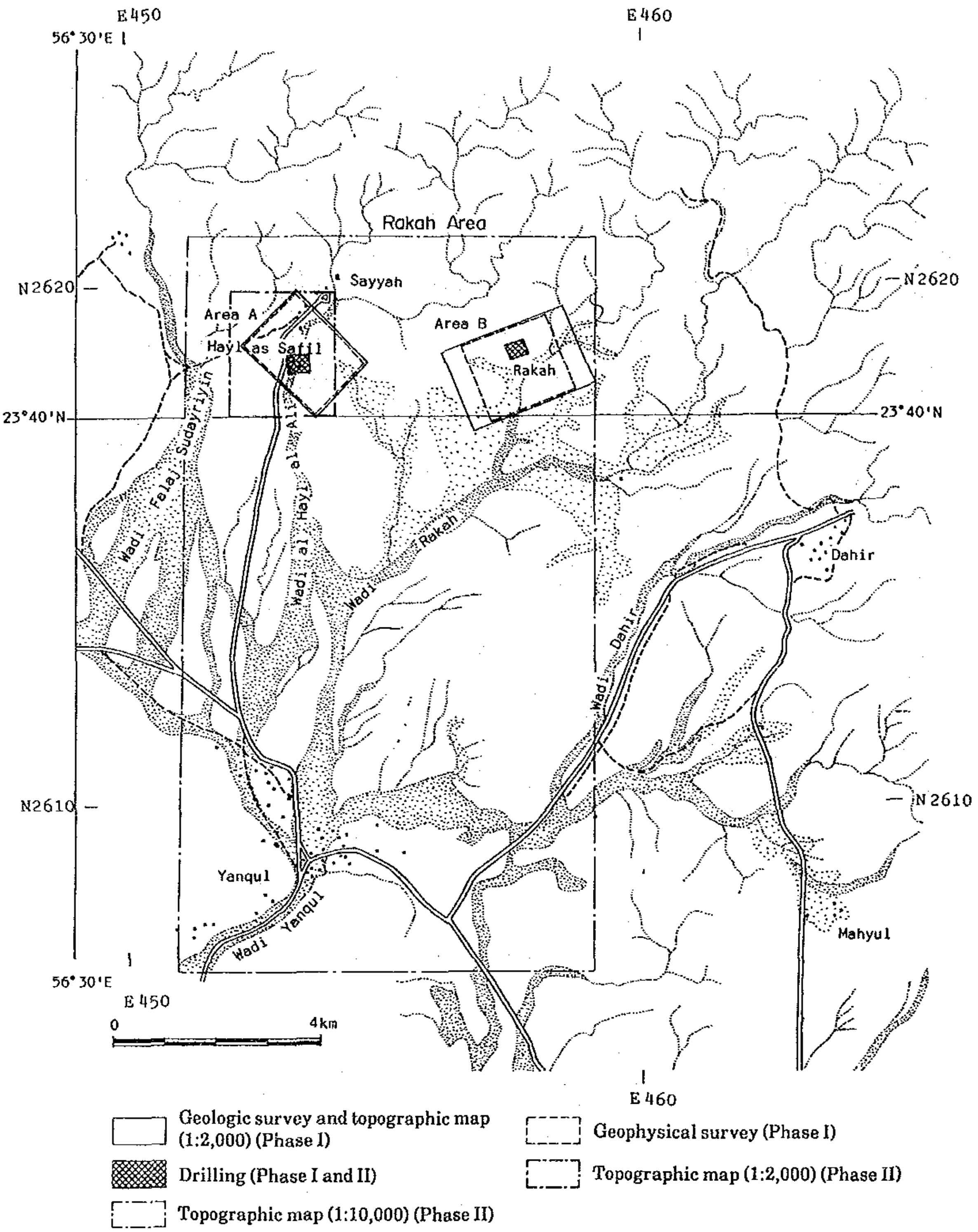

Fig. 2 Location map of survey areas

ABSTRACT

Objectives of "the Mineral Exploration in the Rakah Area, Sultanate of Oman" are to clarify the potential for two known ore deposits of the Hayl as Safil (Area A) and Rakah (Area B) deposits and to carry out a preliminary feasibility study for mine development of these ore deposits. The project was carried out in two years of Phase I (1988) and Phase II (1989). Three reports of Volume I (summary), Volume II (exploration results) and Volume III (mine development) are prepared on the base of these survey results.

The exploration works completed in this area are geologic, geophysical (CP method) and drilling surveys. Ore reserve calculation is also carried out due to the drilling results. Based on the calculated ore reserves, mine development is planned and designed. These survey results are summarized as follows:

The Rakah area is situated in the area of the Samail Nappe which forms the main part of the Oman Mountains, and geology of the area consists of the Samail Ophiolite and Supra-Ophiolite Sediments. The Samail Volcanic Rocks which are the host rocks in this area are found at the top of the Samail Ophiolite. Geologic structure in this area is characterized with the thrust fault related to obduction of the Samail Ophiolite, and lower formations are found topographically at the upper part due to imbrication structure.

Two known ore deposits classified to be Cyprus type massive sulfide deposits are found at the lower part of the Samail Volcanic Rocks. These two ore deposits consist of stockwork, massive and siliceous ores. Intensely gossanized zones are found on the surface of these deposit areas. The ore deposits are characterized with thick stockwork ore zone and high concentration of Au in the massive ore.

The Hayl as Safil deposit and the surroundings (Area A) was covered with geologic, geophysical and drilling (12 holes, 1740.80 m in total) surveys. The results confirmed that this deposit is one of the largest copper deposit in Sultanate of Oman. The total ore reserves estimated for this deposit are 10,553 thousand tons (1.00% Cu, 0.40 g/t Au) which include 8,500 thousand tons (0.73% Cu, 0.26 g/t Au) of newly discovered ore in this project.

Geologic, geophysical and drilling (11 holes, 1,583.25 m in total) surveys were also carried out for Area B centering the Rakah deposit. This ore deposit consisting of two mineralized zones were clearly outlined. A total of 4,750 thousand tons (0.99% Cu, 0.88 g/t Au) were calculated as the ore reserves for this deposit. Furthermore, approximately 300 thousand tons of gossan ore containing about 5.0 g/t Au and 10.0 g/t Ag were also estimated for the gossan zones in this deposit area.

A total of ore reserves estimated for both the ore deposits are 15,303 thousand tons with 0.99% Cu and 0.55% g/t Au.

The optimum mining method selected for both the ore deposits is open pit method and the optimum operation size is 3,000 tons/day.

The minable ore reserves due to these open pits are 8,408 thousand tons (1.26% Cu, 0.59 g/t Au) in case of the cut off grade of 0.35% Cu, and the estimated mine life is 8 years.

Three stages crushing and ore stage grinding, and bulk and differential flotation system are applied as the most feasible process on the base of the results of metallurgical test. The estimated grades for the concentrates are 20.0% Cu and 5.2 g/t Au. The recoveries expected are 88.9% for Cu and 49.3% for Au. Waste dumps and tailing dam are also designed for this mine development planning.

The organization and manning for the operation are planned with reference of the Sohar operation. The manpower is reduced as possible as for the operation and efficient organization is considered. Omanization is applied for the planning. Transportation road, water, power, housing facilities and communication are also planned in the survey.

Financial evaluation was made on the base of the estimated initial, additional and operation costs and 6.40% of IRR was obtained.

The exploration surveys completed for the Hayl as Safil and Rakah deposit clearly outlined these ore deposits, and necessary exploration work for these two ore deposit have been almost completed. Consequently, if these deposits go to the next stage including detailed designing, following survey should be carried out in this area.

① Confirmation of ore reserves for the Au concentrated gossan zones in the Rakah deposit.

② Research of the recovery method for Au in gossan and Cu and Au in massive ore in the Rakah deposit.

③ Drilling at the planned sites including waste dumps, tailing dam and mineral processing plant in order to confirm the no ore potentiality.

④ Survey for used equipments to reduce the initial cost.

Taking account of the risk for mine development, financial IRR is thought to be low. The decision for the feasibility study including detailed designing should be made on the base of not only the mining in the Rakah area but also operation of the Sohar Smelter.

CONTENTS

Preface
Location map of the Rakah area
Location map of survey areas
Abstract
Contents

Chapter 1 Introduction 1
1-1 Background and objectives 1
1-2 Survey methods and amounts 2
1-3 Survey period and members 4

Chapter 2 Geography of survey area 5
2-1 Location and access 5
2-2 Environment of survey area 5

Chapter 3 Summary of previous activity in the Rakah area 7
3-1 Brief history of mining activity 7
3-2 Hayl as Safil deposit (Area A) 7
3-3 Rakah deposit (Area B) 8

Chapter 4 General geology of the area 10

Chapter 5 Exploration results 12
5-1 Geologic survey 12
5-2 Geophysical survey 15
5-3 Drilling survey 16
5-4 Ore reserve calculation 18
5-5 Interpretation for the survey results 19

Chapter 6 Mine development 21
6-1 Outline of the Sohar mine operation 21
6-2 Determination of operation size 21
6-3 Mining 22
6-4 Mineral processing 22
6-5 Waste dump and tailing dam 25
6-6 Suporting, organization and manning plan 25

6-7 Infrastructure 29
6-8 Capital, additional and operating cost 29
6-9 Overall evaluation 30

Chapter 7 Conclusions and Recommendations 34
7-1 Conclusions 34
7-2 Recommendations 37

Reference

Figures and Tables

Chapter 1 Introduction

1-1 Background and objectives

The Oman Mountains in the northern part of the Sultanate of Oman is famous district for ancient copper producing center in the Middle East. The Rakah area is located in the region of the Oman Mountains (Fig. 1) and ancient copper workings are also found in this area. Modern mining activity for the Oman Mountains region was started in 1970's. Oman Mining Company LLC (OMCO) which is wholly owned by the government started the operation for Sohar Smelter and Mine in 1983. About 15,000 tons refined copper have been produced annually to date. Copper is the most important export commodity for Oman other than crude oil.

However, the Sohar mine will be mined out by early 1990's due to limited ore reserves. Because of economic impact to the Sohar region and trade balance, the Government of Oman must find new source of copper ore. The Ministry of Petroleum and Minerals (MPM), Sultanate of Oman, thought the two ore deposits, Hayl as Safil and Rakah deposits, have possibility to be developed. Therefore, the Government of Oman requested to the Government of Japan to confirm the potential and to carry out preliminary feasibility study for these two ore deposits. In response to the request, the Government of Japan sent a mission consisting of Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ). The both governments agreed two years project in the Rakah area and signed the Scope of Work on 7th July 1988.

Objectives of this project are to clarify the potetial for the two known ore deposits of Hayl as Safil and Rakah deposits through the geologic, geophysical and drilling surveys, and also to conduct the preliminary feasibility study including ore reserves estimation, metallurgical test and infrastructure for mine development of these two known ore deposits.

Purposes of the geologic survey are to establish the volcanistratigraphy related to the formation of massive sulfide mineralization and to confirm the potential in the area. The purpose of the geophysical survey was to clarify the extensions of the known ore deposits and to find new targets for further exploration work. Purposes of the drilling are to clarify the nature of the mineralization and to confirm the extensions of the two known ore deposits. Based on the drilling results, ore reserves were estimated.

Purposes of the preliminary feasibility study for mine development are to evaluate the potentiality for mine development of these known two ore deposits based on the planned optimum mining method for estimated ore reserves and the selected optimum ore treatment process according to the results of the metallurgical test.

Summary of the work results in these two years of this project is given in Volume I.

The results of exploration work completed are given in Volume II and the results of the preliminary feasibility study for mine development are given in Volume III separately.

1-2 Survey methods and amounts

The Rakah area consists of two survey areas of Area A (3 km^2) and Area B (4 km^2) as shown in Fig. 2. The area A and B are located centering the Hayl as Safil and Rakah deposits respectively. Geologic, geophysical (charged potential method) and drilling surveys were completed for both the areas. Using the drilling results, ore reserve estimation was completed for both the known ore deposits. Based on the estimated ore reserves, the mine development planning was carried out. The work methods and amounts completed in this project are shown in Table 1, and the flowchart is given in Fig. 3.

Table 1 Summary of methods and amounts of work in this project

Work method	Phase I (1989)	Phase II (1990)	Total amounts
Geologic survey	Area A: 3 km² Area B: 4 km² (1:2,000)	—	Area A and B: 7km² in total (1:2,000)
Geophysical survey (CP method)	Area A: 3 km² 611 stations Area B: 2 km² 402 stations	—	Area A and B: 5km² and 1,013 stations in total
Drilling survey	Area A: 6 holes 898.70 m Area B: 6 holes 811.45 m	Area A: 6 holes 842.10 m Area B: 5 holes 771.80 m	Area A:1,740.80m(12) Area A:1,583.25 (11) 23 holes and 3,324.05m in total
Preparation of totographic map	Area A: 3.0 km² 1:2,000 Area B: 4.0 km² 1:2,000	Area A: 5.2 km² 1:2,000 Rakah Area: 112 km² 1:10,000	1:2,000: 12.2km² in total 1:10,000: 112km² in total
Laboratory studies			
Thin section	30 samples	6 samples	36 samples
Polished section	38 samples	16 samples	54 samples
X-ray diffraction analyses	11 samples	10 samples	21 samples
Whole rock analyses	30 samples	—	30 samples
Minor elements analyses	33 samples	—	33 samples
Ore assaying	265 samples (Au.Ag.Cu.Pb.Zn)	203 samples (Au.Ag.Cu.Zn)	468 samples
EPMA test	12 points	—	12 points
Physical property (PEF.resistivity)	24 samples	—	24 samples

* : Including the mapped area completed in phase I.

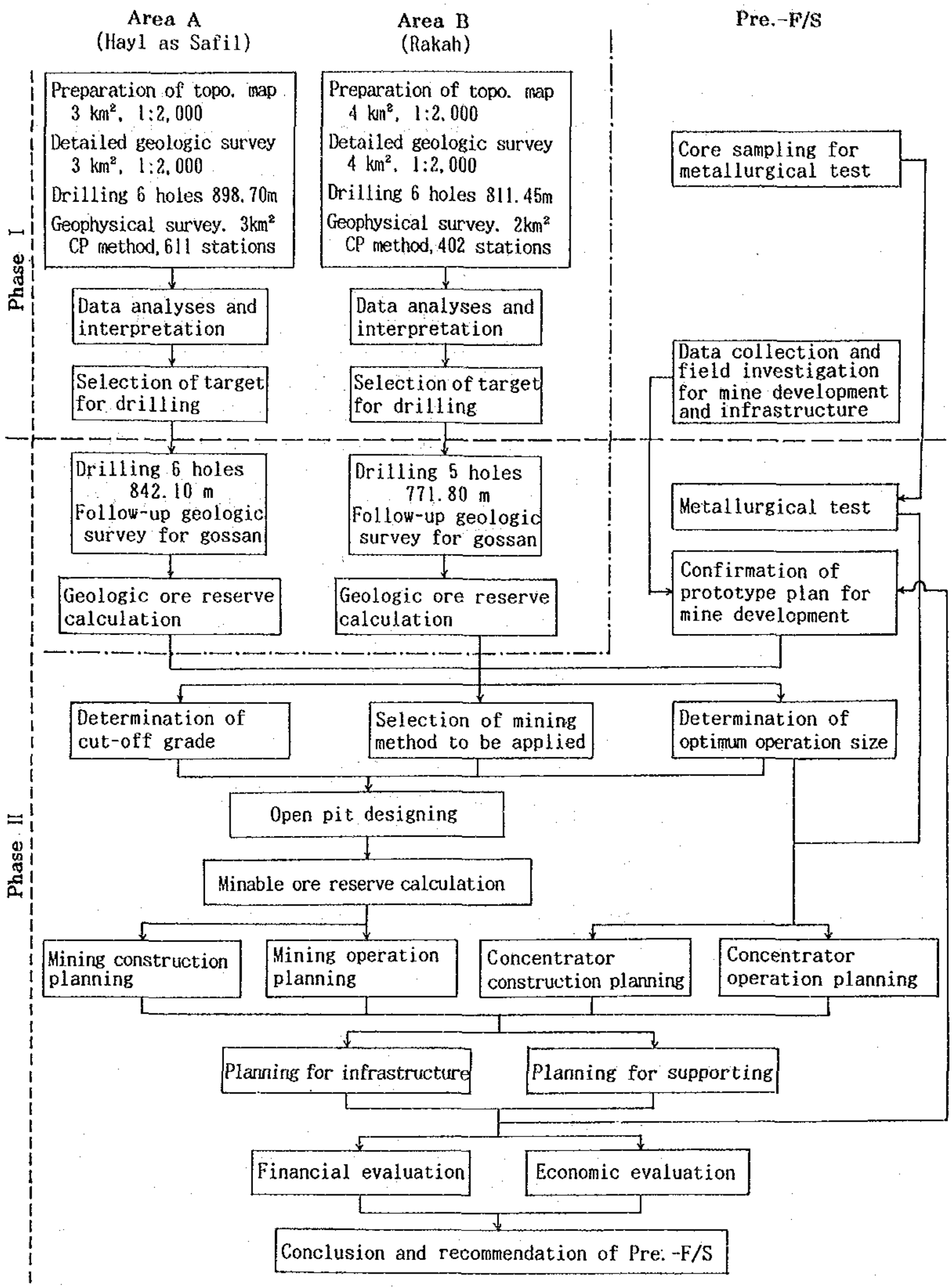

Fig. 3 Flowchart showing the work methods and amounts in this project

1-3 Survey period and members

The members, who participated in the planning and consultations on the survey as well as in the field survey, are shown in Table 2. Periods in Oman for the members are also shown in Table 2.

Table 2 Period and participants for this project

Items		Period	Japanese counterpart	Omani counterpart
Phase I (1988)	Planning and negotiation	30 June, 1988 ~ 9 July, 1988	Takeshi Izumi (MMAJ) Mayuri Jibiki (MFA) Mamoru Yamazaki (MITI) Yoshiyuki Kita (JICA) Hideo Hirano (MMAJ)	Mohammed H. Kassim (MPM) Salim O. Ibrahim (MPM) Hilal M. Al-Azri (MPM) Saif A. Al-Rashidi (MPM) Harib H. Al-Hashmi (MPM) Munir A. Haddadin (MPM) Omer Al-Amin (MPM)
	Geologic and drilling surveys	25 Sep. 1988~ 16 Jan. 1989	Takehiko Nagamatsu (BEC) Mikio Kajima (BEC)	Abdulla H.S. Al-yahya Ey (MPM)
	Geophysical survey	25 Oct. 1988~ 24 Dec. 1988	Susumu Sasaki (BEC) Kohei Sugawara (BEC) Hiroshi Hyodo (BEC)	
	Data collection for Pre-F/S	25 Oct. 1988~ 24 Nov. 1988	Toru Otani (BEC) Hayao Nakayama (BEC)	Saif A. Al-Rashidi (MPM)
Phase II (1989)	Drilling survery	25 July ~ 21 Oct. 1989	Takehiko Nagamatsu (BEC)	Salim O. Ibrahim (MPM) Said S. Al-Fori (MPM) Munir A. Haddadin (MPM)
	Preliminary feasibility study	19 Oct. 1989 ~ 9 Nov. 1989	Takehiko Nagamatsu (BEC) Hayao Nakayama (BEC) Kazumasa Okubo (BEC) Ichiro Sawabe (BEC) Kenkichi Horio (BEC)	Saif A. Al-Rashidi (MPM)

MFA: Ministry of Foreign Affairs, MITI: Ministry of International Trade and Industry
BEC: Bishimetal Exploration Company Limited

Chapter 2 Geography of survey area

2-1 Location and access

The Sultanate of Oman is the second largest country, about 300,000 km^2, in the Arabian Peninsular, lying at its southeast corner, south of the Strait of Hormuz. It is bordered to the west by the United Arab Emirates, Saudi Arabia and the People's Democratic Republic of Yemen, while the coastline faces the Gulf of Oman and Arabian Sea (Fig. 1). Population in Oman is about 1.5 million and the capital is Muscat.

The north of Oman is dominated by the Hajar mountain range (the Oman Mountains), reaching a height of over 3,000 m. The Rakah area is in the western flank of the Oman Mountains and is approximately latitude 23°36'N and longitude 56°24'E.

The Rakah area consists of two survey areas: Area A (3 km^2) centering the Hayl as Safil deposit and B (4 km^2) centering the Rakah deposit as shown in Fig. 2. Area B is approximately 4 km east of Area A.

Access to the area is made by vehicle from Muscat along well-maintained asphalt road to Yanqul through Izuki, Nazwa and Ibri, then along gravel road from Yanqul to the Area A. Access between Area A and B is made by four-wheel drive vehicle. Muscat to Yanqul is about 370 km (4.5 hours driving), and Yanqul to Area A is 13 km (20 minutes driving).

Base camp was established in Sayyah, 1 km north of Area A during this project. Three bedroom house was rented. Water was supplied by a tank truck and electric power was supplied by a generator.

2-2 Environment of survey area

(1) Topography and drainage system

The Rakah area is situated in the western flank of the Oman Mountains and consists of low hills and terraces.

Area A is covered with widespread terraces and forms flat plain except northeastern and northwestern corners where form mountainous zones. Two isolated hills named "Main Gossan" and "Small Gossan" are found in the center of Area A. These hills was formed by strong weathering for the silicified mineralized zones. Terrace can be distinguished into lower and middle terraces. Difference of elevation between these two terraces ranges from 3 m to 8 m. Comparatively large wadi, Wadi al Hayl al Ari, drains southward in the center of the area.

Area B is situated in low hill land except the northern part where is mountainous. The western part is covered with the upper terrace. The middle and lower terraces are also found along wadis. Some gossan zones which are intensely weathered mineralized zone outcrop in the center of the area, and form isolated hills. Wadi Rakah run southwestward in the center of the area. Other wadis are also tributaries of Wadi Rakah.

(2) Climate and vegetation

The west side of the Oman Mountains is a desert of stony plain, and vegetarian is only observed along wadis or in oasis.

In Area A, farm land is found at east to southeast of Main Gossan, and palm tree and several kinds of vegetable are farmed. Water for the farm is supplied from water well or water way (falaj) of several kilometers which has been used from old time. Acacia trees are scattered along wadis but no vegetation are observed on the terrace.

Vegetation in Area B is also limited except small farm and shrubs along wadis.

Average annual rainfall in Muscat (capital city) is 104.3 mm and indicates extremely dry country. Temperature in Oman is very heigh and it reaches more than 40°C in the summer season. Monthly temperature and rainfall of three years from 1986 to 1988 in Buraymi, 100 km northwest of the Rakah area, are shown in Table 3.

Table 3 Monthly temperature and rainfall at Buraymi

	Temperature (°C)						Rainfall (mm)		
	1986		1987		1988		1986	1987	1988
	Max.	Min.	Max.	Min.	Max.	Min.			
January	27	7	25	10	23	11	1.0	0.0	0.5
February	28	9	28	13	26	14	4.6	13.3	73.6
March	35	10	29	17	31	16	0.0	58.0	0.0
April	40	13	35	20	36	21	0.3	3.3	10.8
May	46	16	42	26	42	23	0.0	5.8	0.0
June	46	23	44	27	44	26	3.3	2.0	0.0
July	47	25	45	30	43	31	0.3	2.0	3.0
August	46	26	43	30	44	30	2.0	5.9	3.6
September	43	24	42	28	42	27	2.3	0.3	0.0
October	42	18	37	23	38	22	4.5	0.0	0.0
November	36	14	32	16	31	16	0.0	0.0	0.0
December	28	8	26	12	27	13	6.0	6.5	0.0

Chapter 3 Summary of previous activity in the Rakah area

3-1 Brief history of mining activity

Copper production in Oman can trace back to 5,000 years ago. The ancient name 'Magan' was given to Oman by the Sumerians who used the Omani copper exported to Mesopotamia during the 3rd Millennium B.C. The Sumerian Kings of Ur in Mesopotamia were probably the biggest buyer of copper in accordance with the written record of 4,400 years ago. The copper production in Magan is recorded up to 860 or 940 A.D. Magan is probably the Sohar mine area between Buraymi and Sohar. Plenty of slag and ancient smelter sites are observed in the area.

Several tens thousand tons of slag and ancient smelter sites are also found in the Rakah deposit area and the Tawi Rakah prospect. The Tawi Rakah prospect is situated about 4.5 km southeast of the Rakah deposit. Appearance of the smelter sites are similar to those in the Sohar mine area. Therefore, mining and smelting operation in the Rakah area were possibly conducted in the similar period of those in the Sohar mine area. Survey results for the Rakah deposit confirmed the old working reached at least 38 m below the surface. An old pit is also found in the Tawi Rakah prospect. After the time, no mining work has been recorded in Oman.

3-2 Area A (Hayl as Safil deposit)

During the course of BRGM's mapping program in the Northern Oman Mountains between the years 1983 - 1985, two siliceous caps (Main Gossan and Small Gossan) with noticeable gold content were discovered near the village of Hayl as Safil, about 4 km west of Rakah.

MPM awarded BRGM a contract to explore for copper and associated precious metals in, and around, thirteen promising prospects. Hayl as Safil was one of the prospects. Exploration work in the Hayl as Safil area was carried out systematically by BRGM. The work included: detailed geologic mapping, geophysical surveys, geochemical survey as well as drilling of 8 holes (828.60 m). The work results are summarized below.

① The gossanized zones of Main Gossan and Small Gossan overlie the Lower Volcanics. A major fault (NE-SW) separated these two gossanized zones.

② The magnetic survey delineated two well-marked anomalies. One was located east of Main Gossan and the other was located southwest of Small Gossan.

③ Analytical results for the gossan samples showed good correlation among Cu-Mo-As-Au.

④ Eight drill holes were completed in this area. The most encouraging results were those obtained from the hole HS-6 at the southeast of Main Gossan and hole HS-7 at the north of

Small Gossan. HS-6 results gave 2.29% Cu, 1.67 g/t Au and 14.6 g/t Ag over a thickness of 4.70 m. Hole HS-7 intersected massive sulfide zone and gave an average 3.69% Cu over a thickness of 13.70 m.

Based on the encouraging results, follow-up drilling program was conducted by MPM. A total of 33 drill holes (4,463.30 m in total) was completed before starting this project (see Volume II, Table 1-5). Among these drill holes, 23 holes (3,551.15 m in total) were completed at the southeast of Main Gossan, and following geologic ore reserves were estimated.

2,086,000 tons   2.09% Cu,   0.97 g/t Au,   6.86 g/t Ag

These drill holes were concentrated in the area of massive ore zone, because the stockwork ore at the west and mineralized zone of Main Gossan were interpreted to be formed separately to the massive ore.

The drilling survey in Phase I clarified that the mineralized zones in the Hayl as Safil deposit area are formed as one mineralized zone. Based on this interpretation and recommendation from JICA/MMAJ, MPM carried out 7 holes from HS-34 to HS-40 before starting the Phase II work and confirmed thick stockwork ore zones. The best intersection among these hole was 104.40 m (D.L.) with 1.33% Cu and 0.26% Au in the drill hole HS-35.

3-3 Area B (Rakah deposit)

The gossan of Rakah prospect was discovered in October 1973 by Prospection Ltd. helicopter reconnaissance. During 1973 to 1974, Prospection Ltd. also carried out comprehensive exploration work including geologic, geochemical and geophysical surveys for the Rakah prospect. Based on the surveys results, Prospection Ltd. conducted intense drilling work and a total of 42 drill holes (5,493.32 m in total) were completed (see Volume II, Table 2-3), and estimated 4.15 Mt of ore grading 1.31% Cu and 0.24% Zn.

These ore reserves were re-evaluated OMCO in 1980 (5,210 thousand tons, 1.25% Cu, 1.0 g/t Au). The ore reserves were also evaluated MPM in 1981 (1,310 thousand tons, 2.50% Cu, 1.5 g/t Au) using higher cut-off grade.

Re-interpretation of the Rakah prospect was conducted by BRGM in 1985. The re-interpretation work by BRGM delineated the northwestern part of the Rakah area as the potential area for massive sulfides.

Follow-up surveys including geophysics (IP and SP methods) and drilling were carried out by BRGM based on the re-interpretation results and delineated geophysical anomalous zones. Three diamond drill holes (445.00 m in total) were completed in the prospect in order to examine the nature of the geophysical anomalous body. One of the hole (RA-1) encountered an 8 m thick of massive sulfide body (0.55% Cu, 0.09% Zn, 9.6 g/t Au and 20 g/t Ag).

These survey results completed for the Rakah deposit, had not clarify the relation between the geologic structure and mineralized zones, and only the ore reserves were estimated.

Chapter 4 General geology of the area

The Oman Mountains, forming a part of the Alps-Himalaya orogenic belt, consist of autochtonous and allochthonous units. The autochtonous units form the Arabian Platform and are the Pre-cambrian to Mesozoic formations. The allochthonous units, overthrusted onto the autochtonous units, consist of Hawasina Nappes and overlying Samail Nappe. The Hawasina Nappes are made up of Hawasina Sediments and the Samail Nappe is divided into Samail Ophiolite and Supra-ophiolite Sediments.

The Rakah area is situated in the Samail Nappe and the area consists of the Samail Ophiolite and Supra-ophiolite Sediments. The Samail Ophiolite consists of Tectonites, Cumulate Sequence, High-level Gabbro, Sheeted-dyke Complex and Samail Volcanic Rocks in ascending order, and the Supra-ophiolite Sediments comprise mainly olistostroms. Stratigraphic columnar section is shown in Fig. 4.

Structural development in the Rakah area can be divided into three stages of formation of Samail Ophiolite (stage-1) abduction of Samail Ophiolite (stage-2) and after emplacement (stage-3). The Samail Ophiolite was formed in the spreading ridge of Paloso-Tethys sea from Early to Middle Cretaceous (Lippard et al., 1986). In this stage, (stage-1) the Hawasima basin is situated between the ridge and the Arabian Plate and the Hawasina Sediments had been deposited in the basin. The original structures of ophiolite generally remain in the Tectonites, Cumulate Sequence and sheeted-dyke Complex. The original structures observed in the Rakah area indicate similar trend to the general trend of ophiolite in the Oman Mountains region. Following to the abduction of the Hawasina Nappes and deposition of the Supra-ophiolite Sediments, the Samail Nappe detached from sea-floor and obducted onto the southwestern edge of the Arabian Plate (Oman Platform) in the stage-2. The obduction of Samail Ophiolite is considered to be the Late Cretaceous age (Coleman, 1981 and Lippard et al., 1986). Thrust faults and folds related to the obduction are widely found in the Oman Mountains. In the Rakah area, several thrust faults and folds in this stage are found and the thrust faults form a imbricated structure. The stage-3 is post-obduction and shows a variation in different localities. Several faults in this stage are found in the Rakah area.

The massive sulfide deposits in the Oman Mountains are situated in the lower part of the Samail Volcanic Rocks and are classified into the Cyprus type copper deposits. In general, the Cyprus type copper deposit is understood to be formed on sea-floor and are accompanied with footwall basic volcanics. Judging from the geologic setting of the Hayl as Safil and Rakah deposits, these deposits are possible to classify into the Cyprus type copper deposits.

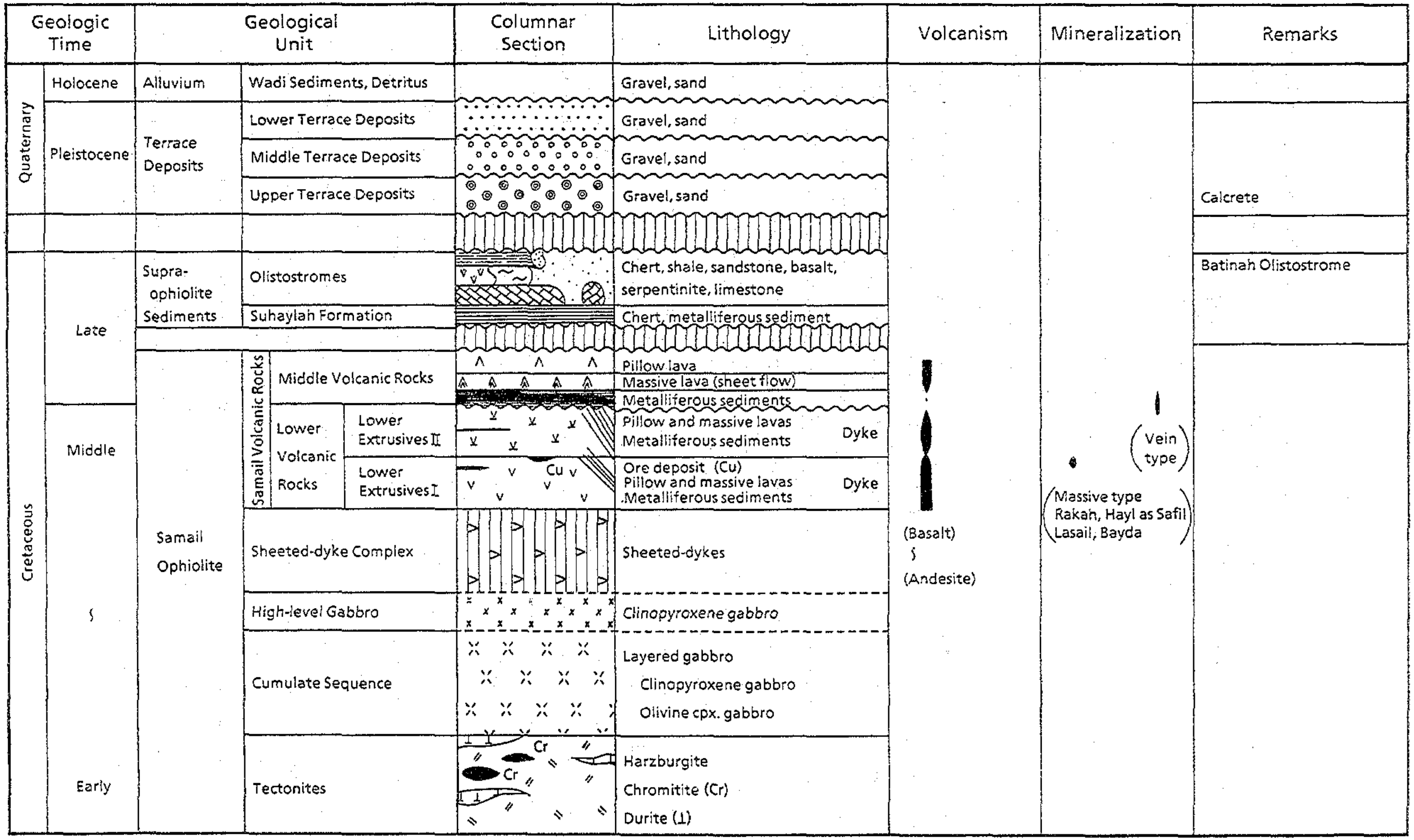

Fig. 4 Stratigraphic columnar section of the Rakah area

Chapter 5 Exploration results

Geologic, geophysical and drilling surveys as well as ore reserve calculation using drilling results were carried out in this survey. Illustrations for the Hayl as Safil and Rakah deposits are shown in Fig. 5 and Fig. 6 respectively. The results are summarized as follows:

5-1 Geologic survey

(1) Geology and mineralization in Area A (Hayl as Safil deposit)

Area A is situated in the western part of the Rakah area and geology of the area consists of the Samail Ophiolite and Supra-ophiolite Sediments as well as widespread terrace deposits. The Samail Ophiolite consists of Tectonites, Cumulate Sequence, High-level Gabbro, Sheeted-dyke Complex and Samail Volcanic Rocks in ascending order as shown in Fig. 4. The Samail Volcanic Rocks are divided into the Lower Volcanic Rocks and Middle Volcanic Rocks. The Upper Volcanic Rocks observed in the Sohar area is not found in this area. The Lower Volcanic Rocks, host rock of the ore deposits in this area, are subdivided into the Lower Extrusives I and II in ascending order. The Supra-ophiolite Sediments consist of olistostrome and overlie the ophiolite. The geologic structure in this area is characterized by thrust faults. The volcanic rocks, stratigraphically upper sequence of the ophiolite, are tectonically found at the bottom due to these thrust faults. Faults trending NW-SE are found in the ore deposit area.

The copper deposits in the Rakah area are found in the similar geologic setting to that of the Lasail and Bayda deposits in the Sohar area, and the massive ore in the ore deposit of both the areas has sedimentary texture. The Lasail and Bayda deposits have been classified into the Cuprus type copper deposits. Because of these similar occurrences, the ore deposits in the Rakah area can be also classified into the Cyprus type copper deposit. Volcanic activity of the Lower Extrusives II has close relation with the formation of the Lasail deposit (Bishimetal, 1987). In the Rakah area, the Lower Extrusives II are developed in the areas of the known ore deposits and show some relationship between the Lower Extrusives II and these ore deposits. The results of the petrochemical studies indicate the Lower Extrusives II were formed by the more primitive magma comparing with the Lower Extrusives I.

The Hyal as Safil deposit is situated at the center of Area A and consists of Main Gossan and Small Gossan which form small hill on the surface, and the mineralized zones under terrace deposits. The geologic survey results confirmed that the Hayl as Safil deposit originally formed as one mineralized zone (900 m × 400 m) and later tectonic movement and erosion separated the these zones. The ore deposits is situated at the top of the Lower Extrusives I and is overlain with the Lower Extrusives II. The orebody extends in a NW-SE direction, similar trend to the Sheeted-dyke Complex. This direction is also similar to the general trend of the ophiolite.

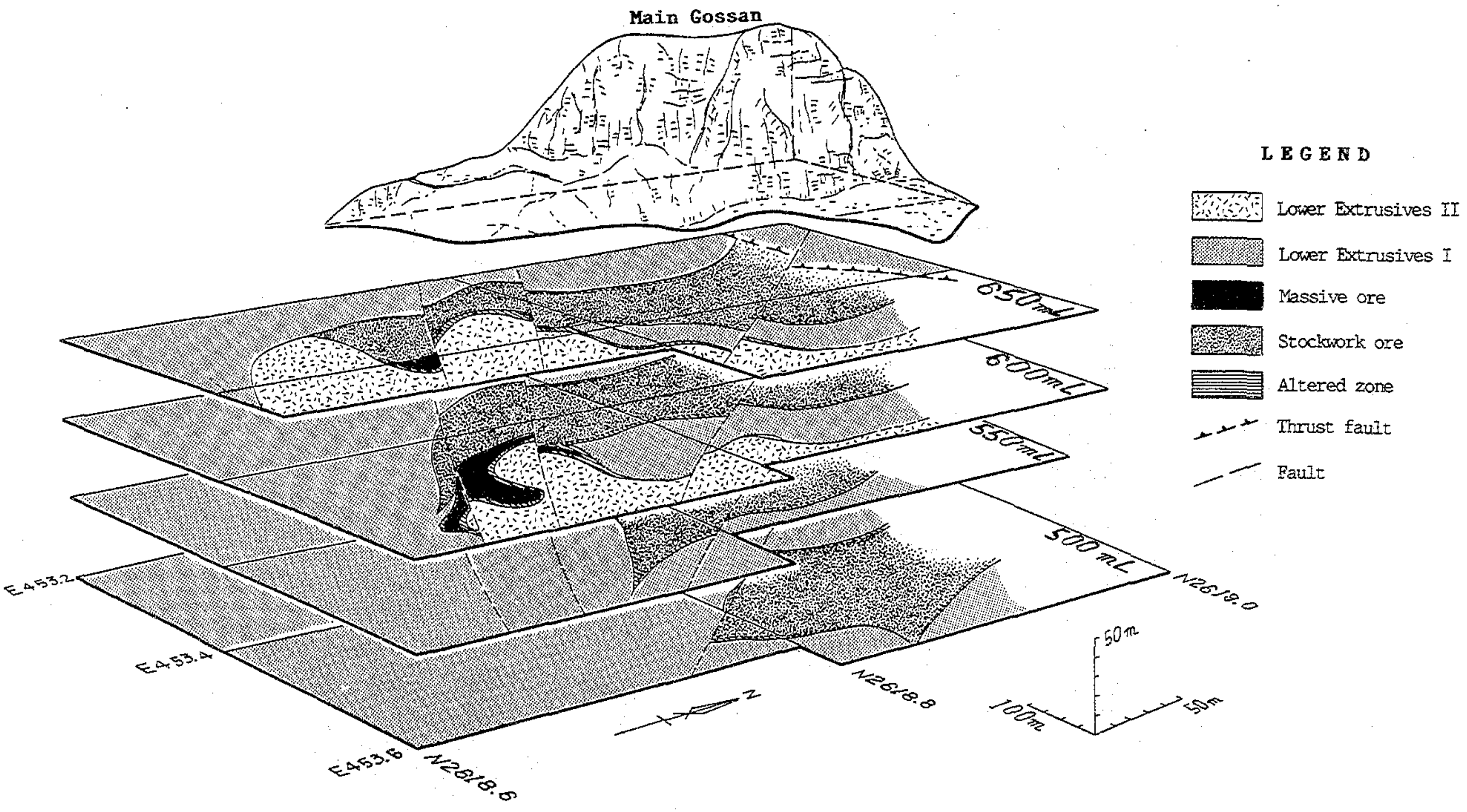

Fig. 5 Three dimensional illustration for the Hayl as Safil deposit

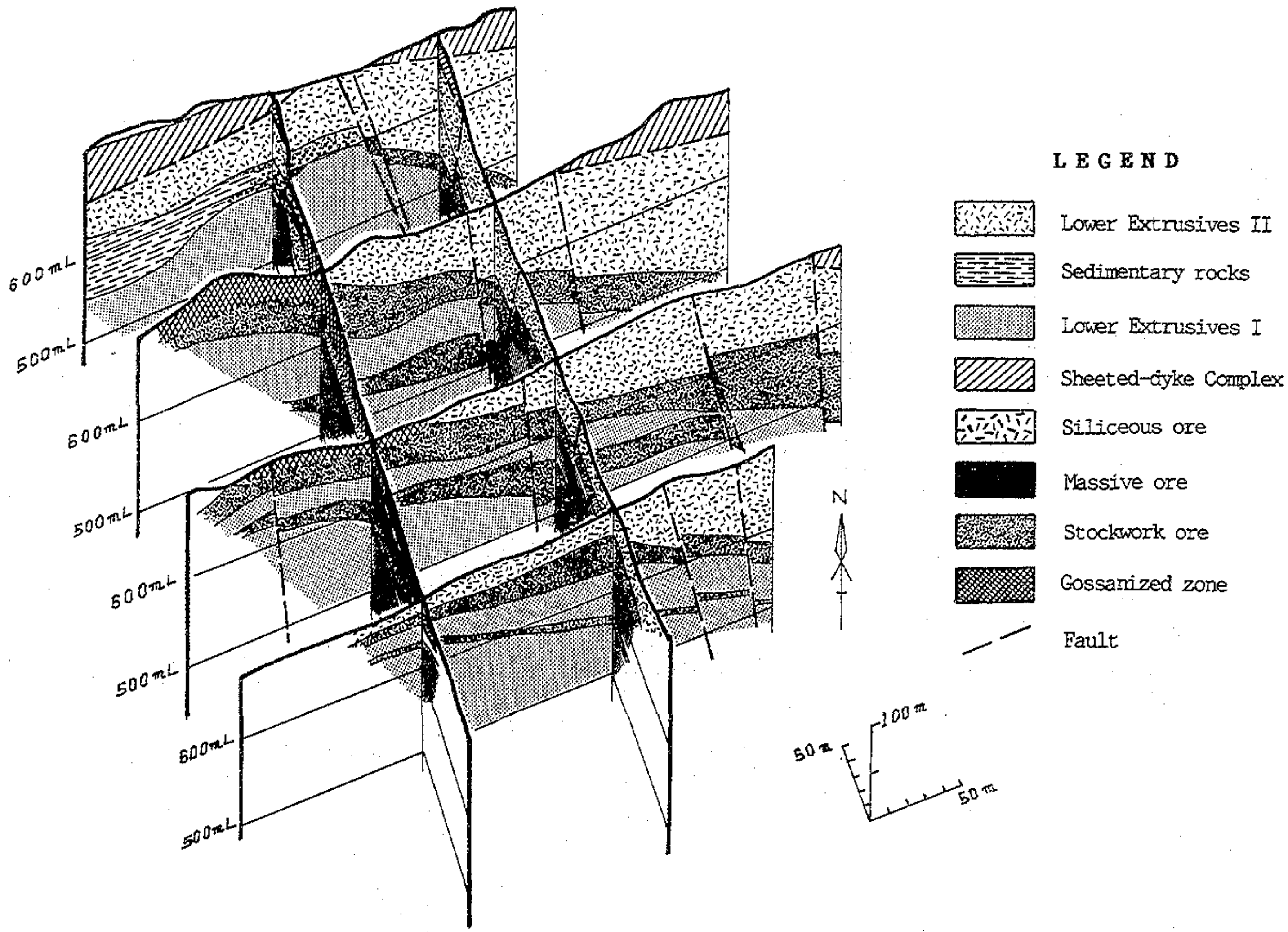

Fig. 6 Three dimensional illustration for the Rakah deposit

In order to clarify the Au and Ag potential in connection with the mine development planning, sampling and arraying were carried out for the gossanized zones. The results should low Au and Ag concentration of less than 1.0 g/t.

(2) Geology and mineralization in Area B (Rakah deposit)

Area B is situated at the eastern part of the Rakah area. Geology of this area also consists of the Samail Ophiolite and Supra-ophiolite Sediments. Stratigraphy of the Samail Ophiolite in this area is same as that in Area A. The Supra-ophiolite Sediments consists of the Suhaylah Formation and Olistostrome in ascending order. The Suhaylah Formation occurs sporadically in the Rakah deposit area covering the volcanic rocks. The Lower Extrusives II of the Lower Volcanic Rocks is widely found in the vicinity of the Rakah deposit.

Geologic structure in Area B is also characterized by the thrust faults. The thrust faults consist of two major faults with minor several faults. Because of these thrust faults, the ophiolite show just like reversed structure. Faults, NW-SE trending, are also predominant in the area.

The Rakah deposit is only the known mineralized zone in Area B. The results of drilling survey confirmed two mineralized zones of the lower and upper mineralized zones. Among these zones, the upper mineralized zone reaches to the surface and is intensely gossanized. Old workings are found in this gossan zone.

Assay results for the sample, collected from the gossans and gossan dump show comparatively high concentration of Au (the best values: 13.7 g/t Au, 21.1 g/t Ag) and these high Au zones are widely found in the Rakah deposit area.

5-2 Geophysical survey

(1) Area A (Hayl as Safil deposit)

In order to clarify the extensions of the Hayl as Safil deposit, the geophysical survey of CP method was carried out in Phase I over Area A. The results are as follows:

① The main part of the Hayl as Safil deposit, evaluated by the geophysical survey results, is distributed with the width of 250 m in N-S and E-W directions each. And the boundary of the main part is assumed around 20 m through 60 m west of MJ0-A5/A6 holes around 20 m north of HS-8 hole, around 140 m east of HS-14 hole, and around HS-19 hole. In this main part, the distribution of the orebody is controlled by the fault structures and the orebody seems to be distributed at relatively large thickness.

② According to the geophysical survey results, the orebody extends toward the northwest (the southern-half part of Main Gossan) and to 100 m west of the western edge of the main part, and in these extensions the thickness of the orebody seems to be thin. And also the northeastern extension of the orebody, which is distributed toward 360 m northeast of HS-14 hole, seems to be existed in the depth.

③ The mineralized zone at the north of the Small Gossan is thought not to continue to the main part of the Hayl as Safil deposit.

Based on these survey results, a drilling survey was carried out for the delineated mineralized zones in Phase II. The results confirm that the presumed mineralized zone by the geophysical survey is well correspond to the exact mineralized zones.

(2) Area B (Rakah deposit)

The geophysical survey of CP method was also carried out for Area B in Phase I. The results are as follows:

① The both of the upper and lower mineralized zones of the Rakah deposit are continued electrically, and those show same distribution area each other. Each of those distribution areas, centering the MJ0-B5 hole, shows width of 400 m in E-W and of 300 m in N-S.

② The Rakah deposit is distributed in an E-W direction wholly and in a NW-SE direction at the western part, including the gossan zone, and the northwestern edge is limited by the thrust fault. While, its eastern fringe is located at 100 m east of the hole 36.

③ The distribution of electric field suggests the existence of the electrical discontinuities (fault structures) trending in E-W, NW-SE and NE-SW directions, which control the distribution of the Rakah deposit.

Based on the survey results, a drilling survey were carried out in Phase II, but only the weakly mineralized zone was confirmed at the east of the Rakah deposit.

5-3 Drilling survey

(1) Area A (Hayl as Safil deposit)

Six drill holes including additional two drill holes were completed in Phase I and confirmed the mineralized zone with thick strockwork ore. In order to clarify the extensions of the Hayl as Safil deposit, six drill holes were also carried out in Phase II at the marginal parts of the deposit. These survey results confirmed the lenticular shape and the extensions of the main part of the Hayl as Safil deposit. The deposit covers 400 m (E-W) by 300 m (N-S) and can be traced to 220 m below the surface.

The drilling survey results clarified following characteristics for the Hayl as Safil deposit.

① The mineralized zone is clearly bounded with a strongly chloritized zone at the footwall and a argillized zone at the hanging wall. Ore consists of stockwork, massive and siliceous ores in ascending order. Large-scale stockwork ore zone is found in the center of the deposit. The massive ore tends to develop in the marginal parts. The stockwork ore zone contracts directly to the massive ore zone in the center of the deposit. But pillow lavas of the Lower Extrusives I are intercalated between these two ore zones in the marginal part.

② The stockwork ore is characterized with intense silicification and repeated brecciation. Stockwork quartz veinlets are found throughout the stockwork ore zone. Horizontally the central part of the deposit shows better grade but vertically the difference is very limited and quartz-hematite is found throughout the ore zone.

③ The massive ore is also intensely brecciated and the matrix is filled with sulfide minerals. Colloform pyrite is found in the pyrite breccia. The massive ore shows high grade of copper and also shows comparatively high Au and Ag grades.

④ The siliceous ore show similar looking to the stockwork ore, but it contains more quartz-hematite and sometime associates clay.

⑤ Ore minerals are pyrite and chalcopyrite with minor sphalerite. The ore deposits at shallower depth contain secondary enriched copper minerals including bornite, covellite and chalcosite under a microscope.

The drilling results suggest that the gossanized zones on the surface are formed by strong weathering for the stockwork ore zone.

(2) Area B (Rakah deposit)

In order to clarify the nature of the mineralization and to examine the Au concentrated zone, six drill holes were carried out in Phase I at the middle of the Rakah deposit. In Phase II, five drill holes were completed at the marginal parts of the Rakah deposit to examine the potential zones delineated by the geologic and geophysical surveys in Phase I. Drilling including previous drilling results clarify that the Rakah deposit consists of two mineralized zones dipping eastward and extends 300 m (E-W) by 300 m (N-S). The zones can be traced 220 m below the surface.

The survey results indicate following characteristics for the Rakah deposit.

① The mineralized zone is situated at the top of the Lower Extrusives I and consists of lower and upper mineralized zones. Weakly mineralized volcanics (Lower Extrusives I) are found between these two zones. These volcanics thin out at the east and two mineralized zones form one zone.

② Ore consists of mostly stockwork ore with minor massive and siliceous ores. The massive and siliceous ores are found at the northwest of the ore deposits and have close relation with the sedimentary rocks at the boundary between the Lower Extrusives I and II. The host rocks of the siliceous ore are inferred to be chart.

③ Host rock of the stockwork ore is silicified, brecciated and strongly chloritized pillow lavas. Strongly chloritized zones are found both the top and bottom of the mineralized zone and the ore zones are bounded very clearly with the hanging wall and footwall volcanics.
Ore minerals are found stockwork veinlets and/or disseminations, and are consist of chalcopyrite and pyrite with minor sphalerite. The mineralized zones near surface contain secondary enriched copper minerals including bornite, calcosite and covellite.

④ The massive ore consists of fine-grained pyrite and is strongly brecciated. Because the massive ore is situated near surface, the copper minerals are mostly secondary enriched copper minerals. Under the microscope, framboidal and colloform pyrite are observed. The massive ore contains higher Au and Ag and the best one meter core section encountered are 16.8 g/t Au and 35.89 g/t Ag (MJ0-B1, 38.80 m ~ 39.80 m). In order to clarify the nature of Au and Ag, many polished sections were examined but could not confirm them. Gold is possible included in pyrite.

⑤ The siliceous ore is mostly found above the massive ore and is almost gossanized. Extreme Au concentrated zone was found in this ore zone. The best intersection is D.L.: 5.95 m, 62.91 g/t Au, 124.9 g/t Ag (MJ0-B8, 18.75 m ~ 24.70 m).

The gossanized zones found at the surface are the gossanized stockwork ore of the upper mineralized zone.

5-4 Ore reserve calculation

Number of drill holes including this survey completed for the Hayl as Safil deposit are 52 holes and for the Rakah deposit are 56 holes. These drill holes clearly outlined the both the Hayl as Safil and Rakah deposit. Based on these drilling results, geologic ore reserves were calculated for these ore deposit using 0.20% Cu as the cut-off grade. And the mine development planning were made based on these calculated ore reserves (see Volume III). The geologic ore reserves calculated for these two ore deposits are 15,303,827 tons, 0.99% Cu, 0.14% Zn, 0.55 g/t Au, 2.44 g/t Ag in total.

(1) Geologic ore reserves for the Hayl as Safil deposit

The ore reserve calculation for this deposit was made for the area including the southern half and the southern and eastern parts of the deposit where the drilling survey was almost completed. Distribution of the ore blocks for each level and ore reserves for each block are shown in Appendix 17 and 18 of Volume II respectively. The total geologic ore reserves estimated for the Hayl as Safil deposit are as follows:

Tonnage (t)	Cu%	Zn%	Au g/t	Ag g/t	Cu (t)	Zn (t)	Au (kg)	Ag (kg)
10,553,091	1.00	0.13	0.40	2.59	105,167.29	13,208.12	4,183.17	27,384.82

Additional Ore reserves are expected for northern outside of the ore blocks calculated in this survey. But the expected ore reserves are thought to be limited and the most of the ore reserves for the deposit are possibly calculated in this survey. MPM estimated ore reserves totaling 2,086 thousand tons with 2.09% Cu and 0.97 g/t Au before starting this project. Therefore, 8,467 thousand tons of ore with 0.73% Cu and 0.26 g/t Au were discovered in this survey for this deposit.

(2) Geologic ore reserves for the Rakah deposit

The ore reserve calculation was made for the two zones of the lower and upper mineralized zone. Because the ore zones were clearly delineated in this survey, the expected ore reserves were almost completely estimated. The ore reserves estimated for the Rakah deposit are as follows:

Tonnage (t)	Cu%	Zn%	Au g/t	Ag g/t	Cu (t)	Zn (t)	Au (kg)	Ag (kg)
4,750,736	0.99	0.18	0.88	2.11	46,824.39	8,511.18	4,163.77	10,020.31

In addition to there ore reserves, about 300 thousand tons of Au concentrated ores are expected in the gossan zones. The expected grades are possibly 5.0 g/t Au and 10.0 g/t Ag. But further survey is required to obtain the accurate ore reserves for these gossan zones.

5-5 Interpretation for the survey results

Based on the survey results completed in the Rakah area, the Hayl as Safil and Rakah deposits are interpreted to have the shapes as illustrated in Fig. 4 and 5 respectively. The results also infer the following formation processes for these two ore deposits in the Rakah area:

① Eruption and deposition of the Lower Extrusives I of the Samail Volcanic Rocks due to volcanic activity by the spreading ridge magmatism.

② Formation of parallel faults to the axis of spreading ridge and of brecciation related to the volcanic activity of the Lower Extrusives II with ascending of the ore forming fluids. Formation of stockwork ore in the brecciated zone and of massive and siliceous ores on the sea floor.

③ Repeated brecciation due to ascending fluid and expansion of the mineralized zones.

④ Eruption and deposition of the Lower Extrusives II. Protection for the mineralized zone from sea weathering.

⑤ Obduction of the Samail Nappe and large dislocation of the mineralized zones due to thrust faults.

⑥ Faults and folds after abduction. Small dislocation of the mineralized zones.

⑦ Deposition of Quaternary sediments.

These formation process are same as those for the ore deposits in the Sohar area. If these process are possible, it is important to take attention to the volcanic activity of the Lower Extrusives II in the exploration work for this type ore deposit.

The ore deposits were clearly delineated in this survey. The potential in the vicinity of the known two ore deposit is thought to be very limited.

Chapter 6 Mine development

6-1 Outline of the Sohar mine operation

The Sohar mine is operated by OMCO at this moment. Underground mining is operated in the Lasail and Bayda deposits. New open pit mining operation has been started since September/1989. Total annual ore production is approximately 1,100,000t and its copper grade is 1.60%.

The concentrate from the mineral processing plant is directly delivered to the smelter. Annual concentrate production is 78,000t and its copper grade is 21.2%.

All the cathode which is 15,000t a year is exported to Japan, Korea, Taiwan and Holland.

6-2 Determination of operation size

Open pit mining method has been selected as the most suitable mining method. Cut-off grade is Cu 0.35%. Following are the reasons for the selection.

① The ore bodies are situated in rather shallow place.

② High grade portions are situated in the upper part of the deposits.

③ The average copper grade is relatively low and the ore reserve for the underground mining which exceeds the cut-off grade is only 240,000t on the geologic ore reserve basis whereas that for the open pit mining is as much as 10,000,000t or more.

④ The high grade portions of the stockwork ore which is the major part of the deposits are not consistently existing in the orebody. Therefore it is difficult to mine the high grade portions selectively by the underground mining method. Whereas open pit mining method does not have such a problem owing to its low cut-off grade and nature of mining method.

⑤ The extremely low precipitation in the region is a suitable condition for the open pit mining method.

⑥ Wide locations for the waste dumps are available adjacent to the pits.

⑦ The pits can be designed within the maximum allowable stripping ratio.

Maximum allowable stripping ratio for the Hayl as Safil and Rakah deposits are 11.33 and 6.78 respectively.

The optimum operation size is 3,000 t/day and the mine life is 8 years. General mine layout is shown in Fig. 7.

6-3 Mining

The pit slope angle used in this pit design is 45°. Both the Hayl as Safil and Rakah pits were designed so that highest ore recovery and lowest stripping ratio can be balanced.

The relatively low bench height, 10 m, is determined considering the size of proposed mining equipment. Mobility is the first priority at heavy equipment selection.

The stripping ratio of the Hayl as Safil pit is 3.44, while its maximum allowable stripping ratio is 11.33. In the Rakah pit, they are 4.13 and 6.78 respectively.

Followings are the minable ore reserves delivered by this pit design. The massive ore of the Rakah deposit is excluded due to the difficulty of mineral processing.

	Tonnage (t)	Cu (%)	Au (g/t)
Hayl as Safil deposit	6,284,436	1.28	0.58
Rakah deposit	2,123,833	1.22	0.62
Total	8,408,269	1.26	0.59

The Hayl as Safil deposit requires 12,000,000 t of pre-stripping and the Rakah deposit does 3,136,000t.

In the Rakah deposit, some gossans which contains relatively high gold is to be stockpiled for the possibility of economical gold recovery in the future.

Wadi al Hayl al Ali should be diverted prior to the commencement of the Hayl as Safil pit operation.

The crude ore production in the first operation year is 80% of following years due to "start up" of operation.

Waste handling volume is planned to be reduced year by year.

6-4 Mineral processing

The flotation characteristics of head samples are;

Hayl as Safil ore; the flotation selectivity of minerals of this ore was not so good because of fine mineral combination of chalcopyrite and pyrite and the oxidization of ore.

Rakah stockwork ore; the selectivity of minerals of this ore was good because the grain size of chalcopyrite and pyrite were coarse and was easily liberated.

Rakah massive ore; this ore could not be processed by flotation because the ore consists of

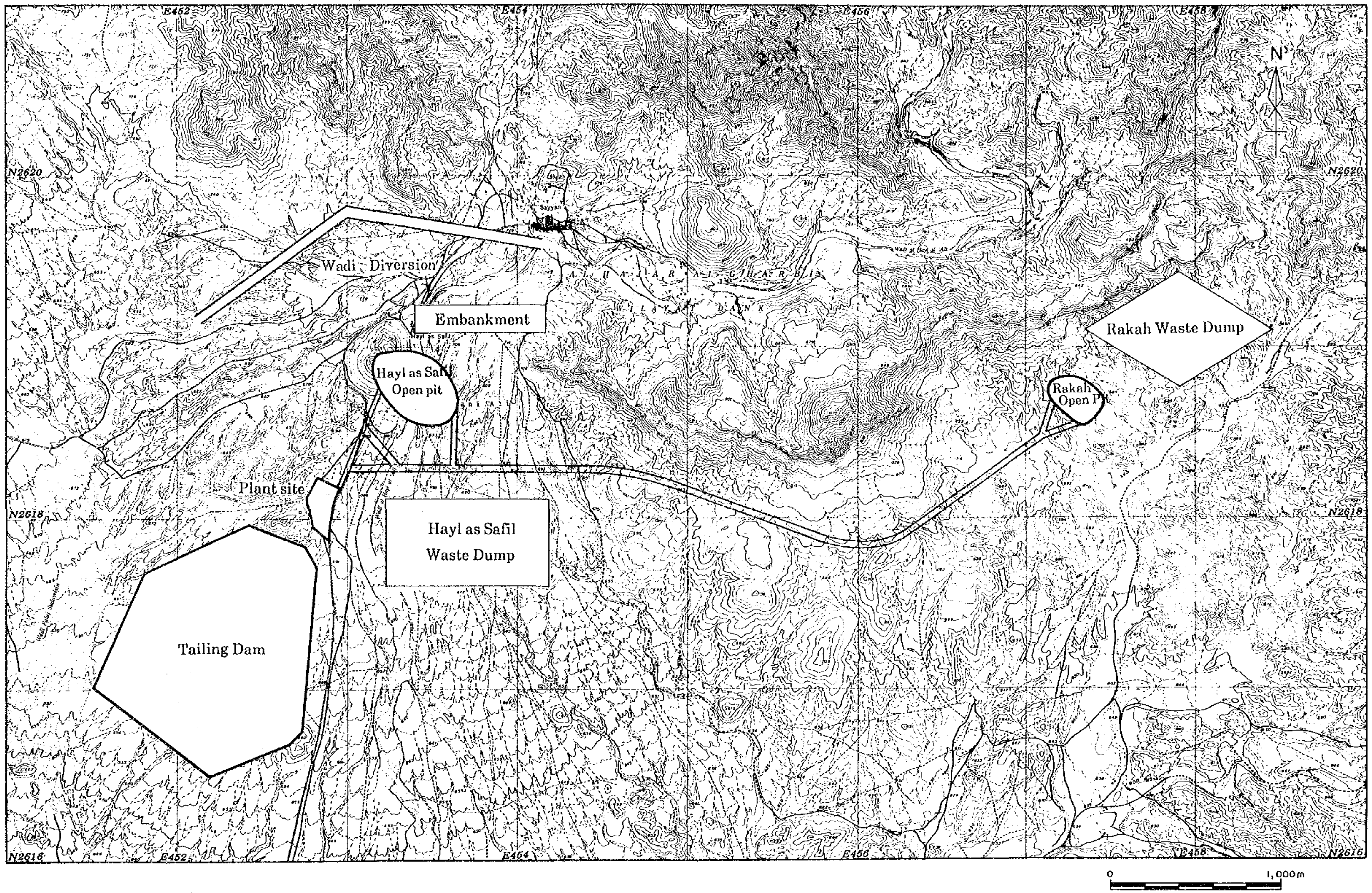

Fig. 7 General mine layout

highly oxidized mineral combination of very fine grain of copper minerals and iron sulfide minerals.

The comminution process is designed in conventional way of three stage crushing and one stage grinding.

Bulk and differential flotation system is taken as a most feasible flotation process of this kind of ore.

Estimated concentrate Cu grade is 20.0%, Au grade is 5.2 g/t, copper recovery is 88.9% and gold recovery is 49.3%.

Mineral processing plant requires 7.5 cubic meter/min of water, where 1.5 cubic meter/min is lost in the tailing dam. Therefore 1.5 cubic meter/min of fresh water should be supplied from outside. Electric power demand is 3,800 kw.

Mineral processing plant flowchart is shown in Fig 8 and general layout of mineral processing plant is shown in Fig. 9.

6-5 Waste dump and tailings dam

Two waste dumps are designed for the Hayl as Safil and Rakah deposits with capacities of 10,000,000 cubic meter and 6,000,000 cubic meter respectively. Both of the dumps are very stable owing to the sufficient area available.

A tailing dam is designed adjacent to the mineral processing plant. The discharge capacity of drain culvert is four times of maximum rain water inflow.

Pit drainage and dust prevention for the mining hauling road are planned.

6-6 Supporting, organization and manning plan

Finance, commerce, general affairs and personnel sections are planned as supporting department. In this project, engineering department is not independently established, the maintenance works are to be carried out by the maintenance group in the mineral processing plant and the repair shop in the mining department respectively.

Every effort is made for establishing an efficient organization with reducing as possible the number of persons in manning plan of each department. However, on the other hand, some increment of personnel are estimated during 5 years from commencement of operation, to promote systematically the Omanization of employee. By this Omanization program, it is planned to upgrade 100 Omani employees and to replace the foreign employees with them.

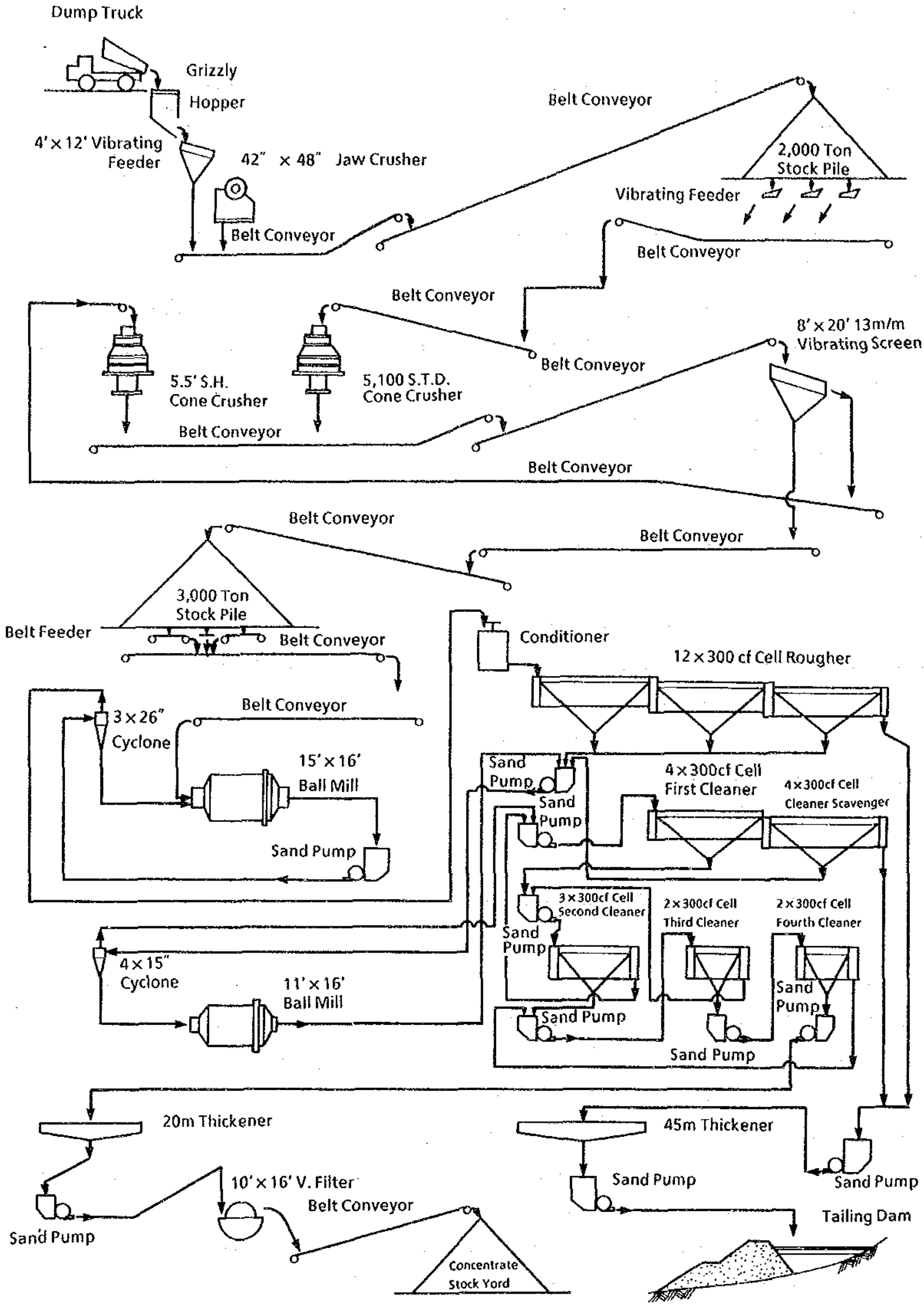

Fig. 8 Mineral processing plant flowchart

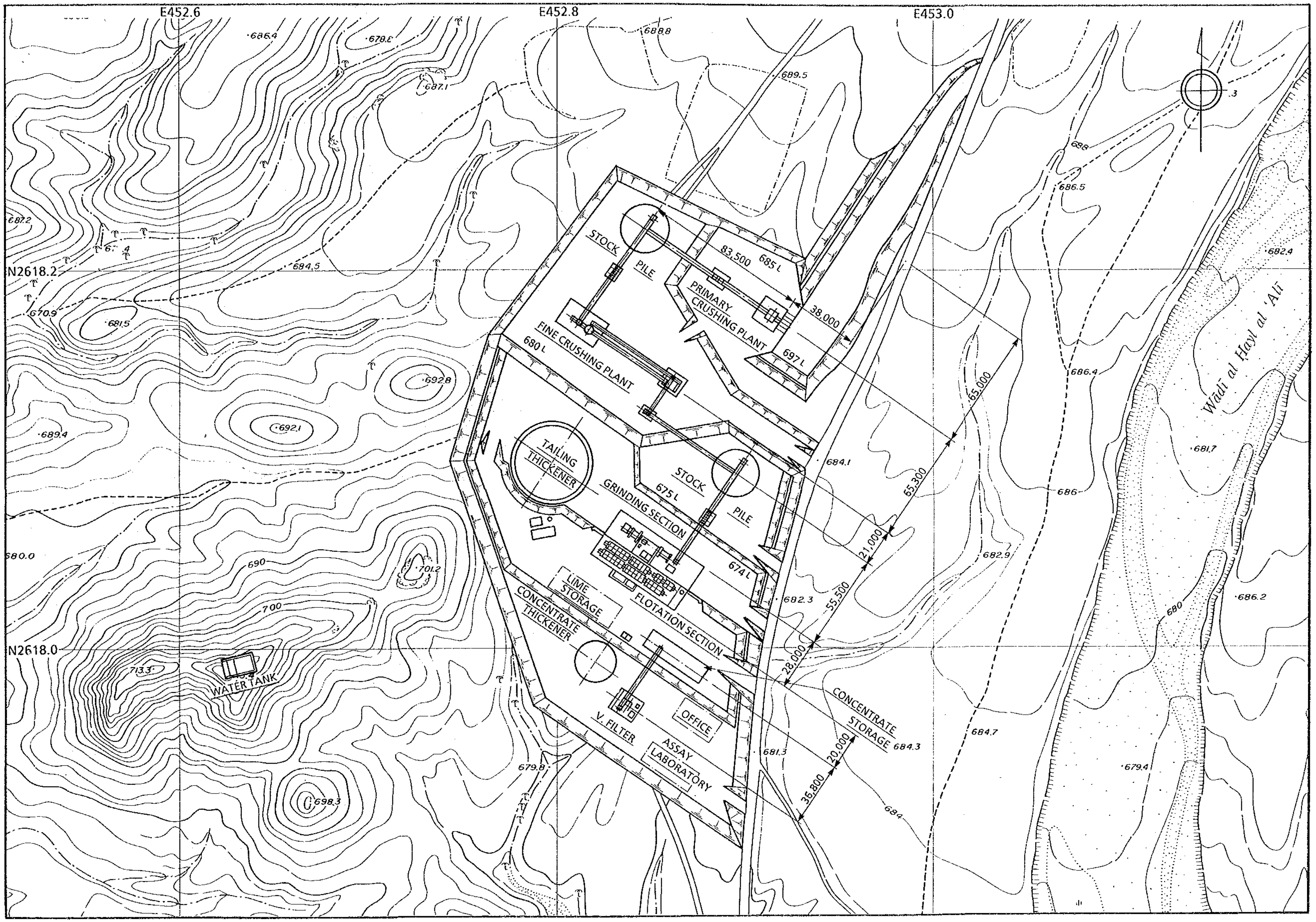

Fig. 9 General layout of mineral processing plant

6-7 Infrastructure

The route of transportation for mine construction machinery, equipment and materials and operating supply is appropriate from Muscat - Nizwa - Ibri - Yanqul to proposed mine site based on the result of site investigation. Most of this route is asphalt paved and no special construction cost is required.

Copper concentrate produced at the mineral processing plant is sent to the Sohar smelter by road. The route is proposed mine site - Yanqul - Ibri - Buraymi - Sohar smelter. The distance is 288 km and most of the route is also asphalt paved. Therefore no special construction cost is required.

The mine operation requires 1.5 cubic meter/min, or 2,200 cubic meter/day of fresh water. Apart from a problem of water utilization right, it is considered to be able technically to secure fresh water through taking subsurface water as a result of site investigation.

The estimated demand of electricity is 4,000 kw mainly for the mineral processing plant operation. The necessary electricity is supplied by construction of power line extension of about 23 km from the Hayl substation.

Communication system of this project is planned with wire telephone and facsimile by constructing telephone wire line for a distance of about 13 km from Yanqul telephone office.

Housing facilities for this project are planned to set up in the urban district of Yanqul. Stores, schools, clinics, mosques and other facilities necessary for lives of employees and their families are already existing in Yanqul.

Number of company house is;

For married employees;

High grade	7 houses
Middle grade	17 houses
Standard grade	25 houses

For single employees;

Dormitory	103 rooms

6-8 Capital, additional and operating costs

Total initial construction cost is US$54,815,500. Summary of construction cost is shown in Table 4.

Table 4 Summary of construction cost

Item	Construction cost	Percentage
	(US$1,000)	(%)
Mining	19,172.7	35.0
Concentrator	21,562.6	39.3
Mine general items	2,935.6	5.4
Infrastructure	3,124.7	5.7
Sub-total	46,795.6	85.4
Contingency	2,506.3	4.6
Design, Engineering and Construction management fee	5,513.6	10.1
Sub-total	8,019.9	14.6
Total	54,815.5	100.0

Additional investment is US$3,328,000 which consists from pre-stripping cost of Rakah deposit, US$1,410,300, and heavy equipment purchasing, US$1,917,700.

Mining unit operating cost for ore of the Rakah deposit is US$1.539/t and for other materials US$1.121/t respectively.

Mineral processing cost is US$4.462/t. Supporting department requires US$1,568,900/year. Copper transportation cost is US$10.0/t of concentrate. Besides these costs, US$303,100/year is allocated for the Omanization program during the first 5 years of operation. The copper break even is US¢99.7/lb.

6-9 Overall evaluation

The major premise for the financial analysis and economic analysis on this project is that the project is financially independent from the Sohar mine.

The smelter terms used in this evaluation is international standard condition at present. The actual cost and recovery of the Sohar smelter were not used in order to evaluate this project objectively.

For a financial evaluation on this project, annual production schedule, estimated annual revenue and annual profit (loss) and cash flow (financial evaluation) are developed. The financial IRR to the project is 6.40% and IRR to the equity is 0.50%.

A sensitivity analysis has been conducted and it is proven that the project is most sensitive to metal price. Annual profit (loss) and cash flow (financial evaluation) is shown in Table 5 and the results of sensitivity analysis are shown in Table 6 and Fig. 10.

Economic evaluation has also been conducted and economic IRR to the project of 8.90% and IRR to the equity of 7.96% are obtained.

Recovery of gold in the gossan and recovery of valuable metals in the massive ore by leaching and/or direct smelting should be researched as the future technical subjects.

It seems no mineral deposit exist under the plant and tailing dam sits from the geology of this area, however, the re-confirmation by drilling should be carried out prior to the construction works.

Table 5 Annual profit (loss) and cash flow (financial evaluation)

Metal Price			IRR
Copper	(US¢/lb)	100	6.40% as R.O.I.
Gold	(US$/troz)	400	0.50% as R.O.E.

(Unit : US$1,000)

	Year -2	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Total
(PROFIT & LOSS STATEMENT)											
1. NET REVENUE			19,009.8	26,362.7	25,151.8	28,220.7	24,830.7	16,263.0	21,020.9	16,272.1	177,131.6
2. COSTS											
Direct Operating Costs											
Mining			2,872.9	5,268.6	4,870.3	4,543.2	3,432.9	2,694.4	2,560.8	2,295.7	28,538.8
Concentrator			3,784.7	4,819.0	4,819.0	4,819.0	4,819.0	4,819.0	4,819.0	4,819.0	37,517.4
Supporting			1,566.9	1,566.9	1,566.9	1,566.9	1,566.9	1,566.9	1,566.9	1,566.9	12,535.2
Conc. Transportation			507.7	704.0	671.7	753.7	663.1	434.3	561.4	434.6	4,730.5
Training Cost			303.1	303.1	303.1	303.1	303.1	0.0	0.0	0.0	1,515.6
Sub-total			9,035.3	12,661.7	12,231.0	11,985.9	10,785.0	9,514.5	9,508.1	9,116.1	84,837.5
Royalty			925.1	1,282.9	1,224.0	1,373.4	1,208.4	791.4	1,023.0	791.9	8,620.1
Depreciation			6,001.1	7,976.5	7,976.5	8,046.5	8,204.0	8,204.0	8,204.0	8,204.0	62,816.4
Interest 10.00%			4,804.3	4,614.6	3,925.0	3,172.0	2,059.9	961.8	448.1	0.0	19,985.8
Total Costs			20,765.8	26,535.7	25,356.5	24,577.7	22,257.3	19,471.8	19,183.2	18,111.9	176,259.8
3. PROFIT BEFORE TAX			-1,756.0	-173.0	-204.7	3,643.0	2,573.4	-3,208.8	1,837.7	-1,839.9	871.8
4. INCOME TAX			0.0	0.0	0.0	96.3	176.1	0.0	0.0	0.0	272.4
5. NET PROFIT AFTER TAX			-1,756.0	-173.0	-204.7	3,546.7	2,397.3	-3,208.8	1,837.7	-1,839.9	599.4
(CASH FLOW STATEMENT)											
Net Profit After Tax			-1,756.0	-173.0	-204.7	3,643.0	2,477.1	-3,384.9	1,837.7	-1,839.9	599.4
Depreciation			6,001.1	7,976.5	7,976.5	8,046.5	8,204.0	8,204.0	8,204.0	8,204.0	62,816.4
Equity	13,703.8										13,703.8
Loan	6,181.0	41,862.4									48,043.4
Capital Expenditure	-19,322.9	-35,492.4									-54,815.4
Interest During Construction	-561.9	-4,111.2									-4,673.1
Additional Capital Expenditure			-2,348.0	0.0	-350.0	-630.0	0.0	0.0	0.0	0.0	-3,328.0
Working Capital Increase (Decrease)		-2,258.8	0.0	-906.6	107.7	61.3	300.2	317.6	1.6	2,377.0	0.0
Loan Repayment			-1,897.1	-6,896.8	-7,529.5	-11,120.8	-10,981.3	-5,136.7	-4,481.2	0.0	-48,043.4
Net Generated Cash			0.0	0.0	0.0	0.0	0.0	0.0	5,562.1	8,741.1	14,303.2
PRINCIPAL		48,043.4	46,146.4	39,249.5	31,720.0	20,599.2	9,617.9	4,481.2	0.0	0.0	
(RATE OF RETURN)											
Net Generated Cash			0.0	0.0	0.0	0.0	0.0	0.0	5,562.1	8,741.1	14,303.2
Capital Expenditure	-19,884.9	-41,862.4									-61,747.3
Repayment Flow Adjustment			1,897.1	6,896.8	7,529.5	11,120.8	10,981.3	5,136.7	4,481.2	0.0	48,043.4
Interest Flow Adjustment			4,804.3	4,614.6	3,925.0	3,172.0	2,059.9	961.8	448.1	0.0	19,985.8
Cash Flow Out and In	-19,884.9	-41,862.4	6,701.4	11,511.5	11,454.4	14,292.8	13,041.2	6,098.5	10,491.4	8,741.1	20,585.2
Discounted Cash Flow at 6.40%	-18,689.3	-36,979.9	5,563.9	8,982.9	8,400.9	9,852.4	8,449.2	3,713.5	6,004.4	4,701.9	-0.0
(RATE OF RETURN TO THE EQUITY)											
Net Generated Cash			0.0	0.0	0.0	0.0	0.0	0.0	5,562.1	8,741.1	14,303.2
Capital Expenditure	-13,703.8										-13,703.8
Cash Flow Out and In	-13,703.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,562.1	8,741.1	599.4
Discounted Cash Flow at 0.50%	-13,635.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,318.7	8,317.2	-0.0

Table 6 Sensitivity analysis on the FIRR (project)

Cu price	Capital cost	Operating cost +20%	+10%	0%	-10%	-20%
-20%	+20%	-16.24	-12.59	-9.34	-6.37	-3.63
	+10%	-15.02	-11.25	-7.88	-4.81	-1.96
	0%	-13.66	-9.75	-6.25	-3.05	-0.07
	-10%	-12.12	-8.04	-4.39	-1.04	2.08
	-20%	-10.35	-6.08	-2.23	1.30	4.60
-10%	+20%	-8.49	-5.63	-2.96	-0.45	1.92
	+10%	-7.03	-4.05	-1.28	1.32	3.80
	0%	-5.38	-2.28	0.61	3.34	5.89
	-10%	-3.50	-0.26	2.78	5.61	8.19
	-20%	-1.33	2.09	5.28	8.15	10.87
0%	+20%	-2.31	0.13	2.46	4.68	6.73
	+10%	-0.63	1.92	4.34	6.58	8.67
	0%	1.27	3.93	6.40	8.68	10.88
	-10%	3.44	6.18	8.70	11.10	13.43
	-20%	5.91	8.72	11.38	13.94	16.43
+10%	+20%	2.98	5.16	7.15	9.04	10.88
	+10%	4.86	7.03	9.08	11.07	13.00
	0%	6.89	9.13	11.29	13.38	15.42
	-10%	9.19	11.55	13.84	16.06	18.24
	-20%	11.87	14.39	16.84	19.23	21.56
+20%	+20%	7.55	9.41	11.23	13.00	14.72
	+10%	9.48	11.44	13.35	15.21	17.03
	0%	11.69	13.76	15.77	17.74	19.67
	-10%	14.24	16.44	18.58	20.68	22.74
	-20%	17.24	19.59	21.89	24.15	26.37

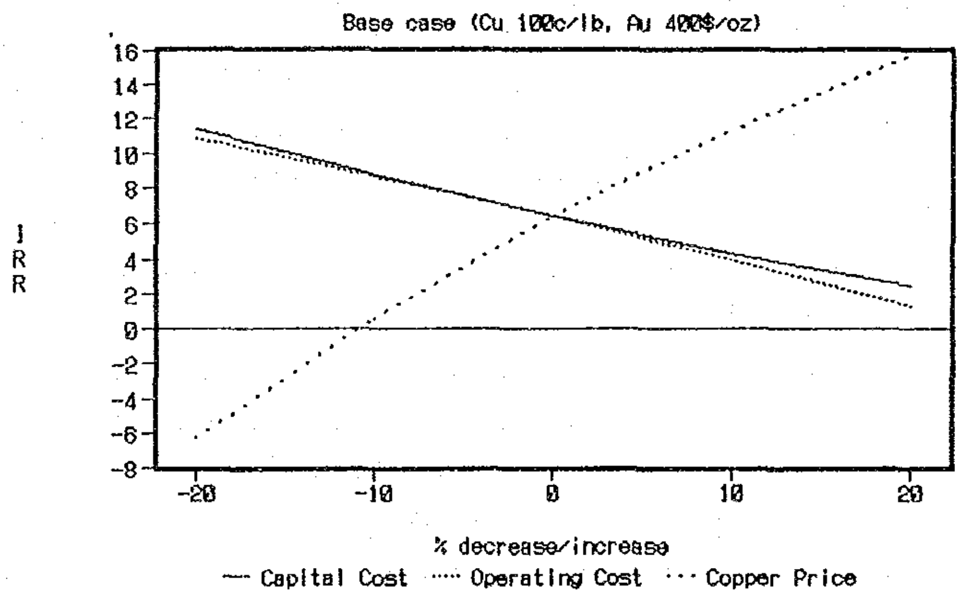

Fig. 10 FIRR sensitivity analysis

Chapter 7 Conclusions and recommendations

7-1 Conclusions

The geologic, geophysical (CP method) and drilling surveys were carried out for the known two ore deposits of the Hayl as Safil (Area A) and Rakah (Area B) deposits in the Rakah area in order to clarify the potential for these two deposits. Based on the results of these exploration works, calculation of the ore reserves and a preliminary feasibility study including metallurgical test for mine development were also carried out in this survey. The exploration works resulted to delineate the deposits very clearly and confirmed approximately 15,300 thousand tons of geologic ore reserves for both the ore deposits.

According to the calculated ore reserves, the optimum mining method and operation size were decided. The mineral processing plant was also designed based on the result of the metallurgical test. Furthermore the infrastructures required for the mine development were also studied. Based on these results, capital, additional and operation costs were estimated and then financial IRR of 6.40% and economic IRR of 8.90% were obtained.

The exploration works and ore reserve calculation completed for the Rakah area are conclusively summarized as follows:

① The Rakah area is situated in the area of the Semail Nappe. Geology of the area consists of Samail Ophiolite and Supraophiolite sediments. The Samail Ophiolite consists of Tectonite, Cumulate Sequence, High-level Gabbro, Sheeted-dyke Complex and Samail Volcanic Rocks in ascending order. The Samail Volcanic Rocks are divided into the Lower Volcanic Rocks and Middle Volcanic Rocks. Furthermore, the Lower Volcanic Rocks are subdivided into the Lower Extrusives I and II in ascending order. The known two ore deposits in the Rakah area are situated at the top of the Lower Extrusives I and are covered with the Lower Extrusives II. This type ore deposit in the Oman Mountain region are syngenetic ore deposit and is found in the area where the Lower Extrusives II are developed. These ore deposits may have close relation with the volcanic activity of the Lower Extrusives II.

② Geologic structure in the Rakah area is represented by thrust faults formed during obduction of the Samail Ophiolite. The thrust faults form imbrication structure and the sequence is appeared to be reversed. Faults and weak folds after the obduction are also found in the area. The known two ore deposits in the area are dislocated due to these tectonic movement.

③ The both ore deposits in the Rakah area consist of stockwork, massive and siliceous ores in ascending order and the stockwork ore is predominant in both the deposits. The massive and siliceous ores are found at the boundary between the Lower Extrusives I and II. The Hayl as Safil deposit is characterized with intense silicification and brecciation. Quartz-hematite (jasper) are also observed throughout the mineralized zone. The stockwork ore in the Rakah deposit is characterized with strong chloritization of the host rocks. The massive and siliceous ores are found at the boundary between the Lower Extrusives I and II and show close relation with sedimentary rocks which occur at the boundary. Ore minerals found in both the ore deposits consist of pyrite, chalcopyrite, sphalerite, covellite, chalcosite and bornite. Among these ore minerals, covellite, chalcosite and bornite are interpreted to be formed as secondary copper enrichment.

④ Based on the guidelines delineated by the geophysical survey of CP method, the drilling survey was carried out and the results show that the ore deposits are exactly delineated by this survey. It is concluded that the CP method using drill holes with intersection of mineralized zone is quite useful for the exploration in this area.

⑤ The geologic ore reserves calculated for both the ore deposits are as follows.

	Tonnage (t)	Cu %	Au g/t	Cu (t)	Au (kg)
Hayl as safil	10,553,091	1.00	0.40	105,167.29	4,183.17
Rakah	4,750,736	0.99	0.88	46,824.39	4,163.77
Total	15,303,827	0.99	0.55	151,991.68	8,346.94

About 8,500 thousand tons of ore (0.73% Cu and 0.26 g/t Au) within the total reserves were discovered in this survey. Because of limited number of drill hole in the western part of the Hayl as Safil deposit the accuracy of the ore reserves are thought to be slightly low. The accuracy of Au and Ag grades for the ore reserves of the Rakah deposit are also slightly low due to limited number of assay results.

⑥ Gossan and gossan dump containing high Au in the Rakah deposit were estimated to be about 300 thousand tons with 5.0 g/t Au and 10.0 g/t Ag. There gossans are situated in the open pit planned in this survey and therefore it is necessary to sample these gossans for assaying at the pre-stripping stage of the mine development.

Based on the geologic ore reserves estimated by the exploration results, a preliminary feasibility study for mine development was carried out for the Hayl as Safil and Rakah deposits. The results are conclusively summarized as follows:

① Because of the situation of ore bodies, ore reserves and distribution tendency of ore grade, the open pit is the optimum mining method. The cut-off Cu grade is 0.35% in the case of open pit mining. The optimum operation size is 3,000 tons/day and the estimated mine life is 8 years.

② Pit slope was designed to be 45° and the pits were designed to maximize the ore recovery with minimum waste rocks. As the results, the stripping ratios for the Hayl as Safil and Rakah deposits are 3.44 and 4.13 respectively. The minable ore reserves due to the designed pits are as follows:

	Tonnage (t)	Cu %	Au g/t	Cu (t)	Au (kg)
Hayl as safil	6,284,436	1.28	0.58	8,0436.1	3,657.64
Rakah	2,123,833	1.22	0.62	25,924.1	1,313.68
Total	8,408,269	1.26	0.59	106,360.2	4,971.32

③ The mineral processing plant was designed based on the results of the metallurgical test completed in this survey. The conventional three stage crushing and one stage grinding were applied for the comminution process. The bulk and differential flotation system is applied as the most feasible flotation process. The estimated grades for the concentrates are 20.0% Cu and 5.2g/t Au. The recavaries for Cu and Au are 88.9% and 49.3% respectively.

④ The waste dumps and tailing dam are designed to avoid the pollution. Suitable sites for these facilities are found near the mineral processing plant. Treatments of waste water from the pit and dust prevention for the ore haul road are also planned.

⑤ Supporting and administration departments are planned. The Sohar operation has independent engineering department, but this section belongs to the mining and mineral processing departments separately in this survey.

⑥ The organization and manning for the operation are planned with reference of the Sohar operation. But minimizing manpower and efficient organization are tried in this survey. The maximum manpower for the operation is 390 and 50% of the manpower is Omani at the final stage.

⑦ As for the infrastructure, transportation roads of equipments and materials for construction and operation, and of copper concentrate for the Sohar smelter are planned. No initial cost are required for the roads because the existing roads have no problem for the transportation. Water, power, facilities and communication are also planned in this survey. Water is technically available at the south of Yanqul.

⑧ Total construction cost is estimated to be US$54,815,500.
Financial and economic evaluation as well as cash flow chart are made based on the estimated costs. The Financial IRR and Economic IRR are 6.40% and 8.90% respectively.

As the results of this survey, the Hayl as Safil and Rakah deposits were clearly confirmed and a great amount of ore reserves was discovered. The mine development plan including necessary infrastructure was constructed. Because the financial IRR is 0.64%, the risk for mine development should be considered for the development of these two ore deposits.

7-2 Recommendations

The geologic, geophysical and drilling surveys as well as the ore reserve calculation completed for the Nayl as Safil and Rakah deposits in the Rakah area clearly confirmed the nature of mineralization and the ore reserves. The necessary exploration work for both the deposit were almost completed. The optimum mining method, operation size and mineral processing method as well as necessary infrastructure were planned and designed in the preliminary feasibility study for mine development of these two ore deposits. No technical difficulty is found for the mine development. Based on the estimated costs for the development and operation, the financial and economic analyses were carried out and 6.40% and 8.90% of IRR were obtained respectively. Sensitivity analysis was also carried out and the result indicated that if the copper price was US$1.10/pound the financial IRR would be more than 10%. It is important to take account of the operation of the Sohar Smelter whether these ore deposits should go to the stage of the feasibility study including detail designing.

If MPM plans more detailed surveys for the mine development of both the deposits, following surveys can be recommended:

① In order to clarify the ore reserves and grades of the gossans with higher Au concentration in the Rakah deposit, it is necessary to carry out 10 m grid drilling. However, if the mine is going to develop, systematic sampling should be carried out in the pre-stripping stage because the gossan zones are situated in the designed open pit. If high grade Au is confirmed in the gossan, it may be possible to recover it. Therefore, the gossan should be treated separately to the waste in the pre-stripping stage.

② Recovery of Au in the gossans and recovery of valuable metals in the massive ore by leaching and/or direct smelting should be researched as the future technical subject.

③ *Before starting the construction, a drilling survey should be carried out for the planned site* areas of the waste dumps, tailing dam and mineral processing plant, in order to confirm the no potentiality of ore in the site areas.

④ Water, mostly used in the mineral processing plant, is technically possible to take at the south of Yanqul. It is necessary to clarify the right of water use.

⑤ The used mining equipments are not considered in this survey. But it is better to survey the used equipments in the stage of the feasibility study in order to reduce the initial cost.

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FIGURES

Fig. 1 Location map of the Rakah area

Fig. 2 Location map of survey areas

Fig. 3 Flowchart showing the work methods and amounts in this project 3

Fig. 4 Stratigraphic columnar section of the Rakah area 11

Fig. 5 Three dimensional illustration for the Hayl as Safil deposit 13

Fig. 6 Three dimensional illustration for the Rakah deposit 14

Fig. 7 General mine layout 23

Fig. 8 Mineral processing plant flowchart 26

Fig. 9 General layout of mineral processing plant 27

Fig. 10 FIRR sensitivity analysis 33

TABLES

Table 1 Summary of method and amounts of work in this project 2

Table 2 Period and participants for this project 4

Table 3 Monthly temperature and railfall at Buraymi 6

Table 4 Summary of construction cost 30

Table 5 Annual profit (loss) and cash flow (financial evaluation) 32

Table 6 Sensitivity analysis on the FIRR (project) 33