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

(PHASE II)

MARCH 1997

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Goverment of Sultanate of Oman, the Japanese Goverment decided to conduct a Mineral Exploration Project in Central 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 July 9, 1996 to December 26, 1996.

The team exchanged views with the officials concerned of the Goverment of Oman and conducted a field survey in the Central 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 geophysical and drilling surveys in 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, 1997.

Kimio Fujita
President
Japan International Cooperation Agency

Shozaburo kiyotaki
President
Metal Mining Agency of Japan

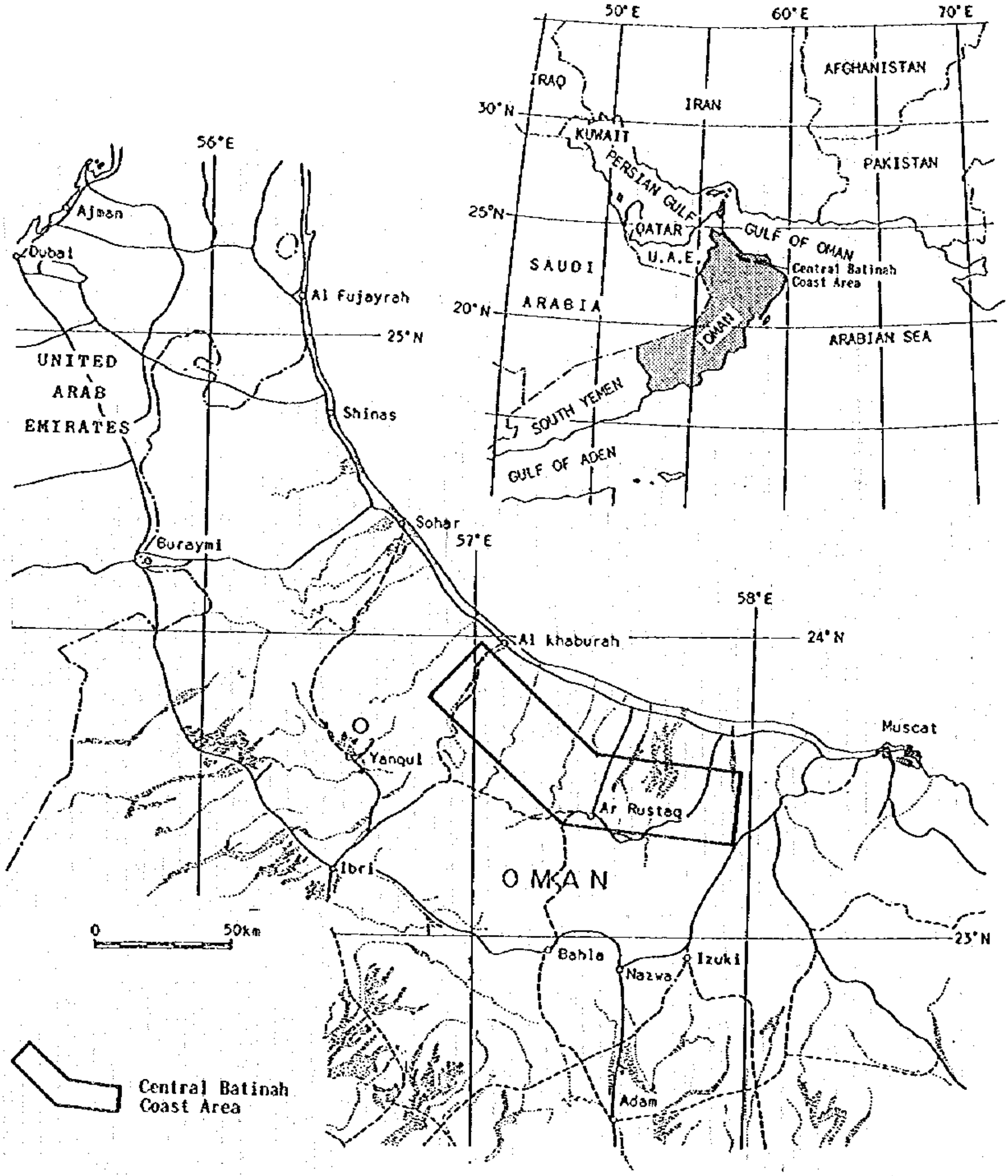

Fig.1 Location Map of the Central Batinah Coast area

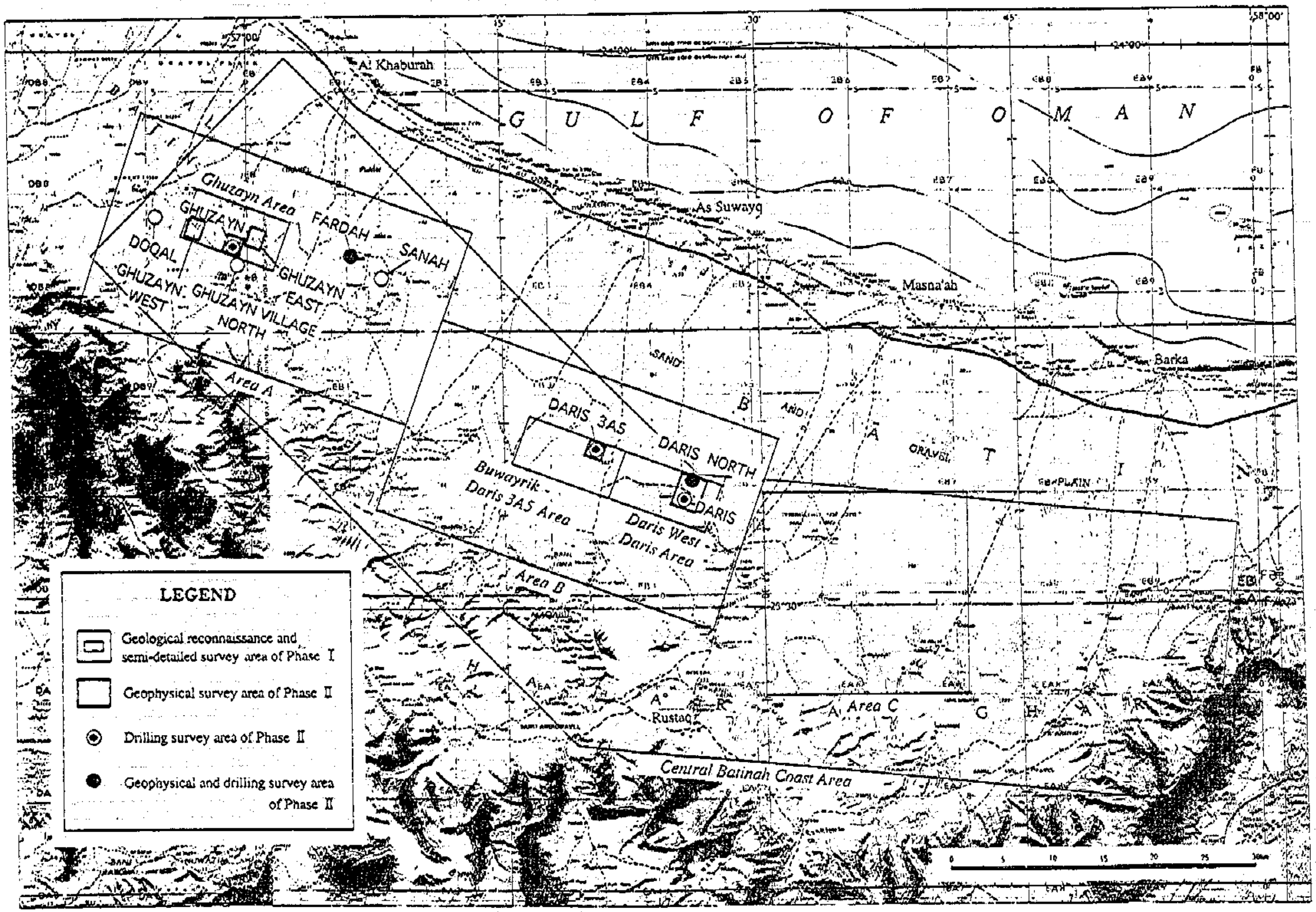

Fig.2 Location map of the survey areas

ABSTRACT

The Government of Sultanate of Oman and the Government of Japan agreed to conduct a mineral exploration project in the Central Batinah Coast area. The Scope of Work for this project was signed by both governments on 7th February,1995. 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, however, other areas have been only partially explored because of wide coverage of Quaternary deposits.

In Phase I, reconnaissance and semi-detailed geological surveys and geophysical survey including TDIP and TEM methods were conducted in the area. These geophysical surveys were carried out in Ghuzayn, Daris 3A5 and Daris Areas selected by the semi-detailed geological survey.

Since the massive sulphide deposits occur along a contact between the Lower extrusive rocks 1 and 2 of the Lower volcanic rocks, the contact was traced throughout the areas. Area A and B shows the extensive distribution of the contact zone, however, the sheeted dyke was overlain directly by the Middle volcanic rocks without the Lower extrusive rocks 1 and 2 in the Area C and consequently the Area C shows a low potencial for the deposits.

In addition to the known gossan in Ghuzayn, Daris 3A5 and Daris, new gossans were found in Doqal, Fardah, Sanah, north of Ghuzayn village and Qulayyah. The samples in Doqal and Fardah show contents of gold and silver.

IP geophysical survey was carried out in the areas of Ghuzayn, Ghuzayn West, Ghuzayn East, Daris 3A5 and Daris. IP anomalies were detected in the north and west of Ghuzayn area, in and around the gossan in Daris. Moreover, a relatively high chargeability zone extending towards west from the gossan was detected in Daris 3A5 area.

TEM survey carried out to confirm the anomalies detected by IP survey, resulted in finding TEM anomalies in the north and west of Ghuzayn, and the north and northwest of gossan in Daris area.

On the basis of the results of Phase I, drilling survey and geophysical survey including TDIP and TEM methods were conducted for Phase II project. The drilling survey was carried out in Ghuzayn, Daris, Daris 3A5, Daris north and Fardah areas, IP survey was carried out in Fardah, Sanah, Ghuzayn village north and Doqal areas, while TEM survey in Ghuzayn, Daris north, Fardah, Sanah and Doqal areas.

Drilling survey conducted in Ghuzayn area intersected massive sulphide ore bodies in two places, i.e., northern and western bodies. The northern body found to the north of gossan, showed a maximum core length of 7.95m with average assays of 4.66% Cu in MJOB-G3 hole. The western body found to the west of gossan, indicated a maximum core length of 37.1m with average assays of 1.88% Cu in MJOB-G14 hole.

In this phase, TEM survey in Ghuzayn area resulted in highlighting the extension of massive sulphide ore bodies which were intersected by drilling in two places. The TEM data also show that the western body has an extension of 150m wide in east-west and 300m long in north-south, while the northern body extends 150m wide in east-west and 100m long in north-south. In some other locations, TEM data also provided interesting anomalies considered to be high potential for massive sulphide ore bodies.

In Doqal area, TEM survey was conducted in order to investigate the high metal factor zone of TDIP. Since anomalies were extracted in the area overlapping the high metal factor zone, it is clear that the area has a high potential for mineralization of massive sulphide.

The above results shows that the Central Batinah Coast area has a high potential for bearing massive sulphide deposits. As a continuation of the exploration program for the project, drilling and geophysical surveys are required to confirm the existence of ore body and its extension in Ghuzayn and Doqal areas. Moreover, it is necessary to evaluate the areas showing high metal factors in the central western part of Daris and the areas around Ghuzayn and Doqal.

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PART I GENERAL

PART II SURVEY RESULTS

PART I GENERAL

CHAPTER 1 INTRODUCTION

1-1 Background and Objectives

This survey was carried out as a cooperative mineral exploration program in the Central Batinah Coast area of Oman based on the Scope of Works agreed on 7th February, 1995 between the Government of Japan and the Government of the Sultanate of Oman.

The survey aimed at discovering new mineral deposits in the Central Batinah Coast area by clarifying the geological setting and characteristics of mineral deposits.

Several exploration works were carried out in this area in and around the known mineralization zones with surface indications. However, these works were limited only to the vicinity of mineralization zones and in view of the whole area, very limited portions were merely explored. This is caused by the fact that the area is covered by Quaternary sediments in very wide range. Therefore, it is important subject for exploration in this area to know how to investigate systematically the underlying part of the sediments.

In Phase I, reconnaissance and semi-detailed geological surveys and geophysical survey, including TDIP and TEM methods, were conducted in the area. In addition to the known gossan in Ghuzayn, Daris 3A5 and Daris, as a results of geological survey, new gossans were found in Doqal, Fardah, Sanah, north of Ghuzayn village and Qulayyah. Samples collected in Doqal and Fardah show contents of gold and silver.

TDIP geophysical survey carried out in the semi-detailed survey areas delineated IP anomalies in the north and west of Ghuzayn area, as well as in and around the gossan in Daris. Additionally, a relatively high chargeability distribution zone extending towards west from the gossan was detected in Daris 3A5 area.

TEM survey was carried out on the anomalies detected by TDIP survey. As a result, TEM anomalies were detected in the north and west of Ghuzayn, and in the north and northwest of gossan in Daris area.

On the basis of the results of Phase I, drilling and geophysical surveys by the methods of TDIP and TEM were recommended for Phase II of this project.

1-2 Coverage and Outline of Works

The Central 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 survey in this year consisted of drilling survey and geophysical survey by the methods of TDIP and TEM. Drilling survey was carried out in Ghuzayn, Daris, Daris 3A5, Daris North and Fardah areas. TDIP survey was carried out in Fardah, Sanah, Ghuzayn village north and Doqal areas, while TEM survey was conducted in Ghuzayn, Daris north, Fardah, Sanah and Doqal areas.

Survey amounts of the drilling and geophysical surveys, as well as the numbers of the laboratory samples are indicated respectively in Tables I-1-1 and I-1-2.

1-3 Members of the Project

The members of the project were as follows:

(1) Inspection of field work

Kenji Nakamura	Metal Mining Agency of Japan

(2) Field work

Japanese Counterpart

Yoshiaki Shibata	Team leader	Bishimetal Exploration Co., Ltd.
Mikio Kajima	Drilling survey	Bishimetal Exploration Co., Ltd.
Toshimasa Tajima	Geophysical survey	Bishimetal Exploration Co., Ltd.
David Escobar	Geophysical survey	Bishimetal Exploration Co., Ltd.
Tosio Kasagi	Geophysical survey	Bishimetal Exploration Co., Ltd.
TakeharuTakahashi	Geophysical survey	Bishimetal Exploration Co., Ltd.
Susumu Endo	Geophysical survey	Bishimetal Exploration Co., Ltd.

Omani Counterpart

Salim Omer Abdullah Ibrahim	Director	Ministry of Petroleum and Minerals
Mohammed Salem Al-Battashi	Geologist	Ministry of Petroleum and Minerals
Durair Ismail A'Shaikh	Geologist	Ministry of Petroleum and Minerals
Mohammed Salieh Hammed Al-Araimi	Geologist	Ministry of Petroleum and Minerals

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

Area and Content	Amount of Work	
1. Geophysical Survey	Total line length	Number of measurements
(1) IP method Doqal, Ghuzayn village north, Fardah and Sanah areas	36.7 km	1,118 points
(2) TEM method Daris north, Doqal, Ghuzayn village north, Fardah,Sanah and Ghuzayn areas	46.8 km	1,018 points
2. Drilling Survey	Total length	Number of holes
Daris, Daris 3A5, Fardah, Daris north and Ghuzayn areas	6,197.80 m	26 holes

Table I-1-2 Laboratory Work in Phase II

Laboratory work	Amount
1. Drilling Survey	
1) Thin section	30 samples
2) Polished section	12 samples
3) X-ray diffraction analysis	20 samples
4) Chemical analysis	
Ore Assay (6 elements : Fe,Cu,Zn,Ag,Au,Pb)	325 samples
2. Geophysical Survey	
1) Resistivity measurement	20 samples
2) Polarizability measurement	20 samples

1-4 Survey Period

The field work and compilation activities were conducted in Oman during the period shown below.

Drilling survey:	July 9, 1996	to	December 26, 1996
Geophysical survey:	September 17, 1996	to	December 7, 1996

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 and having an area of about 300,000km sq. The population is approximately 2 millions and the capital city is Muscat (Fig. 1).

The survey area is located in the west of the capital city of Muscat and has an extension of about 3,300 km sq. running parallel to the Oman Mountains and the Gulf of Oman. The center of the investigation area has approximately a latitude of 23°30'N and a longitude of 57°30'E. It takes about 1.5 hours by vehicle for 130 km driving along coast line from Muscat to As Suwayq, 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 are in order from east to west: Wadi Ajal, Wadi Bani Kharus, Wadi Ma'awil, Wadi al Abiad, wadi Far, Wadi al Hawoayn, Wadi Wadiyah, Wadi Mabrah, Wadi Halhal and Wadi al Hawasinah.

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 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 temperature in summer season (April to October) averages 40°C and sometimes goes up to 50°C. Humidity is 40% during daytime but goes up to nearly 100% during night time. The average temperature in winter season (November to March) is approximately 25°C.

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

3-1 General Geology

Geology of the project area according to 1: 250,000 geological map published by Ministry of Petroleum and Minerals, as shown in Fig.I-3-1, consists of Pre-Late Permian Basement and Hajar unit of Autochthonous to Parautochthonous units, 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.

Pre-Late Permian Basement crops out in the western edge of the area and composed of basaltic and andesitic pillow lavas.

Hajar unit covers the eastern edge and south central part of the area and consists of the Late Permian Akhdar Formation comprising of limestone and dolomite, the Jurassic Sahtan Formation comprising of sandstone and limestone, the Jurassic to Cretaceous Kahmah Formation of limestone beds, the Cretaceous Wasia Formation of limestone beds and the Cretasious Muti Formation consisting of conglomerate, breccia, limestone, sandstone and chert.

Hawasinah Nappe is composed of the Late Permian to Jurassic Baid Formation and Hamrat Formation distributed in the western edge and south central of the area, and of the Triassic Umar Formation cropping out mainly in the northern part of the area. The Baid Formation consists of carbonate rocks, the Hamrat Formation consists of quartz sandstone, shale, chert, limestone, basalt, andesite and keratophyre, and 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

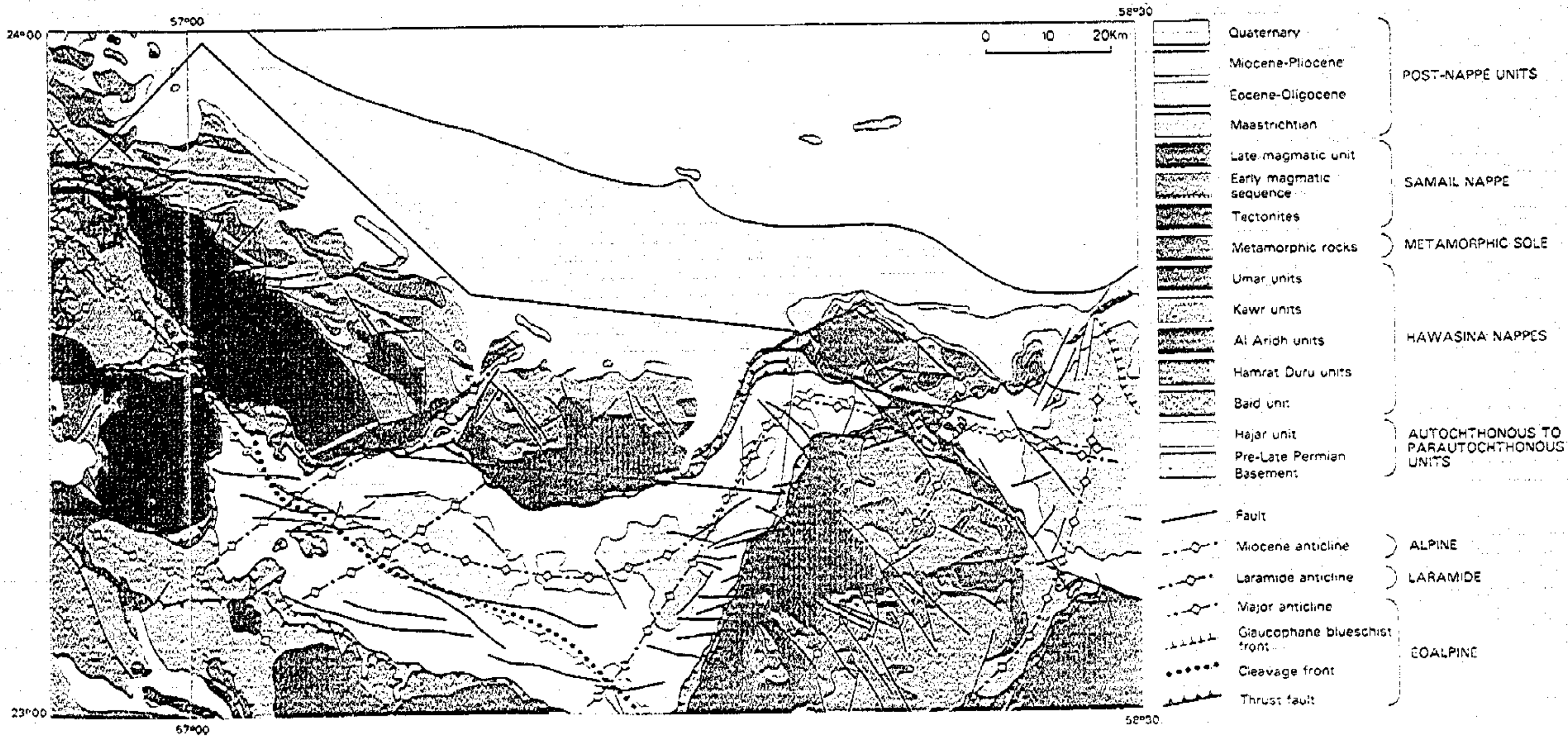


Fig. I-3-1 Geologic map of the Central Batinah Coast area.

Formation, and are cropping out along a line almost parallel to the coastal line.The Aruma Formation is composed of polymict conglomerate and marl and the Hadhramut Formation is composed of limestone, carbonate rocks and marl.

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

Principal geologic structure of the area is 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. The Samail Nappe in the area consists of two blocks which are the Haylayn block in the west and the Rustaq block in the east, and is divided by faults trending northeastly. Many thrust faults are found in the area and constitute boundaries of structural and tectonic units of the Samail nappe, such as Tectonite - Cumulate Sequence - Sheeted dyke Complex - Volcanic rocks.

3-2 Mineralization and Mining Activities

3-2-1 Mineralization

Occurrences of copper deposits, being the main target of the project are schematicaly shown in Fig.I-3-2.

The 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 sea-floor and accompanied with basic volcanics in footwall.

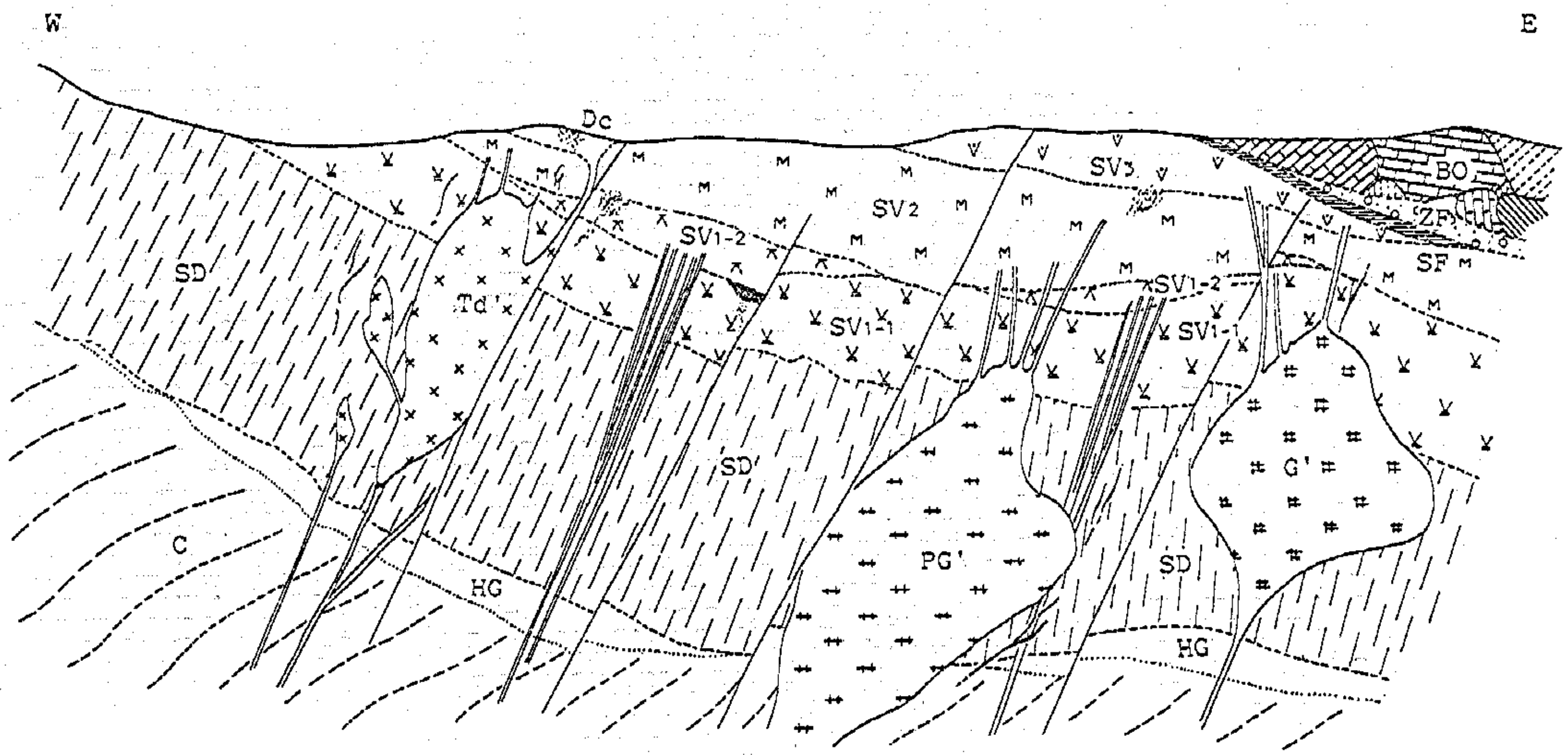
Major Cyprus-type copper deposits in Oman Mountain consist of Lasail and Baida deposits in the Sohar area, Rakah and Hayl as Sahil deposits in the Rakah area. The Lasail deposit is of large scale, and its general features are as follows:

(1) The Lasail deposit occurs along the contact between the Lower extrusive 1 and 2, near a major fault (Lasail Fault) and extends in a NNW-SSE direction, parallel to the fault.

(2) The massive ore zone shows an elongated saucer shape, with a maximum thickness of about 50m at its proximal part, with maximum lengths of 600m and 300m along N-S and E-W directions, respectively.

(3) The deposit is dominated by an abundance of pyrite and chalcopyrite with minor sphalerite, magnetite, hematite, quartz and gypsum.

(4) These minerals mentioned above, represent a distinct zonal arrangement, where chalcopyrite and pyrite are dominant in the proximal zone , while sphalerite, magnetite and hematite are predominant in the distal zone.



C : Cumulate sequence
HG: High-level gabbro
SD: Sheeted-dyke complex
SV_{1-1} : Lower extrusives 1
SV_{1-2} : Lower extrusives 2
SV2 : Middle volcanic rocks

Dc : Dacite
SV_3 : Upper volcanic rocks
SF : Suhaylah formation
ZF : Zabyat formation
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

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 is been said that the exploitation and smelting of copper in the ancient times continued up to around 940 A.D. of the early era of Islam. The copper deposits operated in that period are presumed to be the same as the current exploitation level of the Lasail mine and Rakah deposit and a great volume of slag and ancient smelter sites can be observed in this area 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 Hayl as Sahil and Rakah deposits in Rakah area were explored at that period up to 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, BGRM 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 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 a massive sulphide deposit 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 and Al Ajal 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 Arja 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 Arja 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
Aarja 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 three satellite ore bodies which are 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 tonnes 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 investigations of geophysical and drilling surveys.

CHAPTER 4 SURVEY RESULTS

4-1 Geophysical Survey Results

The geoelectrical structure reflected by massive sulphide deposits is characterized by high chargeability and low resistivity. In this 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 may assist in better defining more 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.

4-1-1 TDIP survey

TDIP survey was carried out to investigate the gossans found in Phase I in areas where massive sulphide bearing formation crops out. The areas selected for investigation, were: Fardah, Sanah, Ghuzayn village north and Doqal.

In Doqal area, a high chargeability anomaly of large extension is delineated in central part of the area, which is accompanied by low resistivity anomalous zone. Metal factor calculated from chargeability and resistivity data show the highest value in the central part which appears to extend in a north-south direction. The results are shown in Fig.II-4-1.

In Fardah and Sanah areas, clear low resistivity anomalies were extracted at the north of argillized gossan trending east to west. Chargeability, however, shows only low values in the area covered by extrusive rocks and consequently only oxidized ore body is considered possible to be found in these areas.

For the area of Ghuzayn village north, no anomalous chargeability and resistivity zones are found and therefore, no further investigation is envisaged in this area.

4-1-2 TEM survey

TEM survey was carried out in the areas of Ghuzayn and Daris North where high metal factor anomalies of wide distribution were delineated during the TDIP survey of Phase I. TEM survey was also conducted in the areas of Doqal, Fardah and Sanah, where IP anomalies were extracted in this Phase II, to clarify the resistivity structure and delineate the target area for drilling survey.

TEM data acquired over Ghuzayn area highlighted the extension of massive sulphide ore bodies which were intersected in two places by drilling conducted in this Phase, showing that the Western body has an extension of 150m wide in east-west direction and 300m long in north-south direction and that the Northern body extends 150m wide in east-west and 100m long in north-south. In addition, TEM data indicate also interesting anomalies which may correspond to high potential locations for massive sulphide mineralization in three places (Fig.I-4-2).

In Doqal area, The TEM survey carried out in order to investigate the high metal factor zone detected byTDIP, delineated a TEM anomaly in the area which agrees well to the high metal factor zone of IP survey and as such, it became clear that this area may have a high potential for mineralization of massive sulphide.

In Daris North area, The TEM survey was conducted to investigate the extensive distribution of IP anomalies trending northwest to southeast detected in Phase I. The result confirmed the large extension of anomalies corresponding to the IP anomalies.

In Fardah and Sanah areas, a TEM anomaly was delineated near the center of a low TDIP resisitivity zone trending east-west direction.

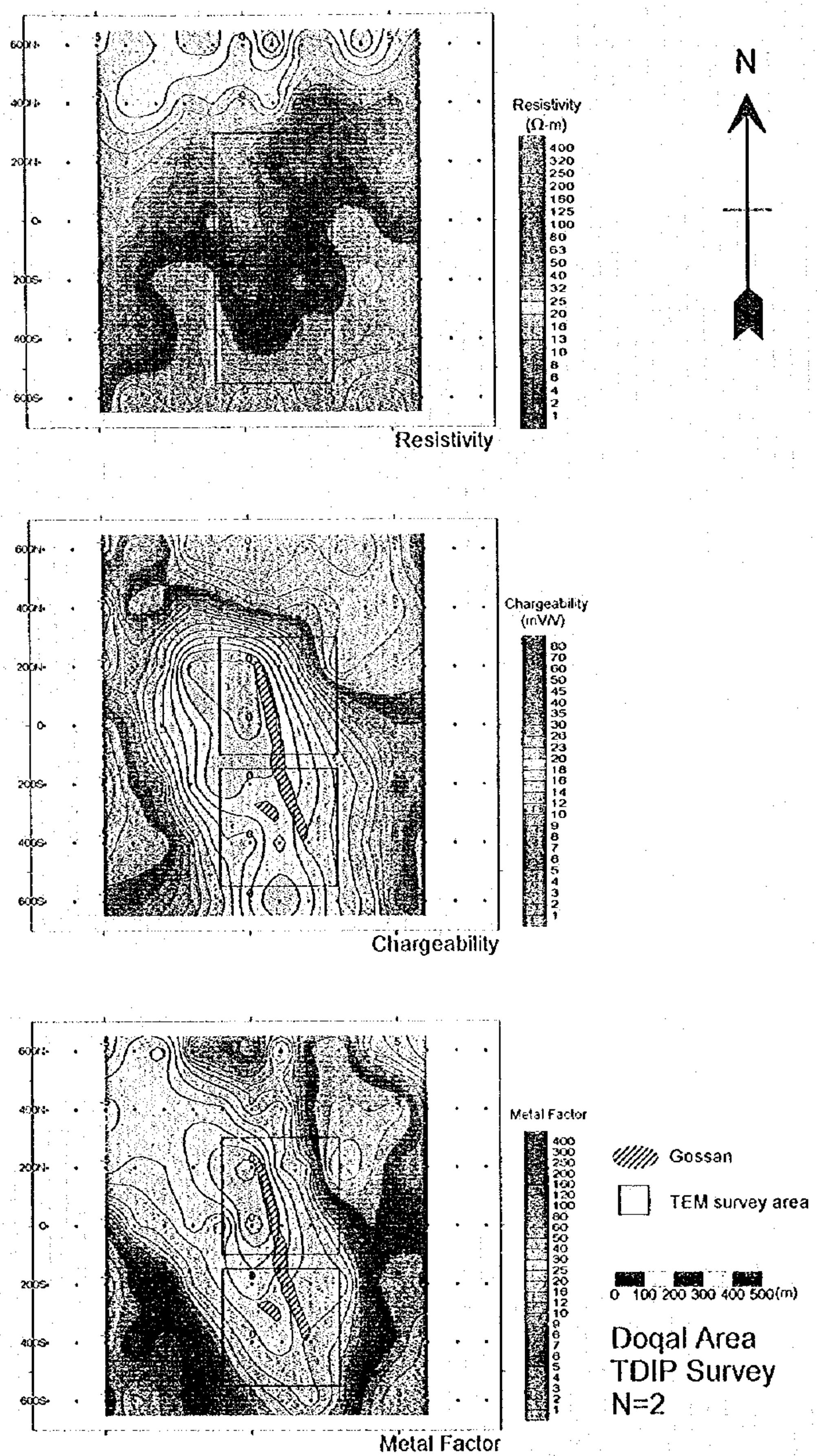
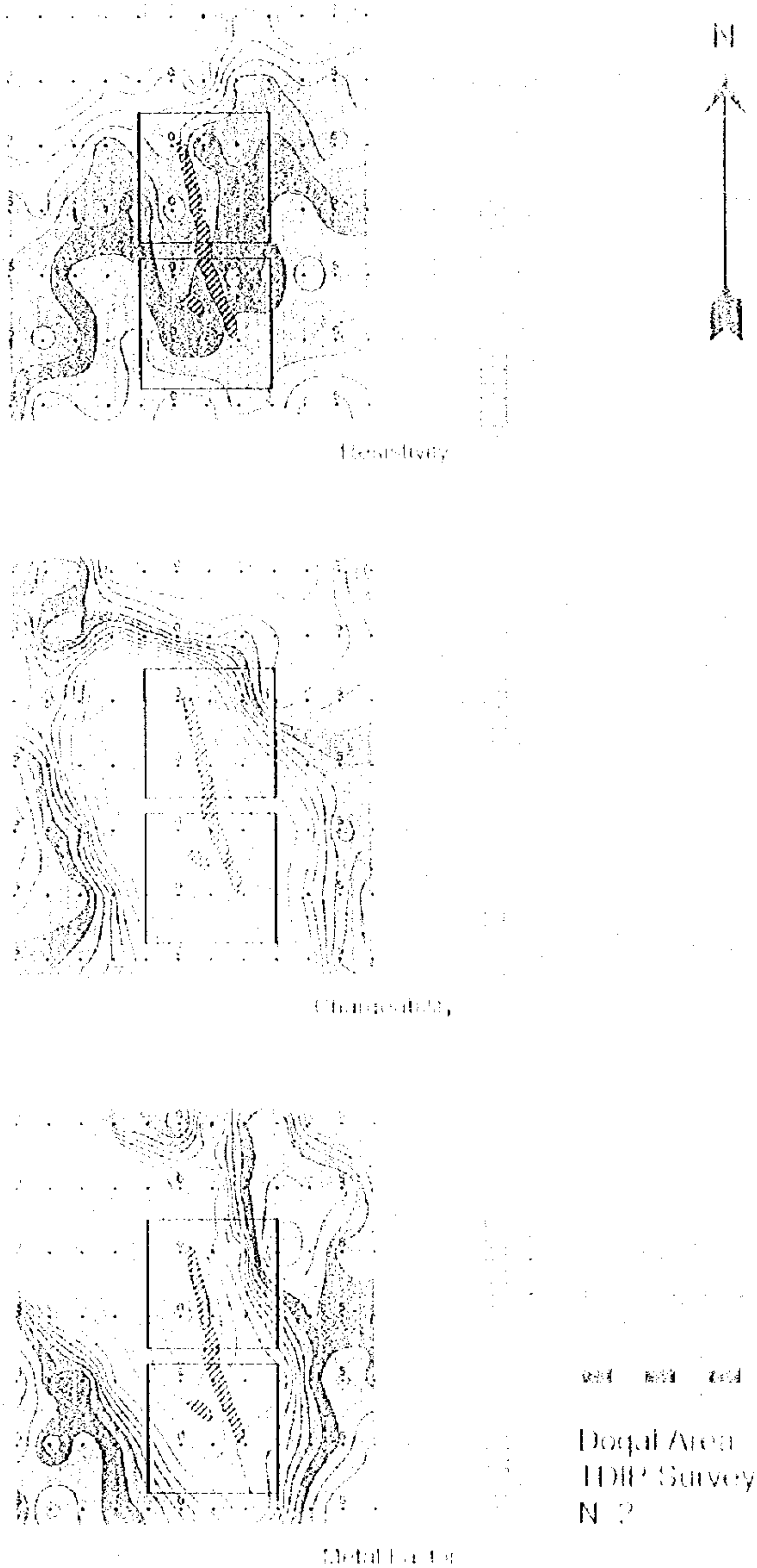


Fig.I-4-1 IP plane map in Doqal area


N
Resistivity
Chargeability
Metal Factor
Doqal Area
TDIP Survey
N

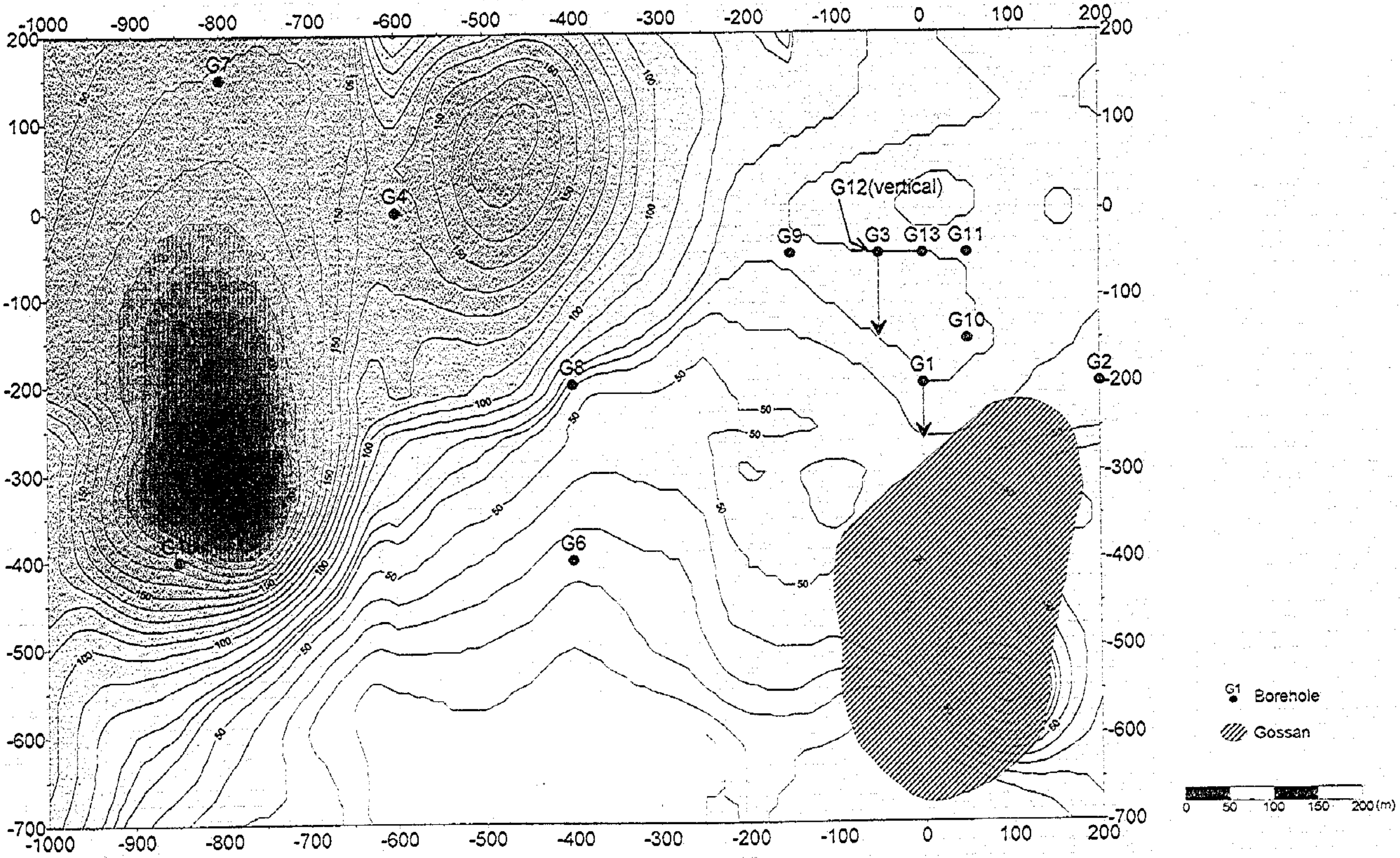
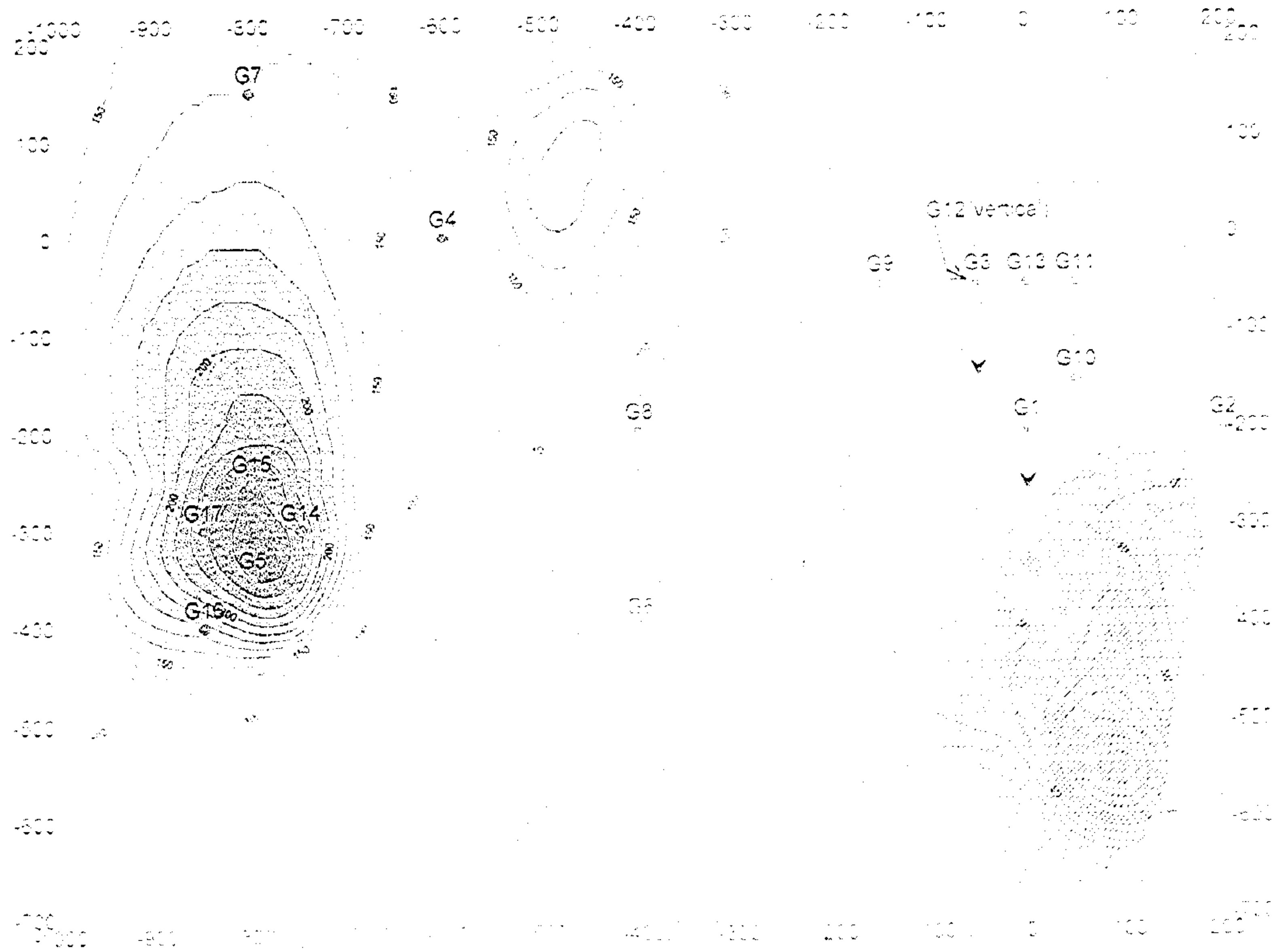


Fig.I-4-2 TEM response compiled map in Ghuzayn area



G7
G4
G12 (vertical)
G9
G3
G13
G11
G10
G1
G2
G8
G15
G17
G14
G5
G16

4-2 Drilling Survey Results

On the basis of the geophysical survey conducted in Phase I and Phase II, drilling survey was carried out in five areas, i.e., Ghuzayn, Daris North, Daris 3A5 and Fardah areas with 26 boreholes and 6,197.8m drilling length in total.

Drilling survey conducted in Ghuzayn area intersected massive sulphide bodies in two places, i.e., in the northern and western part. The Northern body found to the north of gossan was intersected by the boreholes MJOB-G3 and G13 with a maximum core length of 7.95m with average assays of 4.66% Cu in MJOB-G3. The Western body found to the west of gossan was intersected by the boreholes MJOB-G5, G14, G15, G16 and G17. The maximum core length of 37.1m with average assays of 1.88% Cu was found in the borehole MJOB-G14. The other boreholes indicated the following results: Borehole G5: 33.7m with1.47% Cu, G15: 29.9m with 1.55% Cu, G16: 2.5m with 1.63% Cu, and G17: 6.9m with 1.17% Cu. The depth of the ore bodies are thought to range from 130m to 154m in Northern body, and from 134m to 220m in the Western body. In addition to the massive ore body, stockwork ore zones consisting of dissemination and networks were found below the massive ore bodies in MJOB-G3 and G14 holes, with core lengths and assays of 36.6m with 0.47% Cu and 65.75m with 0.61% Cu, respectively. A summary of intersected ore bodies are shown in Table I-4-1, while the location of boreholes in Fig. I-4-3.

Drilling survey in Ghuzayn area also revealed that in this area, the volcanic rocks and massive sulphide ore bodies show a tendency to strike along northeast-southwest and dipping northwest by 20 to 30°.

On the other hand, the drilling surveys in Daris, Daris North, Daris 3A5 and Fardah areas did not find any massive sulphide ore body.

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 (m)	Average Grade	
			from	to		Cu%	Zn(%)
Ghuzayn Northern Body	MJOB-G3	stockwork(upper)	115.15	133.00	17.85	0.22	0.01
		massive sulphide	133.45	138.60	5.15	4.85	0.04
		massive sulphide	140.00	142.80	2.80	3.77	0.06
		stockwork(lower)	142.80	166.65	23.85	0.40	0.11
		stockwork(lower)	167.15	179.90	12.75	0.59	0.03
		stockwork(lower)	185.35	233.50	48.15	0.27	0.02
		stockwork(lower)	246.10	247.25	1.15	0.30	0.17
		stockwork(lower)	279.50	288.20	8.70	0.15	2.66
	MJOB-G13	massive sulphide	152.80	154.40	1.60	0.17	0.04
Ghuzayn Western Body	MJOB-G5	stockwork	134.00	136.90	2.90	0.33	0.01
		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
		stockwork	171.50	230.50	59.00	0.37	0.32
	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	stockwork	186.30	186.90	0.60	0.14	0.04
		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

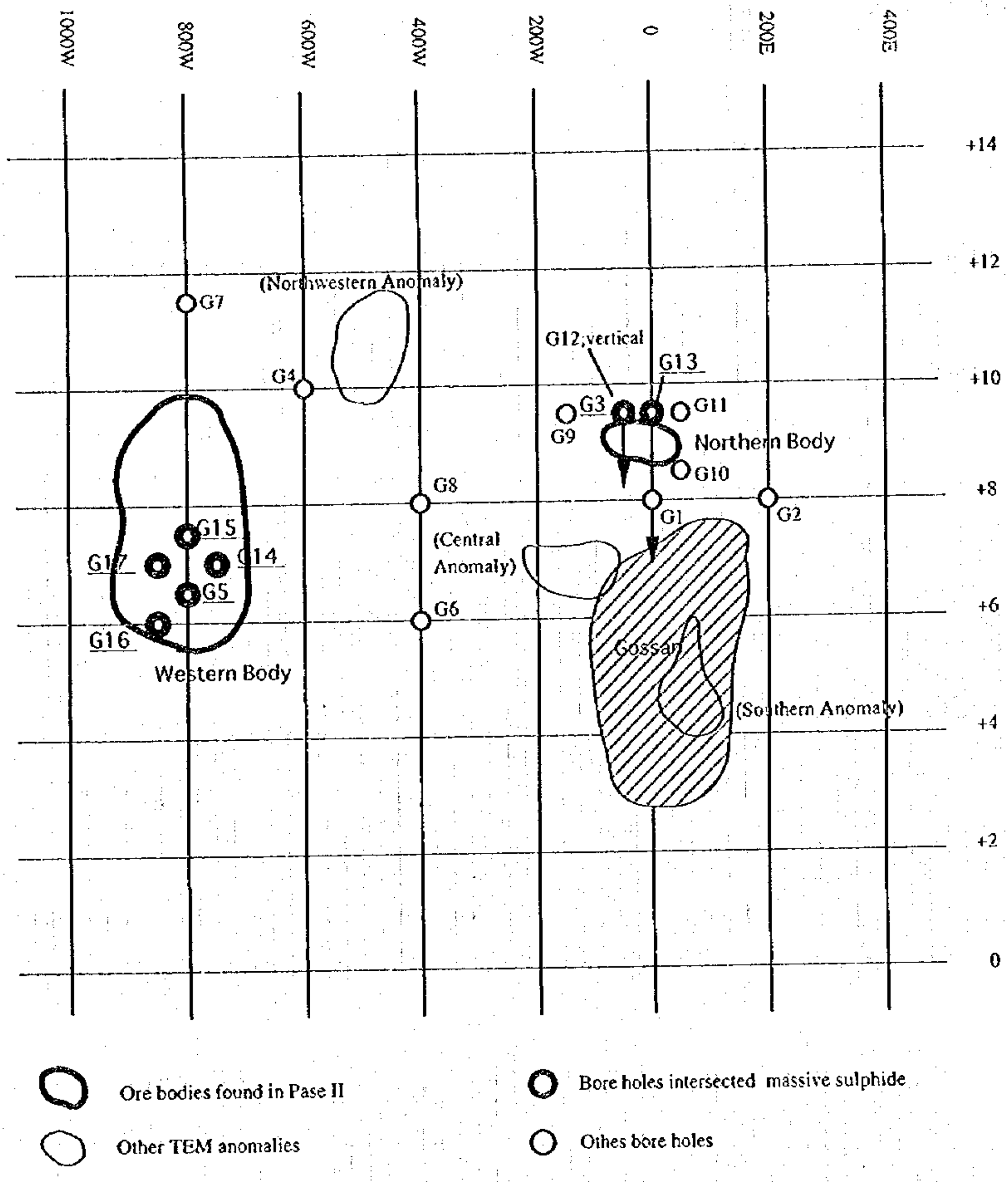


Figure I-4-3 Location map of Ore bodies, TEM anomalies and bore holes in Ghuzayn area

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5-1 Conclusions

The survey results can be summarized as follows:

(1) Drilling survey conducted in Ghuzayn area intersected massive sulphide bodies in two places, i.e., in the northern and western part. The Northern body found to the north of gossan, shows a maximum core length of 7.95m with average assays of 4.66% Cu in MJOB-G3 hole. The Western body found to the west of gossan, shows a maximum core length of 37.1m with average assays of 1.88% Cu in MJOB-G14 hole.

(2) TEM survey in Ghuzayn area highlighted the extension of massive sulphide ore bodies which were intersected in two places by drilling conducted in this Phase. The TEM data show also that the Western body has an extension of 150m wide in east-west direction and 300m long in north-south direction and that the Northern body extends 150m wide in east-west and 100m long in north-south. In addition, TEM data indicate also interesting anomalies which may correspond to high potential locations for massive sulphide mineralization in three places.

(3) In Doqal area, TEM survey was conducted in order to investigate the high metal factor zone detected by TDIP. Since the TEM anomalies extracted in the area correspond well to the high metal-factor zone, it became clear that this area may have a high potential for mineralization of massive sulphide.

(4) Because of the thick coverage of Quaternary sediments, a ground geophysical survey seems to be the most important and effective tool for the exploration of copper deposits in Oman. According to the survey of two years in Central Batinah Coast for the exploration of Cyprus-type massive sulphide deposits, the first step towards the search of these deposits is the utilization of the IP method to cover a wide range. The distribution of prominent IP anomalies permit the extraction of a possible mineralization, which in turns, leads to the second step, i.e., the implementation of a TEM method within the areas delineated by IP method. In addition, the effectiveness can be increased by conducting complemetary TEM surveys by means of small loop(50m x 50m) along with the drilling survey in order to delineate in more detail the extension of ore bodies and allocate better the drilling targets.

5-2 Recommendations

Results of two years surveys show that the Central Batinah Coast area has a high potential for bearing massive sulphide deposits. As a continuation to the exploration program for the project, drilling and geophysical surveys are required in the areas of Ghuzayn, Doqal and Daris area as folows;

(1) Ghuzayn Area

1) Drilling survey is recommended to clarify the details of Northern and Western ore bodies found in this Phase II, along with TEM survey by using small loops(50m x 50m) to delineate in more detail the extension of bodies and to allocate drilling targets.

2) Drilling and TEM small loop surveys are recommended to investigate other anomalies detected by the TEM large loop survey carried out in this phase II.

3) TDIP survey is recommended around the area where TDIP was carried out in Phase I, in order to evaluate the total potential for mineralization in Ghuzayn area.

(2) Doqal Area

1) Drilling survey is recommended to be carried out to investigate the mineralization on the anomalies detected by TDIP and TEM surveys in this Phase.

2) Since TEM anomalies still continue towards north beyond the survey area, it is neccessary to conduct a TEM survey in northern part in order to delineate a more acurate extension of the anomaly zone. In addition, TEM survey is also recommended to be carried out in the western part where IP anomaly shows a continuation.

3) TDIP survey is recommended around the area where TDIP was carried out in Phase I, in order to evaluate the total potential for mineralization in Doqal area.

(3) Daris Area

1) Since the high metal factor zone detected in Phase I during the TDIP survey needs of futher claryfication, it is recommended to continue with TEM survey in selected locations defined by high metal factors detected in the central-western part of this area.

PART II SURVEY RESULTS

CHAPTER 1 OUTLINE OF GEOLOGY OF THE AREA

1-1 Stratigraphy

The geology of the Central Batinah Coast area is composed of Samail ophiolite and supra-ophiolite sediments of allochthonous Samail Nappe and Tertiary and Quaternary formations of post-nappe autochthonous Unit. The stratigraphy of the survey area is shown in Fig.II-1-1.

The Samail ophiolite includes tectonites, a cumulate sequence, a high-level gabbro, a sheeted-dyke complex, Samail volcanic rocks and intrusive rocks from lower part of ophiolite. Within these, the Samail volcanic rocks impregnate a massive sulphide deposits. The survey area in Phase II is mostly covered by Sheeted-dyke complex and Samail volcanic rocks as follows:

1-1-1 Sheeted-dyke complex (SD)

In outcrops, the sheeted-dyke complex appears as a set of sub-parallel dykes of 0.5 to 3 m thick and in general with 5 to 10 cm wide chilled margins, whose composition ranges from microgabbroic to doleritic. The sheeted-dyke complex appears gradually at the bottom of the Lower volcanic rocks.

1-1-2 Samail volcanic rocks (SV)

The Samail volcanic rocks were emplaced during three episodes represented by Lower volcanic rocks (SV1), Middle volcanic rocks (SV2) and Upper volcanic rocks. The Upper volcanic rocks do not appear in the areas.

(1) Lower volcanic rocks (SV1)

The Lower volcanic rocks unit consists of Lower extrusives 1 (V1-1), Lower extrusives 2 (V1-2) and metalliferous sediments (U1). The Lower extrusives 1 and the sheeted-dyke complex bear a gradual relationship. The Lower extrusives 2 conformably overlies the Lower extrusives 1. The metalliferous sediments are observed at the top of the Lower extrusives 1 and/or are intercalated in the Lower extrusives 2.

The Lower extrusives 1 (V1-1) consists of basaltic lavas, and composed mainly by a reddish brown colored big pillow lava of 1.5 m to 2 m size in diameter. The Lower extrusives 1 also consists of reddish brown to grey colored massive lava including sheet flow unit, hyaloclastite and pillow breccia. The pillow lava is aphyric or aphanitic and accompanied with thick interpillow of 10cm to 40cm in thickness. The massive lava shows grey to brownish grey color with a thickness of several 10 cm to several meters. Columnar joints are developed in the thick massive lava.

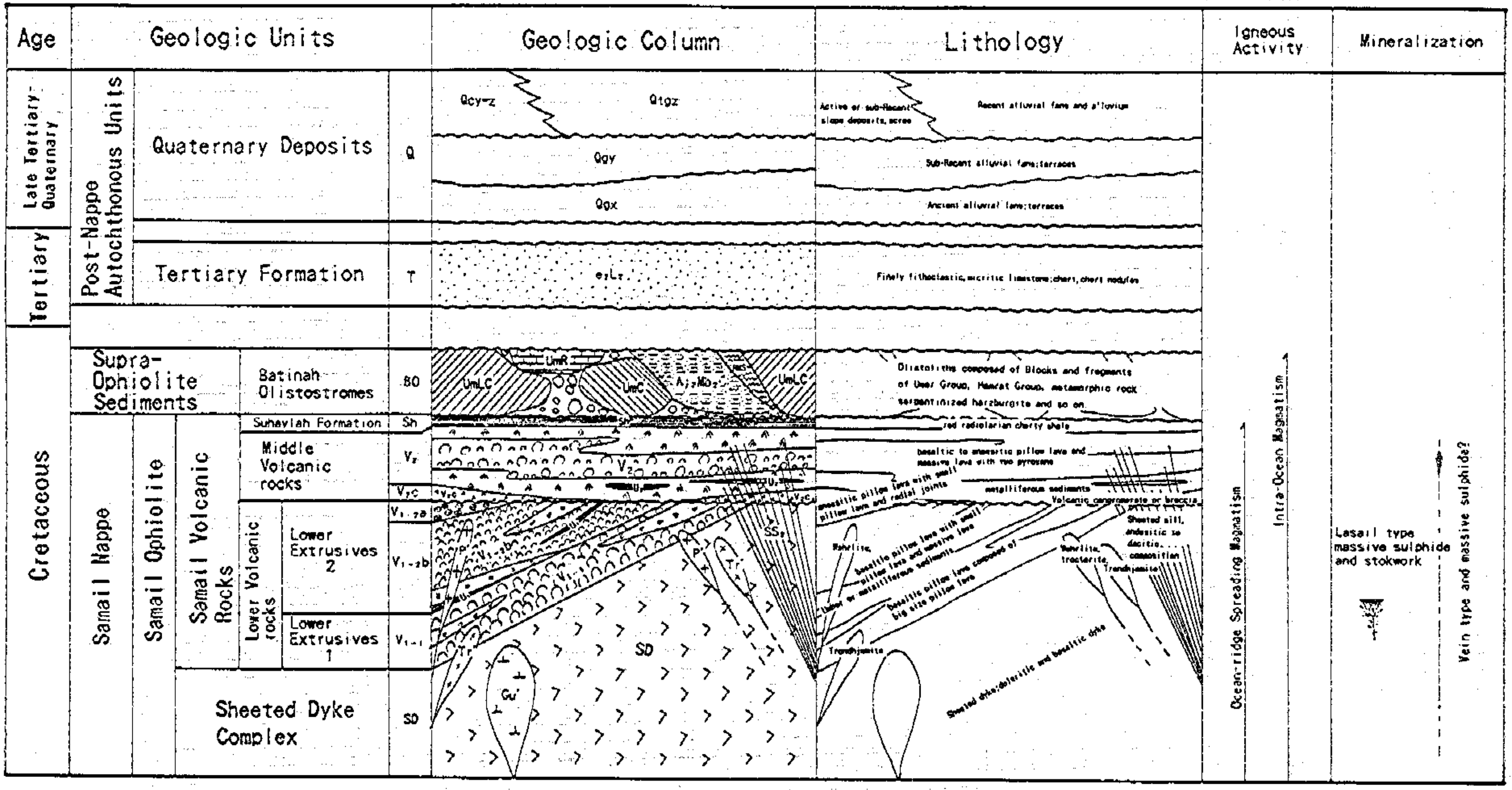


Fig.II-1-1 Stratigraphic columnar section of survey area

The Lower extrusives 2 (V1-2) consists of basalt to andesite and composed mainly of pillow lava acompanied with massive lava. The pillow lava shows light grey to purpulish grey in color with pillow sizes mainly of 10 cm to 1 m in size and maximum of 1.5 m. It is characteristicaly accompanied with small sized pillow lavas of 10 cm to 30 cm in size in many places. This pillow lave, in addition, is phyric and porpyritic and shows a variole-like texture. In contracy to Lower extrusive 1, it is accompanied with thin interpillow of 5cm to 10cm in thickness. The massive lavas show grey to brownish grey color with thickness of several meters. Columnar joints are developed in the thick massive lavas. The upper part of the Lower extrusives 2 includes pillow lavas with radial joints.

Massive sulphide deposits are situated in the contact between V1-1 and V1-2, and seem to be formed on the early time of volcanism of V1-2. This stratigraphic control for ore bodies plays an important role for the exploration activities in the project area and accordingly, it is certainly needed to discriminate between V1-1 and V1-2. Table II-1-1 shows the comparison of pillow lavas of V1-1 and V1-2.

The metalliferous sediments (U1) is the so-called umber which includes many radiolarias. This unit shows dark brown color.

(2) Middle volcanic rocks (SV1)

The Middle volcanic rocks unit (V2) consists of volcanic conglomerate and breccia (V2c), sheeted sills (SS2), Middle extrusives (V2) and metalliferous sediments (U2). The rocks unconformably overlies the sheeted-dyke complex and the Lower volcanic rocks.

The volcanic conglomerate and breccia (V2c) consist of angular to rounded matrices of sand to gravels and of fragments and blocks of sheeted dykes and Lower volcanic rocks.

The sheeted sills (SS2) consist of dykes, sheets and sills of grey-colored andesite to dacite.

The middle extrusives (V2) consist mainly of pillow lavas and massive lavas of andesite containing clinopyroxene and orthopyroxene. Most of the lavas are massive. Those weathered surface show various colors of grey, brownish grey, green, blueish grey, 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 shape and with a diameter of about 0.5 to 1.0 m.

The metalliferous sediments (U2) are the so-called umber and contains many radiolarias. This unit shows brownish black color.

(3) Suhaylah Formation (Sh)

This formation occupies the top of the Samail volcanic rocks and consists of reddish brown cherty shale containing many radiolarias.

Table II-1-1 Comparison of pillow lavas in Samail Ophiolite

Pillow Lavas	Rock Type	Color	Size and Shape	Petrographic Features	Field Observation Features
Pillow lava(V2) of Middle Volcanic rocks	Basalt to andesite	Light green	Size: 0.6m to 2.5m in across. (large sized pillow) Irregular shape.	Sub-ophytic and partially porphyritic textures. Phenocryst: Clinopyroxene and coarse groundmass.	Dominant metalliferous sediment layer. Rugged surface. Amigdaloidal texture.
Pillow lava(V1-2) of Lower extrusive 2, Lower Volcanic rocks	Basalt	Light greenish gray	Size: 0.3m to 0.5m in across. (small sized pillow) Closely packed.	Porphyritic texture. Phenocryst: Clinopyroxene and orthopyroxene	Dominant metalliferous sediment layer. Variole-like texture. Thin interpillows(1cm to 5cm in thickness).
Pillow lava(V1-1) of Lower extrusive 1, Lower Volcanic rocks	Basalt to andesite	Dark brown and greenish brown	Size: 0.6m to 1.2m in across. (medium sized pillow) Round to oval shape, elongated tube with radial cooling joint.	Aphyric and aphanitic texture. Phenocryst: Clinopyroxene	Thick interpillows(5cm to 40cm in thickness).

1-2 Massive Sulphide Deposits in Central Batinah Coast Area

Massive sulphide deposits distributed in the project area are considered to be formed by hydrothermal convection processes in the spreading ridge of the Paleo-Tethys sea during Middle to Late Cretaceous age .

On the basis of the results of exploration project in the northern Oman mountains, Bishimetal(1987) proposed the idea for the formation processes of massive sulphide deposits as follows(Fig.II-1-2):

1) During spreading after the eruption of Lower extrusives1(V1-1), intensive intrusion of dykes occurred around the marginal part of the magma chamber along major normal faults and/or fractures. This intrusion initiated to eruption of Lower extrusives2(V1-2).
2) The intrusion of dykes may have caused local hydrothermal convection around the cluster of dykes, overlaping the pre-existing major convection.
3) This local convection may have provided voluminous hydrothermal fluids containing ore-forming metals which were exhaled to the superficial parts of Lower extrusives 1 and discharged on the seafloor along numerous fractures parallel to the major faults.
4) Ore-forming fluids exhaled on the seafloor precipitated ore minerals and formed a massive sulphide deposits in a relatively large depression formed on an undulating surface of Lower extrusives 1.
5) Then volcanic activities became intense again and above massive sulphide deposits was covered by Lower extrusives 2.

In the project area, massive sulphide deposits of small scale are already found in Ghuzayn, Daris and Daris 3A5 deposits by previous investigations conducted by Prospection Ltd. and BRGM as mentioned below.

1-2-1 Ghuzayn deposit

Ghuzayn deposit is located about 20km south of Al Khaburah in the western edge of the project area. The large siliceous gossan probably corresponds to a completely oxidized stockwork zone emplaced near the contact between Lower extrusives 1 and Lower extrusives 2.

Previous drilling survey conducted by Prospection Ltd. in the vicinity of the gossan during 1975

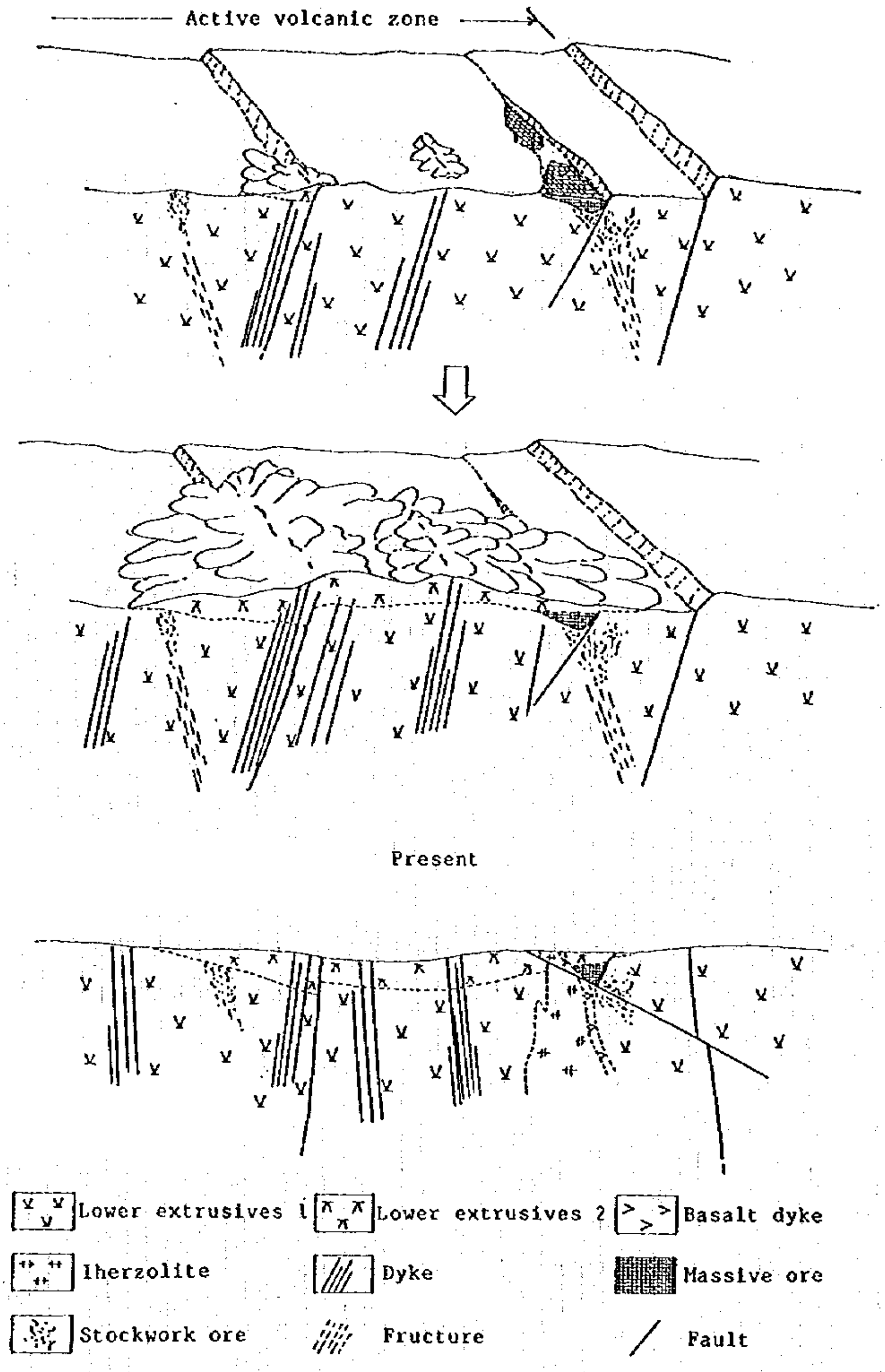


Fig.II-1-2 Schematic formation processes of massive sulphide deposits in Sohar to1977 found a massive sulphide ore body at the depth of about 70m with maximum core length of 19.72m and average grade of 0.2% Cu(Fig.II-1-3 and II-1-4). Stockwork zone composed of pyrite and magnetite stringers were also intersected by these drillings. An estimate reserve of 559,000t at an uneconomic 0.33% Cu was given by this drilling survey(HaddadinM.A.et al, 1983).

1-2-2 Daris deposit

Daris deposit is located in the central part of the project area and about 25km south of As Suwaiq. Small gossan is outcropping in this deposit, in which drilling survey conducted by Prospection Ltd. during 1976 to 1978 confirmed two distinctive mineralized blocks which are the eastern and western blocks(Fig.II-1-5 and II-1-6).

In the eastern block, the top of mineralised part of Lower volcanic rocks occurs as a gossan lying directly below a thin recent overburden. Only small amounts of massive sulphides are locally preserved below weathered Middle volcanic rocks(V2). The primary ore is almost completely oxidized in this block. Prospection Ltd. estimated the reserves of 0.6 Mt at 1.9% Cu.

The western block is downwarped along an inferred fault zone. Two boreholes (DH-12 and DH-26) drilled by Prospection Ltd. intersected a massive sulphide ore body. Drillings conducted later by BRGM in 1986 intersected this ore body by three boreholes of DA-6, DA-8 and DA-9 and encountered the maximum core length of 7m in DA-6 with average assays of 2.36% Cu, 0.15% Zn, 16g/t Ag and 0.86g/t Au. It is confirmed according to the results of these drillings that this orebody is of a small scale and was formed in a narrow (20 to 50 m wide) semi-graben which stretches westwards over at least 200 m. Geological reserves of the western block estimated by BRGM is a 145,000t of sulphide ore averaging 1.95% Cu, 0.21% Zn, 12g/t Ag and 0.6g/t Au.

1-2-3 Daris 3A5 deposit

Gossan with high gold content was found in the area and a drilling survey was carried out around the gossan firstly by BRGM in 1986.

Borehole 3A-3 located 40m north of the gossan, intersected massive sulphide body from 58 to 60.25m in a slightly sheared zone. The 3 m thick (true thickness is 1.5m) sulphide-rich section assays 0.71%Cu, 2.71%Zn, 32g/t Ag and 0.4g/t Au. Borehole 3A-4 was drilled on the same place as 3A-3 by southwestwards inclination and intersected oxidised mineralization from 21.2 to 31.6m in the form of an iron oxide-rich siliceous gossan. The base metal content of this ore is low, but precious metal grades are interesting such as 2.8g/t Au and 28.6g/t Ag over a thickness of 9m. Borehole 3A-2 also intersected an oxidized mineralization, and a 8m thick section assays 3.2g/t Au and 33.5g/t Ag.

After the exploration works by BRGM, the Ministry of Petroleum and Minerals and Oman

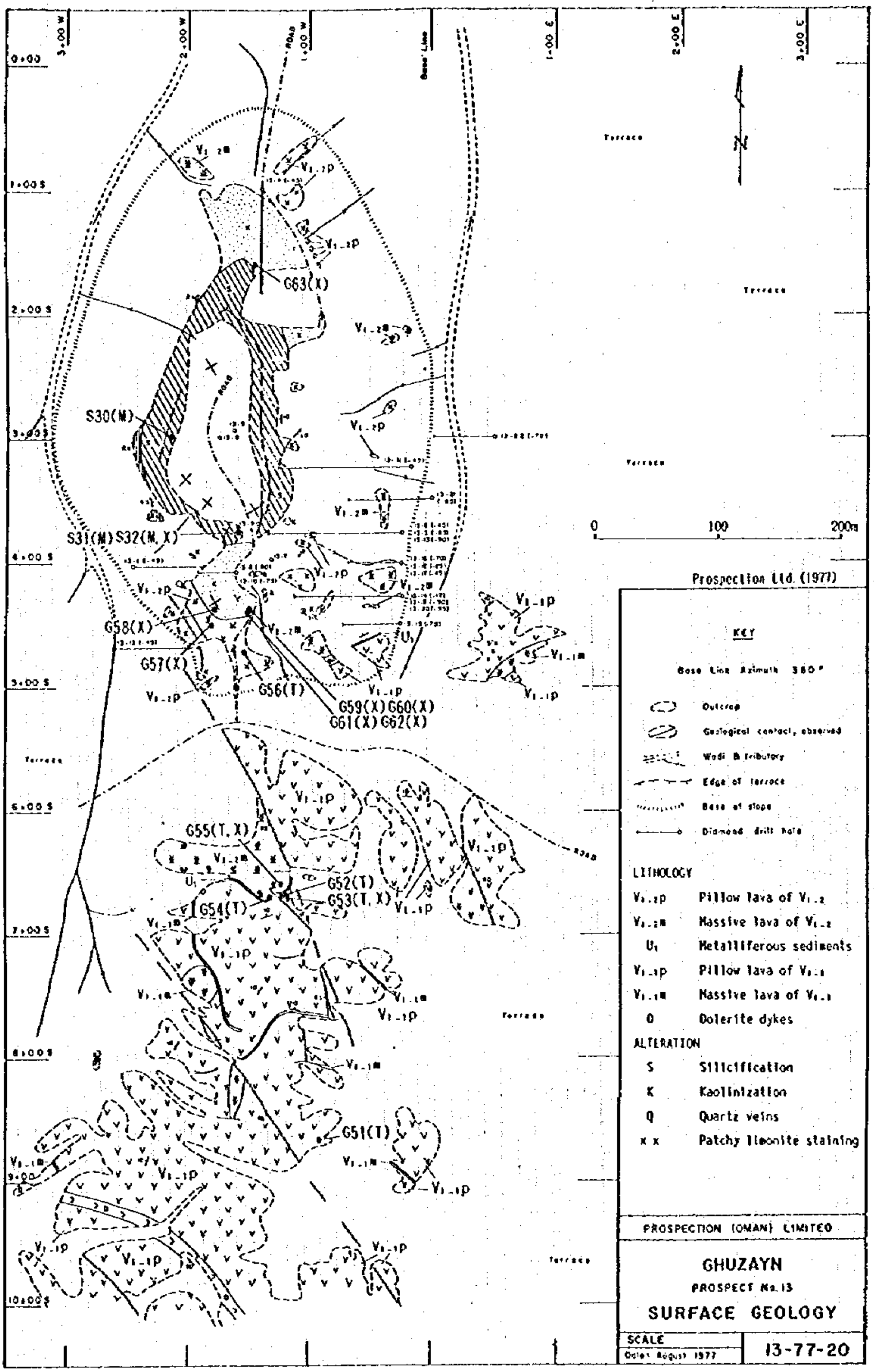


Fig.II-1-3 Geologic map and mineral showing of Ghuzayn Gossan

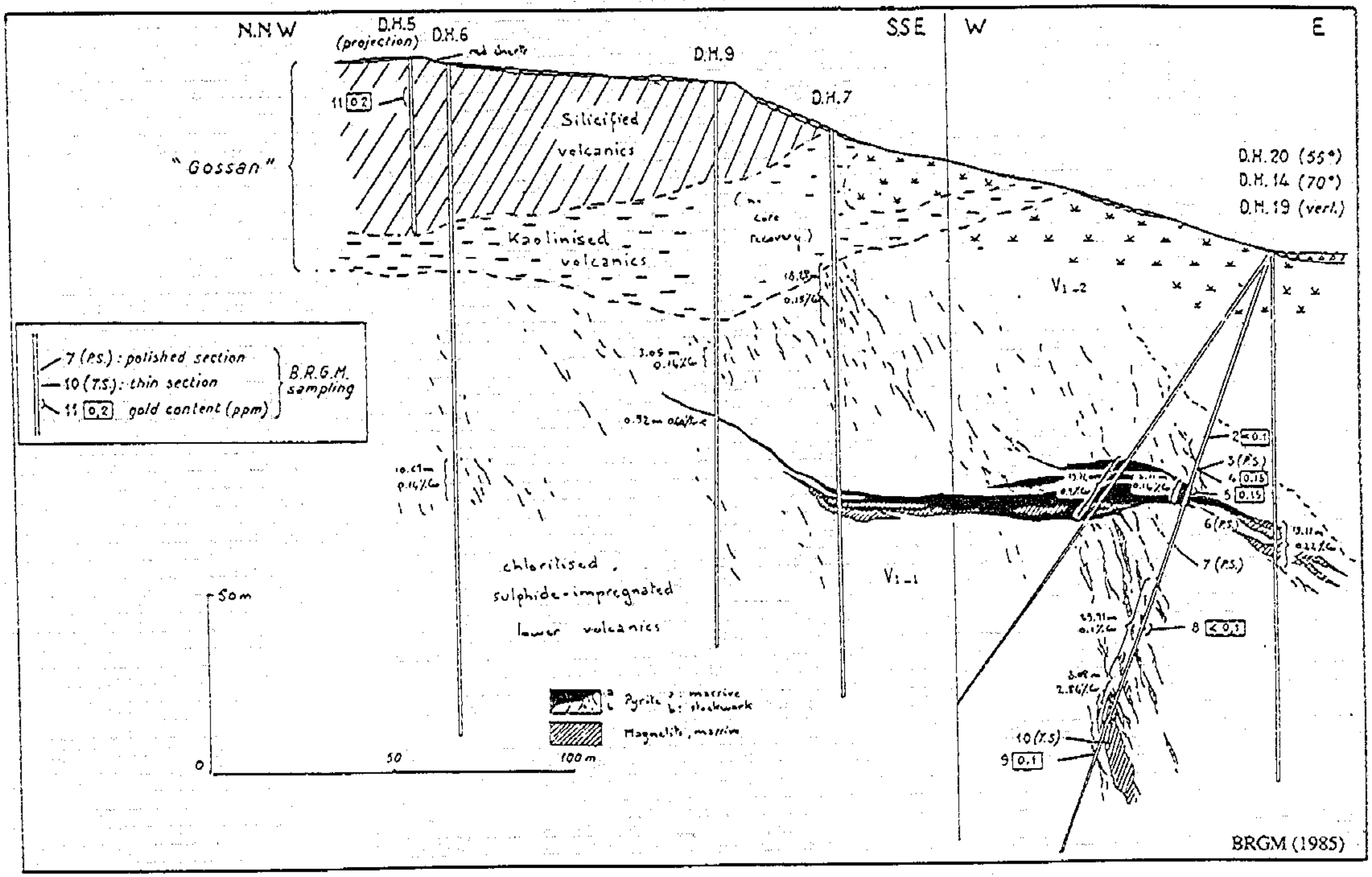
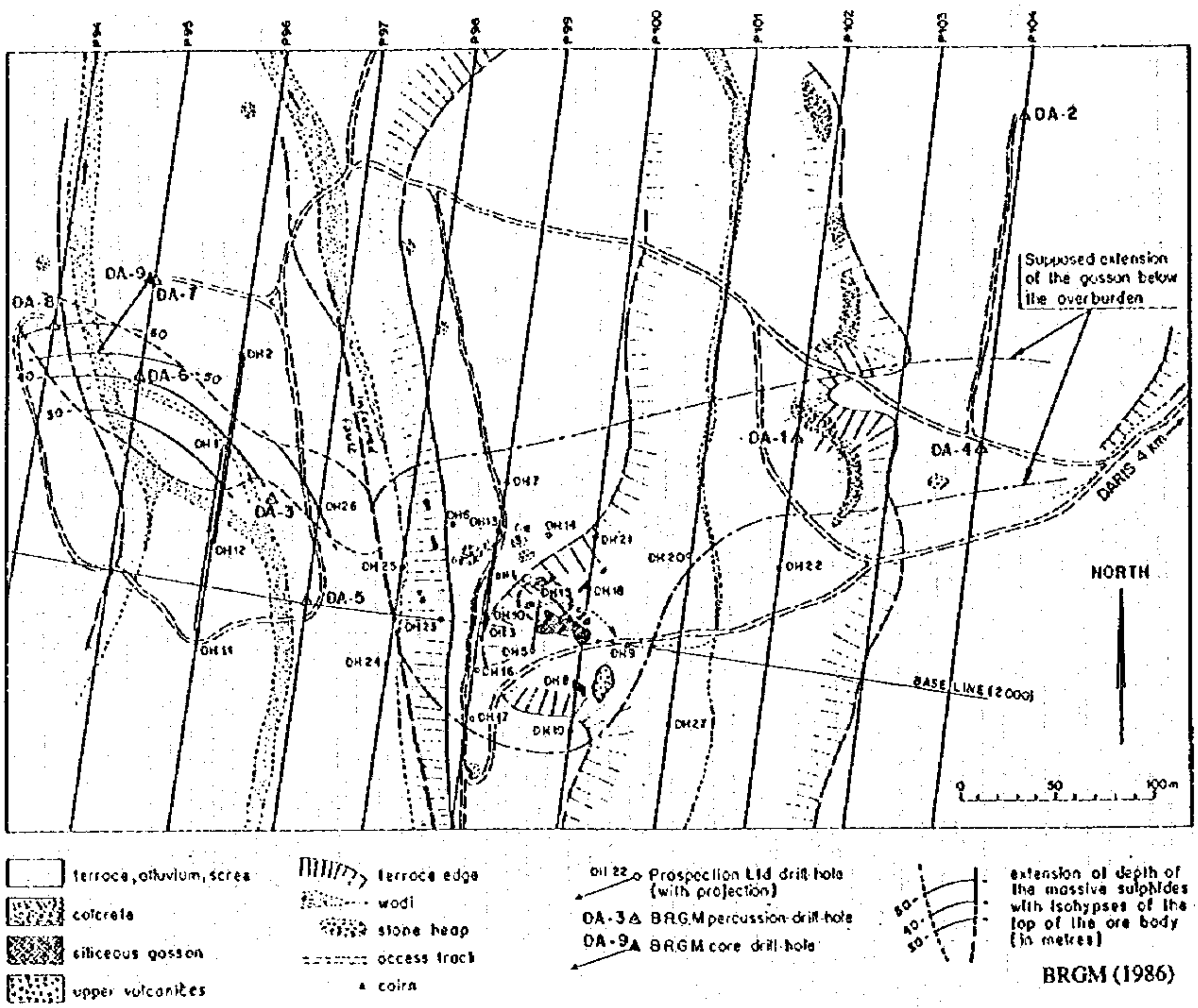


Fig.II-1-4 Geologic profile of Ghuzayn Gossan



BRGM (1986)

Fig.II-1-5 Location map of previous surveys in Daris prospect area

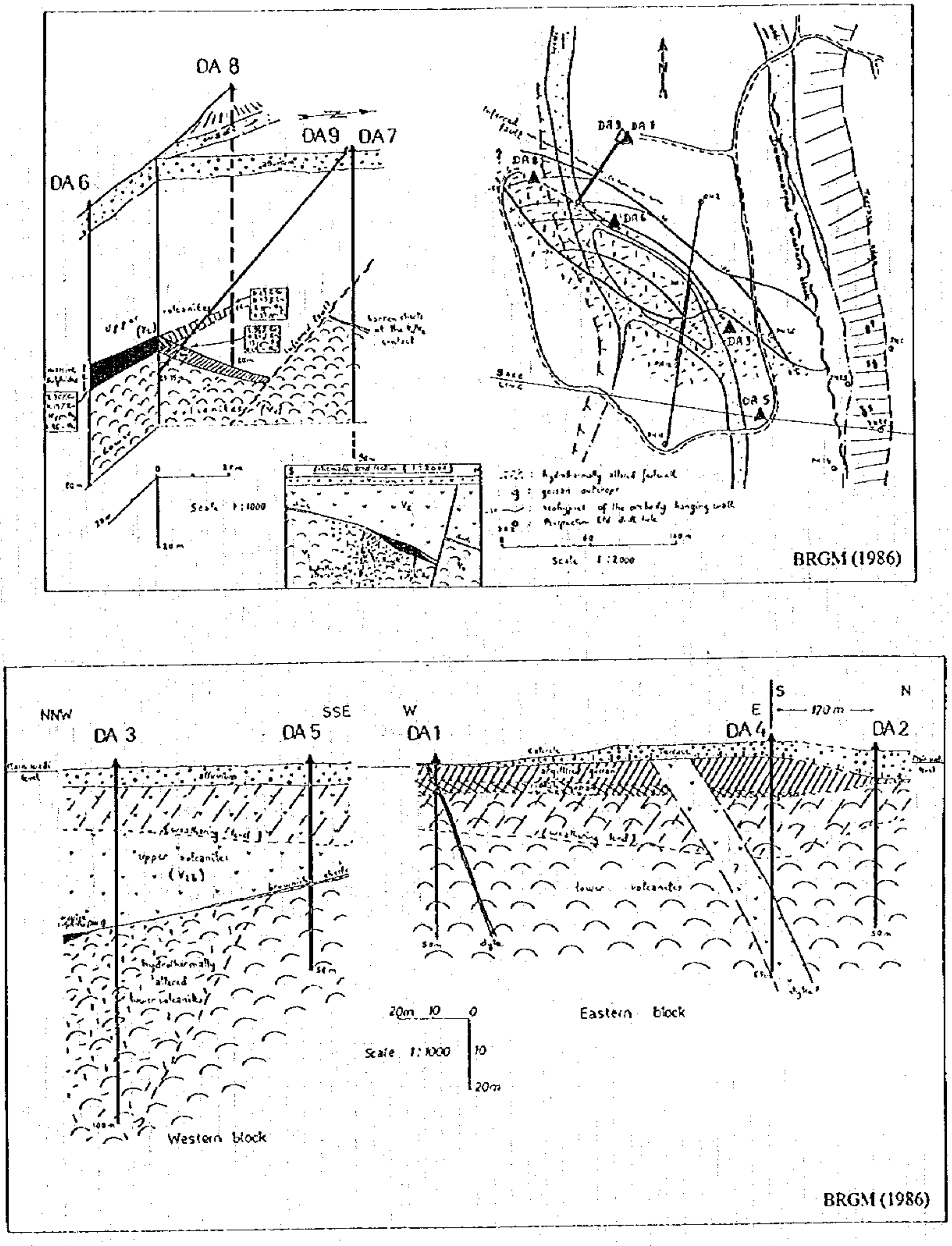


Fig.II-1-6 Cross section of borehole site in Daris prospect area

Mining Company(OMCO) carried out a drilling survey. These survey proved the details of the body dipping northeastwards but thin and small in size as shown in Fig.II-1-7. The estimated ore reserves calculated on the basis of above drilling surveys by OMCO is a 61,146t of massive sulphide ore averaging 5.18% Cu, 0.95g/t Au and a 31,680t of oxidized ore averaging 3.21g/t Au and 0.09% Cu.

1-3 Other Mineral Showings of Massive Sulphide Deposits

New mineral showings accompanied with gossan which seem to be indicating underlying massive sulphide ore bodies were found by the geological survey in Phase I in the areas of Doqal , north of Ghuzayn village, Fardah and Sanah.

Doqal showing is located 10km west of Ghuzayn deposits and to the south of Doqal village. The gossan was found in the Middle volcanic rocks in a narrow zone as shown in Fig.II-1-8. It is a 10m in width and over 600m in length. The 2.0g/t Au and 44.2g/t Ag in maximum were obtained after the analysis of gossan samples in Phase I.

Ghuzayn village north showing is situated 2km northeast of Ghuzayn gossan. As shown in Fig.II-1-9, this showing located near the contact between V1-1 and V1-2 is accompanied by a gossan with oxidized copper and a metalliferous sediment with magnetite. Silicification and argillization can also be observed in the showing.

Fardah showing is located about 12km east of Ghuzayn deposits and near Fardah village. The gossan is found in V1-2 and accompanied by a thick metalliferous sediment of 1km long(Fig.II-1-10). The base of the Tertiary limestone is locally gossanized. White argillaceous zone with a extension of 200m x 200m is also accompanied. Limonitized argillaceous sample shows the contents of small amount of gold and silver.

Sanah showing is situated to the south of Sanah village which is only 4km away from Fardah showing. Conglomerates in the base of the Tertiary limestone overlain by volcanic rocks was gossanized in wide area. The area is a 100m in width and extends more than 900m.

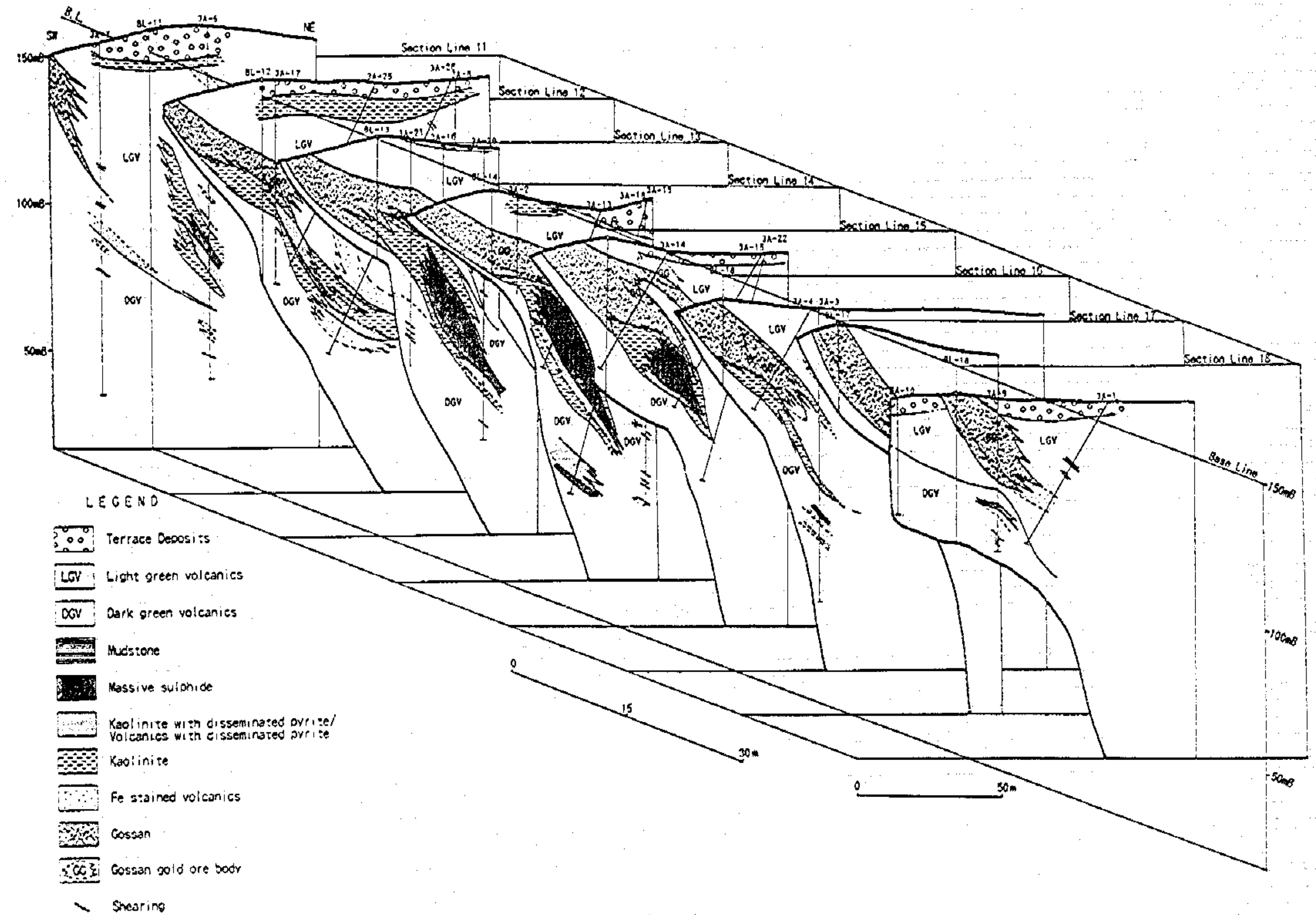
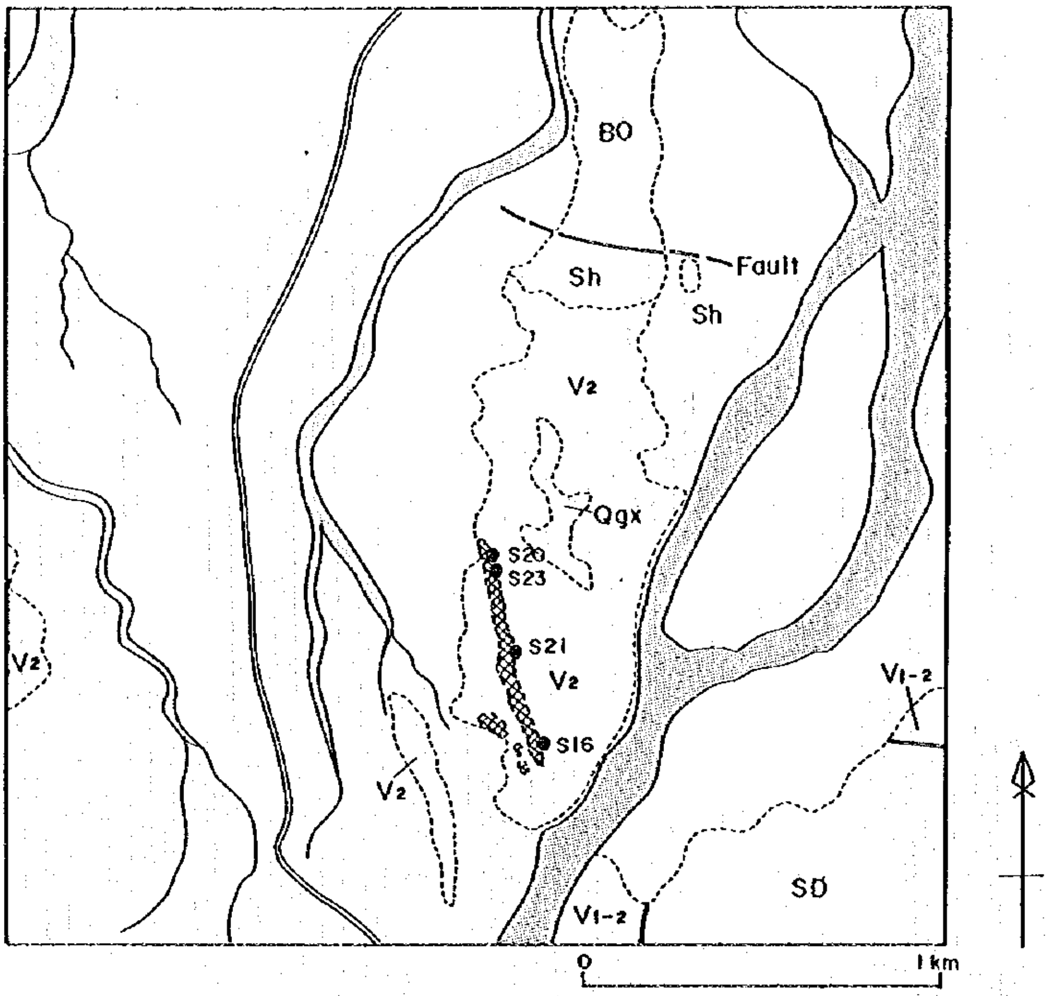


Fig.II-1-7 Panel diagram of Daris 3A5 deposits



LITHOLOGY
QUATERNARY

- Wadi sediments and Sub-recent alluvial fans;terraces
- Qgx — Ancient alluvial fans;terraces

SUPRA-OPHIOLITE SEDIMENTS

- BO — Batinah Olistostromes

SMAIL OPHIOLITE
Samail Volcanic Rocks

- Sh — Suhaylah Formation
- V_2 — Middle Volcanic Rocks
- V_{1-2} — Lower Volcanic Rocks Lower extrusives 2

Sheeted-dyke complex

- SD — Sheeted dykes;dolerite

MINERALIZATION

- Gossan

Other symbols

- ● S20 — Sample location (In Phase I)
- Road
- Wadi

Fig.II-1-8 Mineral showing of Doqal area

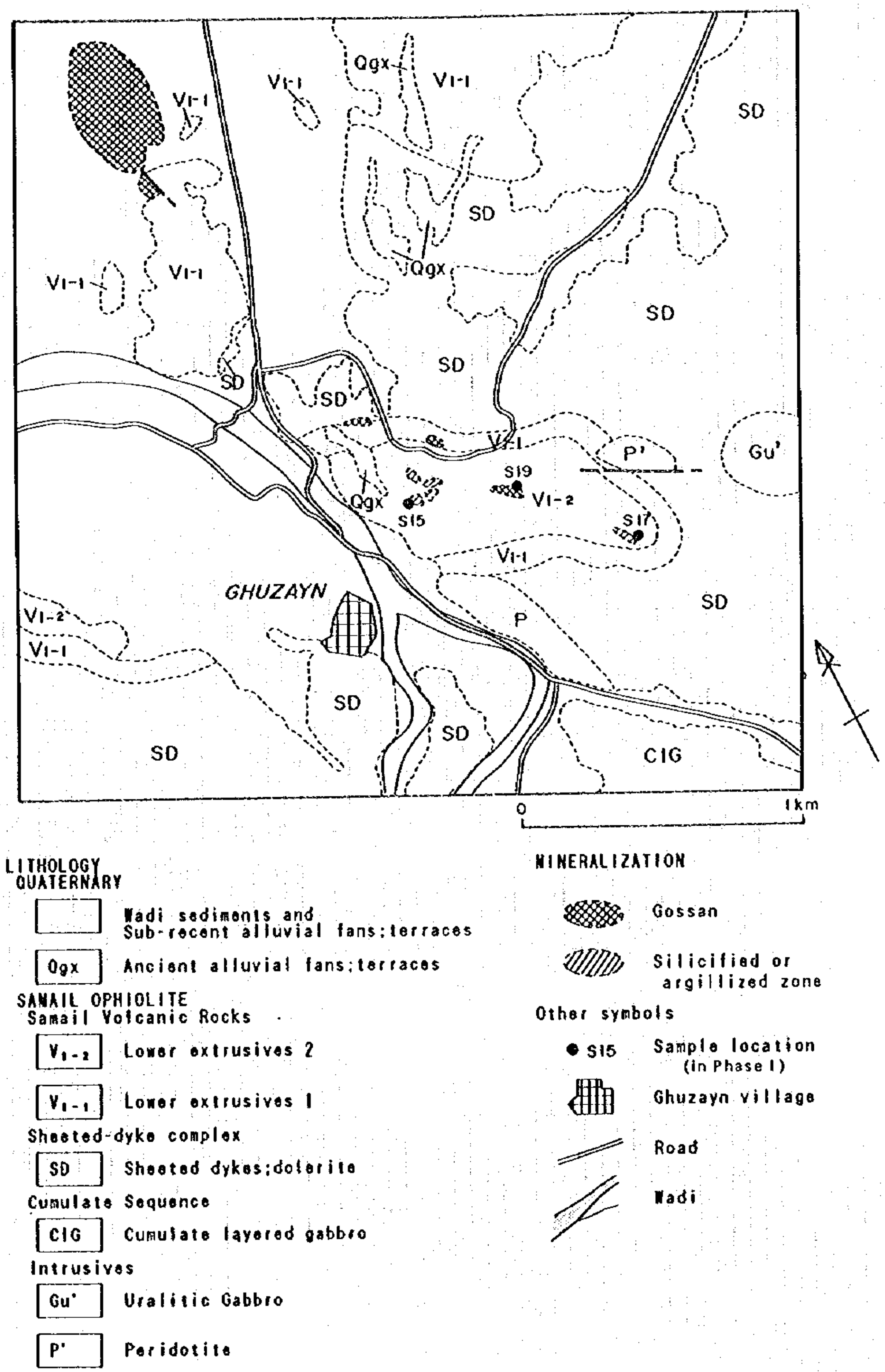
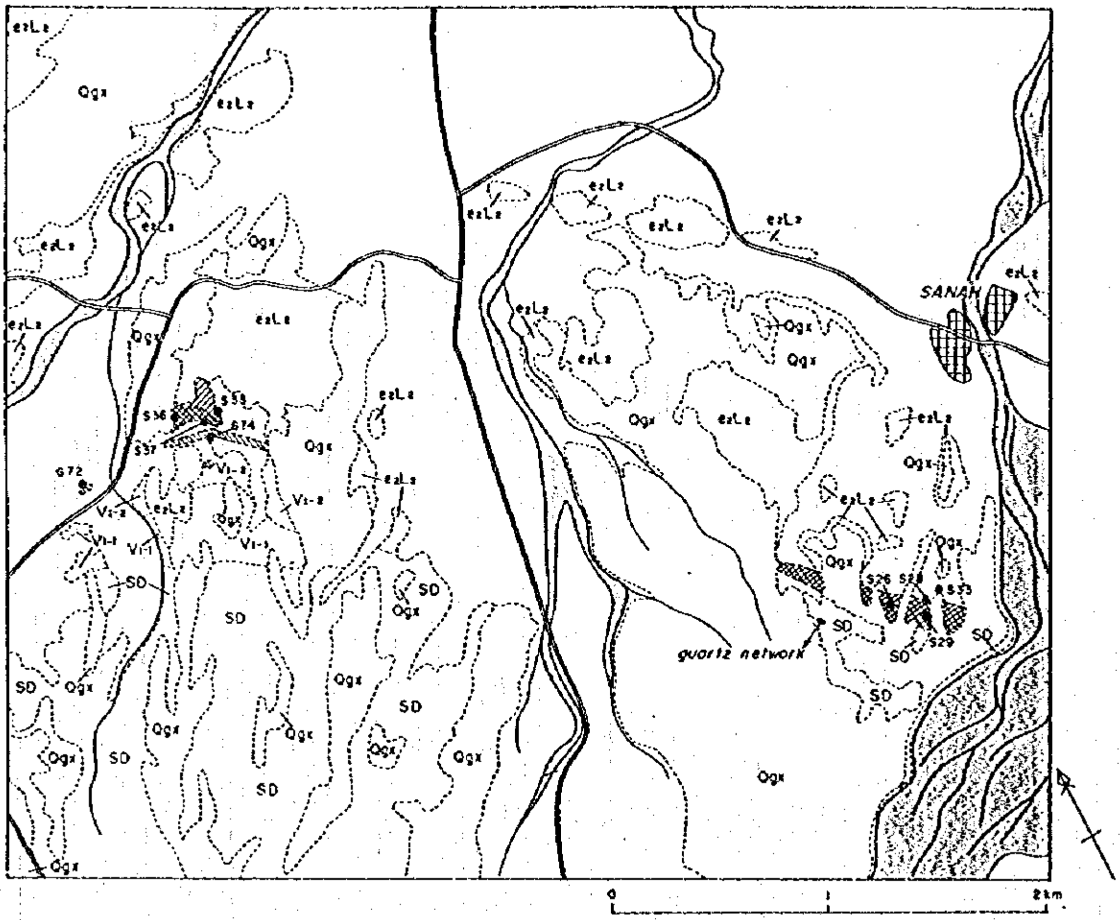


Fig.II-1-9 Mineral showing of Ghuzayn village north area



LITHOLOGY
QUATERNARY

	Wadi sediments and Sub-recent alluvial fans;terraces
Ogx	Ancient alluvial fans;terraces

TERTIARY

e_2L_2	Upper nodular limestone

SAMAIL OPHIOLITE
Samail Volcanic Rocks

V_{1-2}	Lower extrusives 2
V_{1-1}	Lower extrusives 1

Sheeted-dyke complex

SD	Sheeted dykes;dolerite

MINERALIZATION

Gossan

Argillized zone

Gossanized metalliferous sediments

Other symbols

● S36 Sample location (in Phase I)

Road

Wadi

Fig.II-1-10 Mineral showing of Fardah and Sanah area

CHAPTER 2 TDIP SURVEY METHOD

2-1 Objective

Clarify the distribution of the mineralized zone around the mineral showings verified by the geological survey during the First Phase of this project.

2-2 Survey Locations and Specifications

Four survey areas located in the west part of the Central Batinah Coast were selected for further mineral exploration work. These four areas are: Fardah, Sanah, Ghuzayn village North and Doqal. The amounts of survey carried out in these areas are as indicated in the following Table II-2-1.

Table II-2-1 Survey Amounts of TDIP

AREA	LENGTH, Km	NUMBER OF LINES	NUMBER OF POINTS
Fardah	12.5	8 Lines × 1.5 km	368
Sanah	10.5	7 Lines × 1.5 km	322
Ghuzayn village North	3.7	1 Line × 1.5 km 1 Line × 1.6 km 1 Line × 0.8 km	101
Doqal	10.5	7 Lines × 1.5km	322
Total	37.2	25 Lines	1113

2-3 TDIP Survey Method

2-3-1 Procedure

The measurements were carried out by means of 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 field IP surveys, a current is injected into the earth through current electrodes and a 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 charging response is observed in the received waveform.

In order to obtain a desired signal-to-noise ratio, the measurements were, in general, repeated 3 times with a stacking of about 10 times.

2-3-2 Instrumentation

The instrumentation used for the conventional time-domain IP survey are described in the following table:

Table II-2-2 Specifications of TDIP survey instruments

Receiver	Phoenix Multipurpose Receiver V5
Number of Channels	8
Dynamic Range	(+/_)5V
Gain	from 1 to 2,048
Resolution of A/D Conversion	16 bits
Notch Filter	50/60 Hz, 21st order harmonics maximum
Transmitter	Phoenix IPT1
Maximum Output Power	2 kW
Output Current	10 A maximum
Frequency	0.125 Hz, 50 % duty cycle
Generator	Robin
Maximum Output Power	3 kW
Output Voltage	200 V
Output Frequency	50 Hz
Potential Electrode	Non-polarizable Pb/PbCl2 Pot

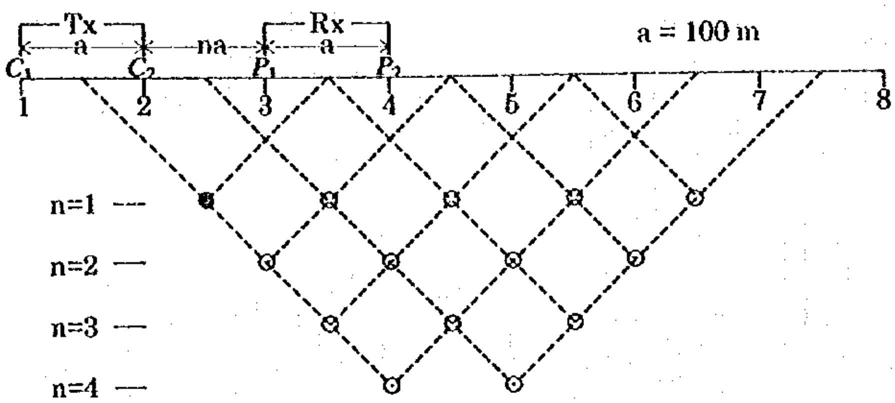


Fig. II-2-1 Dipole-dipole array and plotting procedure

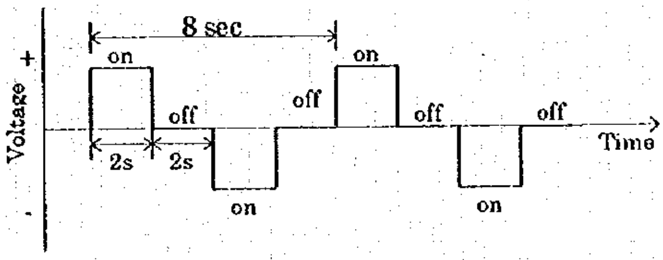


Fig. II-2-2 Waveform produced by the transmitter

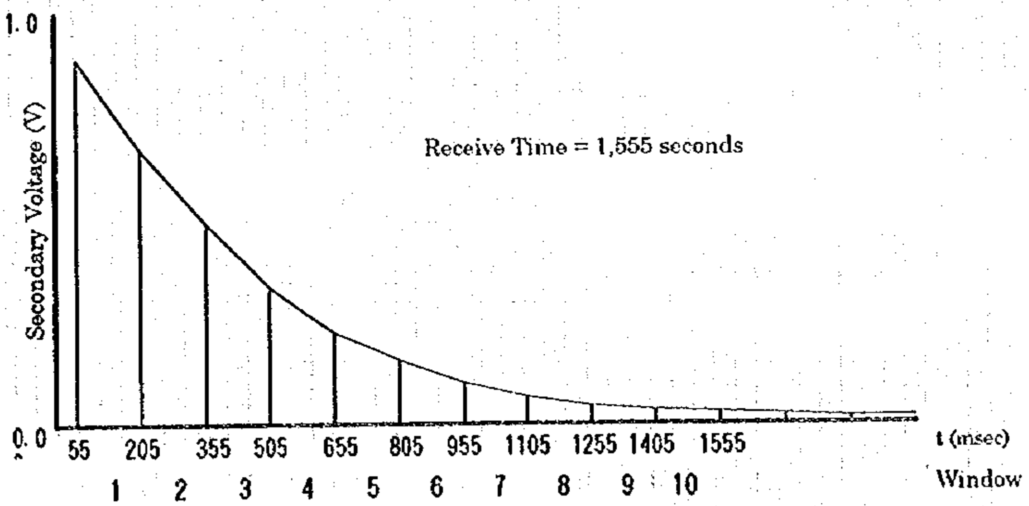


Fig. II-2-3 Sampling interval of the TDIP receiver