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

PHASE III

MARCH 2001

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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 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 third-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 September 1, 2000 to November 17, 2000. The field survey was completed on schedule with the cooperation of the Government of the Kingdom of Saudi Arabia.

Results of the third-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 Economy, Trade and Industry, the Embassy of Japan in Saudi Arabia and the authorities concerned for the close cooperation extended to the team.

March, 2001

Kunihiko SAITO
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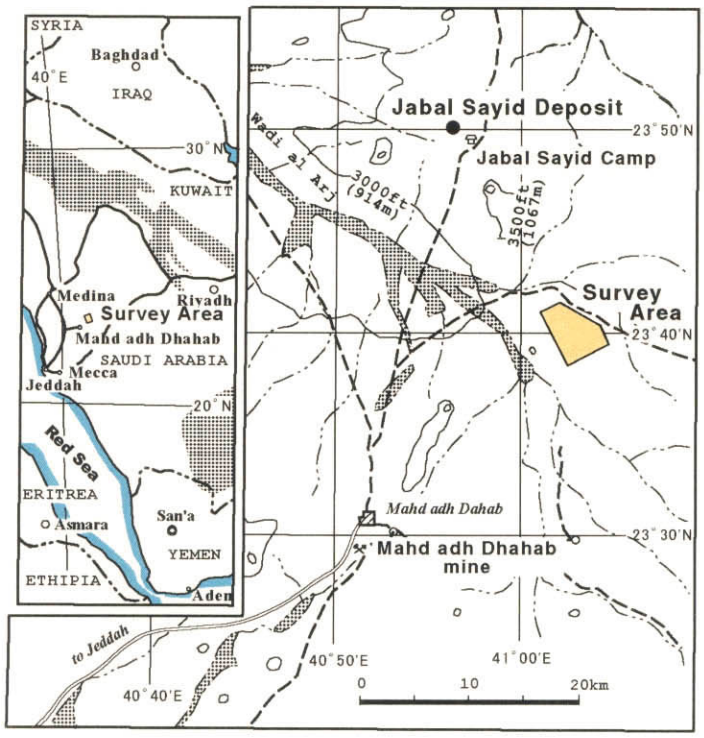

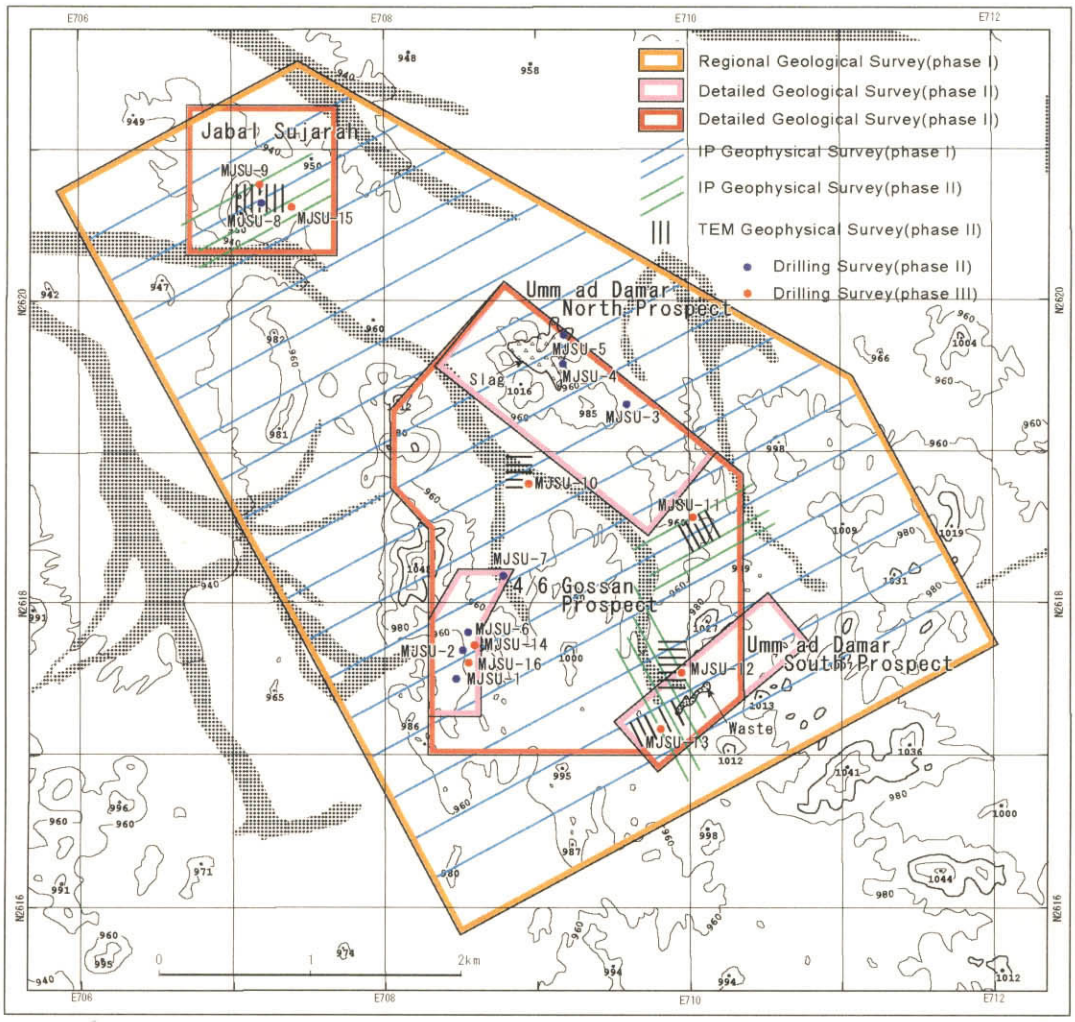

Fig. 1-1 Location Map of the Survey Area

SUMMARY

① During the third year of the Umm ad Damar mineral exploration project, a total of eight holes with a total length of 2,340m were drilled. The objectives of the drilling were to understand the geology of deep subsurface zones and to clarify the details of Au, Cu, and Zn mineralization of the promising areas extracted by geological survey, geophysical survey (IP and TEM methods) and drilling during the first and second years of the project.

② Mineralization including Cu and Zn are confirmed in four localities of Jabal Sujarah, Umm ad Damar North Prospect, Umm ad Damar South Prospect, and 4/6 Gossan Prospect. Drilling was carried out during the present year in the known mineralized zones of Jabal Sujarah, and 4/6 Gossan Prospect. Furthermore, drilling was done in promising areas extracted by geophysical prospecting. These areas were previously not known to be mineralized.

③ In the Jabal Sujarah area, volcanogenic sulfide mineralized zones occur in dacitic pyroclastic rocks. These mineralized zones consist of Cu and Zn-bearing massive ores, pebble ores, and pyrite dissemination zones. The mineralized zone consisting of massive ores and pebbly ores contain intercalation of shale, fine-grained tuff, and chloritized rocks. The massive ores and dissemination zones were confirmed by the present drilling, but content of Cu and Zn in both types ore is poor. The results of the second year and the present results indicate that parts of the massive and pebbly ores are rich in Cu and Zn, but generally they are of low grade. Also their extension in the strike direction is around 200m and very limited. Regarding the disseminated zones, up to 100m of thickness can be expected, but its Au, Cu, and Zn grades are low.

④ Regarding the 4/6 Gossan Prospect, occurrence of volcanogenic massive sulfide mineralization consisting of massive, siliceous, and pebbly ores is noted. These mineralized zones occur within rhyodacitic pyroclastic rocks and they are partly accompanied by basaltic tuffs. This year, the downward extension and southward extension of the known mineralized zones was surveyed. In the deeper extension of the mineralization, a Zn-rich massive ore was confirmed but its thickness was only about 1.8m. In the southern extension, mineralization was not observed. From these results, it is now known that in this prospect, there are three mineralized zones, but they are all small and even the most rich zone is about 100m in the strike direction, 120m in the dip direction and the thickness is less than 10 m

⑤ Survey was carried out in areas other than the above where the chargeability anomalies are high

and conductive plates were inferred to exist. It was clarified that the high chargeability was caused by pyrite dissemination and veinlets, but the penetrated mineralized zones were low in Au, Cu, and Zn grade. We were hoping for the occurrence of vein-type Cu-Zn mineralization and Au-Cu-Zn, but the mineral potential was concluded to be not high for areas other than the known prospects.

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PART I OVERVIEW

PART I OVERVIEW

CHAPTER 1 INTRODUCTION

1-1 Objectives

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 was carried out during the three-year period of fiscal 1998 to 2000. This is the third year of this project.

1-2 Results of the Second-Phase Survey

Drilling, detailed geological survey, IP and TEM geophysical survey were carried out in the Umm ad Damar area during the second year of the project. The results are summarized as follows.

① At total of eight holes with total length of 2,152m were drilled. The drilling sites were selected from the results of the first-phase detailed geological survey on known prospects and of IP reconnaissance with 300m traverse interval.

② Drilling clarified the existence of volcanogenic massive sulfide Cu-Zn mineralization at Jabal Sujarah, 4/6 Gossan, and a part of the North Prospect, also Cu vein mineralization was found to occur at the North Prospect.

③ Volcanogenic massive sulfide mineralization was confirmed at MJSU-2, MJSU-5, MJSU-6, and MJSU-8. In these holes, massive ore and breccia ore consisting of chalcopyrite-sphalerite-pyrite occur in host rock of rhyodacitic pyroclastic rocks. Shale and tuff are intercalated in the mineralized zones. Alteration of the host rock is silicification and chloritization. The main mineralized zones are as follows.

Drill Hole No.	Drilling Depth (m)	Interval (m)	Assay Result			
			Au (g/t)	Ag (g/t)	Cu (%)	Zn(%)
MJSU-2	121.15－125.40	4.25	0.37	23.0	0.96	2.17
	130.10－142.25	12.15	0.37	14.0	1.00	3.67
MJSU-5	268.90－275.40	6.50	<0.05	2.1	0.99	0.20
MJSU-6	134.75－138.00	3.25	<0.05	28.0	0.69	3.84
MJSU-8	73.25－73.55	0.30	<0.05	3.9	0.90	12.74
	82.65－83.35	0.70	0.24	19.5	1.57	0.01

④ Cu vein mineralization was confirmed at MJSU-3, MJSU-4, and MJSU-5 of the North Prospect. The veins and network mineralization observed in these holes consist of chalcopyrite and pyrite. The host rocks are dacite and dacitic pyroclastic rocks. The veins and network contain little silicate and oxide minerals. Chloritization is notable near the veins. Gold and silver grade is low. The main mineralized zones are as follows.

Drill Hole No.	Drilling Depth (m)	Interval (m)	Assay Result			
			Au (g/t)	Ag (g/t)	Cu (%)	Zn (%)
MJSU-3	220.10－220.90	0.80	<0.05	6.6	2.48	0.03
MJSU-4	140.50－147.80	7.30	<0.05	9.1	1.98	0.03
	155.50－158.85	3.35	<0.05	6.3	2.19	0.07
MJSU-5	79.40－82.55	3.15	0.07	15.4	2.25	0.06
	88.90－93.20	4.30	<0.05	13.7	1.93	0.03
	95.50－99.90	4.40	0.06	12.5	3.70	0.02
	245.65－247.70	2.05	<0.05	2.0	1.02	0.02
	328.90－331.20	2.30	0.07	7.1	6.51	0.01

⑤ The cores (drilled in 1977) stored in Jabal Sayid camp were re-arranged. And UAD-3, UAD-4, UAD-6, and UAD-10 cores were examined. Chalcopyrite-pyrite-quartz veins were observed at 105.95 ～ 112.05m depth and pyrite-chalcopyrite-sphalerite dissemination at 112.05～115.00m depth of UAD-4 of the South Prospect. The host rocks were chloritized rocks. The results of assay are as follows.

Drill Hole No.	Drilling Depth (m)	Interval (m)	Assay Result			
			Au (g/t)	Ag (g/t)	Cu (%)	Zn (%)
UAD-4	105.95－112.05	6.10	0.34	22.9	1.97	0.23
	112.05－115.00	2.95	1.14	39.2	3.72	3.07

Ore samples collected from ancient pits of this Prospect also showed 3.0 - 6.2 g/t Au. It is seen that the mineralization of this Prospect has higher Au and Zn content than the Cu veins of the North Prospect.

⑥ IP geophysical survey was carried out in order to clarify the detailed chargeability distribution of the "B-12", "M-27", and "P-18" anomalous zones extracted by IP survey last year. The following was clarified as a result.

B-12 anomaly: The lateral extension of this anomalous zone is the largest in the survey area, and the chargeability is very high.

M-27 anomaly: This anomalous zone consists of northern and southern sub-zones. The northern

strong anomaly sub-zone including station M-27 is oblong and extends in the NE-SW direction. The southern sub-zone occurs around station N-25 and is small.

P-18 anomaly: This anomalous zone extends northward and connects with station O-21.

⑦ Five sub-areas were selected for TEM geophysical survey. They are TB-12, TJ-18, TM-27, TO-21, and TP-18. Selection was based on IP survey and detailed geology. TEM survey resulted in extracting almost vertical conductive plates in these sub-areas.

⑧ The results of detailed geological survey, drilling, examination of existing cores, IP survey, and TEM survey were interpreted comprehensively. The conductive plates extracted in TM-27, TO-21, and TP-18 sub-areas are assessed to indicate vein-type mineralization and the plates in TB-12 and TJ-18 sub-areas volcanogenic massive sulfide mineralization.

1-3 Outline of the Third-Phase Survey

1-3-1 Survey area

The survey area is located in the western part of Saudi Arabia. The areal extent of the survey area is 18 km^2 (Fig. 1-1). The survey area is in the central part of the Proterozoic region in the western margin of the Arabian Peninsula.

1-3-2 Major objective of the survey

The objective of drilling is to clarify the details of the geology of the deeper zones, and Au, Cu, and Zn mineralization in the promising areas extracted from the results of geological surveys, geophysical surveys (IP and TEM) and drilling carried out during the first- and second-phase of this project.

1-3-3 Exploration work

The work of the third-phase survey consisted of drilling and the amount of the work is shown in Table 1-1.

1-3-4 Survey team and survey duration

(1) Survey team

Field Supervisor

Yasunori NUIBE (Technical Cooperation Division, MMAJ)

Survey Team

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

Yoneharu MATANO:	Team leader, Drilling exploration

2) Saudi Arabian side (Saudi Geological Survey)

Ghazi ABDULHAY:	Team leader, Coordinator
Abudullah AL-JEHANI:	Drilling exploration
Zaben AL-GHIDANY:	Drilling exploration
Yahya AL-MUFAREEH:	Drilling exploration
Yasser AL-GHANMY:	Drilling exploration
Ayman NADERAH:	Drilling exploration
Ahmad SARHAN:	Drilling exploration

(2) Duration

Field supervision: 10 to 15 November, 2000 (Yasunori NUIBE)

Field survey

Drilling Exploration: 1 September, 2000 to 15 November, 2000

Laboratory work and report preparation:

18 November, 2000 to 20 March, 2001

Table 1-1 Amount of Work

Survey Method	Amount			
Drilling Exploration	Number of Drill Holes : 8 holes			
	Total Drilled Length : 2,340.65m			
	Drill Hole	Azimuth	Inclination	Drilled Length
	MJSU-9	155°	-55°	380.00m
	MJSU-10	300°	-55°	350.40m
	MJSU-11	150°	-55°	250.10m
	MJSU-12	270°	-55°	250.00m
	MJSU-13	330°	-55°	250.00m
	MJSU-14	245°	-55°	274.60m
	MJSU-15	335°	-55°	375.65m
	MJSU-16	245°	-55°	210.00m
	Laboratory Works			
	Ore Assay(Au,Ag,Cu,Zn,Pb,S)			455 samples
	Thin Sections			32 samples
	Polish Sections			20 samples
	X-ray Diffraction Analysis			60 samples
	Measurement of Rock Resistivity			50 samples

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 easternmost 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.

Hills and mountains in the survey area generally are elongated in the N-S and NW-SE directions, and those in the southeastern part of the survey area are elongated in the NE-SW direction.

In the survey area, permanent rivers do not exist. Wadis in the survey area become lower in elevation to the north or northwest, and join Wadi al Arj at a location northwest of the survey area.

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 $^{\circ}$ C , but it often drops to near 0 $^{\circ}$ 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 GEOLOGY AND MINERALIZATION OF THE SURVEY AREA

3-1 Regional Geology and Mineralization

3-1-1 Regional geology

The geology of 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) based on Kemp et al. (1982).

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 pyroclastic 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 pyroclastic 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.

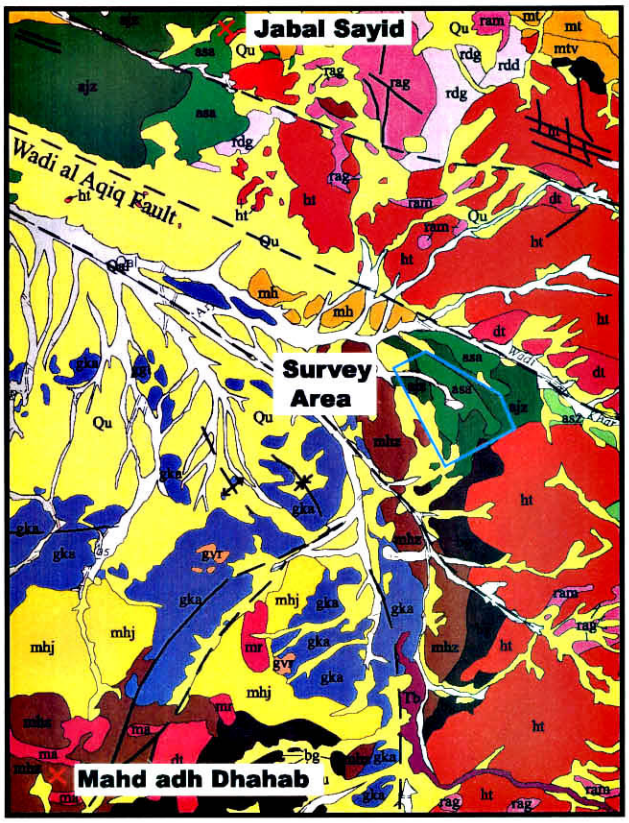
In this area, the distribution of the Arj Group is limited to near the Jabal Sayid deposit and in the survey area. The Group in the survey area has triangular distribution, and it is bounded; to the northeast by NW-SE trending Wadi al Aqiq strike-slip fault, to the south by Bari Granodiorite and Dhukhr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

3-1-2 Mineralization

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 pyroclastic 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



Simplified from Kemp et al. (1982)

0 5 10 15 20 km

Cenozoic
Tertiary Quaternary
Wadi alluvium — Qal — sand, gravel
Qlder Wadi Deposits, Fans, Terraces — Qu — scree
Basalt — Tb

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Proterozoic
Raghiyah Suite
rda — Dayahin Granite (582±26Ma) : porphyritic
rag — Assarah Granite — monzogranite (573±22Ma & 575±28Ma)
ram — red granite and microgranite
rdg — Dumah Granodiorite — granodiorite
rdd — quartz monzodiorite
Subvolcanic Ricks — gvr — Rhyolite to rhyodacite

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Ghamr Group
ggt — tuffaceous member
gka — mafic units
gks — Kharzah Formation : sedimentary units
gkr — silicic units

UNCONFORMITY

Bari Granodiorite
Hufayriyah Tonalite — ht — Tonalite (760±10Ma)
Subvolcanic Rocks
rhr — Rhyolite to rhyodacite
ma — Basalt to andesite

Mahd Group
mtv — Tulaymisah Formation : volcaniclastic rocks (mt) with volcanic units (mtv)
mt
mh — Haf Formation : undiffrentiated (mh), Juraysiyah Member (mhj) - basalt, andesite, rhyodacite
mhj
mhz — Zur Member - rhyolite, sedimentary rocks

UNCONFORMITY

Dhukhr Tonalite — dt — Tonalite (816±4Ma)

Arj Group
asz — Undifferentiated Sayid and/or Jabal Azlam Formations
ajz — Jabal Azlam Formation : volcanic rocks, andesite
Sayid Formation : silicic volcanic rocks

Fig.1-2 Regional Geology of the Survey Area

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 %).

3-2 Geology and Mineralization of the Survey Area

3-2-1 Geology

Simplified geological map of the survey area is shown in Figure 1-3.

The geology of the survey area consists mainly of; rhyodacitic lava and pyroclastic rocks ("Ar" in Fig. 1-3), dacitic lava and pyroclastic rocks (Ad), breccia (Adb), andesitic lava and pyroclastic rocks (Aa), and jasper (Aj) belonging to the Late Proterozoic Arj Group. This group is intruded by diorite/ quartz diorite (D), tonalite (T), andesite/ porphyritic andesite (a), dacite/ porphyritic dacite (d), rhyodacite (r), and basalt/ porphyritic basalt (b) bodies.

Of the above rocks, jasper and dacitic breccia occur mostly near Jabal Sujarah in the northwestern part of the survey area. Granitic rocks occur throughout the area, but are concentrated in the area from the Unnad Damar North Prospect to Umm ad Damar South Prospect.

These units are covered unconformably by Late Proterozoic andesitic lava and pyroclastic rocks (Ha) 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.

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.

3-2-2 Mineralization

The existence of Cu, and Zn mineralization have been confirmed in the following four prospects of the survey area. Jabal Sujarah, the Umm ad Damar North Prospect, the Umm ad Damar South Prospect, and the 4/6 Gossan Prospect (Fig. 1-4).

Volcanogenic massive sulfide-type Cu-Zn mineralization exists in Jabal Sujarah, the 4/6 Gossan Prospect, and a part of the Umm ad Damar North Prospect. Also vein-type Cu mineralization is confirmed in the Umm ad Damar North Prospect, and vein-type Cu-Zn mineralization occurs in the Umm ad Damar South Prospect.

The ore minerals of all three prospects are oxidized to depths of 30～40m and thus only gossan containing oxidized copper minerals, limonite, and hematite occur on the surface.

Mineralization of these prospects is reported below.

(1) Jabal Sujarah

The surface geology of the vicinity consists of, from surface downward, jasper, dacitic breccia, and dacite. These units are intruded by rhyodacite, dacite, andesite, and basalt. The chargeability anomaly detected by IP survey occurs in the parts covered by talus, and exposures are very rare. Thus only strongly carbonatized silicic breccia crops out at the southwestern part of Mt. Sujarah, and ancient pits or gossans are not observed.

The mineralization in this prospect is volcanogenic massive sulfide-type Cu-Zn mineralization. The mineralized zone consists of massive and pebbly ores, and is accompanied by disseminated zone. Several layers of massive and pebbly ores are observed and single ore layer is estimated to be less than 0.8m thick. The whole mineralized zone including these ore layers and intercalated of pyrite dissemination is about 6m thick.

The massive and pebbly ores are partly rich in Cu and Zn, but most of them are of low grade.

Pyrite dissemination occurs between the massive ores and between massive and pebbly ores, and also in the footwall dacitic breccia with thickness exceeding 100m. Large amounts of pyrite are contained but they are poor in Cu and Zn.

(2) Umm ad Damar North Prospect

A large amount of slag occurs at the Umm ad Damar North Prospect, and many ancient pits are distributed in the small hills to the west and southeast of this slag zone. The hill to the southeast was named "Southeast Hill" during the present survey and the one in the west "West Hill". Ancient workings are also distributed in the hills to the southeast of the Southeast Hill. 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.

A total of five main mineralized zones are inferred to exist from the following observations; namely, the distribution of the ancient pits 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, two holes were drilled and MJSU-4 confirmed a mineralized zone 5.6m wide and Cu 1.98%. On No.3 Mineralized Zone, four holes have been drilled and UAD-11 shows a zone of 3.1m width and a grade of Cu 1.87 %. Drilling has not been carried out for No. 4 and 5 Mineralized Zones.

In MJSU-5, low-grade Cu-Zn mineralization was observed at 268.90～275.40m interval, and this mineralization is considered to be volcanogenic sulfide from the texture of the ores. The host rock of this mineralized zone is white rhyodacitic pyroclastic rocks which also hosts the massive sulfide mineralization of the 4/6 Gossan.

(3) Umm ad Damar South Prospect

The major geologic units near this prospect are rhyodacite, andesite, andesitic tuff, and dacitic tuff.

Seventeen ancient pits 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 pits containing oxidized-copper minerals and gossan in trenches.

Eleven holes including UAD-4 have been drilled in the past and mineralized zones were confirmed in four of them. The scale of the mineralized zone inferred from these drilling is less than 7m thick, extension in the strike direction about 300m, and the maximum extension along the dip direction 300m. This mineralized zone consists of chalcopyrite-pyrite-quartz veinlets, and pyrite-chalcopyrite-sphalerite dissemination.

(4) 4/6 Gossan

The geology of this prospect is composed mainly of rhyodacitic pyroclastic rocks with intercalation of basaltic tuff.

The mineralization of this prospect is volcanogenic massive sulfide Cu-Zn type mineralization. The constituents of the mineralized zone are massive, siliceous, and pebbly ores containing chalcopyrite, sphalerite and pyrite.

The massive ores are divided into very high Zn (Zn 11.0 - 35.0%) ore and very low Zn (less than 0.55%) ore. Cu grade is relatively high (average 2.11%). Au grade is high in one part (Au 5.8g/t), but is generally low (less than Au 0.7g/t). Pebbly and siliceous ores have relatively high Zn grade (Zn 0.8 - 9.8%). Cu grade is somewhat lower than that of the massive ores (average Cu 1.24%). Au grade is less than 1.5g/t.

Three layers of mineralization are observed in the upper and lower horizons (apparent) of the basaltic tuff. The mineralized zones below the basaltic tuff are divided largely into two parts. The mineralized zone immediately below the basaltic tuff is the thickest in MJSU-2 with a thickness of about 3.7m. The grade of this zone is Au 0.4g/t, Cu 0.96%, and Zn 2.17%.

The mineralized zone further deep is also thickest in MJSU-2 and is estimated to be about 9.3m thick. The grade is Au 0.4g/t, Cu 1.00%, and Zn 3.67%.

There is also a mineralized zone above the basaltic tuff horizon. This is observed only in MJSU-6 and the average grade is Au 0.1g/t, Cu 0.69%, and Zn 3.99%. It is estimated to be about 2.5m thick.

CHAPTER 4 INTEGRATED ANALYSIS OF THE SURVEY RESULTS

4-1 Geologic Structure and Mineralization Characteristics

The distribution of rhyolitic dacite and its pyroclastic rocks, diorite, and tonalite is shown in Figure 1-4.

Diorite occurs to the west of Umm ad Damar South Prospect, and also near and to the west of Umm ad Damar North Prospect. The diorite body near the Umm ad Damar North Prospect is the largest and occupies an area of about 500×1,500m. Tonalite occurs only near Umm ad Damar South Prospect.

Volcanogenic massive sulfide-type Cu-Zn mineralization, vein-type Cu mineralization, and vein-type Cu-Zn mineralization occur in this area.

The vein-type Cu mineralization is distributed in the Umm ad Damar North Prospect. It occurs as chalcopyrite-pyrite network veins in the fractured zones of dacitic pyroclastic rocks, porphyritic dacite (intrusive), and rhyodacitic pyroclastic rocks at the western periphery of the diorite body. Au, Ag grades are low. The network veins have nearly parallel strike with the western margin of the diorite body.

The vein-type Cu-Zn mineralization is distributed in the Umm ad Damar South Prospect and occurs as chalcopyrite-pyrite-quartz veins and as chalcopyrite-pyrite-sphalerite dissemination in rhyodacitic pyroclastic rocks at the southwestern periphery of a tonalite-diorite body. The latter mineralization contains around 1g/t Au. This mineralized zone strikes in the NE-SW direction similar to the distribution of diorite and tonalite.

Since both vein-type mineralized zones occur near the plutonic bodies and strike in the direction of the elongation of the rock bodies, it is believed that the mineralization was related to the intrusive activities of tonalite and diorite.

Near the Umm ad Damar North Prospect, IP survey indicates that a chargeability anomaly zones extend along the western margin of the diorite body including the network veins. The results of the second year survey show that this chargeability anomaly is caused by the pyrite dissemination within the host rocks. Chargeability anomaly zones occur to the south and west of the vein network. These zones occur continuously or in isolated forms (Fig. 1-5). The drilling carried out during the present year show that these anomaly zones consist of veinlet groups, vein networks, and dissemination composed mainly of

pyrite. Vein-type copper mineralization occurs near the western edge of the diorite body, while such mineralization is not observed in localities at some distances from the diorite. Therefore, although the chargeability anomalies occur extensively, the vein-type copper mineralization is believed to be of limited scale.

Chargeability anomaly zones are distributed extensively on the north side of the Umm ad Damar South Prospect. The occurrence of the anomalies almost coincides with the distribution of the tonalite body, and it extends further to the west. The drilling to the west of the tonalite body show that the chargeability anomalies are caused by pyrite veinlets and dissemination. At Umm ad Damar South Prospect, chargeability anomalies exceeding 15mV/V at elevation of 800m do not cover the mineralized zone completely. Thus these chargeability anomalies probably do not indicate the occurrence of Au-Cu-Zn mineralization but they show the existence of pyrite veinlets and dissemination.

Volcanogenic massive sulfide Cu-Zn mineralization occurs in the 4/6 Gossan Prospect and in the Jabal Sujarah district.

Promising volcanogenic massive sulfide-type Cu-Zn mineralization is observed near the 4/6 Gossan Prospect where rhyodacitic pyroclastic rocks are dominant among rhyodacitic volcanic rocks and dacitic volcanic rocks. Basaltic tuff occurs in both the hanging wall and footwall of the mineralized horizon and bimodal volcanic activity is assumed. But the extent of the basaltic tuff occurrence is limited to the vicinity of the mineralized zone and is small. The massive ores and breccia ores of this mineralized zone alternate with shale and fine tuff, and thus are believed to have deposited during the pauses of volcanic activity.

In the Jabal Sujarah district dacitic volcanic rocks are dominant with minor occurrence of rhyodacitic volcanic rocks. Also it is characteristic of this area that thick jasper layers are developed in the dacitic pyroclastic rocks of the hanging wall of the mineralized zone. Also thick silicified pyrite dissemination zones in the footwall side accompany the massive ores and pebbly ores and this differs from the mineralization of 4/6 Gossan Prospect. Shale and fine-grained tuff also accompany the massive and pebbly ores of this district.

The characteristics of the ore grade of the massive and pebbly ores formed by volcanogenic massive sulfide-type Cu-Zn mineralization of the survey area are the relative abundance of Cu and Zn and the relative paucity of Pb. The volcanogenic massive sulfide-type Cu-Zn mineralization with jasper in the hanging wall in the Jabal Sujarah district appears to be similar to the deposit of Noranda.

4-2 Mineral Potential

An integrated analysis map is laid out in Figure 1-5. The following is the mineral potential of the surveyed areas judged from the results of exploration carried out.

(1) Jabal Sujarah

The mineralization of this district is volcanogenic massive sulfide-type Cu-Zn mineralization. The mineralized zones consist of massive and pebbly ores and are accompanied by pyrite dissemination. The highest chargeability anomaly (exceeds 30mV/V at 800m elevation) in the entire survey area occurs over a range of 200×200m in this district. These anomalies are caused by strong and thick pyrite dissemination zone in the footwall of the massive and pebbly ores. These dissemination zones consist only of pyrite and Au, Cu, and Zn contents are negligible.

There are several layers of massive and pebbly ores and the thickness of the mineralized zone including the intercalated pyrite dissemination is about 6m. The extent of the mineralized zone is about 200m in the strike direction and over 250m in the dip direction. The massive and pebbly ores are partly rich in Cu and Zn, but their grade is generally low consisting mostly of pyrite.

From the above, the potential of this prospect for mineral development is concluded to be low.

(2) Umm ad Damar North Prospect

Existence of five rows of vein-type Cu mineralized zones is inferred in this prospect (these zones are numbered from Mineralized Zone No.1 to No.5).

Five holes have been drilled in Mineralized Zone No.1 and the average thickness of this orebody is 4.8m and the grade Cu 1.40%. Two holes were drilled in Zone No.2, and two to three veinlet groups and dissemination have been confirmed. The average thickness is 3.5m and the grade Cu 2.38%. In Zone No.3, four holes were drilled and the orebody is 3.1m thick and the grade Cu 1.87% at drill hole UAD-11. The Nos. 1 and 2 mineralized zones are expected to extend 400～500m in strike direction, and about 300m for the Zone No.3. Grades of metals other than Cu such as Au and Zn are low.

Aside from Cu veins, volcanogenic massive sulfide mineralization was confirmed by MJSU-5 in this

prospect, but drilling in the vicinity has not encountered such mineralized zones and this is considered to be of small scale.

(3) Umm ad Damar South Prospect

There is one row of vein Cu-Zn mineralized zones in Umm ad Damar South.

Eleven holes were drilled in this mineralized zone in the past and ores were confirmed in four holes. The hole drilled in a location southwest of this mineralized zone this year did not encounter vein-type mineralization. From the above data, this mineralized zone is inferred to be 2.1 - 6.9m thick and 130m long in the dip direction. The Cu grade is 1.99 - 2.93%. Au and Zn has been found in some drill holes and the grade is Au 0.3 - 1.1g/t and Zn 0.2 - 3.1%.

As mentioned above, the data lead us to conclude that this prospect has low potential for mineral development.

(4) 4/6 Gossan Prospect

The mineralization that occur in this prospect is volcanogenic massive sulfide-type Cu-Zn mineralization.

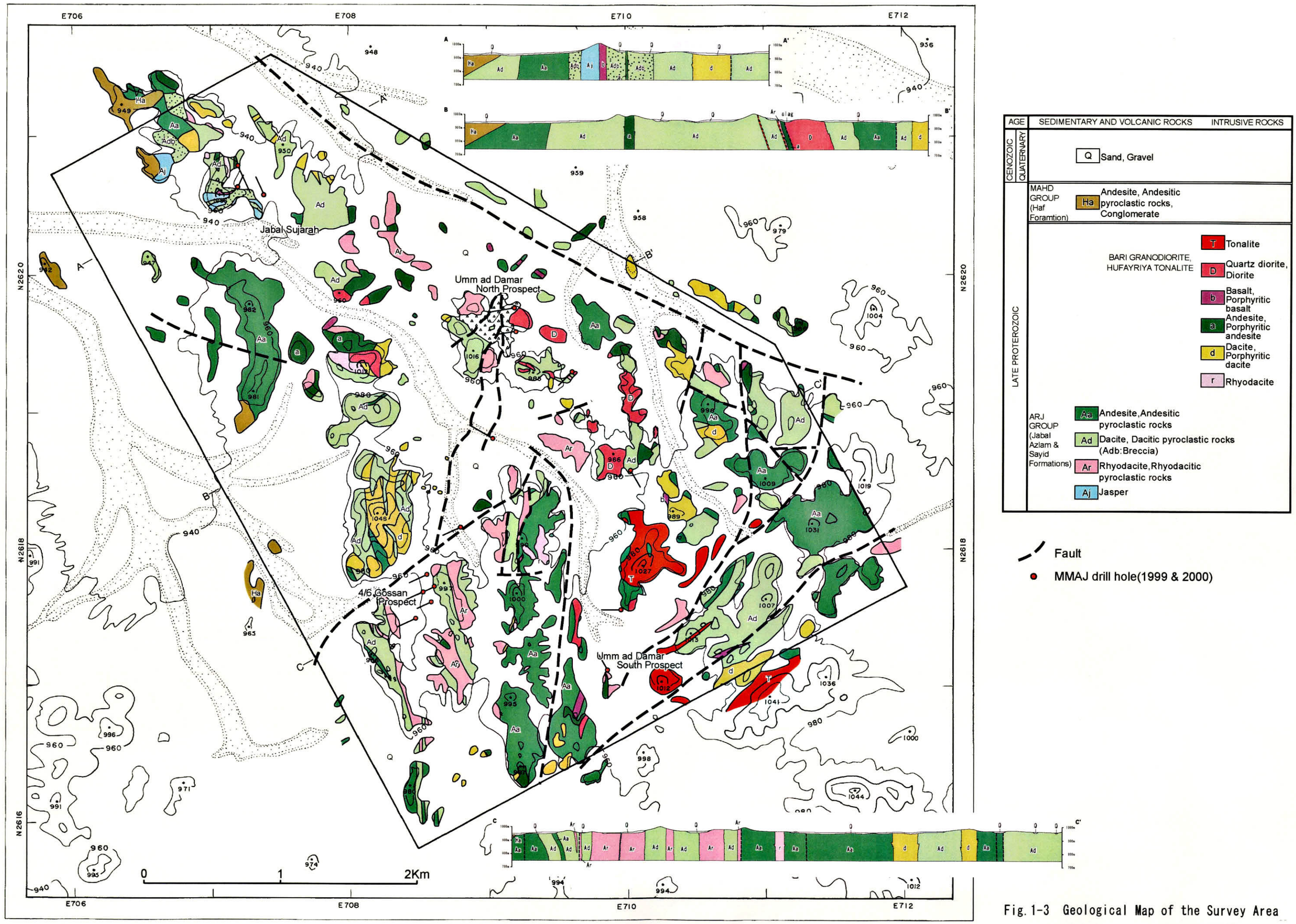
The mineralized zone consists of massive, siliceous, and pebbly ores and contains chalcopyrite, sphalerite, pyrite, and other ore minerals.

Three mineralized layers are observed above and below (apparent) the basaltic tuff. The zone below the basaltic tuff can be divided into two parts. The zone immediately below the basaltic tuff is most thick in MJSU-2 with estimated thickness of 3.7m. The grade here is Au 0.4g/t, Cu 0.96%, and Zn 2.17%.

The mineralized zone further below is 9.3m thick in MJSU-2 which is also the most thick part encountered. The grade is Au 0.4g/t, Cu 1.00%, and Zn 3.67%.

There is a mineralized zone above the basaltic tuff. This is also confirmed in MJSU-6. Here the zone is about 2.5m thick and the grade is Au less than 0.1g/t, Cu 0.69%, and Zn 3.99%.

The two mineralized zones below the basaltic tuff is estimated to be about 100m long in the strike direction and more than 60m and more than 120m respectively in the dip direction. The zone above the basaltic



AGE		SEDIMENTARY AND VOLCANIC ROCKS	INTRUSIVE ROCKS
CENOZOIC	QUATERNARY	Q Sand, Gravel	
LATE PROTEROZOIC	MAHD GROUP (Haf Foramtion)	Ha Andesite, Andesitic pyroclastic rocks, Conglomerate	
			BARI GRANODIORITE, HUFAYRIYA TONALITE: T Tonalite; D Quartz diorite, Diorite
			b Basalt, Porphyritic basalt
			a Andesite, Porphyritic andesite
			d Dacite, Porphyritic dacite
			r Rhyodacite
	ARJ GROUP (Jabal Azlam & Sayid Formations)	Aa Andesite,Andesitic pyroclastic rocks	
		Ad Dacite, Dacitic pyroclastic rocks (Adb:Breccia)	
		Ar Rhyodacite,Rhyodacitic pyroclastic rocks	
		Aj Jasper	

Fault

MMAJ drill hole(1999 & 2000)

Fig. 1-3 Geological Map of the Survey Area

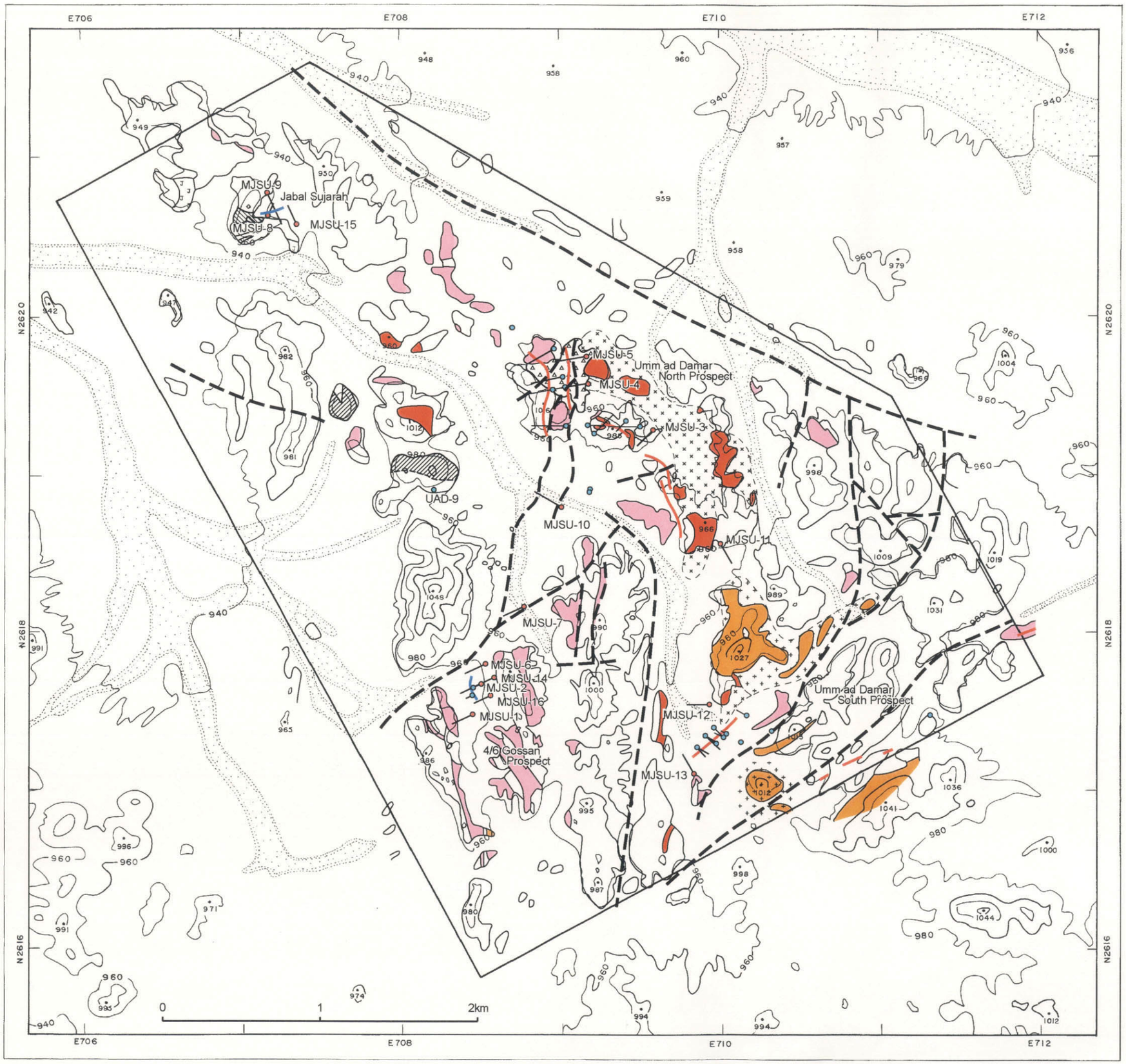


Fig. 1-4 Mineralization Map of the Survey Area

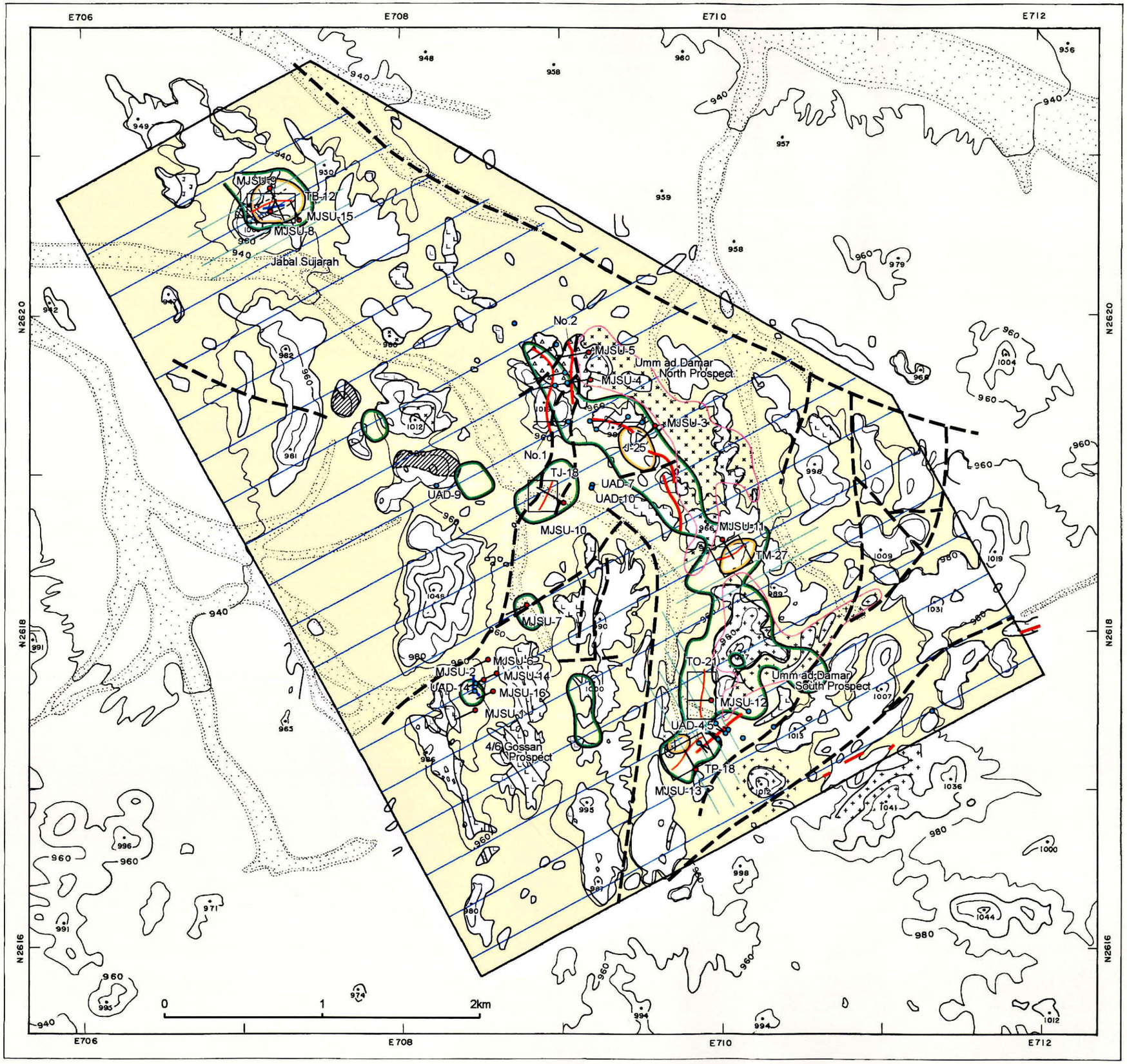


Fig. 1-5 Integrated Interpretation Map

tuff was confirmed only in one hole and is at most 100m long in the strike direction. Therefore, this prospect is considered to have low potential for mineral development.

(5) Other chargeability anomaly zones

The known mineralized zones in Umm ad Damar North Prospect and others are all within the IP chargeability anomaly zones (over 15mV/V, at 800m elevation). Therefore, it was hoped that similar mineralized zones would also occur in high chargeability anomaly zones other than the above known mineralized bodies. Drilling was carried out to ascertain this inference. The results, however, clarified that these anomalies were caused by pyrite veinlets and dissemination, but the Au, Cu, and Zn contents were low.

In the Jabal Sujarah area, the highest chargeability anomaly (over 30mV/V, 800m elevation) in the whole survey area occurs extensively. This chargeability anomaly, however, was formed by the pyrite dissemination in the footwall associated with volcanogenic massive sulfide mineralization. Since chargeability anomaly exceeding 30mV/V does not occur in other prospects of the survey area, mineralization with characteristics of this prospect probably do not occur elsewhere.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5-1 Conclusions

A total of eight holes with a total length of 2,340.65m were drilled this year as the work for the third year of the mineral exploration in the Umm ad Damar area. The major objective of the drilling was to clarify the geology of the deep subsurface zones and the details of Au, Cu, and Zn mineralization of the promising areas extracted by geological survey, geophysical surveys (IP and TEM) and drilling carried out during the first and second years.

The results are summarized as follows.

① Mineralized zones containing Cu and Zn occur in four localities of the survey area. They are Jabal Sujarah district, Umm ad Damar North Prospect, Umm ad Damar South Prospect, and 4/6 Gossan Prospect. During the present year, drilling was carried out in the known mineralized zones of Jabal Sujarah, and 4/6 Gossan Prospect. Further, drilling was carried out also in promising zones extracted by geophysical exploration in other than the known mineralized zones.

② In the Jabal Sujarah district, volcanogenic massive sulfide mineralized zones consisting of massive, pebbly ores, and pyrite dissemination, and containing Cu and Zn occur in dacitic pyroclastic rocks. The massive and pebbly ores contain intercalation of shale, fine-grained tuff, chloritized rocks and the total thickness is estimated to be about 6m. The drilling carried out this year confirmed massive ore and disseminated zones but these do not contain Cu nor Zn. Integrating the work carried out during the second year, Cu and Zn content is indicated in parts of the massive and pebbly ores, but most of them have low grade. The extent of the ores in the strike direction is about 200m and is limited. Pyrite dissemination zones probably attain thickness of 100m, but the Au, Cu, and Zn contents are low.

③ In the 4/6 Gossan Prospect, volcanogenic massive sulfide mineralized zones occur consisting of massive, siliceous, and pebbly ores. During this year, the downward and southward extension of the mineralized zones was surveyed. Zn-rich massive ores were confirmed in the deeper subsurface extension, but the thickness was about 1.8m. Mineralization could not be observed in the southern extension of the ore zone. These results indicate that there are three mineralized zones in this prospect, but the most promising zone is less than 9.3m thick, about 100m long in the strike direction, about 120m in the dip direction and these mineralized zones are of small scale.

④ Outside the known prospects, areas with high chargeability anomalies and inferred conductive plates were surveyed. The results clarified that the high chargeability anomalies were caused by pyrite dissemination and pyrite veinlets, but the Au, Cu, and Zn contents were low.

5-2 Recommendations for the Future Survey

① In the 4/6 Gossan Prospect, products of volcanogenic massive sulfide mineralization such as Cu・Zn-rich massive and pebbly ores occur but they are considered to be of small scale. Thus further exploration is not recommended in this prospect.

② In the Jabal Sujarah area, the products of volcanogenic massive sulfide mineralization were the target of our survey, but Cu and Zn contents were confirmed only in parts of the massive and pebbly ores and the major part of the ores were of low grade. Thus further exploration of this district is not recommended.

③ In areas other than the known prospects, the high chargeability anomalies with inferred conductive plates are mineralized zones of pyrite dissemination and pyrite veinlets. Thus further exploration is not recommended for these areas.