NO. 23

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

(PHASE II)

MARCH 1999

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).

JICA and MMAJ sent to Oman a survey team headed by Mr. Yoshiaki Shibata from September 24th, 1998 to January 27th, 1999.

The team exchanged views with the officials concerned of the Government of Oman and conducted a field survey in the South Batinah Coast area. After the team returned to Japan, further studies were made and present report has been prepared. This report includes the survey results of geological, geophysical and drilling surveys carried out during Phase II.

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, 1999

Kimio Fujita
President
Japan International Cooperation Agency

Hiroaki Hiyama
President
Metal Mining Agency of Japan

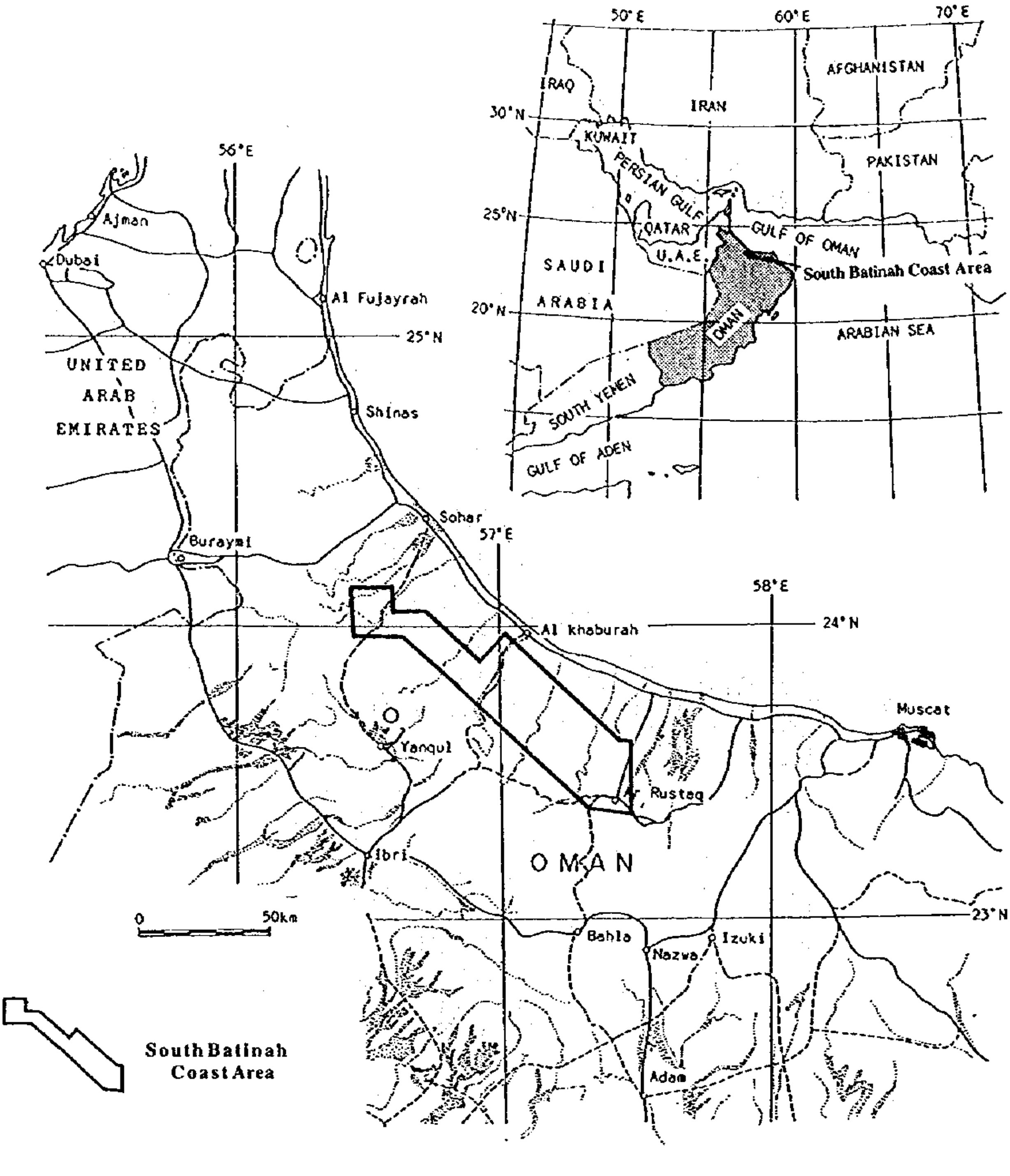

Fig.1 Location map of the South Batinah Coast area

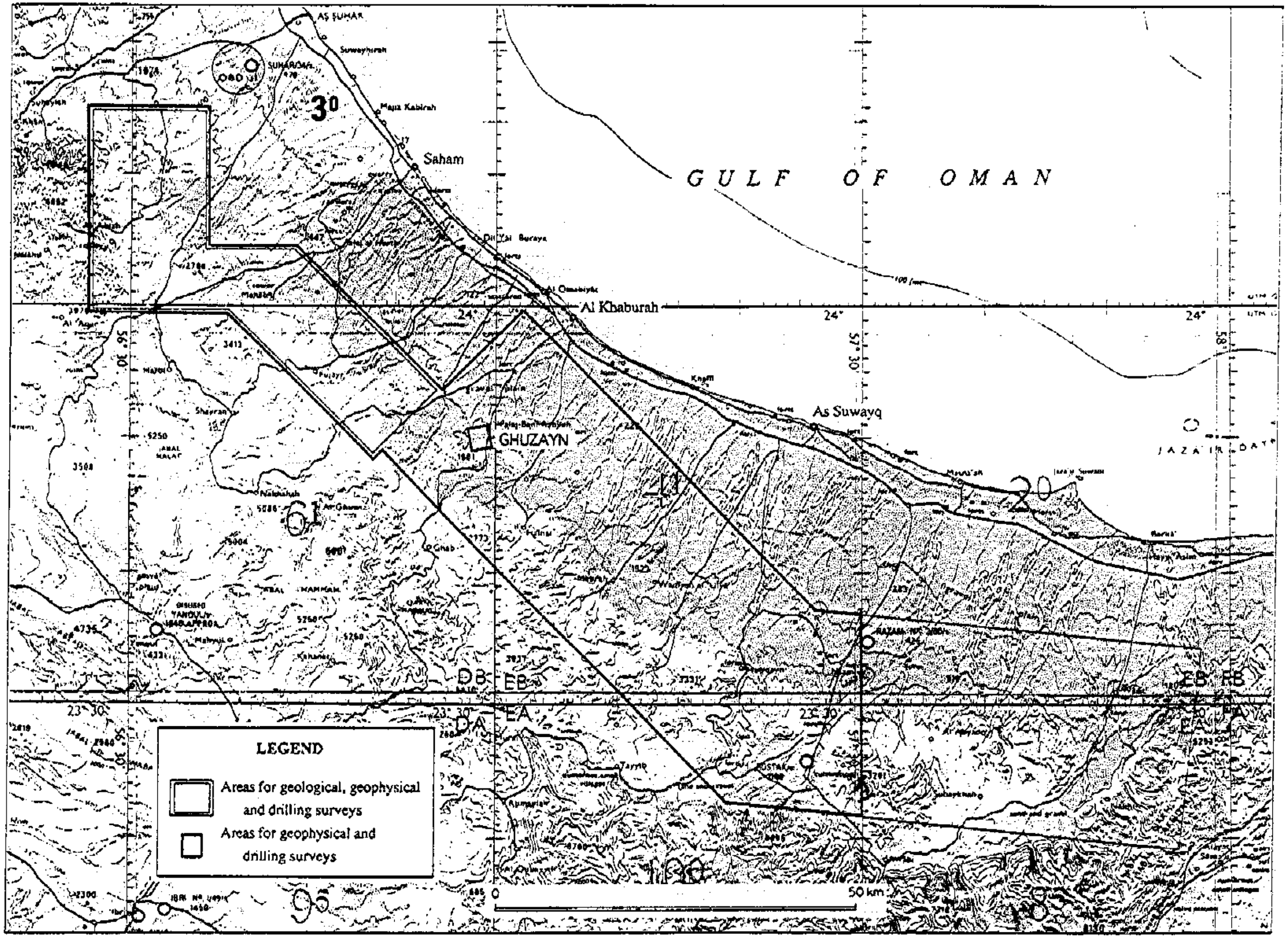

Fig.2 Location map of the survey areas

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. The Scope of Work for this project was signed by both governments on 17th July 1997. The objective of this project is to explore and assess the mineral potential of the survey area. This report includes the survey results of the second year (Phase II).

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 mineralization zones with surface indications and in view of the whole area, very limited portions were merely explored.

The Cooperative Mineral Exploration Project conducted previously during 1995 and 1996 in the Central Batinah Coast area, 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.

As a continuation of the above mentioned works, the Cooperative Mineral Exploration Project in the South Batinah Coast area started in 1997 and as a result, a third ore body was discovered in Ghuzayn area (ore body No. 3).

During the Phase II of the present project and based on the recommendations of the Phase I results, it was decided to carry out geophysical and drilling surveys in Ghuzayn on the basis of the previous results. Geophysical and geological surveys were also carried out in the areas of Sarami, Mahab, Hara Kilab and Maqail. Further drilling works were carried out in Sarami and Hara Kilab areas on the basis of the geophysical results. Geological survey was also carried out in Zuha area.

In relation to the results obtained in Ghuzayn area, the distribution of the ore body No. 3 was confirmed by the results of 6 drillings carried out, for which 4 of them intersected the ore body. From these results, it was confirmed that this ore body is likely to have a semi-ellipsoidal shape with a width of about 200m along the E-W direction and a length of about 250m along the N-S direction. The distribution of the ore body becomes thick in its central portion but gets abruptly thin in the marginal portion.

Among the 5 areas investigated by geophysical methods, the areas of Sarami and Hara Kilab detected promising anomaly results. To confirm these anomalies, 2 drillings were carried in each of the two areas of Sarami and Hara Kilab. In Sarami area, both of the drillings intersected extensive pyrite mineralization related probably to intrusion of basaltic dykes, while for the case of Hara Kilab, the drillings intersected intense pyritization consisting of disseminations and veinlets accompanied partly by chalcopyrite. Therefore, the drilling surveys in these two areas resulted in finding only weak copper mineralization and no massive sulphide. Besides the above-mentioned anomalies, remarkable IP chargeability anomalies were extracted in Maqail area and in the west part of Ghuzayn area. The geological survey carried out in Zuha area found out favorable conditions, such as copper mineralization seen around the large-scaled gossan, metalliferous sediments showing good continuity

and strong epidotization to expect the existence of massive sulphide deposits to the east of the gossan.

Based on the results obtained during the Phase II and in order to confirm favorable sites for the existence of massive sulphide deposits in the South Batinah Coast area, it is recommended for the Phase III of this project to carry out geophysical and drilling surveys in Maqail and Zuha areas, as well as in the surroundings of Ghuzayn area.

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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 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 but 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 search for an effective methodology to investigate in a systematic way, the underlying part of the sediments in this area.

The previous Cooperative Mineral Exploration was carried out in the Central Batinah Coast area from 1995 to 1997, finding that this area presents a high potential for bearing massive sulphide deposits. 2 ore bodies were discovered during that period.

On the other hand, the Cooperative Mineral Exploration in the South Batinah Coast area carried out during last year (Phase I) detected another massive sulphide orebody, the ore body No 3 in Ghuzayn area. This ore body was first intersected by the drilling MJOB-G30 for a core length of 91.4m and an average Cu assay of 2.68%.

From the results of these studies, it can be confirmed that Batinah Coast area presents a high possibility for the existence of massive sulphide ore for which it is necessary the continuation of these studies.

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 Figs. 1 and 2.

The massive sulphides 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 3 years in the Batinah Coast area, the following exploration indicators has been established:

(1) Massive sulphide deposits show stratigraphic control and occur in the contact between V1-1 and V1-2.

(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 magnetic layers with clear stratification and copper mineralization.

Since this area is widely covered by the 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 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.

Regarding ground geophysics used in the above mentioned methodology, the first step is to carry out TDIP in order 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. It is very effective if a program of small loops (50 by 50m) by TEM survey method is used before the drilling survey. Fig.I-1-1 illustrates the flow diagram of all the exploration methodology utilized in the searching of massive sulphide deposits in Batinah Coast.

Based on the results obtained during the surveys carried out in the first phase of the Cooperative Mineral Exploration in the South Batinah Coast area, the second phase was executed during this fiscal year by undertaking the following tasks:

Geophysical and drilling surveys in Ghuzayn area;

Geological and geophysical surveys in the areas of Sarami, Mahab, Hara Kilab and Maqail;

Drilling survey in Sarami and Hara Kilab areas based on the results of the geophysical survey; and

Geological survey in Zuha area.

Survey amounts of geophysics, drilling and geological survey, as well as laboratory studies are all indicated in Tables I-1-1 and I-1-2.

Flow for massive sulphide deposits exploration in Batinah Coast

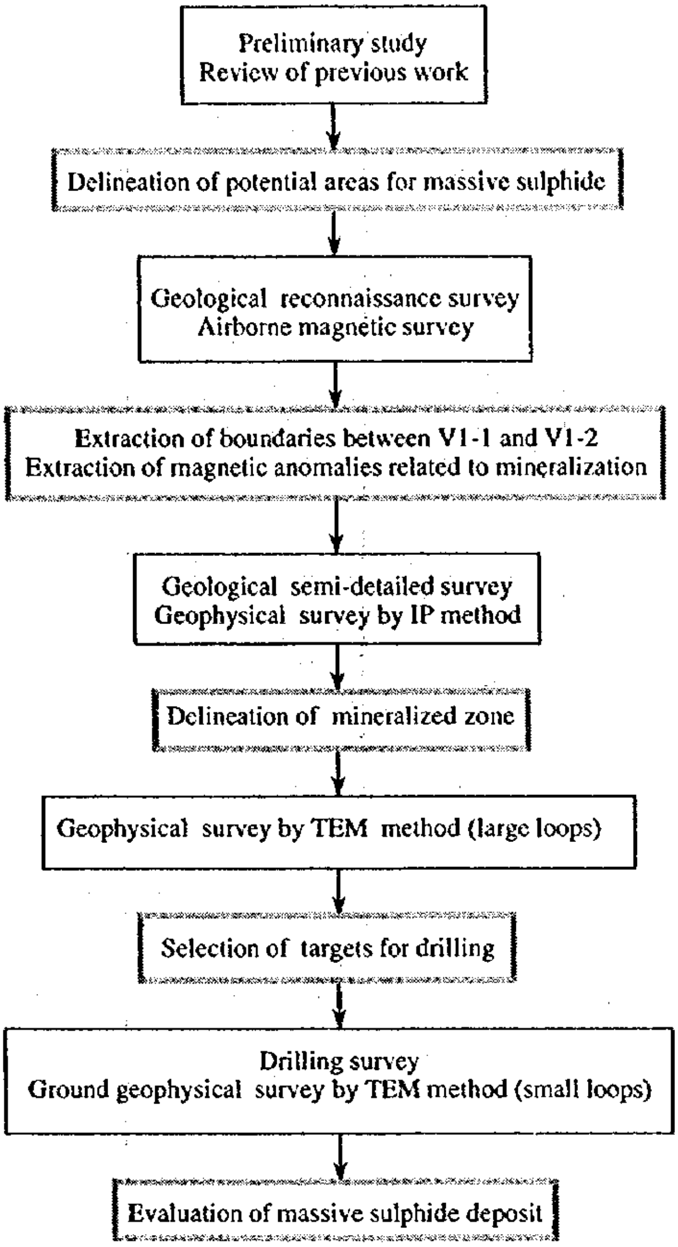


Fig. I-1-1 Flow for massive sulphide deposits exploration in Batinah Coast

Table I-1-1 Content and amount of work for Phase II

CONTENT AND AREA		AMOUNT OF WORK	
1. Geophysical Survey			
1) IP method		Total line length	Number of measurements
	Ghuzayn area	16.5 km	Total 4,484 points
	Mahab area	16 km	Total line length:
	Hara Kilab area	44 km	135.9 km
	Sarami area	44 km	
	Maqail area	15.4 km	
2) TEM method		Number of loops	Number of measurements
	Ghuzayn area	1 loops	Total 1,134 points
	Hara Kilab area	5 loops	Total length of loop:
	Sarami area	8 loops	33.6 km
3) IP tomography method		Total line length	Number of measurements
	Ghuzayn area	2.88 km	2,259 points
2. Drilling Survey		Total length	Grand total length
	Ghuzayn area	1,474.15 m	2,580.40 m
	Hara Kilab area	602.00 m	
	Sarami area	504.25 m	
3. Geological Survey		Survey route	
		54 km	

Table I-1-2 Laboratory work in Phase II

LABORATORY WORK	AMOUNT
1. Geophysical Survey	
1) Resistivity and polarizability measurement	33 samples
2. Drilling Survey	
1) Thin section	14 samples
2) Polished Section	13 samples
3) X-ray diffraction analysis	14 samples
4) Chemical analysis	
ore assay (6 elements: Fe,Cu,Zn,Ag,Au,Pb)	149 samples
3. Geological Survey	
1) Thin section	7 samples
2) X-ray diffraction analysis	7 samples
3) Chemical analysis	
ore assay (6 elements: Fe,Cu,Zn,Ag,Au,Pb)	23 samples

1-3 Members of the Project

The members of the project were as follows:

(1) Project planning and negotiation

Japanese Counterpart

Jiro Osako	Deputy Director General	Metal Mining Agency of Japan
Takashi Kamiki	Deputy Director	Metal Mining Agency of Japan

Omani Counterpart

Mohammed H. Kassim Al-Yafai	Director General	Ministry of Commerce and Industry
Salim Omer Abdullah Ibrahim	Director	Ministry of Commerce and Industry

(2) Inspection of field work

Hajime Hishida	Director	Metal Mining Agency of Japan
Noboru Fujii	Senior Geologist	Metal Mining Agency of Japan
Hiroyuki Katayama	Geophysicist	Metal Mining Agency of Japan

(3) Field work

Japanese Counterpart

Yoshiaki Shibata	Team leader	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.
Hidehiro Tachihara	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Hirohisa Horiuchi	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Junichi Sasaki	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Nobuhide Jomori	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Takeharu Takahashi	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.
Susumu Endo	Geophysical Survey	Mitsubishi Materials Natural Resources Development Corp.

Omani Counterpart

Salim Omer Abdullah Ibrahim	Director	Ministry of Commerce and Industry
Durair Ismail Ali A'Shaikh	Geologist	Ministry of Commerce and Industry
Saeed Bin Monsher Bin Atti Ba-lhaf	Mining Engineer	Ministry of Commerce and Industry

1-4 Survey Period

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

Project planning and negotiation:	September 25, 1998 to September 30, 1998
Inspection of fieldwork:	November 15, 1998 to December 4, 1998
	December 10, 1998 to December 23, 1998
Drilling survey:	September 28, 1998 to January 27, 1999
Geophysical survey:	October 1, 1998 to January 15, 1999
Geological survey:	September 28, 1998 to November 21, 1998

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 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.

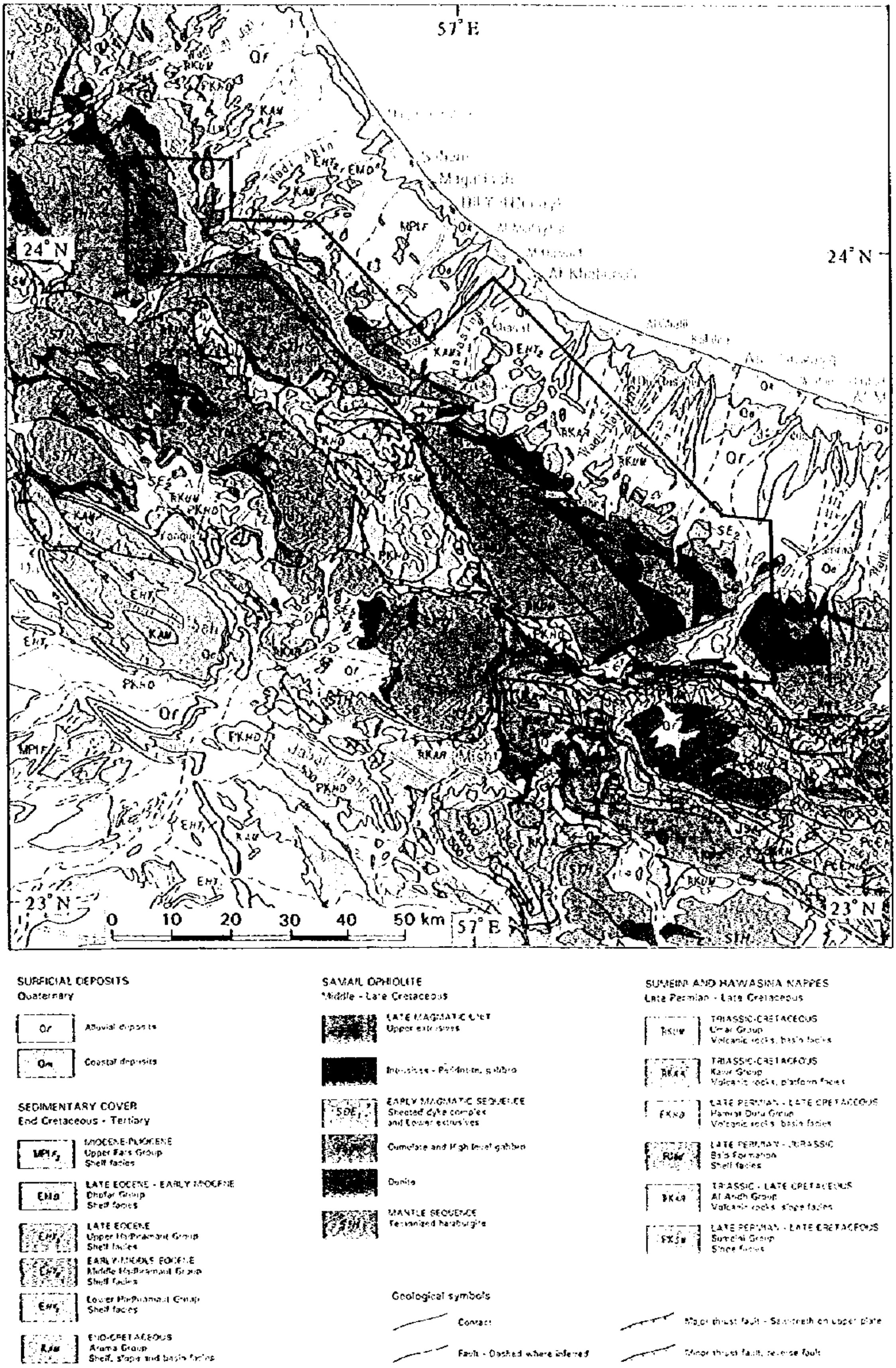
Samail Nappe is mostly composed of Ophiolite (Samail Ophiolite) and extensively distributed in the area. Succession of the Samail Ophiolite, is described as follows:

(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.

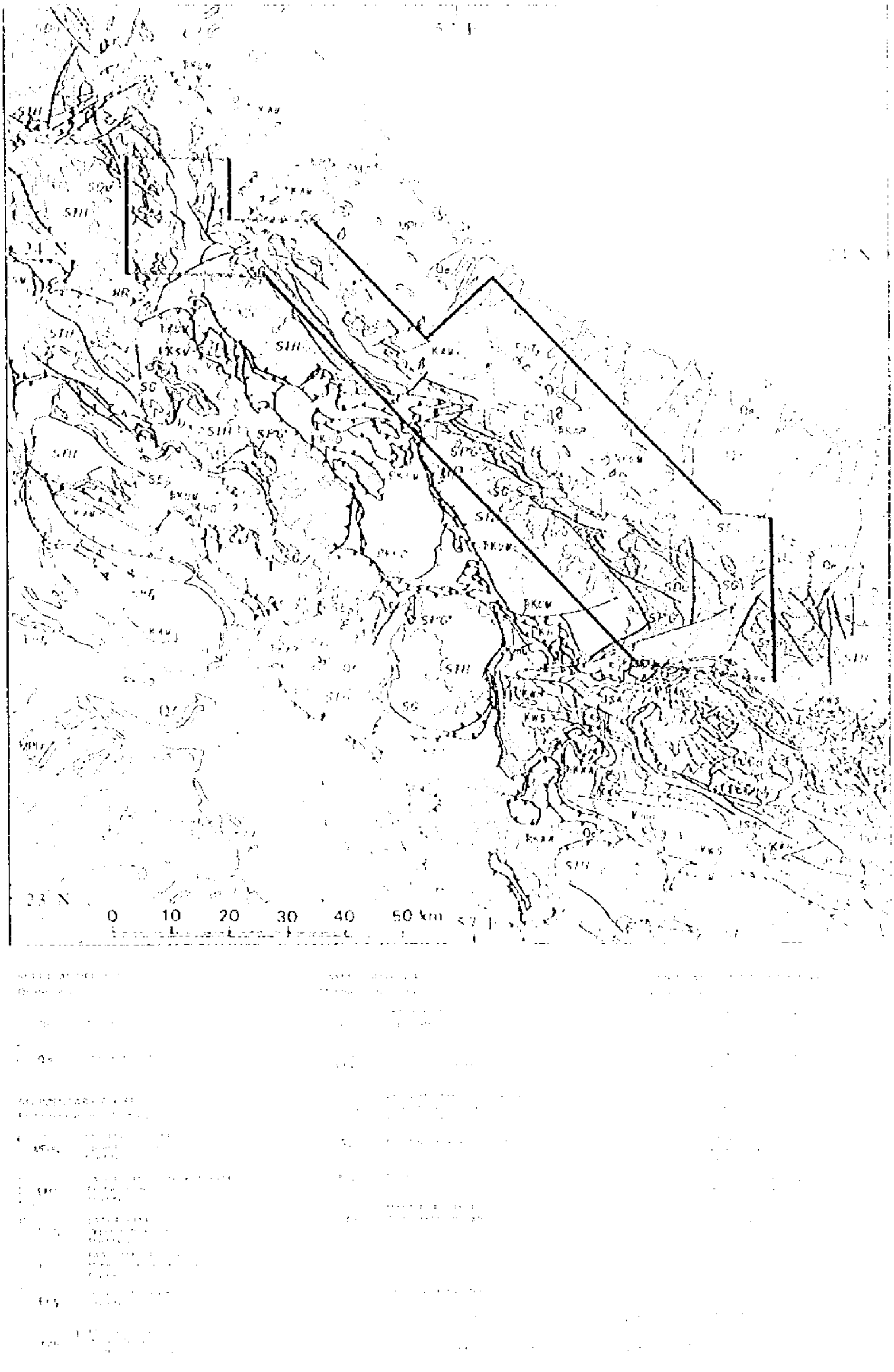
Quaternary sediments are comprised of fan deposits, terrace deposits and stream sediments, which are well exposed in the northern side of the area.

Principal geologic structure of the area consist 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



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, the Cyprus-type copper deposits are understood to be 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 orebody is situated in the lower part of the Samail Volcanic Rocks and occurs in the contact between V1-1 and V1-2 boundary.

(2) One side of the orebody 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 orebody 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

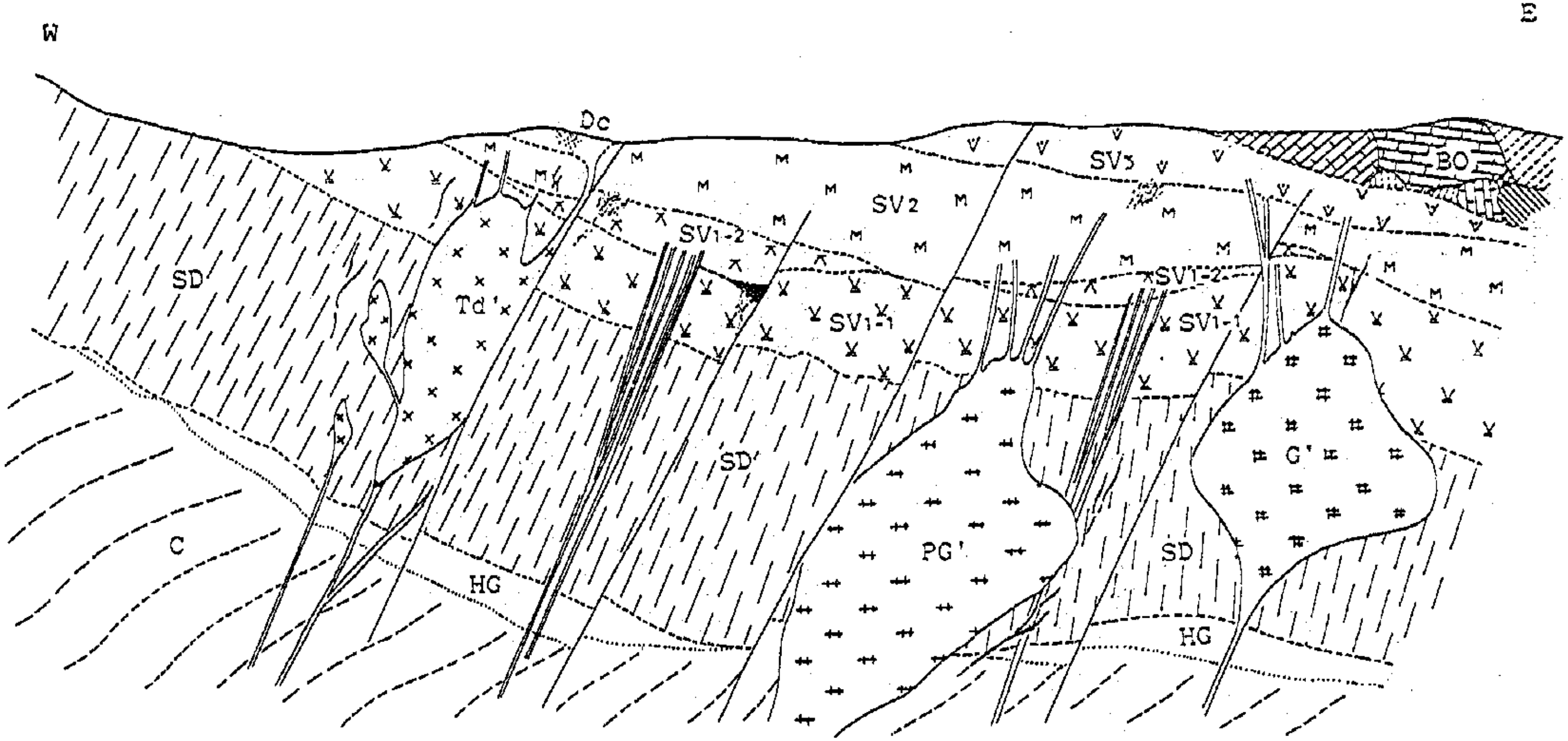
(1) Alteration due to mineralization consists of silicification, chloritization (Clinochlore) and epidotization.

(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



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 geologic model in Batinah Coast

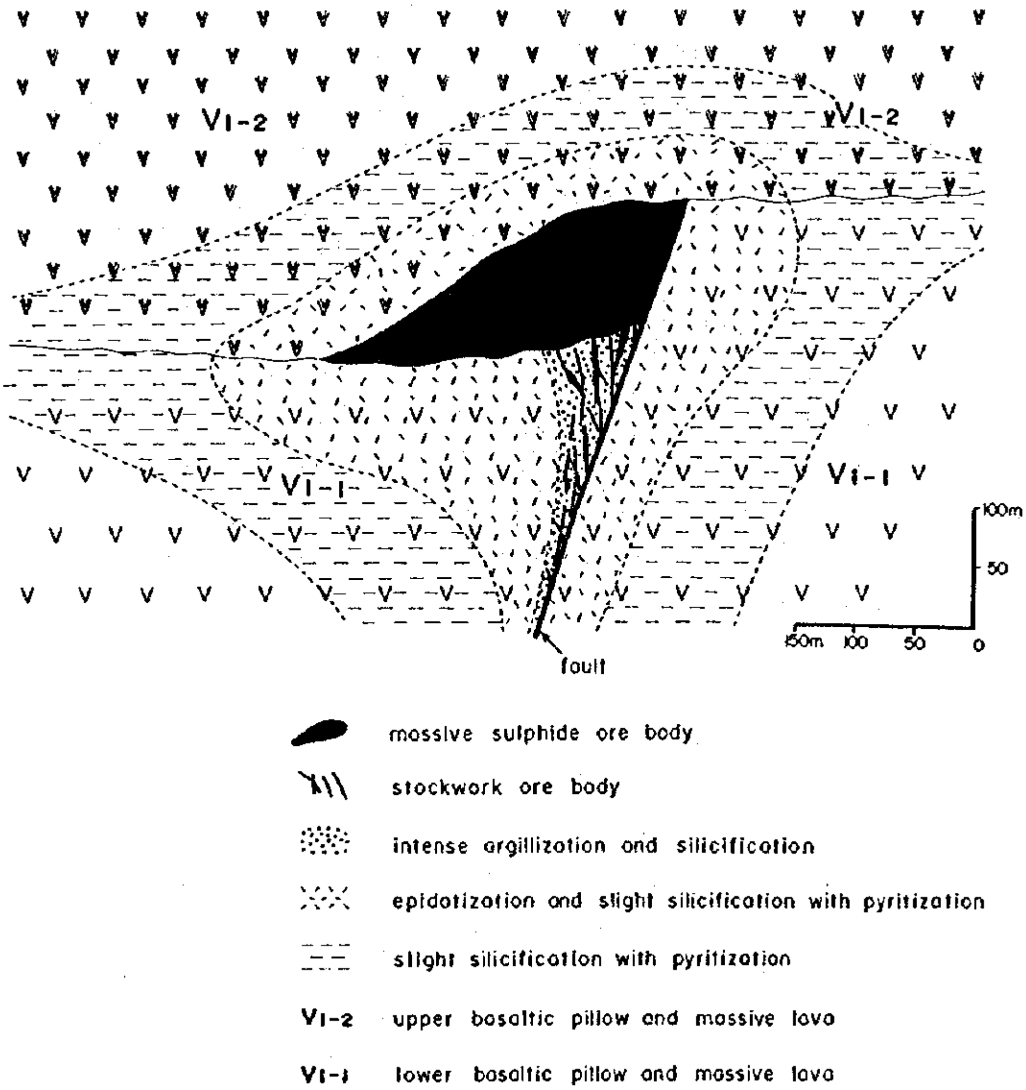


Fig. I -3-3 Schematic model of massive sulphide deposits in Ghuzayn area diamond drillings, confirming the existence of those deposits.

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 sq. 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 and a 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 and since 1995, the present cooperative project commenced by conducting mainly geophysical and drilling surveys.

CHAPTER 4 SURVEY RESULTS

4-1 Geological Survey

A geological survey was conducted in the areas of Sarami, Mahab, Hara Kilab and Maqail. The output of the geological survey served as a base for the delineation of the areas for the geophysical survey.

The results of the geological survey are as follow:

a) In Sarami area, two features can be emphasized: 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, the metalliferous sediments containing magnetite and copper oxides was found in one location. From the above mentioned field evidences, it can be suggested that the location around the silicified zone in the northern part represent the most promising place for further investigation.

b) In 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 is considered to have a high potential for the existence of massive sulphide deposits.

c) In Maqail area, a thick U1 with abundant magnetite is extensively exposed and accompanied with copper mineralization. These features 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.

d) In Mahab area, U1 contains abundant magnetite and a 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.

e) In Zuha area, Three features can be noted: 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 observed in V1-1 and U1 can be continuously traced for a long distance. These facts confirm a high potential for the existence of ore deposits in this area.

4-2 Geophysical Survey

High chargeability and low resistivity characterize the geoelectrical structure reflected by massive sulphide deposits. In these regards, the geophysical methods TDIP and TEM are quite effective for prospecting sulphide deposits.

The TDIP method is generally carried out along lines. This method has the advantage of measuring at the same time the two parameters of chargeability and resistivity, and as such, it is an effective method to delineate horizontally anomalous zones due to mineralization by covering a wide area by the survey lines spread on the area. On the other hand, the TEM method is sensitivity to the electrical response from the underground structure below the observed station, and therefore this method is useful define in more detail, conductive zones such as massive sulfide deposits.

For these reasons, we used the TDIP survey as a reconnaissance method, and TEM as a detailed method.

4-2-1 TDIP survey

TDIP survey was carried out in 5 areas: Ghuzayn, Sarami, Mahab, Hara Kilab and Maqail in order to extract mineralized zones related to the existence of massive sulphide deposits.

With reference to Ghuzayn area, remarkable high chargeability anomalies were extracted (A'Ruwydhat IP anomaly) about 1km northwest of orebody No.3, however interesting low resistivity values were not detected within this anomaly.

In relation to Sarami area, a wide area of extremely high chargeability anomaly (Omah IP anomaly No. 1) was extracted in the north part, while a high chargeability anomaly of small scale (Omah IP anomaly No. 2) was detected in the southern part. These anomalous zones are accompanied by rather low resistivity values and as a result, extremely high metal factor values are present in this zone.

In relation to Hara Kilab area, its central part show low resistivity anomalies accompanied by remarkable high chargeability values (Dhahwa IP anomaly), and consequently this zone shows high metal factor values.

In Maqail area, remarkable high chargeabilities are recognized in the central with continuation along N-S direction. However, within this anomalous zone, low resistivity anomalies were not detected.

In Maqail area, anomalies caused by mineralization were not recognized.

4-2-2 TEM survey

TDIP anomalies detected in the areas of Ghuzayn, Sarami and Hara Kilab were studied in more detail by the application of TEM survey, for which a total of 14 TEM loops were carried out.

In Ghuzayn area, within the zone covered by the A'Ruwydhat IP anomaly mentioned above, TEM survey was carried out. However, this survey did not delineate any promising anomaly.

In Sarami area, 8 TEM loops were carried out in two places located in the central and western part of the Omah IP anomaly No. 1 mentioned above. Two drillings conducted in the detected TEM anomalies intersected extensive pyrite mineralization probably related to intrusion of basaltic dykes.

In Hara Kilab area, 5 loops were carried in central part of Dhahwa IP anomaly. According to the results of the detected TEM anomalies, drilling survey was carried out which intersected intense pyritization in the V1-2 formation.

4-3 Drilling Survey

Drilling survey was carried out in 3 areas, namely, Ghuzayn area, Sarami area and Hara Kilab area

In Ghuzayn area, drilling survey was carried out by drilling 6 boreholes in order to investigate the distribution of ore body No.3. Massive sulphide ore was intersected in 4 boreholes (See Table I-4-1). It was inferred that the shape of ore body No.3 is like a semi-ellipsoidal body with an extension of 200m along the E-W direction and 250m along the N-S direction, and laterally decreasing in thickness. Geological reserves and its average copper grade calculated roughly by the result of 8 boreholes resulted in 8 millions tons and 1.4% respectively (See Fig.I-5-1).

In Sarami area, drilling survey was carried out by 2 boreholes drilled on TEM anomaly zones. It was clarified that intense pyrite dissemination and veinlets are developed in dikes and V1-2.

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

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

Ore Body Name	Bore Hole NO.	Type of Ore	Depth (m)		Thickness	Average Grade	
			from	to	(m)	Cu%	Zn(%)
	(Phase II: 1998)						
Ghuzayn Ore Body No.3	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**
	(Phase I: 1997)						
	MJOB-G30	massive sulphide	**110.40**	**201.80**	**91.40**	**2.68**	**0.01**
		massive sulphide (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**

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5-1 Conclusions

The survey results can be summarized per area as follows:

(1) Ghuzayn

The drilling results reveal that the dimensions of the ore body No.3 is likely to be 200m in width along the E-W direction and 250m in length along the N-S direction. The distribution of the ore body becomes thick in its central portion but gets abruptly thin in the marginal portion (Fig. I-5-1). According to 8 boreholes which intersected the ore body No. 3 in Phases I and II, the geological ore reserves are roughly estimated in 8 millions tons with an average assay of 1.4%Cu.

The IP anomaly detected in A'Ruwydhat, to the north of Ghuzayn area, was examined by a TEM method, however, the TEM survey did not delineate any promising anomaly. In spite of this, there exists the possibility for the existence of stockwork type ore, due not only to the high IP chargeability zone but also to the fact that silicified zone and quartz veinlets associated with copper oxides crops out.

(2) Sarami

Two anomaly zones, Omah No.1 and Omah No.2, were detected by IP survey. Among them, TEM anomalies were delineated in the central and western parts of the Omah No.1 IP anomaly zone.

Two drillings conducted in these TEM anomaly zones intersected extensive pyrite mineralization probably related to intrusion of basaltic dykes.

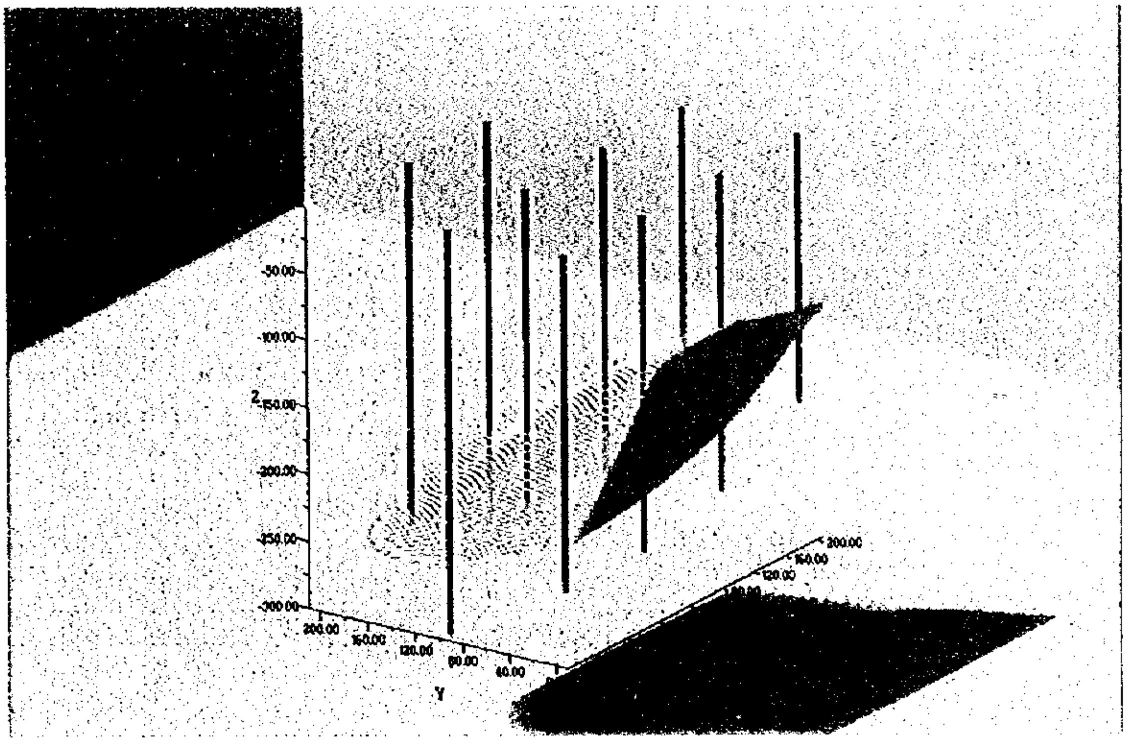
(3) Hara Kilab

Remarkable TEM anomalies were detected in the central part of IP anomalous zone. According to the results of the drilling survey sited on TEM anomalies, intense pyritization consisting of disseminations and veinlets and accompanied partly by chalcopyrite were found in V1-2 formation. This mineralization seems to have taken place at a stage later than the formation of massive sulphide deposits.

Another IP anomaly was detected at the south end of the survey area. The existence of massive sulphide deposits is expected in the vicinity of this anomaly because of strong epidotization and copper mineralization observed at the surrounding.

(4) Maqail

A high chargeability zone with relatively high resistivity values was detected crossing the survey area in the N-S direction. The existence of massive sulphide deposits is expected judging from the IP results and the abundance of mineral showings on the surface.



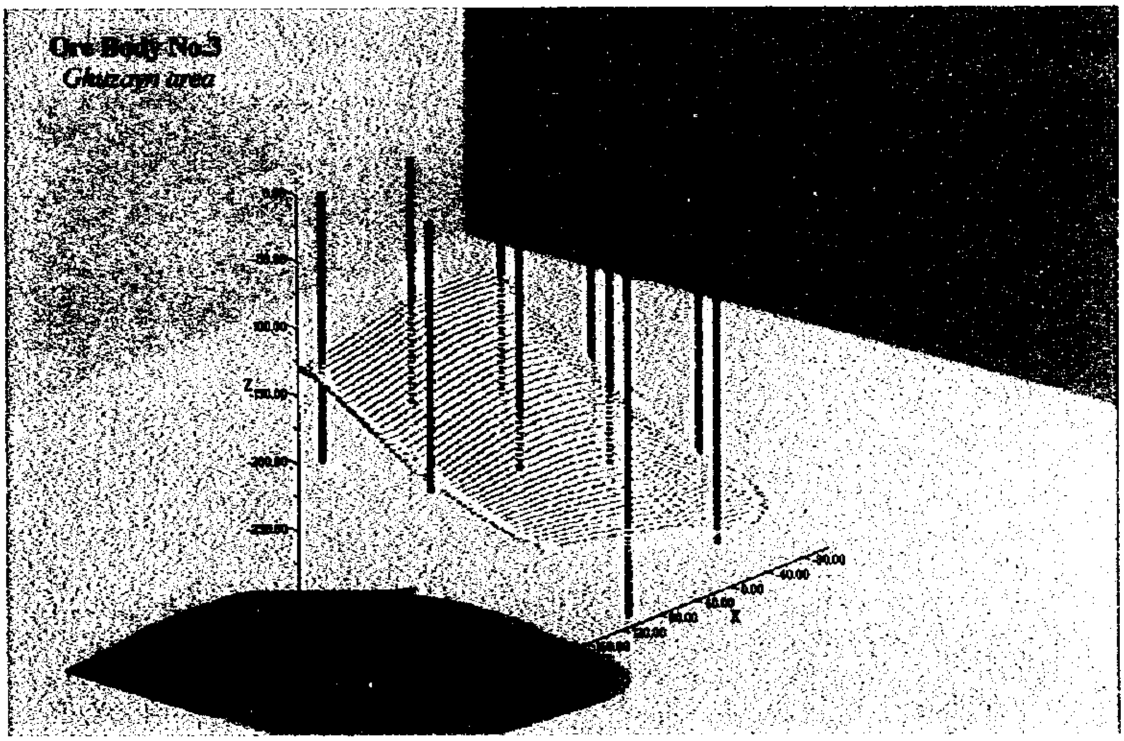
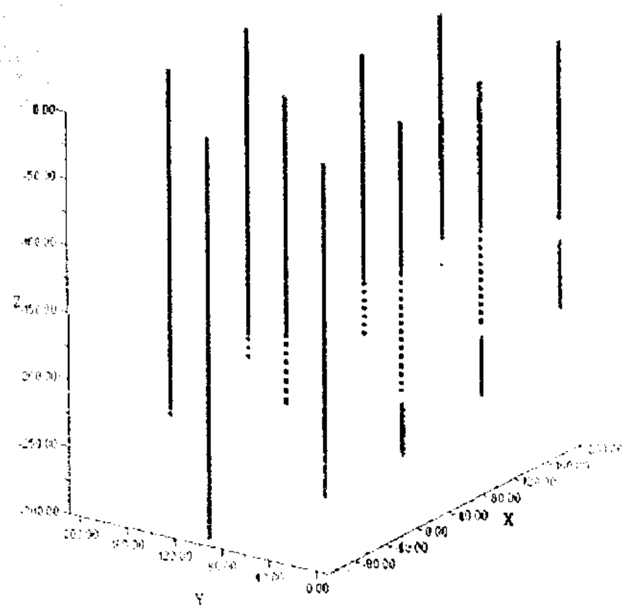
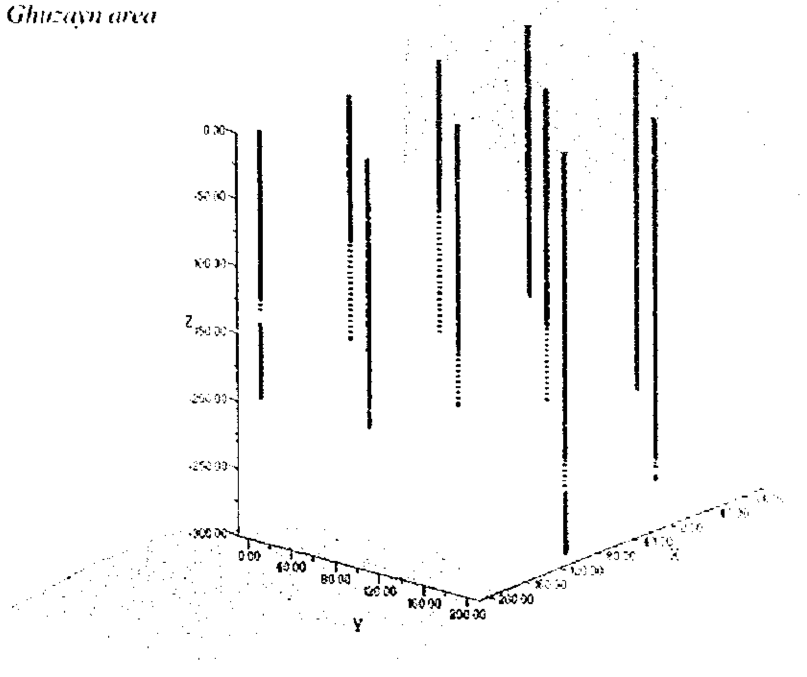


Fig. I -5-1 Schematic view of Ghuzayn Body No.3

Ore Body No.3
Ghuzayn area



Ore Body No.3
Ghuzayn area



[illegible]

(5) **Mahab**

No significant anomaly was detected by the geophysical survey in this area.

The possibility for the existence of massive sulphide deposits is extremely low.

(6) **Zuha**

A large-scaled gossan crops out and abundant copper oxides are distributed in this area. Strong epidotization was found in V1-1 formation and metalliferrous sediments are observed continuously distributed in this area. Judging from the above features, the potential for the existence of massive sulphide deposits seems to be high.

5-2 Recommendations

Further geophysical and drilling survey works are recommended in the following areas that present a high potential for massive sulphide deposits.

(1) **Ghuzayn**

Drilling survey around the ore body No.3 is recommended to clarify its distribution and determine its copper grade.

In A'Ruwydhat area, where a broad high chargeability anomaly zone was delineated, drilling survey is recommended in order to clarify the nature of this anomaly.

Further IP survey covering the east and west extension of the surveyed area is also recommended in order to search for additional massive sulphide deposits.

(2) **Hara Kilab**

Further IP survey is recommended to clarify the IP anomaly detected at the south end of the area.

(3) **Maqail**

Further IP survey is recommended to clarify the north and south extension of the high chargeability zone.

(4) **Zuha**

Drilling surveys previously conducted by Prospection Ltd. and by the Ministry of Petroleum & Minerals were concentrated in the vicinity of the gossan. The east area of this gossan, where the boundary of V1-1 and V1-2 dips eastwards and is covered by the extensive wadi sediments, still remains as a promising target area.

Geophysical exploration followed by drilling survey is recommended in order to discover massive sulphide deposits.

PART II SURVEY RESULTS

CHAPTER 1 GEOLOGICAL SURVEY

1-1 Objectives of the Survey

In Phase I, a 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: Sarami, Mahmum, Mahab3, Mahab4, Hara Kilab and Maqail South.

During this phase, geological survey was conducted in order to investigate in more detail the mineralization and evaluate the potential for the existence of massive sulphide deposits around the above mentioned areas including Zuha area.

According to the results obtained from the geological survey, five areas were selected for further IP survey.

1-2 Survey Areas and Method

As shown in Fig.II-1-1, geological survey was conducted in the following areas: Sarami, Mahab, Hara Kilab, Maqail and Zuha. Additional rock sampling was conducted in Ghuzayn area.

Geological route maps were made at a scale of 10,000 by using topographic maps (1:50,000 to 1:100,000) and aerial photographs (1:20,000). Landsat images as well as existing data were also utilized during the analysis of the survey data. The survey results were compiled in a map at a scale of 1:20,000.

1-3 Geological Survey Indicators

Based on the geology and the mineralization studied in and around the massive sulphide deposits confirmed in Ghuzayn area, some exploration indicators have been found useful for future exploration works. These indicators can be briefly described as follows:

(1) Massive sulphide deposits show stratigraphic control and occur in the contact between the Lower extrusive rocks (V1-1) and the Upper extrusive rocks (V1-2) of Lower Volcanics Rocks of Samail Ophiolite.

(2) The alteration associated with mineralization consists of silicification, chloritization (Mg-rich chlorite) and epidotization.

(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 in the case that the sediments contain magnetite layers with clear stratification and copper mineralization.

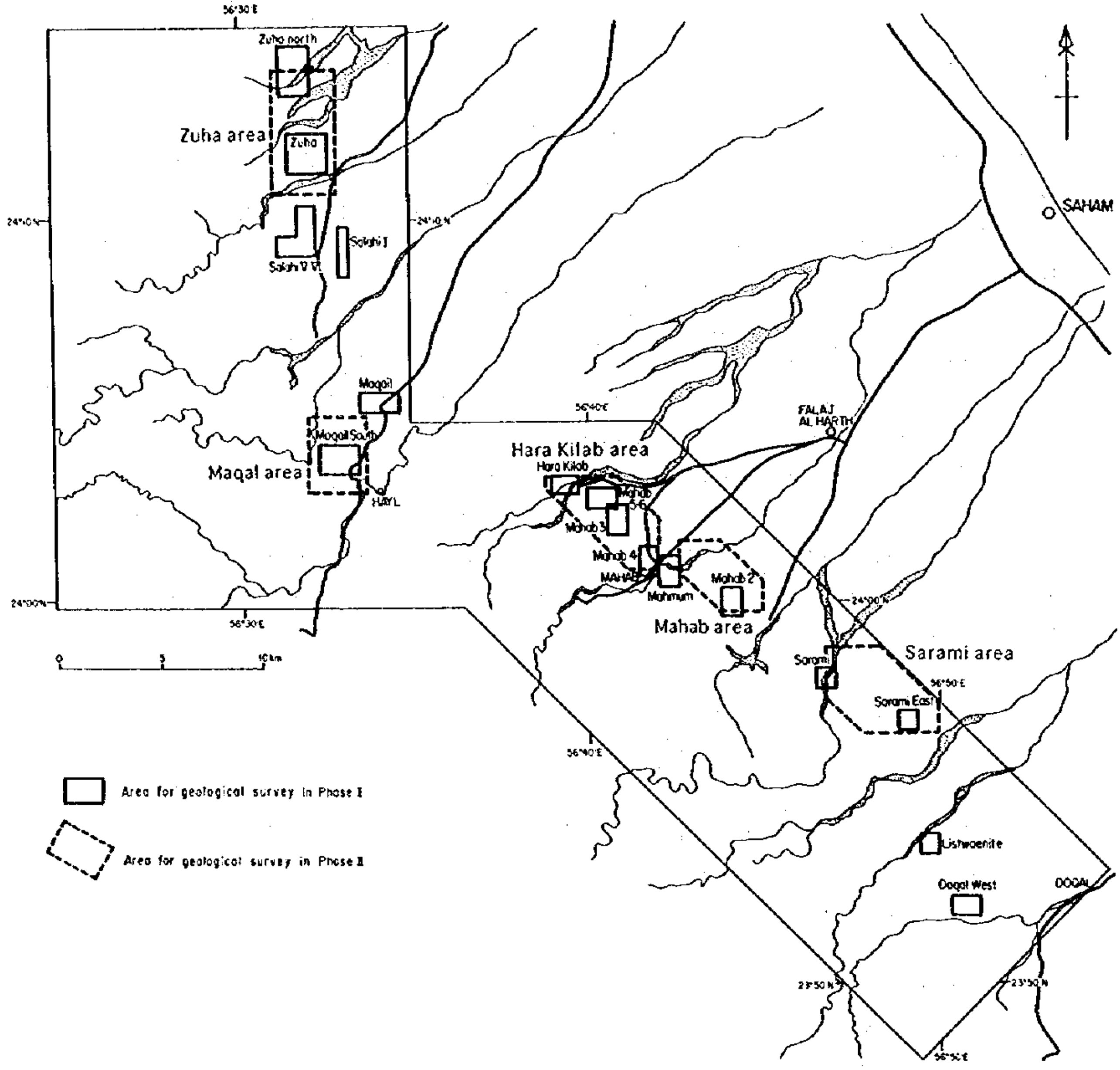


Fig. II-1-1 Location map of geological survey area

1-4 Results

1-4-1 Outline of geology

The general stratigraphy of the area is shown in Fig.II-1-2. The geology of the project area is mainly composed of Samail Ophiolite, Supra-ophiolite Sediments, Tertiary and Quaternary sediments.

The Samail Ophiolite in the surveyed area consists of Cumulate Gabbro (CG), Sheeted-dyke Complex (SD), Samail Volcanic Rocks (SV) and Intrusive Rocks (I')

(1) Cumulate Gabbro (CG)

Cumulate Gabbro appears at the top of the cumulate sequence, separating it from the Sheeted-dyke Complex. It is an equigranular hornblende gabbro with variable grain size.

(2) Sheeted-dyke Complex (SD)

In outcrops, the Sheeted-dyke Complex appears as a set of sub-parallel dykes of 0.5 to 3m wide whose composition ranges from microgabbroic to doleritic. The Sheeted-dyke Complex grades upward into the Lower Volcanic Rocks.

(3) Samail Volcanic Rocks (SV)

The Samail Volcanic Rocks were divided into three members that consist of Lower Volcanic Rocks (SV1), Middle Volcanic Rocks (SV2) and Upper Volcanic Rocks (SV3).

(a) Lower Volcanic Rocks (SV1)

The Lower Volcanic Rocks consist of Lower extrusives rocks (V1-1), Upper extrusives rocks (V1-2) and metalliferous sediments (U1).

V1-1 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. V1-1 also consists of reddish brown to grey colored massive lava, hyaloclastite and pillow breccia. Characteristically, the pillow lava is aphanitic and accompanied with thick interpillows of 5cm to 40cm in thickness. The massive lava shows grey to brownish grey color with a thickness of several tenth centimeters to several meters. Columnar joints are developed in the thick massive lava.

V1-2 consists of primitive basalt lava composed mainly of pillow lava accompanied with massive lava. The pillow lava shows light grey to purplish grey in color with pillow sizes mainly of 10cm to 1m in diameter and 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 V1-1 is accompanied with thin interpillows of 1cm to 5cm in thickness. The upper part of V1-2 includes pillow lavas with radial joints.

U1 is the so-called umber that includes many radiolarias and predominant in iron oxides. This unit shows dark brown color.

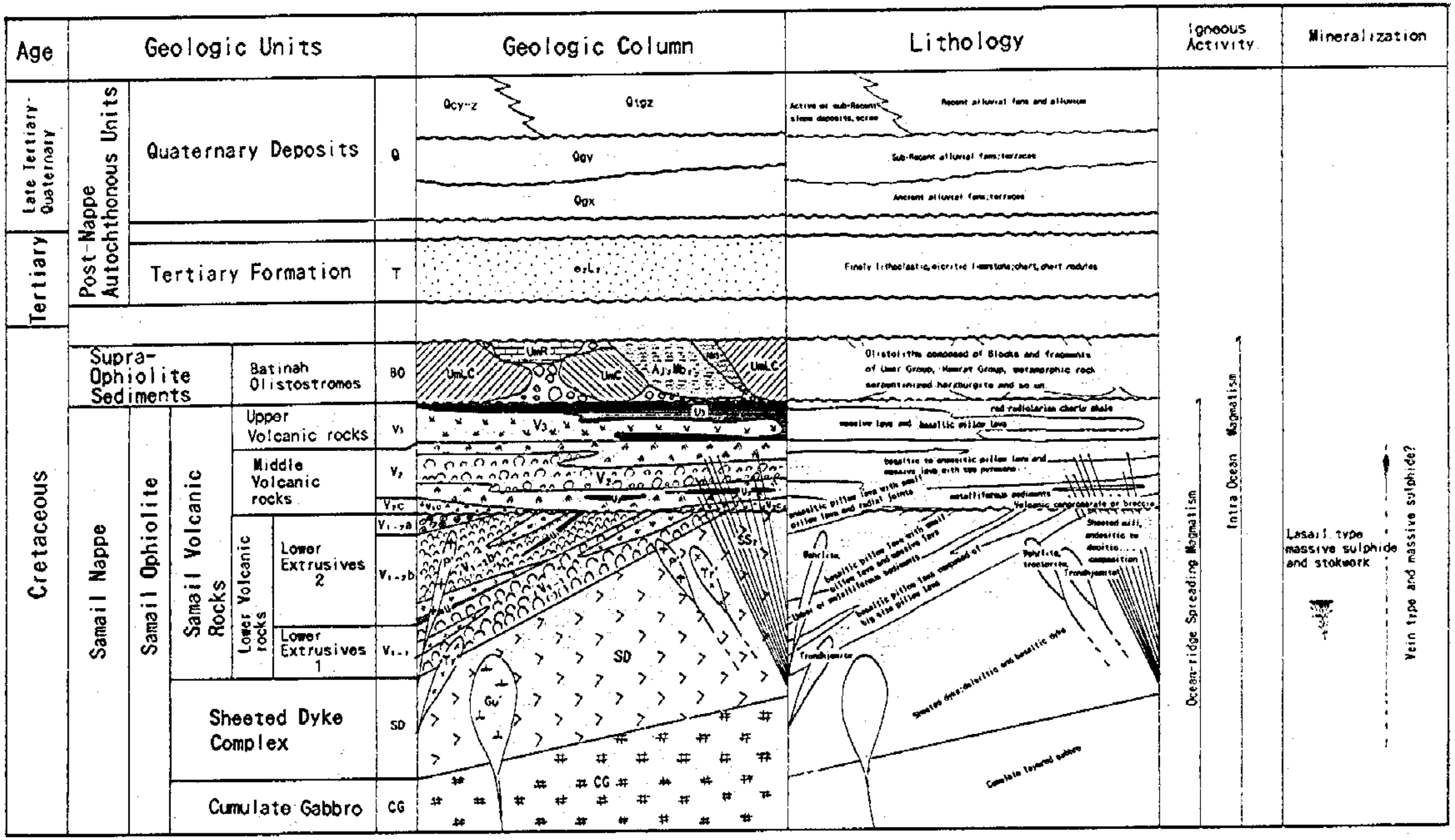


Fig. II-1-2 Stratigraphic columnar section of survey area

(b) Middle Volcanic Rocks (SV2)

The Middle Volcanic Rocks (SV2) consist of volcanic conglomerates and breccia (V2c), extrusives rocks (V2) and metalliferous sediments (U2).

V2c consists of angular to rounded matrices of sand to gravels and of fragments and blocks of Sheeted dykes and Lower Volcanic Rocks.

V2 consists mainly of pillow lavas and massive lavas of andesite containing clinopyroxene and orthopyroxene. Most of the lavas are massive. The weathered surface shows various colors of grey, brownish grey, green, bluish grey and orange color. In general the massive lava shows a doleritic texture. The pillow lavas show purple, green and greenish grey colors. Most of the pillow lavas present irregular pillow shapes with diameters of about 0.5 to 1.0m.

U2 are the so-called umber and contains more radiolarias but fewer amounts of iron oxides than U1. This unit shows brownish black color.

(c) Upper Volcanic Rocks (SV3)

The Upper Volcanic Rocks consist mainly of extrusives rocks (V3) and metalliferous sediments (U3).

V3 is composed of doleritic massive lava (sheet flow) and pillow lava. Massive lava of V3 shows a light greenish grey color and forms a columnar joint in many places. The sheet flow of this massive lava reaches 170m in maximum thickness as one unit. Pillow lava of V3 can be seen in the lowermost, middle and uppermost of SV3, showing in general a dark greenish color. The size of pillows range mostly between 0.6m to 1.2m in diameter.

U3 is interbedded in the uppermost and middle parts of SV3. It is mainly composed of reddish brown sediments predominant in iron materials and accompanied with pinkish shale and jasper.

(4) Intrusive Rocks (I')

The Intrusive Rocks include peridotite (P'), gabbro (Gu'), trondhjemite (Tr') and late dolerite dykes. Peridotite (P') consists of wehrlite, troctolite, plagioclase-bearing dunite and olivine-bearing pyroxenite. Gabbro (Gu') is associated with diorite and quartz diorite. Trondhjemite (Tr') also includes quartz diorite in parts. Late dolerite dykes are accompanied with fine-grained gabbro.

(5) Supra-ophiolite Sediments (Batinah Olistostrome)

The sediments (BO) consist of olistoliths of sedimentary formations formed in Tethys Sea. Olistoliths, which came as result of the obduction process at the same time when Tethys Sea closed, are composed of sedimentary and igneous rocks of Triassic to Cretaceous age.

(6) Post-nappe autochthonous units

These units consist of Tertiary and Quaternary sediments. The Tertiary sediments consist of yellow marl with large foraminifera (e2M1), upper nodular limestone (e2L2) and sedimentary breccia (Br) of late Paleocene to early Eocene. The Quaternary deposits consist of ancient alluvial fans (Qgx), sub-

Recent alluvial fans (Qgy), active or sub-Recent slope deposits (Qcy-z), Khagra depressions with Recent or sub-Recent clay and silt (Qky-z), eolian sand of Recent or sub-Recent dunes (Qdy-z), coating of sub-Recent dunes (Qsy-z) and Recent alluvial fans and alluvium (Qtgz).

1-4-2 Outline of geological structure

Main structure in the South Batinah Coast area is the pile-up structure formed when allochthonous Samail Ophiolite and Supra-ophiolite sediments had been thrust over the Arabian shield at the late Cretaceous age. The Tertiary and Quaternary sediments of the post-nappe autochthonous units unconformably overlie the allochthonous units in the South Batinah Coast area. Many thrust faults are developed in the area that formed contacts of piled-up blocks originated before Tertiary and sliced the autochthonous and allochthonous blocks. High-angle faults developed in the area cut each of the above blocks and displaced the geological boundaries. These faults were formed before Tertiary.

1-4-3 Geology and mineralization of surveyed areas

Geological maps for every surveyed area in this phase are indicated in Figs.II-1-3 to I-1-5 and Figs.II-1-7 to I-1-9.

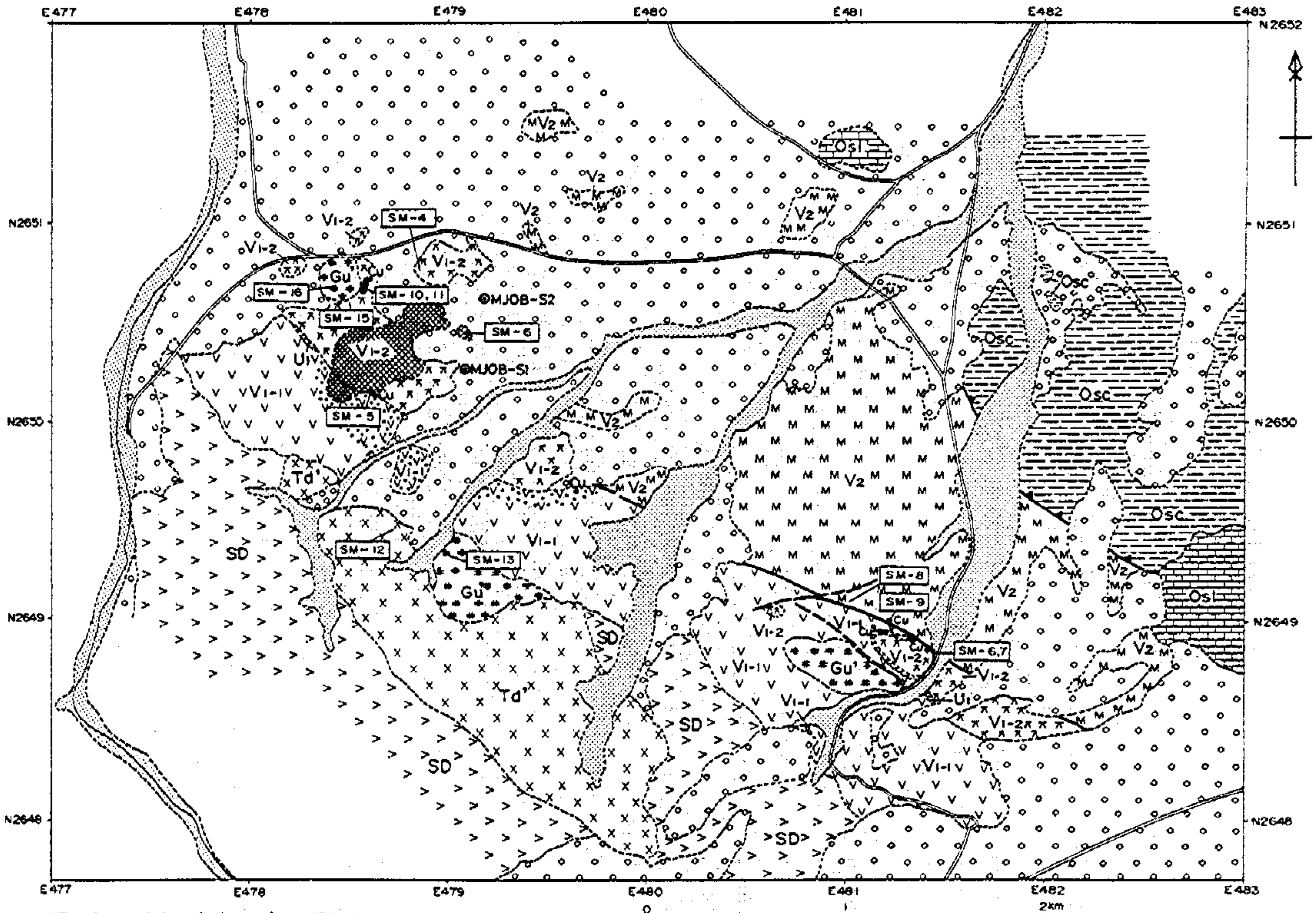
(1) Sarami area

Sarami area is located about 20km SSE of Saham City. As shown in Fig.II-1-3, the geology of this area consists mainly of V1-1, V1-2, U1, V2, Batinah Olistostrome and Quaternary sediments. Gabbro is also found along the boundary between V1-1 and V1-2.

V1-2 crops out in the northern part covering V1-1. In the southern part, however, V1-1 presents a direct contact with V2 through a fault trending NW-SE, while V1-2 is distributed within the limits of the west part of this fault. U1 shows a thickness of about 5 to 30cm, which is siliceous with abundant iron oxides in the northern part and pelitic in the southern part. Massive lava of a thickness of about 10m outcrops over U1 in the southern part. From the structural point of view, V1-2 and U1 in Sarami area strikes N45°W and dips 20°NE.

Silicified zone of V1-2 spreads out in the northwestern part, where many basalt dikes intruded into V1-2 and small-scaled vein-like gossans are distributed parallel to these dikes in many places. Copper mineralization is locally observed in the above mentioned gossans which can also be seen in small-scaled gossans in some places of V1-1 and in U1 with abundant magnetite in the northwestern part. In the southern part, a silicified zone of 2 to 3m in width accompanied by many quartz veinlets and copper oxides is found along a NW-SE trending fault in which V1-1 and V2 indicate a direct contact.

Sampling for chemical analysis for copper and gold was carried out around the above mentioned gossans and silicified zones, in the locations indicated in Fig.II-1-3. The following results were obtained:



(For Legend description refer to Fig. II-1-4.)

Fig. II-1-3 Geologic map of Sarami area

SM-4 : Cu: 0.57%, Au:<0.01g/t: Vein-like gossan in silicified V1-2

SM-5 : Cu: 0.76%, Au: 0.01g/t: Vein-like gossan in silicified V1-2

SM-6 : Cu: 0.21%, Au:<0.01g/t: Vein-like gossan in silicified V1-2

SM-7 : Cu: 2.11%, Au:<0.01g/t: Silicified zone with copper oxides

SM-8 : Cu: 0.04%, Au: 0.42g/t: Small-scaled gossan in V1-1

SM-9 : Cu: 1.54%, Au: 0.06g/t: Silicified zone with Cu oxides (at the extension of SM-7)

SM-10 : Cu: 0.06%, Au: 0.05g/t : Vein-like gossan in silicified zone in V1-2

SM-11 : Cu: 0.07%, Au: 0.07g/t: Vein-like gossan in silicified zone in V1-2.

Epidotization can be seen in V1-1 along the boundary between V1-1 and V1-3. The intensity of epidotization is weak in most of the areas, however it becomes strong in the vicinity of the silicified zone in the northwestern part.

(2) Mahab Area

Mahab area is located about 25km southwest of Saham City and about 4km east of Mahab village.

As indicated in Fig. II-1-4, the geology of the area consists mainly of SD, V1-1, V1-2, U1 and Quaternary sediments. Gabbro is also found exposed in SD along NW-SE trending fault that is almost parallel to the strikes measured on dikes and U1; while in the northern part, an E-W trending fault with a large displacement runs along Wadi Mahmum. Because of these two fault systems, V1-2 is distributed within the limits of this area. On the other hand, U1, which is distributed in the area, contains magnetite layers and a prominent epidotization observed in V1-1 along U1.

Mahab 2 mineral showing is located in the south part of the area, where a relatively large gossan (with abundant copper oxides) can be seen along the NW-SE trending fault mentioned above. Prospection Ltd. conducted a drilling survey in1976 and confirmed a silicified and chloritized zone of several meters in width with sulphide dissemination under the gossan.

(2) Hara Kilab Area

Hara Kilab area is located about 25km southwest of Saham City and extended from Hara Kilab mineral showing in the north, to Mahab 4 mineral showing in the south.

As indicated in Fig.II-1-5, the geology of this area consists mainly of SD, V1-1, V1-2, U1, Batinah Oliststrome and Quaternary sediments. The intrusion of trondhjemite, which is seen cropping out along the boundary between V1-1 and V1-2, caused U1 to be intermittently exposed and in small scales. V1-2 and U1 strike N30°W and dip about 20° to the NE. A brief description of the three major mineral showings in Hara Kilab, Mahab 3, Mahab 4 is as follows:

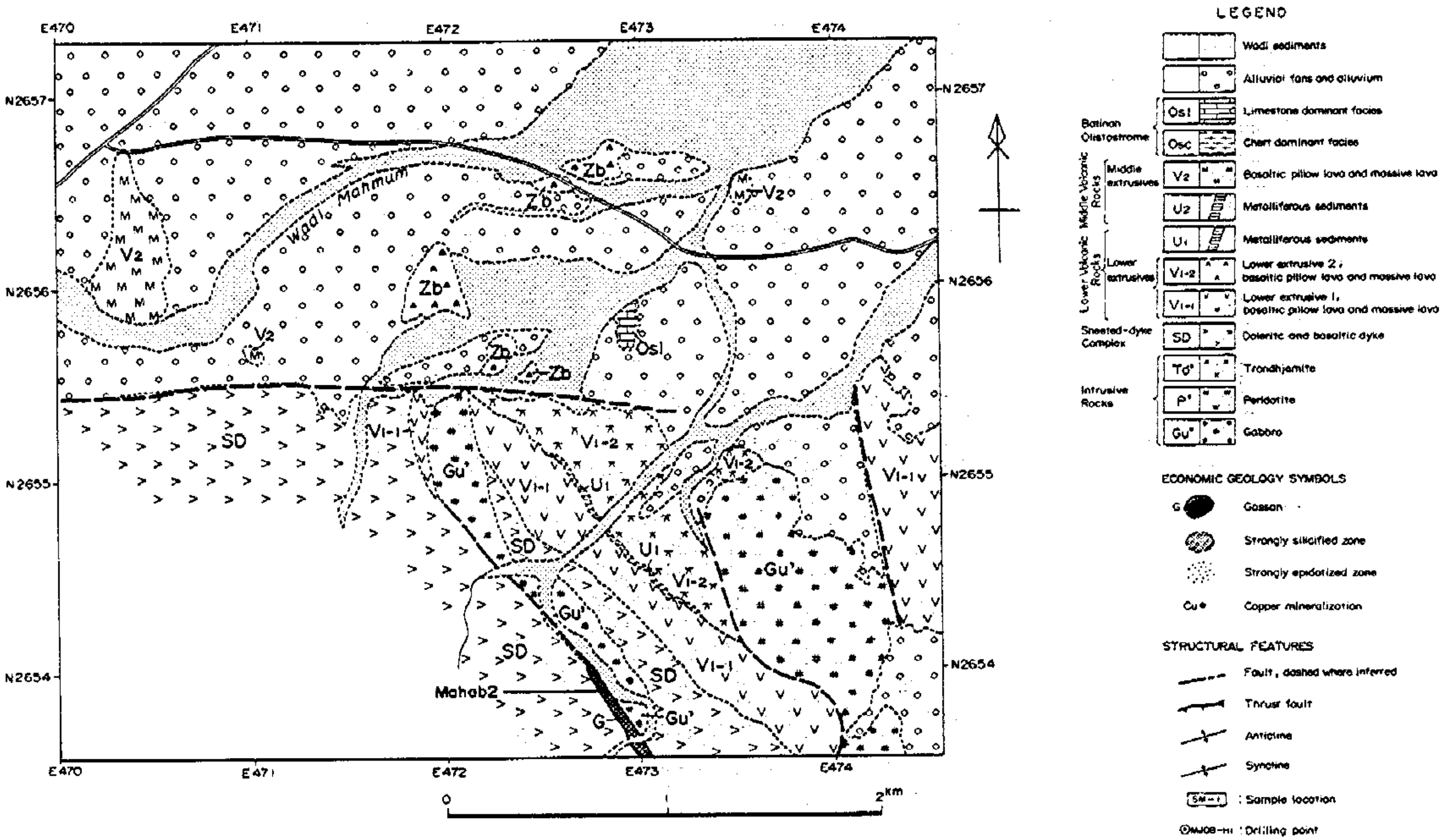
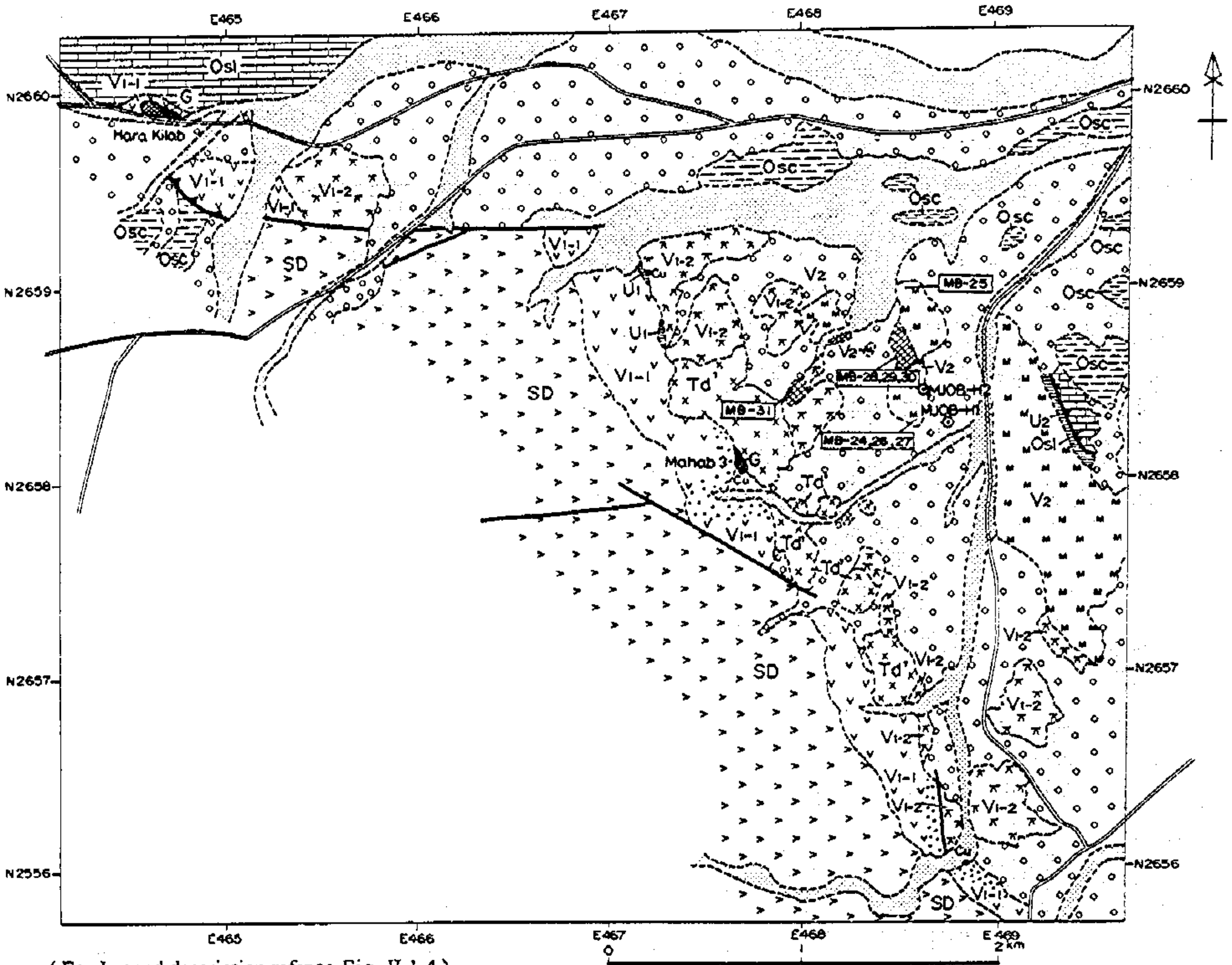


Fig. II-1-4 Geologic map of Mahab area



(For Legend description refer to Fig. II-1-4.)

Fig. II-1-5 Geologic map of Hara Kilab area

Hara Kilab mineral showing

Argillaceous gossan which outcrops in this showing, is distributed over an area of 100m x 150m. Drilling survey in 1976 by Prospection Ltd. found a small massive sulphide body under the gossan as shown in Fig.II-1-6. Ancient mining activity can be observed here and this is the reason of abundant slag found scattered around the gossan.

Mahab 3 mineral showing

Gossan with abundant copper oxide can be seen around the boundary between V1-1 and V1-2. Slags of ancient mining activity can be found more abundantly than those remained in Hara Kilab showing. A large body of trondhjemite is exposed on the north of gossan. The drillings carried out by Prospection Ltd. in 1976 intersected this trondhjemite body at 30m to 40m below the gossan and also confirmed massive sulphide composed mainly of pyrite.

Mahab 4 mineral showing

Thin and continuous metalliferous sediments (U1) are exposed in this showing. Slight copper mineralization is seen on the surface and metalliferous sediments found rather siliceous. The boundary between V1-1 and V1-2 is well exposed in this showing, where limonitized gossan was found with copper oxide along the place of fault contact.

As for other features of mineralization, an intense epidotization is found around Mahab 3 mineral showing and to the north of Mahab village. An extensive silicified zone with iron rusty features is exposed in the area between Mahab 3 mineral showing and Dhahwa village. The chemical analytical results for copper and gold of the samples collected (Fig.II-1-5) in this silicified zone are as follows:

MB-28 : Cu: <0.01% , Au: <0.01g/t : Gossanized and silicified zone
MB-29 : Cu: <0.01% , Au: <0.01g/t : Gossanized and silicified zone
MB-30 : Cu: <0.05% , Au: <0.01g/t : Gossanized and silicified zone
MB-31 : Cu: <0.01% , Au: <0.01g/t : Gossanized and silicified zone

(4) Maqail Area

Maqail area is located 40km southwest of Saham City and includes not only inside but also the surroundings of the Maqail south mineral showing which was surveyed during the Phase I.

As indicated in Fig.II-1-7, the geology consists mainly of SD, V1-1, V1-2, U1, V2, bedded chart of Batinah Olistostrome, and Quaternary sediments. U1 is well exposed in this area, reaches about 2m in thickness at the western side of the central part, is well bedded and contains abundant magnetite. Many basalt and dolerite dikes are intruded into V1-2 at the central and southern parts where a NNW-SSE trending fault runs in V1-2.

Since magnetite predominates in U1 and copper mineralization can be observed in many places, it is likely that U1 graded laterally into a massive sulphide ore. Additionally, silicified zone that is

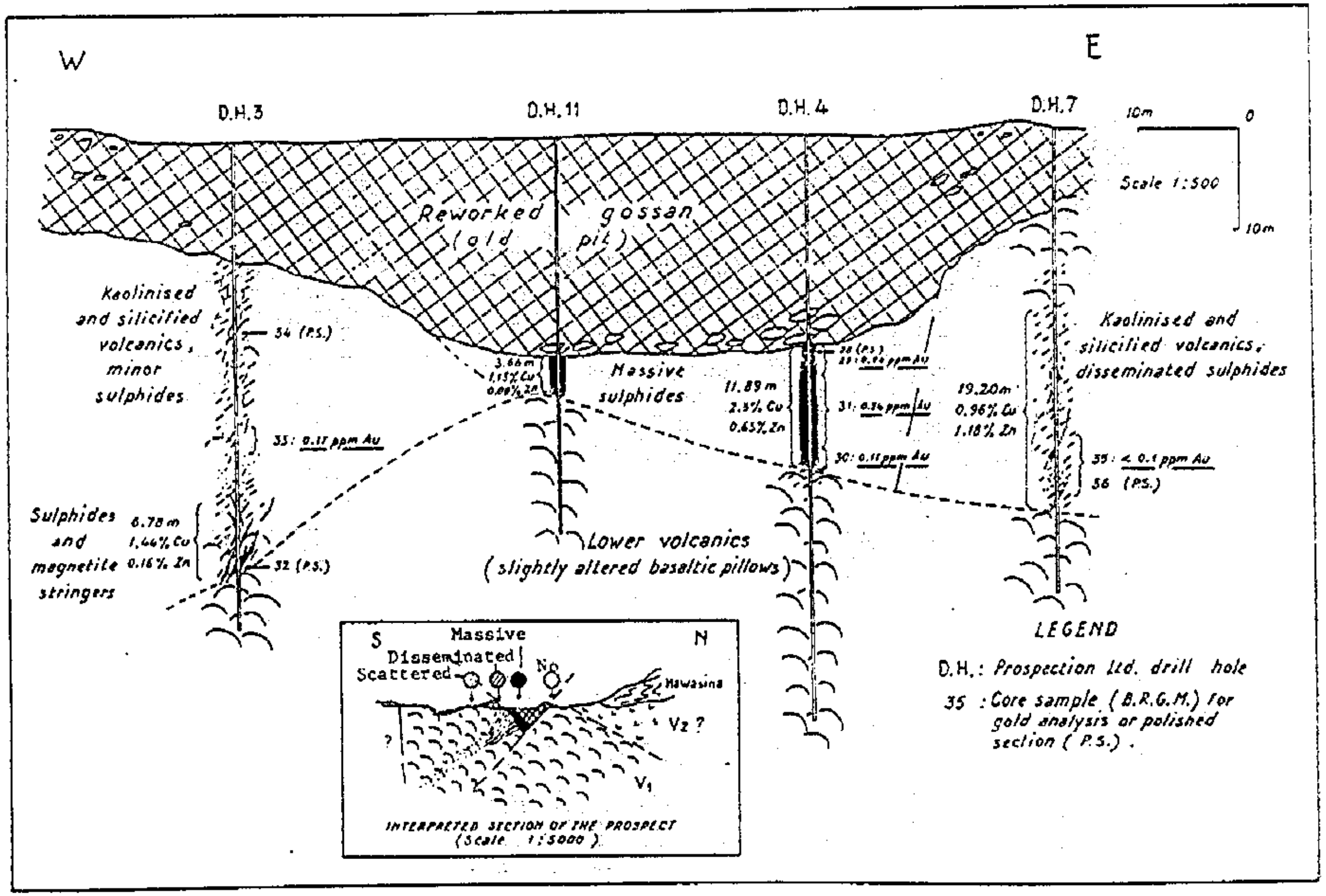
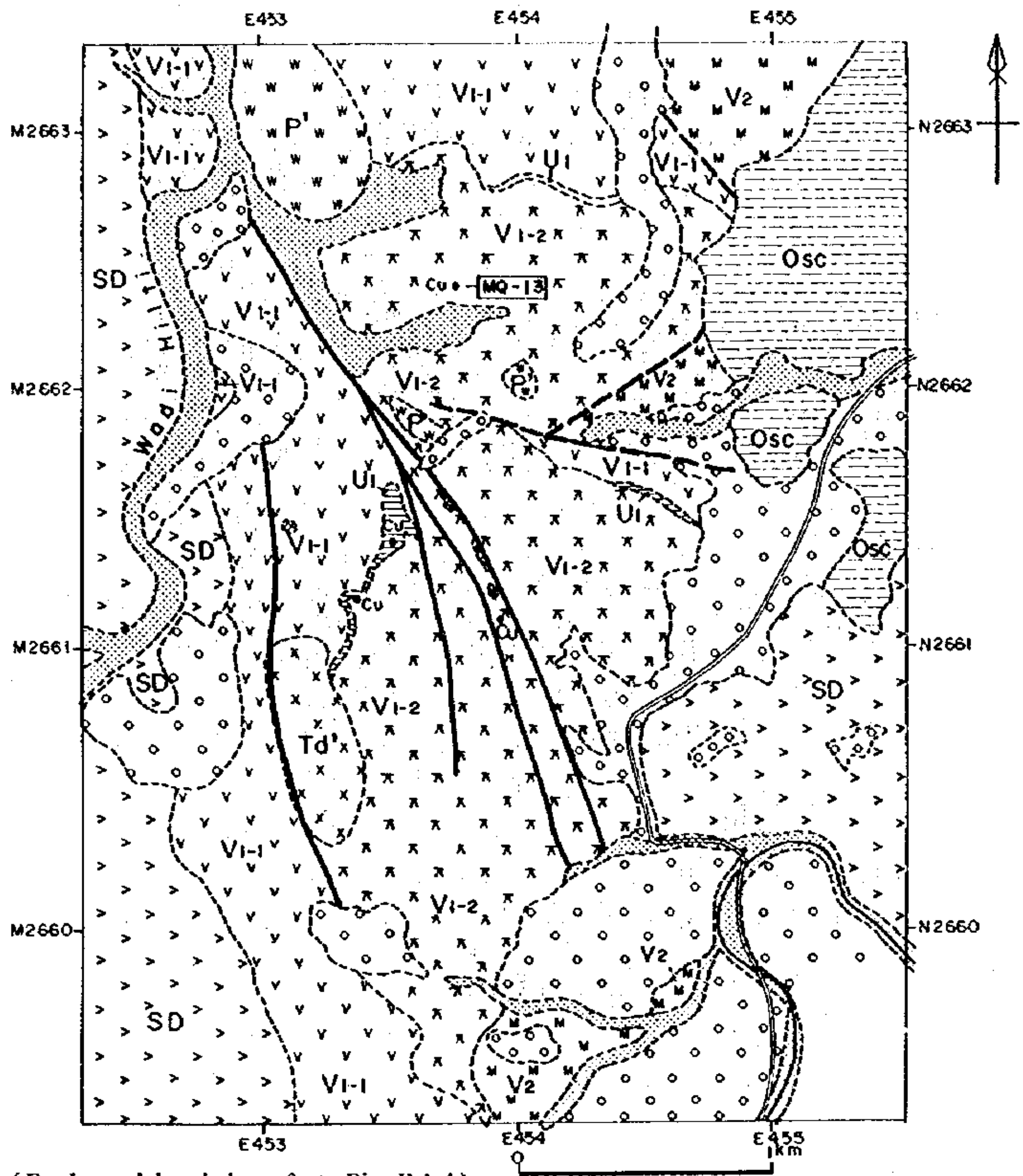


Fig. II-1-6 Cross section of borehole site in Hara Kilab area



(For Legend description refer to Fig. II-1-4.)

Fig. II-1-7 Geologic map of Maqail area

exposed along the NNW-SSE trending fault mentioned above is in places accompanied by copper mineralization. The results of chemical analysis for copper and gold about quartz vein cropping out in V1-2 at the northern part are as follows:

MQ-31 : Cu: <1.12% , Au: <0.01g/t : Quartz vein of 50cm in width and along N35°W strike.

(5) Zuha Area

Zuha area is in the northern most part of the South Batinah Coast project area and located 35km west of Saham City. This area covers both of the mineral showings in Zuha and Zuha North.

As indicated in Fig.II-1-8, the geology consists mainly of V1-1, V1-2, U1, V2, U2 and Quaternary sediments. V1-2 outcrops in the central and southern parts of the area, namely, around the Zuha mineral showing. However, V1-2 is not exposed in the northern part because V1-1 is directly overlaid by V2 around the Zuha North mineral showing.

V1-2 consists of pillow lavas as well as massive lavas. Thick massive lava, with 5m in maximum thickness, is found directly over U1. U1 continuously crops out showing a thickness of about 30 to 50cm. The gossan located in the area graded laterally from this U1, which has a bigger thickness than U1 and is intensely brecciated. The area shows a complicated geological structure consisting of thrust fault, normal fault and folding.

The gossan in this area has almost the same scale as the one in Ghuzayn. Copper mineralization can be seen in many places around the gossan. An ancient smelting site was located in the vicinity of the gossan. Intense epidotization is observed in V1-1 at the contact with V1-2 around the gossan.

The results of the chemical analysis around gossan and gossanized U2 are as follow:

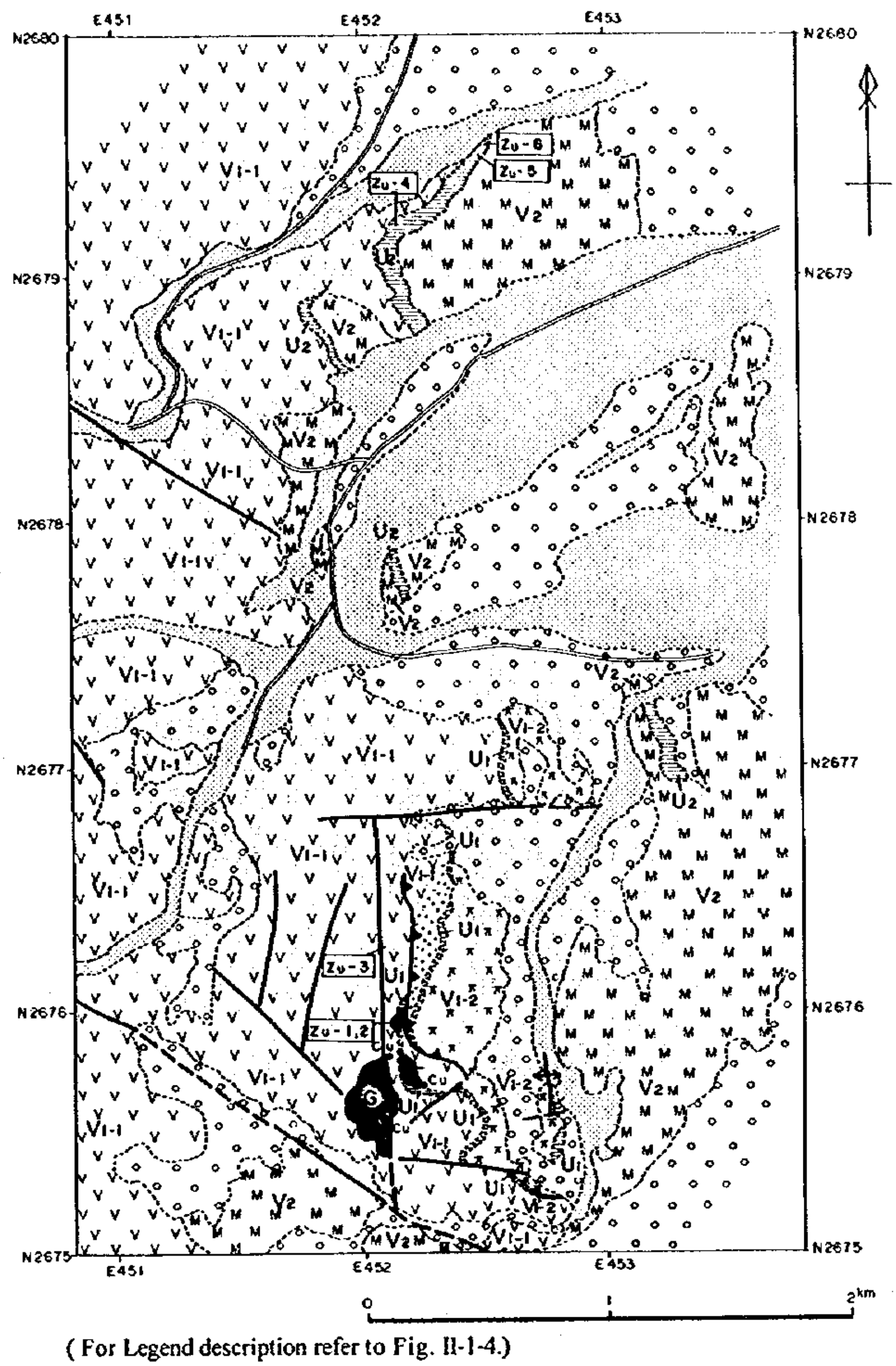
ZU-1 : Cu: 0.58%, Au: <0.01g/t : Limonitic gossan near main gossan
ZU-2 : Cu: 0.04%, Au: 0.01g/t : Hematitic gossan near main gossan
ZU-3 : Cu: 0.01%, Au: 0.01g/t : Hematitic gossan along faults, N of main gossan
ZU-4 : Cu: 0.01%, Au: <0.01g/t : Gossanized U2
ZU-5 : Cu: 0.01%, Au: <0.01g/t : Gossanized U2
ZU-6 : Cu: 0.02%, Au: <0.01g/t : Gossanized U2

(6) Ghuzayn Area

Sampling for chemical analysis of silicified zone and vein exposed in A'Ruwaydhat (west of Ghuzayn village) was carried out on the locations indicated in Fig.II-1-9.

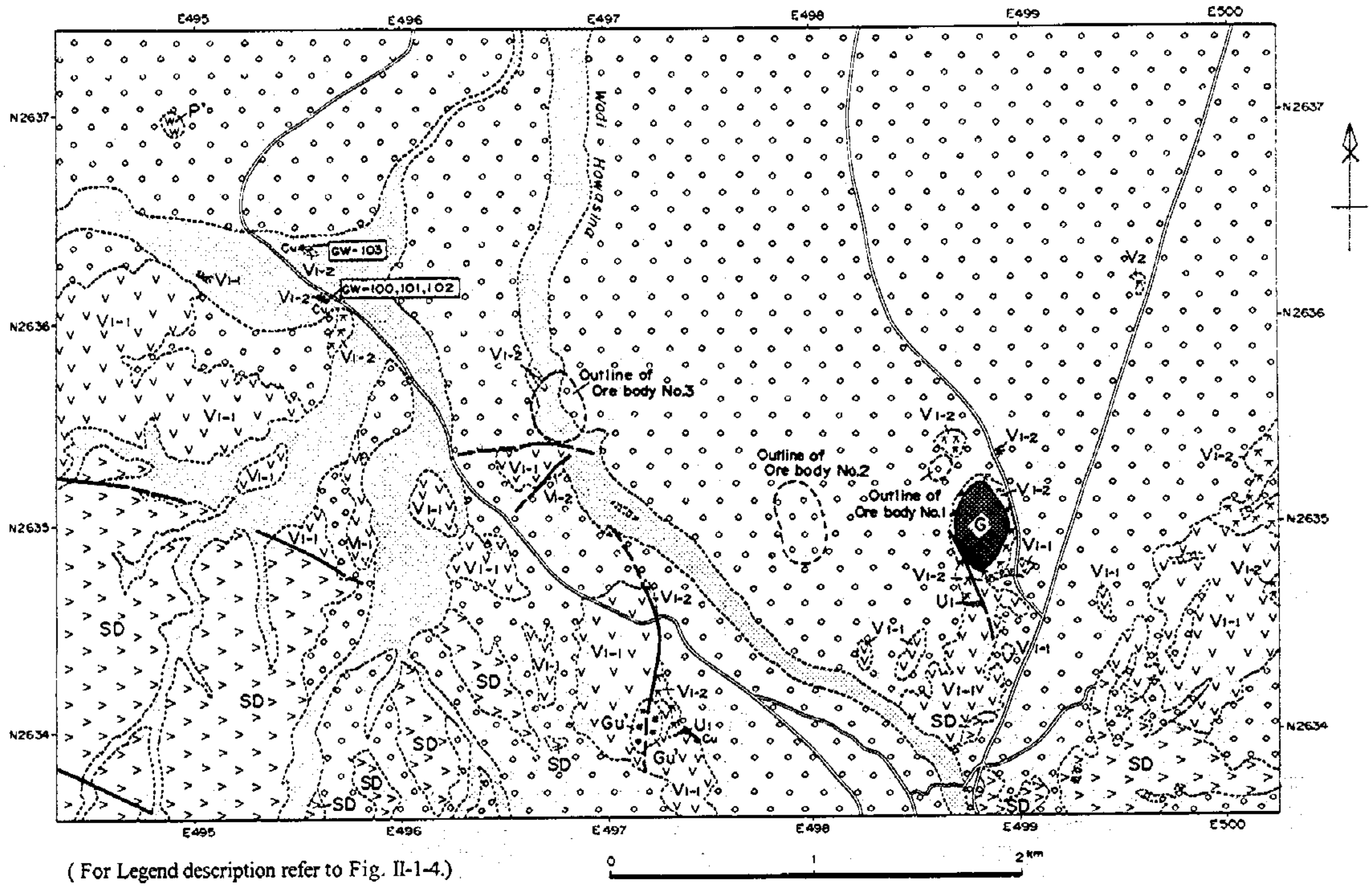
The above mentioned silicified zone and vein are distributed in V1-2. The silicified zone, which is accompanied with abundant oxidized iron minerals and many quartz veinlets, has a scale of 5m by 15m, with copper mineralization seen along fractures. The silicified vein presents a width between 10 to 20cm and found in slightly silicified pillow lava accompanied with epidote and copper oxides.

The results of the chemical analysis is as follows:



(For Legend description refer to Fig. II-1-4.)

Fig. II-1-8 Geologic map of Zuha area



(For Legend description refer to Fig. II-1-4.)

Fig. II-1-9 Geologic map of Ghuzayn area

GW-100 : Cu: 0.86%, Au: <0.01g/t:Channel samples of silicified zone, sampling width: 6.6m

GW-101 : Cu: 0.31%, Au: <0.01g/t:Channel samples of silicified zone, sampling width: 4m

GW-102 : Cu: 0.14%, Au: <0.01g/t:Channel samples of silicified zone, sampling width: 3.6m

GW-103 : Cu: 3.02%, Au: <0.01g/t:Silicified vein, width: 10 to 20cm

1-5 Further Considerations

Further aspects on the results of the geological survey are as follow:

a) In Sarami area, two features can be emphasized: 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, the metalliferous sediments containing magnetite and copper oxides was found in one location. From the above mentioned field evidences, it can be suggested that the location around the silicified zone in the northern part represent the most promising place for further investigation.

b) In 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 is considered to have a high potential for the existence of massive sulphide deposits.

c) In Maqail area, a thick U1 with abundant magnetite is extensively exposed and accompanied with copper mineralization. These features 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.

d) In Mahab area, U1 contains abundant magnetite and a relatively intense epidotization was observed in V1-1. The existence of faults in this area limits the extension of the area for exploration purposes.

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

f) In A'Ruwydhat, to the west of Ghuzayn, the silicified zone and vein accompanied with copper mineralization suggests the high possibility for the existence of promising mineralization within a shallow depth.

Table Ⅱ-1-1 Description of thin sections of surface samples

Ser. No.	Sample No.	Coordination		Rock Name	Geo. Unit	Texture	Primary Minerals											Secondary Minerals													Remarks
		N (km)	E (km)				Quartz	Plagioclase	Hornblende	Biotite	Clinopyroxene	Orthopyroxene	Olivine	Apatite	Spinel	Glass	Opaque minerals	Quartz	Albite	Illite	Chlorite	Epidote	Zoisite	Actinolite	Pumpellyite	Prehnite	Calcite	Smectite	Opaque minerals	Pseudomorph	
1	SM-12	2649.46	478.75	Quartz diorite	Intrusives	Equigranular.	◎	○	●	●				·					○		○	●		·			●		○		Pse: Ho and Bi
2	SM-13	2649.34	479.02	Gabbro	Intrusives	Equigranular.		◎			◎								○		○			◎					●	◎	OM: pyrite, Pse: Cpx
3	SM-14	2648.60	481.36	Basalt	V1-2	Basaltic		◎			○							·	◎		○	·					●		●		OM: pyrite
4	SM-15	2650.60	478.55	Dolerite	Dike	Ophitic		◎							·			●	○	·	●	·					●		●		OM: pyrite
5	SM-16	2650.67	478.48	Micro-gabbro	Intrusives	Equigranular.		○			◎							●	○	·	●	·		◎					●		OM: pyrite
6	MB-24	2658.20	468.51	Basalt	V2	Intersertal, amygdaloidal		○								◎	·	○		·	○						·				
7	MB-25	2658.93	468.45	Basalt	V2	Intersertal, amygdaloidal		◎								◎	·	○			○						·				

◎ : abundant, ○ : common, ● : a little, · : rare,

OM: Opaque minerals, Pse : pseudomorph, Cpx: clinopyroxene, Ho: hornblende, Bi: biotite

Table Ⅱ-1-2 Results of X-ray diffraction analyses of surface samples

Ser. No.	Sample No.	Coordinate		Lithology(Formation)	Identified Minerals									
		N(km)	E(km)		Quartz	Plagioclase	Chlorite	Calcite	Montmorillonite	Epidote	Gypsum	Heulandite	Pyrite	Hematite
1	MB-26	2,658.20	468.51	Minerals filling in vesicles in pillow lava(V2)	●	○	●					◎		
2	MB-27	2,658.20	468.51	Minerals filling in vesicles in pillow lava(V2)	○	∘						◎		
3	MB-28	2,658.60	468.45	Silicified and argillized pillow lava(V2)	○	∘	∘		●		◎			●
4	MB-29	2,658.60	468.45	Silicified and argillized pillow lava(V2)	○	○	●				◎			●
5	MB-31	2,658.45	467.89	Silicified and argillized pillow lava(V1-2)	○	○	○	∘						
6	MB-32	2,658.45	467.89	Silicified and argillized pillow lava(V1-2)	◎	●	●	∘						∘
7	SM-17	2,649.96	478.80	Epidotized interpillow of pillow lava(V1-1)	○	○	●			○				

◎ abundant
○ common
● rare
∘ very rare

CHAPTER 2 TDIP SURVEY

2-1 Background and Objectives

TDIP survey was carried out during this phase 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.

This fiscal year corresponds to the second year since this project started. During the previous Cooperative Mineral Exploration project carried out from 1995 to 1997, massive sulphide ore bodies were discovered in Ghuzayn area.

Due to the possibility of the existence of additional massive sulphide ore bodies in Ghuzayn, TDIP geophysical survey was carried out in the south side of the ore body No. 2 and in the west side of the ore body No. 3.

During the geological survey carried out in the fiscal year 1997, it was understood that the areas of Hara Kilab, Mahab, Sarami as well as Maqail, presented some possibilities for the existence of massive sulphide deposits. To clarify even more these studies, geophysical survey by using TDIP was carried out in these areas.

2-2 Survey Locations and Specifications

During this fiscal year, the following 5 areas were selected for exploration work: Ghuzayn, Hara Kilab, Mahab, Sarami and Maqail. In relation to Ghuzayn area, the exploration work started from 1995 to 1997, but due to the previous results, this year the studies were extended to vicinity areas.

A summary of the TDIP survey performed in the above mentioned 5 areas is indicated in Table II-2-1.

Table II-2-1 Survey amounts of TDIP

AREA	LENGTH(Km)	No.of LINES	No.of POINTS
Ghuzayn	16.5	4 Lines×1.0Km 5 Lines×2.5Km	576
Sarami	44.0	10 Lines×1.7km 15 Lines×1.8Km	1,410
Mahab	16.0	8 Lines×2.0km	528
Hara Kilab	44.0	4 Lines×3.0km 16 Lines×2.0Km	1,480
Maqail	15.4	1 Line×1.4km 4 Lines×1.5Km 4 Lines×2.0Km	490
Total	135.9	71 Lines	4,484

2-3 TDIP Survey Method

2-3-1 Procedure

The TDIP survey was carried out by using a time-domain method and adopting 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. In the field, the TDIP surveys are carried out by injecting a current into the earth through current electrodes and the resulting voltage is measured across potential electrodes. Fig.II-2-1 shows the array utilized as well as the location of the plotting points.

For TDIP surveys, the current is turned on for a certain length of time (on-time) then turned off (off-time). The transmitted waveform is then repeated with current flow in opposite direction. The pair of positive and negative on-off waveforms constitutes a cycle, which in this survey lasted 8 seconds, as indicated in Fig.II-2-2. According to Fig.II-2-3, the polarization of the target creates a transient decay voltage and its corresponding changing response is observed in the received waveform.

In order to obtain a desired signal-to-noise ratio (S/N), the measurements were, in general, repeated 3 times with a stacking of more than about 10 times.

2-3-2 Instrumentation

The instrumentation used for the conventional time-domain IP survey are described in the Table II-2-2.

Table II -2-2 Specifications of TDIP survey instruments

Receiver	Zonge GDP-16	Phoenix V5
Frequency range	DC to 8Khz	Dc to 10Khz
Number of Channels	3	8
Numver of Stackings	8096	No restriction
Detectable signal	1 μ V	1 μ V
A/D Conversion	16 bits	16 bits
Number of Windows	13(from 50 to 1930ms)	13(from 50 to 1550ms)
Transmitter	CH-95A	IPT-1
Output Power	2kw,800v,12A	2kw,800v,10A
Output Frequency	DC to10Khz	DC to 12Khz
Frequency control	Automatic	Automatic
Generator	Geonics GPU2000	Robin
Maximum output	2Kw	3Kw
Output Voltage	120V	200V
Output Frequency	400Hz	50Hz

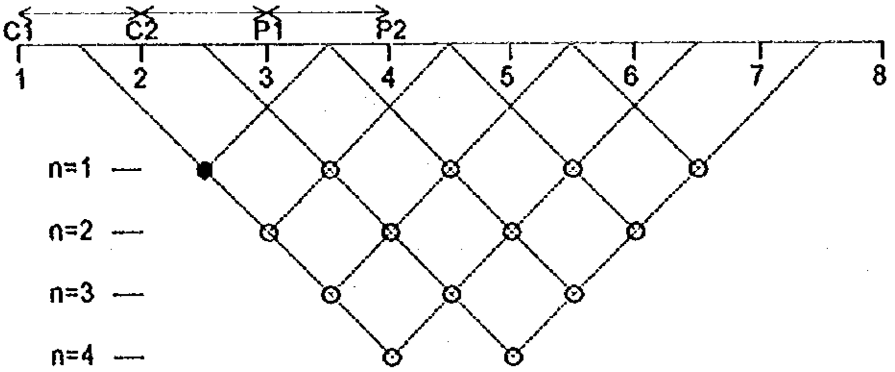


Fig. II -2-1　Dipole-dipole array and plotting procedure

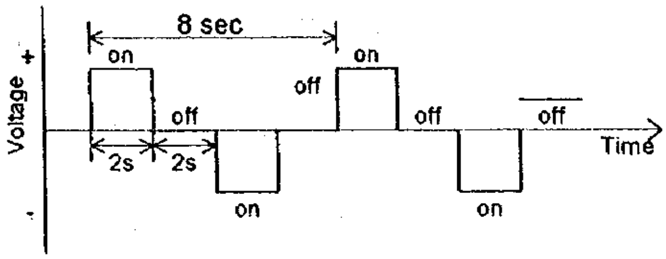


Fig. II -2-2　Waveform produced by the transmitter

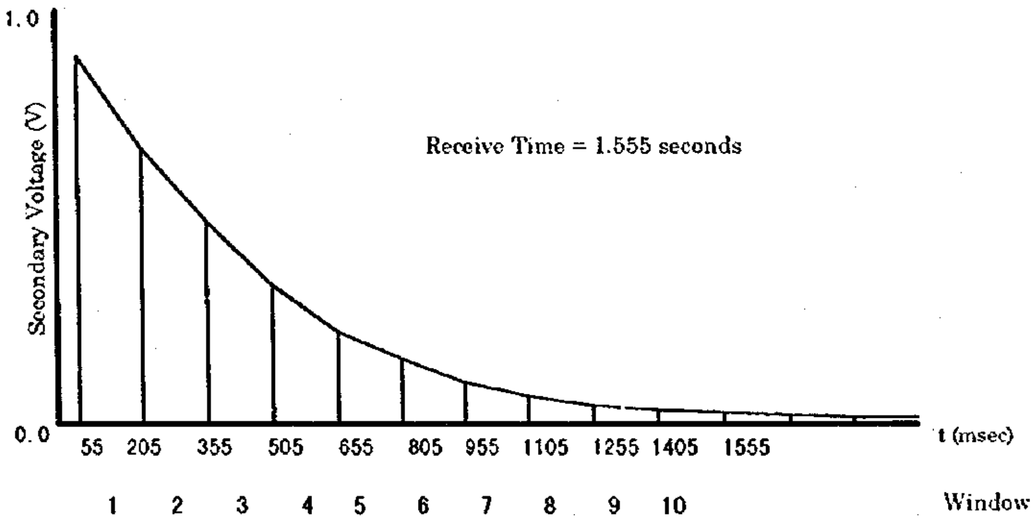


Fig. II -2-3　Sampling interval of the TDIP receiver