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

(PHASE I)

MARCH 1996

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the Government of Sultanate of Oman, the Japanese government decided to conduct a Mineral Exploration in Central Batinah Coast Area Project and entrusted the survey to Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

JICA and MMAJ sent to Sultanate of Oman a survey team headed by Mr. Yoshiaki Shibata from October 10, 1995 to January 9, 1996.

The team exchanged views with the officials concerned of the Government of Sultanate of Oman and conducted a field survey in the Central Batinah Coast area. After the team returned to Japan, further studies were carried out and the present report has been prepared.

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

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

March, 1996

Kimio Fujita
President
Japan International Cooperation Agency

Shozaburo Kiyotaki
President
Metal Mining Agency of Japan

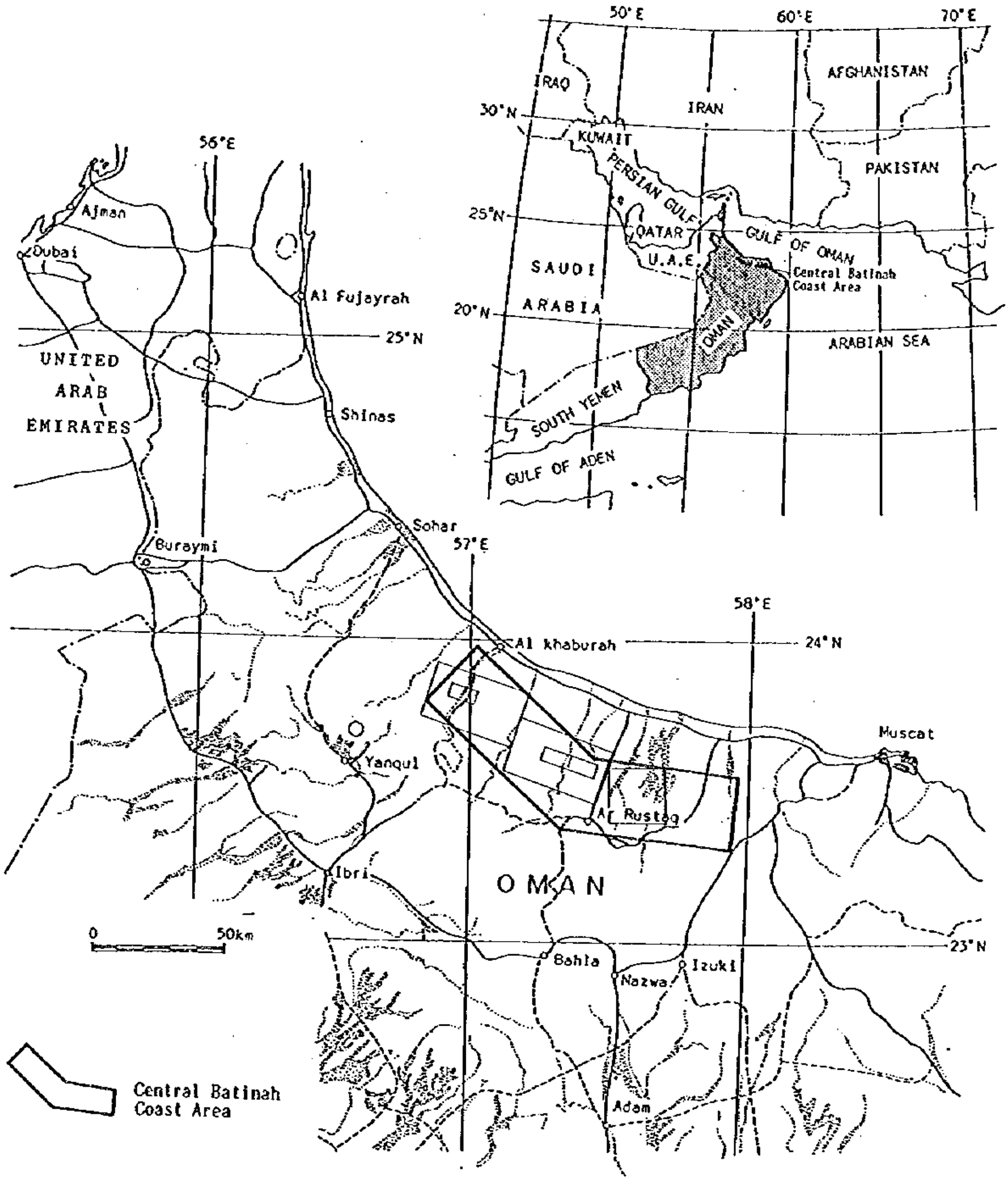


Fig.1 Location Map of the Central Batinah Coast area.

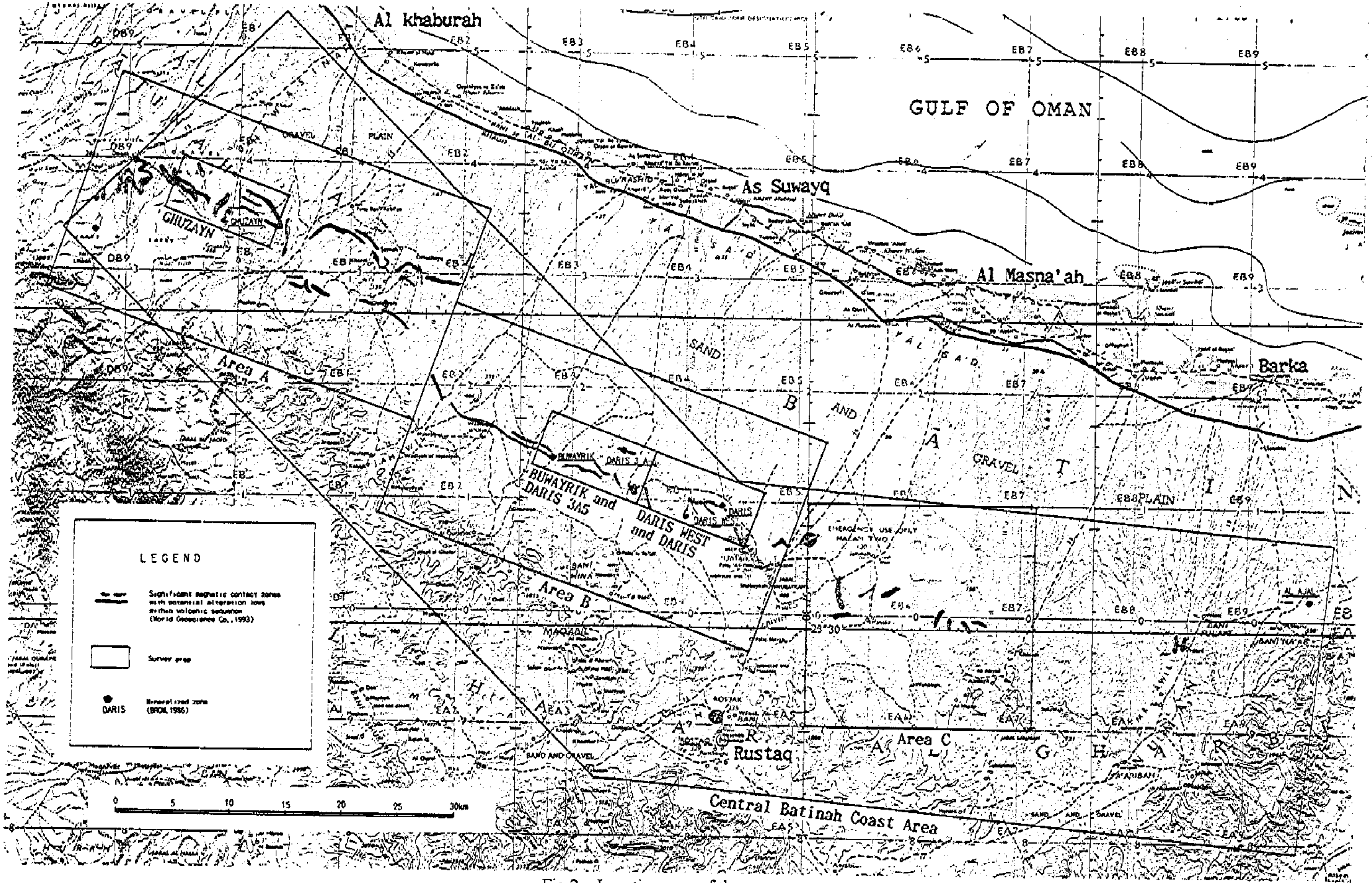


Fig.2 Location map of the survey areas.

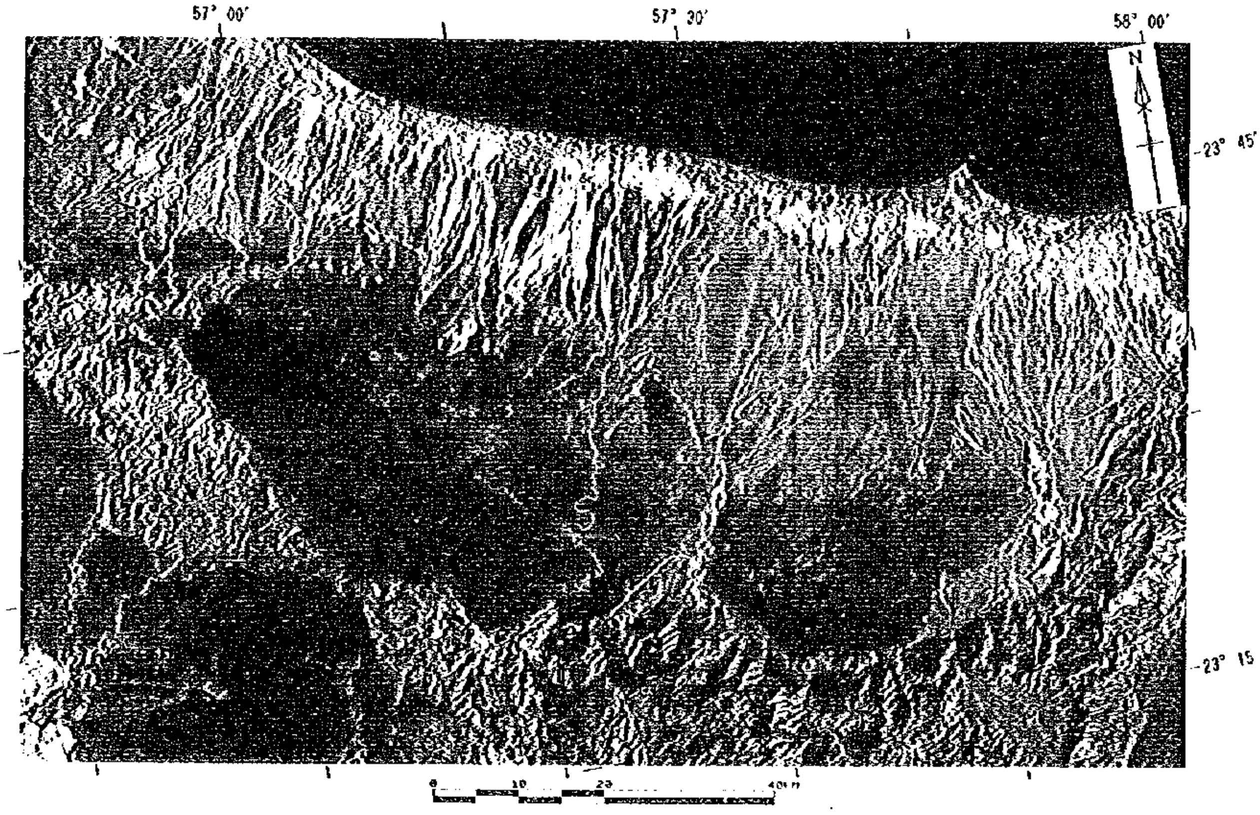


Fig.3 Landsat image of the Central Batinah Coast area.

ABSTRACT

The Goverment of Sultanate of Oman and the Goverment 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 potencial of the survey area.

This report includes the survey results of the first year (Phase I).

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.

Reconnaissance and semi-detailed geological surveys and geophysical surveys including TDIP method and TEM method were conducted in this Phase. These geophysical surveys were conducted in Ghuzayn, Daris 3A5 and Daris areas selected by the semi-detailed geological survey.

Since the massive sulfide 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. However, the sheeted-dyke complex 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 areas, new gossans were found in the Doqal, Fardah, Sanah, north of Ghuzayn village and Qulayyah areas. The samples in Doqal and Fardah areas show contents of gold and silver.

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

TEM survey was carried out to the anomalies detected by IP survey. As a result, TEM anomalies were found in the north and west of Ghuzayn gossan , the north and northwest of gossan in Daris, and in the east and west of Daris prospect area.

On the basis of the results of Phase I, it is recommended for the Phase II of this project, to conduct a drilling survey on the locations where the TEM anomalies were detected in Ghuzayn and Daris areas and on the location of the IP anomalies in Daris 3A5 area. It is also recommended to conduct geophysical and semi-detailed surveys in the areas where gossans were newly found.

CONTENTS

PART I GENERAL

PART II SURVEY RESULTS

PART I GENERAL

CHAPTER 1 INTRODUCTION

1-1 Background and Objectives

This survey is 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 aims at discovering new mineral deposits in the Central Batinah Coast area by clarifying the geological setting and existence of mineral deposits.

Several exploration works have been 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 deposits in very wide range. Therefore, it is important subject of exploration in this area how to investigate efficiently the underlying part of the sediments.

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 consists of three areas, which looking from west to east they are: Area A, Area B and Area C. The location of the survey areas is shown in Figs. 1 and 2.

The survey in this year consists of geological survey and geophysical survey. The geological survey consisted of a reconnaissance geological survey in the 3 areas of A, B and C areas above mentioned, and a seim-detailed geological survey in Ghuzayn area of the Area A, in Buwayrik area, Daris 3A5, Daris West and Daris areas of the Area B. The geophysical survey was carried out by using the IP and TEM methods within the areas covered by the semi-detailed geological survey.

Survey amounts of the geological and geophysical survey and numbers of the laboratory samples are indicated respectively in the Tables I-1-1 and I-1-2.

Table I-1-1 Content and amount of field work

AREA AND CONTENT	AMOUNT OF WORK	
1. Geological Survey	Survey Area	Survey Route
(1) Detail survey Area-A, Area-B, Area-C	1800 km^2	50 km
(2) Semi-detail survey Ghuzayn , Buwayrik-Daris 3A5 and Daris-Daris west Area	150 km^2	81 km
2. Geophysical Survey	Total line length	Number of measurements
(1) IP method Ghuzayn, Buwayrik-Daris 3A5 and Daris-Daris west Area	116 km	3,958 points
(2) TEM method Ghuzayn, Buwayrik-Daris 3A5 and Daris-Daris west Area	10 km	243 points

Table I-1-2 Content and amount of laboratory work

LABORATORY WORK	AMOUNT
1. Geological Survey	
1) Thin section	21 samples
2) Polished section	20 samples
3) X-ray diffraction analysis	22 samples
4) Chemical analysis	
Ore Assay (8 elements :Cr,Mn,Fe,Cu,Zn,Ag,Au,Pb)	56 samples
2. Geophysical Survey	
1) Resistivity measurement	21 samples
2) Polarizability measurement	21 samples

1-3 Members of the Project

The members of the project are as followings:

(1) Project planning and negotiation

<u>**Japanese Counterpart**</u>

Atsuhiko Minowa	Metal Mining Agency of Japan
Nobuyasu Nishikawa	Metal Mining Agency of Japan
Kazuko Matsumoto	Japan International Cooperation Agency

<u>**Omani Counterpart**</u>

Mohammed bin Hussain Kassim Ministry of Petroleum and Minerals
Hilal Mohamed Sultan Al-Azri Ministry of Petroleum and Minerals
Said Salim Al Fori Ministry of Petroleum and Minerals
Salim Omer Abdullah Ibrahim Ministry of Petroleum and Minerals

(2) Inspection of field work

Katsuhisa Ono	Metal Mining Agency of Japan

(3) Field work

<u>**Japanese Counterpart**</u>

Yoshiaki Shibata	Team leader	Bishimetal Exploration Co., Ltd.
Motomu Goto	Geological survey	Bishimetal Exploration Co., Ltd.
Toshimasa Tajima	Geophysical survey	Bishimetal Exploration Co., Ltd.
David Escobar	Geophysical survey	Bishimetal Exploration Co., Ltd.
Junichi Sasaki	Geophysical survey	Bishimetal Exploration Co., Ltd.
Tosio Kasagi	Geophysical survey	Bishimetal Exploration Co., Ltd.
TakeharuTakahashi	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
Hussain Abubaker Al-Zubaidy	Geophysicist	Ministry of Petroleum and Minerals

1-4 Survey Period

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

Geological survey:

Field work	October 10,1995	to	December 30,1995
Compilation work	December 31,1995	to	January 6,1996

Geophysical survey:

Field work	October 10,1995	to	December 30,1995
Compilation work	December 31,1995	to	January 6,1996

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 300,000 km^2. The population is approximately two millions and the capital city is Muscat (Fig. 1).

The area is located in the west of the capital city of Muscat and has an extension of about 3,300 km^2 running parallel to the Oman Mountains and the Gulf of Oman. The central point 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 on the National Highway No. 1 driving along coast line from Muscat to As Suwayq, near the central part of the survey area.

2-2 Tpography and Draninage System

The survey area consists of a hilly land between an altitude of about 100m and 1,000m, forming the foot of the Omain 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 rains 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, Hawasina Nappe and Samail Nappe assumed to have thrust over the Autochthonous to Parautochthonous units, Post-Nappe units and Quternary 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 consist 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 cnsisting of conglomerate, breccia, limestone, sandstone and chert.

Hawasina 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 Formation, and are cropping out in 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 coprised 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 structual 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 Brief history of mining

The Oman Mountain 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. the contract for a copper exploration program in an area of 8,000 km^2 surrounding the Sohar smelter. Investigations were carried out for a period of 4 years up to 1987 and some ore reserves were newly obtained in and around the known deposits, and at the same time, many mineralized zones were confirmed.

On the other hand, 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 confinnation of several mineralized zones near the village of Hayl as Safil, located at the foothills of the

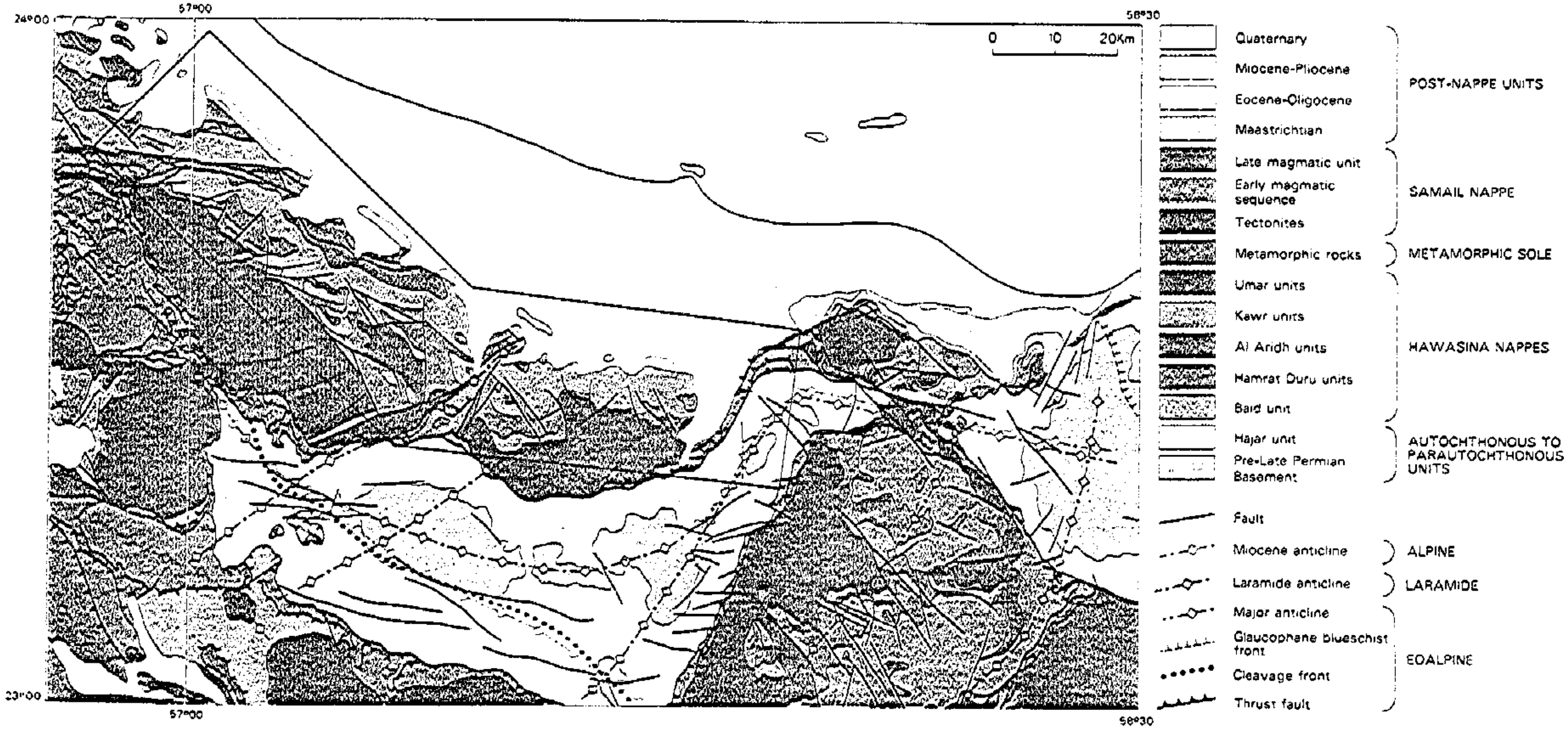


Fig. I -3-1 Geologic map of the Central Batinah Coast area.

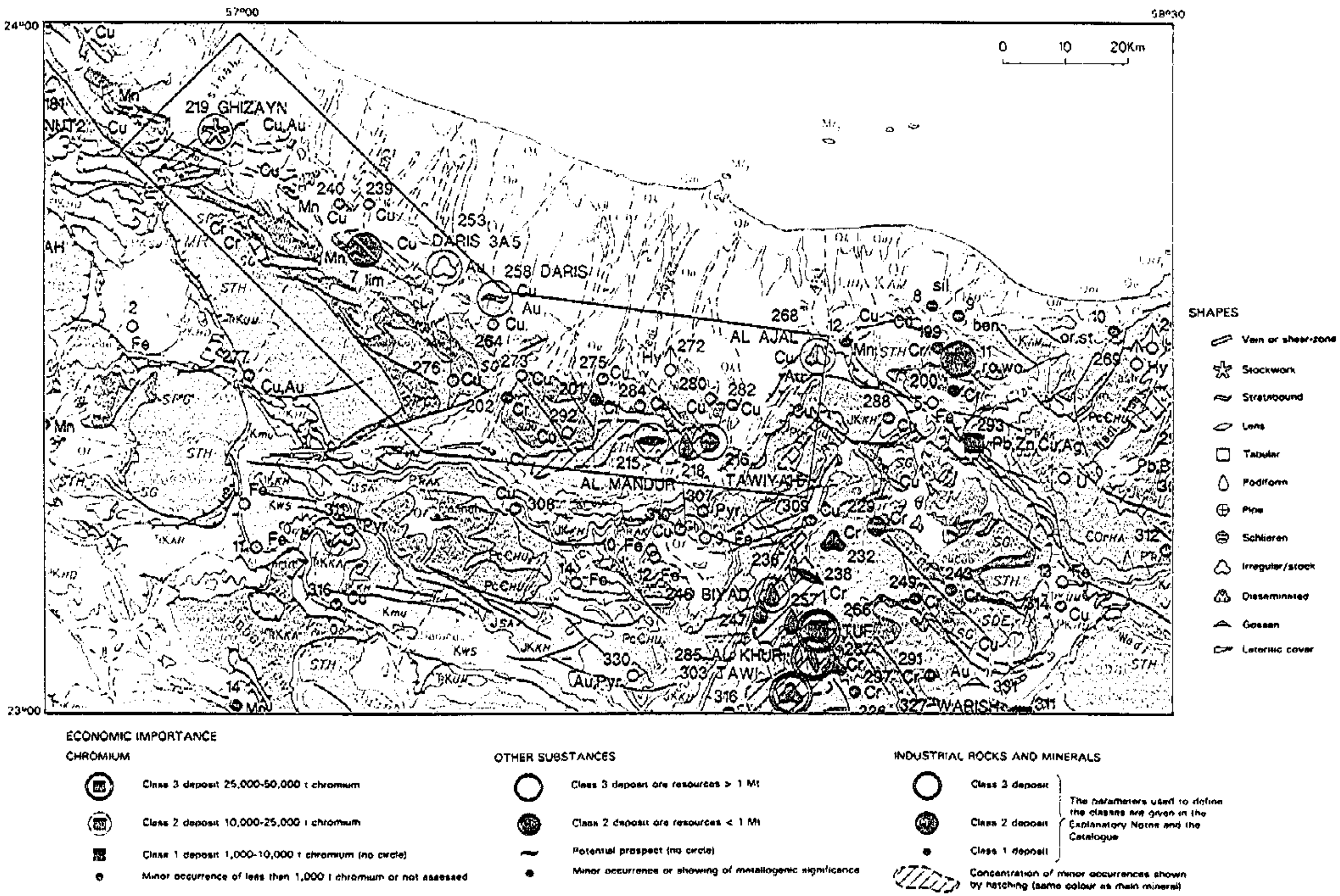


Fig. I -3-2 Mineral occurrence and metallogenic map of Central Batinah Coast area

Table I-1-3 List of mineral deposits and showing in the survey area

BASE AND PRECIOUS METAL OCCURRENCES

Number in map	Occurrence name	Surface	Type	Size	Strike (°)	Dip (°	Host	Miner. (%)	Status	Resourc (ore:Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Class
*219	GHIZAYN	gossan	stock	-	-	-	SE1/SE2	-	0	0.55	0.33	-	-	2
239	--	listwen	-	-	-	-	-	-	0	-	-	-	-	0
240	W MABRAH	jasper	vein	5x0.5	170	90	SE2	-	0	-	-	-	-	0
*253	DARIS 3A5	gossan	massive	30x10	25	80E	SE2	Zn Mn	0	0.1	-	2/3	30	2
*258	DARIS	gossan	stratab	20x5	-	-	SE2	Zn	0	0.145	1.95	0.6	12	2
264	FALAJ WUSTAH	gossan	vein	-	-	-	SD	-	0	-	-	-	-	0
*268	AL AJAL	gossan	stock/massive	200x50	165	-	Hawasina	Zn0.15	0	0.5	0.9	2.5	18	2
273	MAZAHIT NE	slag	-	-	-	-	mant seq	-	1	-	-	-	-	0
275	MAHYUL	-	shz	-	-	-	gabb/cuml	-	0	-	tr	-	-	0
276	W FALLAH	slag	shz	-	-	-	mant seq	-	1	-	-	-	-	0
280	AFI W	slag	shz	-	-	-	SD/gabbro	-	0	-	-	-	-	0
282	AFI	slag	shz	-	-	-	cumul seq	-	0	-	-	-	-	0
284	W. AL ABYAD	staining	shz	-	-	35NE	gabb/cuml	-	0	-	tr	-	-	0
292	BANI SUQ W	coating	-	-	-	-	cumul seq	-	0	-	tr	-	-	0

CHROMITE OCCURRENCES

Number in map	Occurrence name	Size (m)	Type	Strike (°)	Dip (°	Host	Position	Miner.	Status	Resour ore 000t	Access	Cr2O3 (%)	S.G.	Cr/Fe	Class
201	AL GHYAYL	2 x 15	lens	155	90	harzbur	harzbur	M	0	<100	E	40	-	-	0
202	RUSTAQ		pod	-	-	-	mantle sq	M	0	n.e.	E	-	-	-	0
215	AL MANDUL	10 x 115	pod/lens	90	80N	dun/harz	harzbur	D	0	60.00	E	31.50	3.4	2.25	2
216	TAWIYAH south	30 x 60	pipe	140	-	dunite	mantle sq	M	0	40.00	E	31.50	3.5	2.14	2
218	TAWIYAH, NAKHL	60 x 4	pod	140	-	dunite	harzbur	M	1	5.00	E	38/25	-	-	1

INDUSTRIAL ROCKS AND MINERALS OCCURRENCES

Number in map	Occurrence name	Host	Type	Stratigraphy Unit	Stratigraphy Group	Application	Reserves Mt min	Reserves Mt max	Class
7	AK KHADRA	Limestone	Limestone	Hawasina	Hamrat Duru Gr.	Chemical/Filler	0.3	1	2

Status:
- 0: unexploited
- 1: abandoned
- 2: operating mine

Mineralization:
- M: massive
- D: disseminated

Access:
- E: easy
- D: difficult

Class for base and precious metals:
- 3: large deposits
- 2: small deposits
- 1: interesting prospect
- 0: minor occurrences of metallogenic interest

Class for chromite:
- 3: ozer 90,000t
- 2: 35,000t to 90,000t
- 1: 3,500t to 35,000t
- 0: below 3,500t or unknown

Class for industrial rocks and minerals
- 3: large deposits
- 2: small deposits
- 1: interesting prospects
- 0: minor occorrences

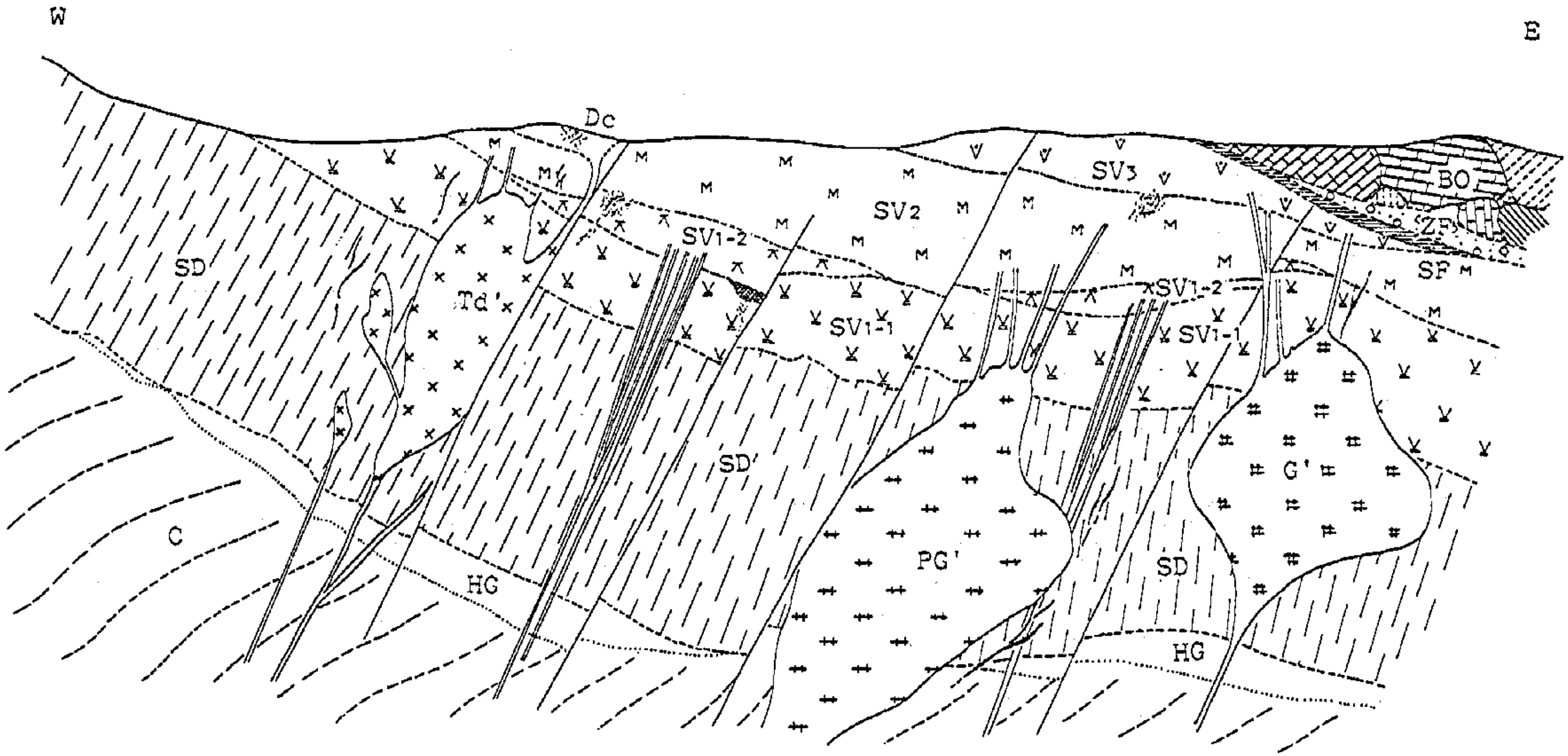
S.G.: specific gravity of ore

Type: vein: vein
- shz : shear-zone
- stratab: stratabound
- stock: stockwork
- dissemin: disseminated

Host: Hawasina: Hawasina Nappe
- cumula sq: Cumulate sequence
- mantle sq: Mantle sequence
- SD: Sheeted dyke
- SE1: Lower Samail volcanics (Lower extrusives)
- SE2: Upper Samail volcanics (Upper extrusives)
- gabb: gabbro
- harzbur: harzburgite

Cr/Fe: chromium iron ratio

(After BRGM, 1994)



C : Cumulate sequence
HG: High-level gabbro
SD: Sheeted-dyke complex
SV_{1-1} : Lower extrusives 1
SV_{1-2} : Lower extrusives 2
SV_2 : 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 -3-3 Schematic distribution of Samail Volcanic Rocks and mineralization in Sohar area.

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 said 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.

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 some satellite ore bodies have been confirmed in the periphery of the known deposits.

Furthermore, to reconsider the results of the exploration works already carried out, the Government of Oman did 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 extracted.

On this basis, investigations consisting mainly of geophysical surveys have been commenced since 1995, and therefore, the present cooperative survey was also established as a part of the investigations.

CHAPTER 4 SURVEY RESULTS

4-1 Geological Survey Results

Previous studies on massive sulfide deposits in Oman corresponding to Lasail and Bayda deposits in Sohar provide the following ideas as survey hypothesis:

(1) The deposit occurs along a contact between the Lower extrusive rocks 1 and 2 of the clasification by Bishimetal (1987).

(2) The central part of large deposits shows relatively low magnetic values caused by the demagnetization related to alteration. It is expected that the magnetic values will provide more information to define interesting areas.

(3) Since the shape of the deposits was affected by the sea floor topography, the time of deposition of the deposit should also be taken into consideration.

(4) Two types of deposits are present: one is consisting mainly of massive ore and the other of stockwork ore. It is likely that these deposits depend on the difference of sedimentary conditions on deposition.

(5) It is important to clarify the zonal arrangement, changes in mineral combinations of ore and texture of minerals within ore bodies.

Geological survey was carried out on the basis of the above hypothesis, especially (1) and (2) for the Phase I. About the magnetic features indicated in (2), significant magnetic contact zones with potencial alteration lows were extracted in the area by the airborne geophysical survey mentioned before. Therefore, the areas in and around these zones were considered as the most potencial areas and in these regards, Area A, Area B and Area C were selected for the survey area of Phase I. Within these areas, moreover, the area around known copper occurrences were chosen as semi-detailed areas.

4-1-1 Reconnaissance geological survey

A reconnaissance geological survey was conducted in the Areas A, B and C to clarify and confirm the mineralization in the area. A discussion on the relationship between mineralization and significant magnetic contact zones was also carried out during the survey. Since the massive sulphide deposits occurs along a contact between the Lower extrusive rocks 1(V1-1) and 2 (V1-2) of the Lower volcanic rocks, the contact was traced throughout the areas and the distribution was clarified. However, the Area C shows a low potencial for the deposits because the sheeted-dyke complex was overlain directly by the Middle volcanic rocks without the Lower extrusive rocks 1 and 2.

In addition to the known gossan in Ghuzayn, Daris 3A5 and Daris, new gossans were found in the Doqal, Fardah, Sanah, north of Ghuzayn village and Qulayyah as follows:

Doqal : This gossan was found in the Middle volcanic rocks (V2) in a narrow zone. 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 the gossanized samples.

Fardah : It is found in Lower extrusive rocks 2 (V1-2) and accompanied by a thick metalliferous sediment of 1km long. The base of the Tertiary limestone was also locally gossanized. White argilaceous zone with a extension of 200m x 200m is also accompanied. Limonitized sample shows the contents of small amount of gold and silber.

Sanah : 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.

Ghuzayn village north : This gossan is located in the small basin formed by the Lower extrusive rocks 2(V1-2). Small scaled gossan and silicified parts were found in several parts.

Qulayyah : The gossan forms a small hill with the size of 10m in width, 50m in length and 5m in height. It is accompanied with a quartz vein emplaced in the sheeted-dyke complex.

Magnetic contact zones were extracted in the all areas where gossans were formed and it is a useful information for exploration. Others, however, they were also extracted in areas where no favorable geologic features for copper mineralization can be observed. Some of the magnetic zones are likely to represent only the flow boundaries of volcanic rocks.

4-1-2 Semi-detailed geological survey

Semi-detailed geological survey was conducted in Ghuzayn area in Area A and Buwayrik-Daris 3A5 area and Daris-Daris West area in Area B in order to clarify the mineralization in the area and evaluate the potencial of copgper deposits.

The following facts were acquired during the survey:

(1) The main gossan in Ghuzayn has the scale of 200m in east-west and 400m in north-south and emplaced in the Lower extrusive rocks 2 (V1-2) close to the boundary with the Lower extrusive rocks 1 (V1-1). It gently dip towards northwest. Abundant copper oxides minerals occur in the basalt lava around the gossan.

(2) In the Ghuzayn area, several copper bearing quartz veins with some length were found in the east and a gossanized basalt lava of the Lower extrusive rocks 1 (V1-1) was observed in the west.

(3) The gossan of Daris 3A5 prospect is emplaced in the Middle volcanic rocks (V2). The samples by chanel sampling show the assay of 3.4g/t Au and 44.5g/t Ag in maximum.

(4) The Buwayrik prospect shows only slight silicification and no favorable geologic features for copper mineralization can be observed.

(5) The gossan of Daris prospect is emplaced in the Lower volcanic rocks (V1-2) with the size of 10m x 30m on the surface.

(6) Only pyritization in some dykes of the Sheeted dyke unit was observed in the Daris West prospect and no favorable geologic features for copper mineralization can be seen.

Based on the above facts, Ghuzayn Gossan, Ghuzayn East, Ghuzayn West, Daris West, Daris 3A5 and Daris areas were selected.

4-2 Geophysical Survey Results

The geoelectrical structure reflected by massive sulfide deposits is characterized by presenting high chargeability and low resistivity. In this regards, the geophysical method TDIP and TEM are quite effective for prospecting sulfide 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 an anomaly zone due to mineralization by covering a wide area covered 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.

4-2-1 TDIP survey

The TDIP geophysical survey method was carried out in order to detect chargeable zones which could arise from sulfide and associated mineralization in Ghuzayn Main Gossan, Ghuzayn East, Ghuzayn West, Daris and Daris 3A5.

In Ghuzayn Main Gossan area, promising IP anomalies were detected at the north and west of the gossan, respectively.

In Daris area, distinctive IP anomalies were detected around the gossan.

No significant IP anomalies were detected in both Ghuzayn West and Ghuzayn East areas.

In Daris 3A5, even though some difficulties appeared during the survey due to the extremely low resistivities, relatively high chargeable zones were delineated trending to the west from the gossan.

4-2-2 TEM survey

TEM survey was carried to examine in more detail the promising anomalous zones delineated by the IP survey in 2 zones in Ghuzayn Main Gossan area (Ghuzayn Gossan north and Ghuzayn Gossan west) and 1 zone in Daris area.

In Ghuzayn Gossan north area, TEM anaomaly was detected at the shallow portion located just at the north of the gossan and trending northwest towards deeper levels. Other TEM anomaly was detected at the deeper portions of the northeastern part of the area.

In Ghuzayn Gossan west area, the TEM anomalies were detected at the shallow portion in the northeastern part, and at relatively deep portions in the southwestern and northwestern parts of the area.

In Daris area, shallow TEM anomalies were detected at zones trending to the northeast from the gossan and also to the northwest from the west of the gossan. Another TEM anomaly was detected at the deep portion in the nortwest of the area.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5-1 Conclusions

The survey results are summarized as follows:

(1) Since the massive sulphide deposits occurs along a contact between the Lower extrusive rocks 1 and 2 of the Lower volcanic rocks, the contact was traced throughout the areas. However, the sheeted-dyke complex 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.

(2) According to the results of the geological survey and among the five prospect areas, Ghuzayn Gossan, Daris 3A5 and Daris areas are considered to be high potencial areas for copper deposits, however, Buwayrik and Daris West areas shows no favorable geologic features.

(3) In Ghuzayn area, several copper bearing quartz veins with some length were found in the east and a gossanized basalt lava of the Lower extrusive rocks 1 was observed in the west.

(4) Gossans were newly found in Doqal, Fardah, Sanah, north of Ghuzayn village and Qulayyah. The samples in Doqal and Fardah show contents of gold and silver. The gossan in Qulayyah is accompanied with a quartz vein emplaced in the sheeted-dyke complex.

(5) As a result of the IP survey in five selected areas, the following conclusions were obtained:

In Ghuzayn Gossan area, two IP promising anomalies were detected in the north and west of the area.

In Daris area, a distinctive IP anomaly was detected around the gossan.

In Daris 3A5 area, a relatively high chargeable zone was found trending to the west from the gossan.

(6) As a result of the TEM survey carried in three selected locations, the following conclusions can be mentioned:

In Ghuzayn Gossan north, a shallow TEM anomaly (about 40m in depth) was detected at the north edge of the gossan and trending northwest toward deep portions. Also a deep TEM anomaly (about 150 in depth) was detected at the northeast of the gossan.

In Ghuzayn Gossan west, the TEM anomalies were detected at the shallow part (about 50m in depth) in the northeast, at a relatively deep part (about 80m in depth) in the southeast and at a deep part (about 100m in depth) in the northwest of the survey area.

In Daris area, a shallow (about 20m in depth) TEM anomalies was detected at a zone trending to the northeast from the gossan. A shallow anomaly (about 40m in depth) was detected at a zone trending to the northwest from the west of the gossan. Another deep anomaly (about 150 to 200m in depth) was detected in the northwest of the area.

5-2 Recommendations

Semi-detailed, geophysical and drilling surveys mentioned below in the areas shown in Fig.I-5-1 are recommended for Phase II project.

(1) Semi-detailed survey

It is recommended to carry out a semi-detailed survey to acquire detailed informations on the mineralization in Doqal, Fardah, Sanah and north of Ghuzayn village where gossans were newly found in Phase I.

(2) Geophysical survey

IP and TEM geophysical surveys are recommended around gossans found in the Doqal, Fardah, Sanah and north of Ghuzayn village in order to assess the potential of massive sulphide deposits. It is also recommended to conduct TEM survey in the northern part of Daris area where the wide IP anomaly was detected in Phase I.

(3) Drilling survey

In order to check ore bodies, it is recommended to conduct drilling surveys of 150m to 300m in depth around the TEM anomalies detected in the north and west of Ghuzayn main gossan (refer to Fig.I-5-2), the north and northwest of gossan in Daris (refer to Fig.I-5-3), the east and west of Daris prospect area (refer to Fig.I-5-4) and about the IP anomalies detected in the Daris 3A5. Additionally, it is also necessary to carry out drillings on the promising anomalies likely to be detected by geophysical surveys of Phase II.

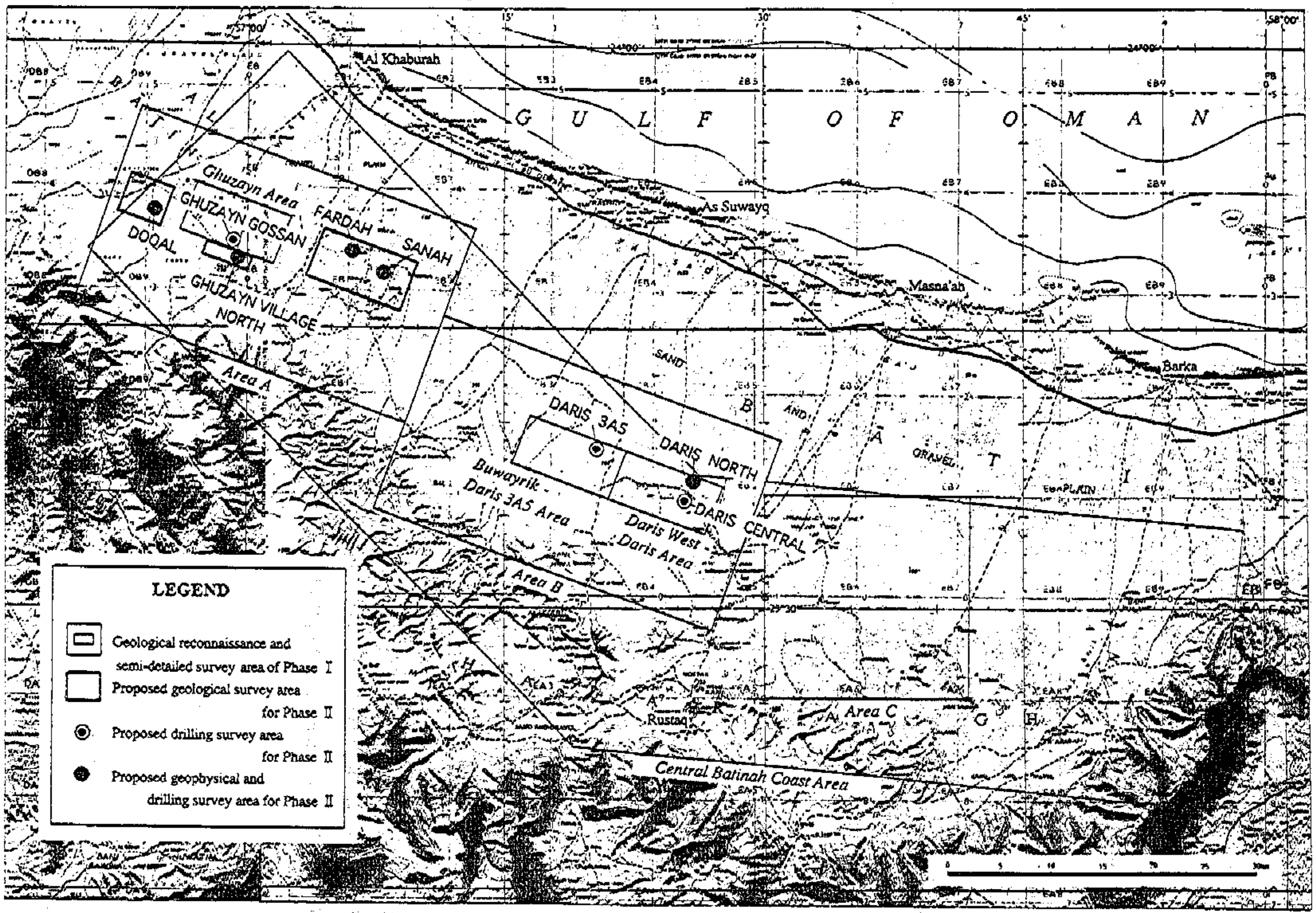
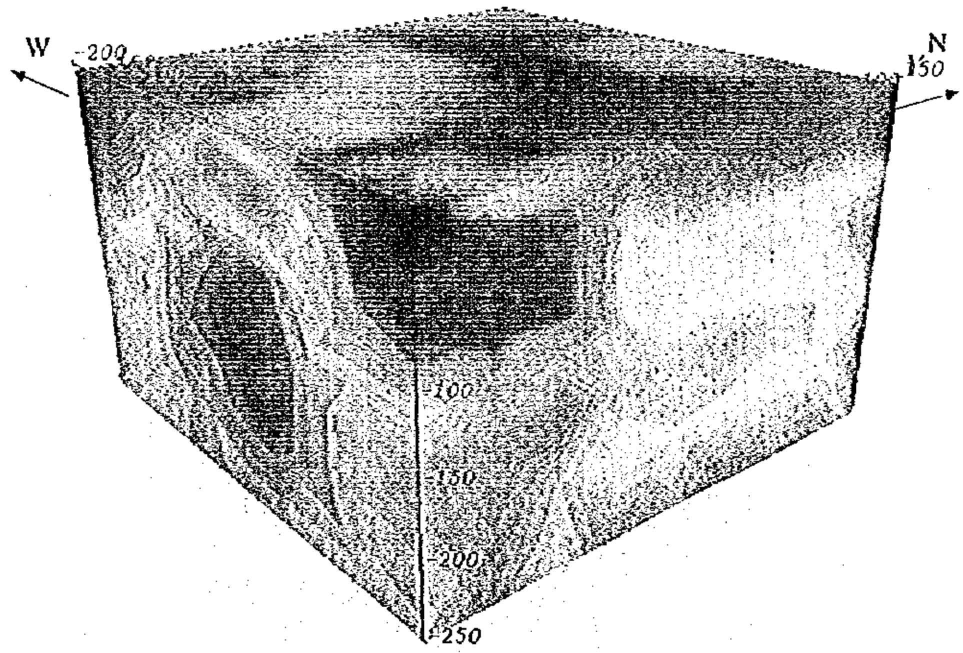


Fig. I-5-1 Location map of proposed survey area for PhaseII



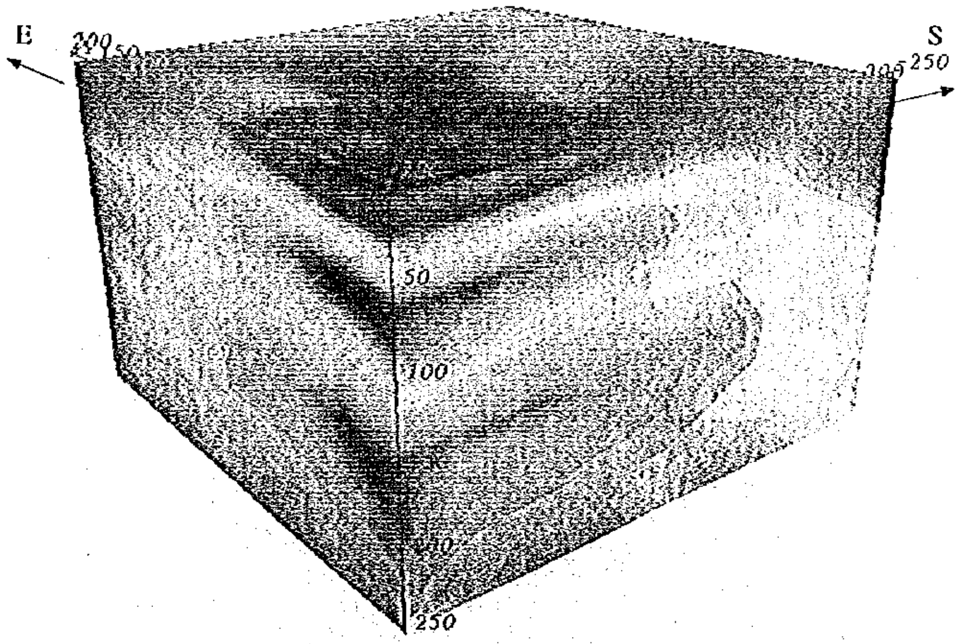
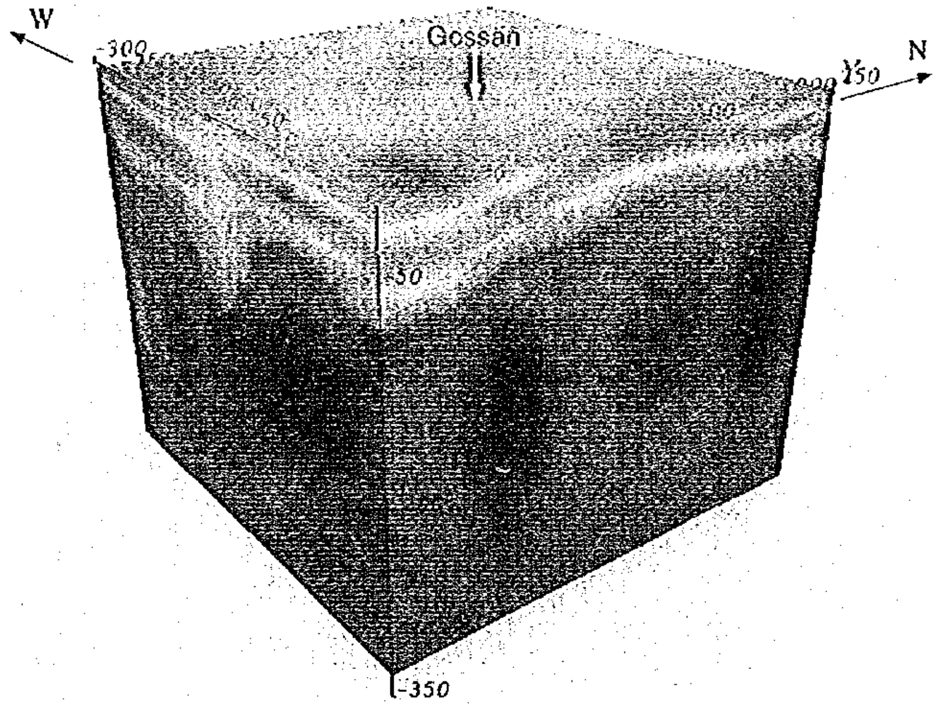


Fig. I -5-2 3-D TEM resistivity view in Ghuzayn Gossan north area



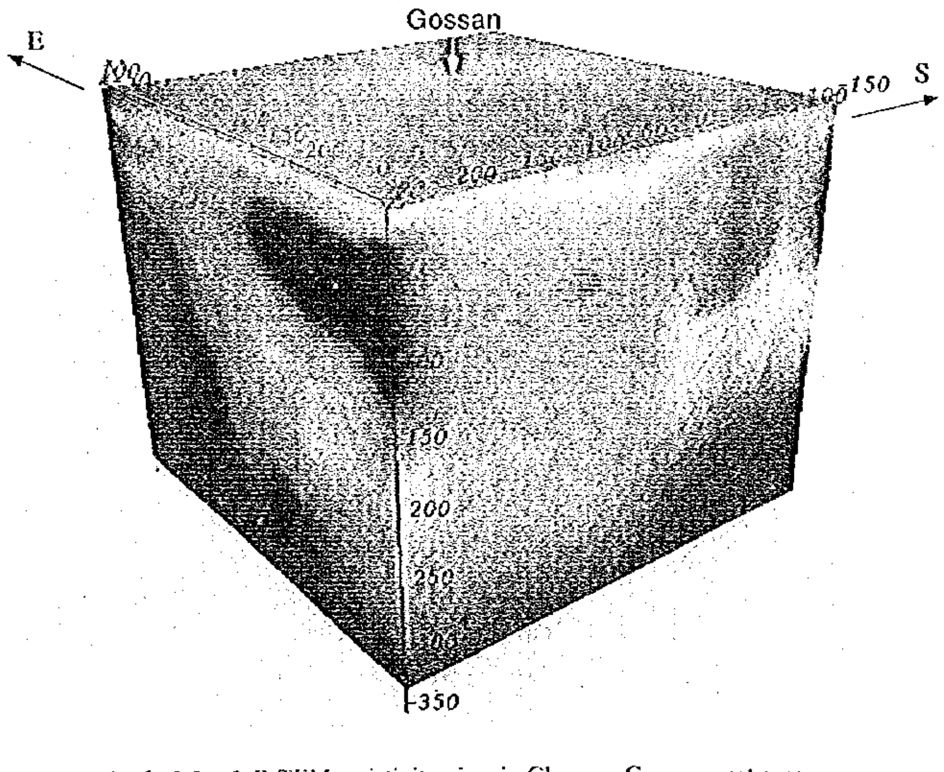


Fig. I -5-3 3-D TEM resistivity view in Ghuzayn Gossan west area

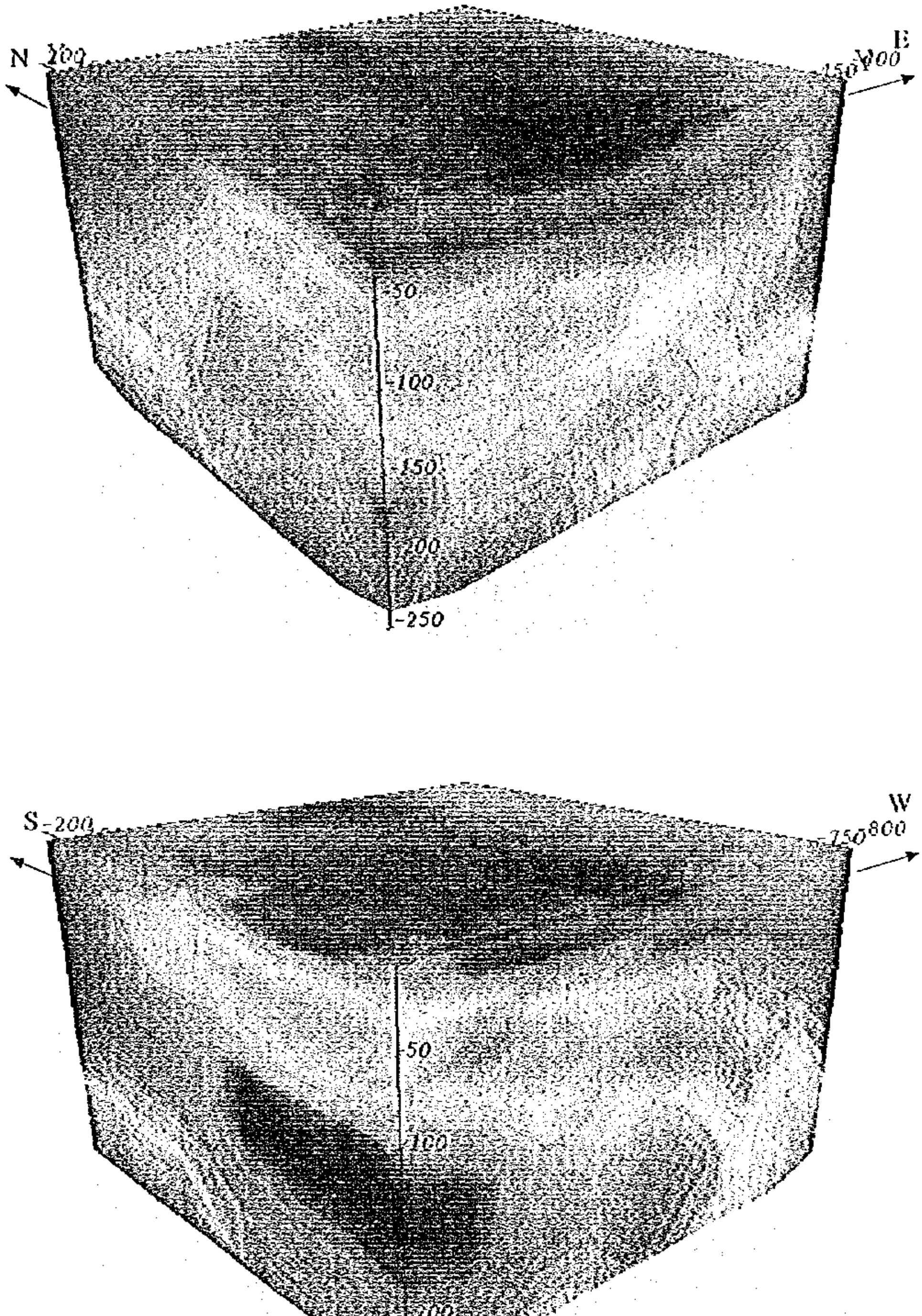


Fig. I -5-4 3-D TEM resistivity view in Daris Gossan west area

PART Ⅱ SURVEY RESULT

CHAPTER 1 PRELIMINARY STUDIES OF PREVIOUS EXPLORATION DATA

1-1 Summary of Previous Exploration Works

Preliminary studies on the survey area were carried out by using the data of previous mineral exploration projects and as a result, potencial areas for copper deposits were extracted in the area. In the area, Prospection Ltd., Ministry of Petroleum and Minerals, BRGM (Bureau de Recherches Geologiques et Minieres) and OMCO(Oman Mining Company) have carried out geophysical survey, drilling survey and geochemical survey for finding copper deposits. WGC (World Geoscience Corporation) also conducted a heliborne geophysical survey and ground geophysical survey. The results of these surveys are described below.

Six prospect areas for copper deposits are located in the area, which are, in order from west to east, Ghuzayn, Buwayrik, Daris West, Daris 3A5, Daris and Al Ajal prospects. Massive sulfide deposits of small size were already found in Daris 3A5 and Daris prospect. The contents and amount of works of previous exploration works are shown in Table II-1-1 and the results are summarised below.

1-1-1 Ghuzayn prospect area

Prospection Ltd., Ministry of Petroleum and Minerals and BRGM carried out exploration works such as geophysical and drilling survey in the Ghuzayn prospect area. The locations of each survey are shown in Fig. II-1-1.

The large siliceous gossan probably corresponds to a completely oxidised sulphide body emplaced near the contact between Lower and Middle Volcanic Rocks(V1 and V2 respectively) of the BRGM classification. This contact corresponds to Lower member(called V1-1) of Lower Volcanic Rocks and Upper member(called V1-2) of Lower Volcanic Rocks on the basis of Bishimetal classification (1987). Previous drilling survey conducted by Prospection Ltd. in the vicinity of the gossan revealed that the gossan was situated in an eastwards-plunging stockwork zone composed of pyrite and magnetite stringers crossing altered rocks of Lower Volcanic Rocks. An estimate of 559,000t at an uneconomic 0.33% Cu was given by this drilling survey with 15 holes and 3,462.8m in total length.

Since the favourable V1/V2 contact is assumed to dip northwestwards regionaly surrounding the gossan, BRGM extended the geophysical survey by using SP method northwards in order to determine the extensions of oxidised orebody. Two SP anomalies detected in the northern part were examined by the three percussion holes, but they did not encounter any interesting mineralisation.

Table II-1-1 Previous survey in the prospect areas

Ser. No	Name of prospect area	Survey Methods			
		Geological Survey	Geochemical Survey	Geophysical Survey	Drilling Survey
1	GHUZAYN	Detailed survey by BRGM		SP electric survey by BRGM Down-hole electric survey by BRGM	Performed by Prospection Performed by BRGM - 3 holes: GZ1, GZ2 & GZ3 (T:258m) 2 holes in 1987
2	BUWAYRIK	Detailed survey by BRGM	Stream sediments geochemical survey by BRGM	SP electric survey by BRGM Down-hole electric survey by BRGM	Performed by BRGM - 2 holes: BW1 & BW2 (T:100m)
3	DARIS WEST	Detailed survey by BRGM		SP electric survey by BRGM Down-hole electric survey by BRGM	Performed by BRGM - 2 holes: DW1 & DW2 (T:100m)
4	DARIS 3 A-5	Reconnaissance geological mapping by BRGM Detailed survey by BRGM	Detailed rock geochemical survey by BRGM	SP electric survey by BRGM Magnetic survey by BRGM TEM survey by OMCO (after 1993)	Performed by BRGM - 4 holes: 3A-1, 3A-2, 3A-3 & 3A-4 (T:230.20m) Performed by MPM - 8 holes 1991 to 1992 (T:811.90m) Performed by OMCO - 15 holes (T:1,272.85m) Total :28 holes
5	DARIS	Detailed geological survey by BRGM Trench survey by BRGM	Stream sediments geochemical survey by BRGM Gas geochemical survey by BRGM	Magnetic survey SP electric survey by BRGM Down-hole electric survey by BRGM	Performed by Prospection Ltd. DH1 to DH27 Performed by BRGM DA1 to DA8 :percussion (T:573m) DA9:core:83m Performed by MPM - 1 hole: DA10
6	AL AJAL	Regional geological mapping by BRGM Detailed geological survey by BRGM	Detailed geochemical survey by BRGM	SP electric survey by BRGM Down-hole electric survey by BRGM	Performed by BRGM - 4 holes : AJ1, AJ2, AJ3 & AJ4 (T:573m) - 2 percussions

Remarks; T:Total length

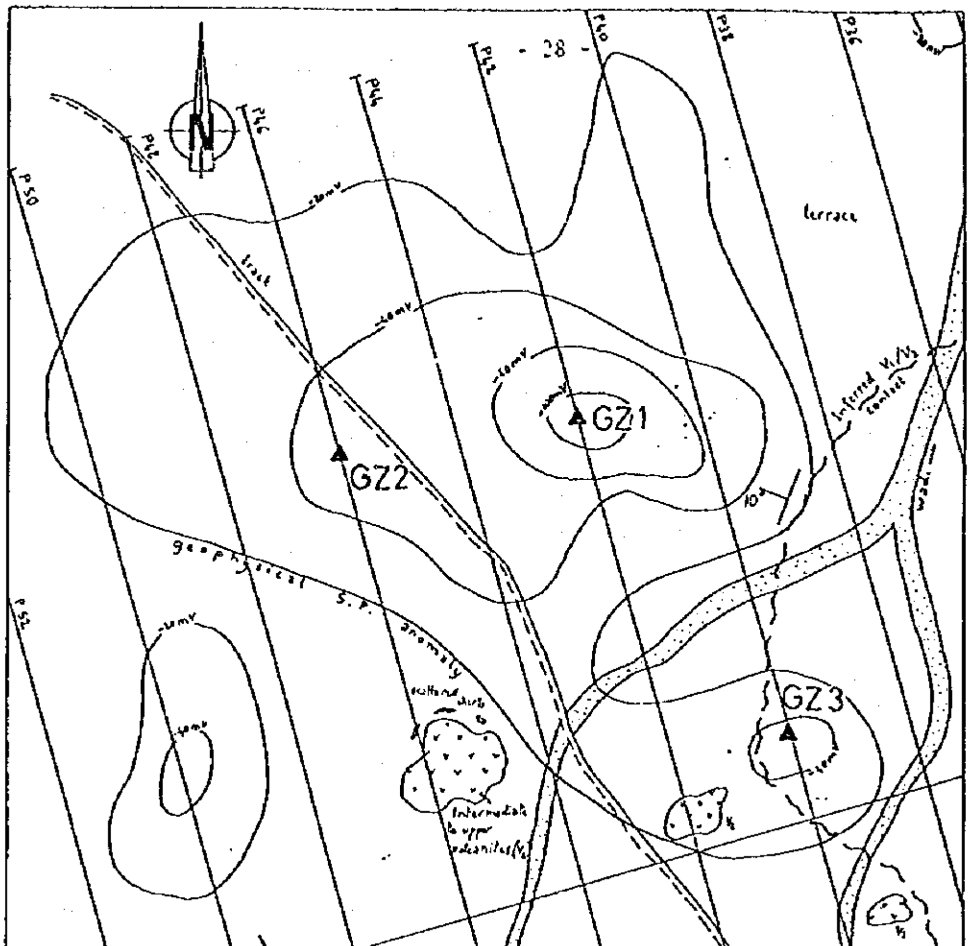


Fig.II-1-1 Location map of previous surveys in Ghuzayn prospect area

1-1-2 Buwayrik prospect area

BRGM carried out geochemical, geophysical and drilling surveys in this prospect area in 1985. SP survey which was conducted over the areas of stream-sediment geochemical anomaly, detected a wide SP anomaly, associated to a strong magnetic gradient and to a shallow, well-marked conductive zone. Drilling survey carried out in the above SP anomaly resulted in encountering only scattered pyritization.

1-1-3 Daris West Prospect Area

BRGM carried out SP survey in the prospect area in 1985 as well. Three SP anomalies were detected in the area. One of them, located near the inferred V1/V2 contact and associated to a shallow conductor, was selected for exploration drilling. The mineralized V1/V2 contact is seen preserved only in borehole DW1, which consists of an oxidised siliceous layer carrying low copper grade with 0.2%. At depth below 30 to 35m, Lower Volcanic Rocks are slightly hydrothermally altered and impregnated by scattered pyrite and some magnetite.

1-1-4 Daris 3A5 prospect area

BRGM, Ministry of Petroleum and Minerals, WGC and OMCO carried out exploration works in the Daris 3A5 prospect area(Fig. II -1-2). Gossan with high gold content was found in the area and as a result, four holes were Drilled around the gossan 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 ore consists of massive to sub-massive pyrite, sphalerite, chalcopyrite, marcasite and pyrrhotite with rare galena, bornite, covellite and digenite. A 3 m thick (true thickness is 1.5m) sulphide-rich section assays 2.71%Zn, 0.71%Cu, 32g/t Ag and only 0.4g/t Au. Pb and As contents are 0.05% and 0.13% respectively. Downwards, scattered sulphides in hydrothermally altered basaltic pillow lavas carry noticeable Zn values (0.9% over a total thickness of 12m).

Borehole 3A-4 was drilled at the same place as 3A-3 and inclined southwestwards. It intersected oxidised mineralization from 21.2 to 31.6m in the form of an iron oxide-rich siliceous gossan. Limonite, goethite, hydro-hematite, together with traces of native gold and pyrite, were observed in a polished section. Base metal content is low, but precious metal grades are interesting such as 2.6g/t Au and 28.6g/t Ag over a thickness of 9m. The middle zone of the gossan appears to be preferentially enriched and a 4m thick section assays 4.5g/t Au and 43.7g/t Ag.

Borehole 3A-2 was located 40m west of the boreholes 3A-3 and 3A-4 in order to test the western extension of the 3A5 gossan. It intersected an oxidised mineralization, similar to that detected in 3A-4, from 15.2 to 28.5m. Specks of native gold were noted on cuttings taken at about 24m depth. A 8m thick section assays 3.2g/t Au and 33.5g/t Ag.

After the exploration works by BRGM, Ministry of Petroleum and Minerals carried out a drilling survey

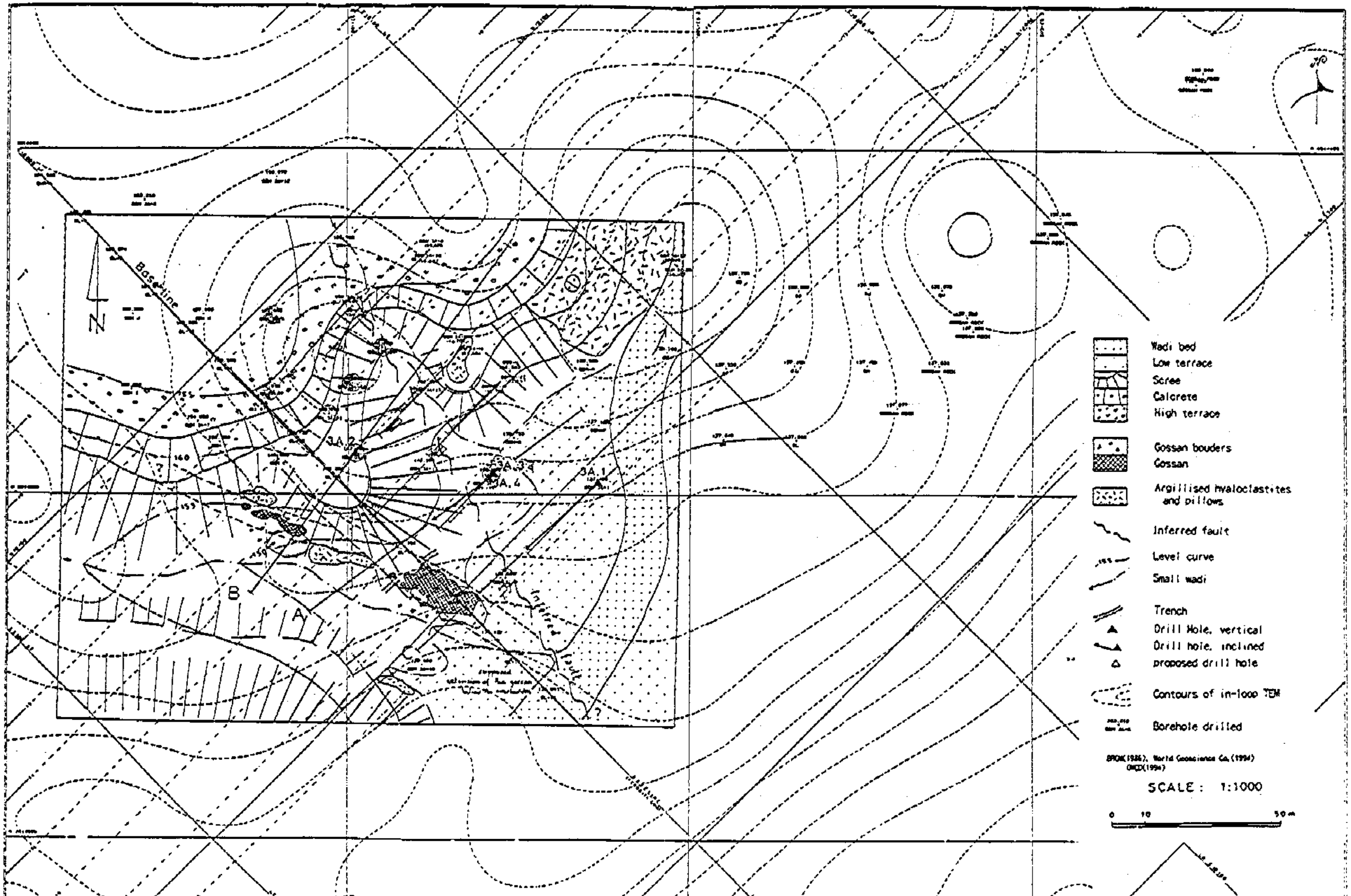


Fig.II-1-2 Location map of previous surveys in Daris 3A5 prospect area of 8 boreholes with a total length of 811.9m during 1991 and 1992. One of them intersected a massive sulphide body which assays 9.65% Cu, 4.2g/t Au and 37.6g/t Ag in a 3.5m thick. OMCO followed the work after the Ministry and carried out a drilling survey of 15 boreholes with a total length of 1,272.85m during 1993 and 1994. This survey proved useful to find more details of the body dipping northeastwards but thin and small in size as shown in Fig. II -1-3.

Table II-1-2 shows the estimated ore reserves calculated on the basis of above drilling surveys.

Table II-1-2 Estimated ore reservoirs of Daris 3A5 deposit

TYPE OF ORE	AMOUT	ORE GRADE		METAL CONTENT	
	(t)	g/t Au	% Cu	kg Au	t Cu
Gossan	31,680	3.21	0.09	100	
Sulphide	61,146	0.95	5.18	58	3,200
Total	92,826			158	3,200

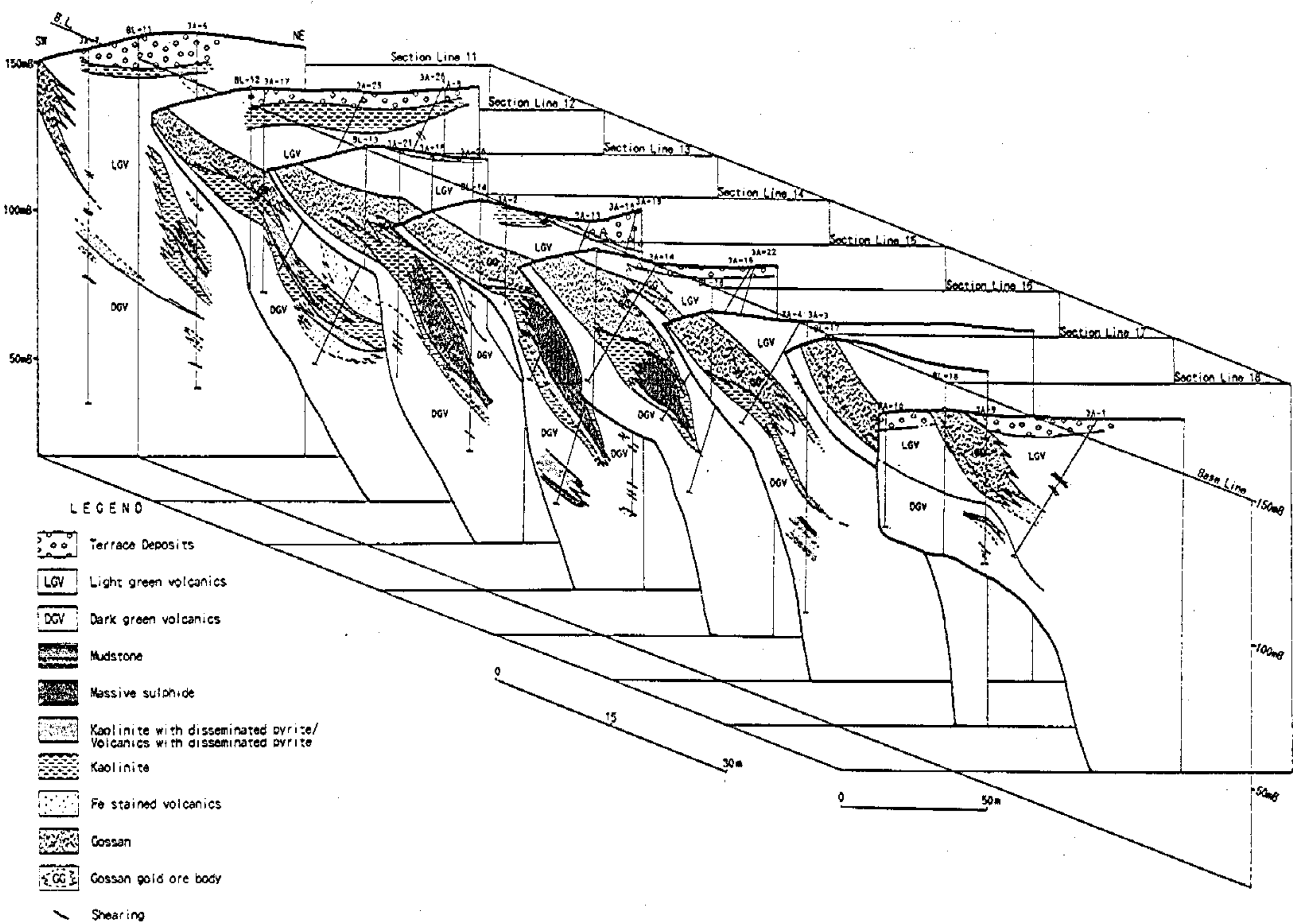


Fig.II-1-3 Panel diagram of Daris 3A5 deposits

1-1-5 Daris prospect area

Exploration works in the area were carried out by Prospection Ltd.and BRGM(Fig. II-1-4). Drilling survey conducted by Prospection Ltd. confirmed two distinctive mineralized blocks which are the eastern and western blocks(Fig. II-1-5).

In the eastern block, the top of mineralised part of Lower Volcanic Rocks occurs as a gossan lying directly below a thin recent over-burden. Only small amounts of massive sulphides are locally preserved below weathered Upper Volcanic Rocks in the central zone. The primary ore is almost completelv oxidised in this block. Prospection Ltd. estimated the reserves of 0.6 Mt at 1.9% Cu.

The western block is downwarped along an inferred submeridian fault zone. Two holes (DH-12 and DH-26) drilled by Prospection Ltd. intersected typical massive sulphides. Results of these 6 drill holes drilled by BRGM together with those of Prospection Ltd. allowed to define the shape and extension of the small orebody. It is confirmed that the orebody was formed in a narrow (20 to 50 m wide) semi-graben which stretches westwards over at least 200 m.

In addition to the mentioned above, BRGM discovered massive sulphides crossed by the boreholes DA-6, DA-8 and DA-9 between 40 and 60m in depth, and discovering a 100m western extension of the small orebody described above. This massive sulphide shows the assemblage of pyrite-chalcopyrite-(marcassite-sphalerite- pyrrhotite) and its metal grade decreases from SE to NW together with the thickness. A 7m thick ore in DA-6 assays 2.36% Cu, 0.15% Zn, 16g/t Ag and 0.86g/t Au. A 4m thick ore in DA-9 assays 1.94% Cu, 0.21% Zn, 13g/t Ag and 0.47g/t Au. A 2m thick ore in DA-9 assays 0.23% Cu, 0.09% Zn, 4g/t Ag and 0.22g/t Au.

Geological reserves of the western block, considering a probable extension over a 6,000m² surface area, can be estimated at 145,000t of sulphide ore averaging 1.95% Cu, 0.21% Zn, 12g/t Ag and 0.6g/t Au.

1-1-6 Al Ajal prospect area

BRGM carried out exploration works in Al Ajal prospect area. Al Ajal prospect area is the only prospected area located within the Hawasina allochthonous formations. In view of the high gold grades detected by preliminary sampling of the gossan during the course of the BRGM regional mapping, this prospect was selected for detailed geochemical and geophysical investigations.

Geologically, the mineralized facies occur at the top of a reversed Upper Permian basaltic formation capped by folded limestones and schists. The whole unit is sliced and thrust southwards along N70° E extensive faults. Mineralization crops out east-west over a 300m long band and is composed of iron oxide-rich altered volcanites, silicified and kaolinised gossan, jasper and hematite layer associated eastwards with siderite-bearing cherts.

The original ore geometry which is hydrothermally altered basalts - stockwork ore - massive sulphide

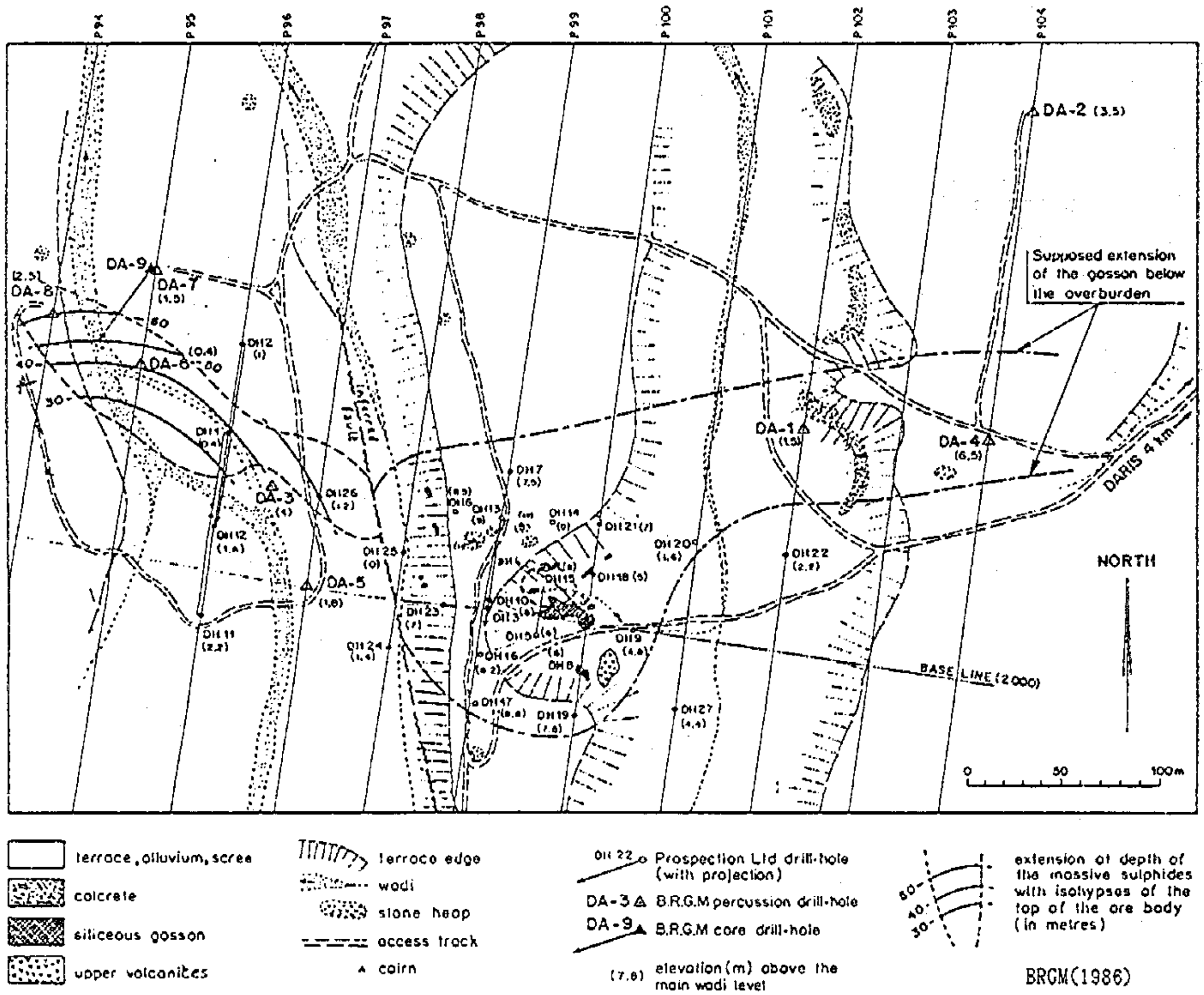


Fig.II-1-4 Location map of previous surveys in Daris prospect area

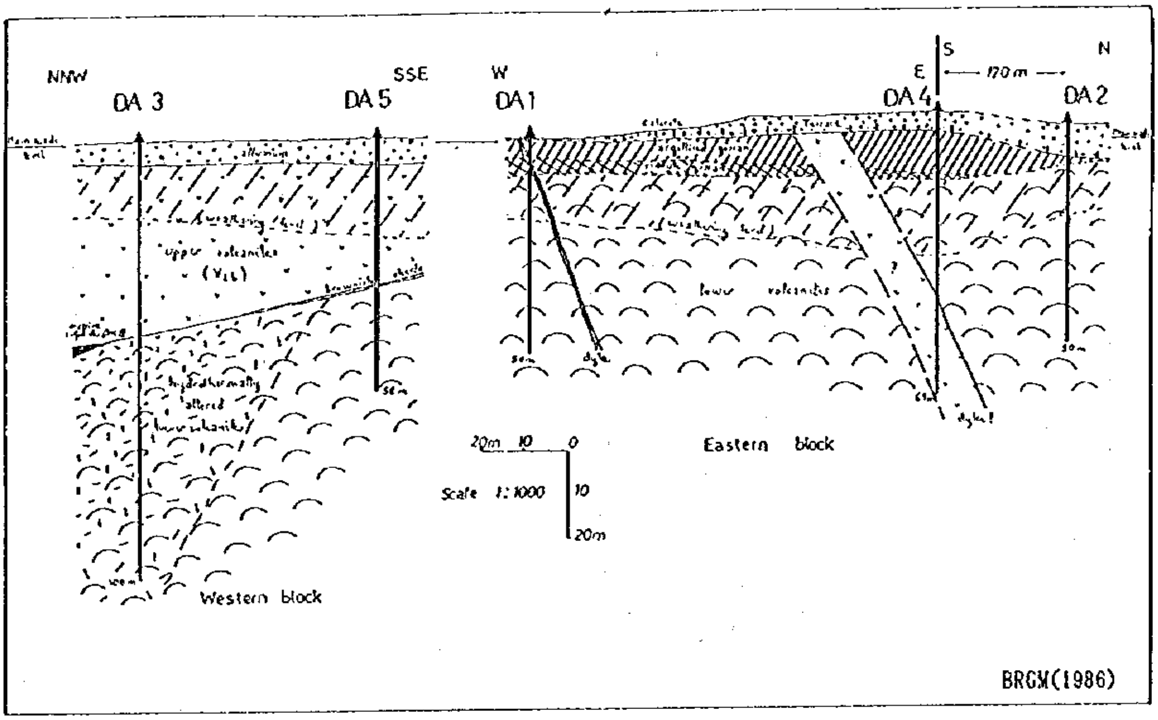


Fig.II-1-5 Cross section of borehole site in the western block of Daris prospect area

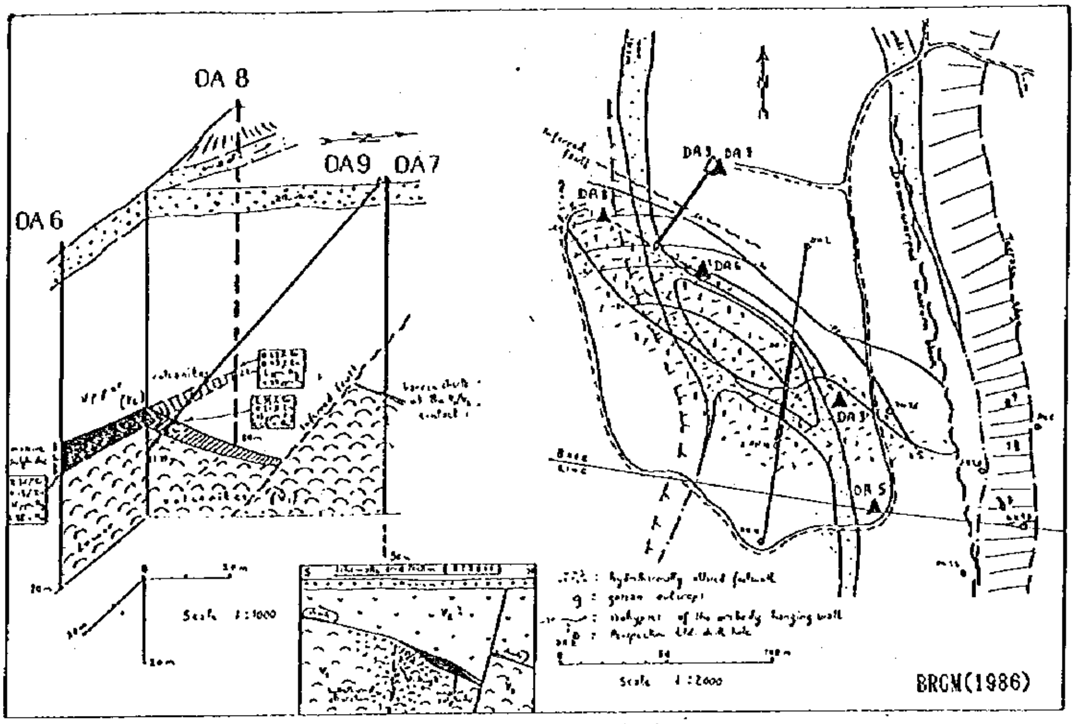


Fig.II-1-6 Plan map and cross-section of borehole site in the eastern block of Daris prospect area deposit grading laterally into hematite layer and siderite-bearing cherts - upper schists and limestones, was intensively disturbed by subsequent thrusting and associated folding.

Based on the results of geochemical and geophysical SP surveys, BRGM conducted the 4 drillings AJ-1, AJ-2, AJ-3 and AJ-4. From the information gathered of these boreholes, it was found that the massive sulphides intersected have a total average thickness of about 9 m and extend over 140m length and at least 90m downdip. And possible lateral extensions of the Al Ajal orebody appear to be very limited. The ore represents about 0.5Mt assaying 0.89% Cu, 0.51% Zn, 18g/t Ag and 2.5g/t Au on average. Base and precious metals contents of the ore of AJ-2 drilling vary considerably, as show in Table II -1-3.

Table II-1-3 Composition of the Al Ajal massive ore in the AJ-2 borehole

TYPE OF DRE	SECTION (m)		Cu	Zn	Ag	Au
	From	To	(%)	(%)	(ppm)	(ppm)
Massive sulphide and stockwork	76	78	0.73	0.19	80	8.2
Massive sulphide and stockwork	80	84	0.06	0.09	4.8	8.2
Massive sulphide	90	95	1.23	0.09	8.5	3.2
Massive hematite	103	108	0.15	0.16	1.6	0.9
Massive sulphide and siliceous ore	108	114	0.93	1.26	18.5	0.9
Average	Total thickness: 22 m		0.64	0.43	15.5	2

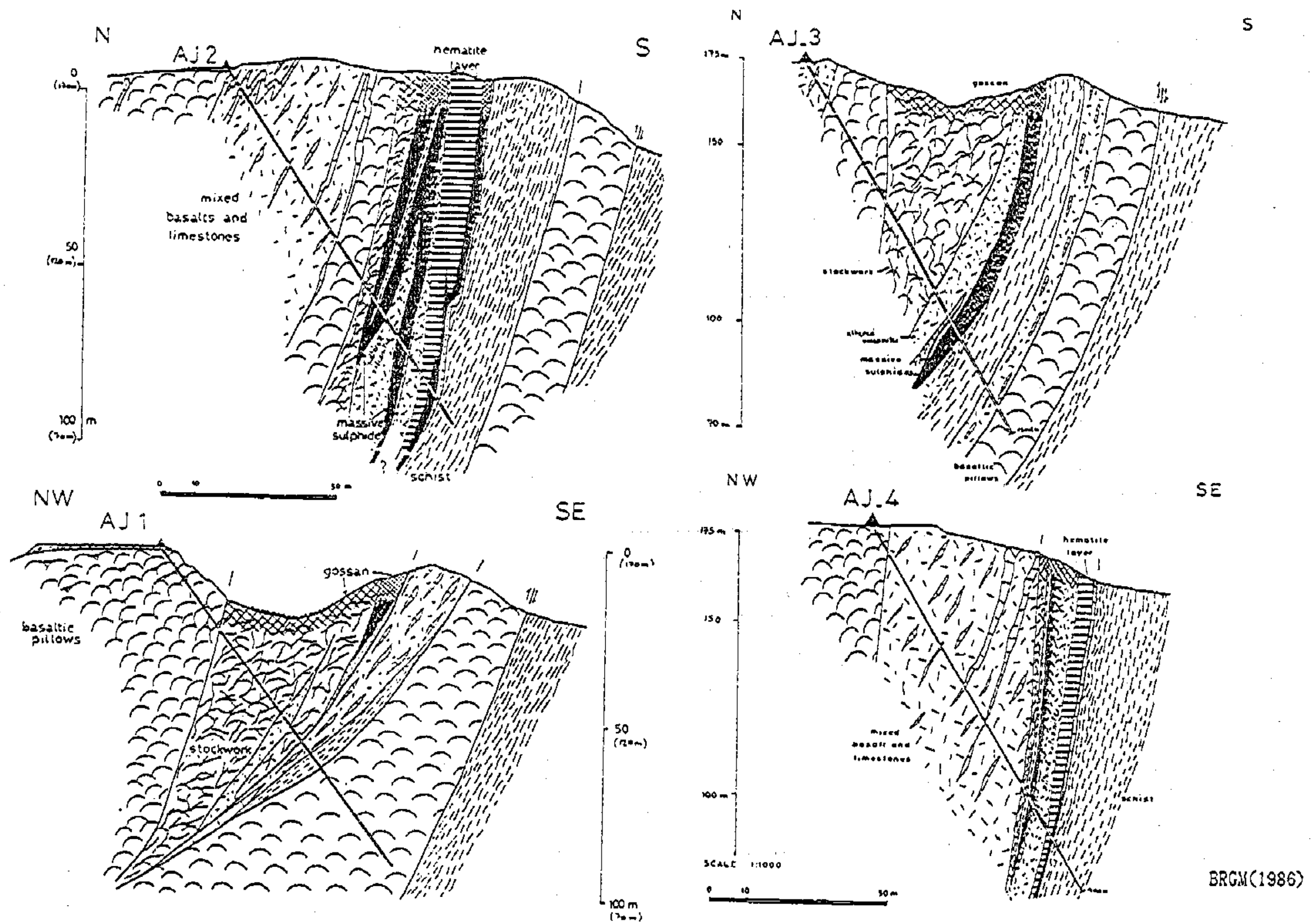


Fig.II-1-7 Cross section of borehole site in the Al Ajal prospect area

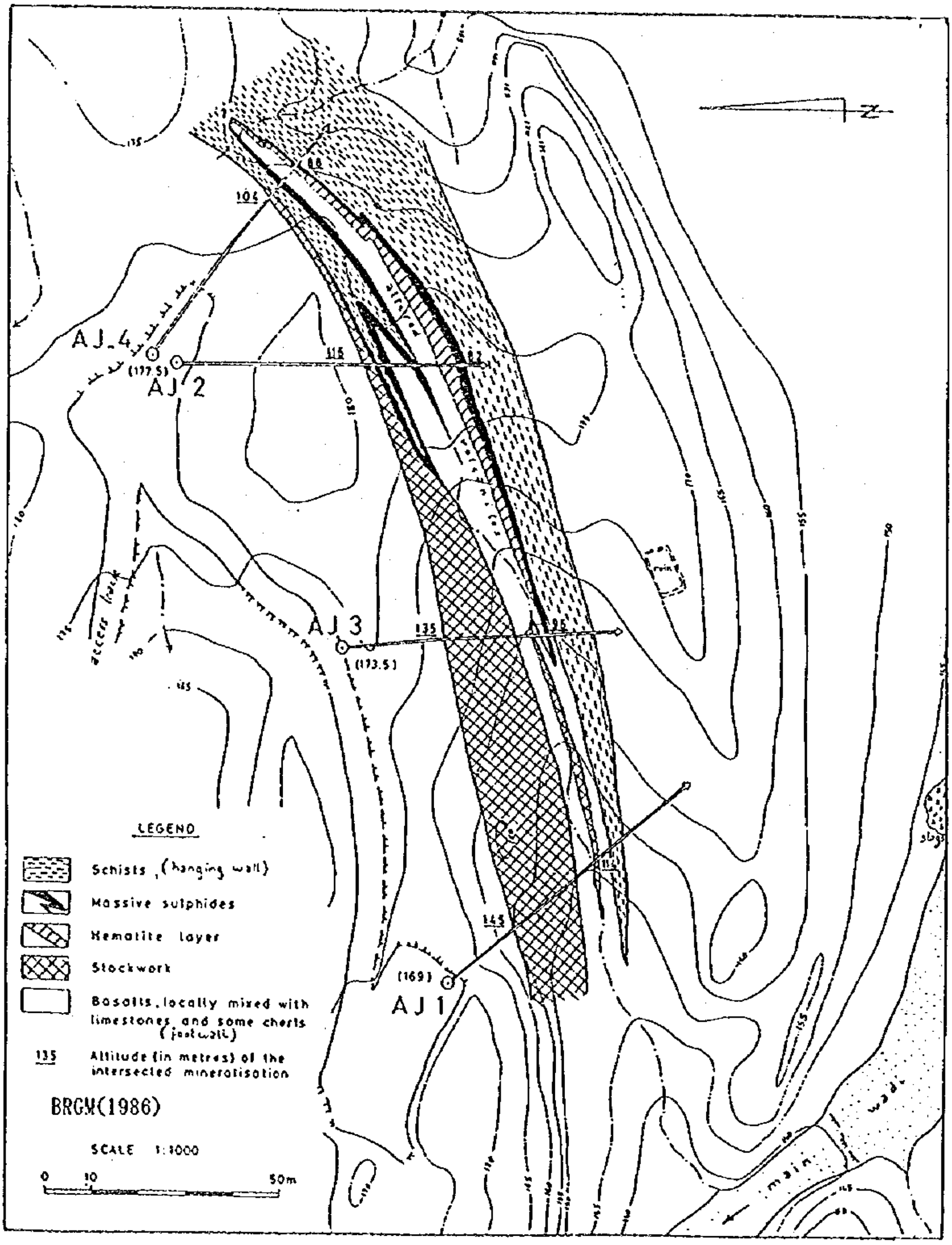


Fig.II-1-8 Horizontal projection of the intersected mineralization in Al Ajal prospect area

1-2 Summary of AirborneGeophysical Survey

1-2-1 Summary of airborne geophysical survey

The airborne geophysical survey using a helicopter was carried out by World Geoscience Corporation(WGC) in order to map Samail Ophiolite mostly overlain by Quaternary sediments and to extract potential area for mineral exploration during 1992 and 1993. The surevy covered the area from Shinas to the northwest and from Sib to the southeast along Batinah Coast. Parameters of data acquisition are shown in Table II-1-4.

Table II-1-4 Acquisition parameters for airborne geophysical survey conducted by WGC

ITEM	SPECIFICATION
Aircraft	RockwellShrikeCommanderVH-MEH
Magnetometer	ScintrexV201cesiumvapourmagnetometer
• along line sampling	0.2 seconds (14 meters approx.)
Spectrometer	Exploranium GR800B (256 channel)
• along line sampling	1 second (70 meters approx.)
Digital data acquisition system	Picodas PDAS 1000
Analogue data acquisition system	RMS GR33A chart recorder
Flight line spacing	200 meters
Tie line spacing	2,000 meters
Flight line direction	030° -210°
Tie line direction	120° -300°
Survey height	80 meters mean terrain clearance
Navigation	GPS Global Positioning System
Total line kilometers in final data set	49,351 line kilometers
Total area covered in final data set	8,500 km^2

As shown in Table II-1-4, a spectrometric survey was simultaneously conducted over the same area. However, the interpretation has been carried out only for Sohar area.

The followings are the results of airborne magnetic survey according to the final report prepared (1992) by WGC.

Since the volcanic suite has characteristic magnetic responses, the survey has delineated extensive areas where the volcanic sequence occurs at shallow depths (less than 100m) beneath recent cover.

The major rock units show the following characteristic magnetic responses:

(1) Samail volcanic sequence shows very high intensity and very high variability response.

(2) Sheeted-dyke complex has an extremely uniform response.

(3) The sediments overlying the Ophiolite are essentially non magnetic.

(4) The lower sections of the Ophiolite suite have a weak to moderate and certainly less characteristics response than the volcanic rocks and sheeted dykes.

1-2-2 Target areas derived from the airborne geophysical survey

Based on the study of relationship between the known mineralization in particular magnetic units and the contacts within the volcanic sequence, it can be inferred that the mineralization appears to be associated with either magnetic contact zones or linear magnetic "low zones" as follows:

Magnetic contact zones : For the most part, they are likely to represent flow boundaries for which the magnetic contact zones provide the first level of focus within the volcanic rocks.

Linear magnetic "low zones" : These are interpreted as zones of tectonic control on mineralization. Bayda Graben as illustrated in Bathelor (1992) provides a geological model for these observed magnetic features.

In addition to above facts and considering the presence of known mineralization as major positive factor, target areas for exploration were selected as shown in Fig.II-1-9. The areas consist of 13 areas which are, from west to east, Doqal, Ghuzayn, Ghuzayn West, Mashin North, Fardah, Mushayq, Qulayyah,Wadiyah, Buwayrik, Daris, Mansur, Khatum West and Hibra.

1-3 Selection of the Phase I Survey Areas

1-3-1 Discussion of previous data

The massive sulphide deposits in the Oman Mountains occur along a contact between Lower extrusive 1 and 2 of the Lower volcanic rocks and are classified into the Cyprus type copper deposits. Previous studies on massive sulphide deposits in Oman corresponding to Lasail and Bayda deposits in Sohar area provide the following ideas as survey hypothesis:

(1) The deposit shows a stratigraphic control and occurs along a contact between the Lower extrusive rocks 1 and 2 of the clasification by Bishimetal (1987).

(2) The central part of large deposits shows relatively low magnetic value caused by the

demagnetization related to alteration. It is expected that the magnetic values will provide more information to define interesting areas.

(3) Since the shape of the deposits was affected by the sea floor topography, the time of deposition is an important fact to be considered.

(4) Two types of deposits are present: one is consisting mainly of massive ore and the other of stockwork ore. It is likely that these deposits depend on the difference of sedimentary condition on deposition.

(5) It is important to clarify the following factors: zonal arrangements, lateral changes in mineral combinations of ore and texture of minerals within ore bodies.

For the Phase I survey, the (1) and (2) of above hypothesis are considered to be most important. The following data were used for preparation of composite images for the discussion of target area selection.

a. Geological map of 1: 100,000 and 1:250,000
b. Airborne geophysical data
c. Interpretation map of airborne geophysical data
d. Satellite remote sensing data (Landsat TM and JERS-1 OPS data) e. Location of mineral occurrences

Several combinations of data images were prepared in order to assist in the search of potential areas for mineralization.

Fig. II-1-10 shows a superposition of magnetic contact zones on the image of total magnetic field, while Fig.II-1-11 shows the superposition of the distribution of magnetic contact zones and volcanic rocks.

Fig.II-1-12 and Fig.II-1-13 are images that show the locations of magnetic contact zones and previous prospect areas on the Landsat images in Daris and Ghuzayn areas . In Fig.II-1-13, the Ghuzayn gossan can easily be seen as a small spot of bright reddish tint.

1-3-2 Selection of the survey areas

Fig.II-1-14 and Fig.II-1-15 are the composite images of magnetic contact zones, volcanic rocks outcropping areas, locations of mineral occurrences and Landsat TM data. The survey areas for the Phase I project were selected based on the following targeting procedure using above images:

(1) To find target zones by using the interpretation results of the airborne magnetic data.

(2) To find the contact zone between Lower extrusive rocks 1 and 2

(3) To give a higher priority to the areas where mineral occurrences are known.

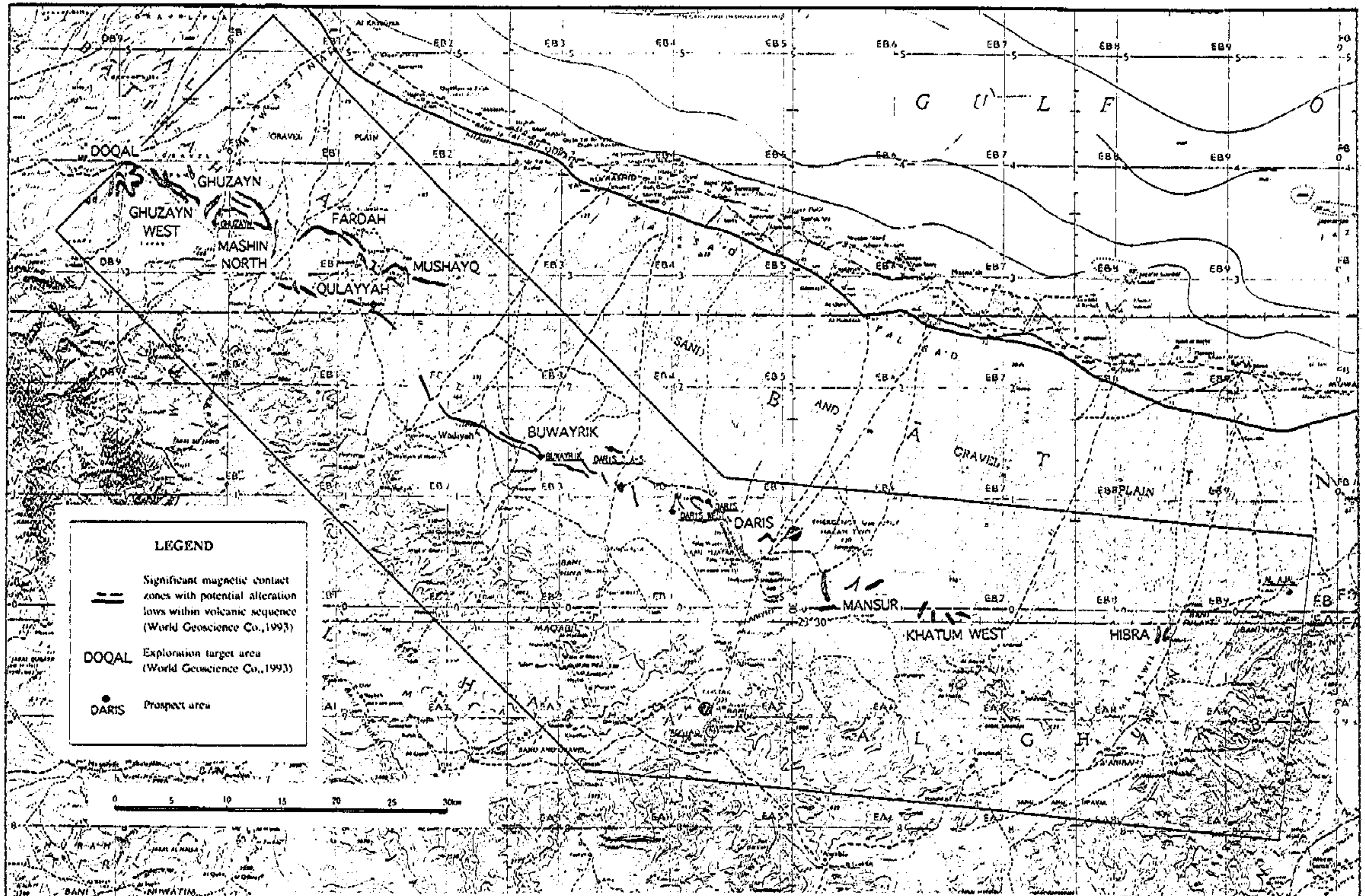


Fig.II-1-9 Location map of exploration target area based on airborne geophysical survey prospect area

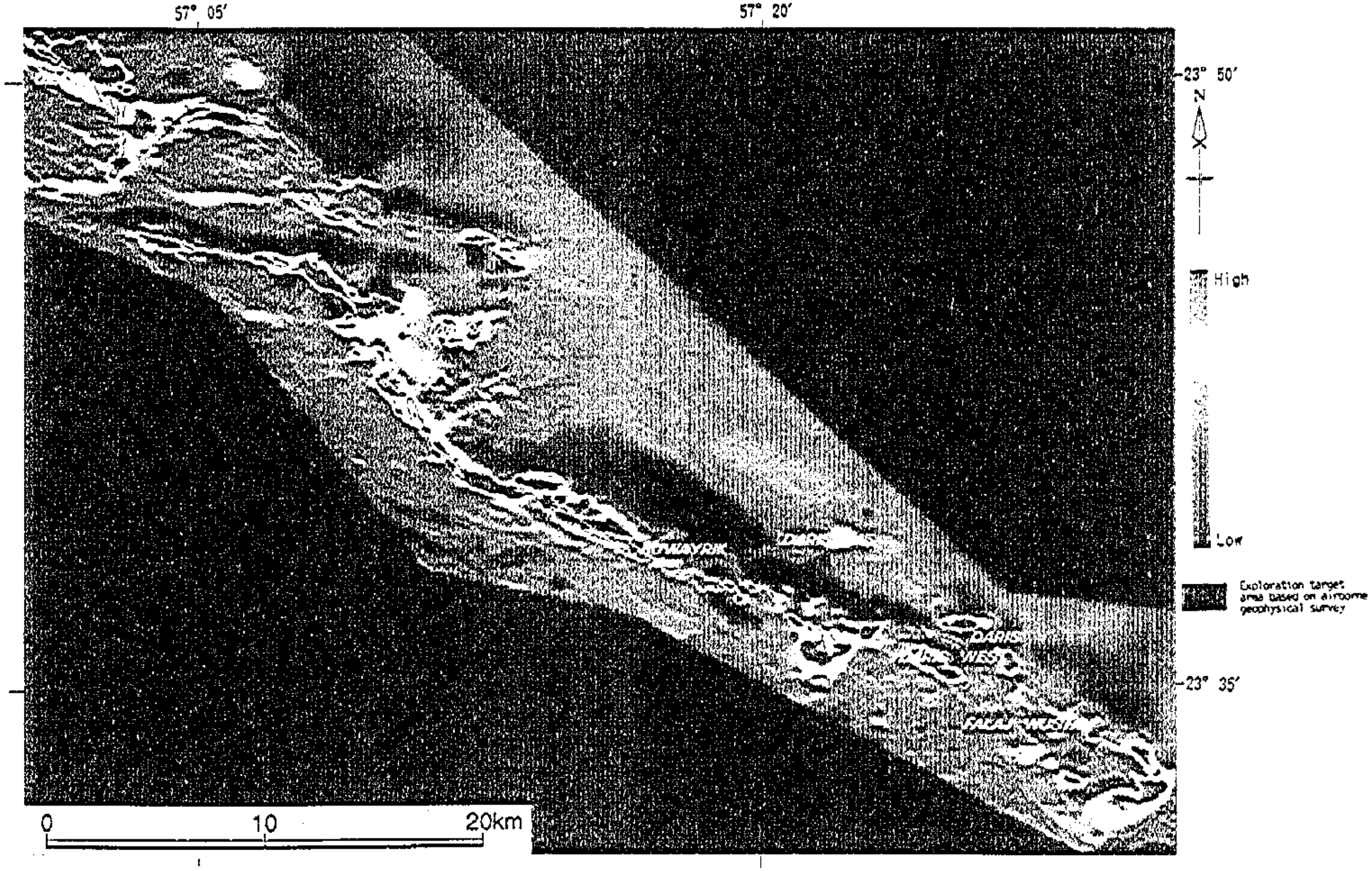


Fig.II-1-10 Composite image of pseudocolor total magnetic data and significant magnetic contact zone

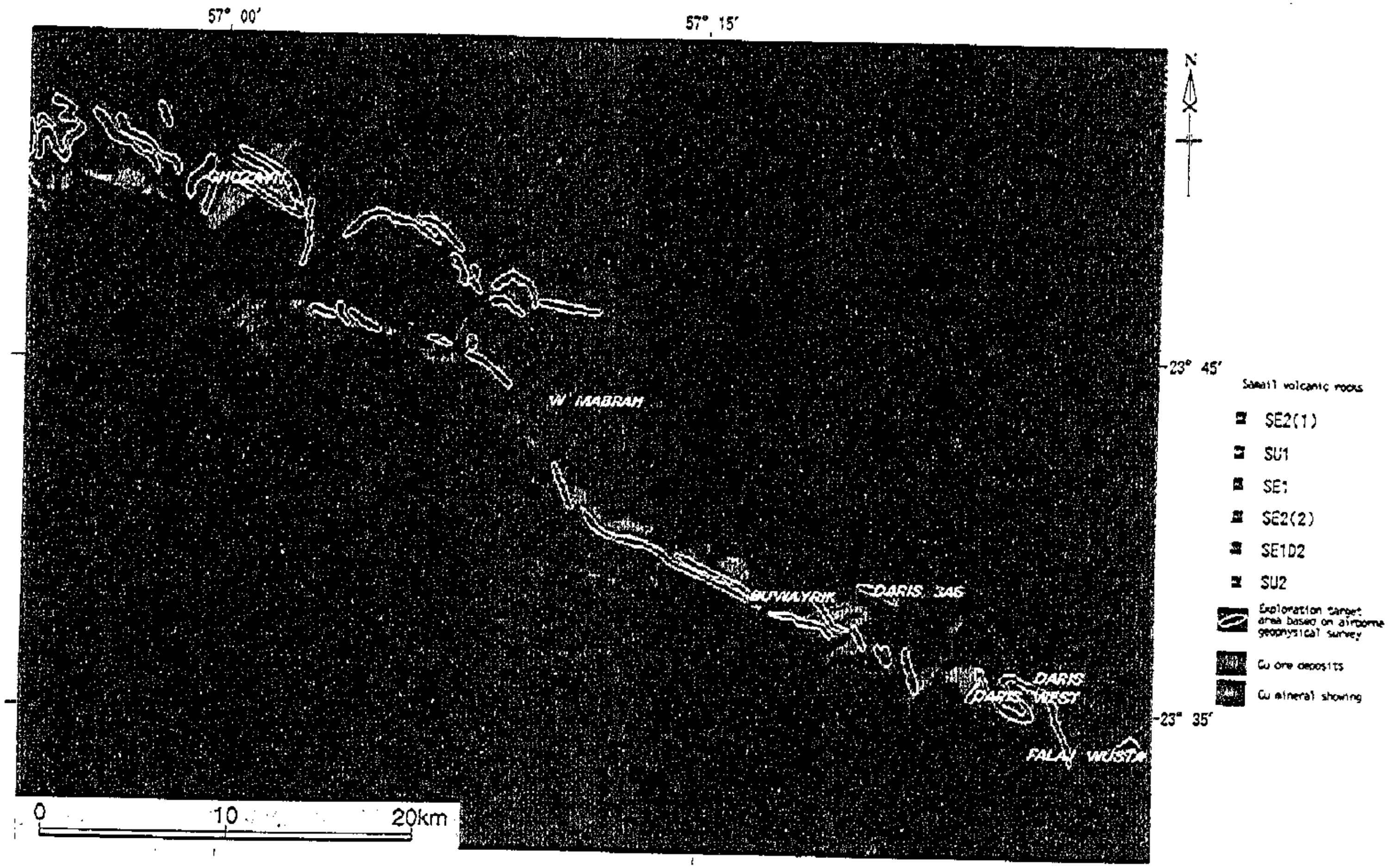


Fig.II-1-11 Composite image of volcanic rocks outeroping and significant magnetic contact zone

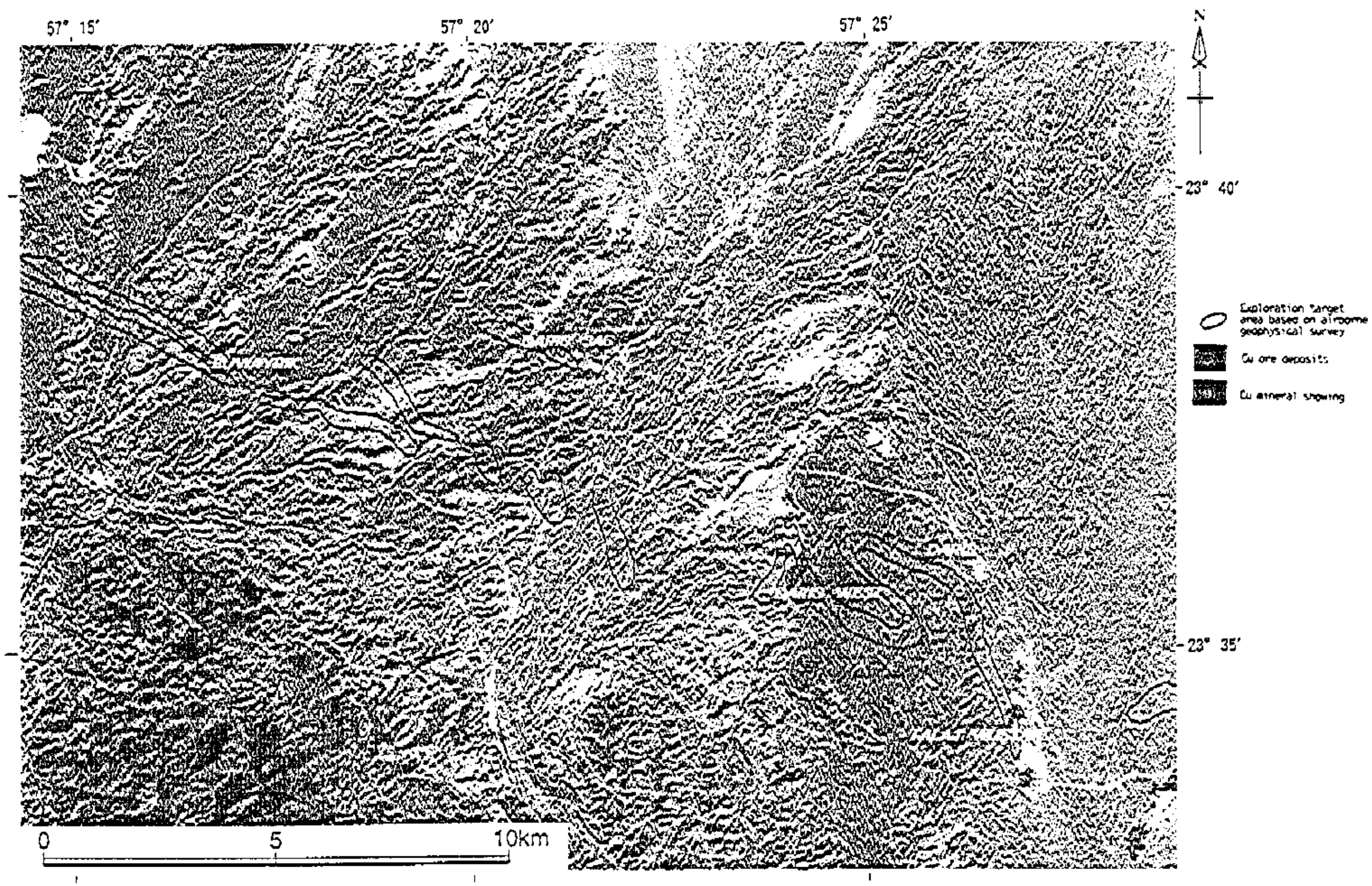


Fig.II-1-12 Landsat image with significant magnetic contact zone in the central survey area

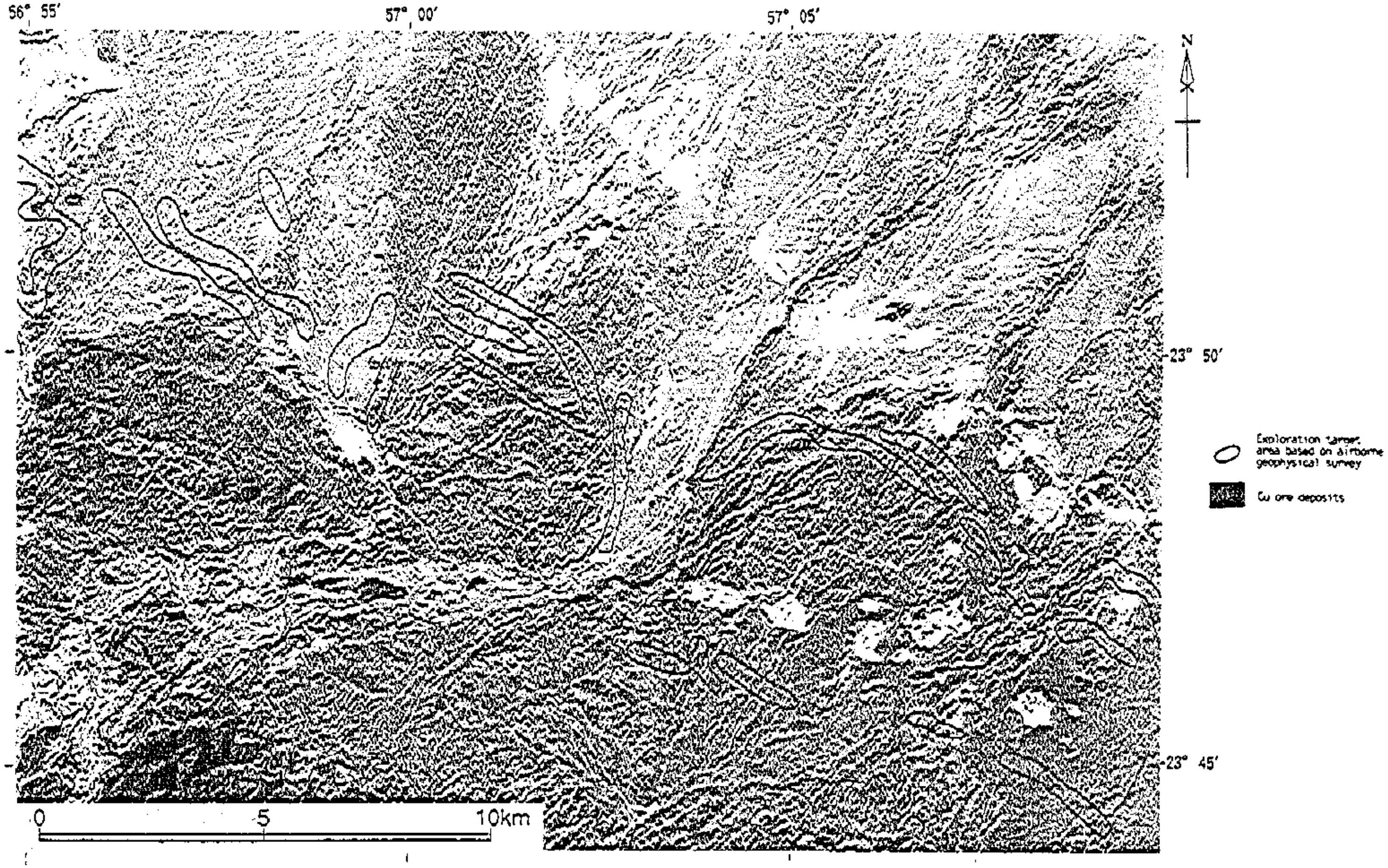


Fig.II-1-13 Landsat image with significant magnetic central zone in the western survey area

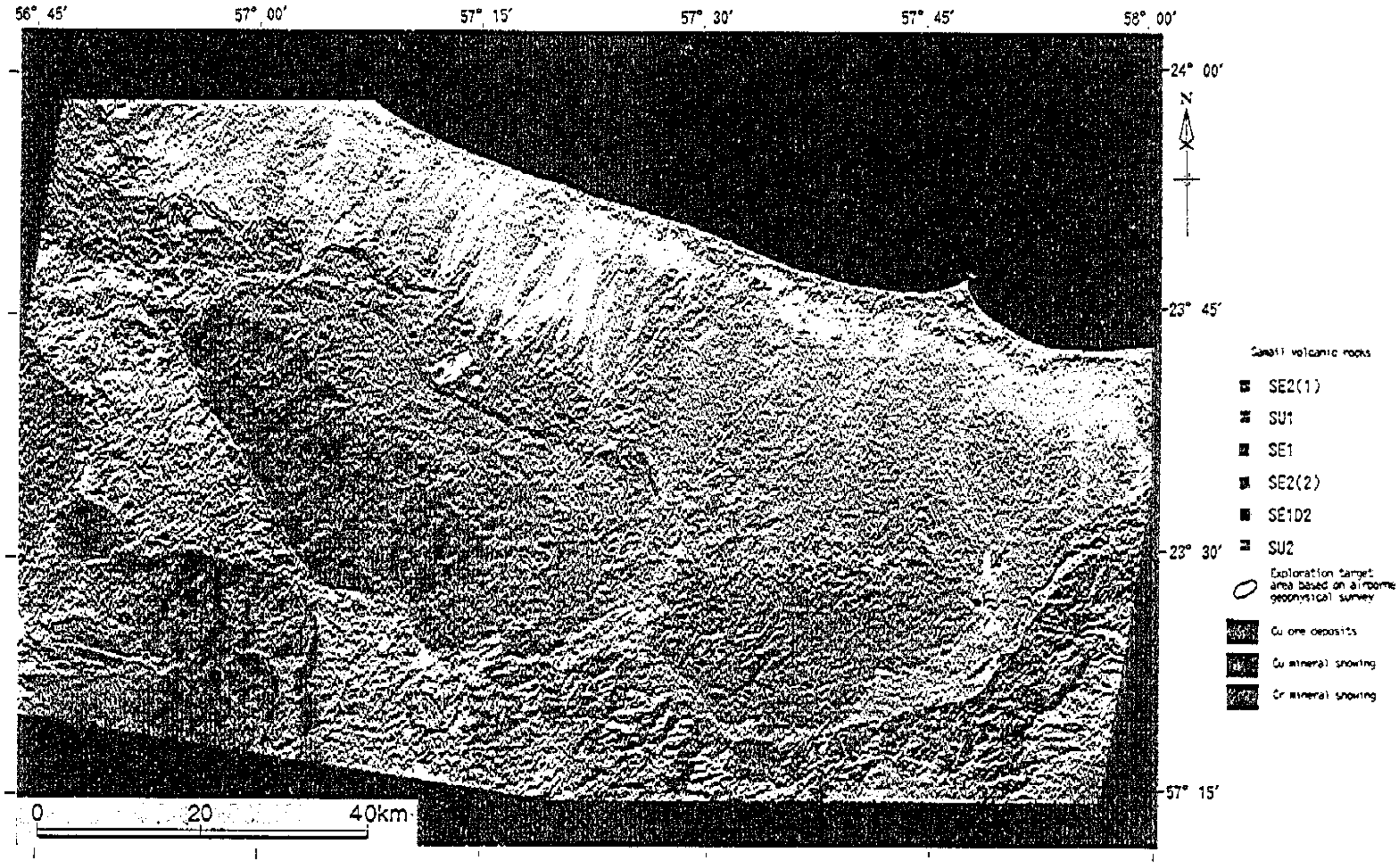


Fig.II-1-14 Landsat image with volcanic rocks outcroping, copper prospect area and significant magnetic contact zone

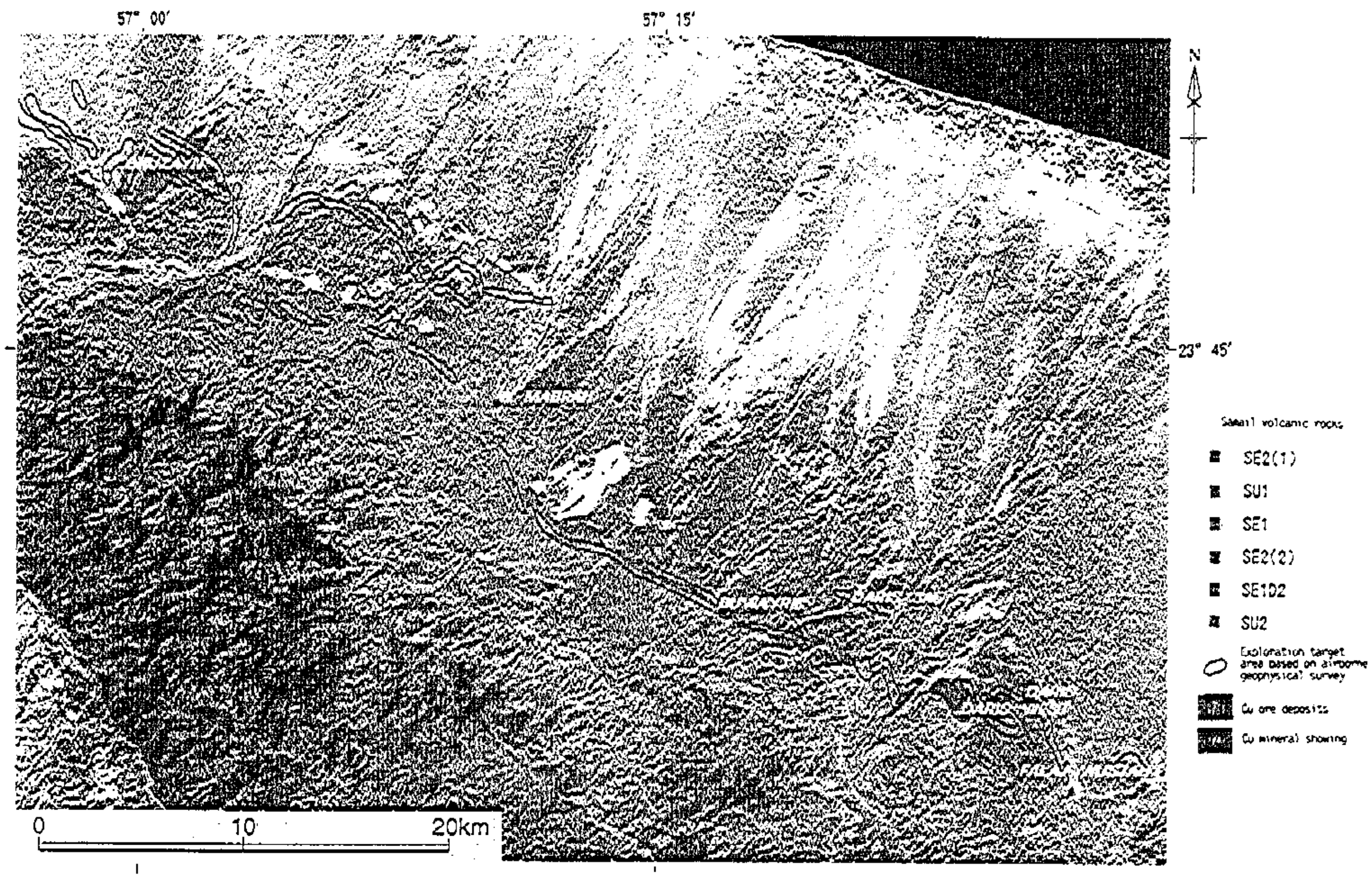


Fig.II-1-15 Landsat image with volcanic rocks outcroping, copper prospect area and significant magnetic contact zone in the central to western survey area

The selected areas are the following 3 areas indicated in Fig.2.

Area-A : the area around the Ghuzayn prospect area

Area-B : the area including Daris, Daris 3A5, Daris West and Buwayrik prospects

Area-C : the area to the east of daris, no mineral occurrences have been yet found.

CHAPTER 2 RECONNAISANCE GEOLOGICAL SURVEY

2-1 Background and Objectives of the Survey

Many geoscientifical explorations have been performed on the middle of the known mineralized zones of the area, however, the explorations have been done at some limited zones within the project area.

The objectives of the project, which includes the Area A, Area B and Area C, where massive sulphides can be expected, are to find new ore deposits by clarifying the geology, the mineralization and the relation between mineralizations and magnetic zones.

2-2 Survey Areas and Method

The locations of the 3 surveyed areas: Area A, Area B and Area C, are shown in Fig.2. The amount of survey covered in these 3 reconnaissance areas are as follow:

RECONNAISSANCE SURVEY AREA	AMOUNT SURVEYED km^2
Area A	700
Area B	700
Area C	400

The route maps were made by using topographic maps for geological survey at 1:50,000 map but enlarged from 1:100,000 maps. After the study of the existing data, the survey routes were selected in the areas where Sheeted-dyke Complex and Samail Volcanic rocks are distributed. Landsat image, air photos and existing data were used for the geological survey. The survey results, including the existing data, were compiled on a 1:50,000 map.

2-3 Geological Survey Results

2-3-1 Outline of geology

The geology and geological structure of Area A, Area B and Area C are described below based on the existing data (Bechennec et al,1986, Beurrier et al,1986, Bishimetal,1987, Raabu et al,1986,World geoscience,1992) and the results of this geological survey.

(1) Stratigraphy

The stratigraphy of the survey areas is shown Fig.II-2-1. The geology of the areas are composed of Samail Ophiolite and Supra-ophiolite Sediments of allochthonous Samail Nappe and Tertiary and Quaternary of post-nappe autochthonous unit.

(a) Samail Ophiolite

The Samail Ophiolite includes tectonites (TH), a cumulate sequence (C), high-level gabbro (HG), a sheeted-dyke complex, Samail volcanic rocks (SV) and intrusive rocks (I') from lower part of ophiolite.

a-1. Tectonites (TH)

Most of the outcrops of the tectonite consist of brown-weathering harzburgite. It also includes small dunite bodies and subordinate lherzolite.

a-2. Cumulate sequence (C)

The cumulate sequence consists of cumulate dunite (CD/D), cumulate peridotite (CP), cumulate peridotite and dunite (CPG), cumulate layered gabbro (ClG) and cumulate planar-laminated gabbro (CpG). The cumulate dunite comprises mainly of chrome-spinel dunite, clinopyroxene dunite, troctolite and wehrlite. The cumulate peridotite is made up of alternating layers of dunite, wehrlite, troctolite, clinopyroxenite and in some places, lherzolite. The cumulate peridotite and dunite consists of gabbro alternating with wehrlite, troctolite, clinopyroxenite and dunite. The cumulate layered gabbro comprises mainly gabbro with layers of troctolite, wehrlite and clinopyroxenite. The cumulate planar-laminated gabbro occupies the top of the cumulate sequence with the gabbro displaying a marked planar orientation of the minerals.

a-3. High level gabbro (HG)

The high level gabbro appears at the top of the cumulate sequence, separating it from the sheeted-dyke complex. It is a equigranular hornblende gabbro with a variable grain size.

a-4. 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.

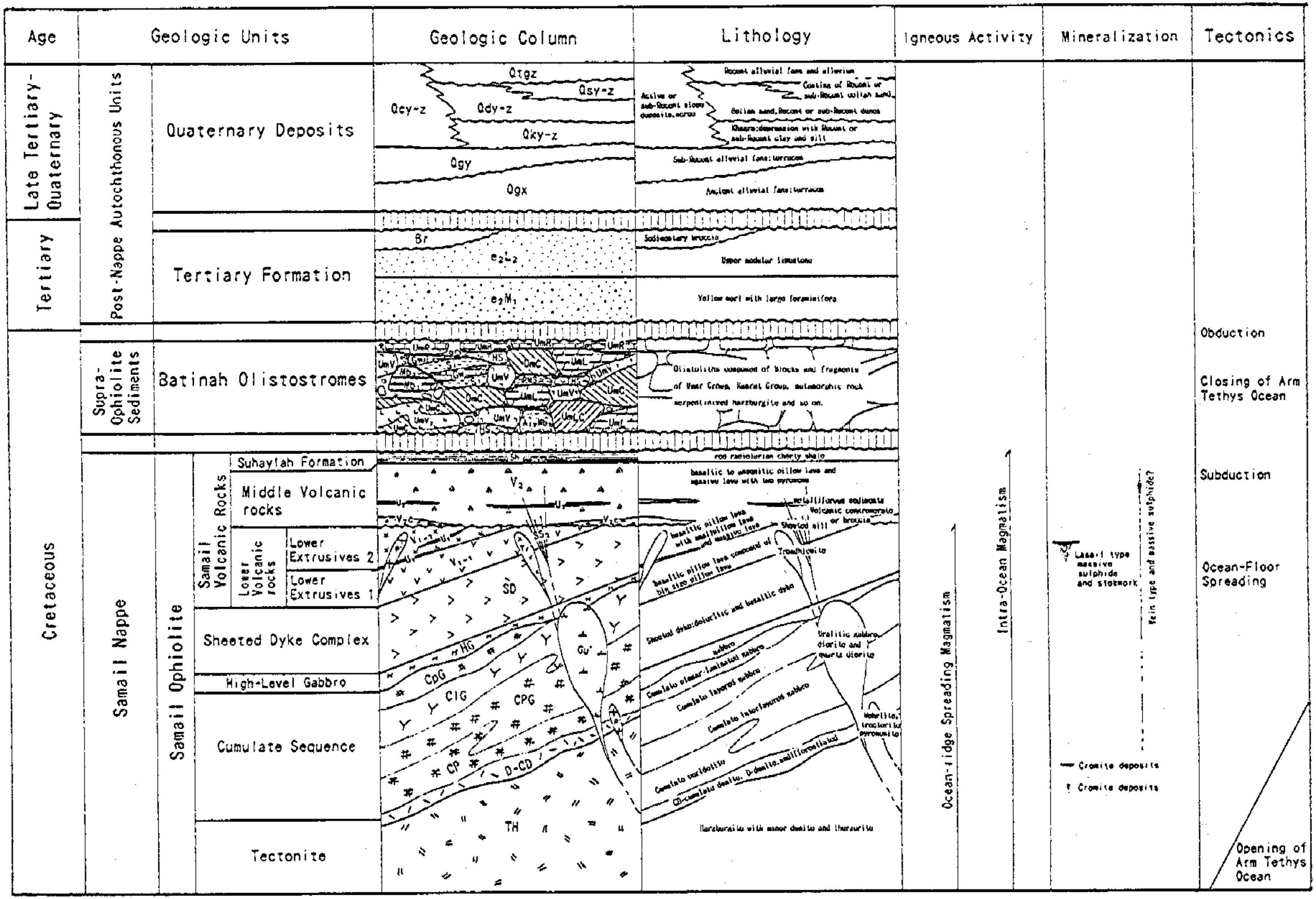


Fig.II-2-1 Stratigraphic Columnar Section of Area A, Area B and Area C.

a-5. Samail volcanic rocks (SV)

The Samail volcanic rocks were emplaced during the three episodes represented by the lower volcanic rocks (SV1), middle volcanic rocks (SV2) and upper volcanic rocks. The lower volcanic rocks appear gradually at the top of the sheeted-dyke complex. The middle volcanic rocks overlies unconformably the sheeted-dyke complex and the lower volcanic rocks. The upper volcanic rocks do not appear in the areas.

i) Lower volcanic rocks (SV1)

The lower volcanic rocks consist of lower extrusives 1 (V1-1), lower extrusives 2 (V1-2) and lower metalliferous sediments (U1).

The lower extrusives 1 (V1-1) and the sheeted-dyke complex bear a gradual relationship. The lower extrusives 2 conformably overlies the lower extrusives 1. The lower 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 differential basalt to andesite, and composed mainly by colored reddish brown big pillow lavas of 1.5 m to 2 m -size in diameter. The lower extrusives 1 also consists of massive lavas, hyaloclastite and pillow breccia. The weathered surfaces of the pillow lavas have sharp cracks like a saw edge. The massive lavas show grey to brownish grey color with a thickness of several 10 cm to several meters. Columnar joints are developed in the thick massive lavas.

The lower extrusives 2 (V1-2) consists of primitive basalt to andesite and is composed of pillow lavas and massive lavas. The pillow lavas are big pillow lavas colored light grey to purpulish grey with sizes mainly of 10 cm to 1 meters in size and maximum of 1.5 meter. It is characteristic that the lower extrusives 2 includes small pillow lavas of 10 cm to 30 cm in size. The upper part of the lower extrusives 2 includes pillow lavas with radial fractures. The massive lavas show grey to brownish grey color with thickness of several meters. Columnar joints are developed in the thick massive lavas.

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

ii) Middle volcanic rocks (SV1)

The middle volcanic rocks(V2) consist of volcanic conglomerate and breccia (V2c), sheeted sills (SS2), middle extrusives (V2) and middle metalliferous sediments (U2). 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. This unit uncorformably overlies the sheeted-dyke complex and the 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 including clinopyroxene and orthopyroxene. Most of the lavas are massive. Its weathered surfaces show the colors of grey, brownish grey, green, blueish grey, orange color, etc.. Especially most of the chilled margin of lavas show orange color. The center of massive lavas show green and blueish grey colors. The lowest part of the massive lavas show dirty brownish grey color and of 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 upper matalliferous sediments (U2) are the so-called umber and includes many radiolarias. This unit shows brownish black colors.

iii) Suhaylah Formation (Sh)

This formation is occupying the top of the Samail volcanic rocks and consists of reddish brown cherty shale including many radiolarias.

a-6. Intrusive rocks (I')

The intrusive rocks include peridotite (P'), uralitic gabbro (Gu'), Trondhjemite (Tr') and late dolerite dykes. The peridotite (P') also includes wehrlite, troctolite, plagioclase-bearing dunite and olivine-bearing pyroxenite. The uralitic gabbro (Gu') also includes diorite and quartz diorite. The Trondhjemite (Tr') also includes quartz diorite. The late dolerite dykes consist of dolerite and fine-grained gabbro.

i) Supra-ophiolite Sediments (Batinah Olistostrome)

The sediments (BO), so-called Batinah Olistostrome, consist of the olistoliths of Tethys Sea sedimentary rocks formed at the same time when Tethys Sea was formed. The olistoliths came as a result of the obduction process at the same time when Tethys Sea closed. The olistoliths are composed of mega-fragments of Hamurat Duru Group and Umar Group, metamorphic rocks (RMS) andserpentinized peridotite (THS). The Hamurat Duru Group consistsof Matbat formation, Guwayza formation and Sid formation. The Umar Group consists of lower formation, upper formation and olistoliths of reef limestone (UmR).

The Matbat formation is composed of radiolarian chert, siltstone and sandstone(AJ2Mb2), brown limestone with microfilaments (pelagic pelecypods)(Mb1) and russet sandstone with calcareous matrix (Mb2). The Guwayza formation consists of oolitic limestone. The Sid formation consists of chert and silicified micritic limestone. The lower formation consists of Umar group undifferentiated Triassic volcanic rocks (UmV) and basaltic to andesitic pillow lavas (UmV2), and the upper formation consists of red radiolaria cherts with micritic limestone (UmC), fine lithoclastic, micritic limestone with chert and chert nodules (UmLC) and white, massive sparry limestone with chert (UmL).

ii) Post-nappe autochthonous units