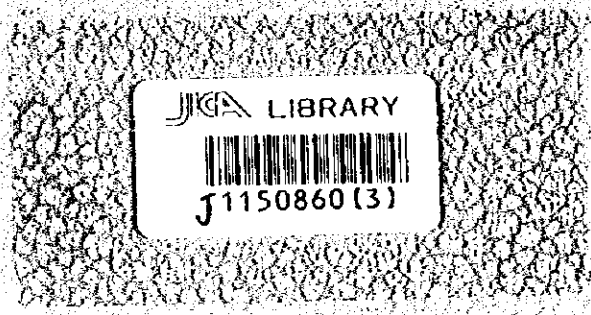
REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE UMM AD DAMAR AREA
THE KINGDOM OF SAUDI ARABIA

PHASE I

MARCH 1998



JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Kingdom of Saudi Arabia, the Japanese Government decided to conduct a Mineral Exploration Project consisting of analysis of existing data, geological survey, and IP geophysical survey and other relevant work in the Umm ad Damar area to clarify the potential of mineral resources, and entrusted the survey to Japan International Cooperation Agency (JICA). The JICA entrusted the survey to Metal Mining Agency of Japan (MMAJ), because contents of the survey belong to a very specialized field of mineral exploration.

The survey conducted during this fiscal year is the first-phase of a three-phase project to be completed in 2001, MMAJ sent a survey team headed by Mr. Yoneharu MATANO to the Kingdom of Saudi Arabia from January 30, 1999 to March 17, 1999. The field survey was completed on schedule with the cooperation of the Government of the Kingdom of Saudi Arabia.

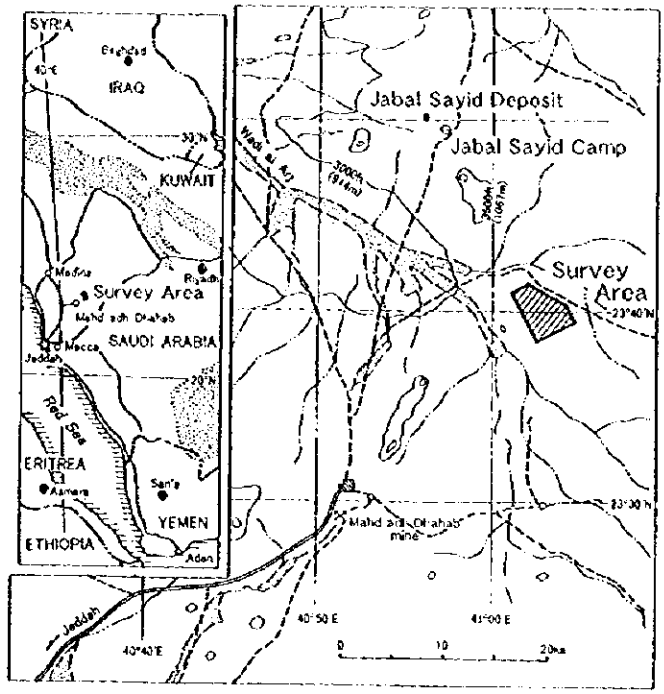
Results of the first-phase survey are summarized in this report which constitutes a part of the final report.

We wish to express our deep appreciation to the persons concerned of the Government of the Kingdom of Saudi Arabia, the Ministry of Foreign Affairs of Japan, the Ministry of International Trade and Industry, the Embassy of Japan in Saudi Arabia and the authorities concerned for the close cooperation extended to the team.

March 1999

Kimio FUJITA
President
Japan International Cooperation Agency

Hiroaki HIYAMA
President
Metal Mining Agency of Japan



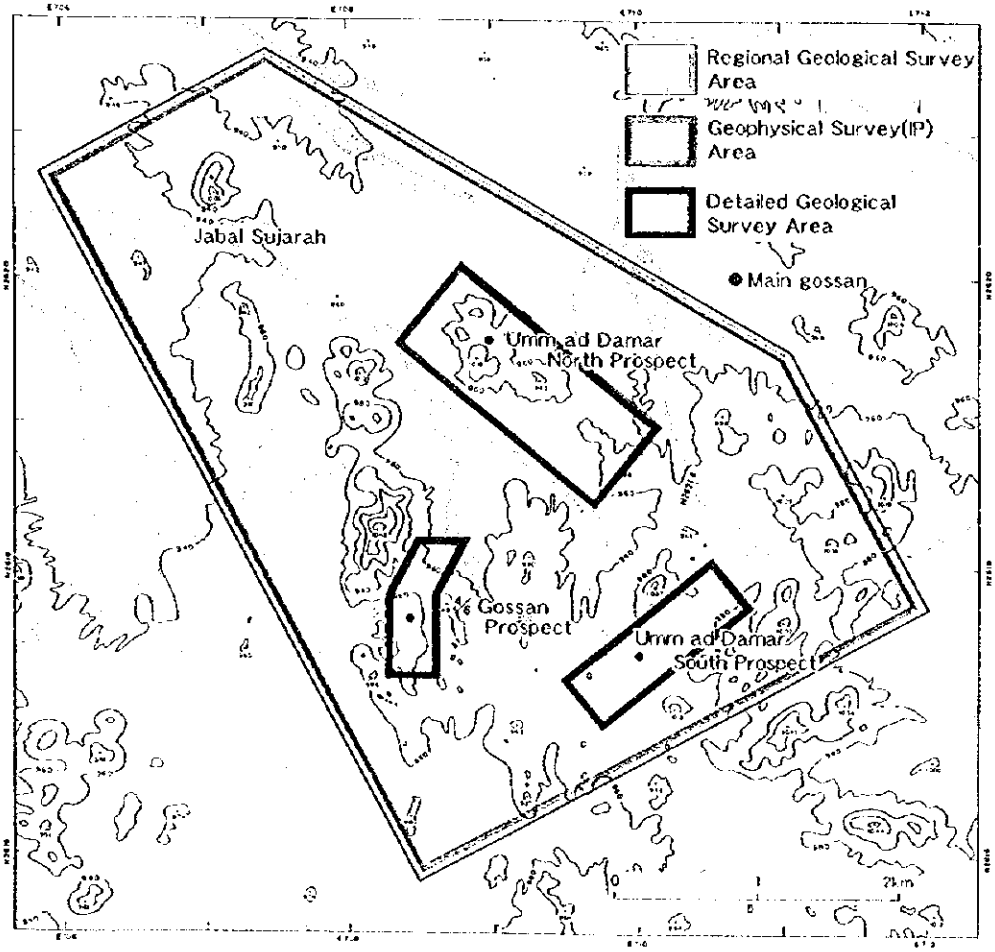


Fig.1-1 Location Map of the Survey Area

SUMMARY

Analysis of existing data, photogeologic investigation, geological survey, and IP geophysical survey were carried out during the first year of the mineral exploration of the Umm ad Damar area of the Kingdom of Saudi Arabia. The results of the above are summarized below.

The geology of the survey area consists mainly of; Late Proterozoic andesite, dacite, and rhyodacite lavas and volcaniclastic rocks belonging to the Arj Group. This group is intruded by diorite, quartz diorite, tonalite, andesite, dacite, rhyodacite, and other rock bodies. These units are covered unconformably by Late Proterozoic andesitic lava and volcaniclastic rocks of the Mahd Group in the western edge of the survey area.

Three known mineral prospects, namely Umm ad Damar North, Umm ad Damar South, and 4/6 Gossan occur in the survey area. The mineralized zones of these prospects are products of dissemination to network copper hydrothermal activity, and the zone of the 4/6 Gossan has particularly high gold, silver, lead and zinc grade. The mineralized zones occur in the shear zones within dacite, rhyodacite, and volcaniclastics of the Arj Group. These prospects have already been surveyed geologically, geophysically by IP, geochemically, by trenching, and by drilling. The ore reserves of Umm ad Damar South and 4/6 Gossan Prospects were calculated to be 1 million tons (Cu 2 %, Zn 1—2.5 %) and 0.16 million tons (Au<15 g/t, Ag<450 g/t), respectively.

From results of the detailed geological survey carried out this year and the past drilling data, the existence of seven main mineralized zones is inferred in these prospects. They are; five (Nos. 1—5) in Umm ad Damar North, one in Umm ad Damar South, and one in 4/6 Gossan Prospects. And it is considered that the prospectivities of the following areas are high. Namely, the part below the slags at Umm ad Damar North, western extension of the mineralized zone in Umm ad Damar South, and the lower and southern parts of the mineralized zone in the 4/6 Gossan.

The mineralization of this survey area is rich in sulfides such as pyrite. Thus IP method was considered to be an effective exploration tool for this area, and was used by private industries and government agencies. During the present work, strong chargeability anomalies exceeding 24 mV/V were extracted in four areas, namely Jabal Sujarah ("B-12" anomalous zone), southeastern extension of the No.3 Mineralized Zone in the Umm ad Damar North Prospect ("J-25"), an intermediate point between Umm ad Damar North and Umm ad Damar South ("M-27"),

and western edge of the Umm ad Damar South Prospect ("P-18"). The surface of these anomalies is covered by sand and gravel and the subsurface conditions are not clear.

Carbonatization is strong near "B-12" and it is located at the intersection of NE-SW and NW-SE faults. Also "B-12" is geologically similar to the Jabal Sayid deposit by the occurrence of jasper and rhyodacite, and other factors. "J-25" is located between NW-SE trending No. 3 and No. 4 Mineralized Zones of the Umm ad Damar North Prospect. "M-27" and "P-18" occur near a NE-SW trending fault, and an oxidized copper-bearing quartz vein and ancient workings are distributed near "M-27". The above four anomalous zones have high resistivity, and it is concluded from various aspects including laboratory tests that the high chargeability anomalies are reflection of the sulfide bodies in the deeper parts.

It is recommended that drilling be carried out to the part below the slags and "J-25" chargeability anomalous zone at Umm ad Damar North, and the lower and southern parts of the mineralized zone in the 4/6 Gossan. Also the centers of mineralization in the "B-12", "M-27" and "P-18" chargeability anomalous zones should be clarified by IP geophysical survey with closely-spaced IP lines and TEM (Time Domain Electromagnetic Method) geophysical survey.

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PART I OVERVIEW

CHAPTER 1 INTRODUCTION

1-1 Background and Objectives

In response to the request of the Government of the Kingdom of Saudi Arabia to conduct mineral exploration, the Japanese Government dispatched a mission to discuss the details of the project in July 1998. And as a result of the consultations with Deputy Ministry for Mineral Resources (DMMR) an agreement was reached for cooperative exploration of the Umm ad Damar area and the "Scope of Work" was signed by representatives of both Governments in 6 July 1998.

The objective of this project is to discover new ore deposits through clarification of the geologic conditions and mineralization of the survey area. This project will be carried out during the three-year period of fiscal 1998 to 2000. This is the first year of this project.

1-2 Work during the First Year

The survey area is located in the northern part of Saudi Arabia. An area of 18 km^2 was surveyed (Fig. 1-1).

The work of the first year survey consisted of preparation of topographic maps, analysis and interpretation of existing data, photogeologic interpretation, geological survey, and IP geophysical survey. The amount of work carried out is shown in Table 1-1.

Before field work, topographic maps (1:10,000) of an area of 100 km^2 including the survey area were prepared, and also another topographic map of 1:5,000 scale was prepared for an area of 9 km^2 including the known prospects. This work was carried out in Japan. Photogeologic interpretation was carried out in Japan for an area of 90 km^2 including the survey area.

Existing information and data were acquired regarding the results of past geological surveys, geophysical surveys, and drilling. These data were analyzed and interpreted both in Japan and in Saudi Arabia.

Geological survey was carried out for the survey area and its vicinity and a 1:10,000 scale geological map was prepared. At the same time, detailed geological survey was done on the three known prospects and 1:2,500 scale geological maps were prepared. Drill holes, trenches and ancient workings were plotted on these detailed maps.

IP geophysical survey was carried out along NE-SW trending line, which is normal to the trend of the geologic structure. The objective of this survey was to assess the resistivity and chargeability of the whole survey area, and thus the line interval was set at 300 m.

Table 1-1 Amount of Work

Survey method	Amount	
Topographic map		
scale 1:10,000	Areal extent	100 km^2
scale 1:5,000	Areal extent	9 km^2
Photogeological interpretation	Areal extent	90 km^2
Geological survey	Areal extent	18 km^2
	Laboratory works	
	Thin section microscopy	25 sections
	Polished section microscopy	8 sections
	X-ray diffraction	10 samples
	Ore assay (Au,Ag,Cu,Pb,Zn,Fe)	33 samples
	Fluid inclusion	
	Homogenization Temperature	14 samples
	Salinity	14 samples
Geophysical Survey (IP)	Total length of survey lines	55 km
	Survey lines	17 lines
	Number of measuring points	1,962 points
	Measurement of rock resistivity and chargeability	36 samples

1-3 Members of the Survey Team

(1) Mission for Scope of Work Consultation

1) Japanese side

Takeru SASAGUCHI (Team leader, Executive Director, MMAJ)

Hiroyuki OKAJIMA (Development Cooperation Division, Ministry of Foreign Affairs)

Tatsuya TAKAHASHI (Mining Division, Agency of Natural Resources and Energy, MITI)

Takafumi TSUJIMOTO (Technical Cooperation Division, MMAJ)

Noboru FUJII (Technical Cooperation Division, MMAJ)

Nobuyasu NISHIKAWA (Representative of Paris Office, MMAJ)

2) Saudi Arabian side

Mohammed TAWFIQ (Assistant Deputy Minister for Survey and Exploration, DMMR)

Ghazi ABDULHAY (Director of Survey and Exploration Program Department, DMMR)

Mohamad SAHL (DMMR)

(2) Field supervisor

Taro KAMIYA (Mining and Industrial Development Study Department, JICA)

Takafumi TSUJIMOTO (Technical Cooperation Division, MMAJ)

Hiroshi SHIBASAKI (Technical Cooperation Division, MMAJ)

(3) Survey Team

1) Japanese side (Nikko Exploration and Development Co., Ltd.)

Yoneharu MATANO (Team leader, Senior Geologist)

Yoshihiro KIKUCHI (Geological survey)

Takashi YAMAISHI (IP survey)

Shin-ichi SUGIYAMA (IP survey)

Saburo TACHIKAWA (IP survey)

Satoshi HIROOKA (IP survey)

Tadanori IWASAKI (IP survey)

2) Saudi Arabian side (DMMR)

Ghazi ABDULHAY (Team leader, Coordinator)

Mohamad SAHL (Geological survey)

Abudullah AL-JOHANI (Geological survey)

1-4 Duration

Scope of Work consultation:	25 June 1998 to 8 July 1998
Field supervising:	
Takafumi TSUJIMOTO	30 January 1999 to 7 February 1999
Hiroshi SHIBASAKI	5 March 1999 to 16 March 1999
Taro KAMIYA	9 March 1999 to 16 March 1999
Analysis of existing information and data:	30 January 1999 to 8 February 1999
Geological and IP survey:	30 January 1999 to 17 March 1999
Laboratory work and report preparation:	18 March 1999 to 24 March 1999

CHAPTER 2 GEOGRAPHY OF THE SURVEY AREA

2-1 Location and Access

The survey area is located about 300-km northeast of Jeddah. DMMR camp near the Jabal Sayid deposit was used as the base camp (shown in Fig. 1-1). This is located about 20-km northwest from the survey area. The survey area is about 30-minute drive from the base camp.

2-2 Topography and Drainage

The topography of the region including the survey area consists, from the west; the Red Sea, coastal plain of the Red Sea – hilly zone, the Hijaz Mountains, Harat Rahat (basalt plateau), sabkha zone, and low-relief mountainous zone. And the survey area is located at the eastemmost part with low-relief mountains. The altitude gradually increases eastward from the Red Sea, the Hijaz Mountains are 1,200—2,300 m high, the highest part of the Harat Rahat is 1,500 m, the altitude of the sabkha zone and the low-relief mountains are 1,000—1,200 m.

The low-relief mountains including the survey area are a part of the Najd Plateau located to the east of the Hijaz Mountains. The topography of the survey area consists of flat zone with altitude of about 900 m with hills and small mountains ranging in relative height from 50 m to 100 m.

2-3 Climate and Vegetation

Saudi Arabia is located at the central part of the great tropical desert, which extends from northern Africa to Asia. In the highlands, the day time temperature exceeds 40 ° C , but it often drops to near 0 ° C at night in winter. The average annual precipitation at Mahd ad Dhahab is 62 mm.

Vegetation is sparse in the survey area with only acacia growing along wadis.

CHAPTER 3 PREVIOUS EXPLORATION WORK

Three prospects are known in the survey area; namely Umm ad Damar North, Umm ad Damar South, and 4/6 Gossan (henceforth the North Prospect, the South Prospect, and the 4/6 Gossan, respectively). The range of these prospects has been drawn in various ways by past surveys. In the present survey, the area shown in Figure 1-1 was decided for detailed survey from the distribution of ancient workings, trenches, and drill holes. In the North and South Prospects, disseminated to network pyrite-chalcopyrite mineralized parts occur intermittently in lens-form within the sheared zones. In this survey, the belt containing the linearly distributed mineralized lenses is called the mineralized zone.

The North and South Prospects have been explored in the past by various methods, including airborne geophysical survey, ground geophysical survey, geological survey, and drilling. The organizations concerned with these surveys were; DGMR (1936-1965), BRGM (1969-1971), SEREM (Societe d'Etudes de Recherches et d'Exploitation Minieres)/US Steel (1976-1977), and Riofinex (1981-1983). Regarding the 4/6 Gossan, Riofinex carried out trenching, geochemical survey, IP geophysical survey, and other types of exploration during 1982 to 1983, and Riofinex conducted drilling in 1983.

Ground geophysical survey was carried out intermittently from 1961 to 1983, but the area surveyed is not clear except for the work done by Riofinex during 1982 and 1983. The latter survey included the above three prospects and IP and geomagnetics were used. Although there are some exceptions, the chargeability anomalous zone exceeding 12.5 mV/V of Riofinex, mostly coincides with the mineralized zone.

A total of 27 holes were drilled in the survey area and the sum of the hole lengths attains 4,821 m. Of the 27 holes drilled, 12 holes were in the North Prospect and 11 in the South Prospect. It is seen that drilling was concentrated in these two prospects and only 2 holes were drilled in the 4/6 Gossan.

CHAPTER 4 REGIONAL GEOLOGICAL SETTING

4-1 Regional Geology

The geology of the area including the survey area, Jabal Sayid deposit and Mahd adh Dhahab mine (the above area will be called "this area" in this section) will be reported below (Fig. 1-2).

The Late Proterozoic Arj Group, Mahd Group, and Ghamr Group, in ascending order, occur in this area. These units are intruded by Dhukur Tonalite, Fufayriyah Tonalite, Bari Granodiorite, and granites of the Raghiyah Suite.

The Arj Group is the lowermost unit of this area, and the base of this Group is not known. The Arj Group in this area consists of Sayid Formation (asa in Fig. 1-2) composed of silicic volcanic rocks, Jabal Azlam Formation (ajz) composed of volcaniclastic rocks and andesite, and undifferentiated rocks (asz). The main component of Sayid Formation is dark gray to green massive silicic rocks accompanied by sedimentary rocks. The lower part of the Jabal Azlam Formation consists of basaltic to andesitic breccia·tuff breccia and andesite, and the upper part of this formation of breccia, sandstone, and conglomerate. This Group is unconformably overlain by the Mahd Group.

The Mahd Group in this area consists of Tulaymisah and Haf Formations. Tulaymisah Formation is divided into volcaniclastic rock unit (mtv) and volcanic rock unit (mt). Haf Formation is further divided into Juraysiyah Member (mhj), Zur Member (mhz), and undifferentiated rocks (mh). The Juraysiyah Member consists of basalt, andesite, and rhyodacite, while the Zur Member is composed of rhyolite and sedimentary rocks.

Ghamr Group in this area consists of Tuff Member (ggt) and Kharzah Formation. Kharzah Formation is further divided into mafic unit (gka), silicic unit (gkr), and sedimentary unit (gks).

Dhukhr Tonalite (dt) consists of gabbro – trondhjemite·granodiorite, and mostly of quartz diorite – tonalite. The relation between Dhukhr Tonalite and Arj Group is not clear. The age of the tonalite was measured by U-Pb (zircon) method and is reported to be 816±4 Ma.

The composition of the Fufayriyah Tonalite (ht, 760±10 Ma) is that of quartz diorite – tonalite.

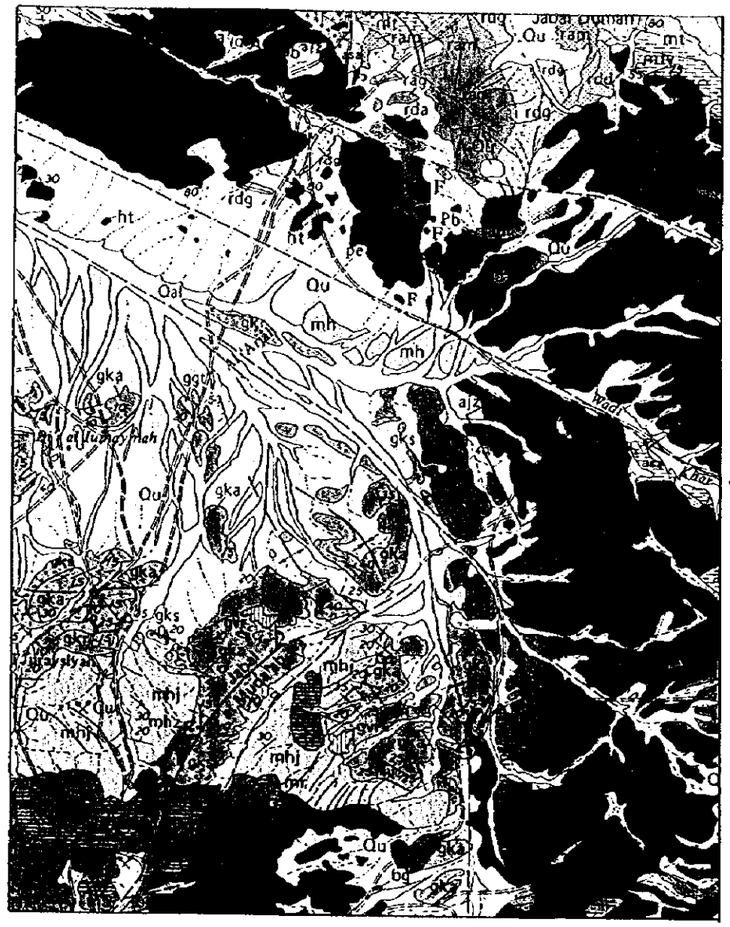
Bari Granodiorite (bg) intruded into the Mahd Group, and the latter is contact metamorphosed. The Granodiorite is covered by unmetamorphosed Ghamr Group. The composition of the Bari Granodiorite is the same as that of tonalite – trondhjemite.

Raghiyah Suite is divided into Dayahin Granite (rda, 582±26 Ma), Assharah Granite, and Dumah Granodiorite. Assharah Granite is further divided into monzogranite (rag, 573±22 Ma and 575±28 Ma) and red granite – microgranite (ram). Dumah Granodiorite is divided into granodiorite (rdg), and quartz monzodiorite (rdd).

Of the above geologic units, Sayid and Jabal Azlam Formations of the Arj Group occur in the survey area.

4-2 Geologic Structure

In this area, the distribution of the Arj Group is limited to near the Jabal Sayid deposit and in the survey area. The Group in the survey area has triangular distribution, and it is bounded; to the northeast by NW-SE trending Wadi al Aqiq strike-slip fault, to the south by Bari Granodiorite and Dhukhr Tonalite, and to the west by the Mahd Group.



AGE		SEDIMENTARY, VOLCANIC AND METAMORPHIC ROCKS		INTRUSIVE ROCKS
CENOZOIC	QUATERNARY	WADI ALLUVIUM	Qal	sand, gravel
		OLDER WADI DEPOSITS, FANS, TERRACES	Qu	SCREE(Qu)
	TERTIARY	BASALT		
UNCONFORMITY				
PROTEROZOIC		RAGHIYAH SUITE		Dayahin Granite(582±26Ma): porphyritic rag: Assharah Granite: monzogranite(rag, 573±22Ma&575±28Ma), red granite and microgranite(ram) ram rdg: Dumah Granodiorite: granodiorite(rdg), quartz monzodiorite(rdd) rdd
		SUBVOLCANIC ROCKS	gvr	Rhyolite to rhyodacite
		GHAMR GROUP	gst	tuffaceous member
			gka	Kharzah Formation: mafic units(gka), silicic units(gkr), sedimentary units(gks)
			gks	
			gkr	
UNCONFORMITY				
		BARI GRANODIORITE		
		HUFAYRIYAH TONALITE		tonalite(760±10Ma)
		SUBVOLCANIC ROCKS	r	rhyolite to rhyodacite
			b	basalt to andesite
		MAHD GROUP	mtv	Tulaymisah Formation: volcaniclastic rocks(mt) with vocanic units(mtv)
			mt	
			mh	Haf Formation: undifferentiated(mh), Juraysiyah Member(mhj)-basalt, andesite, rhyodacite,
			mhj	
			mhz	Zur Member(mhz)-rhyolite, sedimentary rocks
UNCONFORMITY				
		DHUKHR TONALITE		tonalite(816±4Ma)
		ARJ GROUP	asz	Undifferentiated Sayid and or /Jabal Azlam Formations
				Jabal Azlam Formation: volcaniclastic rocks, andesite
				Sayid Formation: silicic volcanic rocks

Fig. 1-2 Regional Geology of the Survey Area

4-3 Ore Deposits in the Vicinity of the Survey Area

The Jabal Sayid deposit occurs about 20-km northwest and the Mahd adh Dhahab mine is about 25-km southwest of the survey area.

The Jabal Sayid deposit is a stratabound massive sulfide deposit consisting of four orebodies. It is accompanied by a stockwork orebody below. The orebodies occur in the upper part of the silicic rocks of the Sayid Formation. These are overlain by chemically precipitated chert – carbonate formation. The sulfide minerals constituting the massive sulfide orebodies are mainly; pyrite, pyrrhotite, sphalerite, and chalcopyrite. The sulfides of the stockwork body are mainly pyrite and chalcopyrite with smaller amount of sphalerite. The volcaniclastic rocks, the host of the stockwork body, are chloritized. The results of the feasibility study carried out by BRGM in 1985 show the combined reserves of Orebodies No.1 and No.2 to be 19.93 million tons (Cu 2.68 %).

Mahd ad Dhahab mine has been mined since ancient times (3,000 BP), and it is still being mined underground. The mineralization, which formed the deposit of this mine, was a vein-type Au-Ag-Cu-Zn hydrothermal activity. The age of this mineralization is 649 Ma. The deposit occurs in andesitic tuff, andesite, agglomerate, and sandstone of the Haf Formation. The main ore minerals are; chalcopyrite, galena, sphalerite, and pyrite. The gangue minerals are quartz and chlorite. The host rock is silicified, chloritized, and potash-metasomatized. The ore reserves of the mine as of 1992 are 1.14 million tons (Au 31.8 g/t, Ag 167 g/t, Cu 0.87 %, Zn 3.24 %).

CHAPTER 5 GEOLOGY OF THE SURVEY AREA

5-1 Geology

The geology of the survey area consists mainly of; lavas and volcaniclastic rocks of Late Proterozoic rhyodacite, andesite, dacite, and jasper belonging to the Arj Group. This group is intruded by diorite, quartz diorite, tonalite, andesite, dacite, rhyodacite, and basalt bodies. These units are covered unconformably by Late Proterozoic andesitic lava and volcaniclastic rocks of the Mahd Group in the western edge of the survey area. The rocks of the Arj Group are regionally chloritized and epidotized, and schistosity is partly developed.

5-2 Geologic Structure

The strike of the Arj Group is NE at the South Prospect and the eastward, but it is NW – N in other parts of the survey area. The dip of the formations of this group is steeper than 60°. The attitude of the Mahd Group is NNW and 20 – 40° W.

NE-SW system faults are predominant in the survey area. The existence of a NW-SE fault, almost parallel to Wadi al Aqiq Fault is inferred in the northeasternmost part of the survey area.

5-3 Mineralization

The mineralization, which formed the mineralized zones of the North Prospect, the South Prospect, and the 4/6 Gossan, is hydrothermal activity and it formed copper dissemination to network type occurrences. Of these mineralized zones, the 4/6 Gossan has a particularly high Au, Ag, Pb, and Zn content.

In these three prospects, oxidized zones have been formed from the surface to 30—40 m depth. Thus, on the surface, only gossan consisting mostly of hematite and limonite containing oxidized copper minerals is observed.

A large amount of copper slag is distributed at the North Prospect. Many ancient workings occur on the hills surrounding this slag distribution, namely West Hill to the west and Southeast

Hill to the southeast. These workings also occur on the hilly zone to the southeast of the Southeast Hill. The geology of this prospect, consists mostly of rhyodacite and dacite of the Arj Group. Diorite occurs to the northeast of this prospect intruding the Arj Group rocks. Mineralization is observed in the Arj Group and not in the diorite bodies. A total of five main mineralized zones are inferred to exist from the following observations; namely, the distribution of the ancient workings and gossan in trenches, and the results of drilling carried out in the past. The inferred five mineralized zones are; one in West Hill, another under the slag zone, one in Southeast Hill, and two in Southeast Extension. In this report, these zones will be numbered serially from No.1 to No.5 Mineralized Zones.

Regarding No. 1 Mineralized Zone, five holes have been drilled and DA-5 encountered ore zone of 2.6 m in width and Cu content of 2.17 %. For No.2 Mineralized Zone, drilling has not been carried out. On No.3 Mineralized Zone, four holes have been drilled and UAD-11 shows a zone of 3.1 m width and a grade of Cu 1.87 %. Drilling has not been carried out for No. 4 and 5 Mineralized Zones.

Eleven grab samples were collected on the surface of this prospect, but the gold content was low at Au 0.6 g/t maximum.

The geology of the South Prospect consists of rhyodacite, andesite, andesitic tuff, and dacitic tuff of the Arj Group. Seventeen ancient workings are confirmed in this prospect. The number of the main mineralized zone of this prospect is inferred to be one, from the distribution of ancient workings containing oxidized-copper minerals and gossan in trenches. Eleven holes have been drilled for this mineralized zone, and ore zone encountered in UAD-2 is 6.9 m wide and Cu 1.99 %. Two grab samples collected at the surface contain Au 6.2 g/t and Au 3.0 g/t. Thus this Cu mineralization is believed to be accompanied by Au contrary to that of the North Prospect.

The geology of the 4/6 Gossan consists of dacite, dacitic tuff, and rhyodacite of the Arj Group. There is one mineralized zone in this prospect and the zone mainly occurs in dacitic tuff. Two holes have been drilled here, and the ore zone encountered in UAD-14 is 2.1 m wide and contains Au 16.1 g/t, Ag 449.8 g/t, Cu 1.15 %, Pb 1.02 %. The grab samples collected in the trenches contain Au 3.7 g/t and Au 1.6 g/t.

CHAPTER 6 RESULTS OF GEOPHYSICAL SURVEY

Chargeability anomalous zones were clearly extracted by 2-D (two-dimensional) Inversion. At deeper parts (e.g. 800 m above sea level, approximately 150m below surface), large and strong anomalous zones exceeding 24 mV/V were extracted at three localities, namely near B-12, near J-25, and near M-27 measuring points. These localities will be called "B-12" anomalous zone etc., in this paper.

The physical properties of the samples collected on the surface indicate that the chargeability background values of the survey area is rather low. The primary cause of strong chargeability anomalies is believed to be sulfide minerals consisting mainly of pyrite. The physical properties of gossan indicate that, if pyrite is oxidized in the shallow parts the chargeability anomalies will be weak. Rocks containing large amount of graphite also cause strong chargeability anomalies, but in these cases, the resistivity is low corresponding to the strength of chargeability anomalies. The high chargeability anomalous zones exceeding 24 mV/V of this survey area show high resistivity values and thus these anomalies cannot be caused by graphite.

A total of seven chargeability anomalous zones except for the above-mentioned three large anomalous zones were also extracted by the 2-D Inversion. They are located near P-18, near G-11, near I-15, near J-18, near M-18, near L-14, and near N-14 measuring points. Locations, chargeability, surface geology, and drilling exploration history of the ten anomalous zones including "B-12", "J-25", and "M-27" will be reported below (refer to Figure 1-3).

"B-12": This anomalous zone is located on the eastern slope of Jabal Sujarah, and the chargeability is stronger than 24 mV/V. Talus deposits cover the surface. The center of this anomalous zone is at the intersection of faults of NE-SW and NW-SE systems. Also the dacite and andesite on the western slope of Jabal Sujarah are strongly carbonatized.

"G-11" and "I-15": These anomalous zones are located to the south-southeast of Jabal Sujarah, and the chargeability ranges 15 to 24 mV/V. Quaternary sand and gravel cover the surface. Drilling has not been carried out in both zones. Silicified rocks with weak gossan are distributed near these anomalous zones. Both zones and the silicified rocks are aligned in the NW-SE direction.

"J-18": This anomalous zone is located to the south of the West Hill of the North Prospect,

and the chargeability ranges 15 to 24 mV/V. Quaternary sand and gravel cover the surface. Drilling has not been carried out in this anomalous zone. The center of this zone is located 300m south of the N-S trending No.1 Mineralized Zone in the West Hill.

"J-25": This zone is located between the No.3 Mineralized Zone of the Southeast Hill and No.4 Mineralized Zone of the Southeast Extension in the North Prospect. The chargeability is high at more than 24 mV/V. The surface is covered by Quaternary sand and gravel, but strongly hematitized rhyodacite is observed in a trench, which intersects this anomalous zone in the E-W direction. Four holes had been drilled in the Southeast Hill, but none has been drilled toward this anomalous zone.

"M-8" and "L-14": The chargeability of these two anomalous zones ranges 15 to 24 mV/V. The "M-8" zone occurs over a mineralized zone in the 4/6 Gossan. A trench exists within the "L-14" anomalous zone and gossan is observed within this trench. The chargeability trend of these two anomalous zones was pointed out to be same by the past IP survey (Harvey 1984, Fig.2-1-1).

"N-14": This zone is located about 700 m east of the 4/6 Gossan, and the chargeability ranges 15 to 24 mV/V. Andesite of the Arj Group occurs on the surface. The andesite near this anomalous zone is epidotized and weakly silicified. Mineralization is not observed in this alteration zone.

"M-27" and "P-18": The area with chargeability exceeding 15 mV/V, and including the North Prospect continues southward. "M-27" zone with chargeability exceeding 24 mV/V occurs within the central part, and "P-18" zone with chargeability exceeding 24 mV/V occurs within the southern part. Ancient workings are found at two localities to the north of "M-27" and at one locality to the southeast. A 30-cm wide quartz vein is observed on the area to the south of this zone, and the sample collected from this vein contains 1.48 % of Cu. Drilling has not been carried out in these anomalous zones.

CHAPTER 7 COMPREHENSIVE ANALYSIS OF THE SURVEY AREA

7-1 Geologic Structure, Mineralization Characteristics, and Mineralization Control

Outcrops of the survey area consist mainly of; Late Proterozoic rhyodacite, dacite, and andesite and their volcaniclastic rocks belonging the Arj Group. The Group does not have clear bedding due to schistosity and regional metamorphism, and thus the stratigraphy of volcanic and volcaniclastic rocks in the Group is not clear. Kemp et al., (1982) stated that the Sayid Formation (silicic rocks) lie in the lower part of the Group and the Jabal Azlam Formation (andesite and its volcaniclastic rocks) in the upper part. In the survey, schistosity is developed in the silicic rocks, and usually it is not observed in the andesitic rock. Therefore, from Kemp et al., (1982) and difference of deformation, rhyodacite and its volcaniclastic rocks which are mainly distributed near the mineralized zones in the three known mineral prospects are considered to locate in the lower part of the Group, and andesite and its volcaniclastic rocks which are mainly distributed in the areas to the north and south of Jabal Sujarah, and to the west and northeast of the South Prospect, are to locate in the upper part.

The Group is intruded by diorite, quartz diorite, tonalite, andesite, dacite, rhyodacite, and basalt bodies. The Arj Group is covered unconformably by Late Proterozoic andesite and its volcaniclastic rocks of the Mahd Group in the western edge of the survey area.

In the survey area, NE-SW faults are predominant. Trends of some faults are parallel to the strike directions of shear zones, which are estimated from localities of ancient workings and gossans. The mineralized shear zones do not show a definite strike direction due to displacement by faulting after mineralization.

From results of the detailed geological survey carried out during this fiscal year and the past drilling data, the existence of seven main mineralized zones are inferred in the survey area. They are; five in the North Prospect, one in the South Prospect, and one in the 4/6 Gossan.

The mineralization, which formed the mineralized zones in the North and South Prospects, is copper-bearing hydrothermal activity and it formed disseminated to networked pyrite and chalcopyrite occurrences in the shear zones. The mineralization in the South Prospect is thought to contain also gold contrary to the North Prospect, from assay results of samples collected from the surficial zone of the mineralized zone in the Prospect, In the past, ores of these two prospects were believed to be parts of stockwork of stratabound massive sulfide

deposits, and the mineralization was considered to be of syngenetic nature. However, it was maintained by authors after Howes (1984) that the mineralization had epigenetic characteristics. During this survey, it was confirmed that the strike direction of the mineralized zone in the South Prospect was slightly oblique to those of the country rocks, and some mineralized zones of the Southeast Hill and the Southeast Extension in the North Prospect intersect each other. Therefore, the mineralization in the North and South Prospects is considered to be of epigenetic nature.

Two drilling explorations carried out in the 4/6 Gossan have not confirmed primary ores below the secondary enrichment zone. Therefore, the mineral assemblage of sulfides of the mineralized zone is not clear. Gold, silver, lead and zinc grades are high in the enriched zone similar to the copper grade. The mineralization in the 4/6 Gossan is also considered to have epigenetic nature (Howes, 1984). During this survey, it was confirmed that the strike direction of the mineralized zone in this prospect was slightly oblique to those of the country rocks, and therefore the mineralization in this prospect is also considered to be of epigenetic nature.

Mineralized zones of the three prospects lie in the shear zones within rhyodacite, dacite, and their volcaniclastic rocks, and the mineralization is not confirmed in andesite and its volcaniclastic rocks of the Arj Group, and intrusive bodies. Therefore, the mineralization is considered to have occurred after deposition of silicic rocks and before intrusion of diorite and tonalite. Faulting after the mineralization displaced the mineralized zones. For example, a NE-SW fault near the mineralized zone in the 4/6 Gossan is estimated to be right-lateral strike slip fault and this fault separated a single mineralized zone into southern mineralized zone inferred from "M-8" chargeability anomaly and northern mineralized zone from "L-14" with 250m displacement. Igneous rocks related to the mineralization in the survey area have not been reported, and was not determined during this survey.

Alterations associated with the mineralization in the three prospects are silicification, chloritization, and pyritization. Pyrites in the pyritized rocks are altered to hematite and geothite by weathering. Reddish silicic rocks with these iron oxide minerals occur near mineralized zones in the three prospects. Also distribution of chargeability anomalous zones exceeding 15 mV/V coincide with those of reddish silicic rocks. Therefore, mineral potential is thought to be high in the areas where hematized silicic rocks distribute.

7-2 Chargeability Anomalies and Mineralization

Integrated analysis map is laid out in Figure 1-3 and Plate 7. These maps contain the following information.

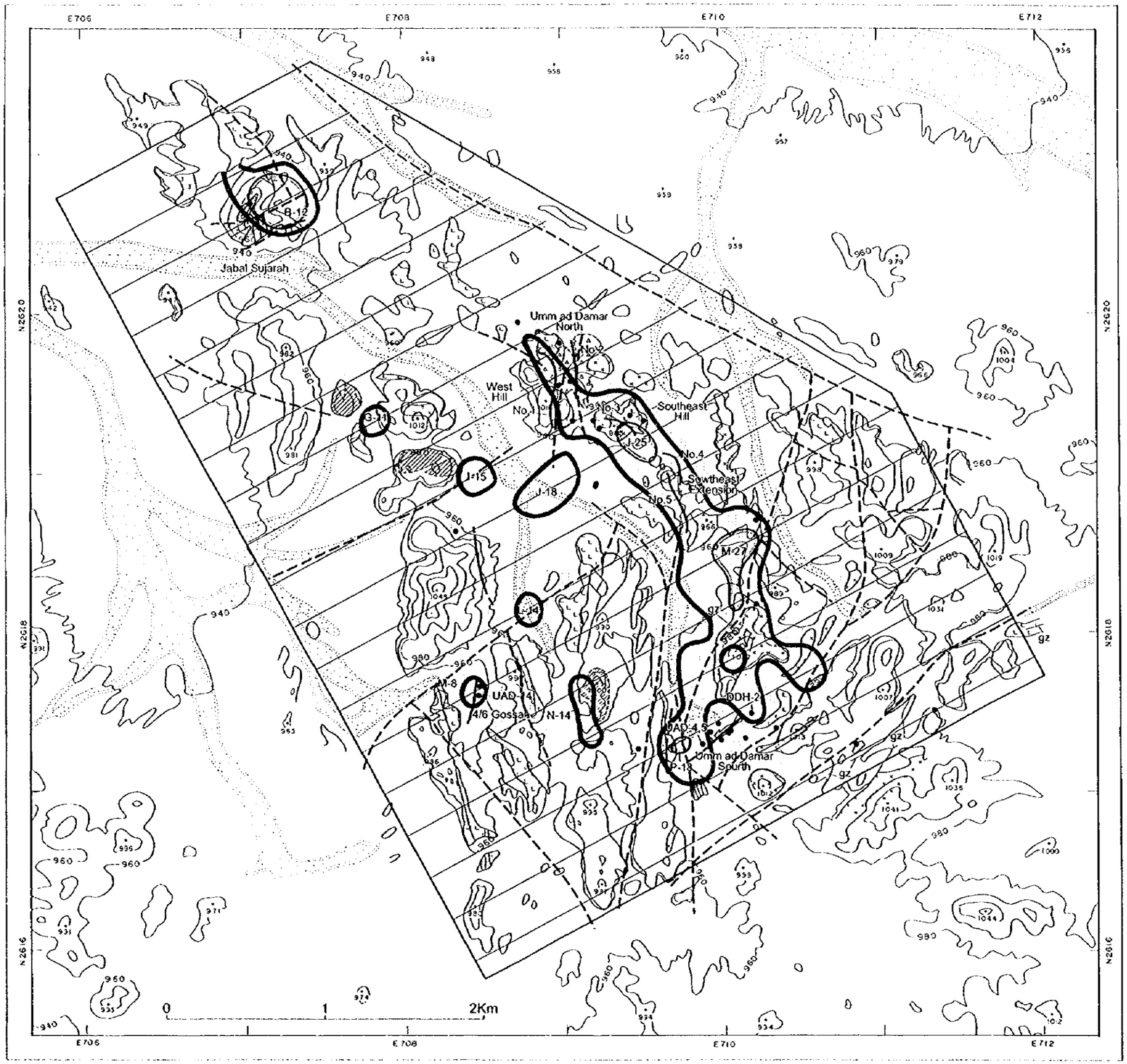
- Boundary of Proterozoic and Quaternary (sand and gravel, talus deposits) Systems
- Distribution of; Arj Group rhyodacite/volcaniclastic rocks, jasper, plutonic rocks (tonalite, diorite), slag at the North Prospect
- Faults
- Distribution of mineralized zones and alteration zones
- Location of ancient workings
- Drilling sites
- IP survey lines
- Distribution of chargeability anomalies

Relations between the ten chargeability anomalous zones which were mentioned in Chapter 6 and their mineralizations is summarized as follows.

"B-12", "J-18", "J-25", "M-27", and "P-18" chargeability anomalous zones are believed to reflect mineralized zones containing sulfide minerals in the deeper parts of these zones, since they are high in resistivity. The mineralization type is inferred to be a pyrite-chalcopyrite dissemination and network mineralization in the sheared zone within the Arj Group similar to that of the North and South Prospects.

However, there is the possibility of the existence of Jabal Sayid-type stratabound massive sulfide ores in the subsurface parts of "B-12" anomalous zone, because rhyodacite, similar to the host rock of Jabal Sayid deposit, occur on the northeastern slope of Jabal Sujarah, and jasper, which lies over Jabal Sayid deposit occur widely on the southern slope of Jabal Sujarah.

It is interpreted that both of "G-11" and "I-15" anomalies indicate the existence of the silicified rocks associated with sulfide minerals in the deeper parts, and "N-14" anomaly reflect the epidotization and silicification zone near this anomaly.



IP anomaly chargeability > 15mV/V

IP anomaly chargeability > 24mV/V

Quaternary gravel & sand

Arj Group rhyodacite

Arj Group jasper

Diorite, tonalite

Other rocks

Slag

Fault

Carbonatization

Silicification

Epidotization & week silicification

Mineralized zone

Drill hole

Ancient working

Quartz vein

IP line

Fig. 1-3 Integrated Interpretation Map

7-3 Mineral Potential

From integrated study of the results of the past drilling exploration and present detailed geological and geophysical surveys, the following zones are considered to have prospectivity; namely No.2 Mineralized Zone (<30m wide, 400m long) under the slag in the North Prospect, western extension of the mineralized zone (<30m wide, 400m long) of the South Prospect, and the lower and southern parts of the mineralized zone (<8m wide, 250--300m long) of the 4/6 Gossan.

"B-12", "J-25", "M-27", and "P-18" anomalous zones exceeding 24 mV/V show high resistivity. Therefore, it is inferred that these chargeability anomalies are reflection of sulfide bodies consisting mainly of pyrite in the deeper parts and not of graphite-bearing rocks. These zones are also considered to have prospectivity.

CHAPTER 8 CONCLUSIONS AND RECOMMENDATIONS

8-1 Conclusions

Analyses and interpretation of existing data, photogeological interpretation, surface geological survey, and IP geophysical survey were carried out in the Umm ad Damar area as the first phase of this project and the following conclusions were obtained.

1. The geology of the survey area consists mainly of; lavas and volcaniclastic rocks of Late Proterozoic rhyodacite, andesite, dacite, and jasper belonging to the Arj Group. This group is intruded by diorite, quartz diorite, tonalite, andesite, dacite, rhyodacite and basalt bodies. These units are covered unconformably by Late Proterozoic andesitic lava and volcaniclastic rocks of the Mahd Group in the western edge of the survey area. The rocks of the Arj Group are regionally chloritized and epidotized, and schistosity is partly developed.

2. Three known prospects, namely Umm ad Damar North, Umm ad Damar South, and 4/6 Gossan occur in the survey area. The mineralized zones of these prospects are products of dissemination to network copper hydrothermal activity, and the zone of the 4/6 Gossan has particularly high Au, Ag, Pb, Zn grade. The existence of seven mineralized zones are inferred in these prospects. They are; five (Nos.1－5) in the North Prospect, one in the South Prospect, and one in the 4/6 Gossan.

3. In the past, geological survey, IP geophysical survey, trenching, and drilling have been carried out for these prospects. Sufficient exploratory work has not been carried out, however, for the lower part and extensions of the mineralized zones. Also the area covered by sand and gravel, which constitutes 60% of the survey area, has not been explored sufficiently.

4. It is concluded from integrated study of the results of the past drilling exploration and present detailed geological survey, that the following zones warrant further exploration; namely under the slag in the North Prospect, western extension of the mineralized zone of the South Prospect, and the lower and southern parts of the mineralized zone of the 4/6 Gossan.

5. Strong chargeability anomalous zones exceeding 24 mV/V were extracted at the following four localities by IP geophysical survey. These zones are at; Jabal Sujarah ("B-12" anomalous zone), southeastern extension of No.3 Mineralized Zone of the North Prospect ("J-

25"), intermediate point between the North and South Prospects ("M-27"), and western edge of the South Prospect ("P-18").

6. Carbonatization is strong near "B-12" which is located at the intersection of NE-SW and NW-SE faults. Also "B-12" is geologically similar to the Jabal Sayid deposit by the occurrence of jasper, rhyodacite, and other factors. "J-25" is located between NW-SE trending No.3 and No.4 mineralized zones of the North Prospect. "M-27" and "P-18" occur near a NE-SW trending fault, and an oxidized copper-bearing quartz vein and ancient workings are distributed near "M-27". The above four anomalous zones have high resistivity, and it is concluded from various aspects including laboratory tests that the high chargeability anomalies are reflection of the sulfide bodies in the deeper parts.

8-2 Recommendations for the Second Year

8-2-1 Drilling exploration

Umm ad Damar North Prospect: Most of the No.2 Mineralized Zone is covered by slag and thus this zone is not well known. Drilling is recommended in this zone for detailed assessment. "J-25" zone is located between the No.3 Mineralized Zone of the Southeast Hill and the No.4 Mineralized Zone of the Southeast Extension and drilling aimed at the lower part of this zone is concluded to be necessary.

4/6 Gossan Prospect: This IP anomalous zone is relatively small, and thus strong and large scale mineralization cannot be anticipated, but the mineralization of this prospect is rich in Au and Ag. It is deemed worthwhile to clarify the mineral potential of this prospect by drilling in the deeper parts of the mineralized zone and in sites south of UAD-13.

8-2-2 Geophysical survey

Geophysical surveys in the following zones are considered to be desirable.

"B-12" anomalous zone: This is the largest anomalous zone in the survey area. The elongation and the center of this zone could not be clarified because the IP line interval was large at 300m. Thus drilling cannot be immediately undertaken. IP survey with line interval of about 100m and TEM survey will be the next step of exploration in this zone.

Area including "M-27" and "P-18" anomalous zones: These anomalous zones are inferred to indicate the existence of mineralized zone along the weak line with NE-SW strike, or "P-18" anomalous zone might be the western extension of the mineralized zone of the South Prospect. It is recommended to clarify the continuity and the center of the anomaly by IP geophysical survey with about 100-m line interval and TEM survey.

PART II DETAILED DISCUSSIONS

PART II DETAILED DISCUSSIONS

CHAPTER 1 ANALYSIS OF EXISTING DATA

1-1 Survey Area

1-1-1 Past exploration

The exploration history of the North and South Prospects was summarized by Ransom (1982). Ancient workings are concentrated in these two prospects. Particularly in the North Prospect, a large amount of copper smelting slag is accumulated, and it is inferred to amount to 108,000 t containing 0.91 % of Cu. During the past several decades, airborne geophysical survey, surface geophysical survey, geologic survey, and drilling were carried out on both prospects by DGMR (1936-1965), BRGM (1966-1971), SEREM /US Steel (1976-1977), and Riofinex (1981-1983).

Gossan was discovered in the 4/6 Gossan around 1980 to 1981, and trenching, geochemical prospecting, and IP geophysical survey were carried out from 1982 to 1983. Drilling was done in 1983 (BRGM-OF-07-6).

1-1-2 Mineralization

Regarding the mineralization of the above three prospects, various theories were proposed as shown in Table 2-1-1 on the basis of drill core investigation and other studies. The mineralized zones of the prospects can be summarized from mode of occurrence, form, and major elements of ores as follows.

North and South Prospects:

> Disseminated to network pyrite-chalcopyrite mineralized zone forms intermittently continuous lenses in shear zones. In the past, the ores of these prospects were believed to be parts of stockwork of stratabound massive sulfide deposits, and the mineralization was considered to be of syngenetic nature. In 1984, it was maintained by Howes (1984) that the mineralization, which formed these prospects, had epigenetic characteristics.

4/6 Gossan:

> The mineralization of this prospect has been considered to be epigenetic (Howes, 1984). Cu-Au-Ag-Pb-Zn mineralized zone forms intermittently continuous lenses in

Table 2-1-1 Mineralization of Prospects in the Survey Area

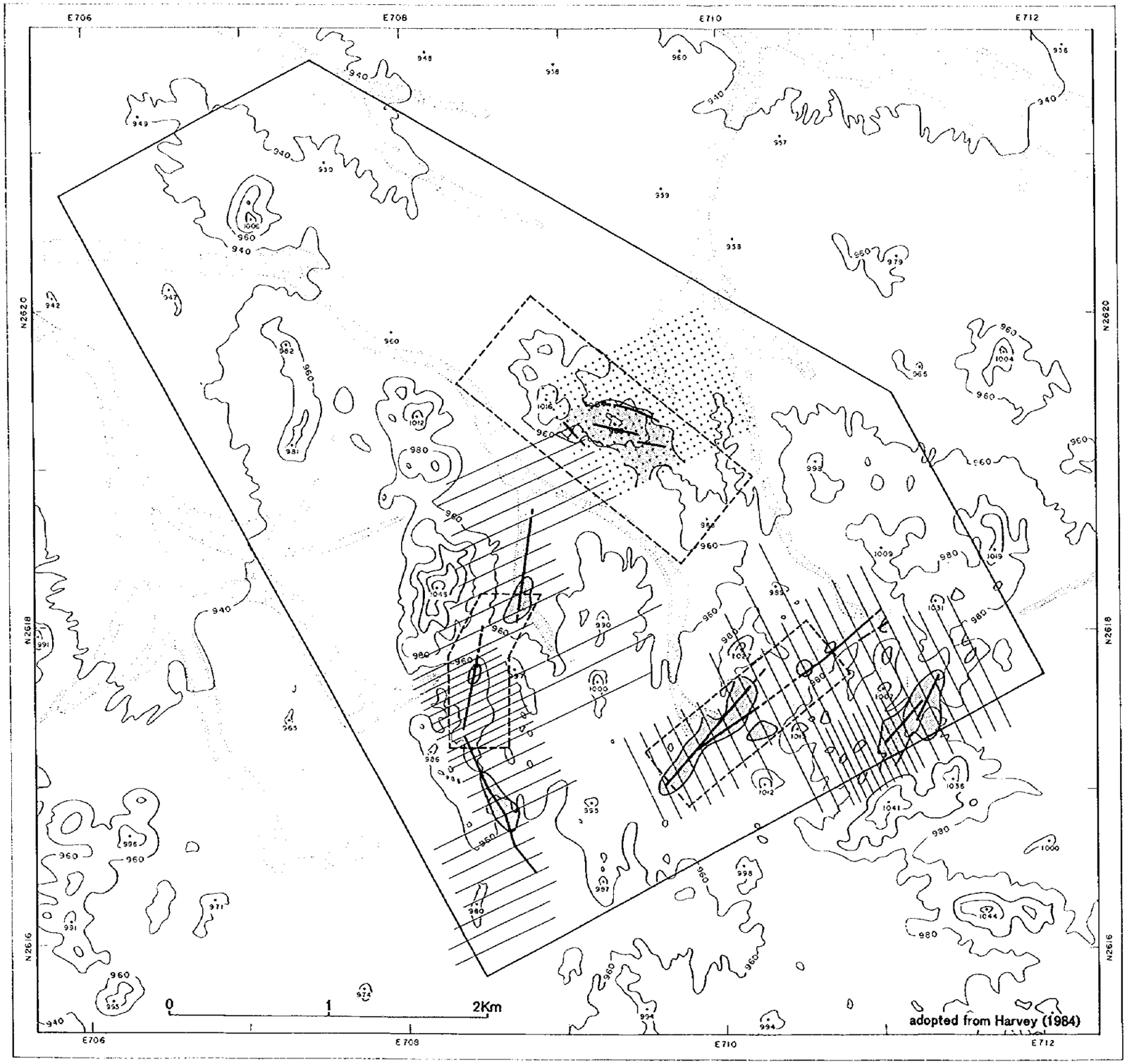
Prospect	Literature or Researcher	Mineralization
Umm ad Damar North	Sahl, 1979	Drill Hole DA-4(84-95m): massive pyrite with few chalcopyrite veinlets.
		Drill Hole DA-5(102-106m): stringer chalcopyrite and disseminated pyrite.
	Bowden and Smith,1981	Widely spaced, discontinuous pyritic lenses with low Cu-Zn grades.
	Howes, 1984	Southeast Hill: Epigenetic Cu mineralization.
	Ramson,1984	Drilled Core: predominantly vein-like quartz-pyrite-chalcopyrite rocks.
	DGMR,1994	Well-developed networks of quartz, pyrite, chalcopyrite and chlorite vein that form widely spaced and discontinuous lenses. Southeast Hill: ancient working occurs at the intersection of east-, north-, and northwest-trending linear shear zones.
Umm ad Damar South	Sahl, 1979	Drill Hole UAD-2(70-100m): dissemination of pyrite and very few stringer of chalcopyrite Drill Hole UAD-4(113.0-113.5m): massive sulfide.
	Bowden and Smith,1981	Ancient workings aligns along southeast-trending shear zone. Drill Hole UAD-4: bedded, massive and sub-massive mineralization.
	Ramson,1982	The mineralization at Umm ad Damar South may be conventionally interpreted as the deformed stringer zone of a volcanogenic massive sulfide. The mineralization at Umm ad Damar South may have been emplaced after deposition.
	Howes, 1984	Structurally emplaced Cu mineralization.
	DGMR,1994	Sulfide mineralization occurs in lenses 2-8m wide over strike length of about 200m. Structurally emplaced and epigenetic mineralization.
4/6 Gossan	Howes, 1984	Epigenetic shear Cu-Zn-Ag-Au-Pb mineralization.
	DGMR,1994	Discontinuous lenses of pyrite and associated Cu-Pb-Zn mineralization.

shear zones.

1-1-3 Results of geophysical survey

Ground geophysical survey was carried out intermittently in the present survey area including the above three prospects from 1961 to 1983. But the areas of these surveys are not clear except for the work done by Riofinex from 1982 to 1983.

Riofinex carried out geophysical survey (IP and magnetic prospecting) in areas including the North Prospect, the South Prospect, and the 4/6 Gossan. The IP results are shown in Figure 2-1-1. The distribution of chargeability anomalies exceeding 12.5 mV/V coincides with that of the mineralized zones.



Grid point

IP line

IP anomaly trend

Area of chargeabilities over 12.5mV/V

Fig. 2-1-1 Previous Geophysical Surveys in the Survey Area

1-1-4 Results of drilling exploration

The results of drilling in the three mineral prospects are shown in Table 2-1-2. A total of 27 holes were drilled by DGMR, BRGM, SEREM/US Steel, and Riofinex during the period from 1964 to 1983, and the total length of drilling attained 4,821 m. These holes are; 12 in the North Prospect, 11 in the South Prospect, and 2 in the 4/6 Gossan. It is seen that drilling was concentrated in the first two prospects.

Also of the 27 holes drilled, 15 encountered mineralized zones, but none exceeds 10 m in width with Cu grade exceeding 1 %.

As results of the past drilling exploration, ore reserves of the North Prospect and the 4/6 Gossan were estimated as follows.

Prospect	Length (m)	Width (m)	Depth (m)	Reserve (t)	Grade	Data
Umm ad Damar South	Unknown	Unknown	Unknown	1,000,000	Cu 2 % Zn 1 --2.5%	SEREM/US Steel
4/6 Gossan	700	2	45	160,000	Au<15g/g Ag<450g/g	BRGM-OF-07-6

Table 2-1-2 Results of Drilling Exploration

		Drill Hole	Date	Organization	Azimuth(°)	Dip(°)	Length(m)	Intersection(m)		Depth of intersection(m)		Width(m)	True width(m)	Value				
														Cu(%)	Au(g/t)	Ag(g/t)	Zn(%)	Pb(%)
UAD North Prospect	West Hill	DDH-6	1964	DGMR	270	-43	300.00	161.0	154.0	-103.0	-105.0	3.0	2.4	0.95	-	-	-	-
		DDH-7	1964	DGMR	240	-35	222.00	39.0	42.0	-22.4	-24.1	3.0	2.9	1.00	-	-	-	-
								119.0	119.7	-68.3	-68.6	0.7	0.6	5.00				
		DA-3	1968	BRGM	0	-90	164.30	32.0	40.0	-32.0	-40.0	8.0	2.5	0.90	-	-	-	-
		DA-4	1968	BRGM	259	-36.5	282.20	87.0	92.0	-51.7	-54.7	5.0	4.8	1.03	-	-	-	-
								137.0	141.0	-81.5	-83.9	4.0	3.8	1.17	-	-	-	-
								183.0	184.0	-108.9	-109.4	1.0	1.0	2.40	-	-	-	-
		DA-5	1968	BRGM	257.8	-38	257.30	102.7	106.3	-63.2	-65.4	3.6	3.2	1.40	-	-	-	-
								120.0	123.0	-73.9	-75.7	3.0	2.6	2.17	-	-	-	-
								203.9	205.0	-125.5	-126.2	1.1	1.0	5.10	-	-	-	-
		UAD-8	1977	SEREM/US Steel	-	-	240.25	-	-	-	-	-	-	Negligible Cu grades				
	Southeast Hill	DDH-4	1964	DGMR	90	-43.5	150.90	108.0	109.0	-74.3	-75.0	1.0	-	1.26	-	-	low	-
		DDH-5	1964	DGMR	270	-40	300.00	167.0	170.0	-107.3	-109.3	3.0	-	2.25	-	-	low	-
		UAD-6	1977	SEREM/US Steel	45	-60	270.40	98.0	100.0	-75.1	-76.6	2.0	-	2.05	-	-	0.02	-
		UAD-11	1983	Rofinex	223	-50	150.00	66.0	68.0	-52.1	-67.4	20.0	18.0	0.66	-	12.9	0.12	-
								68.0	71.5	-52.1	-54.8	3.5	3.1	1.87	-	25.8	0.48	-
		UAD-7	1977	SEREM/US Steel	-	-90?	140.00	84.5	87.1	-	-	2.6	-	Very rich pyrite, negligible Cu grades				
		UAD-10	1977	SEREM/US Steel	-	-90	98.66	-	-	-	-	-	-	Negligible Mineralization				
UAD South Prospect		DDH-1	1964	DGMR	300	-45	51.80	31.2	31.5	-22.1	-22.3	0.3	0.3	2.28	-	-	-	
		DDH-2	1964	DGMR	300	-45	106.70	30.0	100.0	-21.2	-70.7	70.0	-	Traces dss. pyrite and chalcopyrite				
		DDH-3	1964	DGMR	300	-64	91.40	67.0	71.0	-60.2	-63.8	4.0	2.1	2.93	-	33.4	0.73	
		DDH-3A	1964	DGMR	295	-61	125.00	-	-	-	-	-	-	Traces disseminated pyrite at 56 and 96m				
		DA-1	1968	BRGM	0	-90	161.00	-	-	-	-	-	-	Intercalations of black graphite schist, pyrite throughout				
		DA-2	1968	BRGM	0	-90	150.40	-	-	-	-	-	-	As DA-1				
		UAD-1	1977	SEREM/US Steel	135	-61	188.35	-	-	-	-	-	-	No mineralization				
		UAD-2	1977	SEREM/US Steel	133	-55	222.60	73.0	78.0	-59.8	-63.9	5.0	2.6	0.56	-	-	-	-
								78.0	91.0	-63.9	-74.5	13.0	6.9	1.99	-	-	-	-
								91.0	98.0	-74.5	-80.3	7.0	3.7	0.62	-	-	-	-
		UAD-3	1977	SEREM/US Steel	120	-70	237.60	50.8	116.1	-47.7	-109.1	65.3	-	5 to 15% pyrite				
		UAD-4	1977	SEREM/US Steel	138	-55	136.45	106.0	115.0	-86.8	-94.2	9.0	3.1	2.3	-	27.5	-	
								111.0	115.0	-90.9	-94.2	4.0	1.4	-	-	-	2.36	
		UAD-5	1977	SEREM/US Steel	134	-70	230.15	-	-	-	-	-	-	Negligible Cu grades				
4/5 Gossan Prospect		UAD-13	1983	-	243	-60	84.00	24.0	27.0	-20.8	-23.4	3.0	1.5	0.13	<0.1	1.1	0.49	-
								40.0	54.0	-34.6	-46.8	14.0	7.0	0.05	0.1	0.6	0.14	-
								67.0	70.0	-58.0	-60.6	3.0	1.5	0.91	0.7	8.2	0.75	0.002
								71.0	76.0	-61.5	-65.8	5.0	2.5	1.01	0.8	7.7	2.75	0.005
								76.0	84.0	-65.8	-72.7	8.0	4.0	0.22	0.1	3.2	0.54	0.001
		UAD-14	1983	-	243	-60	90.00	8.0	18.0	-6.9	-15.6	10.0	5.0	0.04	<0.1	0.5	0.99	-
								20.0	36.0	-17.3	-31.2	16.0	8.0	0.41	<0.1	2.1	1.05	-
								52.0	56.2	-45.0	-48.7	4.2	2.1	1.15	16.1	449.8	0.25	1.02
Western Part of Survey Area		UAD-9	1977	SEREM/US Steel	-	?	258.45	53.0	84.0	-	-	31.0	-	Cu and Zn <0.3%				
								157.5	158.7	-	-	1.2	-	90%pyrite				
Southern Margin of Survey Area		UD SE-2	-	-	-	-55	93.15	-	-	-	-	-	-			-		

1-2 Ore Deposits in the Vicinity of the Survey Area

Jabal Sayid deposit occurs about 20-km northwest of the survey area, and Mahd adh Dhahab mine is located 25-km southwest of the present area. The outline of the above is reported below.

1-2-1 Mahd adh Dhahab mine

The geology of the Mahd adh Dhahab mine has been reported by Bowen and Smith (1981), Kemp et al., (1982), and DGMR (1994).

(1) History

The operations of this mine dates back to 3,000 BP. Since then, it has been a very important source of gold and silver for Saudi Arabia.

Saudi Arabian Mining Syndicate operated the mine from 1939 to 1954, and 22 t of gold and 28 t of silver were produced during this period.

USGS began survey of this mine and the neighboring areas in 1972, and discovered 1.7 million tons of ore (Au 27 g/t, Ag 73 g/t) at 700 m south of the then known deposit.

The production of this mine in 1992 was 162,404 t (Au 24.2 g/t) of ore by underground mining, and 158,484 t (Au 50.1 g/t) by open pit mining. Although open pit mining has ceased recently, underground mining continues to the present.

(2) Mineralization

The ore deposits of this mine were formed by vein-type Au-Ag-Cu-Zn mineralization, which occurred 649 Ma (DGMR, 1994). Many quartz veins with N-S strike occur within an area of 900 m X 900 m.

(3) Ore minerals and gangue minerals

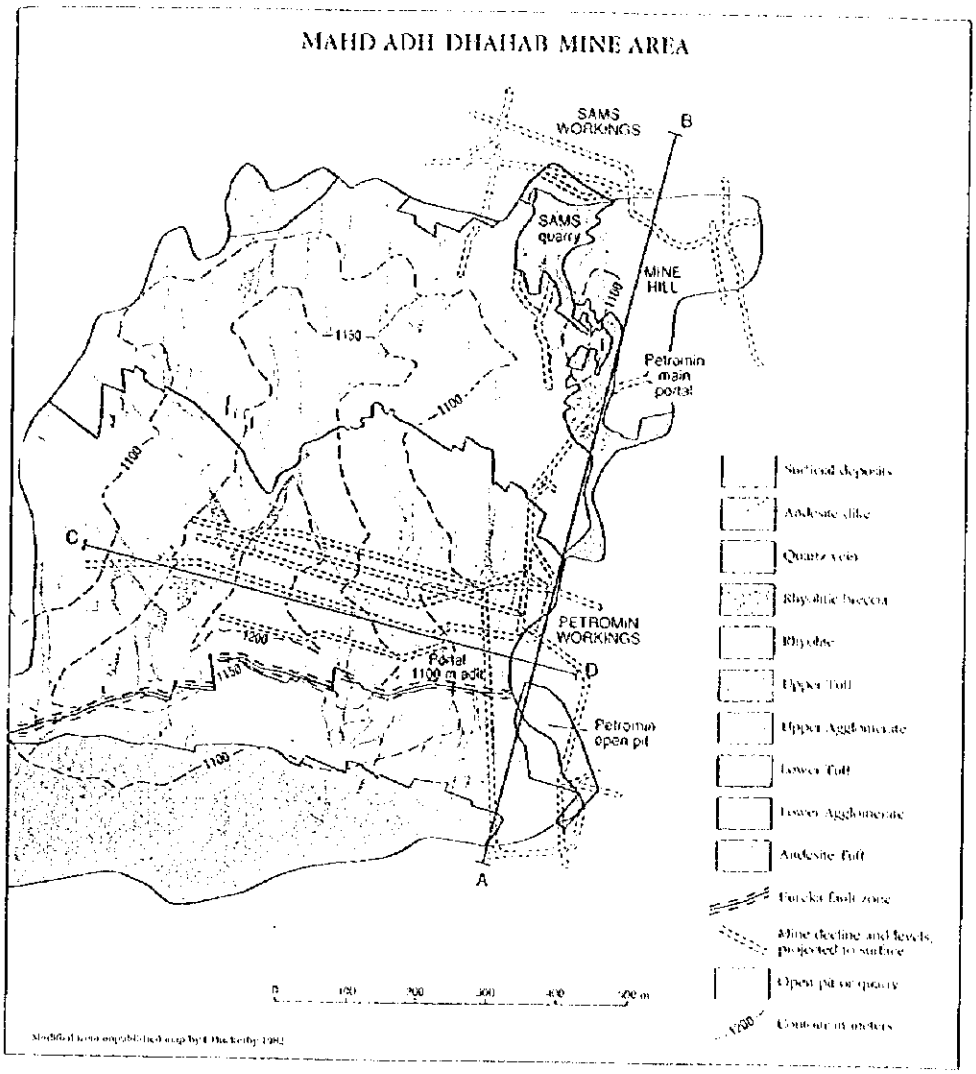
The main ore minerals are; chalcopyrite, galena and sphalerite. The reported ore minerals are listed in Table 2-1-3. About 70 % of the precious metals occur as telluride minerals, namely hessite, petzite, and sylvanite (DGMR, 1994).

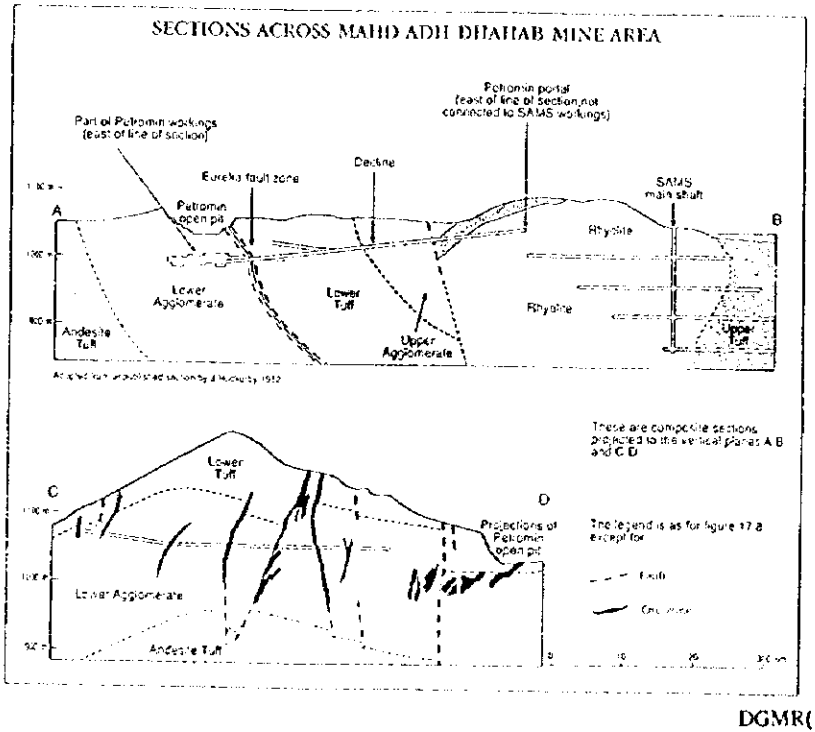
The main gangue minerals are quartz and chlorite.

Table 2-1-3 Ore Minerals Reported from the Umm ad Damar North Prospect, the Jabal Sayid Deposit and the Mahd adh Dhahab Mine

Ore Minerals			Umm ad Damar North		Jabal Sayid Deposit			Mahd adh Dhahab Mine (primary/supergene zone)		
			DDH-5	UAD-6						
Name		Chemical Composition	Ransom (1982)	This Study K9030301	Sabir (1981)	DGMR(1994)	This Study K9030305 K9030306 K9030307	Lewis & Martin (1983)	DGMR(1994)	This Study K9030308 K9030310
Pyrite		FeS_2	○	○	○	○	○	○	○	○
Pyrrhotite		FeS	○	○	○	○	○			
Galena		PbS			○	○		○	○	○
Sphalerite		ZnS		○	○	○	○	○	○	○
Wurtzite*		ZnS						○	○	
Greenockite*		CdS						○	○	
Copper Minerals	Chalcopyrite	$CuFeS_2$	○	○	○	○	○	○	○	○
	Cubanite	$CuFe_2S_3$	○		○					
	Idaite	$Cu_5Fe_4S_7$	○							
	Tetrahedrite	$(Cu,Ag)_{10}(Fe,Zn)_2Sb_4S_{13}$			○					○
	Bornite*	Cu_5FeS_4	○					○	○	○
	Covellite*	CuS		○				○	○	
	Chalcocite*	Cu_2S						○	○	
	Neodigenite*	Cu_9S_5						○	○	
Hematite		FeO						○		○
Magnetite		Fe_3O_4		○	○	○	○			
Arsenopyrite		FeAsS			○					
Cobaltite		CoAsS	○							
Ilmenite		$FeTiO_3$			○					○
Cassiterite		SnO_2			○					
Causthalite		PbSe						○		
Native gold		Au			○				○	
Electrum		(Au, Ag)							○	
Argentite		Ag_2S						○		
Telluride	Petzite	$AuAg_3Te_2$						○	○	
	Sylvanite	$AuAgTe_4$						○	○	
	Montbrayite	Au_2Te_3						?		
	Calaverite	$AuTe_2$						?		
	Melamite	$NiTe_2$	○							
	Hessite	Ag_2Te	○		○			○	○	
	Altite	PbTe	○		○			○		
	Tertadymite	Bi_2Te_2S	○		○					
	Tellurobismuthite	Bi_2Te_3			○			○		
	Coloradoite	HgTe	○					?		

*secondary mineral in supergene ore





DGMR(1994)

Fig. 2-1-2 Geological Map and Geological Sections of the Mahd adh Dhahab Mine

(4) Host rocks and alteration

The ore deposits of this mine occur in the Haf Formation of the Mahd Group, and the host rocks are; andesitic tuff, andesite, agglomerate, sandstone, and other rocks (Fig. 2-1-2).

Regarding alteration, silicification , propylitization, pyritization and potassium metasomatism are reported.

(5) Ore reserves

The mineable ore reserves of this mine were calculated to be 1.14 million tons (Au 31.8 g/t, Ag 167 g/t, Cu 0.87 %, and Zn 3.24 %) as of 1992.

(6) Results of the present survey

During the present phase of this project, we surveyed the East and West Veins in the southern part of the mine area on 16 February, 1999.

East Vein was surveyed at 899-m level (899 m above sea level) and at 988-m level. This vein occurs in the host rock containing large crystals of potash feldspar. The main ore minerals are sphalerite and galena, and there is a chalcopyrite vein in the central part of this vein. The main gangue mineral is quartz, but the amount is small. The vein is 1 – 2.5-m wide but changes significantly.

The West Vein was surveyed at 1,029 and 1,039-m levels. This is also a sphalerite – galena vein and has a quartz veinlet in the central part.

Three samples collected underground were assayed. They are; quartz vein containing chalcopyrite-sphalerite from 988-m level of East Vein (K9030308), quartz veinlet containing small amount of pyrite and chalcopyrite from 899-m level (K9030309), and ore vein consisting mainly of chalcopyrite – galena from 899-m level (K9030310).

Polished section microscopy revealed that the samples (K9030308, K9030310) consist mainly of chalcopyrite and sphalerite, and unlike the ore minerals of the Jabal Sayid deposit, pyrrhotite and magnetite were not observed (Table 2-3-2).

X-ray diffraction studies were carried out on the host rock of the quartz veinlet (K9030309) and

the host rock of the ore vein (K9030310). Large amounts of chlorite and quartz were detected (Table 2-3-4). These rocks are andesitic agglomerate and thus silicification are inferred to have been strong.

The homogenization temperature and salinity were measured for the two samples (K9030308, K9030309) collected during the present survey. The average homogenization temperature for K9030308 is 221° C (Table 2-3-5). But this temperature fluctuates between 140° C and 270° C (Appendix-1) and the averaged value is not reliable. Also that of sample K9030309 is 198° C. The dispersion of this temperature is small. The average salinity of these inclusions is low at 0.9 wt % NaCl for K9030308 and 0.2 wt % NaCl for K9030309.

1-2-2 Jabal Sayid ore deposit

The details of this deposit has been reported by Sabir (1981), Bowen and Smith (1981), and Kemp et al., (1982).

(1) History

Gossan (No.1 orebody) was found in 1965. In 1974, a joint venture of SEREM and US Steel obtained exploration rights, and surveyed the area in detail for a period of two years.

(2) Mineralization

The Jabal Sayid deposit is a stratabound massive sulfide deposit accompanied by stockwork orebody in the lower zones. The deposit consists of four orebodies, namely No.1, No.2, No.3, and No.4 orebodies (Fig. 2-1-3).

(3) Ore minerals

The massive orebodies consist mainly of pyrite, pyrrhotite, sphalerite, and chalcopyrite, and the zinc grade is similar to that of copper or higher. The stockwork orebody consists mainly of pyrite and chalcopyrite, and the content of sphalerite is lower. Also, both types of ores contain small amount of gold and silver as follows.

Type of orebody	Au (g/t)	Ag (g/t)
massive	0.5	30–50
stockwork	0.1	10

(4) Host rocks and alteration

The footwall of the orebodies consists of crystal tuff and pyroclastic flows of the upper felsic rocks of the Sayid Formation, and the hanging wall consists of fine- to coarse-grained rhyolitic rocks and quartz phenocryst rhyodacitic pyroclastic rocks. Chemically precipitated chert and carbonates occur intermittently between the hanging and foot walls, and overlie the orebodies. The pyroclastic rocks, which are the host to the stockwork orebody, are chloritized.

(5) Ore reserves

The total ore reserves of No.1 and No.2 orebodies have been assessed to be 19.93 million tons with grade of Cu 2.68 %, according to the feasibility study carried out by BRGM in 1985.

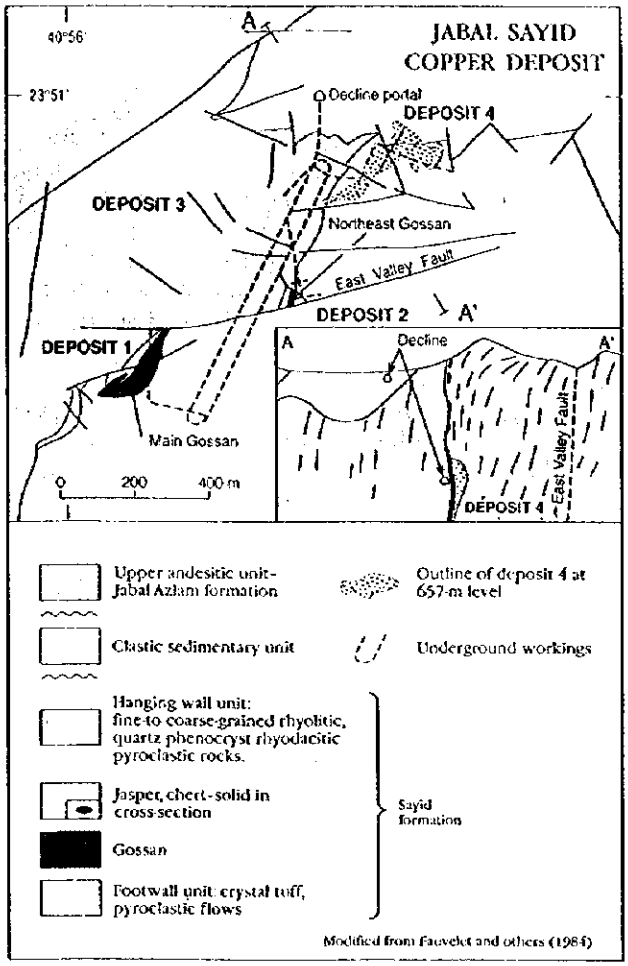
(6) Results of the present survey

During the present phase of this project, we surveyed the gossan and its vicinity of No. 1 orebody on 15 February and 5 March. Also we collected samples from the stockpile, and one pyrite-chalcopyrite dissemination sample (K9030302), two massive ore samples (K9030305, K9030306), and one silicified ore sample (K9030307) were analyzed.

The results of polished section microscopy (K9030305, K9030306, and K9030307) show the existence of pyrite, chalcopyrite, sphalerite, and small amount of pyrrhotite and magnetite (Table 2-3-2).

X-ray diffraction results (K9030303) revealed the occurrence of large amounts of chlorite (Table 2-3-4), and the chloritization of the host rocks is very strong.

Sample K9030307, collected during the course of this phase, is the silicified ore containing pyrite-chalcopyrite bearing quartz vein. The fluid inclusions in this quartz were analyzed and average homogenization temperature of 260 ° C was obtained (Table 2-3-5). As seen in Appendix-1, however, the homogenization temperature is scattered within the range of 210 ° to 310 ° C, and thus the averaged value is not reliable. The average salinity of these inclusions is high at 8.3 wt % NaCl.



DGMR(1994)

Fig. 2-1-3 Geological Map and Geological Section of the Jabal Sayid Deposit

CHAPTER 2 PHOTOGEOLOGY

2-1 Analytical Methods

An area extending about 90 km^2 and including the survey area was analyzed photogeologically. Aerial photographs were viewed stereoscopically and geological units (henceforth units) were separated by "color tone of photographs", "texture of photographs", "drainage pattern", "drainage density", "resistance of rocks", and "existence of bedding". And further fold structures were extracted from the dips of the bedding, and lineaments were extracted from linear topography.

2-2 Results of Analysis

2-2-1 Geologic units

The area shown in Figure 2-2-1 was divided into 15 units by analysis of aerial photographs. The characteristics of each unit are reported below.

(1) Volcanic and sedimentary rocks

Units "asa" and "ajz"

These two units occur within the survey area and in the vicinity. Bedding is hardly observed in these units, and they are clearly distinguished from Units "mh_{1-3}", which have clear bedding. Units "asa" and "ajz" are distinguished by the color tone and the difference in resistance. It is concluded from correlation with previous data that Unit "asa" corresponds to Sayid Formation of the Arj Group, and Unit "ajz" to Jabal Azlam Formation of the same Group.

Units "mh_{1-3}"

Units "mh_1", "mh_2", and "mh_3" are distributed to the west of the survey area. Bedding is observed in many of these units, and is inferred to consist of volcaniclastic rocks. The dips of the bedding indicate the existence of anticlinal structure with NNW-SSE elongation and SSE plunge. These units are divided, from lower horizon upward into "mh_1", "mh_2", and "mh_3". These are distinguished by the difference in texture, resistance, and other characteristics. From comparison with the existing data, these units are concluded to correspond to the Zur Member of the Haf Formation of the Mahd Group.

Unit "mh"

This unit is distributed at the extensional part of the anticlinal structure formed by Units "mh_{1-3}". This unit differs from Units "mh_{1-3}" by the absence of bedding. From comparison with existing data, this unit is concluded to correspond to the volcaniclastic unit of the Tulaymisah Formation of the Mahd Group.

Unit "gk"

This unit occurs in the southwest corner of the area covered by photogeologic investigation. This unit has bedding, and correlation with existing data of this area indicates that this unit corresponds to the mafic unit of Khazrah Formation of the Ghamr Group.

Units "t", "a", and "w"

These units consist of Quaternary sand and gravel. Unit "t" consists of talus deposits near the Unit "gk". Unit "a" occupies most of the flat land of this photogeologic area, and is correlated to old wadi deposits of the existing data. Unit "w" corresponds to the present wadi deposits.

Unit "gy"

This unit is distributed in small patches to the southwest of the survey area. It is white and occurs within the Unit "a", which consists old wadi deposits. Thus it is believed to be gypsum-type sediments.

Unit "s"

This unit is observed only in the North Prospect. It is dark gray, and has the appearance of basalt, but ground-truth survey showed that the distribution almost agrees with that of slag.

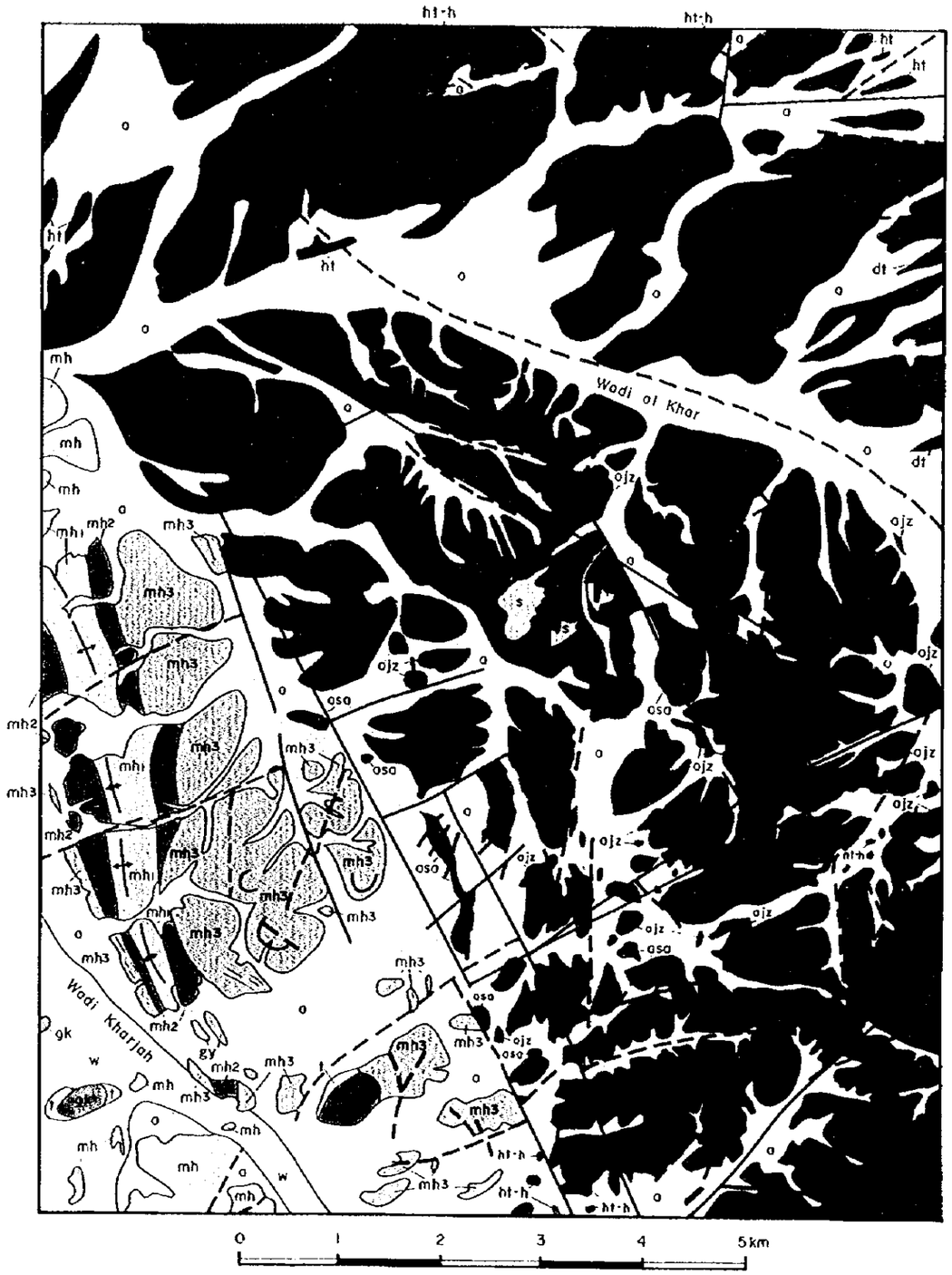
(2) Intrusive bodies

Unit "dt"

This unit is distributed to the northeast of the survey area. It is distinguished from Units "ht" and "ht-h", which will be mentioned later, by the color tone and resistance. This is concluded to correspond to Dhukhr Tonalite from study of existing data.

Units "ht" and "ht-h"

Unit "ht" occurs in the northern edge of the photogeologic area, while Unit "ht-h" is distributed in the northern edge and southeastern part of the above area. The two units are distinguished by the difference in resistance and "ht-h" has higher resistance. Existing data indicate these



Photogeologic units				Photo Characteristics		Geomorphologic Features				Correlation with geology in the existing data
Sedimentary and volcanic rocks		Intrusive rocks				Drainage		Rock Property		
Symbols	Possible lithology	Symbols	Possible lithology	Tone	Texture	Pattern	Density	Resistance	Bedding	
s	Slag			dark gray	rough	dendritic	low	high	none	not correlated
gy	Gypsiferous deposits			white	smooth	none	none	very low	none	not correlated
w	Wadi deposits			whitish	smooth	dendritic	low	very low	none	Wadi alluvium(Qal)
a	Alluvium, gravel			light gray	smooth	dendritic	low	very low	none	Older wadi deposits(Qu)
t	Talus deposits			light gray	fine	sub parallel	low	low	none	
	Sedimentary and pyroclastic rocks			gray	fine	parallel	medium	medium	often	Mafic units(gka) of Kharzah Formation of Ghamr Group
			granitic rocks	gray	medium	trellis	medium	low-medium	none	Hufayriya Tonalite(ht)
			granitic rocks	dark gray	rough	trellis	high	high	none	
mh	Lava, pyroclastic rocks			gray	medium	sub-dendritic	low-medium	low-medium	none	Volcaniclastic rocks(mt) of Tulaymisah Formation of Mahd Group
mh3	Mainly pyroclastic rocks			gray	rough	parallel	high	medium	partly	
	Lava, pyroclastic rocks			dark gray	medium	parallel	medium	high-medium	often	Zur member(mhz) of Haf Formation of Mahd Group
mh1	Lava, pyroclastic rocks			dark gray	fine	parallel	medium	high	often	
			granitic rocks	gray	rough	trellis	high	medium	none	Dhukhr Tonalite(dt)
	Andesitic volcanic rocks			gray	medium	dendritic	medium	medium	partly	Jabal Azlam Formation(ajz) of Arj Group
	Acidic volcanic rocks			light gray	rough	dendritic	high	low-medium	partly	Sayid Formation(asa) of Arj Group

Annular structure

Lineament(certain)

Lineament

Anticlinal axis

Joint/bedding trace/small dyke

Fig. 2-2-1 Photogeological Interpretation Map

units to be Hufayria Tonalite.

2-2-2 Geologic structure

Only NW-SE trending fault in Wadi al Khar is shown in the regional geological map laid out in Figure 1-2. As a result of these photogeologic studies, however, many lineaments in the NE-SW and NW-SE direction were extracted from the survey area and the vicinity. It is inferred that faults in these directions exist in the area.

Bedding is dominant and anticlinal structure is extracted in Units "mh_{1-3}", which correspond to the Mahd Group, while such structure is not extracted in Units "asa" and "ajz", which correspond to the Arj Group.

CHAPTER 3 GEOLOGICAL SURVEY

A geological map of the survey area at 1:25,000 scale was prepared on the basis of the results of the geological survey carried out during this year and of the results of the photogeologic interpretation. This map is shown in Figure 2-3-1 and a geological map of 1:10,000 scale in Plate 1. A schematic stratigraphic column of the survey area is shown in Figure 2-3-2.

3-1 Outline of Geology

The geology of the survey area consists mainly of; lavas and volcaniclastic rocks of Late Proterozoic rhyodacite, andesite, and dacite, belonging to the Arj Group. This group is intruded by diorite, quartz diorite, tonalite, andesite, dacite, rhyodacite, and basalt bodies. These units are covered unconformably by Late Proterozoic andesitic lava and volcaniclastic rocks of the Mahd Group in the western edge of the survey area.

3-2 Stratigraphy

3-2-1 Arj Group

Kemp et al., (1982), in their 1:250,000 scale geological map, divided the Arj Group into; the Sayid Formation consisting of felsic volcanic rocks, and the Jabal Azlam Formation consisting of andesitic volcanic and sedimentary rocks and overlying the Sayid Formation. In the present survey area, however, felsic and andesitic volcanic rocks occur alternately and the boundary of the two formations is not clear. Therefore, we divided the Arj Group into units by rock types; rhyodacite and rhyodacitic volcaniclastic rocks (Ar), dacite and dacitic volcaniclastic (Ad), andesite and andesitic volcaniclastics (Aa), and jasper (Aj).

(1) Rhyodacite and rhyodacitic volcaniclastic rocks (Ar)

This unit is mainly distributed near the North Prospect and the 4/6 Gossan.

Rhyodacite is generally white and often shows flow structure. Some have small quartz phenocrysts. Also, some are totally vitreous. The rhyodacitic volcaniclastic rocks are vitreous and in some places they contain augen quartz grains, lapilli size rock fragments, and glass shards. The rock is partly disseminated by hematite.

Many of these rocks are massive, but those to the west and south of the 4/6 Gossan have strongly developed schistosity.

(2) Dacite and dacitic volcaniclastic rocks (Ad)

This unit is distributed mainly to the east of Jabal Sujarah, near the 4/6 Gossan and to the north, and to the east of the South Prospect.

Dacite is dark green and contains small quartz phenocrysts. Dacitic volcaniclastics consist of tuff, lapilli tuff, tuff breccia, sandstone, and conglomerate, and they partly contain augen quartz and feldspar grains. Most of these rocks are massive, but sandstone, conglomerate, and some of the tuff contains clear bedding.

Of these dacite and dacitic volcaniclastics, dacite and tuff are dominant near the 4/6 Gossan and northward, while lapilli tuff and tuff breccia are dominant to the east of Jabal Sujarah and in the eastern part of the survey area. Dacite, sandstone, and conglomerate are predominant to the east of the South Prospect.

(3) Andesite and andesitic volcaniclastic rocks (Aa)

This unit is distributed mainly near Jabal Sujarah and southward, and to the west and northeast of the South Prospect. The main distribution of this unit coincides well with that of the Jabal Azlam Formation of Kemp et al., (1982, geological map 1:250,000).

Andesite is dark green to purplish dark gray to dark gray. And phenocrysts are not observed by unaided eyes. Andesite is generally epidotized. Andesitic volcaniclastics consist of agglomerate, volcanic breccia, tuff breccia, lapilli tuff, and tuff.

Lithologically, many kinds of tuff occur near Jabal Sujarah while lapilli tuff is dominant to the north, and lava is dominant to the south of Jabal Sujarah, west and northeast of the South Prospect. It is also noted that agglomerate and tuff breccia occur in large amount in the northeastern part of the survey area.

(4) Jasper (Aj)

This rock occurs mostly at Jabal Sujarah and to its west. It is generally white, and is intercalated in rhyodacitic to andesitic volcaniclastic rocks. Those containing large amount of

hematite is red.

3-2-2 Mahd Group

The andesite and andesitic volcaniclastics, which occur in the western edge of the survey area, correspond to the Zur Member of Haf Formation of the Mahd Group of Kemp et al., (1982, geological map 1:250,000). According to Kemp et al., (1982), the Zur Member consists of rhyolite and sedimentary rocks, but it consists of andesitic rocks in the present survey area.

(1) Andesite and andesitic volcaniclastic rocks (Ha)

These rocks occur in the western end of the survey area.

Andesite is purplish-greenish gray. Volcaniclastic rocks consist of tuff, lapilli tuff, and tuff breccia with intercalations of conglomerate and sandstone.

The relation with underlying Arj Group cannot be observed directly, but the Arj Group strata have steep dip exceeding 60°, while the present unit have low dip of 20 – 40°. It is believed that this unit overlies the Arj Group unconformably.

3-3 Intrusive Rocks

(1) Tonalite (T)

This rock is distributed near the South Prospect. It is medium to fine-grained, equigranular, and holocrystalline rock. It is observed microscopically that the mafic minerals are all decomposed to chlorite and epidote (Table 2-3-1).

(2) Diorite, quartz diorite (D)

These rocks are distributed in the North Prospect and the vicinity. They are dark green and fine-grained. Microscopically they have porphyritic to sub-ophitic texture, and some of the diorite (sample K9022005) shows myrmekitic texture.

(3) Andesite (a)

Andesite is dark green and show porphyritic texture with large phenocrysts. Microscopically all mafic minerals are decomposed to chlorite and epidote.

(4) Dacite (d)

This rock occurs mostly intruding into dacite and dacitic volcaniclastics of the Arj Group. It contains quartz phenocrysts of about 5mm in size. Microscopically, mafic minerals are almost all decomposed to chlorite and carbonate minerals.

(5) Rhyodacite (r)

This rock has intruded into the andesite and andesitic volcaniclastics of the Arj Group to the northwest of the South Prospect. It has flow structure and similar characteristics as the rhyodacite of the Arj Group.

(5) Basalt (b)

This rock is dark green and occurs generally in small bodies intruding into the Arj Group. Basalt is also observed within tonalite at south of the South Prospect. Microscopically, it shows porphyritic texture and almost all mafic minerals are decomposed to chlorite.

3-4 Geologic Structure

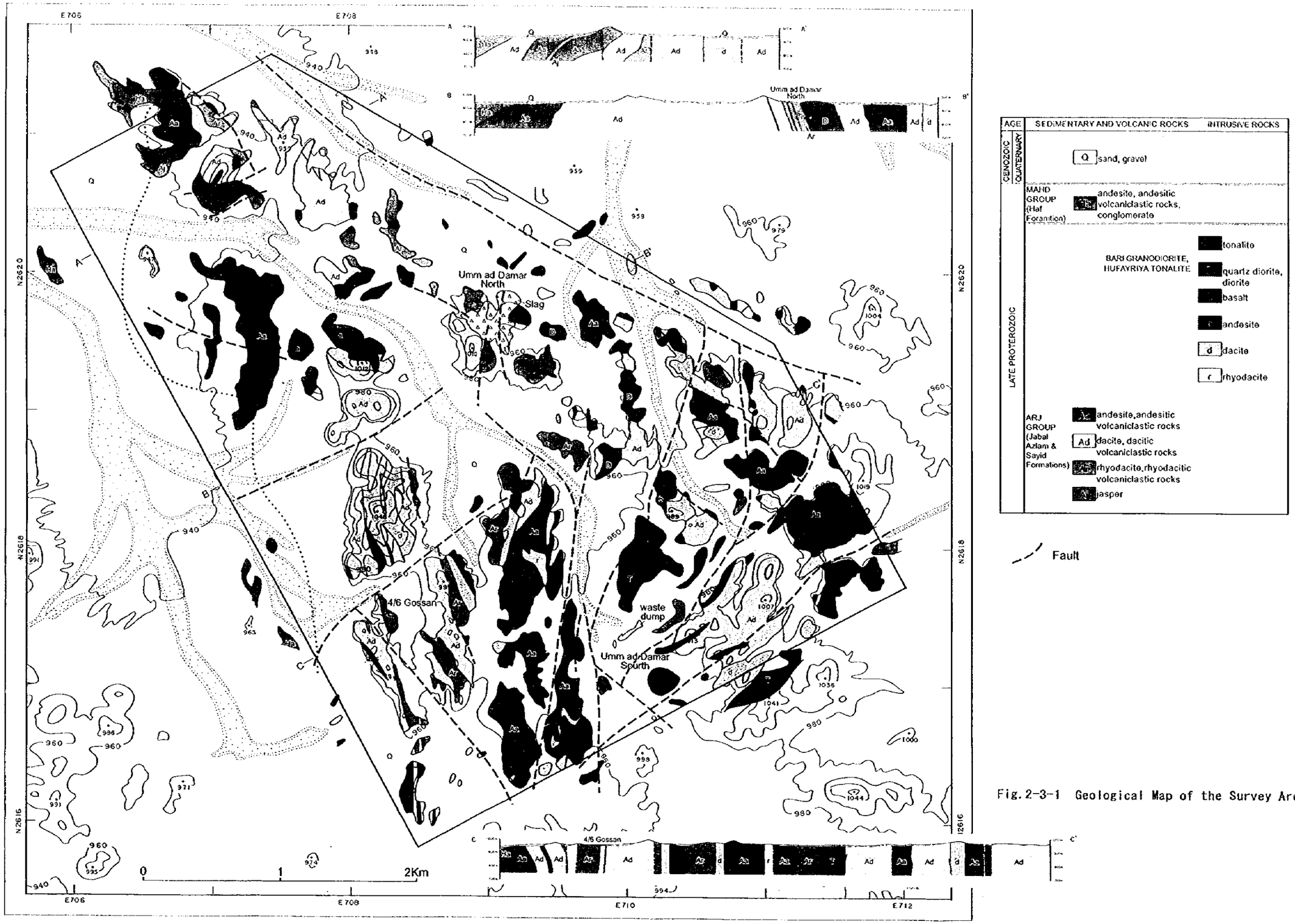
The rocks of the Arj Group of the survey area are regionally chloritized and epidotized, and schistosity is developed in the volcaniclastic rocks. The strike and dip of the volcaniclastics can be measured only at few places. The Arj Group rocks have steep dip of more than 60° at places where bedding could be confirmed. On the other hand, Mahd Group units have low dip of 20 – 40° W.

The faults of NE-SW system are dominant. The existence of a NW-SE trending fault parallel to Wadi al Aqiq Fault is inferred in the northeastern edge of the survey area.

Because shear zones containing mineralized zones are generally covered by the Quaternary gravel and sand in the survey area, the distribution of the shear zones is generally not clear. Therefore, the distribution is not laid out in the geological map of Figure 2-3-1. However, in the surrounding areas of mineralized zones, faults parallel to the mineralized zones are distributed. For examples, two faults located near the slag distribution area in the North Prospect show N-S trend similar to those of No.1 and No.2 Mineralized Zones which will be mentioned latter. Faults to the south of the South Prospect show NE-SW trend similar to that of a mineralized zone in this prospect. A fault to the east of the 4/6 Gossan has N-S trend

almost similar to that of the mineralized zone in this prospect. Therefore, shear zones are considered to have been formed at the formation age of faults near the shear zones.

As to the reason why the mineralized zones in the survey area do not show definite trends, it is considered that faulting after the mineralization displaced the mineralized zones. For example, a NE-SW fault between "M-8" and "L-14" chargeability anomalous zones with the same chargeability trend in the 4/6 Gossan is estimated to be right-lateral strike slip fault with 250m displacement judging from the distribution map of chargeability anomaly shown in Figure2-1-1.



AGE		SEDIMENTARY AND VOLCANIC ROCKS	INTRUSIVE ROCKS
CENOZOIC	QUATERNARY	Q sand, gravel	
LATE PROTEROZOIC	MAHD GROUP (Haf Foramtion)	Hc andesite, andesitic volcaniclastic rocks, conglomerate	
			BARI GRANODIORITE, HUFAYRIYA TONALITE: tonalite; quartz diorite, diorite; basalt; andesite; d dacite; r rhyodacite
	ARJ GROUP (Jabal Azlam & Sayid Formations)	Ja andesite,andesitic volcaniclastic rocks	
		Ad dacite, dacitic volcaniclastic rocks	
		Ar rhyodacite,rhyodacitic volcaniclastic rocks	
		Jr jasper	

Fig. 2-3-1 Geological Map of the Survey Area

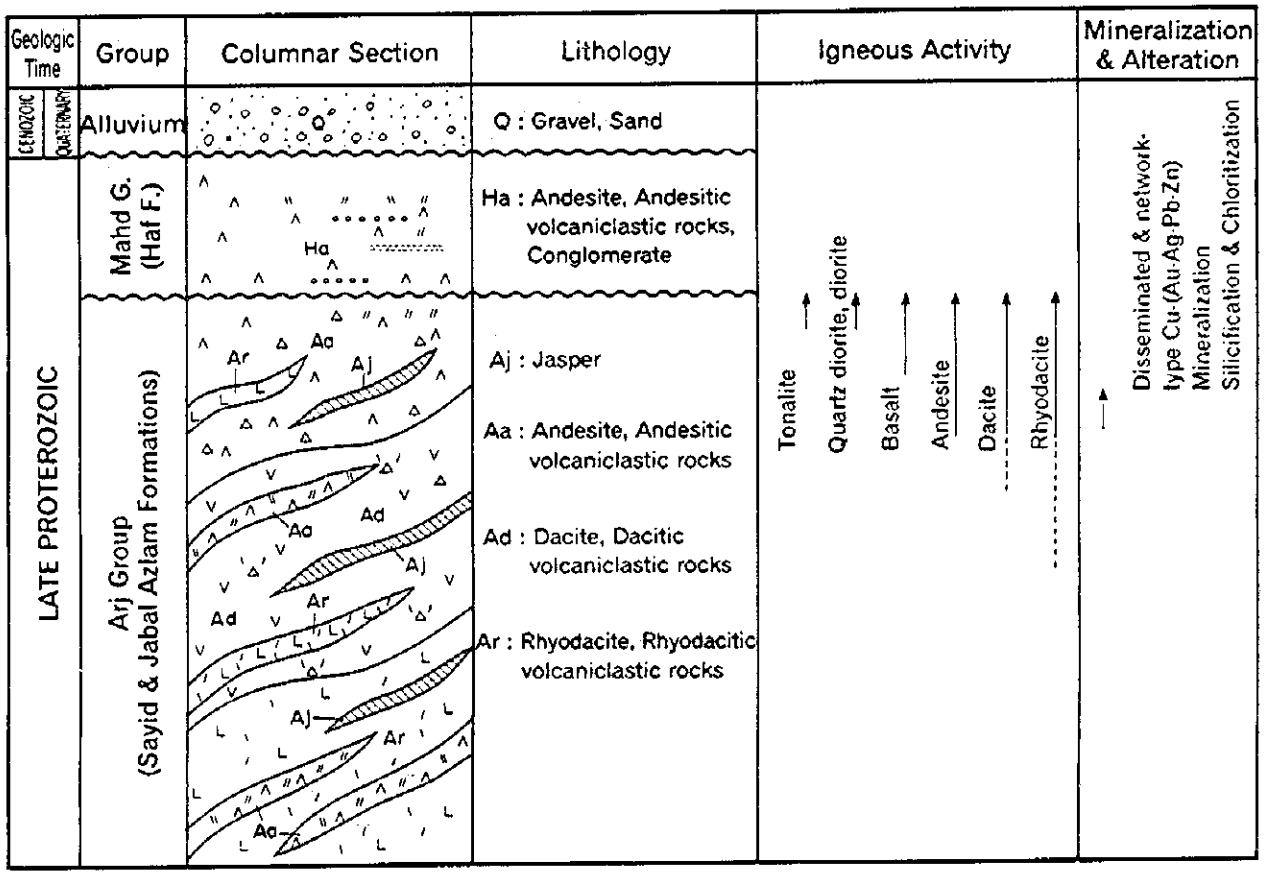


Fig. 2-3-2 Schematic Stratigraphic Columns

Table 2-3-1 Results of Microscopic Observation of Thin Sections

Sample No.	Symbols	Locality	Rock type	Texture	phenocryst or fragment								groundmass or matrix								metamorphic or alteration						
					MP	opx	hb	qz	pl	Kf	op	others	MP	hb	qz	pl	Kf	gl	op	others	ep	chl	amp	ser	tit	cb	others
K9021803	a	[illegible]	meta-volcanics weakly meta.	subophitic									⟨○⟩		○	◎		⟨◎⟩	○		○	◎		◎	△		
					Mafic minerals replaced totally by chlorite and qz. Pl into albite and epidote.																								
K9021804	Ad	[illegible]	dacite weakly meta.	subophitic	⟨△⟩			○	◎		△		⟨△⟩		○	◎	○	⟨◎⟩	-	apa (-)		△		△	-	○	
					Mafic minerals replaced totally by chlorite.																						
K9021805	Ad	[illegible]	dacitic tuff weakly meta.	clastic			◎	△	-						◎	○		⟨◎⟩	-			△		○	-	○	goe (△)
					Pl replaced by sericite. Carbonate vein. Sericite occurs along the cracks.																								
M9022013	Ha		tuff breccia weakly meta.	clastic to porphyritic	⟨△⟩		⟨○⟩	◎	△						○	○	△	⟨◎⟩	○		△	○	○	△		△	
					Hb replaced by secondary amphibole aggregate. Other mafic phenocryst repalced by chlorite. Carbonate vein.																							
M9020909	Aa		andesite tuff weakly meta.	porphyritic	⟨○⟩		△	◎	-				⟨○⟩		△	○		⟨◎⟩	○		○	○	○	○	-	○	
					Mafic minerals repleced totally by chlorite and carbonate. Pl into albite, sericite and epidote.																							
M9021004	Aa		andesitic lapilli tuff weakly meta.	clastic	⟨○⟩	△		◎							△	○		⟨◎⟩	△		○	◎		△		○	
					Mafic mineral except opx replaced totally by chlorite. Pl into sericite and epidote. Epidote vein.																							
M9021801	Aj		jasper [illegible]	microcrystalline											◎				○								
					Calcedonic quartz and hematite.																						
K9022803	Ad	UAD N.	dacite weakly meta.	porphyritic	⟨○⟩			○	◎		△				◎	◎	○	⟨◎⟩	△		○	○			△		
					Mafic minerals replaced totally by chlorite and epidote. Pl partly by sericite and epidote.																							
K9030101	Aa	UAD N.	trachytic andesite weakly meta.	trachytic	⟨△⟩								⟨○⟩		◎	◎		⟨◎⟩					◎		△		
					Mafic minerals and groundmass totally replaced by chlorite, quartz and albite. Plagioclase into sericite.																							
M9020804	a	UAD N.	andesite weakly meta.	porphyritic	⟨○⟩			◎			△		⟨△⟩		○	◎		⟨◎⟩	-			○	○		△		
					Mafic minerals replaced totally by chlorite and epidote. Opaque minerals into titanite.																							
K9021305	D	UAD N.	porphyritic diorite weakly meta.	porphyritic	⟨○⟩			◎			△				◎	◎	○		△			○	○		△	△	△	
					Myrmekite texure is widespread. Mafic minerals replaced totally by chlorite and epidote.																							
K9022701	Ad	UAD N.	dacite weakly meta.	porphyritic	⟨○⟩			○	○	△	△		⟨△⟩		◎	○	○		-			◎		△			goe(○)
					Mafic minerals repalced totally by chlorite and goethite.																							
K9022502	Ad	UAD N.	dacite weakly meta.	porphyritic	⟨○⟩			◎								○	○	⟨◎⟩	△	apa (-)		◎					
					Mafic minerals replaced totally by chlorite. Quartz vein.																							
K9022004	d	UAD N.	dacite weakly meta.	porphyritic			○	◎	△						△	○		⟨◎⟩	△		○	◎		○		○	
					Hornblende is strongly replaced by chlorite and carbonate. Plagioclase into sericite.																							
K9022005	D		porphyritic diorite weakly meta.	porphyritic to subophitic	⟨△⟩		⟨○⟩	◎	-				⟨△⟩		○	◎	○		△		△	○	○	○	△	○	
					Hornblende replaced totally by green amphibole and chlorite. Myrmekite texure is common.																							
K9022401	D	UAD S.	microdiorite weakly meta.	subophitic			⟨◎⟩	○	◎												○			△	△	○	oly(◎)
					Hornblende decomposed into clay minerals. Plagioclase into epidote and albite.																							
K9021806	D	UAD S.	microdiorite weakly meta.	subophitic			⟨○⟩		◎		△				○	◎						○	○		△		
					Hornblende totally into green amphibole and chlorite. Plagioclase into epidote and albite.																							
K9021807	Aa	UAD S.	andesite weakly meta.	porphyritic			⟨○⟩	△	○		-				◎	○		⟨◎⟩	△	apa (-)	○	○	○				
					Quartz xenocryst surrounded by amphibole. Hornblende by green amphibole. Plagioclase by partly epidote.																							
K9021302	T		tonalite weakly meta.	holocrystalline	⟨○⟩			○	◎	△	△										○	○		△		△	
					Mafic minerals replaced totally by chlorite and epidote. Pl into sericite and epidote. Carbonate vein.																							
K9021401	d		dacite weakly meta.	porphyritic	⟨○⟩		◎	○			△				◎	○		⟨◎⟩	△			△		○	△	△	
					Mafic minerals replaced totally by carbonate and chlorite. Pl partly into sericite.																							
K9021403	Ab		metabasalt weakly meta.	porphyritic		○		○					⟨△⟩		◎			⟨◎⟩	-		○	○	○		△	△	
					Cpx partly by amphibole and chlorite. Pl by epidote. Epidote and carbonate veins.																							
K9022001	T		tonalite weakly meta.	holocrystalline			⟨○⟩	○	◎	○	△	apa (-)									△	△	○	△			
					Hornblende totally by green amphibole and chlorite. Pl by epidote and sericite.																							
K9022002	d		dacite weakly meta.	porphyritic	⟨△⟩		◎	○			△		◎	○	△	⟨◎⟩	△					○		○		○	
					Mafic minerals replaced totally by chlorite and carbonate. Pl by sericite.																							
K9022003	Ab		basalt weakly meta.	porphyritic	⟨△⟩			△	-				⟨○⟩			○		⟨◎⟩	△		○	○				○	
					Amygdule filled by epidote. Mafic minerals replaced by chlorite. Carbonate and quartz veins.																							
K9022101	a		andesite weakly meta.	porphyritic	⟨○⟩			◎			△				○	◎	△	⟨◎⟩	△		△	○		△		○	
					Mafic minerals replaced totally by chlorite and epidote. Pl partly by sericite. Carbonate and chlorite veins.																							

abbrev. MP=pseudomorphs of mafic minerals, opx=orthopyroxene, pl=plagioclase, op=opaque minerals, qz=quartz, hb=hornblende, kf=K-feldspar, ep=epidote, gl=glass or microcrystalline aggregate, amp=green amphibole, cb=carbonate, ser=sericite, tit=titanite, apa=apatite, oly=clay minerals

⟨ ⟩ shows totally decomposed

◎abundant, ○common, △small, -rare

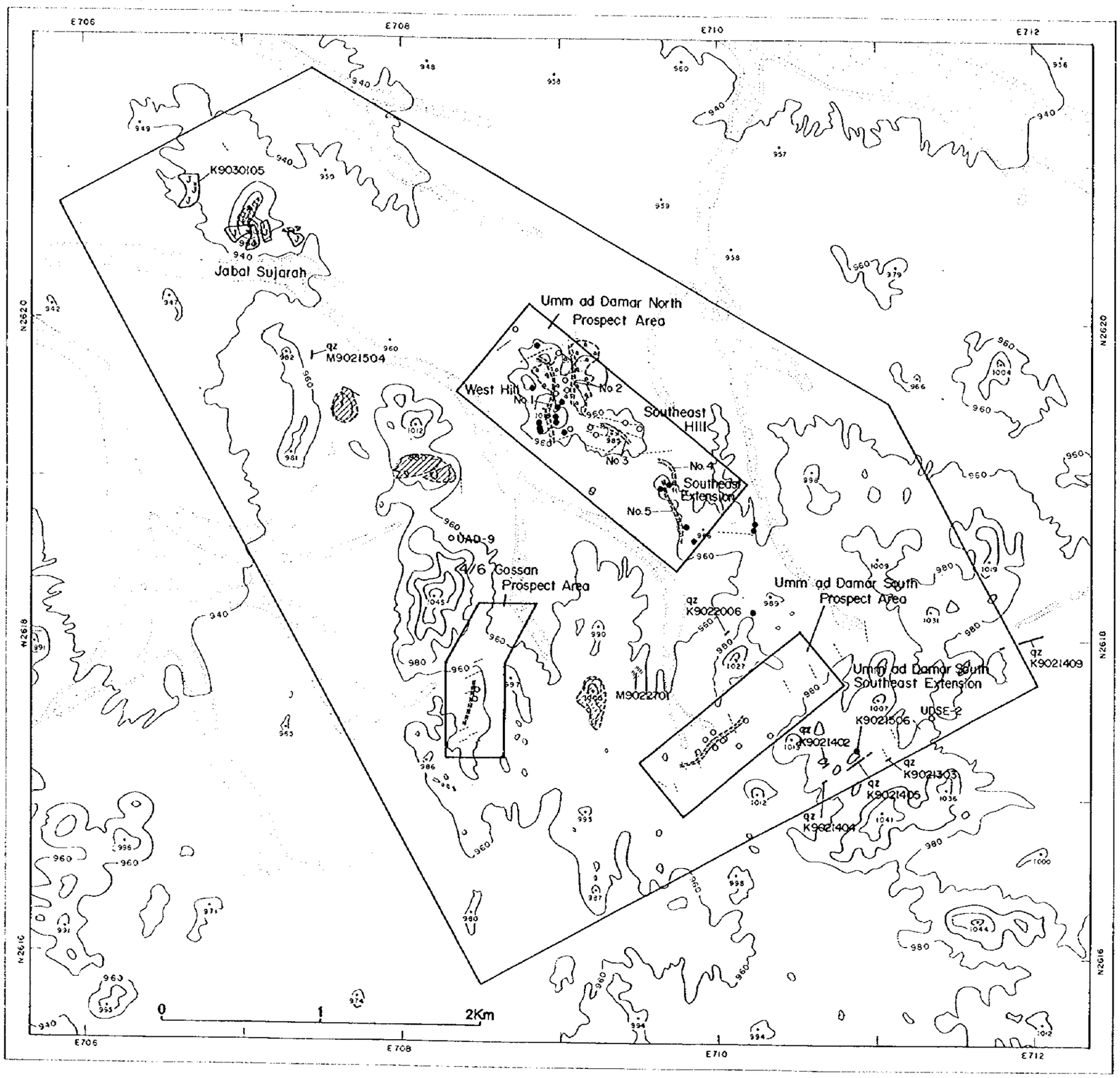
3-5 Mineralization

The three known mineral prospects of the North Prospect, the South Prospect, and the 4/6 Gossan are shown in Figure 2-3-3 and Plate 2 together with other mineralized zones and altered zones in the survey area.

The mineralization, which formed mineralized zones of the North and South Prospects, is a pyrite–chalcopyrite dissemination to network copper mineralization in the sheared zone within the Arj Group. On the other hand, the mineralization in the 4/6 Gossan also appears to have characteristics similar to that of the North and South Prospects, but the Au, Ag, Pb, and Zn contents of the former prospect are higher. The ore minerals of all three prospects are oxidized to depths of 30—40 m and thus only gossan containing oxidized copper minerals, limonite, and hematite occur on the surface.

During the present survey, the exposed geologic units were surveyed in detail, the ancient workings were studied, location of the drill hole sites and trenches were determined, and the geologic conditions of the trenches were confirmed. Also 32 samples were collected from the ancient workings and trenches, and one sample was obtained from UAD-6 core box No.17 abandoned in the Jabal Sayid camp. These samples were assayed. The elements analyzed are Au, Ag, Cu, Pb, Zn, and Fe. The surface samples have been oxidized and sulfide minerals were generally not observed and thus S was not analyzed. During the past drilling survey, Au was not analyzed with the exception of the two holes of the 4/6 Gossan, and Ag content was determined only for parts of the drill cores. Thus Au and Ag were analyzed during this survey.

Results of microscopic observation of polished sections, ore assay, and X-ray diffraction analysis are shown in Table 2-3-2, Table 2-3-3, and Table 2-3-4, respectively.



- Arj Group jasper
- Slag
- Carbonatization
- Silicification
- Epidotization & week silicification
- Mineralized Zone
- Drill hole
- Trench
- Ancient working
- Quartz vein

Fig. 2-3-3 Mineralization Map of the Survey Area

Table 2-3-2 Results of Microscopic Obervation of Polished Sections

Localities		Sample No.	Rock Name	Pyrite	Chalcopyrite	Tetrahedrite-Tennantite	Bornite	Sphalerite	Pyrrhotite	Hematite	Magnetite	Ilmenite	Galena	Covellite	Malachite
Jabal Sayid		K9030305	massive ore	◎	△			△							
		K9030306	massive ore	◎	○			○	△		△				
		K9030307	silicified ore	◎	○			△	△						
Mahd adh Dhahab		K9030308	cp-sp quartz vein	△	○		△	◎					△		
		K9030310	cp-ga massive vein	△	○	△		◎		△		△	△		
Umm ad Damar Prospect	West Hill	K9030102	gossan	△						◎					
	Southeast Hill	K9030301	sulfide veinlet ore, UAD-6 No.17	◎	○			△	△		△			△	
Umm ad Damar South Southeast Extension		K9021409	quartz vein		◎					◎				○	△

abbrev. cp:chalcopyrite, sp:sphalerite, ga:galena
◎abundant, ○common, △small

Table 2-3-3 Results of Ore Assay

Localities		Sample No.	Rock Name	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Fe %
4/6 Gossan Prospect		K9021701	gossan	3.7	287	1.96	3.45	0.61	35.33
		K9021702	gossan	1.6	23.6	0.58	1.49	1.98	31.25
		K9021703	gossan	<0.1	3.4	6.59	0.04	1.70	12.61
		K9021801	gossan	<0.1	2.3	0.05	<0.01	0.03	4.63
		K9021802	gossan	<0.1	1.9	0.03	0.01	0.01	11.29
West of Jabal Sujarah		K9030105	jasper	0.4	5.9	0.21	<0.01	<0.01	2.02
North of Umm ad Damar South		K9022006	quartz vein, wd 0.3m	<0.1	0.8	1.48	<0.01	<0.01	3.01
Southeast of Jabal Sujarah		M9021504	quartz vein, wd 0.12m	<0.1	0.4	0.09	<0.01	<0.01	2.15
Umm ad Damar North Prospect	West Hill	K9021101	gossan	0.3	3.3	10.12	<0.01	0.04	8.97
		K9030102	gossan	<0.1	2.2	0.14	<0.01	0.01	12.18
		K9030103	quartz vein	0.3	18.9	0.17	<0.01	0.02	9.23
		K9022704	gossan	0.6	4.5	5.67	0.32	0.40	42.13
		K9022705	gossan	0.4	1.9	0.05	<0.01	0.04	25.66
	Southeast Hill	K9030301	sulfide veinlet ore, UAD-6 No.17	<0.1	3.8	0.19	<0.01	0.01	17.49
		K9022702	gossan	<0.1	0.5	0.04	<0.01	<0.01	22.88
		K9022703	gossan	<0.1	0.6	0.13	<0.01	0.02	33.28
	Southeast Extension	K9022501	quartz vein	<0.1	1.5	0.11	<0.01	0.03	6.38
		K9022503	gossan	<0.1	2.3	0.52	<0.01	0.03	28.28
		K9022504	quartz vein	<0.1	1.5	0.60	<0.01	0.02	5.56
		K9022505	silicified ore	0.1	8.1	2.04	0.01	0.06	11.94
Umm ad Damar South Prospect		K9022403	quartz-hematite veinlet rock	<0.1	1.7	0.06	<0.01	<0.01	14.00
		K9022404	gossan	6.2	5.5	0.89	<0.01	0.04	57.44
		K9022405	quartz veinlet rock	0.2	5.5	0.21	<0.01	0.05	7.43
		K9022406	silicified ore	0.4	18.2	1.91	<0.01	0.36	5.24
		K9022407	silicified rock	1.4	13.1	1.07	0.03	0.41	20.74
		K9022408	ore containing Cu-oxide minerals	0.3	7.3	7.91	<0.01	1.22	18.71
		K9030313	ore containing Cu-oxide minerals	3.0	14.7	0.76	0.01	0.40	38.02
Umm ad Damar South, Southeast Extension		K9021303	gossan, wd 0.3m	0.2	15.0	14.44	<0.01	0.02	13.20
		K9021402	quartz vein, wd 1.0m	<0.1	1.0	0.45	<0.01	<0.01	0.54
		K9021404	quartz vein, wd 0.3m	<0.1	1.6	0.45	<0.01	<0.01	1.01
		K9021405	silicified rock, wd 2~3m	<0.1	0.9	0.82	<0.01	<0.01	0.38
		K9021409	quartz vein, wd 0.3m	<0.1	0.9	1.25	0.05	<0.01	1.39
		K9021506	siliceous ore, float	<0.1	18.6	4.50	<0.01	<0.01	1.39

Table 2-3-4 Results of X-ray Diffraction Analysis

Localities		Sample No.	Rock Name	Quartz	Calcite	Chlorite	Sericite	Epidote	Talc	Albite	Alunite	Gypsum	Tremolite	Pyrite	Chalcopyrite	Sphalerite
Jabal Sayid		K9030303	py, cp disseminated altered rock	◎		◎	△		△					○	○	
Mahd adh Dhahab		K9030309	host rock of quartz vein	◎		◎	△	△						○	○	
		K9030310	host rock of cp-ga massive vein	◎		○				○						△
West of Jabal Sujarah		K9030105	jasper	◎										△		
Jabal Sujarah		K9030302	carbonatized rock	○	◎	△		△								
Northwest of Umm ad Damar South		M9022701	epidotized rock	△	◎	△		△					◎			
Umm ad Damar North Prospect	West Hill	K9022801	hematite rock	◎		○	△									
		K9022802	dacite	◎		◎	△									
	Southeast Hill	K9030301	sulfide veinlet ore, UAD-6 No.17	○		◎								△		
Umm ad Damar South Prospect		K9022409	clay	◎		△					○	△				

◎abundant, ○common, △small

3-5-1 Umm ad Damar North Prospect

A large amount of slag occurs at the North Prospect, and many ancient workings are distributed in the small hills to the west and southeast of this slag zone. The southeast hill is called "Southeast Hill" and the west hill was named "West Hill" during the present survey. All these zones are combined and called the North Prospect. Ancient workings are also distributed in the hills to the southeast of the Southeast Hill and these are called "Southeast Extension". This extension was included in the present detailed survey of the North Prospect.

The geological map of this prospect, prepared by the present detailed survey is laid out in Figure 2-3-4, and the six new geological cross sections incorporating the past drill holes in Figure 2-3-5. The same geological map and geological cross sections in scale 1:2.500 are shown in Plate 3.

(1) Geology

The major geologic units near this prospect are rhyodacite and dacite of the Arj Group, and are elongated in the NW-SE direction. Diorite bodies have intruded into the Arj Group in the northeastern part of this prospect. Mineralization occurs only in the Arj Group and is not observed in the diorite bodies.

(2) The distribution and size of the mineralized zones on the surface

Occurrence of five main mineralized zones has been inferred in this prospect by study of ancient workings, mineralization in trenches, and the results of drilling. The distribution of these mineralized zones is one in the West Hill, one in the slag distribution area, one in the Southeast Hill, and two in the Southeast Extension. The surface width and length of these mineralized zones are as follows.

Name	Location	Strike	Dip	Width on surface (max. m)	Length (m)
No.1	West Hill	N−NW	80°E	7	500
No.2	Slag Distribution Area	N	80°E?	30	400
No.3	Southeast Hill	WNW	65°N	20	200
No.4	Southeast Extension	NW−NNW	Unknown	10	200
No.5	Southeast Extension	NNW	Unknown	10	400

(3) Grade of ores

Surficial zone

Eleven ore samples were collected from the ancient workings and trenches. The analytical results of these samples are shown in Table 2-3-3. It is seen that the Cu grade ranges from 0.04 % to 10.12 %. The Au and Ag grades are very low.

Lower zone

The results of drilling carried out in the past are listed in Table 2-1-2. Of the 12 holes drilled in this prospect, 9 encountered mineralized zones. The Cu grade of the mineralized zones ranges from 0.90 % (true width 2.5m) to 5.10 % (true width 1.0 m).

(4) The downward extension of the mineralized zones

The downward extension of the No.1 Mineralized Zone was penetrated by the following five drill holes.

Drill hole	Depth (below surface) of ore (m)	True width (m)	Cu grade (%)
DDH-7	68.3—68.6	0.6	5.0
DA-5	73.9—75.7	2.6	2.17
DA-4	51.7—54.7	4.8	1.03
DA-3	32.0—40.0	2.5	0.90
DDH-6	103.0—105.0	2.4	0.95

Thus the conditions below 100-m depth is not known.

No.2 Mineralized Zone was not drilled, and thus the downward extension of the mineralization is totally unknown.

No.3 Mineralized Zone was explored by drill holes DDH-4, DDH-5, UAD-6, and UAD-11. The DDH-4 and DDH-5 were drilled in the strike direction. Therefore, it is not possible to measure the width of the mineralized zone by these holes. The following data, however, have been acquired by UAD-11 and UAD-6 holes.

Drill hole	Depth (below surface) of ore (m)	True width (m)	Cu grade (%)
UAD-11	52.1—54.8	3.1	1.87
UAD-6	175 —178 ?	2 ?	0.35

Thus the Cu grade of No.3 Mineralized Zone below approximately 150-m depth is seen to be low.

No.4 and No.5 Mineralized Zones were not drilled and thus the downward extensions of these zones are not known.

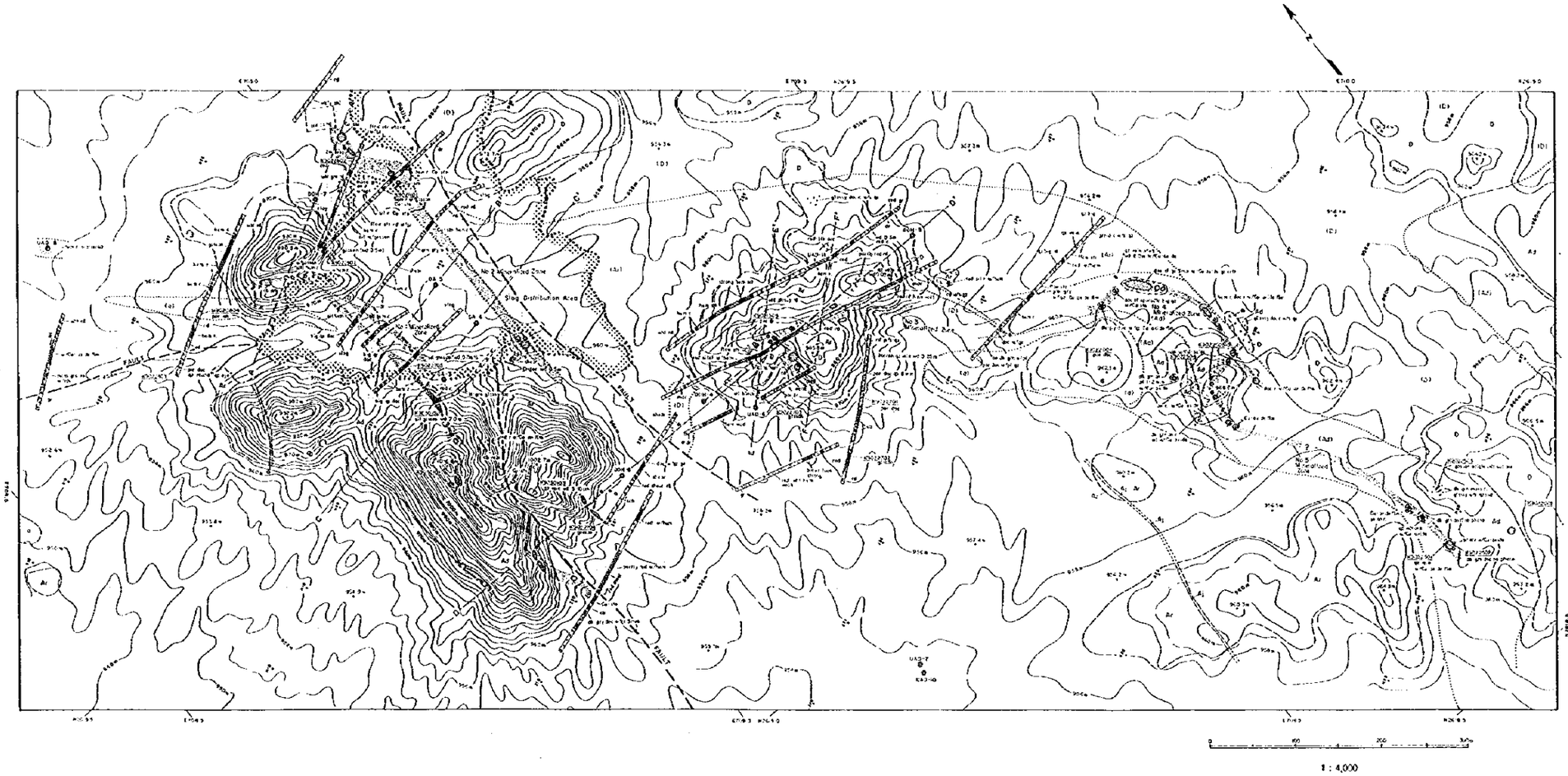
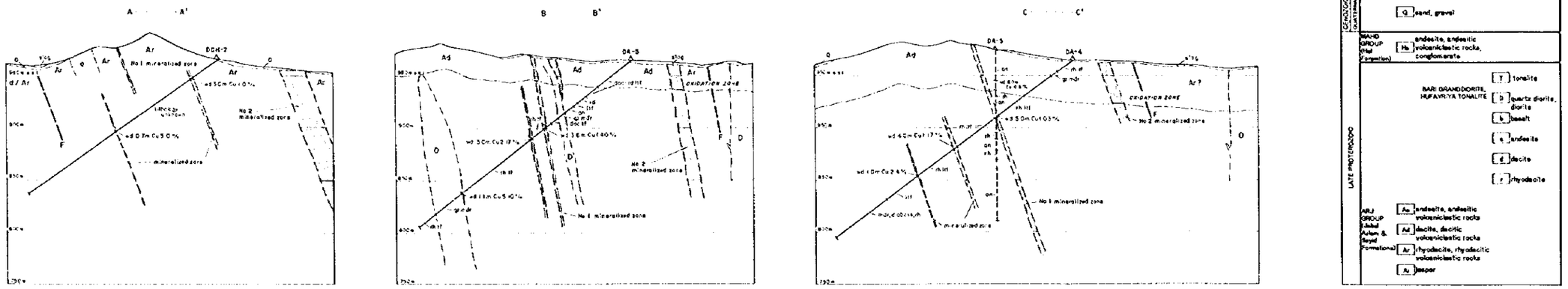


Fig. 2-3-4 Detailed Geological Map of the Umm ad Damar North Prospect



AGE	SEDIMENTARY AND VOLCANIC ROCKS	INTRUSIVE ROCKS
CENOZOIC (QUATERNARY)	Q sand, gravel	
LATE PROTEROZOIC	WAHO GROUP (Hail Formation) Ha andesite, andesitic volcaniclastic rocks, conglomerate	
		BARI GRANODIORITE, RUFAYRIYA TONALITE: T tonalite; D quartz diorite, diorite; b basalt; a andesite; d dacite; r rhyodacite
	ARJ GROUP (Abul Arjam & Bayad Formations) Aa andesite, andesitic volcaniclastic rocks; Ad dacite, dacitic volcaniclastic rocks; Ar rhyodacite, rhyodacitic volcaniclastic rocks; As lapar	

agglomerate	agl	moderate	mod
amphibole	amp	network	ntwk
andesite	an	opaque minerals	op
andesitic	an	phenocryst	pheno
apatite	apa	phyllitic	phy
basic	b	plagioclase	pl
black	blk	porphyritic	por
breccia	brec	pyrite	py
brecciated	brecd	quartz	qz
carbonate	cb	rhyodacite	rd
chert	cht	rhyolite	rh
chlorite	chl	rock	r.
chloritized	chl	rounded	round
clay minerals	cly	sandstone	sst
clinopyroxene	cpx	schist	sch
dacite	dac	sericite	ser
dark	dk	shale	sh
diorite	dr	sheared	shear
disseminated	diss	siliceous	sil
dotted	dott	silicified	silci
epidote	epi	spotted	spot
film	flm	stain	stn
gravel	gr	structure	str
gray	gry	sulfide	sul
green	grn	titanite	tit
hematite	hem	tonalite	to
hornblende	hb	tuff	tf
intrusive	int	veinlet	vnlt
K-feldspar	kf	weakly	wkly
lapilli tuff	ltf	white	wht
light	lt	width	wd
massive	mass	with	w/
microdiorite	mdr		

Fig. 2-3-5 Geological Sections of the Umm ad Damar North Prospect

3-5-2 Umm ad Damar South Prospect

The geological map prepared by the present detailed survey is laid out in Figure 2-3-6, and four new geological cross sections incorporating the past drill holes are laid out in Figure 2-3-7. The same geological map and geological sections with scale of 1:2,500 are shown in Plate 4.

(1) Geology

The major geologic units near this prospect are rhyodacite, andesite, andesitic tuff, and dacitic tuff of the Arj Group, and are elongated in the NE-SW direction.

(2) The distribution and size of the mineralized zones on the surface

Seventeen ancient workings have been confirmed in this prospect. The number of major mineralized zone is inferred to be one on the basis of the distribution of ancient workings with oxidized copper minerals and the gossan in the trenches. This mineralized zone is slightly oblique to the strike direction of the country rocks, and occurs mainly in tuff. The zone has a maximum width of 30 m and the extension in the strike direction is 400 m on the surface.

(3) Ore grade

Surficial zone

Seven samples were collected from the ancient workings, trenches, and the waste dump. The results of assay are laid out in Table 2-3-3. Copper grade ranges from 0.06 to 7.91 %. The Au grade of sample K9022404 from ancient working between DDH-1 and UAD-1 holes is 6.2 g/t, and that of sample K9030313 from the waste dump to the north of DDH-1 hole is 3.0 g/t. Thus contrary to the North Prospect, the mineralization of this prospect contains gold.

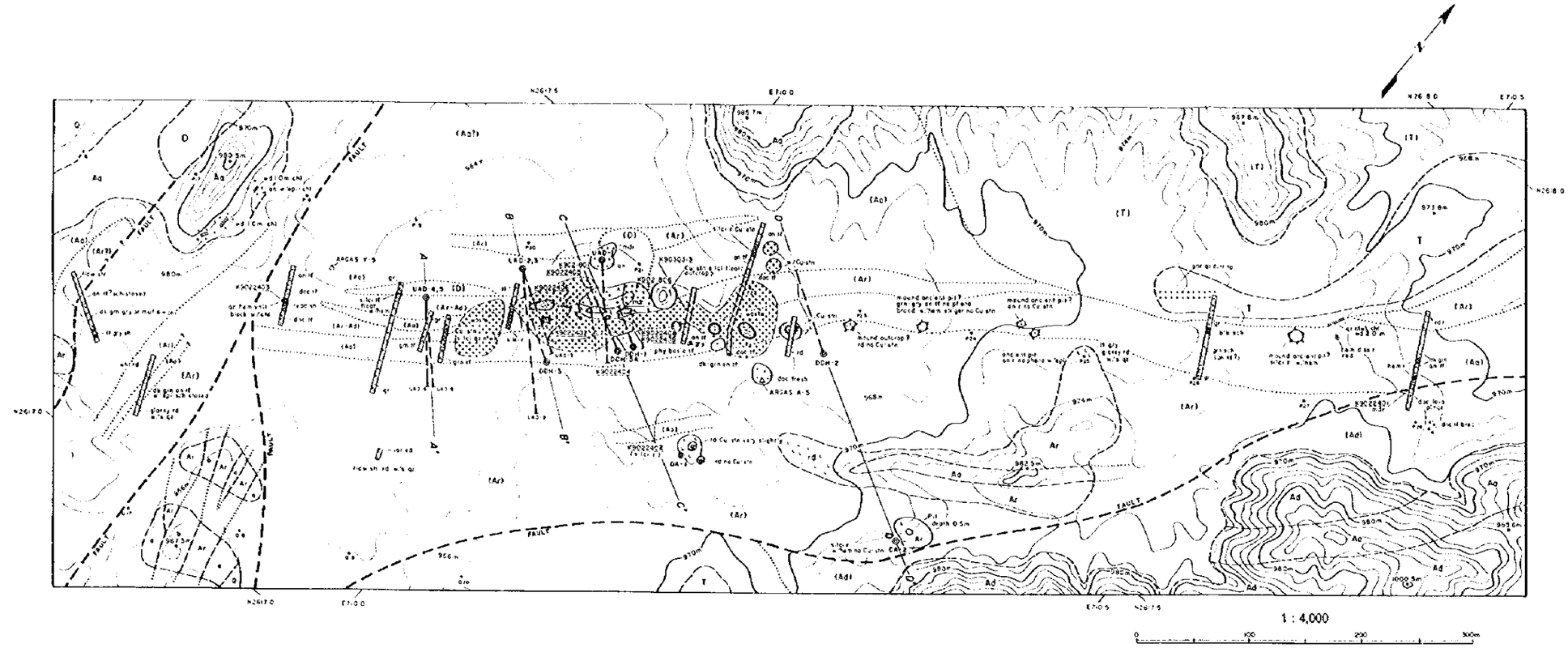
Lower zone

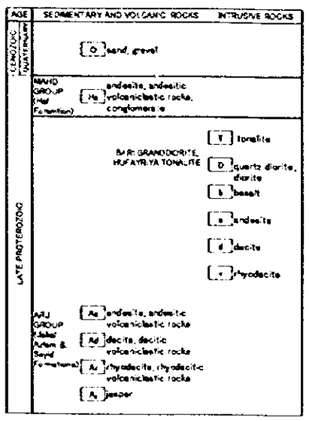
The results of drilling carried out in the past are listed in Table 2-1-2. Of the 11 holes drilled in this prospect, 4 encountered mineralized zones. The Cu grade of the mineralized zones ranges from 1.99 % (true width 6.9m) to 2.93 % (true width 2.1m).

(4) Downward extension of the mineralized zones

It is seen from the geological cross section (section D-D') of Figure 2-3-7, that mineralized zones do not exist to the northeast of DDH-2 in this prospect. DDH-3A was drilled to the lower zones of the ancient working, but mineralization was not observed (section C-C'). Near UAD-2 and -3, the mineralized zone is inferred to continue to depth of 130 m (B-B'). Near UAD-4 and -5, the mineralized zone is encountered by UAD-4. But UAD-5, which was

aimed to lower zones than UAD-4, did not encounter the mineralized zone. The reason for this is believed to be that UAD-5 was drilled in the dip direction of the mineralized zone (section A-A').





Abbreviation

agglomerate	agl	moderate	mod
amphibole	amp	network	nfwk
andesite	an	opaque minerals	op
andesitic	an	phenocryst	pheno
apatite	apa	phyllitic	phy
basic	b	plagioclase	pl
black	blk	porphyritic	por
breccia	brec	pyrite	py
brecciated	brecd	quartz	qz
carbonate	cb	rhyodacite	rd
chert	cht	rhyolite	rh
chlorite	chl	rock	r.
chloritized	chl	rounded	round
clay minerals	cly	sandstone	sst
clinopyroxene	cpx	schist	sch
dacite	dac	sericite	ser
dark	dk	shale	sh
diorite	dr	sheared	shear
disseminated	diss	siliceous	sil
dotted	dott	silicified	silci
epidote	epi	spotted	spot
film	flm	stain	stn
gravel	gr	structure	str
gray	gry	sulfide	suf
green	grn	titanite	tit
hematite	hem	tonalite	to
hornblende	hb	tuff	tf
intrusive	int	veinlet	vnlt
K-feldspar	kf	weakly	wkly
lapilli tuff	ltf	white	wht
light	lt	width	wd
massive	mass	with	w/
microdiorite	mdr		

Fig. 2-3-6 Detailed Geological Map of the Umm ad Damar South Prospect

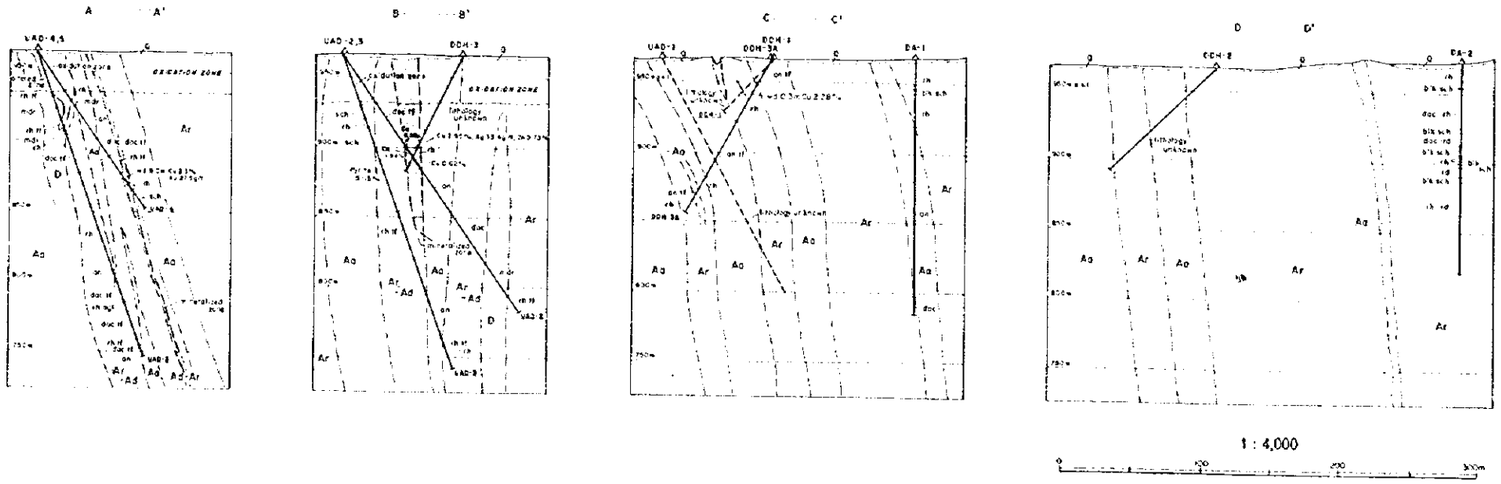


Fig. 2-3-7 Geological Sections of the Umm ad Damar South Prospect

3-5-3 4/6 Gossan Prospect

The geological map prepared by the present detailed survey and two new geologic cross sections incorporating the past drill holes are laid out in Figure 2-3-8. And the same geological map and geological sections with scale 1:2,500 are shown in Plate 5.

(1) Geology

The major geologic units near this prospect are dacite, dacitic tuff, and rhyodacite of the Arj Group, and are elongated in the NNE-SSW direction.

(2) The distribution and size of the mineralized zones on the surface

There is one mineralized zone in this prospect. This zone is somewhat oblique to the strike of the country rock, and occurs mainly in the dacitic tuff. The zone is 0.3—8 m wide on the surface and the extension in the strike direction is inferred to be 250—300 m.

(2) Ore grade

Surficial zone

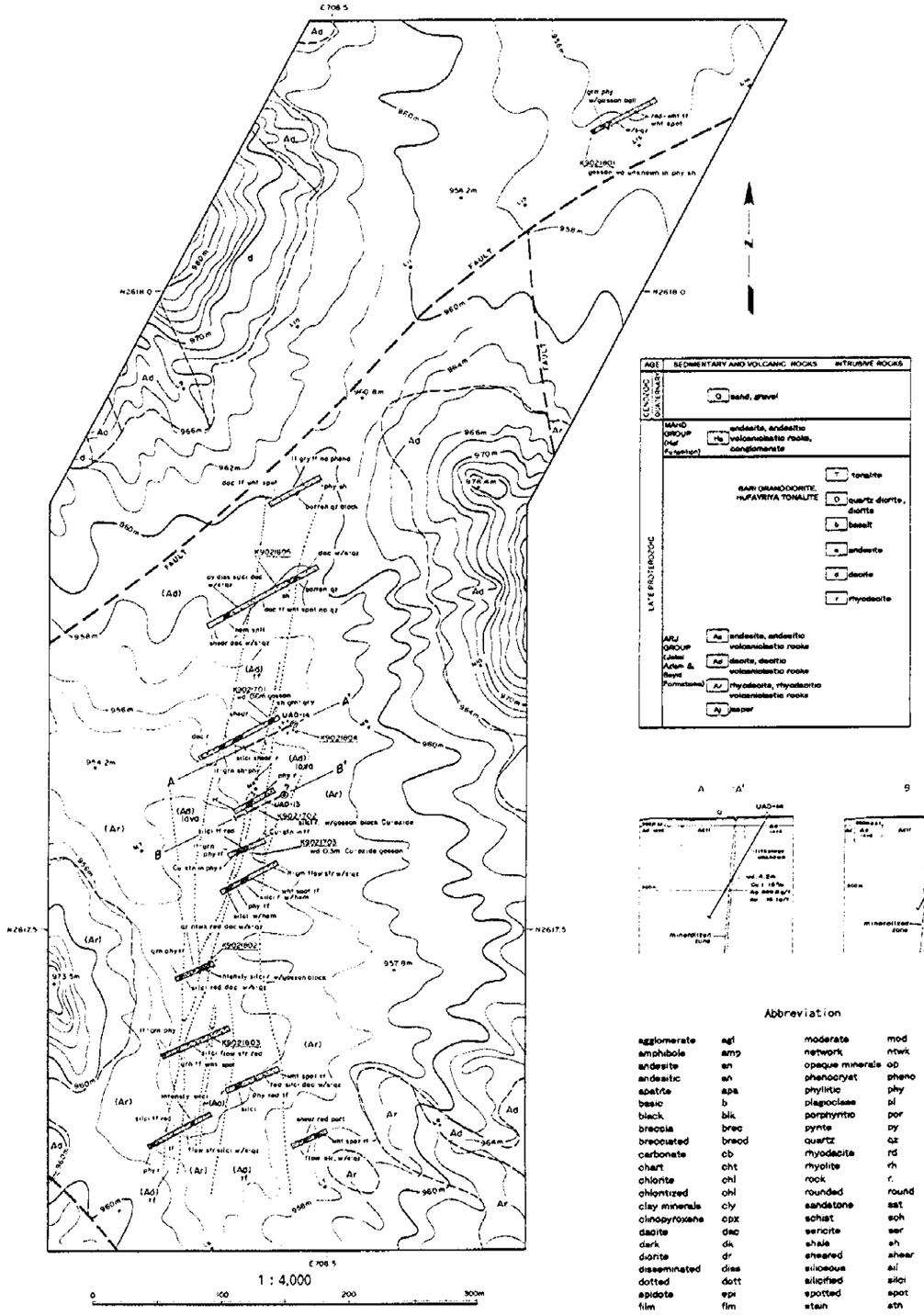
Five samples were collected from the gossan in the trenches and were chemically analyzed (Table 2-3-3). The Cu grade ranges from 0.03 to 6.59 %. Also sample K9021701 contains 3.7 g/t of Au and 287 g/t of Ag, and sample K9021702 contains 1.6 g/t of Au. Thus the gold and silver grades are high in these samples. These two samples also have high Pb and Zn grades.

Lower zone

Of the two holes drilled in this prospect, the mineralized zone encountered in UAD-14 has high Au, Ag grade of Au 16.1 g/t and Ag 449.8 g/t (Table 2-1-2).

(4) Downward extension of mineralized zones

As shown in the geological cross section of Figure 2-3-8, the mineralized zone is confirmed to be continuous to a depth of near 60 m. Deeper drilling has not been carried out.



Abbreviation

agglomerate	agl	moderate	mod
amphibole	amp	network	ntwk
andesite	an	opaque minerals	op
andesitic	an	phenocryst	pheno
apatite	apa	phyllitic	phy
basic	b	plagioclase	pl
black	blk	porphyritic	por
breccia	brec	pyrite	py
brecciated	brecd	quartz	qz
carbonate	cb	rhyodacite	rd
chert	cht	rhyolite	rh
chlorite	chl	rock	r.
chloritized	chl	rounded	round
clay minerals	cly	sandstone	sst
clinopyroxene	cpx	schist	sch
dacite	dac	sericite	ser
dark	dk	shale	sh
diorite	dr	sheared	shear
disseminated	diss	siliceous	sil
dotted	dott	silicified	silci
epidote	epi	spotted	spot
film	flm	stain	stn
gravel	gr	structure	str
gray	gry	sulfide	sul
green	grn	titanite	tit
hematite	hem	tonalite	to
hornblende	hb	tuff	tf
intrusive	int	vemlet	vnlt
K-feldspar	kf	weakly	wkly
lapilli tuff	ltf	white	wht
light	lt	width	wd
massive	mass	with	w/
microdiorite	mdr		

Fig. 2-3-8 Detailed Geological Map and Geological Sections of the 4/6 Gossan Prospect

3-5-4 Other mineralized zones

At least four quartz veins occur to the southeast of the South Prospect (Fig.2-3-3), and oxidized copper minerals and chalcopyrite are observed in them. This part has been called "Southeast Extension". Each vein strikes NE-SW, which is the strike direction of the faults nearby, and the continuity is not good. Samples were collected at six localities during the present survey. The quartz veins in this part is low in gold and silver content as shown in Table 2-3-3.

The mountain to the north of the South Prospect consists of tonalite, and a fault zone extending in the NE-SW direction is observed at the boundary of the tonalite and the Arj Group rocks to the north. A total of seven short trenches have been dug across the fault zone, and a quartz vein was observed in one of the trenches. This vein is about 30cm-wide, and contains oxidized copper minerals. A sample of the vein (K9022006) contains 1.48 %Cu, but the Au and Ag contents are low.

A 12-cm wide quartz vein was found 1-km southeast of the Jabal Sujarah summit. Oxidized copper minerals and hematite were observed, but the gold, silver, and copper grade is low in the sample M9021504.

Oxidized copper minerals were observed in a part of the jasper formation, which is exposed 400-m northwest of the Jabal Sujarah summit. One sample (K9030105) was collected from this part, but the gold, silver, and copper grades were low.

Aside from the above, evidence of carbonatization was observed in Jabal Sujarah, and that of silicification in the west of the North Prospect. Also silicified and epidotized rocks were observed in the mountainous zone between the 4/6 Gossan and the South Prospect.