NO.

REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE SOUTH BATINAH COAST AREA
SULTANATE OF OMAN

CONSOLIDATED REPORT

MARCH 2000

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 South Batinah Coast area and entrusted the project to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

This project was carried out in three years from 1997 to 1999 and completed on schedule with good collaboration of the relevant governmental agencies of the Sultanate of Oman, especially of the Ministry of Commerce and Industry. This report is a summary of the survey results conducted during these three years.

We hope that this report will serve for the development of the mineral resources 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, 2000

Kimio Fujita
President
Japan International Cooperation Agency

Naohiro Tashiro
President
Metal Mining Agency of Japan

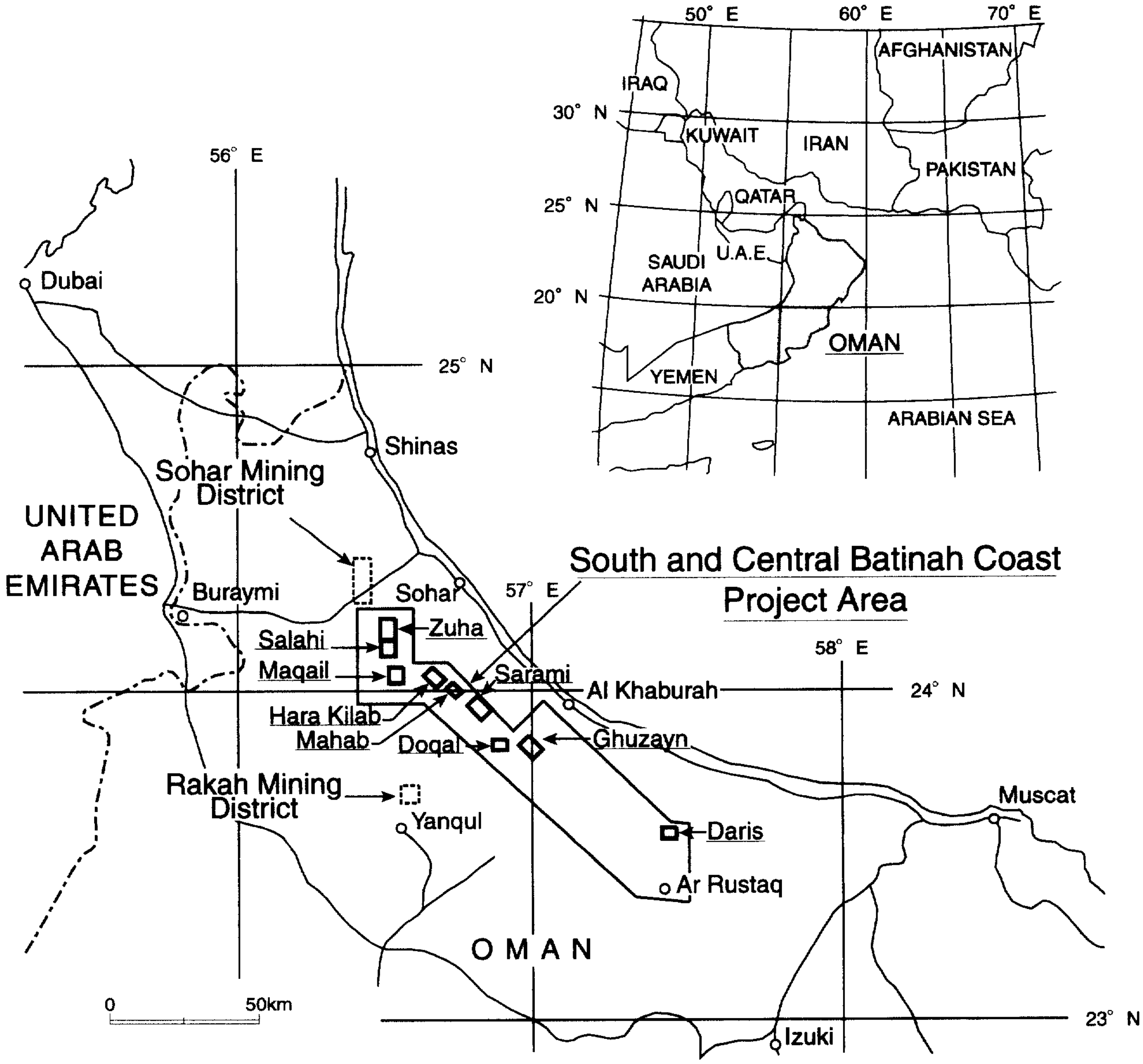

Fig.1 Location map of the surveyed area

ABSTRACT

The Government of Sultanate of Oman and the Government of Japan agreed to conduct a mineral exploration project in the South Batinah Coast area. Both governments on 17th July 1997 signed the Scope of Work for this project. The objective of this project was to discover new mineral deposits in the South Batinah Coast area by clarifying the geological setting and characteristics of mineral deposits.

In the area under study, several exploration works have been already carried out mostly near the known mineral occurrences. These works, however, were limited only to the vicinity of zones with mineral indications and in view of the whole area, very limited portions were merely explored. This is caused by the fact that Quaternary sediments cover this area in a very wide range and therefore, it is very important to find the best ways to investigate effectively and systematically the underlying part of the sediments.

The Cooperative Mineral Exploration project conducted previously during 1995 and 1996 in the Central Batinah Coast, was successful to discover massive sulphide ore bodies at two locations in Ghuzayn area (ore bodies No.1 and No.2), proving that the Batinah Coast area presents high potential for bearing massive sulphide deposits.

The survey carried out during this project for three years from 1997, included geological, geophysical, and drilling surveys. Most important results can be summarized as follow:

In Ghuzayn area we discovered the third ore body (ore body No.3) estimated with a geological reserve of about 8.6 million tons averaging 1.5%Cu grade. The best scale and grade was intersected in the drilling MJOB-G30, which presented a core length and Cu grade of 91.4m and 2.68%, respectively. And from all the results obtained so far, it can be estimated that the total reserve of the three bodies is around 14 million tons averaging 1.4%Cu. Not only in Ghuzayn but also in all the South Batinah Coast area, mineralization was detected in several places, but the existence of massive sulphide deposits that has economical meaning is limited to Ghuzayn area.

In exploration for copper deposits in Oman, ground geophysics plays an important part because of wide coverage of the Quaternary deposits in the area. For the exploration of massive sulphide deposits of Cyprus-type in the Cooperative Mineral Exploration project in Central Batinah Coast area, it was confirmed the effectiveness of a systematic methodology to carry out the geophysical methods, i.e., the first step is to carry out TDIP survey to clarify the mineralized zones. And as a second step, TEM geophysical method is utilized as a suitable method to extract possible ore bodies from the mineralized zone.

From the above results, it is recommended to carry out more detailed studies in Ghuzayn deposit and proceed with the economical evaluation. However, it seems rather complex to develop this area in an independent manner because the deposit in Ghuzayn is rather deep and not accompanied by gold. To develop this deposit in a more efficient way, it is recommended to carry out an economical evaluation together with the existing deposit in Yanqul area, where only a part of the gossan has been developed. It is also recommended to continue the exploration studies to find new ore deposits in potential areas yet to be studied, such as around Rakah area, old gossan of Sohar and other areas around the Oman Mountains.

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PART II SURVEY RESULTS

PART I GENERALITIES

CHAPTER 1 INTRODUCTION

1-1 Background and Objectives

This survey was carried out as a Cooperative Mineral Exploration program in the South Batinah Coast area of Oman based on the Scope of Works agreed on 17th July 1997 between the Government of Japan and the Government of the Sultanate of Oman.

The survey aimed at discovering new mineral deposits in the South Batinah Coast area by clarifying the geological setting and characteristics of mineral deposits. In the area under study, many exploration works have been already carried out mostly near the known mineral occurrences. However these works were only limited to the vicinity of mineralization zones with surface indications and if the whole area is taken into consideration, it is reasonable to think that only very limited portions were merely explored. In view of this matter and considering that Quaternary sediments cover the area in a very wide range, an important subject to be undertaken for exploration was the finding of an effective methodology to investigate in a systematic way the underlying part of the sediments in this area

During the previous Cooperative Mineral Exploration carried out in the Central Batinah Coast area from 1995 to 1996, two ore bodies (ore body No.1 and ore body No. 2) were discovered in Ghuzayn area, confirming that the Batinah Coast area presents a high possibility for the existence of massive sulphide ore deposits.

1-2 Coverage and Outline of Works

The South Batinah Coast area, the objective area of this survey, is located in the west of Muscat, the capital of the country, and lies between the Oman Mountains and the Gulf of Oman. The survey area is shown in Fig. 1.

The massive sulphide deposits distributed in Oman are of the Cyprus-type copper deposits. These deposits occur within the volcanic rocks consisting mainly of basaltic pillow lava and associated to a stratigraphic control. Based on the survey results obtained during the last years in the Batinah Coast area and the previous results from Sohar area, the following exploration indicators have been established:

(1) Massive sulphide deposits show stratigraphic control and occur in the contact between the two formations of basaltic lava; namely, V1-1 (Geotimes unit) and V1-2 (Lasail unit).

(2) The alteration associated with mineralization consists of silicification, chloritization (Mg-rich chlorite) and epidotization. Silicification and epidotization are remarkable even in the margin of the massive sulphide ore body.

(3) The generation of massive sulphide deposits is closely related to faults.

(4) There exists the possibility that metalliferous sediments grade laterally into massive sulphide ore bodies in the case that the sediments contain many magnetite with clear stratification and copper mineralization.

Since this area is widely covered by Quaternary sediments, the distribution of mineral showings is rather limited in the surface and for this reason, the mineral exploration can be more effective if the following steps, as indicated in the flow chart of Fig. I-1-1, are taken into account:

1) The selection of potential areas for this type of deposits can be achieved by first selecting the most suitable zones by means of geological and airborne magnetic methods. The airborne magnetic method is useful to delineate demagnetized zones associated to mineralization.

2) The zones selected by the above methodology can be further investigated by appropriate ground geophysical methods in order to delineate in more detail areas with high potentiality.

3) A suitable exploratory drilling program can finally confirm the results of the geophysical methods.

Fig. I-1-2 summarizes the exploration flow of the conducted works during the three phases. As shown in this flow chart, the following works were carried out:

In Phase I, we carried out geophysical and drilling surveys in Ghuzayn, Doqal and Daris and at the same time we carried out geological survey in and around the mineral showings in the northwestern part of the area.

In Phase II, we carried out geophysical and drilling surveys as well as continuation of the exploration works in Ghuzayn. Geophysical surveys were carried out in Sarami, Mahab, Hara Kilab and Maqail. In Sarami and Hara Kilab, drilling survey was carried out on the basis of the geophysical results, while geological survey was carried in Zuha.

In Phase III, by taking into account the results of Phase II, geophysical and drilling surveys were carried out in Ghuzayn, Zuha and Maqail. Geophysical survey was done in Salahi.

Survey amounts for each method, as well as laboratory studies are all indicated in Tables I-1-1.

Flow for massive sulphide deposits exploration in Batinah coast

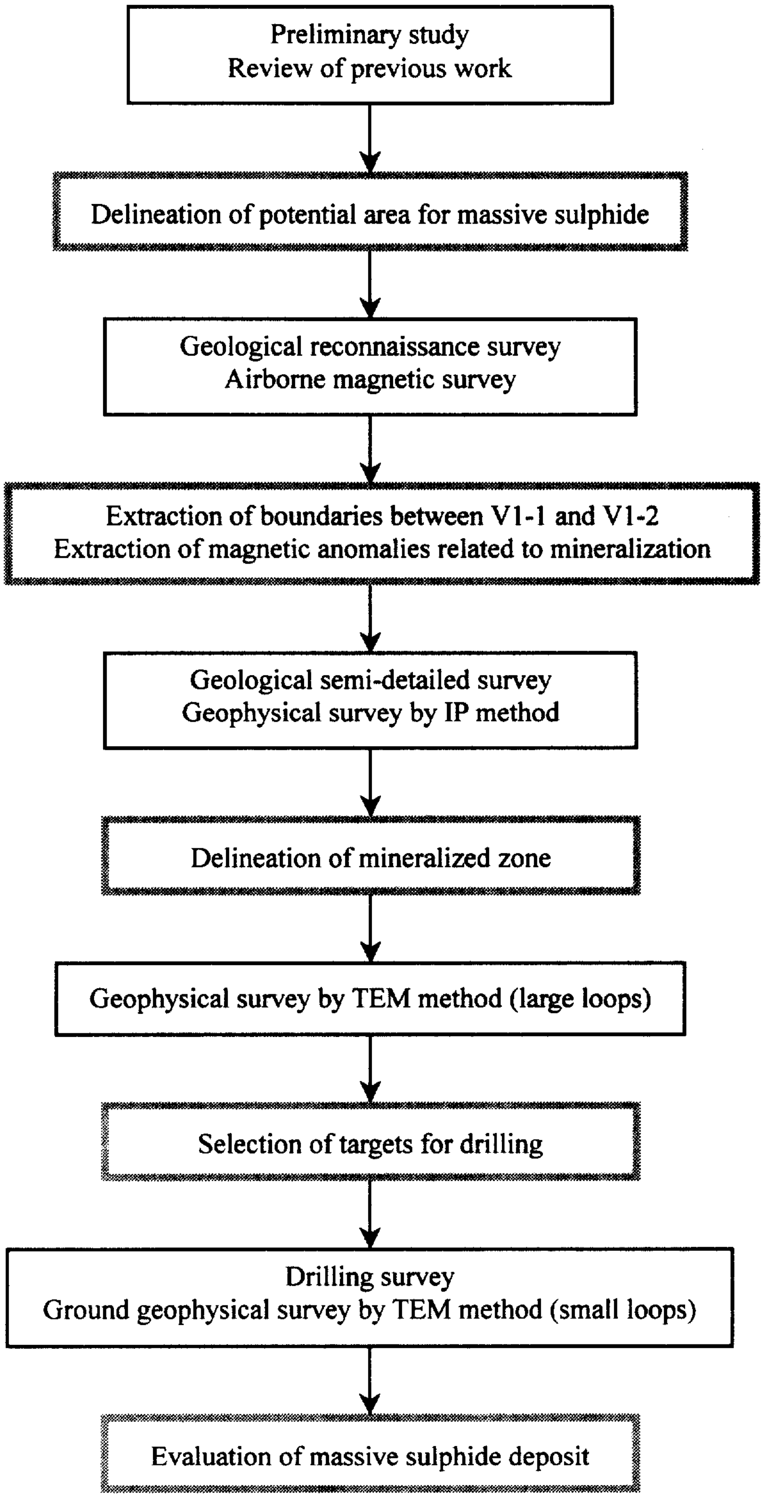


Fig.I-1-1 Flow for massive sulphide deposits exploration in Batinah Coast

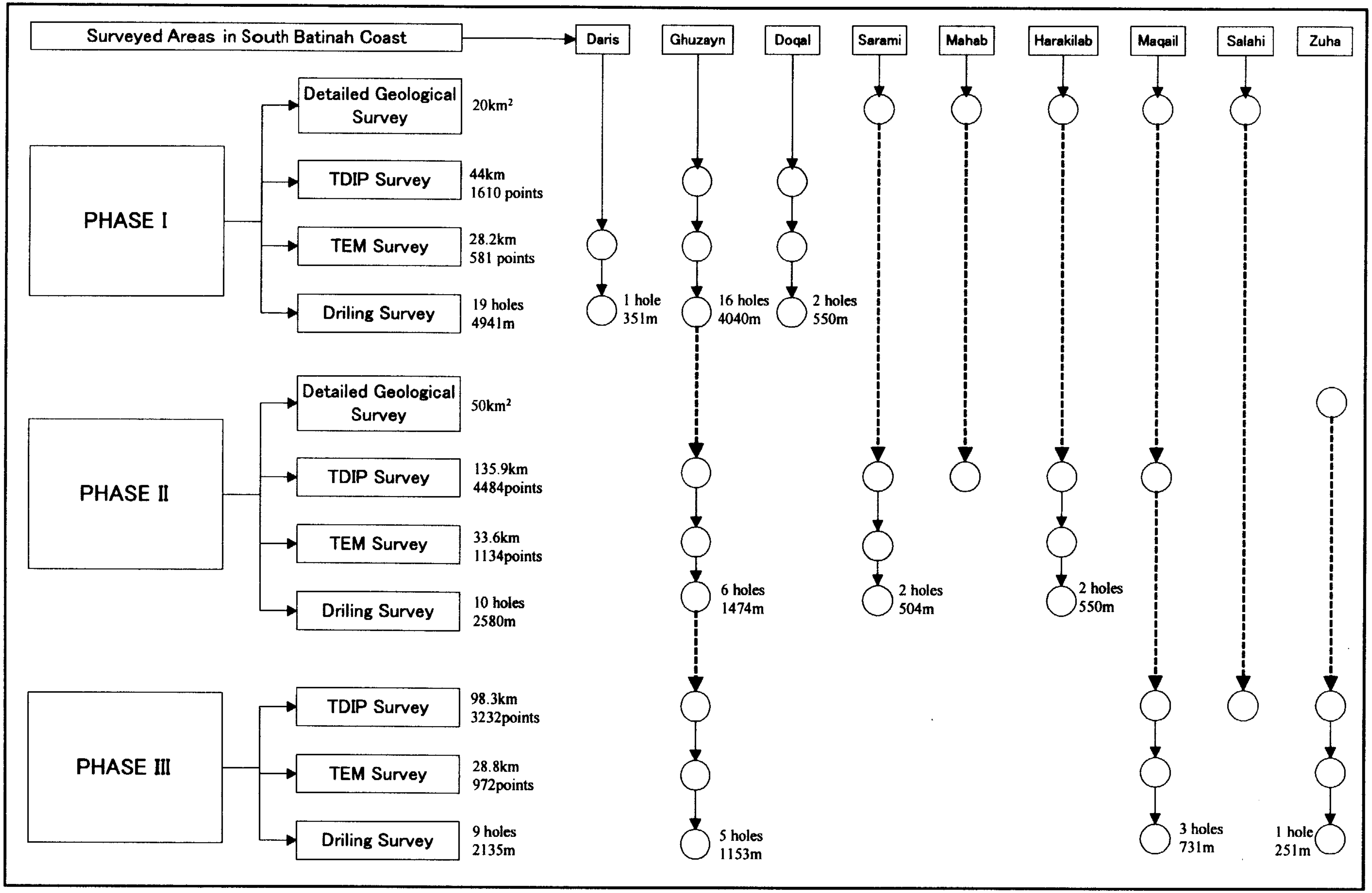


Fig.I-1-2 Flow of the project

Table I-1-1 Amounts of works

CONTENTS	PHASE I		PHASE II		PHASE III	
Detailed Geological Survey	Area coverage	20 km^2	Area coverage	50 km^2		
	Laboratory work		Laboratory work			
	- Thin sections	6 samples	- Thin sections	7 samples		
	- Polished sections	7 samples	- X-ray diffraction	7 samples		
	- X-ray diffraction	19 samples	- Chemical analysis	23 samples (ore)		
	- Chemical analysis	60 samples (ore)				
TDIP Survey	Survey areas	Ghuzayn, Doqal	Survey areas	Ghuzayn, Mahab, Harakilab, Sarami, Maqail	Survey areas	Ghuzayn, Maqail, Salahi, Zuha
	Line length	44 km	Line length	135.9 km	Line length	98.3 km
	Measurement points	1610 points	Measurement points	4484 points	Measurement points	3232 points
	Laboratory work	32 samples	Laboratory work	33 samples	Laboratory work	30 samples
TEM Survey	Survey areas	Daris, Ghuzayn, Doqal	Survey areas	Ghuzayn, Sarami, Harakilab	Survey areas	Ghuzayn, Maqail Zuha
	Line length	28.2 km	Line length	33.6 km	Line length	28.8 km
	Measurement points	581 points	Measurement points	1134 points	Measurement points	972 points
Drilling Survey	Daris area	1 hole, 350.50m	Ghuzayn area	6 holes, 1474.15m	Ghuzayn area	5 holes, 1153.50m
	Ghuzayn area	16 holes, 4040.10m	Sarami area	2 holes, 504.25m	Maqail area	3 holes, 731.40
	Doqal area	2 holes, 550.65m	Harakilab area	2 holes, 602.00m	Zuha area	1 hole, 250.90
	Total amount --	19 holes, 4941.25m	Total amount --	10 holes, 2580.40m	Total amount --	9 holes, 2135.80m
	Laboratory work		Laboratory work		Laboratory work	
	- Thin sections	30 samples	- Thin sections	14 samples	- Chemical analysis	82 samples
	- Polished sections	11 samples	- Polished sections	13 samples		
	- X-ray diffraction	21 samples	- X-ray diffraction	14 samples		
	- Chemical analysis	427 samples (ore)	- Chemical analysis	149 samples (ore)		

1-3 Members of the Project

The members of the project were as follows:

(1) Project planning and negotiation

Japanese Counterpart

Jiro Osako	Metal Mining Agency of Japan
Tadashi Itoh	Metal Mining Agency of Japan
Takashi Kamiki	Metal Mining Agency of Japan
Kenji Seiyama	Metal Mining Agency of Japan
Hiroshi Shibasaki	Metal Mining Agency of Japan

Omani Counterpart

Mohamed H. Kassim Al-Yafai	Ministry of Commerce and Industry
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

Hashime Hishida	Metal Mining Agency of Japan
Noboru Fujii	Metal Mining Agency of Japan
Hiroyuki Katayama	Metal Mining Agency of Japan
Ken Yoshioka	Metal Mining Agency of Japan
Kazuo Masuda	Metal Mining Agency of Japan

(3) Field work

Japanese Counterpart

Yoshiaki Shibata	Team leader	Mitsubishi Materials Natural Resources Development Corp.
Masanori Furuno	Geological Survey	Mitsubishi Materials Natural Resources Development Corp.
Toshimasa Tajima	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
David Escobar	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Junichi Sasaki	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Hirohisa Horiuchi	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Takehara Takahashi	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Susumu Endo	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Hidehiro Tachihara	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Nobuhide Jomori	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.

Omani Counterpart

Salim Omer Abdullah Ibrahim	Ministry of Commerce and Industry
Ali Salim Al-Rajhi	Ministry of Commerce and Industry
Durair Ismail A'Shaikh	Ministry of Commerce and Industry
Saeed Bin Monsher Bin Atti Ba-lhaf	Ministry of Commerce and Industry

1-4 Survey Period

The field work and compilation activities were conducted in Oman during the following period:

Phase I

Geological survey:	October 21, 1997 to November 21, 1997
Geophysical survey:	September 16, 1997 to January 2, 1998
Drilling survey:	August 17, 1997 to January 9, 1998

Phase II

Geological survey:	September 28, 1998 to October 28, 1998
Geophysical survey:	October 1, 1998 to January 15, 1999
Drilling survey:	September 28, 1998 to January 27, 1999

Phase III

Geophysical survey:	December 7, 1999 to March 10, 2000
Drilling survey:	December 7, 1999 to March 15, 2000

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 (Fig. 1).

The survey area is located to the west of the capital city of Muscat and has an extension of about 2,900km^2 running parallel to the Oman Mountains and the Gulf of Oman. The center of the investigation area has approximately a latitude of 23°50′N and a longitude of 57°00′E. It takes about 2 hours by vehicle for 170km driving along coastline from Muscat to Al Khaburah, near the central part of the survey area.

2-2 Topography and Drainage System

The survey area consists of a hilly land between an altitude of about 100m and 1,000m, forming the foot of the Oman Mountains and a coastal plain along the Gulf of Oman (Batinah Coast Plain).

Dry rivers, so-called wadis, run almost S-N in the Batinah Coast Plain from hilly land in the south to the Golf of Oman. Major wadis from east to west are: Wadi Hawqayn, Wadi Mabrah, Wadi Halhal, Wadi al Hawasinah, Wadi Shafan, Wadi Sarami, Wadi Sakhin and Wadi Hilti.

2-3 Climate and Vegetation

Climate of the Batinah Coast Plain is semi-dry type, though it presents high temperature and some 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, usually the rain falls 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 lime, mango, tobacco, etc. However, excepting cultivated land, vegetation is very scarce and the vegetation of acacia, etc. is observed only in and around the wadis.

The maximum temperature in summer season (April to October) reaches more than 40°C and sometimes goes up to 50°C. Humidity is 40% during daytime but goes up to nearly 100% during night-time. The maximum temperature in winter season (November to March) goes down to about 25°C.

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

3-1 General Geology

The geology of the project area, according to 1: 250,000 geological map published by Ministry of Petroleum and Minerals, is as shown in Fig.I-3-1. It consists of Hawasinah Nappe and Samail Nappe assumed to have thrust over the Autochthonous to Parautochthonous units, Post-Nappe units and Quaternary sediments, which are distributed in this order from south to north.

Hawasinah Nappe is composed of the Late Permian to Jurassic Hamrat Duru Formation distributed in the north and central of the area, and of the Triassic Umar Formation cropping out in a limited way in the central part of the area. The Hamrat Duru Formation consists of quartz sandstone, shale, chert, limestone, basalt, andesite and keratophyre. The Umar Formation consists of chert, limestone and breccia.

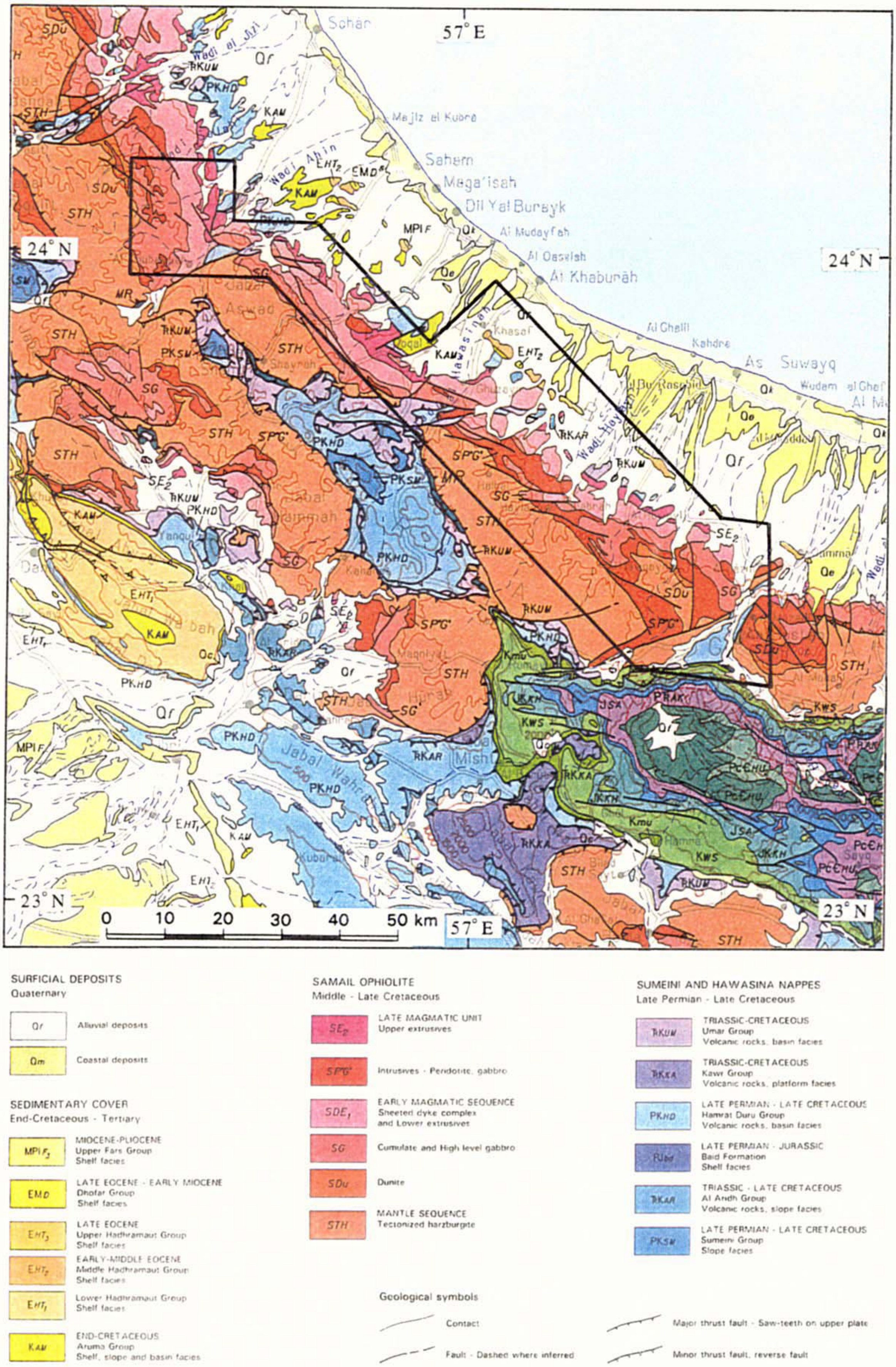
Samail Nappe is mostly composed of Ophiolite (Samail Ophiolite) and extensively distributed in the area. Succession of the Samail Ophiolite, is described as follows:

(Bottom) (1) Tectonites
(2) Cumulate Sequence
(3) High-level Gabbro
(4) Sheeted-dyke Complex
(Top) (5) Samail Volcanic Rocks

Post-Nappe units consist of the Upper Cretaceous Aruma Formation and Tertiary Hadhramut Formation, and which are cropping out along a line almost parallel to the coastal line. The Aruma Formation is composed of polymict conglomerate and marl, while the Hadhramut Formation is composed of limestone, carbonate rocks and marl.

Quaternary sediments are comprised of fan deposits, terrace deposits and stream sediments, which are well exposed in the northern side of the area.

Principal geologic structure of the area consists of the piled-up structure formed in the time when the Samail Nappe was detached from the ocean floor and obducted over the Arabian platform during the Late Cretaceous Alpine orogenic cycle. Many thrust faults are found in the area which constitute boundaries of structural and tectonic units of the Samail nappe, such as Tectonite-Cumulate Sequence-Sheeted dyke Complex -Volcanic rocks.



Ministry of Petroleum and Minerals (1993)

Fig. I -3-1 Geologic map of the South Batinah Coast area

3-2 Mineralization and Mining Activities

3-2-1 Mineralization

Occurrences of copper deposits, the main target of the project, are schematically shown in Fig.I-3-2. 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 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-3-3. As indicated in this figure, the following characteristics in geological structure and alteration about the deposit can be summarized as follows:

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 V1-1 and V1-2.

(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.

(3) The ore body shows sedimentary structure on its edge where the ore body grade laterally into metalliferous sediments that are rich in abundant magnetite.

Characteristics of the alteration

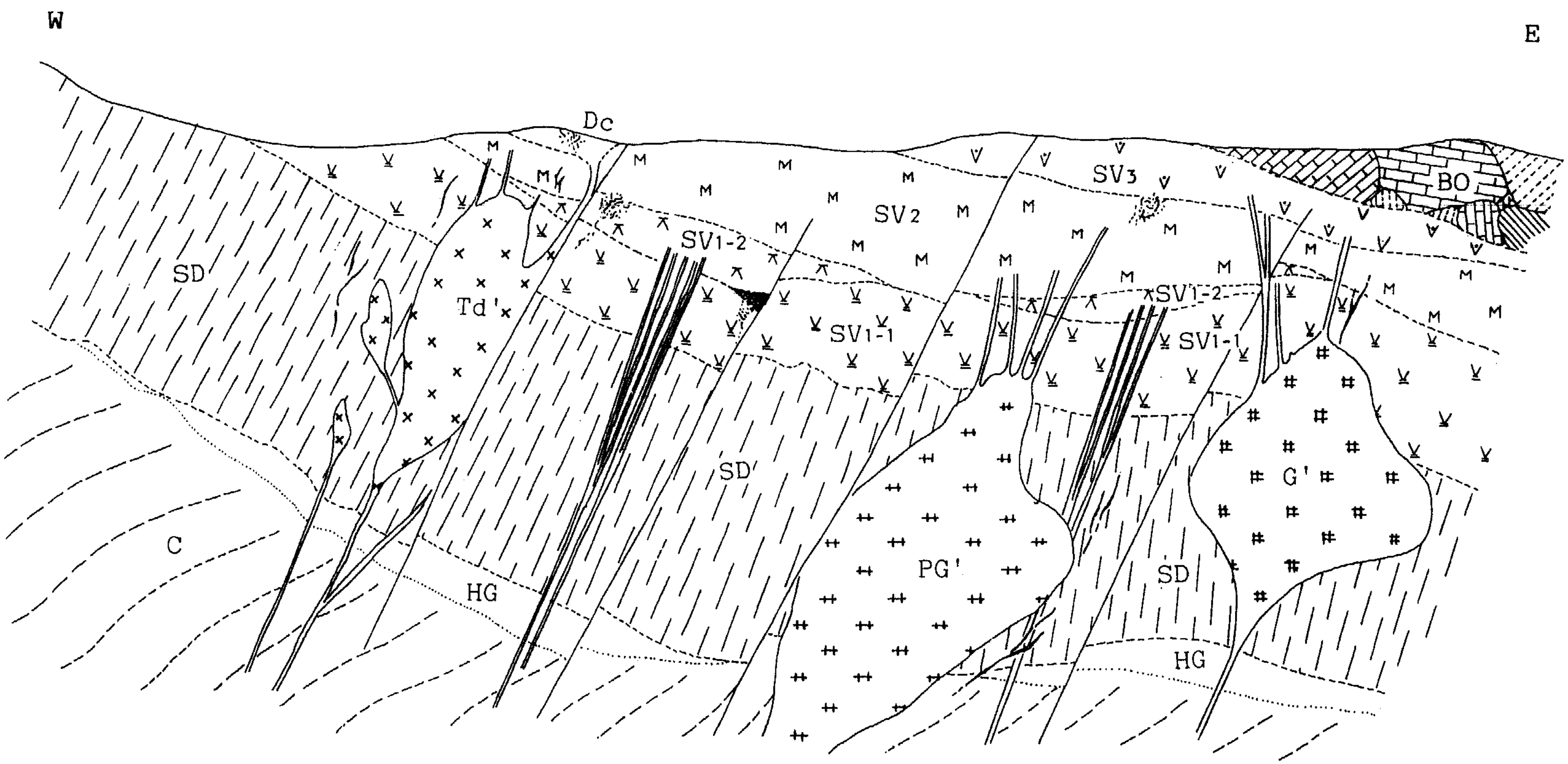
(1) Alteration due to mineralization consists of silicification, chloritization (Clinochlore) and epidotization.

(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 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, 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 explored at that period up to diamond drillings, confirming the existence of those deposits.



C : Cumulate sequence
HG: High-level gabbro
SD: Sheeted-dyke complex
SV1-1 : Lower extrusives 1
SV1-2 : Lower extrusives 2

SV2 : Middle volcanic rocks
Dc : Dacite
SV3 : Upper volcanic rocks
BO : Batinah olistostrome
G' : Gabbro

PG': Peridotite and gabbro complex
Td': Trondhjemite
: Massive type mineralization
: Vein type mineralization
: Stockwork/dissemination type mineralization

Fig. I -3-2 Schematic distribution of Samail Volcanic Rocks and mineralization in Sohar area

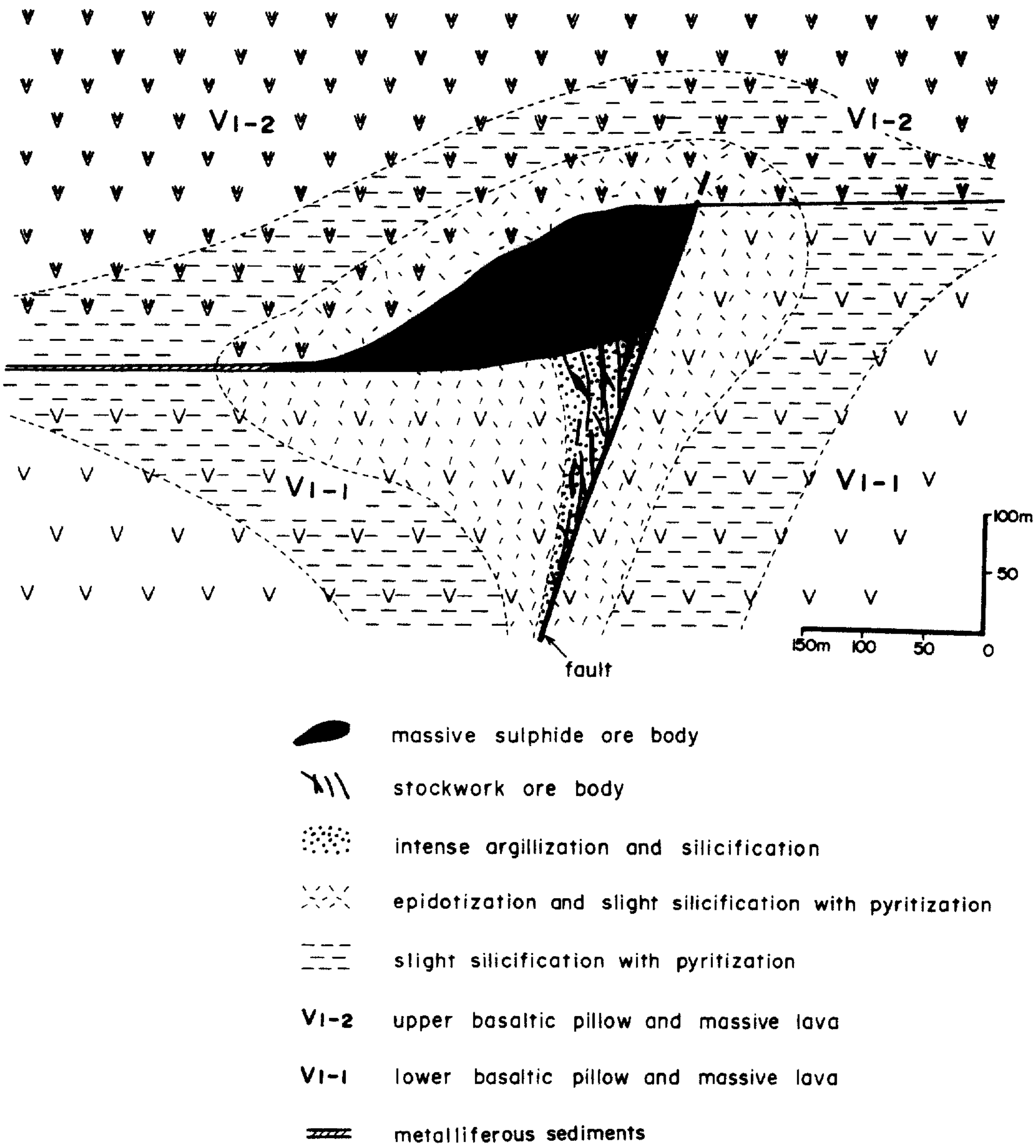


Fig. I -3-3 Schematic model of massive sulphide deposits in Ghuzayn area

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 OMCO (Oman Mining Company), 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 some ore reserves were newly obtained in and around the known deposits, and at the same time, 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. The objective areas of the present cooperative mineral exploration program, such as Ghuzayn, Buwayrick, Daris West, Daris 3A5, Daris, Mahab6, Mahmum and Bir Mohsen were included in the above mentioned 13 mineralization zones.

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 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 Asgher 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.

Furthermore, to reconsider the results of the exploration works already carried out, the Government of Oman conducted an airborne magnetic survey in the northeastern side of the Oman Mountains from 1990 to 1992, and as a result, magnetic anomalous zones related to mineralization were delineated.

On this basis, conducting mainly geophysical and drilling surveys since 1995 has commenced the present cooperative project.

CHAPTER 4 SURVEY RESULTS

4-1 Geological Survey

According to the exploration indicators described in Chapter 1 of Part I, detailed geological survey was carried out in and around mineral showings in the northwestern part of the project area. On this basis, the following 6 mineral showings were selected as promising areas for further study: Zuha, Salahi, Maqail, Hara Kilab, Mahab and Sarami. Big scale gossan exists in Zuha and small massive sulphide deposit had been recognized in Hara Kilab, for which these two areas were considered to have high potential for the existence of massive sulphide deposits. The results of geological survey in the above mentioned promising areas, were as follows:

Zuha area: Three features can be noted, i.e. a large scaled gossan of almost the same size as the gossan in Ghuzayn, an ancient smelting site nearby the gossan and abundant copper oxides around the gossan. The intense epidotization is observed in V1-1 and U1 can be continuously traced for a long distance. These facts confirmed a high potential for the existence of ore deposits in this area.

Hara Kilab area: Good indications for the existence of massive sulphide deposits are given by two ancient mines located in the area and by a widely distributed silicified zone that is partly gossanized. Intense epidotization can be seen around ancient mining sites as well as near Mahab village in the southern part of the area. Since small-scaled massive sulphide deposits were already confirmed and several features of mineralization were observed in the area, the area was considered to have a high potential for the existence of massive sulphide deposits.

Salahi area: U1 with copper oxides and magnetite was recognized in many locations. Intense epidotization was also recognized in some location. Especially, U1 with abundant magnetite outcropping in the north part has 2m in thickness, shows developed stratification, and accompanied by copper oxides. These features present the aspect of being the end part of a massive sulphide ore.

Maqail area: A thick U1 with abundant magnetite is extensively exposed and accompanied with copper mineralization. These characteristics support the idea that U1 grades laterally into massive sulphide ore. Moreover, a gossanized zone with copper mineralization over V1-2 crops out along the faults of NNW-SSE trending in the central part.

Mahab area: U1 contains abundant magnetite and relatively intense epidotization is observed in V1-1. The existence of faults in this area, however, limits the extension of the area for exploration purposes.

Sarami area: Two features can be emphasized, i.e. a copper mineralization seen in V1-1 in several locations and a wide silicified zone with a small-scaled gossan found in V1-2 cropping out in northern part. Intense epidotization was confirmed in V1-1 outcropping around this silicified zone. In addition, metalliferous sediments containing magnetite and copper oxides were found in one location.

4-2 Geophysical Survey

The utilization of the TDIP (Time Domain Induced Polarization) method as a first step is very effective to delineate a promising sulphide mineralized zone while covering a wide area. As a second step, the implementation of TEM (Transient Electro-Magnetic) method is an excellent technique to delineate the most promising locations for drilling.

4-2-1 TDIP survey

TDIP survey was carried out in order to extract mineralized zones related to the existence of massive sulphide deposits in the South Batinah Coast area on the basis of the results of the geological survey previously carried out.

For the TDIP survey it was used a time-domain method and adopted a dipole-dipole electrode configuration with a separation factor from 1 to 4. IP data were taken along lines every 100m by keeping a potential dipole of 100m and line spacing of 200m. During this project, the following 8 areas were selected for exploration work: Ghuzayn, Zuha, Hara Kilab, Maqail, Sarami, Doqal, Mahab and Salahi. A summary of these results is as follows:

Ghuzayn area: As indicated in Fig.I-4-1, high chargeability anomalies accompanied by low resistivity were detected in the central western part of the explored area. The metal factor (ratio between chargeability and resistivity) anomaly shows the highest value in Ghuzayn area and this distribution is seen extended from south to north. On the other hand, although high chargeability values were widely detected in the east part of the gossan and west of A'Ruwydhat, they were not accompanied by low resistivity anomalies. Moreover, TDIP survey was also conducted to the west and east extension of the already explored area, but no anomaly indicative of mineralization around favorable horizon of massive sulphide ore was detected.

Zuha area: Around gossan and its north part, the TDIP survey detected high chargeability not only in V1-1, but also in the favorable horizon. However, low resistivity was not detected outside of the area where V2 is distributed.

Hara Kilab area: A clear high chargeability (Dhahwa IP anomaly) with low resistivity anomaly was detected in the northeast of the central part of the area. This anomaly shows also high metal factor values.

Maqail area: High chargeability is widely detected in the central and northwest part of the area. In the northwest part of this zone, a relatively low resistivity anomaly distribution was detected.

Sarami area: Very high chargeability (Omah No.1 IP anomaly) was found widely distributed in the northwest of the central area. In the southwest part of this central area, a small-scale chargeability zone (Omah No.2 IP anomaly) was also detected, which partially shows relatively low resistivity.

Doqal area: IP anomaly was confirmed by a clear high chargeability anomaly that was detected in the previous project in the Central Batinah Coast area. This anomaly extends continuously in the east part of this area along north-south and northwest directions from the gossan and its surroundings. In Doqal area,

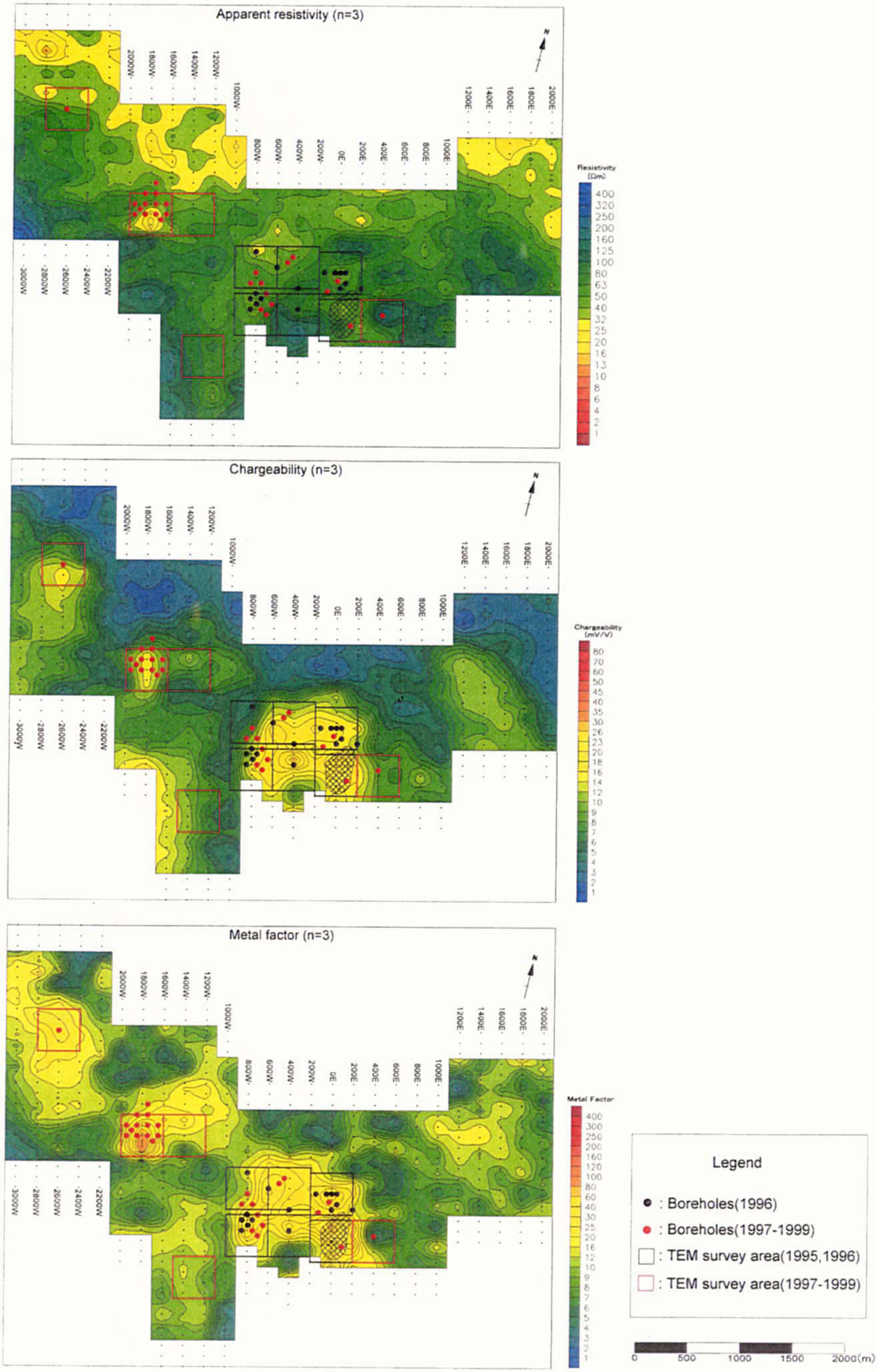


Fig.I-4-1 IP plane map in Ghuzayn area

though high chargeability was found, clear low resistivity values were not detected within the limits of the high chargeability zone.

Salahi and Mahab areas: Within V1-1 and in one part around the favorable horizon, high chargeability values were detected but they were not accompanied by low resistivity. Only low resistivity anomalies were found in V2. As a result of this survey, geophysical anomalies related to mineralization for massive sulphide deposit could not be confirmed.

Through the survey results of the 3 years of duration of this project, it was found that the massive sulphide ore and its host rocks present the following IP characteristics:

a) Massive sulphide presents medium to high chargeability accompanied by low to medium resistivity.
b) V1-1 presents in general high chargeability accompanied by high resistivity
c) V1-2 presents in general low chargeability accompanied by high resistivity
d) V2 located above V1-2, presents in general low chargeability accompanied by low resistivity.

4-2-2 TEM survey

The TEM (Transient Electro-Magnetic) survey, sensitive to conductive bodies, such as massive sulphide deposits, was conducted to clarify the nature of the sulphide mineralization within the area delineated by the results of the TDIP survey.

During this survey it was used the configuration of large fixed-loop. For the case of large loops, a large, single-turn square loop of wire of 600m by 600m is laid out on the ground. The measurements are carried out along lines surveyed within the loop to a distance of 100m away from the loop and a grid interval of 50m is kept between the observed points.

TEM survey was carried out in the 7 places where IP anomalies were detected by the TDIP survey. These areas were Ghuzayn, Zuha, Hara Kilab, Maqail, Sarami, Doqal and Daris. Summary of the results is as follows:

Ghuzayn area: The TEM survey conducted in the west side of this area clearly shows the massive sulphide deposit (ore body No.3) intersected by the drilling survey. According to the survey results, this ore body is inferred to have an extension of about 200m along the east west direction and 300m from south to north conforming an oval shape as indicated in Fig. I-4-2. It can also be inferred that this ore body is thicker in the south part and probably bordered by a fault in the south edge, but dipping slowly towards the north direction where its thickness decreases.

The TEM survey carried out in A'Ruwydhat on an IP anomaly zone, did not detect any TEM anomaly, but the TEM results obtained in the east of the gossan detected only high TEM response at shallow levels.

Hara Kilab area: High TEM responses probably caused by mineralization were detected in the central part of the Dhawha IP anomaly.

Maqail area: From the 3 loops conducted during the TEM survey, only one loop was able to detect high TEM responses that suggest the existence of massive sulphide ore body.

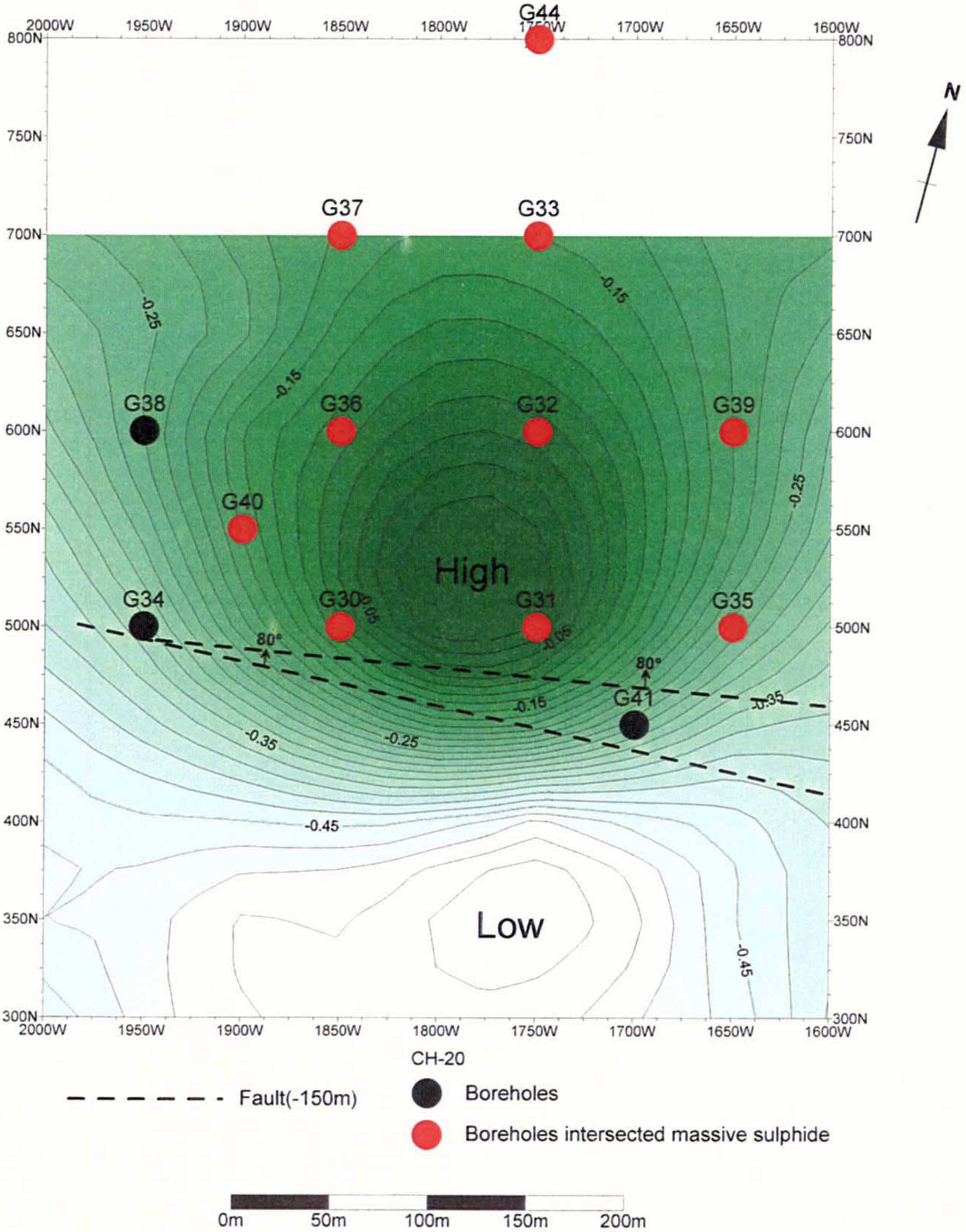


Fig.I-4-2 TEM response map of Ghuzayn area

Sarami area: High TEM responses, which are likely to be caused by mineralization, were detected in 2 parts of the west of Omah No.1 IP anomaly.

Daris area: 2 places were selected from a wide IP anomaly zone. In one of them, high TEM responses were detected.

Zuha and Doqal areas: any anomaly that may suggest the existence of massive sulphide ore body was detected in these areas.

4-3 Drilling Survey

According to the results obtained from the geophysical exploration, 38 boreholes with a total length of 9657.45m were drilled in 7 areas: Daris, Ghuzayn, Doqal, Sarami, Mahab, Hara Kilab and Maqail.

In Ghuzayn area the 27 boreholes drilled until the present time are illustrated in Fig.I-4-3. Table I-4-1 summarizes the results of the drilling survey including the places where massive sulphide ore was intersected.

Drilling survey was also carried out to investigate the extension and assay distribution of the ore bodies No.1 and No.2 that were discovered during the Cooperative Mineral Exploration in the Central Batinah Coast Area project. According to these investigations, in the ore body No.1, the borehole MJOB-G25 intersected massive sulphide ore with a core length of 7.45m and an average Cu assay of 3.51%.

About the ore body No.2, massive sulphide ore was intersected in 5 drilled boreholes and in the other 2 holes, it was confirmed about 1 to 2 meters of metalliferous sediments predominant in magnetite and which can be considered as marginal faces of the massive sulphide ore body. As a result of these investigations, it is inferred that the ore body No.2 presents an oval shape with the following dimensions: an extension of 400m along the north-south direction, 200m wide along the east-west direction and an average of about 20m in vertical thickness between the depths of about 90m and 280m. The ore body dips by 20° to 40° along the northwest direction.

On the other hand, the drilling survey investigated the clear anomaly detected by the geophysical survey in the western part of this area. As a result of the drilling, massive sulphide ore body was intersected by 10 holes (ore body No.3). The borehole MJOB-G30 presented a maximum ore core length of 91.4m and the highest average Cu assay of 2.68% detected so far in the area. The intercepted depth of the ore body was between 110m and 280m. In the boreholes MJOB-G31, MJOB-G33 and MJOB-G40 it was also confirmed in the upper and lower part of the massive ore, the existence of stockwork consisting of dissemination and veinlets.

As a result of this survey, it was clear that the ore body No.3 is asymmetric along the east-west direction, i.e., the thickness of the ore body is thicker in the west side and becomes rapidly thin in the west edge. This orebody presents a length of about 300m, and the bottom surface dips monotonously around 20° towards northwest.

In the drilling survey in A'Ruwydhat, intense silicification was recognized but mineralization is not found so remarkably. Only weak pyrite dissemination was detected. The drilling survey to the east of the

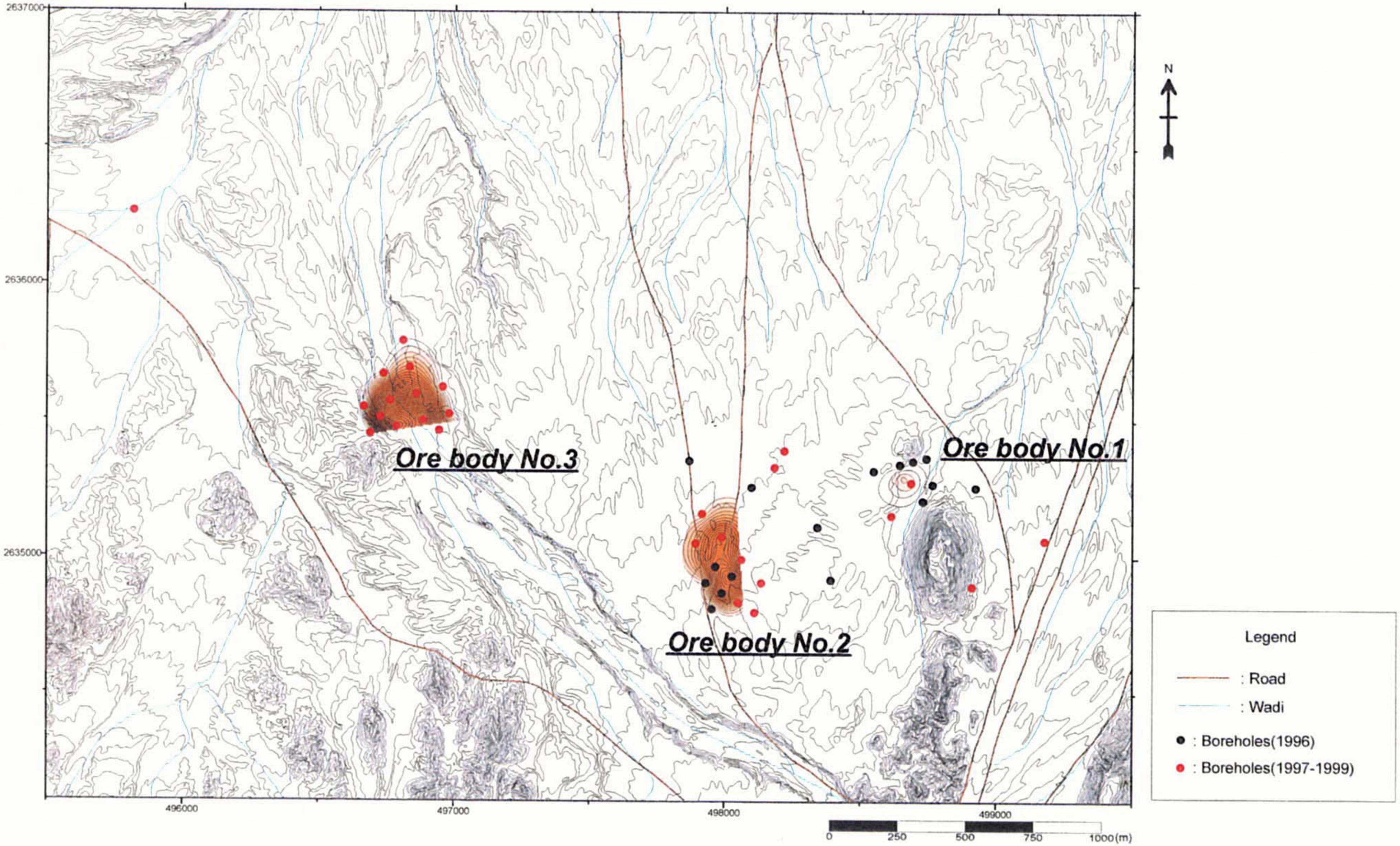


Fig.I-4-3 Location map of boreholes and confirmed orebodies of Ghuzayn area

Table I-4-1 Summary of results on drilling survey in Ghuzayn area

Ore Body Name	Bore Hole No.	Type of Ore	Depth (m)		Thickness	Average Grade	
			from	to	(m)	Cu(%)	Zn(%)
Ghuzayn Body No.1	MJOB-G3	massive sulphide	**133.45**	**142.80**	**9.35**	**4.66**	**0.04**
		stockwork	142.80	179.90	37.10	0.47	0.11
	MJOB-G13	massive sulphide	**152.80**	**154.40**	**1.60**	**0.17**	**0.04**
	MJOB-G25	massive sulphide	**115.60**	**123.05**	**7.45**	**3.51**	**0.03**
Ghuzayn Body No.2	MJOB-G5	massive sulphide	**136.90**	**170.60**	**33.70**	**1.47**	**0.04**
	MJOB-G14	massive sulphide	**119.80**	**164.75**	**37.10**	**1.88**	**0.04**
		stockwork	164.75	171.50	6.75	2.74	0.44
	MJOB-G15	metaliferous sediment	178.85	179.20	0.35	2.10	0.01
		massive sulphide	**179.20**	**212.30**	**29.90**	**1.55**	**0.05**
	MJOB-G16	massive sulphide	**186.90**	**189.40**	**2.50**	**1.63**	**0.05**
	MJOB-G17	massive sulphide	**215.90**	**222.80**	**6.90**	**1.17**	**0.05**
	MJOB-G18	massive sulphide	**251.80**	**267.00**	**15.20**	**0.96**	**0.08**
	MJOB-G19	massive sulphide	**194.10**	**227.50**	**33.40**	**1.15**	**0.05**
	MJOB-G20	massive sulphide	**273.90**	**279.30**	**5.40**	**0.69**	**0.02**
	MJOB-G21	massive sulphide	**126.10**	**138.75**	**12.65**	**0.50**	**0.01**
	MJOB-G22	massive sulphide	**96.55**	**110.20**	**13.65**	**2.70**	**0.03**
		stockwork	117.85	127.85	10.00	3.56	0.10
	MJOB-G29	stockwork	132.75	142.85	10.10	1.16	0.05
Ghuzayn Body No.3	MJOB-G30	massive sulphide	**110.40**	**201.80**	**91.40**	**2.68**	**0.01**
		(high grade part)	114.40	126.40	12.00	7.71	0.01
	MJOB-G31	massive sulphide	**109.30**	**181.30**	**72.00**	**1.66**	**0.04**
		stockwork	181.30	213.25	31.95	0.27	0.01
	MJOB-G32	massive sulphide	**169.35**	**209.00**	**39.65**	**1.13**	**0.05**
	MJOB-G33	stockwork	223.20	230.95	7.75	0.70	0.04
		massive sulphide	**230.95**	**247.40**	**16.45**	**0.83**	**0.06**
	MJOB-G35	massive sulphide	**127.25**	**133.35**	**6.10**	**0.80**	**0.04**
	MJOB-G36	massive sulphide	**177.00**	**231.25**	**54.25**	**1.14**	**0.05**
	MJOB-G37	massive sulphide	**255.05**	**259.15**	**4.10**	**1.59**	**0.08**
	MJOB-G39	massive sulphide	**188.05**	**188.95**	**0.90**	**0.84**	**0.09**
	MJOB-G40	massive sulphide	**141.95**	**199.05**	**57.10**	**2.10**	**0.05**
		stockwork	199.05	216.80	17.75	1.06	0.22
	MJOB-G44	massive sulphide	**277.10**	**280.00**	**2.90**	**0.79**	**0.02**

gossan found only weak silicification and mineralization.

In Hara Kilab area, drilling survey was carried out by drilling 2 boreholes on TEM anomaly zones. The intense mineralization recognized in V1-2 in each borehole consisted mainly of pyrite dissemination and veinlets with intense silicification and argillization.

In Sarami area, as a result of the two drillings conducted on remarkable TEM zones, it became clear that intense pyrite mineralization and veinlets are developed in basaltic dykes and in V1-2.

In other areas, the results of drilling survey in the areas of Zuha, Maqail, Daris, and Doqal detected mainly strong pyritization and silicification, pyrite disseminations as well as alteration in V1-1, but no massive sulphide ore was detected.

4-4 Preliminary Evaluation of Ghuzayn Deposit

Table I-4-2 shows a comparison of preliminary results of the 3 ore bodies intersected by drilling in Ghuzayn area. This table shows only a preliminary estimation of massive ore, however, stockwork ore was not taken into consideration because the extension of the stockwork distribution is narrow and the information is not enough at the present time.

Table I-4-2 Comparison of ore bodies in Ghuzayn area

(Cut off grade: 0.5% x 4m)

Ore Body Name	Ore Body No.1	Ore Body No.2	Ore Body No.3
Geologic ore reserves (t)	180,000	5,000,000	8,650,000
Average Cu grade (%)	3.0	1.2	1.5
Average Au grade (g/t)	0.1	0.1	0.1
Average thickness (m)	6	20	33
Areal extension (m^2)	9,000	73,000	74,000

(Cut off grade: 1.0% x 4m)

Ore Body Name	Ore Body No.1	Ore Body No.2	Ore Body No.3
Geologic ore reserves (t)	180,000	3,600,000	7,430,000
Average Cu grade (%)	3.0	1.4	1.6
Average Au grade (g/t)	0.1	0.1	0.1
Average thickness (m)	6	22	46
Areal extension (m^2)	9,000	47,000	47,000

As seen in Table I-4-2, a total reserve of 14 million tons for the ore bodies No.2 and No.3 can be inferred as a result of the exploration studies. However, if mine development takes place only for them, several difficulties are likely to be faced. Main economical reasons to be cited are:

a) The ore body is at a depth of 100m and the waste ratio for open pit is as high as 6 to 7.

b) Considering the mining cost, the grade of 1.4%Cu is low and the gold grade is very low.

c) The scale of the ore reserve is small and the mining operation is limited to a maximum of 3000t/day.

To make feasible the development, it is therefore important to discover a new ore body to develop together with the ore bodies No.2 and No.3. Additionally the new ore body should be found at a depth nor less than 100m and with a gold content of at least 0.5g/t. If these conditions are not met, the scale of the new deposit should have at least a double scale of the already estimated. However and to be on the realistic side, to discover a new ore body with the above mentioned economical requirements in Ghuzayn and its surroundings presents very low possibilities according to the results of this project.

Now the government of Oman is discussing about the promotion of exploration of new areas and the development of Rakah deposit. There are some potential areas that remain yet unexplored, such as areas in Rakah, Sohar old mines or other areas surroundings of the Oman Mountains. From this point of view, it seems necessary to think about resource evaluation and development in a global view and within a whole strategy for the entire country of Oman. For instance, a marginal deposit may become feasible if the totality of its initial costs and operation costs are decreased by developing the deposit together with the mine development of another area, thereby enlarging the scale of the operation and minimizing the common expenditures.

About Ghuzayn deposit only the first exploration has been finished and therefore studies towards the mine development will be a task for the future. As a conclusion of the above discussion, the economical evaluation of Ghuzayn deposit must be considered together with the mine development in Rakah and Hayl as Safil deposits in Yanqul area.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5-1 Conclusions

During the Cooperative Mineral Exploration in the South Batinah Coast that lasted 3 years from 1997 to 1999, the results obtained from the geological, geophysical and drilling surveys can be summarized as conclusions as follows:

(1) Ghuzayn area

The third massive sulphide deposit was discovered in Ghuzayn (ore body No. 3) and its preliminary results shows an ore reserve of about 8.6 million tons with an average Cu grade of 1.5%. The best scale and grade was intercepted in the drilling MJOB-G30, which presented a core length and copper grade of 91.4m and 2.68%, respectively. And from all the results obtained so far, it can be estimated that the total reserve of the three bodies is probably around 14 million tons with an average Cu grade of 1.4%.

(2) Other areas

Not only in Ghuzayn area but also in South Batinah Coast, mineralization was detected in several places, but the existence of massive sulphide deposits that has economical meaning is limited to Ghuzayn area.

(3) Importance of the methodology

In exploration for copper deposits in Oman, ground geophysics plays an important part in the exploration because of wide coverage of the Quaternary sediments in the area. For the exploration of massive sulphide deposits of Cyprus-type in the Cooperative Mineral Exploration project in Central Batinah Coast area, it was confirmed the effectiveness of a systematic methodology to carry out the geophysical methods, i.e., the first step is to carry out TDIP to clarify the mineralized zones, and as a second step, TEM geophysical method is utilized as a suitable method to extract possible ore bodies from the mineralized zone.

(4) Further exploration studies

In Ghuzayn as well as in other areas around the Oman Mountains, many exploration works have been already carried out mostly near the known mineral occurrences. However these works were only limited to the vicinity of mineralization zones with surface indications and if the whole area is taken into consideration, it is reasonable to think that only very limited portions were merely explored. Therefore, it is likely that massive sulphide deposits of the Cyprus type remain yet undiscovered in Oman.

5-2 Recommendations

To obtain a more realistic economical evaluation of the reserve it is recommended to carry out a more detailed exploration and precise evaluation because from the 3 ore bodies detected in Ghuzayn, a preliminary estimation of the reserve resulted in about 14 million tons. However, it seems rather risky to develop this area in an independent manner because the deposit in Ghuzayn is relatively deep and not accompanied by gold. To develop this deposit in a more efficient way, it is recommended to carry out an economical evaluation together with the existing deposit in Yanqul area, where only a part of the gossan has been developed.

It is also recommended to continue the exploration studies to find new ore deposits in potential areas yet to be studied, such as around Rakah area, old mines of Sohar and other areas around the Oman Mountains.