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

(PHASE I)

MARCH 2001

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 a Mineral Exploration Project 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 project commenced in fiscal year 2000 as the First Phase, and JICA and MMAJ dispatched to Oman a survey team consisting of 6 members from August 29, 2000 to February 14, 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 has been prepared. This report includes the survey results of metallurgical tests, environmental studies and geological, geophysical and drilling surveys carried out during the duration of this phase.

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 2001

Kunihiko Saito
President
Japan International Cooperation Agency

Naohiro Tashiro
President
Metal Mining Agency of Japan

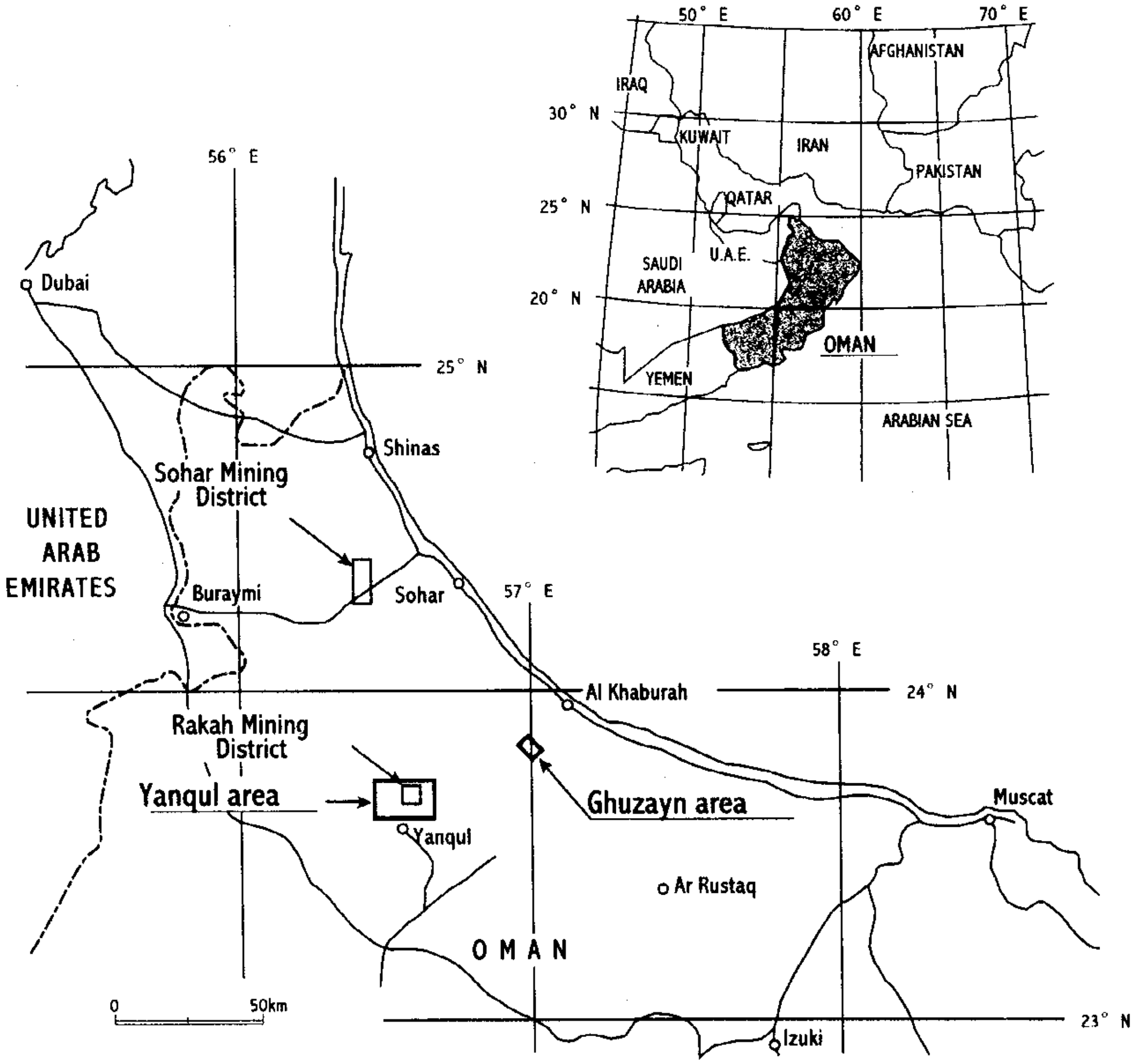

Fig.1 Lacation map of the surveyed area

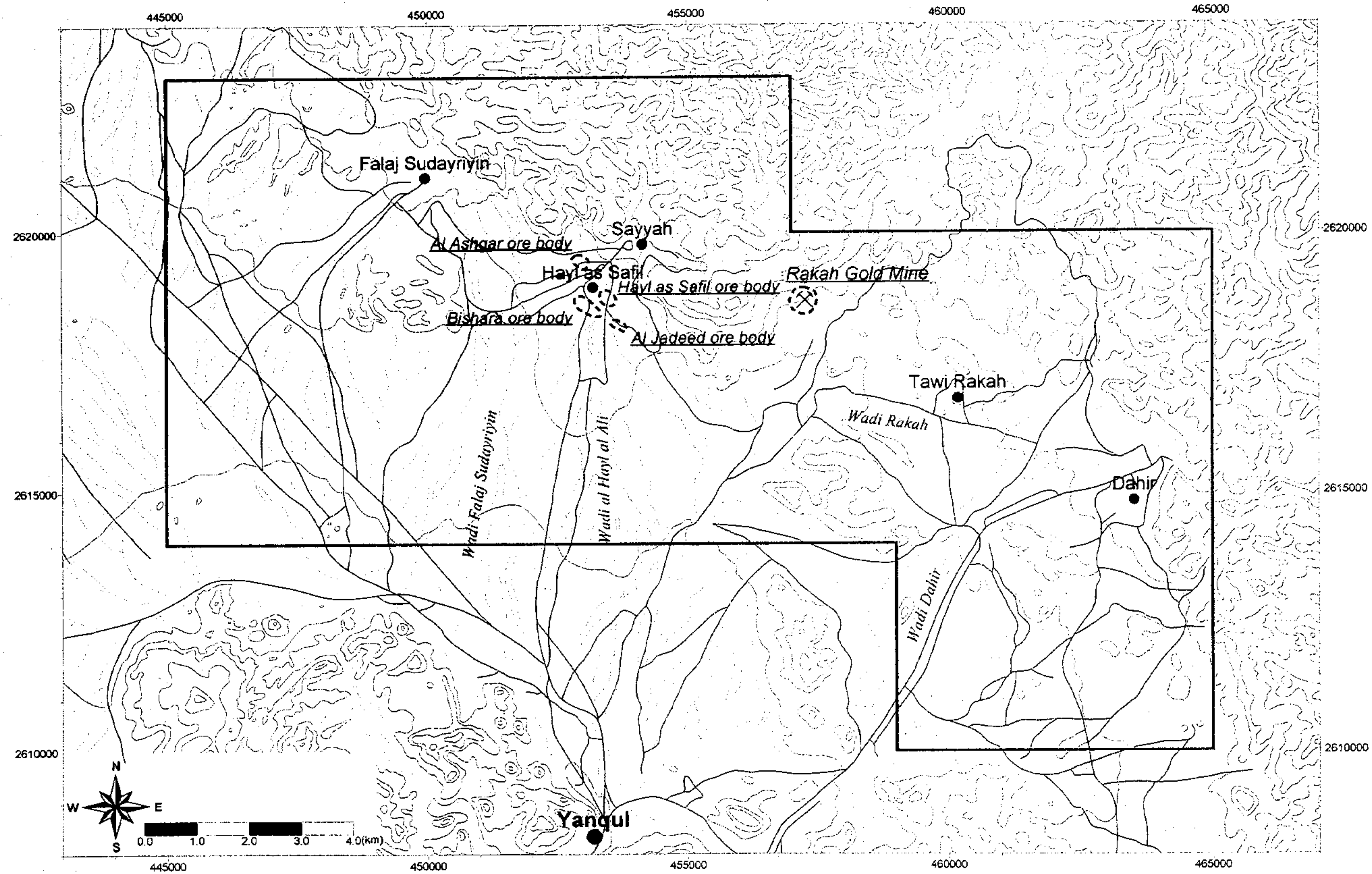

Fig. 2 Lacation map of Yanqul area

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.

The northern part of Oman is well known since ancient times as copper production areas 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 Oman 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, has 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 regard, the Omani government requested the Japanese government to conduct 2 years pre-F/S survey to evaluate in an integrated manner, in an integrated manner, the ore deposits already confirmed. This year is the first phase of this program including metallurgical tests, existing data analysis, and environmental, geological, geophysical and drilling surveys

The main results are as follow:

(1) Metallurgical tests

i) Copper recoveries form rougher/scavenger flotation varied from 94% to 96% for the stockwork samples and from 80% to 90% for the breccia and massive sulphide samples. Concentrate grades also varied, ranging from 42% in the rougher 1 concentrate for Rakah massive sulphide to 22% to 25% for the remaining samples.

ii) A significant result of the test program is that all samples responded well to the same collectors, with pH being the only main variable between the conditions suitable for the respective ore types.

iii) As a results of the mineralogical tests, it is found that reground level can be achieved without using ultra fine grinding technology. Therefore, normal tower mill or ball mill are considered

to be good enough. Decision for re-grounding level is one of the activities scheduled for the next year's metallurgical tests.

iv) Cyanid leaching of pyrite concentrates was low at approximately 30%. Re-grinding increased the extraction.

(2) Environmental Survey

i) In order to study ground water movement, permeability and water quality near Rakah and Hayl as Safil mining areas were studied by measuring water recovery and water quality in 5 drillings made for that purpose.

ii) All the wells, which were drilled in a wadi, showed a little amount of water due to recent dry weather conditions.

iii) Water quality results indicate a weak alkalinity with a little higher pH in comparison with the Japanese river waters. Total dissolved solids (TDS) show high values ranging from 200 to 1200 mg/l with high calcium hardness. Compared with previous data, Nitrite Nitrogen values indicate extraordinarily higher values.

(3) Existing Data Analysis

i) In order to confirm the geological and minable ore reserves, the following items are to be needed to clarify: detailed geological and ore body model, distribution of each ore type, proper method for ore reserve calculations and optimization of the ore reserve parameters.

ii) Mineralization at Yanqul region is mainly stockwork accompanied by massive and brecciated ore types.

(4) Exploration

i) Geophysical anomalies were found in five areas including known mineralized zones: Quron Al-Akhbab, Tawi Rakah mineral showing, Rakah gold mine, Najaid area, and Hayl as Safil ore deposit.

ii) Among the above 5 areas, a promising copper mineralization (stockwork mineralization) was detected in Quron Al-Akhbab.

iii) Geophysical anomalies detected over Hayl as Safil deposit were effective to delineate the location of the deposit, indicating a good coincidence of massive sulphide distribution with high TEM responses.

The second phase, the last phase of this project conducted in these areas, will mainly consists of the continuation of the activities carried out during the first phase as well as infrastructure study, and financial and economic evaluation. A comprehensive evaluation is expected to be done on the basis of the results of the second phase results.

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PART II SURVEY RESULTS

PART III CONCLUSIONS AND RECOMMENDATIONS

PART I GENERALITIES

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 Oman 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, has 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 they are separated by the Oman Mountains, Ghuzayn to the north and Yanqul to the south. The survey areas, shown in Fig.1, is 20km^2 in Ghuzayn and 180km^2 in Yanqul. Fig.2 shows the location map of Yanqul region.

This year, the first phase of this project, included metallurgical tests, existing data analysis, and environmental, geological, geophysical and drilling surveys. The content and amount of works of these surveys are indicated in Tables 1-1-1 to 1-1-4.

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

・Drilling survey

Area	No.	Length	Inclination	Direcion
Yanqul Area	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°	
Grand total of length		1904.25m		

・Drilling for metallurgical test

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

・Drilling for environmental survey

Area	No.	Length	Inclination	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		

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

・Geological survey

Area coverage	Scale	Length of Survey route
$60km^2$	1/25,000	74.3km

・Geophysical survey(1)

Area name	Method	Length of measurment
Yanqul Area	IP method	95.9km
Total length of measurement	95.9km	
Number of measurement point	3,220 points	

・Geophysical survey(2)

Area name	Method	Number of loop
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 -1-3 Content and amount of laboratory work

Survey	Laboratory work	Amount
Geological survey	Thin sections	22 samples
	X-ray difraction analysis	21 samples
	Chemical analysis of ore (Au,Ag,Cu,Pb,Zn,Fe)	17 samples
Environmental survey	pH, conductivity, groundwater temperature	5 samples
	Chemical analysis of groundwater (Cu,Zn,Pb,Ni,Cr,Fe,Mn,Hg,SO_4)	5 samples
Geophysical survey (IP method)	Resistivity and polarizability measurement	41 samples
Drilling survey	Thin sections	10 samples
	Polished sections	20 samples
	X-ray difraction analysis	10 samples
	Chemical analysis of ore (Au,Ag,Cu,Pb,Zn,Fe)	275 samples

Table I -1-4 Content and amount of metallurgical test

Test Item	Details	Amount
1. Sampling	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	Weighting, crushing and blending	4 sets of ore samples, 1,000kg in total
3. Characreristics of feed ore	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	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, Al_2O_3, CaO, Fe_2O_3, K_2O, MgO, MnO, Ma_2O, P_2O_5, SiO_2, TiO_2, Hg, F)	3 products × 26 elements
	Mineralogical test for flotation products	12 products
	Settling and filltering tests	each 1 set for 4 samples
5. Leaching	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 Members of the Project

The members of the project were as follows:

(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 Deve. Corp.
David Escobar	Geophysical Survey	Mitsubishi Materials Natural Resources Deve. Corp.
Susumu Endo	Geophysical Survey	Mitsubishi Materials Natural Resources Deve. Corp.
Yoshimitsu Negishi	Geophysical Survey	Mitsubishi Materials Natural Resources Deve. Corp

Omani Counterpart

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

1-4 Survey Period

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

(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

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.

CHAPTER 3 GEOLOGY AND ECONOMIC GEOLOGY OF THE SOUTH BATINAH COAST AREA

3-1 General Geology

The Oman Mountains, forming part of the Alps-Himalaya orogenic belt, consist of autochthonous and allochthonous units. The autochthonous units form the Arabian Platform and consists of 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 consist of Hawasina Sediments and the Samail Nappe is divided into Samail Ophiolite and Supra-ophiolite Sediments. The study area is located on the Samail Nappe.

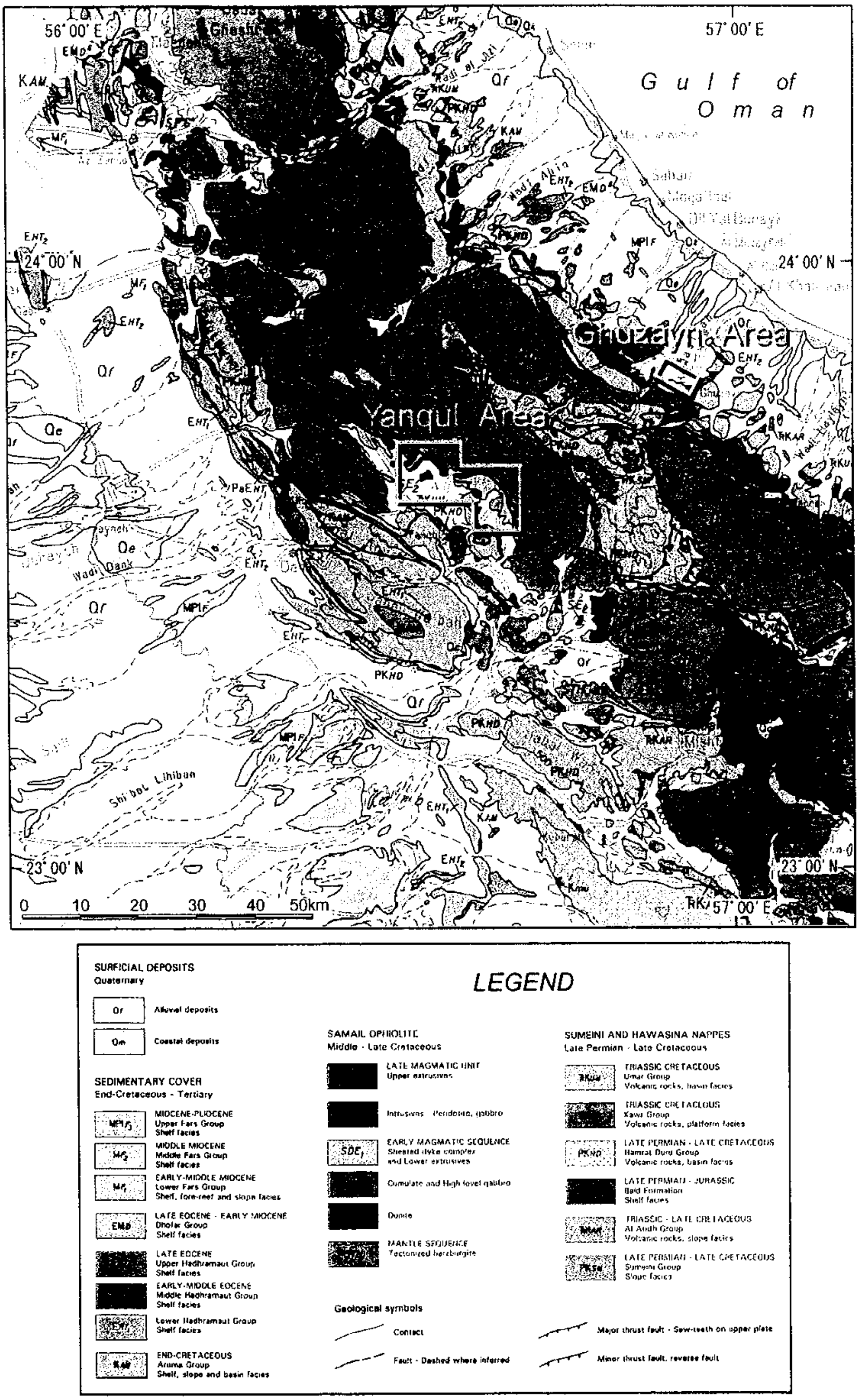
The Samail Ophiolite consists of Tectonites, Cumulate Sequence, High-level gabbro, Sheeted-dyke Complex and Samail Volcanic Rocks in ascending order. The Supra-ophiolite Sediments comprise mainly olistostroms. The geological map of the study area is shown in Fig. I -3-1.

Structural development in the area can be divided into three stages; formation of Samail Ophiolite (stage-1), obduction of Samail Ophiolite (stage-2), and after emplacement (stage-3). Samail Ophiolite was formed in the spreading ridge of Palaeo-Tethys sea from early to Middle Cretaceous (Lippard et al., 1986). In this stage, (stage-1), the Hawasina basin was situated between the ridge and the Arabian Plate and the Hawasina Sediments were deposited in the basin. The original structures of Ophiolite generally remain within 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 the obduction 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 an imbricated structure. The stage-3 corresponds to post-obduction and shows a variation in different localities. Several faults in this stage are found in the Rakah area.

3-2 Mineralization and Mining Activities

3-2-1 Mineralization

Massive sulphide 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, it is understood that the Cyprus-type copper deposits are formed on the sea floor and accompanied with basic



Ministry of Petroleum and Minerals (1993)

Fig. I-3-1 Geological map of the Yanqul - Ghuzayn area.

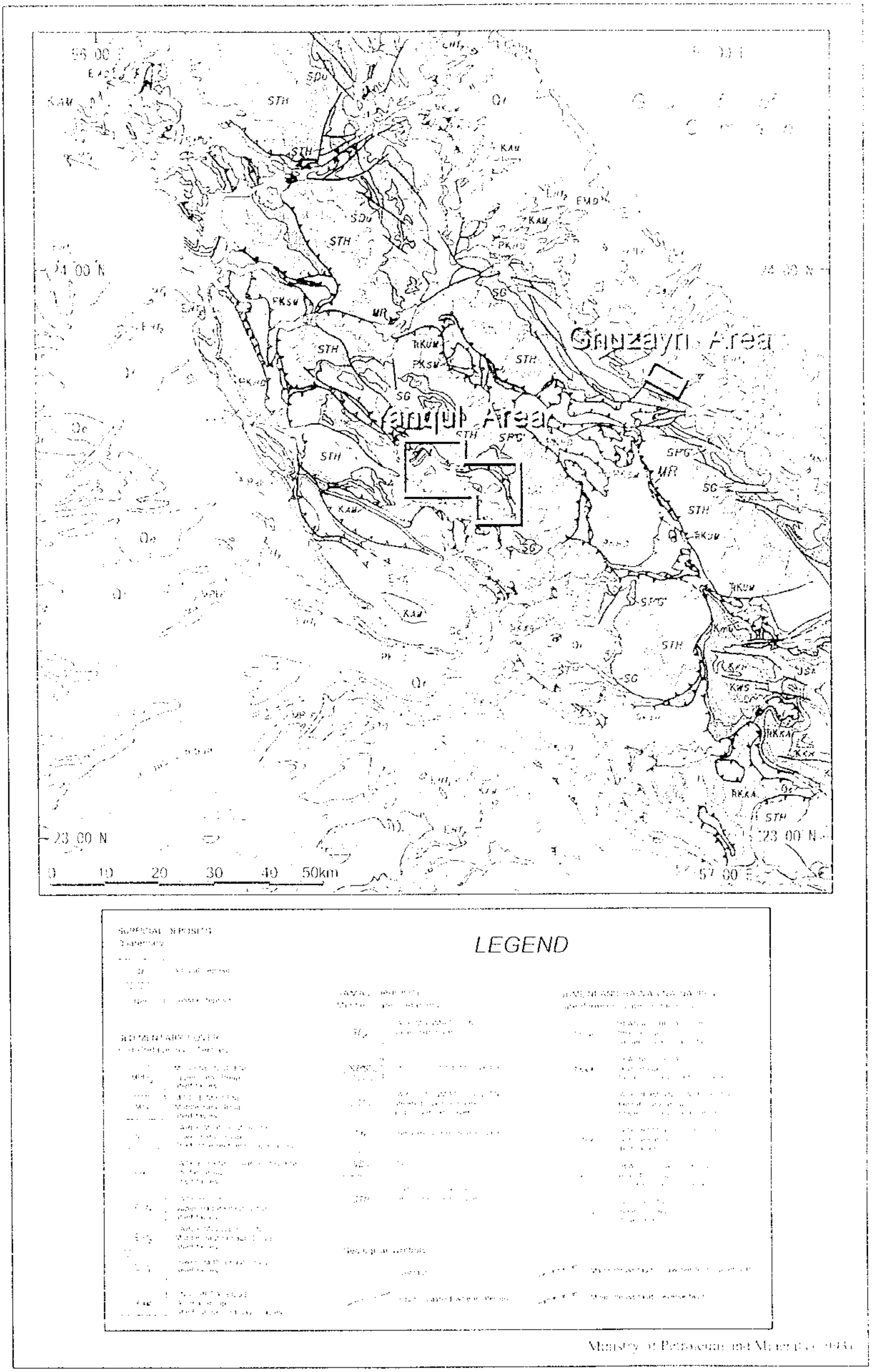


Fig. 1-3-1 Geological map of the Yanqul - Ghuzayn area.

volcanics rocks.

Major Cyprus-type copper deposits in Oman Mountains consist of Lasail, Aarja and Bayda deposits in the Sohar area, Rakah and Hayl as Safil deposits in the Rakah area. Additionally, as a result of this cooperative mineral exploration survey, the Ghuzayn deposit has been discovered.

Based on the survey results around the Ghuzayn deposit, its geological structure and mineralization can be schematically described as shown in Fig. I -3-2. As indicated in this figure, the following characteristics in mineralization, geological structure and alteration about the deposit can be summarized as follows:

Characteristics of the mineralization

① Consists mainly of massive ore. Ore minerals are composed of pyrite and chalcopyrite accompanied by a slight amount of sphalerite, magnetite and hematite.

② The massive ore shows a brecciated texture and consists of pyrite breccia, fine grained matrix of pyrite and chalcopyrite and large crystals of anhedral chalcopyrite.

③ The massive ore shows sedimentary structure on its edge where the ore body grades laterally into metalliferous sediments that are rich in magnetite.

④ Under the massive ore body, stockwork ore consisting of chalcopyrite and pyrite is developed in places. This stockwork ore is accompanied by pyrite dissemination in many places and sphalerite dissemination in some places.

⑤ Above the massive ore, pyrite dissemination is widely distributed and stockwork consisting of chalcopyrite and pyrite can be seen in places.

Characteristics of the geological structure

① The ore body is situated in the lower part of the Samail Volcanic Rocks and occurs in the contact between Geotimes Unit and Lasail Unit.

② One side of the ore body is limited by the fault that formed before the ore body formation, for which the ore body shows its maximum thickness in the vicinity of this fault.

Characteristics of the alteration

① Alteration due to mineralization consists of silicification, chloritization (Clinochlore) and epidotization.

② These alterations show stronger intensity when closer to the ore body. At the footwall side this alteration is stronger than at the hanging wall side.

3-2-2 Brief history of mining

The Oman Mountains region in the northern part of Oman is known as a major producer of copper during the era of Mesopotamia. It has been said that the exploitation and smelting of copper in the ancient times continued up to around 940 AD of the early era of Islam. The copper deposits operated in that period are presumed to be in the same location as the Lasail mine and Rakah deposit and a great

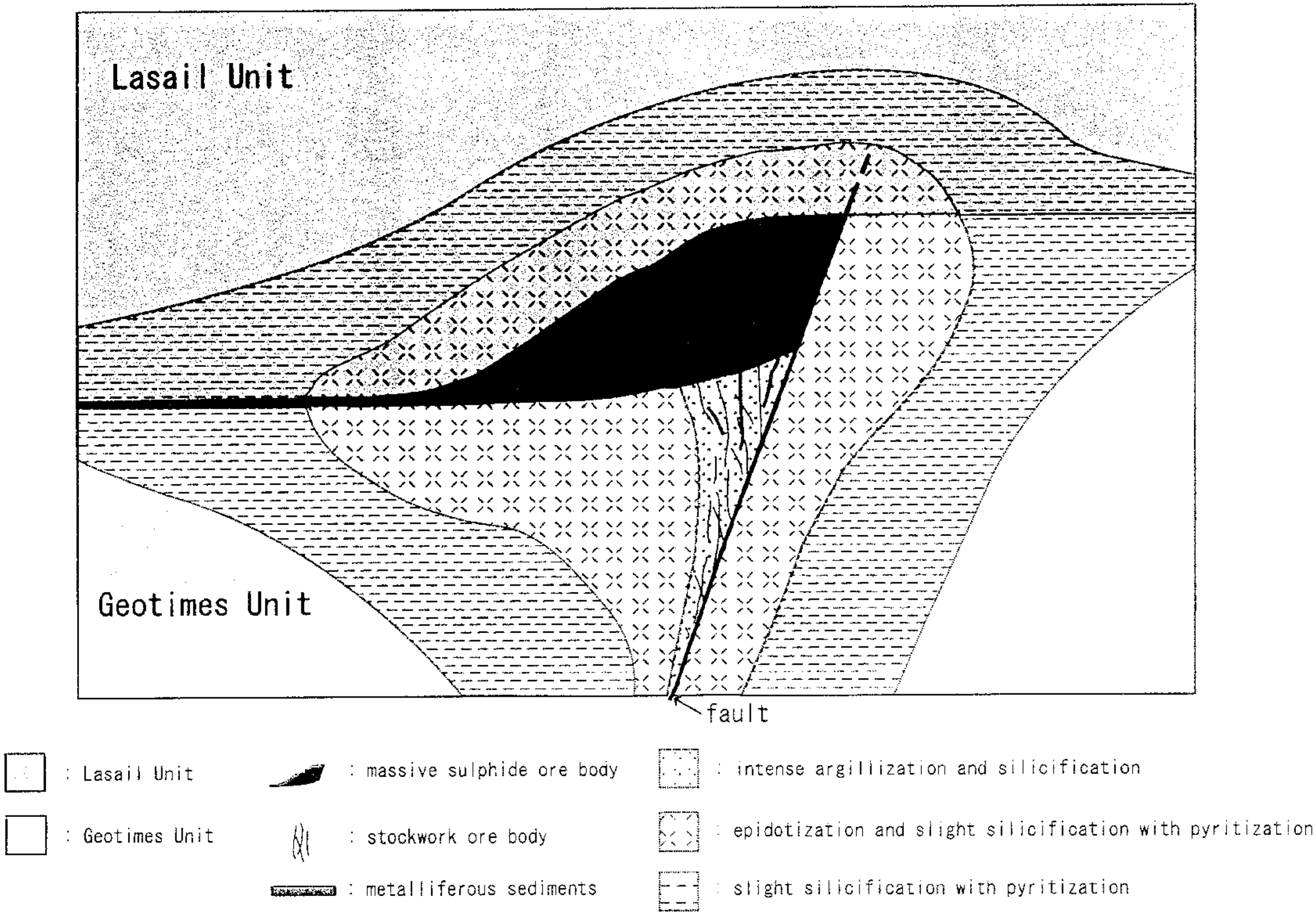


Fig. I -3-2 Schematic model of massive sulphide deposits in Ghuzayn area

volume of slag and ancient smelter sites can be observed in these sites even at the present days.

The modern exploration activity, mainly aimed to copper deposits in the Oman Mountains, was commenced by Prospection Ltd. of Canada in the decade of 1960. Presently known deposits of Lasail, Bayda, Aarja in Sohar area and Rakah deposits in Rakah area, were confirmed by this exploration including drillings.

In the decade of 1970, the Government of Oman purchased the title of property owned by Prospection Ltd. and started the mine development in Sohar area. Consequently in 1983, the operations of Lasail and Bayda mines and Sohar copper smelter were commenced by Oman Mining Company (OMCO), which was established and fully owned by the Government of Oman. The capacity of this smelter has a copper metal production of 24,000 tons per year.

For the purpose of keeping a stable supply of raw material to the Sohar smelter, the Government of Oman awarded in 1984, through international tender, to Bishimetal Exploration Co., Ltd. a contract for a copper exploration program in an area of 8,000 km^2 surrounding the Sohar smelter. Investigations were carried out for a period of 4 years up to 1987 and during which some ore reserves were newly obtained in and around the known deposits, as well as many mineralized zones were confirmed.

On the other hand, BRGM of France was awarded in 1983, a project of geological mapping in the northern Oman Mountains region by the Government of Oman and carried out such works until 1985. During the course of their mapping program, a zone of large scaled gossan was discovered together with the confirmation of several mineralized zones near the village of Hayl as Safil, located at the western foothills of the Oman Mountains.

The Government of Oman awarded in 1985 to BRGM a contract until 1986 for the exploration of 13 major copper mineralized zones discovered in the course of mapping. As a result, the existence of massive sulphide deposits was confirmed in the gossan zone near the village of Hayl as Safil.

In 1988, the Government of Oman requested to the Government of Japan to investigate the possibility of developing the Hayl as Safil and the Rakah deposits. In response to such request, the Government of Japan carried out a Cooperative Mineral Exploration Program (Regional Development Plan) through Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ) in order to study the possibility of mining development in this area.

On the other hand, in 1988 OMCO commenced the mine development of Aarja deposit in Sohar area by supplying raw material to the Sohar smelter due to the exhaustion of ore reserves at Lasail and Bayda mines. However, the Aaja deposit was mined out in 1993 and as such, the smelter operates by using the purchased ore from abroad. The total production and grade of closed mines are as follows:

Lasail Mine	9,183,677 tonnes	1.42% Cu
Aaja Mine	2,561,887 tonnes	0.97% Cu
Bayda Mine	790,891 tonnes	1.60% Cu
Lasail West Mine	434,478 tonnes	1.02% Cu

From the above-mentioned background, the Government of Oman and OMCO are aggressively continuing exploration activities for the development of the domestic mines. Especially in Hayl as Safil deposit, intensive exploration works has been carried out and the three satellite ore bodies of Al Jadeed, Al Asghar and Al Bishara have been confirmed in the periphery of the main deposits. The ore reserves and grade obtained by these exploration are about 11 millions tons with 1.44% Cu and 0.73g/t Au including Hayl as Safil deposit, its satellite ore bodies and Rakah deposits.

In 1994, Rakah gold mine started the operation utilizing gold rich gossan near surface and has been produced about 500kg gold annually. A gold rich gossan was also confirmed in Al Bishara ore body with an approximate ore reserve and grade estimated by OMCO as 0.5 million tons with 6.35 g/t Au.

In response to a request made by the Government of Oman, JICA/MMAJ carried out in the Batinah Coast area, a Cooperative Mineral Exploration Program that consisted of a Mineral Exploration Project during 1995 to 1996 in the Central Batinah Coast Area followed by another Mineral Exploration Project during 1997 to 1999 in the South Batinah Coast Area. These projects resulted in the discovery of three massive sulphide bodies in Ghuzayn with an approximate ore reserve and grade of 14 million tons and 1.64%Cu, respectively.

CHAPTER 4 SURVEY RESULTS

The results obtained during this project are based on the metallurgical tests, existing data analysis, and environmental, geological, geophysical and drilling surveys carried out in Yanqul area.

4-1 Metallurgical Tests

In order to assist in the judgement on possibilities of improvement for useful mineral recoveries, especially for gold, basic testing of gold recovery from pyrite concentrate was carried for ore samples obtained from each ore bodies of Hayl as Safil and Rakah areas in Yanqul region. And studies were also conducted on matters related to the design of concentrator.

4-1-1 Characteristics of Tested Samples

Four samples for testing were collected by the drilling during this phase, each representing a different ore type. Head assays for the major elements are summarized in the following table (Table I -4-1).

Table I -4-1 Head assays of major elements

Body name and Type of ore	Rakah Body Stockwork	Rakah Body Massive	Hayl as Safil Body Stockwork	Bishara Body Breccia
Cu, %	1.15	1.82	0.915	1.45
Au, g/t	0.45	3.78	0.16	1.06
S total, %	3.35	39.0	7.40	28.3
S sulphide, %	3.30	38.8	7.40	28.1

These samples were examined mineralogically to determine the location of gold and to provide general information regarding the mineralogy of the samples. The results are shown in Table I -4-2.

Table I -4-2 Occurrence of gold minerals

Location of Gold	Proportion of Gold, %			
	Rakah Body Stockwork	Rakah Body Massive	Hayl as Safil Stockwork	Bishara Body Breccia
Liberated native gold	15	3	19	3
Locked in sulphides	46	57	37	60
Locked in silicates	12	4	17	4
Undifferentiated -20μm	27	36	27	33

4-1-2 Batch Flotation Tests

The best flotation results obtained for each sample in the rougher series are shown in Table I -4-3. Although pH varied for the different samples, all tests used a collector mixture comprising SIPX and M2030.

Copper recoveries from rougher/scavenger flotation varied from 94% to 96% for the stockwork samples to 80 to 90% for breccia and massive sulphide samples. Concentrate grades also varied, ranging from 42% in the rougher 1 concentrate for Rakah Massive sulphide to 22 to 25% for the remaining samples.

With the exception of the Bishara Breccia, the Oman Copper samples responded very well to rougher-scavenger flotation at a moderately fine grind P_{80} of 70 microns. Finer grinding failed to improve the metallurgical response of the Bishara sample in which the copper losses in the scavenger tailings were entirely locked. The intermediate level of rougher-scavenger recovery for the Rakah Massive Sulphide sample was also due to liberation limitations.

A significant result of the test program is that all samples responded well to the same collectors, with pH being the only main variable between the conditions suitable for the respective ore types.

Table I -4-3 Summary of best rougher/scavenger flotation tests

Body name and Type of ore	Rakah Body Stockwork	Rakah Body Massive	Hayl as Safil Stockwork	Bishara Body Breccia
Test No	FL06	FL14	FL13	FL15
Grind P_{80}, μm	70	70	70	70
PH	9.5	11.0	12.5	9.5
Cu Recovery, %				
Cu Ro Con 1	53.9	38.7	72.9	38.2
Cu Ro/Sc Con	95.7	88.0	94.4	80.8
Cu Grade, %				
Cu Ro Con 1	24.8	41.5	22.0	22.6
Cu Ro/Sc Con	8.6	18.1	10.7	10.3
Au Recovery, %				
Cu Ro/Sc Con	86	27.6	40.9	23.9
Py Con	--	35.6	--	28.5(1)
Au Grade, g/t				
Cu Ro/Sc Con	3.2	10.8	1.3	2.4
Py Con	--	3.5	--	1.4(1)

(1) Results for pyrite concentrate produced in test FL23

4-1-3 Gold Recovery by Cyanide Leaching

Only the Rakah Massive Sulphide and Bishara Breccia samples contained sufficient quantities of gold in the copper flotation tailings to warrant investigation of recovery of gold. Furthermore, production of a pyrite concentrate from both samples resulted in significant gold in the tailings, so that extraction tests on both pyrite concentrate and tailings were undertaken.

Pyrite concentrate samples were leached 'as floated', after regrinding and after roasting, while the tailings were leached 'as floated'. The results of leaching test are shown in Table I -4-4.

Table I -4-4 Cyanide leaching of pyrite concentrates

	Rakah Body: Massive ore			Bishara Body: Breccia ore		
	As Floated	Re-ground	Calcined	As Floated	Re-ground	Calcined
Grind P_{80}, μm	70	34	70	70	18	70
Head Assay, Au g/t	3.53	3.53	5.30	1.84	1.84	2.26
Calc. Head Assay, Au g/t	3.37	3.61	8.12	1.97	1.91	2.16
Residue Assay, Au g/t	2.42	1.93	1.18	1.40	1.13	0.75
Au Extraction, %						
8 hours	28	40	82	28	36	62
48 hours	28	44	85	30	42	66
NaCN Cons, kg/t	5.9	7.8	13.2	17.6	22.9	46.1

According to the table, Gold recoveries from the 'as floated' concentrate of both samples were low at approximately 30%. Re-grinding increased the extraction to 40 to 45%, while roasting resulted in the highest extractions of 85% for Rakah Massive Sulphide and 66% from Bishara Breccia.

The low extractions and the relatively minor increase in extraction after re-grinding suggests that the contained gold is extremely finely disseminated in the sulphides (pyrite and possible, arsenopyrite).

Cyanide consumptions recorded during the leaches were high, particularly after roasting. On the basis of the test results, cyanide costs would exceed the value of gold recovered from the Bishara Breccia sample and a major proportion of the gold recovered from the Rakah Massive Sulphide concentrate.

The overall gold recoveries obtained by the various stages of processing, as a percentage of total gold, are shown in the Table I -4-5. The figures in *italics* represent actual extractions of gold from the feed samples.

Table I -4-5 Overall gold recoveries

	Rakah Body Stockwork	Rakah Body Massive	Hayl as Safil Stockwork	Bishara Breccia
Test No	FL06	FL14	FL13	FL15,FL23
Head assay, Au g/t	0.45	3.78	0.16	1.06
Au recovery to Cu con, %	***86.1***	***27.6***	***40.9***	***23.9***
Au recovery to Py con, %		35.6		28.5
Au extraction by cyanidation of Py con (calcine), %		***31.3***		***18.8***
Au recovery to Py tail, %		36.8		43.4
Au extraction by cyanidation of Py tail, %		***12.9***		***8.2***
Total Au Recovery, %	***86.1***	***71.8***	***40.9***	***50.9***

Thus gold grades and recoveries varied considerably between the samples.

It should be remembered that cyanide leaching of the Rakah Massive Sulphide and Bishara Breccia pyrite concentrates and tailings resulted in excessive cyanide consumptions, to the point that the cyanide cost would exceed the value of gold recovered. In addition, oxidation of the pyrite concentrates was required to allow reasonable gold extractions to be achieved.

Based on the nature of the samples tested, the benefit of a specific circuit for gold recovery will depend on the quantity of ore containing significant gold grades.

Quantities of the various ore types aside, the relatively refractory nature of the gold will create difficulties in processing, so that an option to be considered might be to examine ways of maximizing gold recovery to copper flotation concentrates from all ore types.

4-2 Environmental Survey

Ground water movement, permeability and water quality was investigated near Rakah and Hayl as Safil deposit by measuring water recovery and water quality in 5 drillings made for that purpose.

Due to recent dry weather, all the wells that were drilled in a wadi, did not show enough amount of water.

Water quality results indicate a weak alkalinity with a little higher pH in comparison with the Japanese river waters. Total dissolved solids (TDS) show high values ranging from 200 to 1200 mg/l with very high calcium hardness. Compared with previous data, Nitrite Nitrogen values show extraordinarily higher values.

4-3 Analysis of Existing Data

The geological and minable reserves are discussed here on the basis of the existing data provided by Ministry of Commerce and Industry and OMCO. Five ore bodies confirmed in Yanqul has been investigated by the drillings of 446 holes with a total length of 49,466.27m. These drilling data, including analysis data and core logs and several reports of a previous preliminary feasibility study were used for the present analysis.

A preliminary calculation by using the software called MINEX utilized the prepared data and applied parameter obtained from the Follow-up survey conducted by JICA/MMAJ in 1998. In addition to this, it was analyzed the principal idea of the process and methodology used for the ore reserve calculation of the feasibility study carried out previously. To calculate in more detail the geological and minable reserves detail, the following items should be considered:

① Detailed and precise modeling of the ore bodies including the geology.

② Classification of ore types and their distribution.

③ Confirmation of reserves and average grade for each ore type.

④ Determination of the proper method to calculate the ore reserve of the confirmed ore bodies.

⑤ Determination of the proper parameters used during the calculations.

In this phase, the above items 1) and 2) were conducted and the distribution of each ore type was confirmed after generation of the geologic sections for each ore body. The ore type for each ore body are as follows:

- Rakah body : stockwork ore >> massive ore
- Hayl as Safil body : stockwork ore >> massive ore
- Al Bishara body : breccia ore > massive ore
- Al Asghar body : massive ore (>> breccia ore, stockwork ore)
- Al Jadeed body : breccia ore (> massive ore)

4-4 Exploration

The target mineralization can be seen around the boundary between the Geotimes and Lasail units of Samail volcanic rocks. The geophysical survey was carried out over these units within an area previously delineated by the geological survey. Several geophysical anomalies were detected in the following 5 locations, including the known mineralized zone.

- Quron Al-Akhbab area
- Tawi Rakah mineral showing
- Rakah gold mine
- Najaid area
- Hayl as Safil deposits

Within these areas, drilling survey was conducted in 4 areas excluding Najaid area. Promising copper mineralization of stockwork type was confirmed in Quron Al-Akhbab area.

4-4-1 Quron Al-Akhbab area

As it is shown in Fig. I -4-1, drilling survey was carried out within a remarkable chargeability anomaly detected by TDIP survey. All of the 5 holes intersected a stockwork zone with core ranging from 17.70m to 89.70m in depth at MJOY-2 and showing relatively higher Cu grade of 0.83% in average. Judging from the results of the geophysical survey and its subsequent drilling, the mineralized zone at Quron Al-Akhbab area extends 250m in east-west direction and 150m in north-south direction(Fig. I -4-2).

4-4-2 Tawi Rakah mineral showing

A chargeability anomaly was extracted to the north of the known mineral showing, which is similar to that of Quron Al-Akhbab. Low resistivity was also detected in the shallow part of the showing. The drilling carried out at the northern anomaly intersected a stockwork zone of low Cu grade from surface to 140m in depth with intense pyrite dissemination from 14.90m to 107.00m in depth. As compared with previous survey results and the results of IP survey of this project, the probability for finding new ore body still remain in the west and south part of known showing.

4-4-3 Rakah gold mine

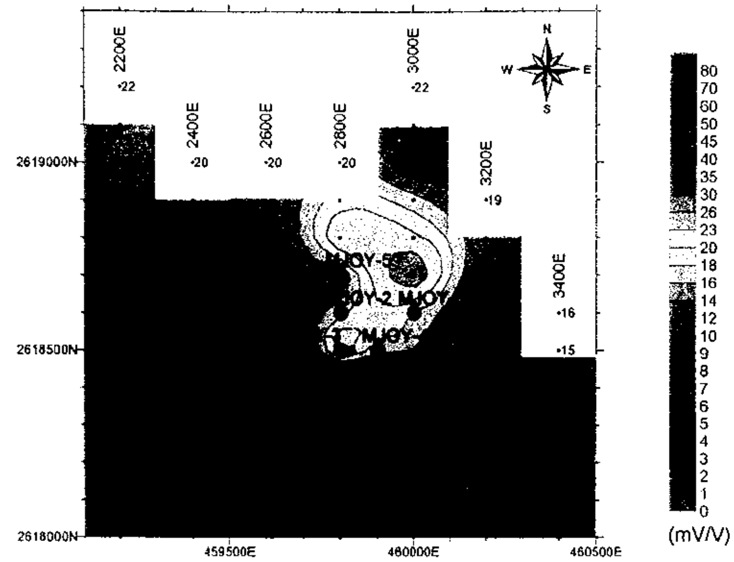
IP survey detected a high chargeability anomaly in the southeastern part of Rakah gold mine pit. The drilling survey was conducted on the basis of results of TEM survey carried out within the IP anomaly. This hole intersected a low grade stockwork zone with chalcopyrite veinlets in places. Although the stockwork zone was mainly confirmed in the northeastern part of the pit by previous drill holes, the center of IP anomaly was detected in the southern part. Accordingly, further survey is required around the pit to acquire a additional reserve.

4-4-4 Najaid area

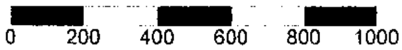
Remarkable chargeability anomaly was detected by IP survey at the shallow depth in Najaid area and expected to be a stockwork type mineralization.

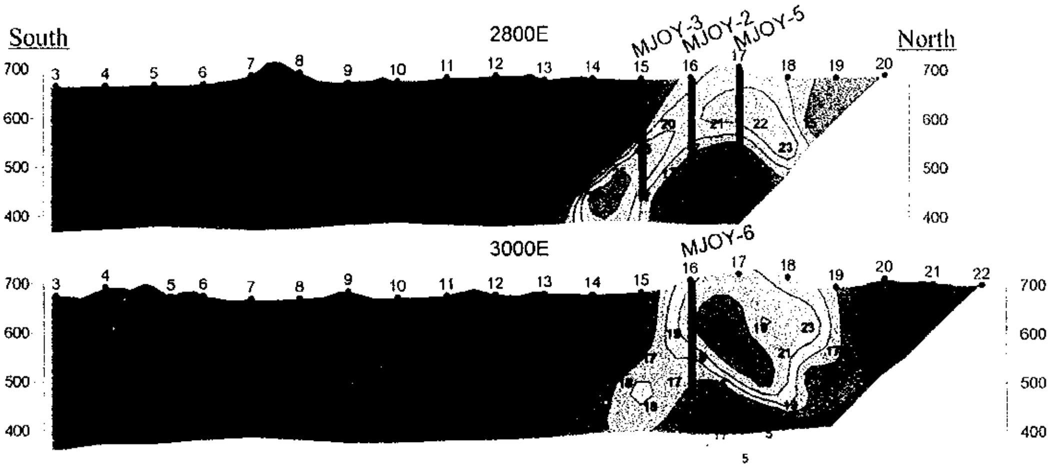
4-4-5 Hayl as Safil deposits

In this area, remarkable chargeability anomaly was detected around the gossan. At the south part of this anomaly zone, low resistivity was also detected and showed high metal factor. Drilling survey was carried out at one borehole in this high metal factor zone. As a result, intense silicification was recognized but no mineralization was observed. Fig. II -7-5 shows cross sections across the borehole. As the result of geophysical survey, high metal factor zone of N=1 corresponds to the location of existing ore and high TEM response zone has a good correlation with the location of massive sulphide ore. There is the interesting place for exploration around and to the north of Hayl as Safil ore body, where no drilling survey are carried out yet(Fig. I -4-3).

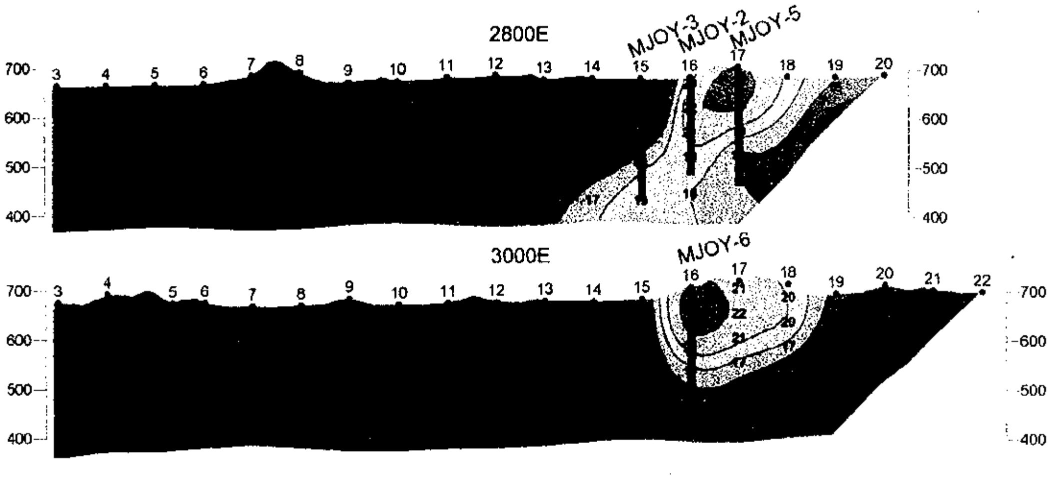


Chargeability plane map for N=2



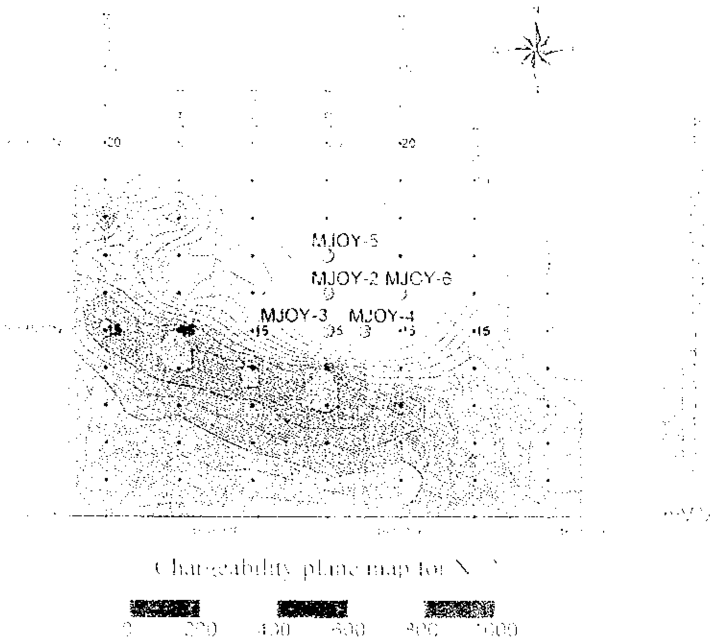


Chargeability pseudo section

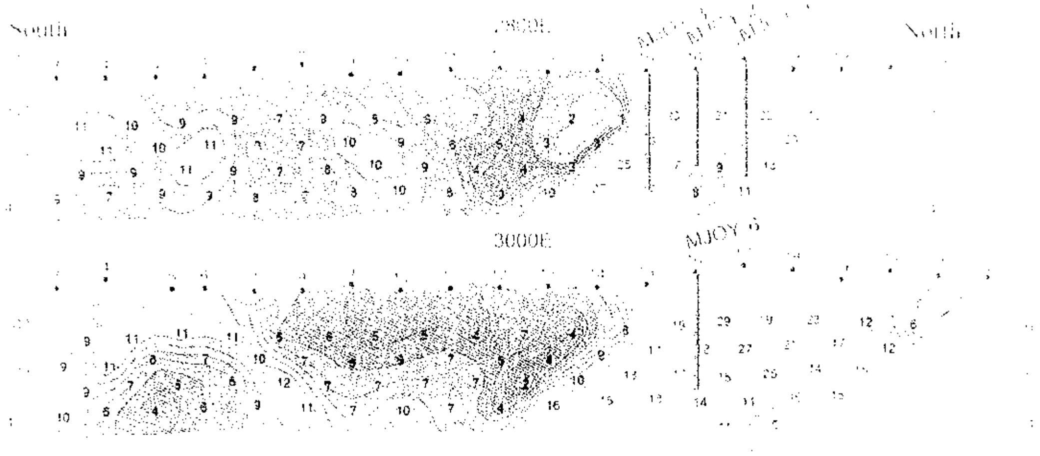


2D modeling for Chargeability

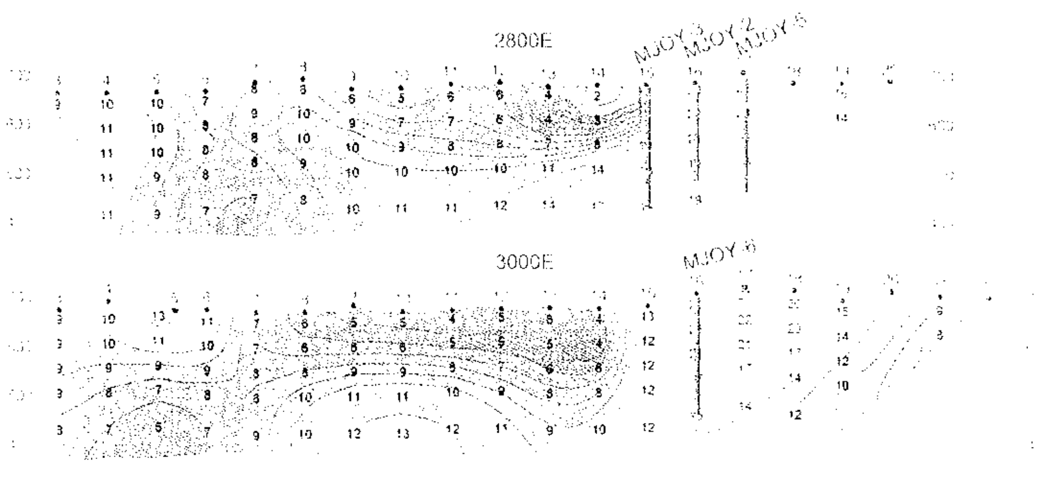
Fig. I -4-1 Results of TDIP survey in Quron Al-Akhbab



Chargeability plane map for N



Chargeability pseudo section



2D modeling for Chargeability

Fig. I-4-1 Results of IDIP survey in Quron Al-Akhbab

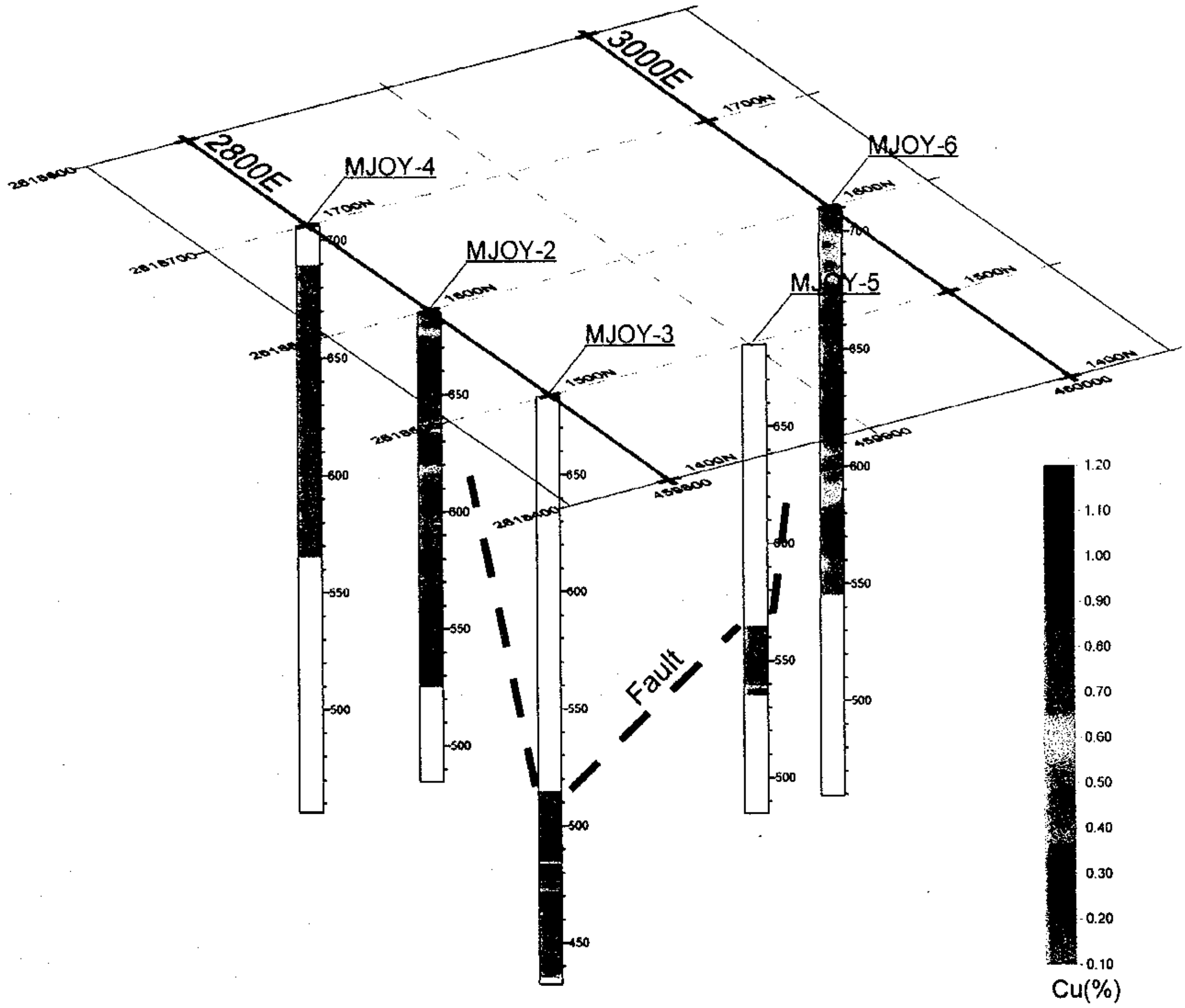
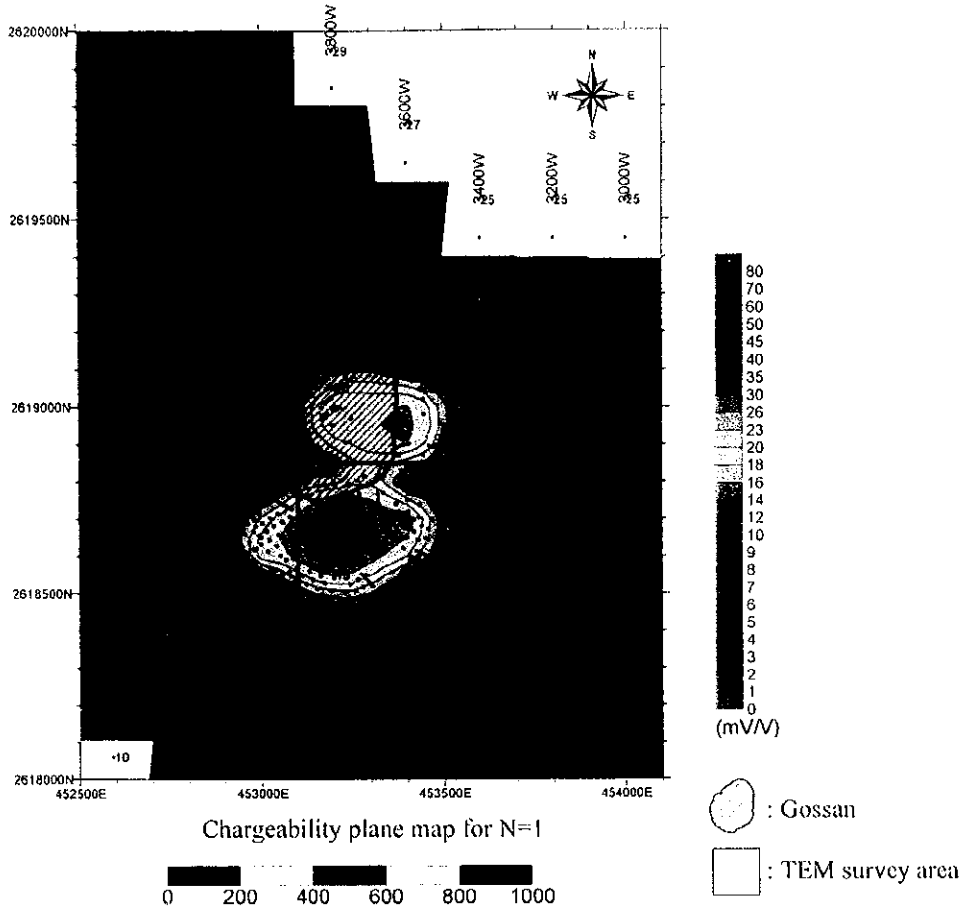
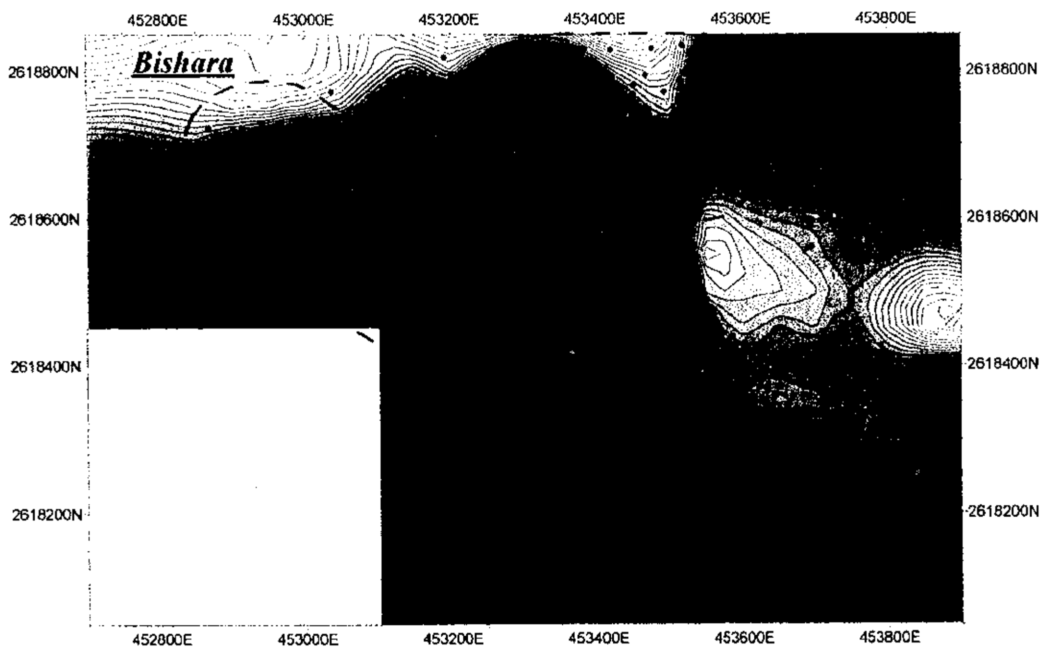


Fig. I -4-2 Results of drilling survey in Quron Al-Akhbab area

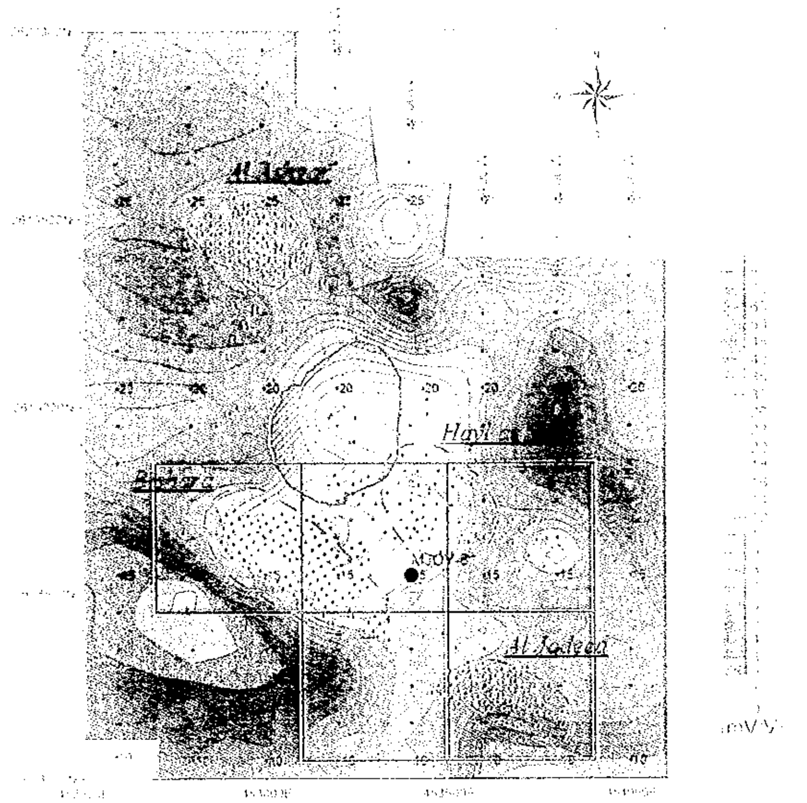


Chargeability plane map for N=1



TEM response map

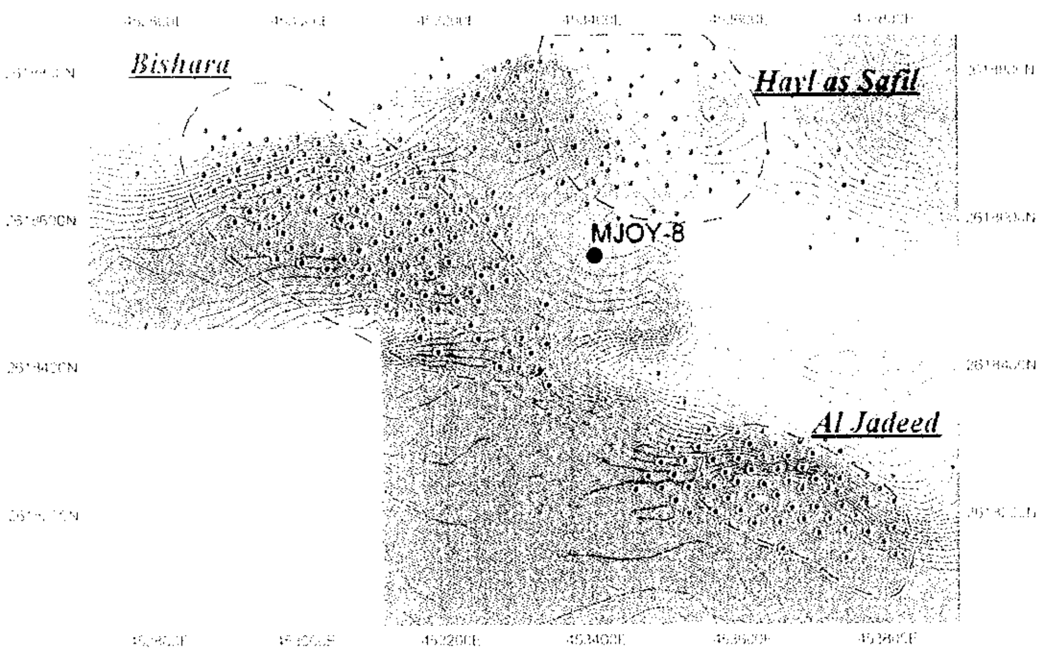
Fig. I -4-3 Results of TDIP and TEM survey in Hayl as Safil deposits



Chargeability plane map for N=1

0 200 400 600 800 1000

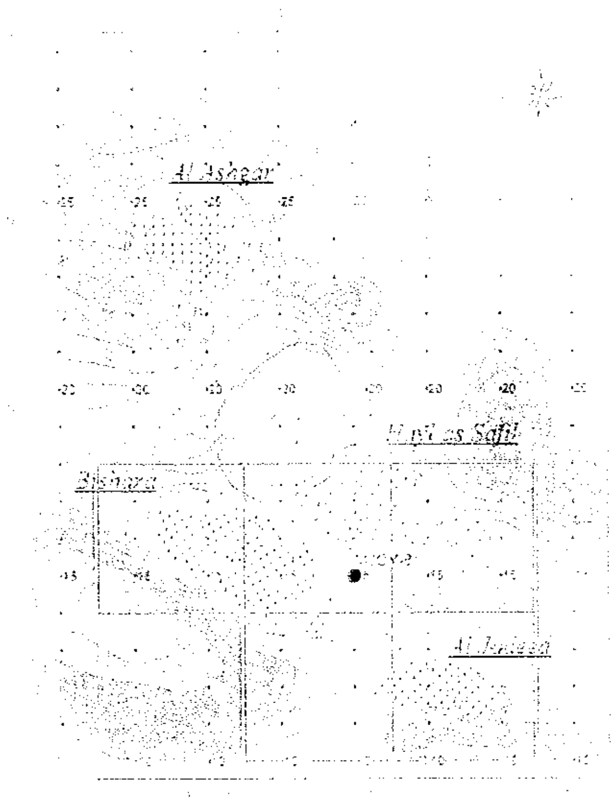
TEM survey area



TEM response map

0 200 400 600 800 1000

Fig. I-4-3 Results of TDIP and TEM survey in Hayl as Safil deposits



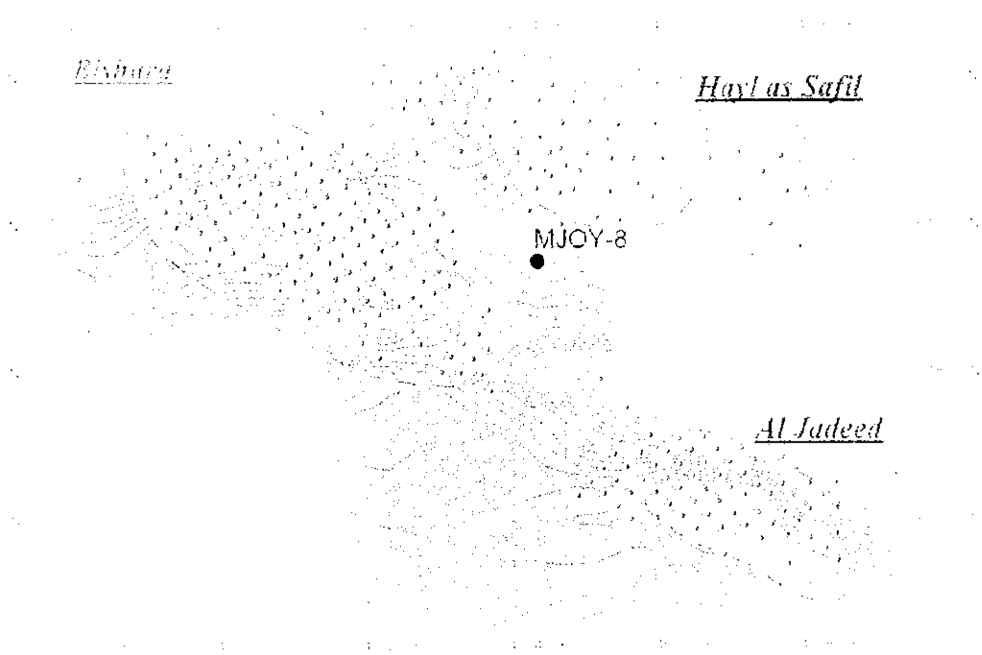


Fig. 4.3.3 Results of HDP and HEM survey in [illegible] deposits

4-4-6 Geologic Characteristics

The geological and drilling surveys indicate several differences on the geology and mineralization in Yanqul region from Batinah coast area. The characteristics of Yanqul region are as follows:

a. The formations and ore bodies were repeated stratigraphicaly because of thrust faults.
b. The stockwork ore is mainly developed in the Lasail unit.
c. Metalliferous sediments at the lower part of Lasail unit are developed only in Hayl as Safil deposit area and those are rarely seen in other part in Yanqul except some part of Rakah deposit.
d. Breccias of sulphide ore and pillow lava of Lasail unit are observed in the metalliferous sediments of the Lasail unit in and around Hayl as Safil deposit area. These evidence indicates theat the volcanism was already started during the deposition of metalliferous sediments and massive sulphide ore.

These facts are considered to be a important rule for further exploration in Yanqul area.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5-1 Conclusions

The main objectives of this project during this fiscal year in Yanqul areas are:

1. Examination of various processing methods to increase the recovery of copper and gold together with planning the processing flow.
2. Confirmation of minable ore by re-interpretaion of existing data.
3. Increase the amount of minable ore by finding new ore bodies.
4. Collection of basic environmental data.

The survey results can be summarized as conclusions as follows:

(1) Metallurgical tests

i) Copper recoveries form rougher/scavenger flotation varied from 94% to 96% for the stockwork samples and from 80% to 90% for the breccia and massive sulphide samples. Concentrate grades also varied, ranging from 42% in the rougher 1 concentrate for Rakah massive sulphide to 22% to 25% for the remaining samples.

ii) A significant result of the test program is that all samples responded well to the same collectors, with pH being the only main variable between the conditions suitable for the respective ore types.

iii) As a results of the mineralogical tests, it is found that reground level can be achieved without using ultra fine grinding technology. Therefore, normal tower mill or ball mill are considered to be good enough. Decision for re-grounding level is one of the activities scheduled for the next year's metallurgical tests.

iv) Cyanid leaching of pyrite concentrates were low at approximately 30%. Re-grinding increased the extraction.

(2) Environmental Survey

i) In order to study ground water movement, permeability and water quality near Rakah and Hayl as Safil mining areas were studied by measuring water recovery and water quality in 5 drillings made for that purpose.

ii) All the wells, which were drilled in a wadi, showed a little amount of water due to recent dry weather conditions.

iii) Water quality results indicate a weak alkalinity with a little higher pH in comparison with the Japanese river waters. Total dissolved solids (TDS) show high values ranging from 200 to

1200 mg/l with high calcium hardness. Compared with previous data, Nitrite Nitrogen values indicate extraordinarily higher values.

(3) Existing Data Analysis

i) In order to confirm the geological and minable ore reserves, the following items are to be needed to clarify: detailed geological and ore body model, distribution of each ore type, proper method for ore reserve calculations and optimization of the ore reserve parameters.

ii) Mineralization at Yanqul region is mainly stockwork accompanied by massive and brecciated ore types.

(4) Exploration

i) Geophysical anomalies were found in five areas including known mineralized zones such as: Quron Al-Akhbab, Tawi Rakah mineral showing, Rakah gold mine, Najaid area, and Hayl as Safil ore deposit.

ii) Among the above 5 areas, a promising copper mineralization (stockwork mineralization) was detected in Quron Al-Akhbab.

iii) Geophysical anomalies detected over Hayl as Safil deposit were effective to delineate the location of the deposit, indicating a good coincidence of massive sulphide distribution with high TEM responses.

5-2 Recommendations

Since the Phase II will be the last year of this project, final interpretation must be conducted during the phase.

The works for following items are proposed for the next phase.

1) Metallurgical aspects
   a. Decision on the metallurgical method and design of plant
   b. Additional metallurgical tests
2) Mining aspects
   a. Minable ore reserve calculation (for each ore type)
   b. Pit design
   c. Mining schedule and production plan
3) Infrastructure
   a. Waste dam design
   b. Environmental countermeasures for the waste dam
   c. Electricity and water supply
   d. Diversion of Wadi and roads
   e. Peripheral facilities

4) Environment

Collection of basic environmental data.

5) Financial and economic evaluation

6) Exploration

a. To delineate ore reserve in Quron Al-Akbab a detailed survey shall be conducted.

b. In other areas among various geophysical anomalies, detailed geophysical and drilling surveys should be carried out to evaluate the mineral potential.

7) Comprehensive evaluation.

PART II SURVEY RESULTS

CHAPTER 1 GEOLOGICAL SURVEY

1-1 Stratigraphy

Allochtonous unit (nappe) in the Oman Mountains forms two layered structure consisting of Hawasina Nappe and Samail Nappe in ascending order. The Samail Nappe, consisting of Samail Ophiolite, is widely distributed in the Yanqul area. The Samail Ophiolite generally consists of Tectonite, Cumulate sequence, High-level gabbro, Sheeted dyke complex, and Samail volcanic rocks in ascending order. The geological map and profile are shown in Fig. II -1-1 and Fig. II -1-2, respectively. The general stratigraphy of the area is also shown in Fig. II -1-3.

Massive sulphide deposits in Oman Moutains occurs in the Samail volcanic rocks. This Samail Volcanic Rocks are divided into three formations which consist of Geotimes , Lasail and Alley units in Yanqul area, and the ore deposits are situated near the boundary between Geotimes and Lasail units.

The Samail volcanic rocks are described below in detail.

1-1-1 Samail Volcanic Rocks

(1) Geotimes unit

The Geotimes unit consists of differential basaltic to andesitic lavas, and composed mainly of reddish brown colored pillow lava with large pillow size of 1m to 2m in diameter. It also consists of reddish brown to gray colored massive lava, hialoclastite and pillow breccia. Characteristically, the pillow lava is aphanitic and accompanied with thick interpillows of 5cm to 40cm in thickness. The massive lava shows gray to brownish gray color with a thickness of several tenth centimeters to several meters. Columnar joints are developed in the thick massive lava.

(2) Lasail unit

The Lasail unit consists mainly of primitive basaltic lava composed of pillow lava accompanied with massive lava. The pillow lava shows light gray to purplish gray in color with pillow sizes mainly of 10cm to 1m in diameter and a maximum of 1.5m. It is characteristically accompanied with small sized pillow lavas of 10cm to 30cm in many places. Additionally, this pillow lava is porphyritic and shows a variole-like texture. In contrary to Geotimes unit, this pillow lava is accompanied with thin interpillows of 1cm to 5cm in thickness. Many basalt dikes intruded into the unit in the eastern part of the area. Metalliferous sediments and massive lave can be seen close by the boundary with geotimes unit.

Metalliferous sediments is the so-called umber that includes many radiolarians and predominant in iron oxides. It shows dark brown color and grades laterally into massive sulphide ore bodies in the case that the sediments contain many magnetite with clear stratification and copper mineralization.

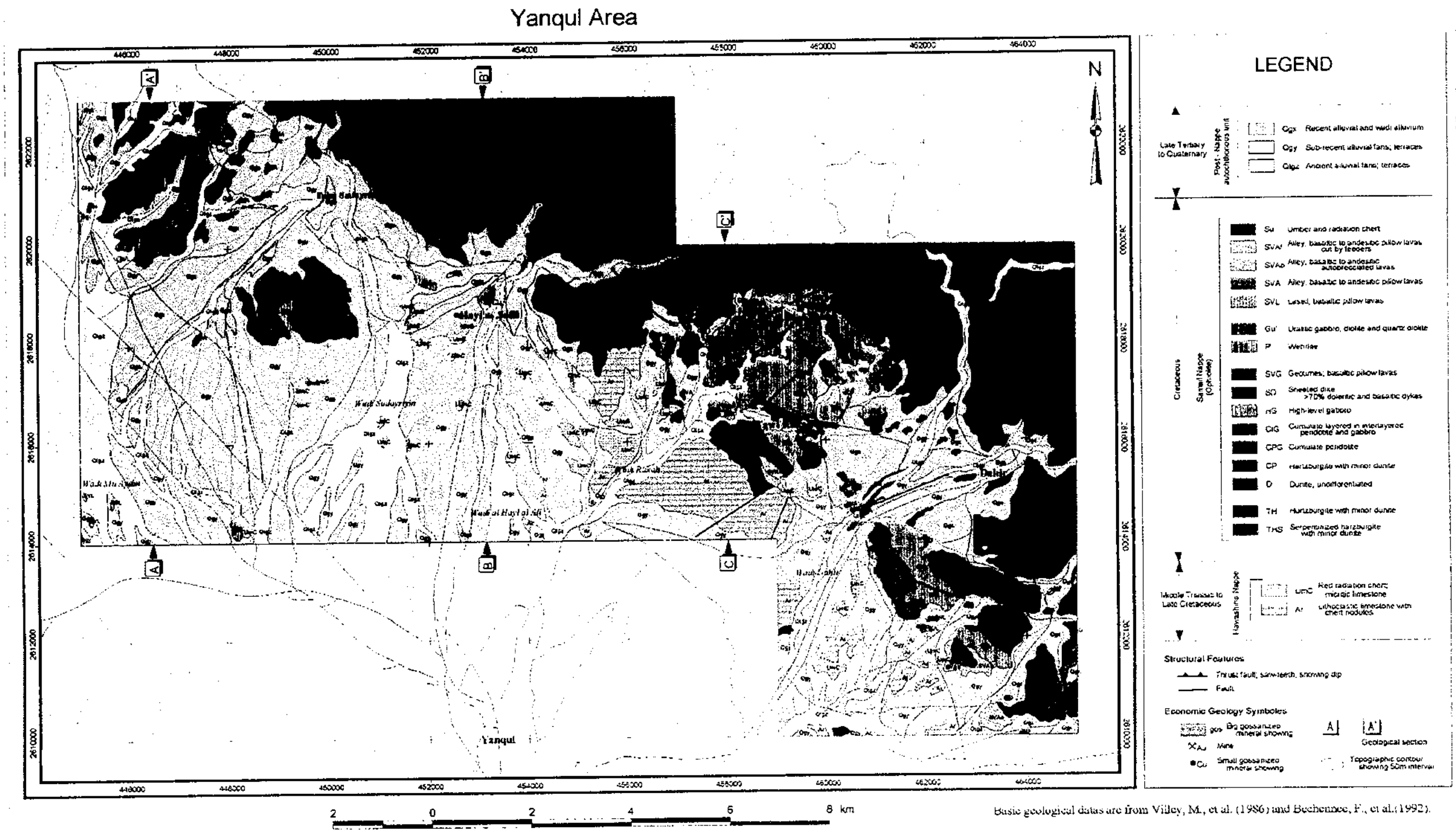


Fig. II-1-1 Geological map of Yanqul area.

Yanqul Area

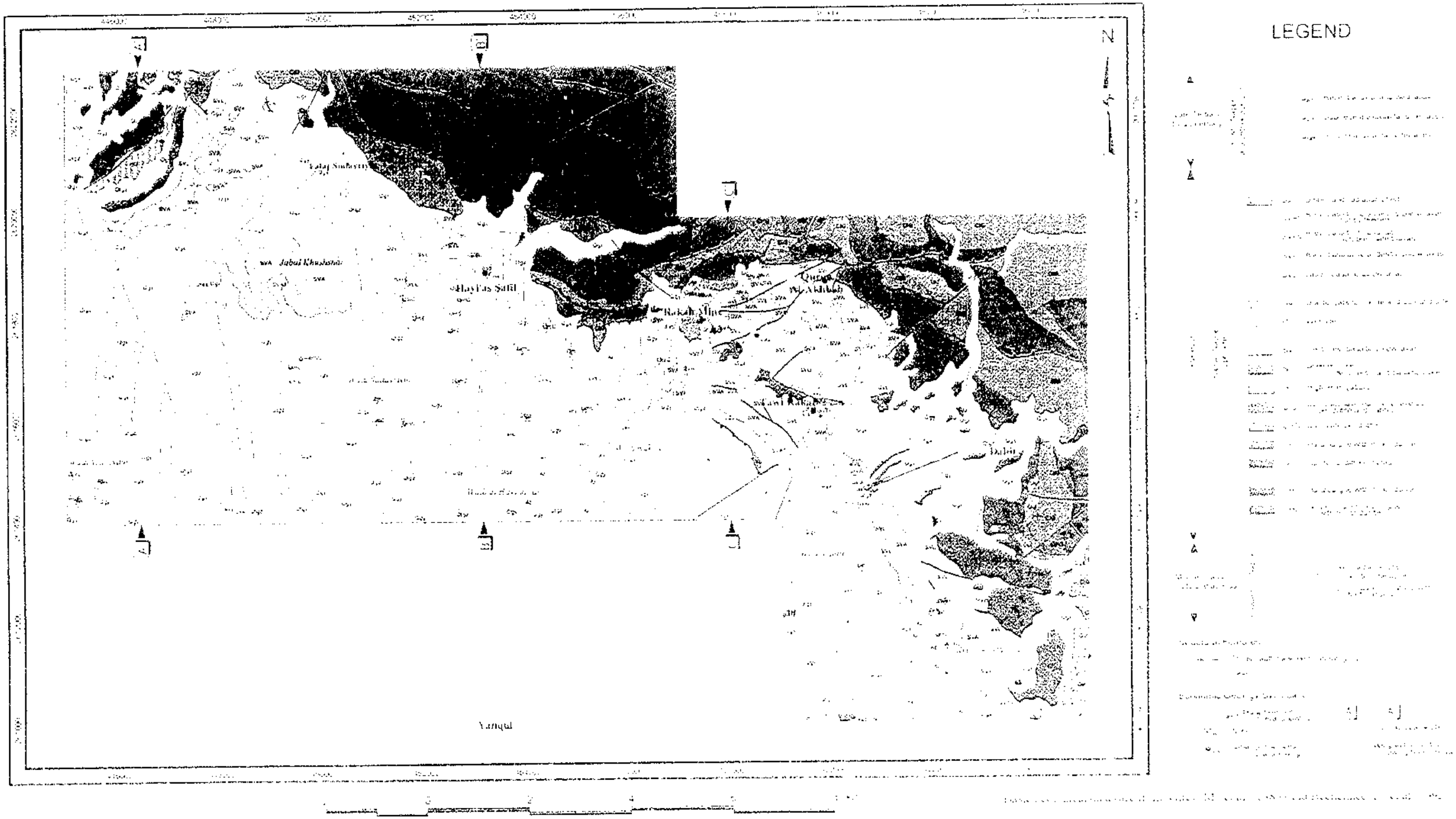
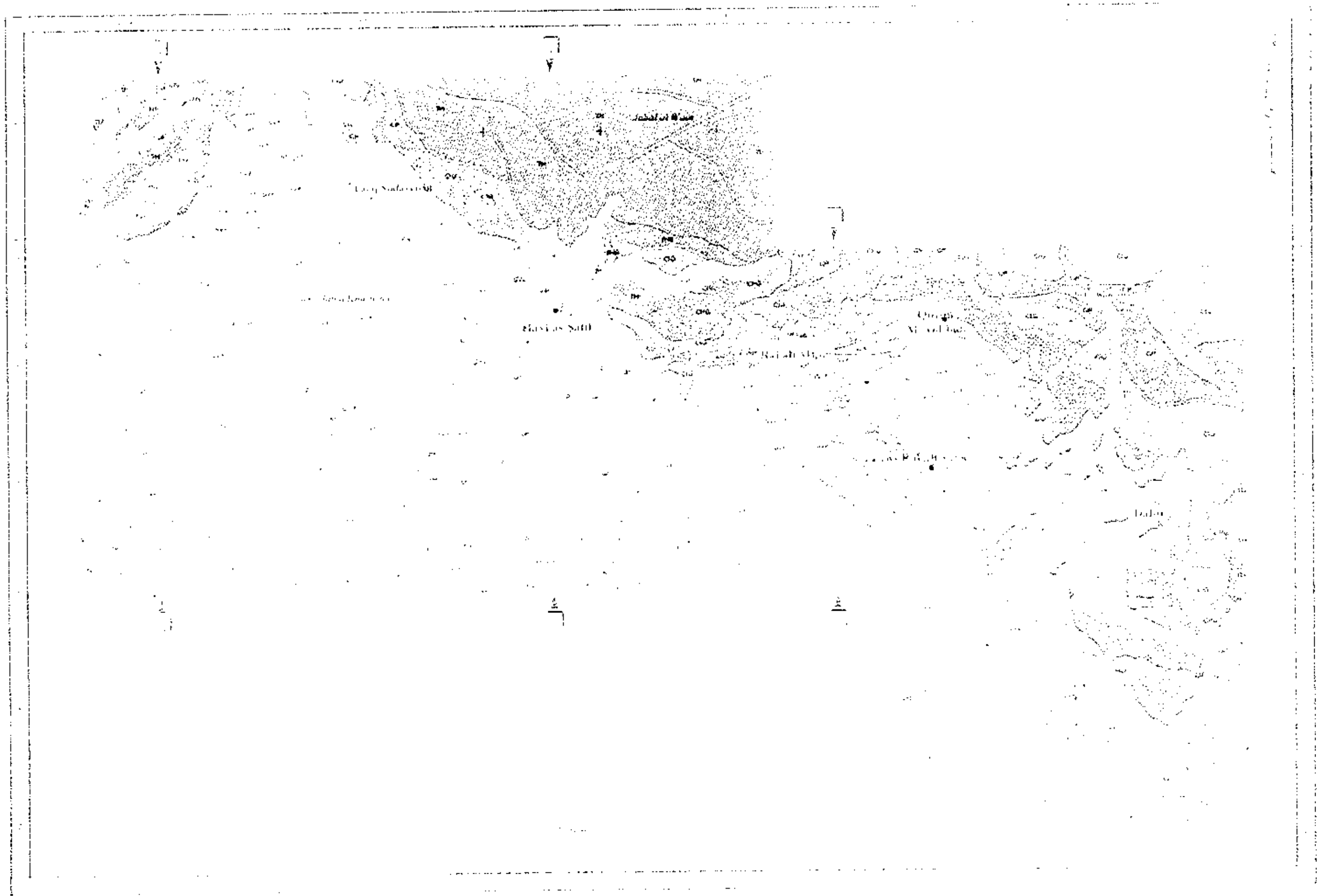


Fig. II-1-1 Geological map of Yanqul area.

Yarqa Area



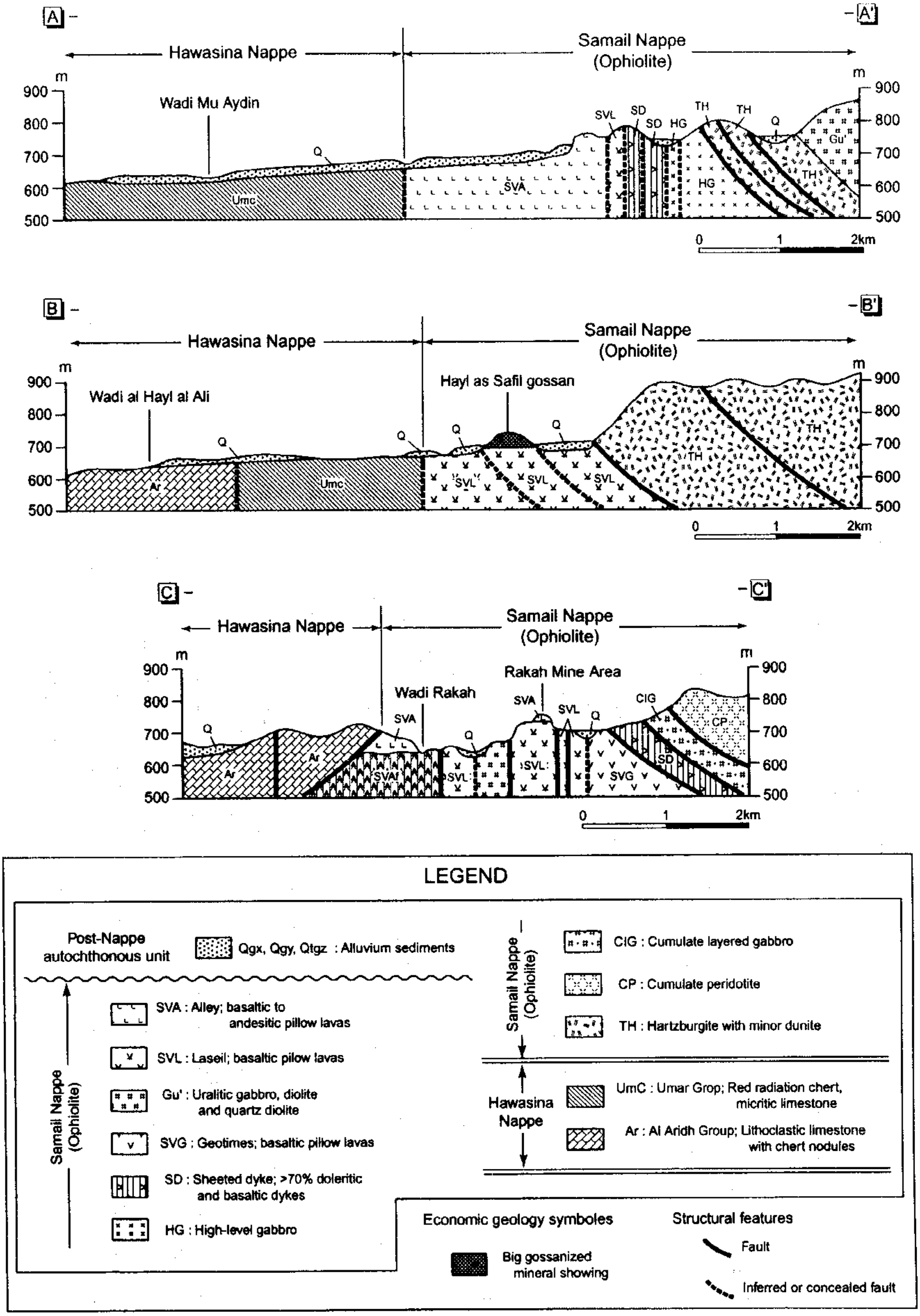


Fig. II-1-2 Geological section of Yanqul area.

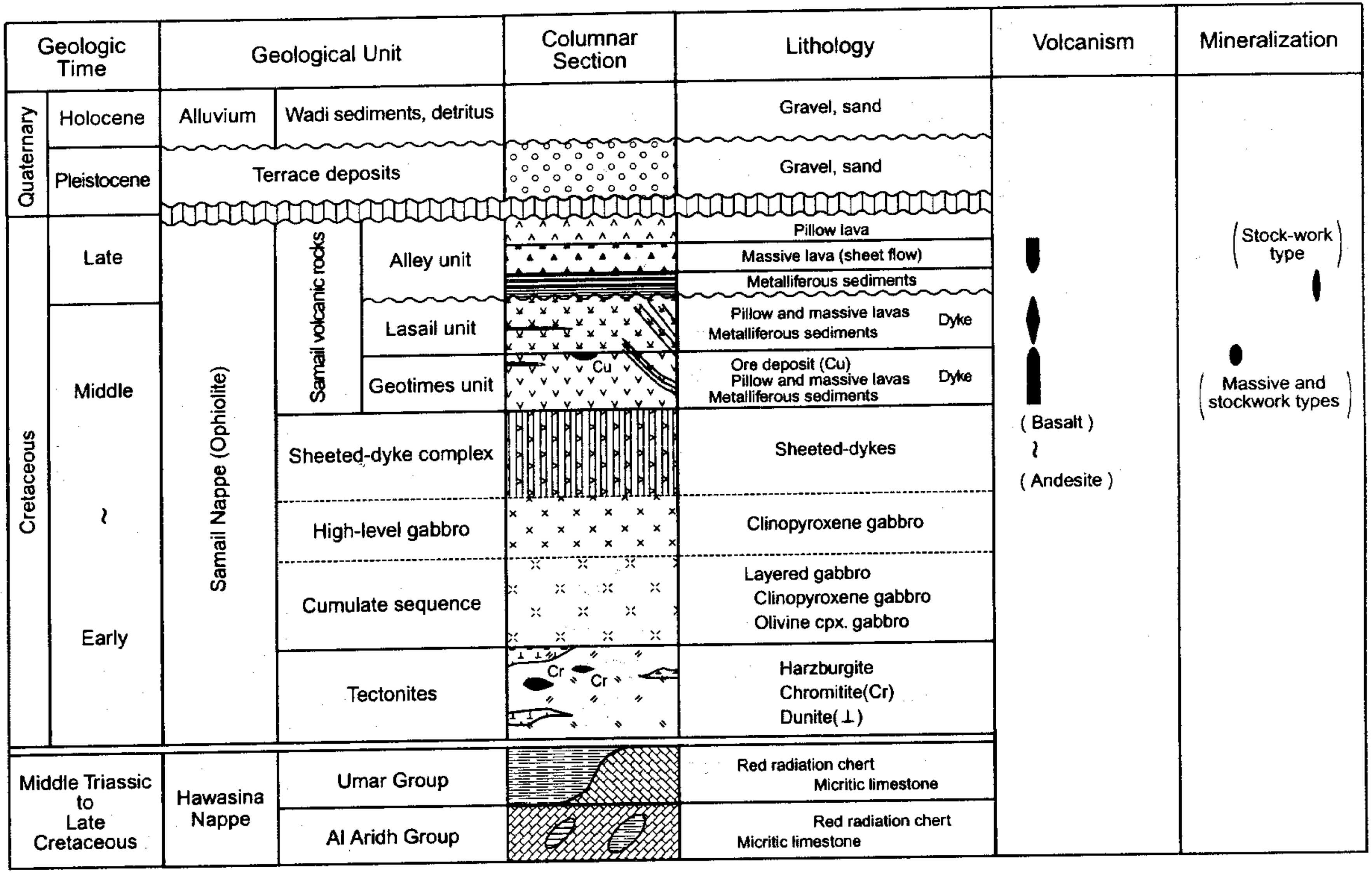


Fig. II-1-3 Geological columnar section of Yanqul area.

The sediments are well developed in the area of Hayl as Safil deposit and reach 50m in thickness. In some places, they grade into the rock called Peperite which consists of basalt breccia and sediments and formed by the intrusion of basaltic magma into the sediments of unconsolidated condition.

(3) Alley unit

The Alley unit consists of pillow lava, massive lava and autobrecciated lava ranging from basaltic to andesitic composition and metalliferous sediments.

The pillow lavas show purple, green and greenish gray colors. Most of the pillow lavas present irregular pillow shapes with diameters of about 0.5 to 1.0m. Only this pillow lava shows a clear pillow structure among pillow lavas in three units in Yanqul. The massive lava shows various colors of gray, brownish gray, green, bluish gray and orange color on the weathered surface. In general the massive lava shows a doleritic texture.

Metalliferous sediments are the so-called umber and contains more radiolarians but less amounts of iron oxides than Lasail unit. They show a brownish black color.

1-2 Geological Structure

Structural geology in the Yanqul area is characterized by imbrication structure, consisting of thrust faults inclined to the northeast to north, and shows apparently inverted structure due to thrusting. Normal fault system consists of two directions, namely E-W and N-S, and these faults are mostly steep.

1-3 Mineralization

Two copper deposits of Rakah and Hayl as Safil were found in the Yanqul region. These are considered to belong to the Cyprus type copper deposits as same as the deposits of Sohar region and occur near the boundary between Geotimes and Lasail units.

The geological ore reserve of known 5 ore bodies of above deposits is shown in Table Ⅱ-1-1 according to OMCO(1995).

1-3-1 Rakah deposit

Rakah deposit is located in the upperstream of Wadi Rakah and was found under the small hilly gossan along the middle terrace surface. Ore body strikes northwest to southeast and dips to northeast. The ore body is affected by the repetition from thrust faults and the blocking from normal faults.

Ore is classified in stockwork ore and massive ore, and a stockwork ore is predominant. Host rock of stockwork ore is markedly brecciated. Ore minerals are mainly pyrite, chalcopyrite and subordinate sphalerite, bornite, chalcocite, covelline, etc.

1-3-2 Hayl as Safil deposit

Hayl as Safil deposit consists of 4 ore bodies; namely Al Ashgar, Hayl as Safil, Bishra and Al Jadeed ore bodies from northwest to southeast. Large scaled gossan is prominent in the center of the deposit. These ore bodies belong to a large scale continuous mineralized zone of 500m wide and 1,500m long.

Ore is classified in stockwork ore, massive ore, brecciated ore consisting of reworked and brecciated massive ore. Stockwork ore is especially developed in Hayl as Safil deposit. Al Ashgar ore body mostly consists of massive ore, but Bishara and Al Jadeed ore bodies consists mainly of reworked and brecciated ore and partly accompanied by massive ore.

Ore minerals are mainly composed of pyrite, chalcopyrite and subordinate sphalerite, bornite, chalcocite, covelline, etc.

Table II-1-1 Geologic ore reserves of known five bodies

Ore Body	Geologic Ore Reserves (tonne)	%Cu	%Au
Rakah	2,392,363	1.24	0.99
Hayl as Safil	4,748,443	1.37	0.47
Al Jadeed	660.442	1.38	0.85
Al Asghar	893,679	2.48	1.22
Al Bishara	2,116,259	1.32	0.74

OMCO(1995)

CHAPTER 2 METALLURGICAL TESTING

2-1 Background and Objective

In order to improve the efficiency in the mineral recoveries, especially for gold, basic testing of gold recovery from pyrite concentrate was carried out for ore samples obtained from each deposit of Hayl as Safil and Rakah area in Yanqul region as objective ores. Studies were also conducted on matters related to design of mineral processing facilities, including pollution control facilities.

2-2 Survey Amounts and Method

2-2-1 Survey amounts

The drilling of five holes was carried out in order to collect samples for metallurgical tests as shown in Table I -1-1. The amount of metallurgical tests is shown in Table I -1-4.

2-2-2 Survey method

The flowsheet of test program is shown in Fig. II -2-1

(1) Flotation Tests for sulphide minerals

Flotation tests were made on each core sample of four kinds of ores. The tests were carried out by laboratory scale. Referring to concentration flow, based on the optimum recovery conditions in scalping bulk differential tests which were obtained as results of straight tests conducted by organization of the counter part in 1994 and follow-up study conducted by MMAJ in 1997, chalcopyrite concentrates, pyrite concentrate and tailing are recovered.

Chemical analyses, preparation and mineral identification on polished sections were also carried out on each feed, middling and product to identify behavior of copper and gold in concentrating processes. Studies on the following items were executed.

1) The optimum condition in each processing item

a. Grind size

b. Flotation reagent

c. Flotation time

d. Number of cleaning stage

2) Proper ore processing flow sheet

3) Matters related to the design of ore processing facilities

(2) Leaching tests

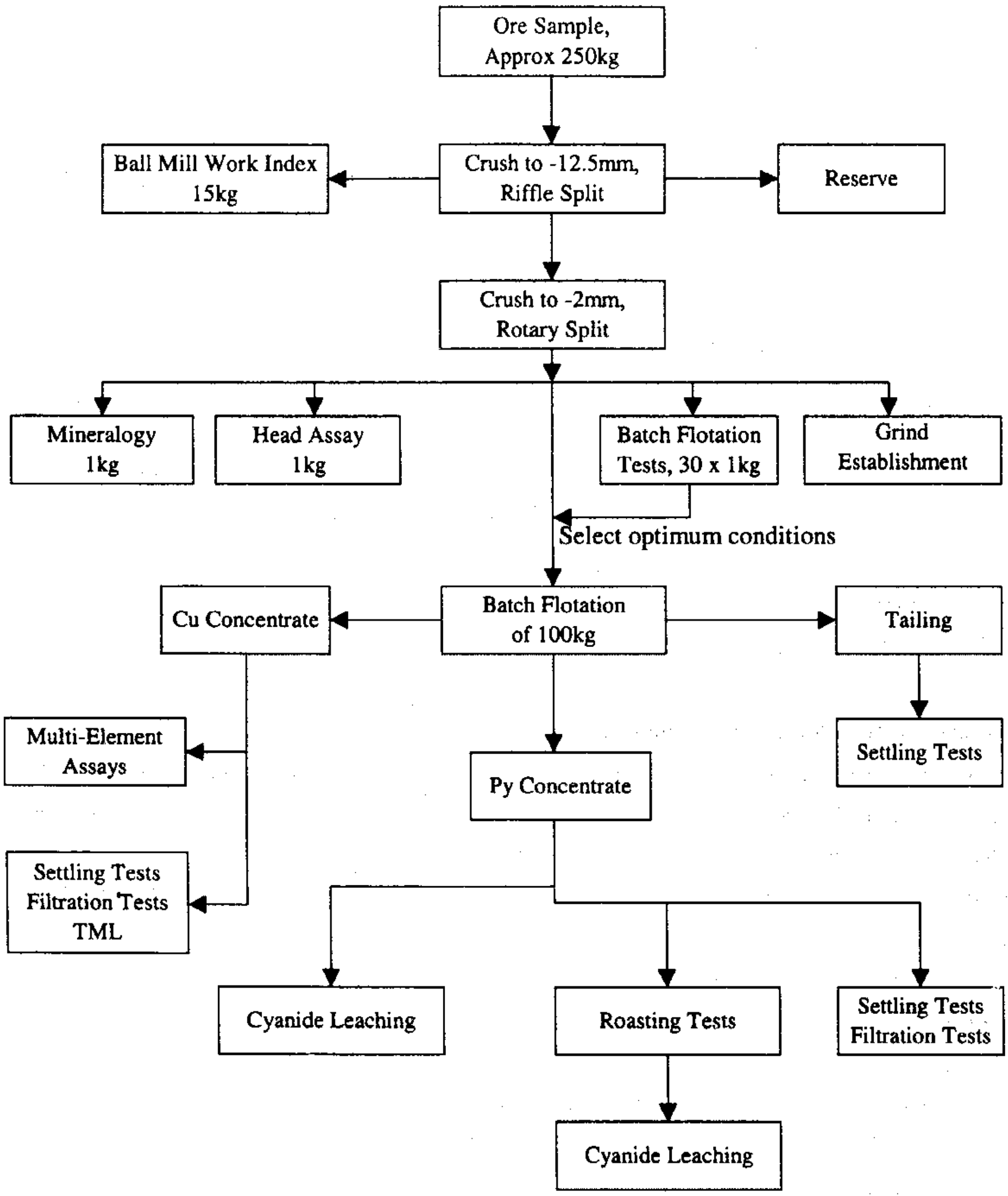


Fig. II-2-1 Metallurgical test program flowsheet

By conducting agitation cyanide leaching tests in laboratory scale and agitation cyanide leaching tests combined with roasting referring to the pyrite concentrate produced in above said flotation tests, the following studies were made.

1) The optimum condition for gold leaching
   a. Grind size
   b. Cyanide concentration
   c. Additional reagents
   d. Oxygen addition
2) Proper ore processing flow sheet
3) Matters related to the design of ore processing facility

2-3 Collecting Samples

Core samples were taken by core drilling from the three deposits of Bishara, Rakah and Hayl as Safil. Drilling locations were selected based on the existing data as shown in Fig. Ⅱ-2-2.

Samples used for metallurgical testing were summarized in Table Ⅱ-2-1.

Table Ⅱ-2-1 Samples used for metallurgical tests

Body Name	Type of Ore	Sampling Source	
		Drill Hole No.	Sampling Depth
Rakah Body	Massive sulphide ore	MJOY-P1	0m to -7.30m
Rakah Body	Stockwork ore	MJOY-P2	-13.40m to -31.35m
do.	do.	do.	-32.90m to -43.60m
do.	do.	do.	-63.15m to -122.10m
Hayl as Safil	Stockwork ore	MJOY-P3	-49.65m to -118.25m
Bishara Body	Breccia ore	MJOY-P5	-45.70m to -68.65m
do.	do.	do.	-69.75m to -93.60m

2-4 Survey Results

2-4-1 Head assays

One charge (1kg) of each sample was used for head assay for a range of elements. The complete head assay results are contained in Appendix 8A, while assays for the major elements are summarized in Table Ⅱ-2-2.

Table Ⅱ-2-2 Head assays of major elements

Body name and Type of ore	Rakah Body Stockwork	Hayl as Safil B. Stockwork	Rakah Body Massive	Bishara B. Breccia
Cu (%)	1.15	0.915	1.82	1.45
Au (g/t)	0.45	0.16	3.78	1.06
S in total (%)	3.35	7.40	39.0	28.3
S in sulphide (%)	3.30	7.40	38.8	28.1

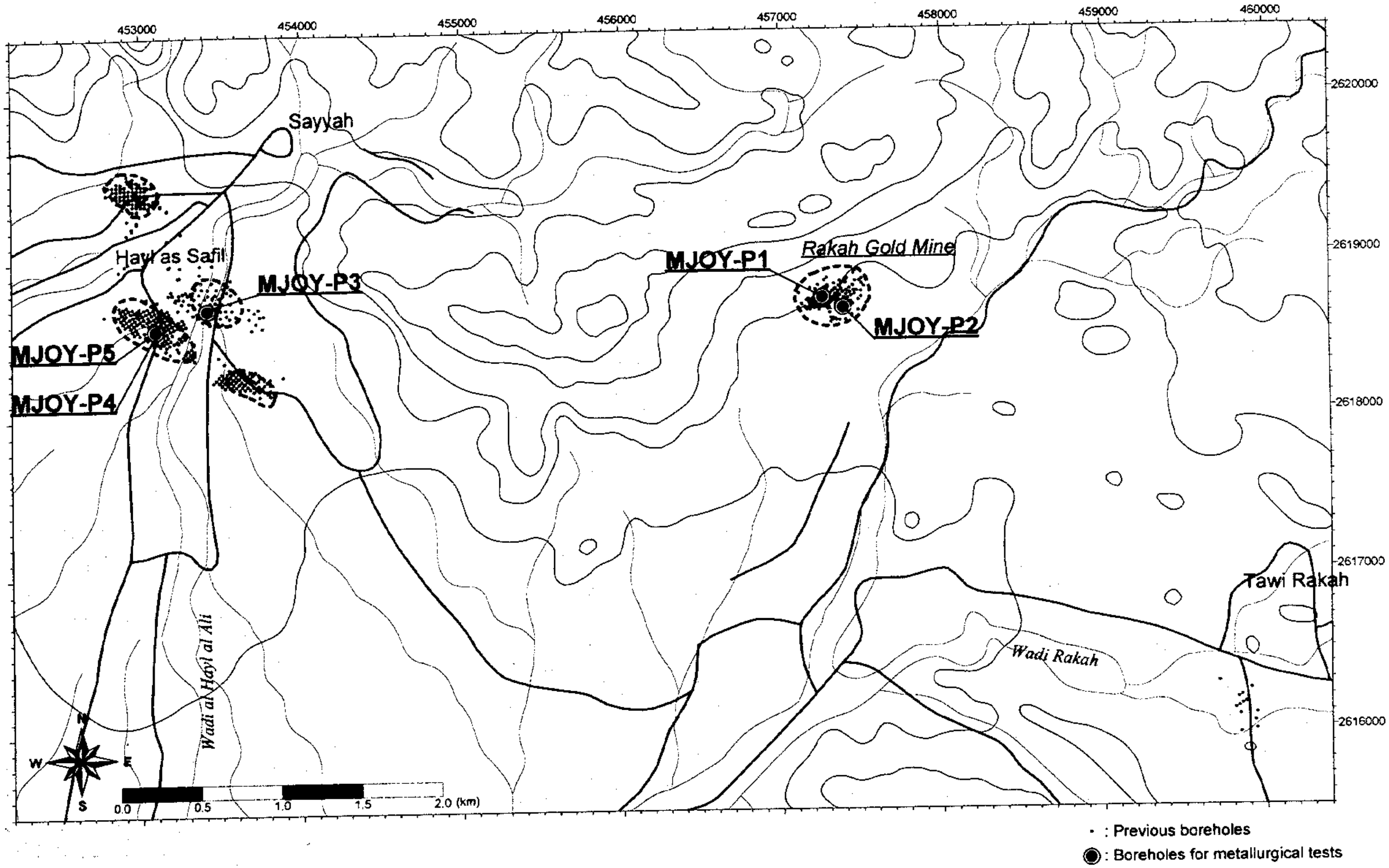


Fig. II-2-2 Location map of boreholes for metallurgical tests