THE REPUBLIC OF TURKEY

REPORT ON THE COOPERATIVE MINERAL EXPLORATION OF GUMUŞHANE AREA

PHASE 3

DECEMBER, 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

The Government of Japan, in response to the request extended by the Government of the Republic of Turkey, agreed to conduct a metallic mineral exploration survey in the Gümüşhane Area, and commissioned its implementation to the Japan International Cooperation Agency. The agency, taking into consideration the importance of the technical nature of this survey, sought the cooperation of the Metal Mining Agency of Japan in order to accomplish the contemplated task.

The Government of the Republic of Turkey appointed the Mineral Research and Exploration Institute(M.T.A.) to execute the survey as a counterpart to the Japanese team. The survey is being carried out jointly by experts of both Governments.

The third phase of the collaboration survey consists of geophysical surveys and diamond drilling for metallic mineral exploration.

This report summarizes results of the third phase of the survey, and it will also form a portion of the final report that will be prepared with regard to the results to be obtained from the completed survey.

We wish to take this opportunity to express our gratitude to all sides concerned in the execution of the survey.

December, 1986

Keisuke ARITA

President,

Japan International Cooperation Agency

Junichiro SATO

President,

Metal Mining Agency of Japan

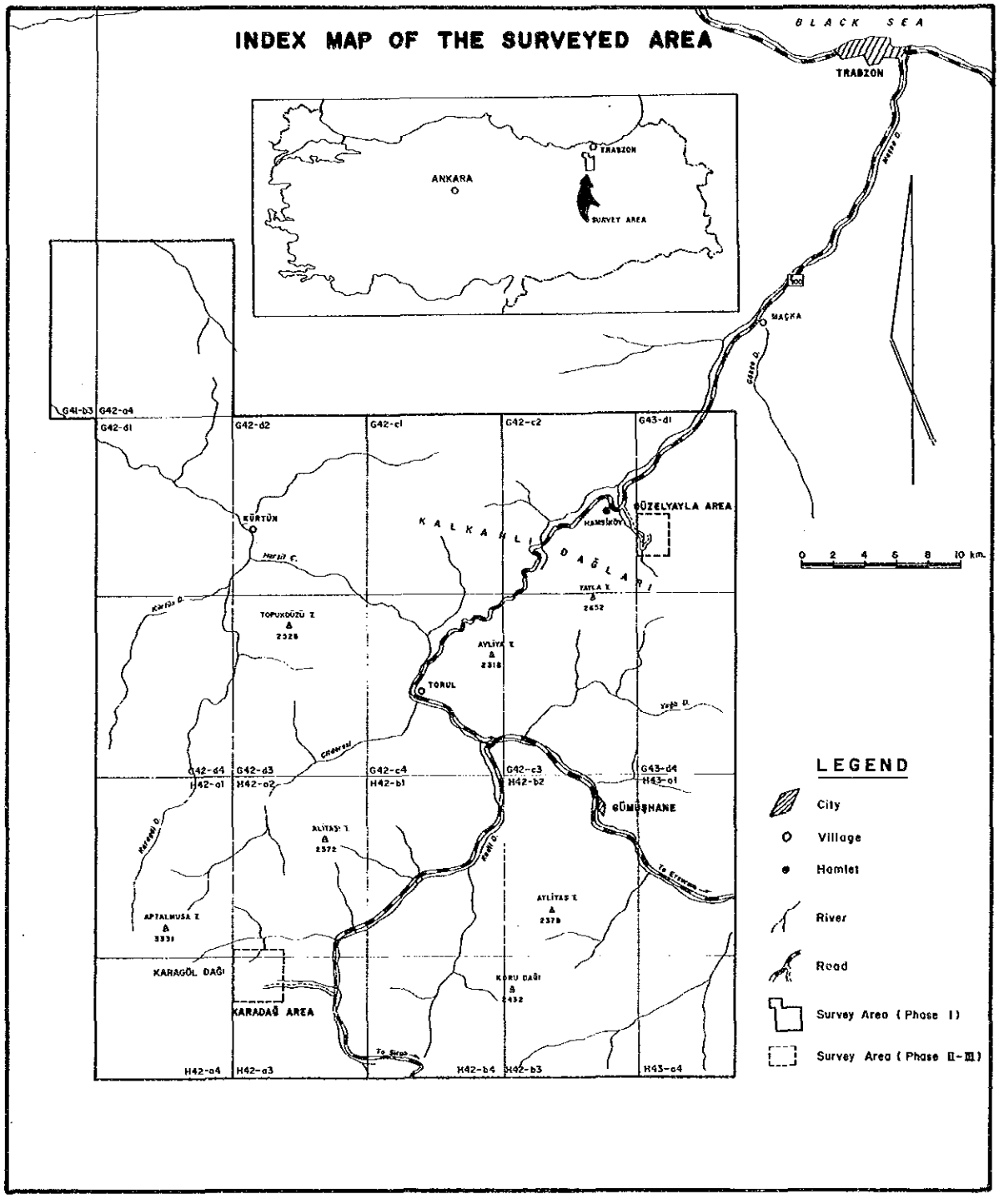

Fig. 1 Index Map of the Surveyed Area

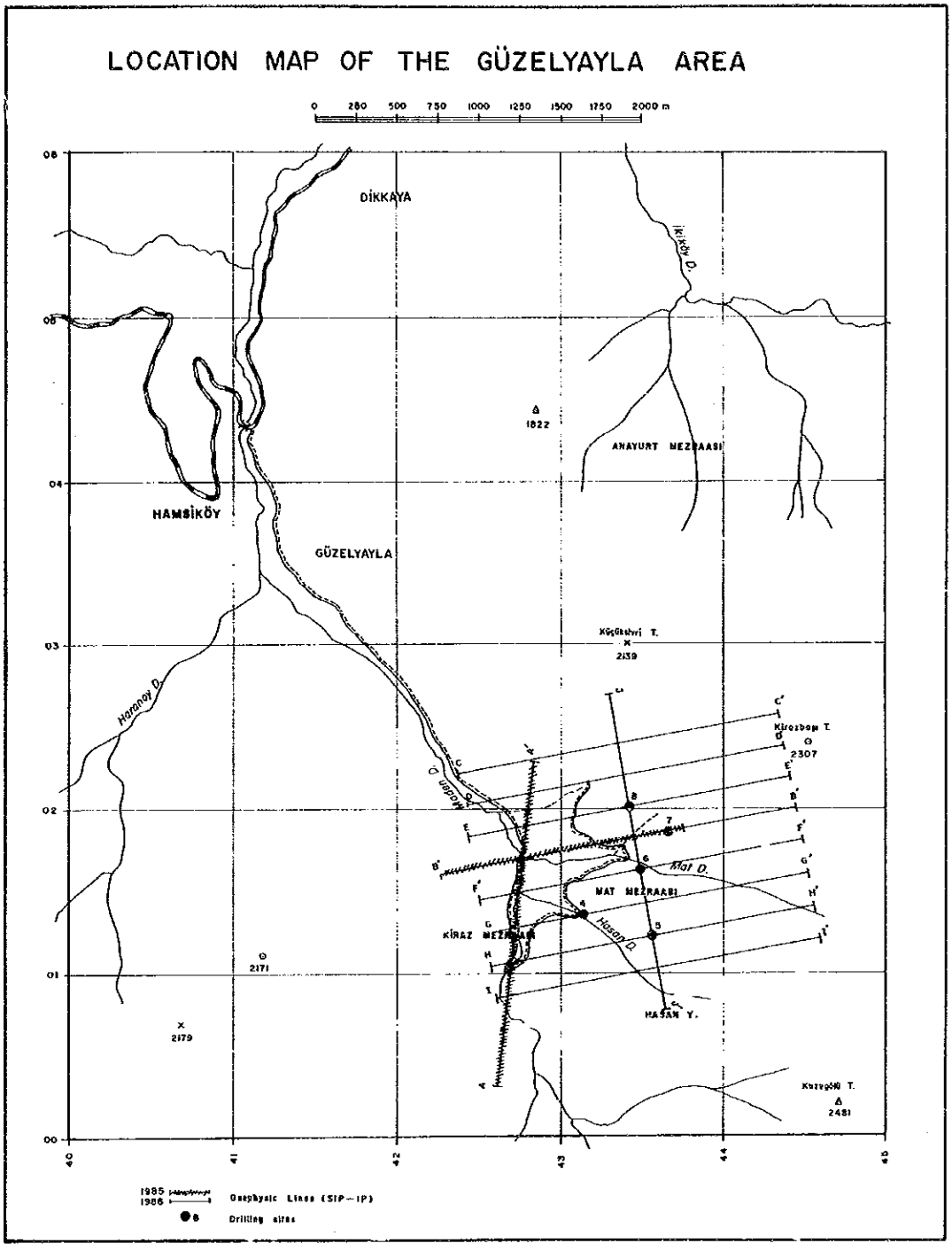

Fig. 2 Location Map of the Güzelyayla Surveyed Area

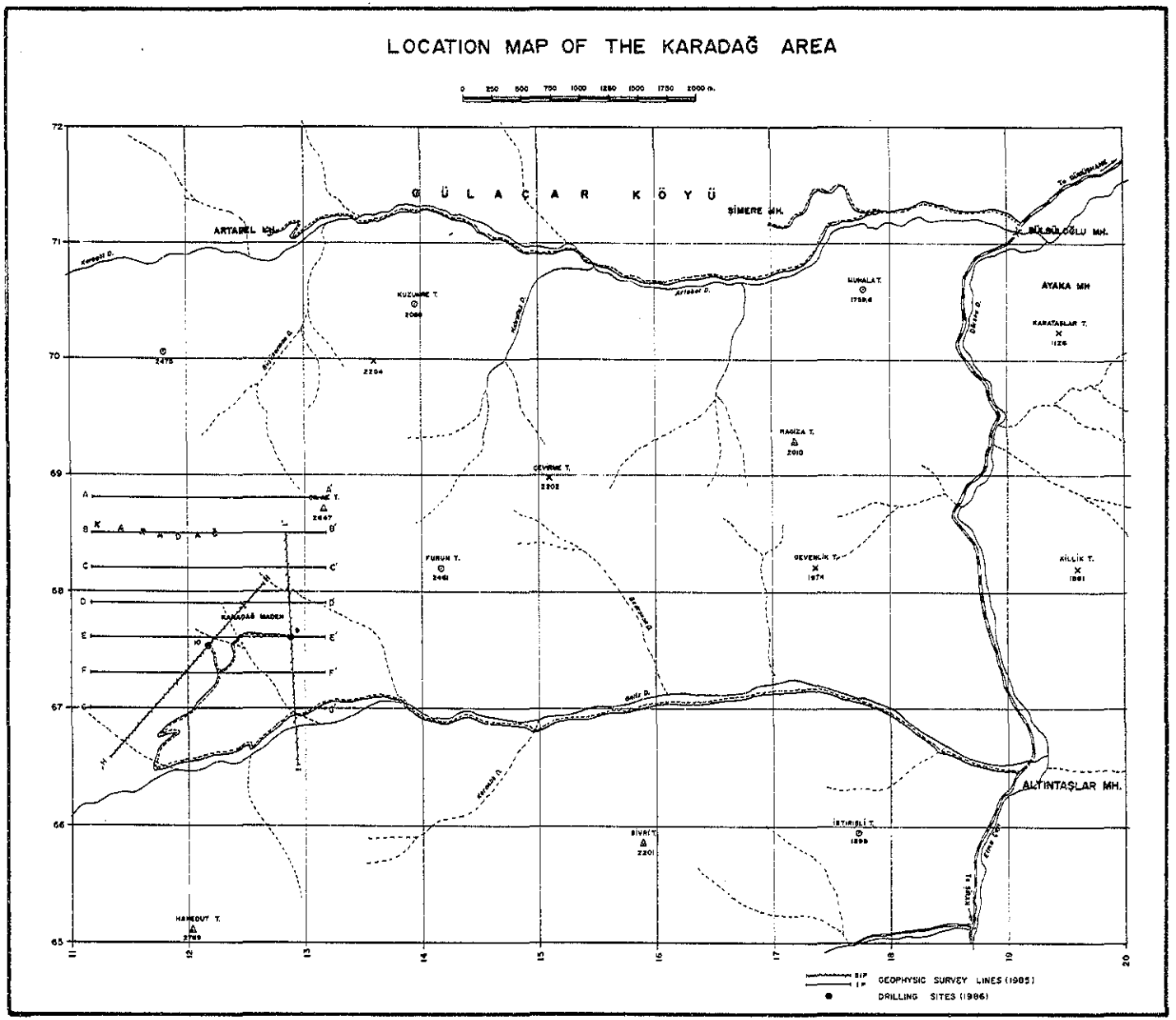

Fig. 3 Location Map of the Karadağ Surveyed Area

SUMMARY

The initial survey on the Cooperative Mineral Exploration Survey of the Gümüşhane Area of the Republic of Turkey was conducted with the aim of determing the occurrence of non-ferrous (silver, copper, lead, zinc, molybdenum etc.) ore deposits. Geological and geochemical surveys were carried out over an area of 2,800 km². As a result, the following two areas were isolated as promising, and the second and third phase surveys consisting of geological, geophysical and drilling surveys were performed. The third phase was conducted as follows :

1. Güzelyayla Area	:	Geophysical survey (SIP method)	6.00 km²
		Geophysical survey (IP method)	12.00 km²
		Drilling survey (5 holes)	1,505.00 m
2. Karadağ Area	:	Drilling survey (2 holes)	652.00 m

These survey results are summarized as below.

1. Güzelyayla Area

The initial survey indicated that geochemical anomalies of Ag, Cu, Mo, Pb, Zn, Sn and W were found, and an emplacement of a porphyry copper-type mineralized zone was expected through geological survey. In the second phase, the distribution of porphyry copper type mineralization caused by intrusion of altered porphyritic granite (Pgl) was delineated by geological and geochemical surveys. A drilling survey was conducted in the area of intrusive rock and andesite of the Zigana Formation which was accompanyed by mineralization, and a promising mineralized area of copper and molybdenum was obtained. In the third phase, geophysical surveys (IP and SIP methods) were carried out in the mineralized zone. Drilling surveys were performed around the center of the potassic zone (MJT-4), the southern phyllic zone (MJT-5) and the anomalous area obtained through the geophysical surveys (MJT-7 and MJT-8). Results of the drilling surveys are as follows :

MJT-4 ; The hole was drilled to 301.00m in depth through low grade copper-molybdenite mineralization in the porphyritic granite (Pgl). The mineralization contains a grade of 0.105% copper equivalent in the range from 0.00m to 301.00m, and is embedded in a potassic zone of alteration.

MJT-5 ; The hole was drilled to 301.00m through the porphyritic granite (Pgl) and andesite of the Zigana Formation. The drilling found low grade copper-molybdenum zones bearing mineralization as good as those in MJT-1～4. The mineralization has a grade of 0.071% copper equivalent in the range from 0.00m to 301.00m in depth, and is embedded in a phyllic zone of alteration. The

enriched zone has a grade of 0.066% copper from 9m to 105m.

MJT-6 ; The hole was drilled to 301.00m through the copper-molybdenite mineralized zone in altered porphyritic granite (Pg1). Intrusions of porphyritic granite (Pg2) occurred from 43m to 53m and from 112.5m to 244m. Also, sheets of basalt were found as intrusions from 289m to 301m. The mean ore grade is 0.487% copper equivalent within Pg1. Alteration in the mineralized area varies from phyllic (0.00～112.50m) to potassic (244～289m).

MJT-7 ; The hole was drilled to 301.00m in depth through low grade copper-molybdenite mineralization in the porphyritic granite(Pg1). The mineralization contains a grade of 0.247% copper equivalent in the range from 0.00m to 301.00m, and is embedded a phyllic (0～254m) and a potassic zone (254～301m) of alteration. The enriched zone has a grade of 0.287% copper from 6m to 57m.

MJT-8 ; The hole was drilled to 301.00m in depth through low grade copper-molybdenite mineralization in the porphyritic granite (Pg1) and andesite of the Zigana Formation. The mineralization contains a grade of 0.264% copper equivalent in the range from 0.00m to 301.00m, and is embedded in a phyllic zone (0～41m), a propylitic zone (41～233.4m), a potassic zone (233.4～283m) and a phyllic zone (283～301m) of alteration. The enriched zone has a grade of 0.314% copper from 9m to 54m.

Results of the geophysical survey (IP and SIP methods) revealed that there is strong mineralization accompanied by pyrite in the periphery of the altered porphyritic granite, and also that the mineralized area and unmineralized area are divided by a fault. After due consideration of the geophysical anomalies, the drilling sites for MJT-7 and MJT-8 were selected.

Although rock properties of drill cores show specific types of phase spectra, they do not correspond with specific metal contents of Cu and Mo, but may be related with pyrite mineralization.

As a result of the drilling surveys in the second and third phases, the promising mineralized zones were intercepted by a drill hole, and geological ore reserves were calculated as approximately 49 million tonnes using the assay data of MJT-3, 6 and 8 (ore grade of 0.356% copper equivalent), and as roughly 104 million tonnes including the predominantly molybdenum mineralized zones of MJT-7 and the lower part of MJT-8 (ore grade of 0.300% copper equivalent)

2. Karadağ Area

A geochemical anomaly of Ag, Cu, Mo, Pb, Zn, and W was found, and according to the initial survey, dissemination-type mineralization was expected to be embedded in the survey area. In the second phase, semi-detailed geological and geophysical surveys (IP and SIP methods) were conducted, and the geophysical

survey obtained three promising anomalies. Two extensive anomalies out of these three are expected to be dissemination-type mineralization embedded in the granodiorite stock and the andesite of the Zigana Formation, 200 m to 300 m below the surface. The third is inferred to be skarn type mineralization owing to the existense of limestone at depth.

The old Karadağ ore deposit located up the Maden Stream is embedded in the skarn zone of limestone, and is accompanied by copper, lead and zinc ores. The old mine had produced ore in the vicinity of the above-mentioned skarn type anomalous area. However, the geophysical survey could not directly clarify the emplacement of old Karadağ ore deposits because they may be embedded in the shallow part, oxidized completely, or small in scale. In the third phase, two holes were drilled in the anomaloaus areas expected to be dissemination-type mineralization and skarn type mineralization . Results of the drilling survey are as follows :

MJT- 9 ; The hole was drilled to 301m through altered basaltic andesite of the Zigana Formation and granodiorite. Basaltic andesite (3～182.2m) altered the propylitc zone with pyrite, and granodiorite altered the sericitized zone with magnetite-hematite-pyrite. It is considered that the geophysical anomalies indicated pyritization in the andesite and granodiorite.

MJT-10 ; The hole was drilled to 351m through altered granodiorite and limestone. Granodiorite (0.7～46m) altered the sericitized and chloritized zone with pyrite. Limestone (46～351m) gradually changed through massive to saccharoidal facies, and a partly skarn zone with malachite and pyrite occurred. Here also, it is considered that the anomaly indicated weak mineralization of the skarn zone.

In the Güzelyayla and the Karadağ Areas, promising ore deposits are expected: namely a copper and molybdenum ore deposit in the former, and a copper, lead and zinc ore deposit in the latter. Further exploration is requested in both areas. It is necessary to plan a drilling program for locating a higher copper and molybdenum grade section in the Güzelyayla mineralized zone. On the other hand, it is considered that the geophysical anomalies indicated pyritization in andesite and granodiorite, so an area apart from the geophysical anomalies should be explored.

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Part 3 KARADAĞ AREA

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Part 1 INTRODUCTION

Part 1 INTRODUCTION

Chapter 1 Outline of the Survey

1-1 Introduction

The Turkish-Japanese joint survey has been conducted with the objective of clarifying the occurrence of non-ferrous (silver, copper, lead, zinc etc.) ore deposits of the Gümüşhane Area. Geological surveys and geochemical prospecting were conducted over an area of 2,800 km^2. As a result, the following two areas were isolated as promising in the second phase.

1. The Güzelyayla Area where molybdenum-copper dissemination deposits can be expected.
2. The Karadağ Area where copper-zinc dissemination deposits can be expected.

Also in this phase, a cooporative survey was conducted in the Güzelyayla and Karadağ Areas

Güzelyayla Area : Geological, geophysical (SIP method), and drilling surveys of the second phase indicated that a promising porphyry copper type ore deposit is expected to be emplaced in the area centered at Mat and Hasan Deres.

The Drilling survey revealed that grade of ore improved from MJT-1 to MJT-2 to MJT-3. A secondary enrichment zone occurs, even though it is thin, and the mean value of 0.345% equivalent copper grade (the highest grade among the three drill holes) ranges from surface to hole bottom (401m) in MJT-3. It is expected that the result of future drilling surveys will show that this mineralization will prove to be minable.

In the third phase, drilling surveys (MJT-6～MJT-8) were performed around MJT-3 based on the results of the IP and SIP surveys. They were carried out to trace the extent of the mineralization and to reveal the high copper-molybdenum grade zone. On the other hand, MJT-4 and MJT-5 were drilled in the Potassic Zone and the Phyllic Zone to evaluate the potentiality of mineralization in Guzelyayla area.

Karadağ Area : Three anomalous areas regarded as mineralization were found by the geophysical surveys (IP and SIP methods) in the second phase. In the area, an inferred fault striking NE～SW was interpreted through geological surveys, and intrusive rocks have intruded into the structurally weak zone, accompanyed by mineralization. Drilling surveys (MJT-9 and MJT-10) in two anomalous areas were carried out to confirm an ore deposit in the expected mineralized area in the third phase.

1-2 Duration and Organization of the Survey

The third phase survey was carried out during the period from 12 May 1986 to 9 October 1986. The field survey and the organization of the survey team were as follows.

(1) Duration of the Field Survey

Geophysical survey : From 14 May 1986 to 7 July 1986

Drilling survey [starting date] [completion date]

Guzelyayla Area : From 24 June 1986 to 23 September 1986

Karadag Area : From 7 July 1986 to 15 August 1986

(2) Members of the Survey Team

Supervisers of Planning and Coordinating

Japan	Turkey (MTA)
Makoto ISHIDA (MMAJ)	Orhan ÖZKOÇAK
Hideki OKAMOTO (MMAJ)	Ramiz ÖZOCAK
Yoshiyuki KITA (MMAJ)	Ömer T. AKINCI
Kenichi ORITA (MITI)	Temel Y. NEBİOĞLU
Takashi KAMIKI (JICA)	

Geophysical and Drilling Surveys

Japanese Survey Team (NED)		Turkish Survey Team (MTA)	
Hisashi MIZUMOTO		Dr. Yusuf Z. ÖZKAN	
(Leader)		(Coordinator)	
Core Survey			
Hisashi MIZUMOTO	(Geologist)	Murat ER	(Geologist)
		Kemal ÖZDOĞAN	(Geologist)
Geophysical Survey (IP & SIP Method)			
Masao YOSHIZAWA	(Geophysicist)	Mustafa DEMİRHAN	(Geophysicist)
Shinichi SUGIYAMA	(Geophysicist)	Hasan UĞURLU	(Geophysicist)
Kazuyasu SUGAWARA	(Geophysicist)	Ethem OFLU	(Topographer)
		Cemil ÖZTÜRK	(Topographer)
Drilling Survey (Güzelyayla Area)			
Saichi ISHII	(Drill.Eng.)	Cemal ÖZSOY	(Mining Engineer)
Mitsuo NOMURA	(Drill.Eng.)	Ali KARTAL	(Mining Engineer)
Yoshiwo SASAKI	(Drill.Eng.)		
Drilling Survey (Karadağ Area)			
Takashi KAKISHITA	(Drill.Eng.)	Yemlihan YÜREKLİ	(Mining Engineer)

Tadao SUGIBUCHI (Drill.Eng.) İlker ÖZKAN (Mining Engineer)
Junichi KATO (Drill.Eng.)

MMAJ: Metal Mining Agency of Japan
JICA: Japan International Coorporation Agency
MITI: Ministry of International Trade and Industry
MTA : General Directorate of Mineral Research and Exploration of Turkey
NED : Nikko Exploration and Development Co. Ltd.

1-3 Survey Methods and Amount of Work

(1) Geophysical Survey

Güzelyayla Area SIP method	Survey length	6km
	Survey station	240 stations
IP method	Survey length	12km

(3) Drilling Survey

Güzelyayla Area	MJT-4	301.00m
	MJT-5	301.00m
	MJT-6	301.00m
	MJT-7	301.00m
	MJT-8	301.00m
	Total	1,503.00m
Karadağ Area	MJT-9	301.00m
	MJT-10	351.00m
	Total	652.00m

(4) Laboratory Work Samples Collected

Analysis Item and element	Amount
Rock thin section	30 pieces
Ore polished specimen	30 pieces
Chemical analysis	
Cu, Mo	506 samples
Cu, Zn	60 samples
Au, Ag, Mo, Sn, W	10 samples
Fluid inclusion (Homogenization temperature and salinity)	50 samples
X ray diffraction analysis	100 samples
Physical property measurement	35 samples

of rock samples for SIP

Chapter 2 Outline of the Survey Area

2-1 Güzelyayla Area

The Güzelyayla Area is located at Güzelyayla of Hamsiköy Village, approximately 50km south from Trabzon. The area belongs to Güzelyayla Village, Maçka District, Trabzon Province and is under the administrative organization of the Turkish Government. The area is in a highland region at an altitude ranging from 1,400m to 2,400m above sea level. It takes about an hour by car from Trabzon to Hamsiköy, the location of the base camp during the third phase survey.

On the Trabzon side, situated on the north side of the Zigana Mountain Range which runs in an east-west direction, the climatic condition is very humid, and there are very many rainy days during all seasons. Average precipitation reachs 700~1,000mm per year. As the Güzelyayla area is close to the north side of the pass of the mountain range, it is usually foggy and there are few clear days throughout the year. Field survey can be performed during the period from April to October.

The Güzelyayla area is close to Trabzon, a large city neighbouring the Black Sea, and it has moderate precipitation. Thus there are many fertile and productive meadows, and villages are distributed along Route 65 at the foot of the mountain from Hamsiköy to Dikkaya.

2-2 Karadağ Area

The Karadağ Area is located approximately 40km south-east of Torul and 5km west of Altıntaşlar Village, Torul District, Gümüşhane Province. It is accessable by jeep ; about an hour from Torul, the base camp for the initial phase survey. The area is highly mountainous, rising from 2,000 to 2,700m above sea level around Cilaz Mountain (2,647 m s.l.) which is a part of the Karadağ Mountain Range.

Climatic conditions around the area are inland with low humidity and little precipitation. However, there is heavy snow during the winter season in this area, because of the high mountains. Thus the period from May to September is the most favorable season for field surveys.

2-3 Previous Works

There are few studies on the geology and mineral deposits of the project area. In 1962, the geological map of the Trabzon area on a scale of 1:500,000 was compiled and published by M.T.A. based on of the geological maps of 1:100,000 and 25,000 compiled in 1959. Recently, M.T.A. has conducted a geological survey in the southwestern portion of the project area. Gümüşhane Granite, widely distributed in the project area, was petrographically studied by YILMAZ(1974).

With respect to mineral occurrence in the project area, there is a report on two mines, Hazine Mağara and Kırkpavli, in Eski Gümüşhane. Kovenko(1937) reported that Hazine Mağara is a silver replacement deposit in calcareous sediment overlaying Paleozoic Granite (Gümüşhane Granite), and that Kırkpavli is of gold-silver vein type. M.T.A. has since carried out a follow-up survey in the Eski Gümüşhane area. A regional geochemical reconnaissance survey was carried out in the Merzifon-İspir and Menderes Massif areas jointly by the United Nations and the Government of Turkey between 1970～1974. This work resulted in the recognition of 47 geochemical anomalies in the Merzifon-Ispir area, 8 of which are concerned with the Gümüşhane area. The Gümüşhane area is the central portion in the Merzifon-İspir area, about 24,000 km^2.

2-4 General Geology and Ore Deposits of the Survey Area

Turkey is geologically divided into four tectonic units from north to south : Pontids, the Anatolids, the Taurids and the Border Folds. These belts generally extend in an E-W direction. The surveyed area belongs in the Pontids, consisting of the Ordovician to Oligocene.

The Pontids is characterized by extensive volcanic deposits, including calc-alkaline basalt-andesite-dacite series in the Upper Cretaceous-Tertiary period. This violent volcanism was acccompanied with emplacement of granitic rocks. Most of the ore deposits in the Pontids are genetically related to this magmatism.

The surveyed area is predominated by andesite and its equivalent pyroclastics of the Upper Cretaceous (Zigana Formation), dipping gently northward, with some subsidiary folds. Contrastingly, according to the results of the collaborotive mineral exploration program in 1974～1976 (Trabzon area), dacite series are mainly distributed to the north of the survey area.

The great majority of the massive sulfide deposits are located along the Black Sea Coast, and stockwork sulphide deposits are located inland. The former deposits are associated with dacite series of the Upper Creataceous, and are

similar to the Kuroko deposits in Japan with regard to geological environments and modes. Murgul is a representative operating mine in this region. The Rize-Çayeli copper deposit near Trabzon (indicated reserves: 30 million tons, 3.3% Cu, 10.2% Zn, 1.1 g/t Au, 55 g/t Ag) is planned to be developed by Etibank and a joint venture of Phelps Dodge, Gama Industrie and Demir Export.

In the Eastern Pontids, a few porphyry copper type deposits were explored by drilling at Bakırçay and Ulutaş. The mineralization, mainly of copper and molybdenum, is related to Laramian quartz diorite and quartz monzonite.

Skarn-Type mineralization is found in limestone intercalated in andesite piles in this region. Main ore minerals are iron oxides, with a small amount of copper, lead and zinc.

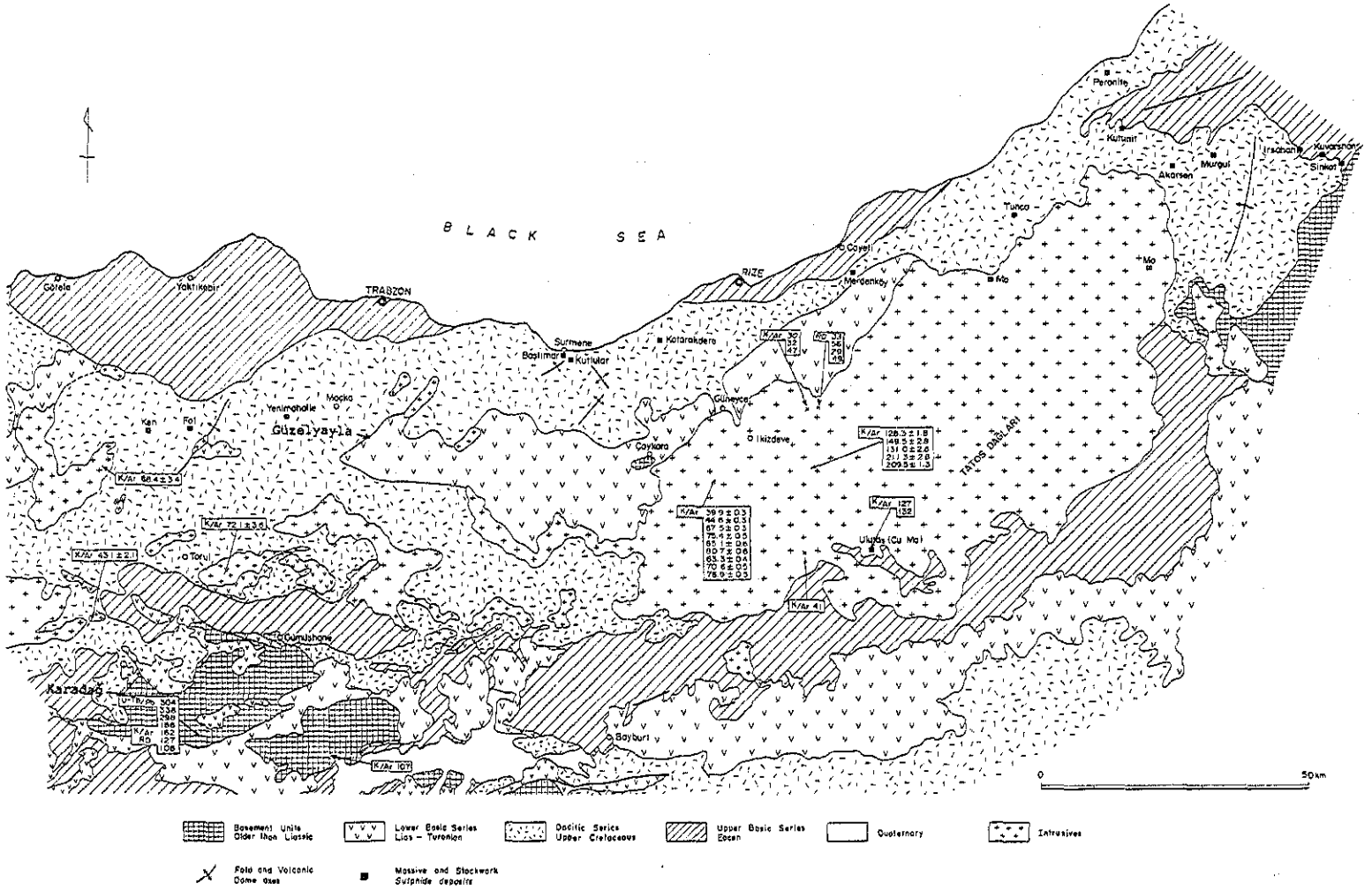


Fig. 4 Generalized Map of the Surveyed Area

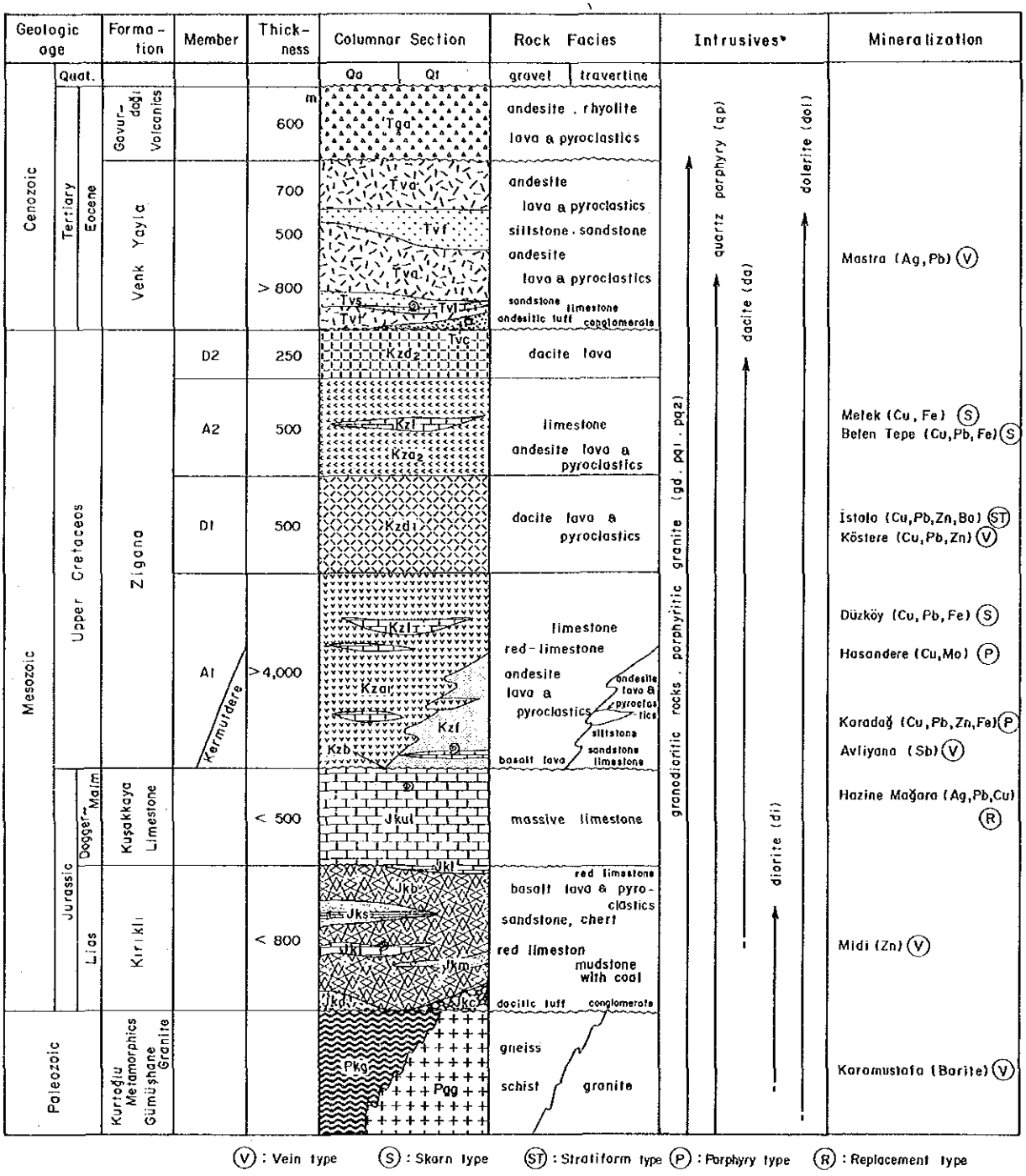


Fig. 5 Schematic Geological Column of the Gümüşhane Area

Part 2 GÜZELYAYLA AREA

Part 2 GÜZELYAYLA AREA

Chapter 1 Outline of the Survey

1-1 Summary of the Initial and Second Phase Surveys

The surveyed area is situated in the Pontids Belt, and is characterized by deposits from plutonic intrusion activity which occured in the period from Late Cretaceous to Eocene. The surveyed area is occupied by the Zigana Formation, correlated to Late Cretaceous, and porphyritic granite intruded into the Zigana Formation. The Zigana Formation consists of andesite, andesitic pyroclastic rocks and intercalations of thin limestone and siltstone beds. The Zigana Formation is correlative with the A1 Member as divided by the initial phase survey. Distributed in the area from Maden Dere to Turnagol River, the porphyritic granite was so named by the initial phase survey because of the predominant existence of a porphritic texture with quartz and plagioclase, even though partly equigranular texture occurs. The porphyritic granite is classified into two types on the basis of their mode of alteration, namely altered porphyritic granite (Pg1) and unaltered porphyritic granite (Pg2). The former constitutes a small body distributed in an area from Hasan Dere to Mat Dere, and has undergone mineralized alteration associating it with sericite and biotite. Porphyry copper type mineralization is emplaced in the rock. On the other hand, the latter is an intrusion, elongated in an ENE-WSW direction . It has been proposed by the second phase survey that the latter had intruded into the former although the intrusion times of both are unclear.

Based on the discovery of a copper and molybdenum anomalous area by the stream sediment geochemical survey conducted by the United Nations Development Program during the period from 1970 to 1974 in the Hasandere Area, geological and stream sediment geochemical surveys of the cooperative exploration survey was commenced in 1984. MTA also carried out additional soil geochemical surveys. The soil geochemical surveys resulted in the detection of values five to nine times higher than values in stream sediments. It had been presumed that the Cu and Mo anomalous area had a range of 1.7 km × 1.4 km, and might extend toward the northern and north-western side. Through additional soil geochemical surveys in the second phase, the presumption was proven to be correct. The anomalous area extended 1.8 km × 1.8 km as predicted.

Alteration, detected by X-ray diffraction analysis and microscopic observation, is zoned from the center of the altered porphyritic granite (Pg1) toward the marginal part as potassic → phyllic → propylitic. The core of Pg1

is a potassic zone of alteration and the alteration changes to a phyllic zone in the periphery of Pgl. In andesite intruded by the Pgl stock, propylitic zones are commonly distributed, while the phyllic zone is present close to Pgl. The potassic zone is characterized by the presence of a small amount of potassic feldspar, much biotite and anhydrites, the phyllic zone mostly by $2M_1$ type sericite, and the propylitic zone by chlorite and many magnetites. The alteration pattern of this survey area resembles the pattern of the Ulutas porphyry copper type ore deposit. A neighbour of this survey area, it lacks potassic feldspar, and biotitization of hornblende exists in mineralized granodioritic porphyry (Taylor and Fryer, 1980).

As a result of the discovey of the promising anomalous area of Cu and Mo, three drill holes, totaling 1,003 m in length, were carried out to explore this mineralized area which was expected to be emplaced underground. These three holes discovered a copper and molybdenum mineralized zone, although the grade of Cu and Mo varies. The grade of Cu and Mo improved successively from MJT-1 to MJT-2 to MJT-3; 0.091% of mean equivalent Cu in MJT-1 (9.90m～301.00m), 0.257% in MJT-2 (9.50m～301.00m) and 0.345 % in MJT-3 (0.00m～401.00m). The highest grades for Au (60ppb), Sn (2ppm) and W (17ppm) were also obtained from these holes, but gold content is lower than expected.

Fracture pattern is an important factor in exploring the mineralized zone, for example, in the planning of drilling inclination. Geological and core logging surveys were performed to detemine the regularity of fracture patterns in the intrusuve rock (Pgl) and in the andesite intruded by Pgl. However, the survey could not define any regularity of fracture patterns in the rocks.

Mineralization paragenesis are mostly pyrite-quartz, pyrite-molybdenite-quartz, chalcopyrite-pyrite, and chalcopyrite-pyrite-quartz, all embedded along fissures. Mineralization in MJT-1 and MJT-2 are emplaced along fissures, while disseminated mineralization is mainly in MJT-3. Predominant dissemination in MJT-3 results in a higher grade of Cu and Mo in comparison with grades of MJT-1 and MJT-2.

Fluid inclusions are mostly gaseous and liquid phases smaller than 10 μ in size. Polyphase inclusions are included in very small amounts considering that it is a porphyry type ore deposit. Solid materials in the inclusions are mostly halite. Intrusive rock contains a very small amount of gaseous inclusions. On the other hand, the potassic zone of Pgl, distributed around the area from Mat Dere to Hasan Dere, contains a large quantity of gaseous inclusions, and their homogenizatiom temperatures are higher compared with inclusions of other areas. Around that area, solid inclusions predominantly occur, and the co-existence of dense fluid inclusions (polyphase) and thin fluid inclusions (gaseous phase) reveals that there might have been boiling

conditions at the formation time of these inclusions.

The geophysical survey (SIP method) carried out using drill holes obtained PFE anomalies in the area of strong pyrite-mineralization, and distinguished the non-mineralized part bounded by the fault. The data obtained are very effective for further exploration work on the mineralization.

1-2 Purpose of the Third Phase Survey

Geological, geophysical (SIP method) and drilling surveys of the second phase indicate that a promising porphyry copper type ore deposit is expected to be emplaced in the area centered at Mat and Hasan Deres.

The drilling survey reveals that mineralization improves in grade of ore from MJT-1 to MJT-3. Secondary enrichment occurs, even though it is thin, and the mean value of 0.345% equivalent copper grade ranges from surface to hole bottom (401m) in MJT-3. As a result of future drilling surveys, it is expected that this mineralization will prove to be mineable. It is the aim of the geophysical survey (SIP and IP methods) to trace the extension of the mineralization, and that of the drilling survey to reveal the mineralized zone.

1-3 Survey Methods and Amount of Work

In the second phase survey, two survey lines were laid down; namely Line A connecting holes MJT-1 and MJT-2, and Line B connecting holes MJT-2 and MJT-3. IP and SIP survey lines of the third phase were carried out with 4 lines in the north side and 3 lines in the south side parallel with Line B. Intervals were situated every 200m, the length of an individual line was 2 km. IP survey was conducted on 2 lines (4 km) by the MTA geophysical team after a coorporative survey was finished. The area and arrangement of survey lines are illustrated in Fig.2. A drilling survey of 5 holes (total: 1,505m) was carried out in the potassic and phyllic zones

Samples for laboratory testing, microscopic observation (rock thin section and ore polish specimen), chemical analysis (Cu, Mo), fluid inclusion studies (salinity and homogenization temperature) and X ray diffraction analysis were collected in order to study and clarify characteristics of mineralization and alteration.

Chapter 2 Geology

2-1 General Geology

The geology of the Güzelyayla Area is divided roughly into the Jurassic Kırıklı Formation, the Kuşakkaya Limestone Formation and the Upper Cretaceous Zigana Formation. The Zigana Formation is further divided into five stratigraphic unit- namely the Kermutdere, A1, D1, A2 and D2 Members in ascending order as determined by the first phase survey, but only the A1 Member of lowest Zigana Formation is distributed in the surveyed area. Porphyritic granite and quartz porphyry have intruded into the formations, and small andesite and basalt dykes are observed in the area.

Porphyritic granite is classified into two types, namely altered porpyrytic granite having a close relationship with mineralization and unaltered porphyritic granite having no association with mineralization. The former type is a small rock body distributed around Hasan Dere, while the latter type forms a rock body elongated in the ENE-WSW direction

The geological map, geological profile maps and schematic geological column are shown respectively in Fig.6～8.

2-2 Stratigraphy

Kırıklı Formation : This formation is distributed from the north west part to around Hamsiköy in the surveyed area, and consists of basaltic lava and basaltic pyroclastic rock. At the north-western part of the surveyed area, only basaltic lava is exposed in small range This rock is a dark green to reddish brown finely grained massive, and has undergone strong chloritization and epidotization. Amigdaloidal texture is microscopically common, and plagioclase is chloritized.

Kuşakkaya Limestone Formation : This formation consists of massive limestone, and its distribution is limited to a locality downstream of the Kiraz Dere. However, it is widely distributed around Dikkaya Village in the northern part of the surveyed area, overlying Kırıklı Formation. The limestone of this formation is grayish white to white and mostly massive with no bedding. Downstream of the Kıraz Dere, this limestone has been altered to crystalized limestone owing to thermal metamorphism by intrusion of porphyritic granite, but is not accompanied by sulphide ores. As will be mentioned later, this limestone lies in fault contact with the Zigana Formation which is the upper

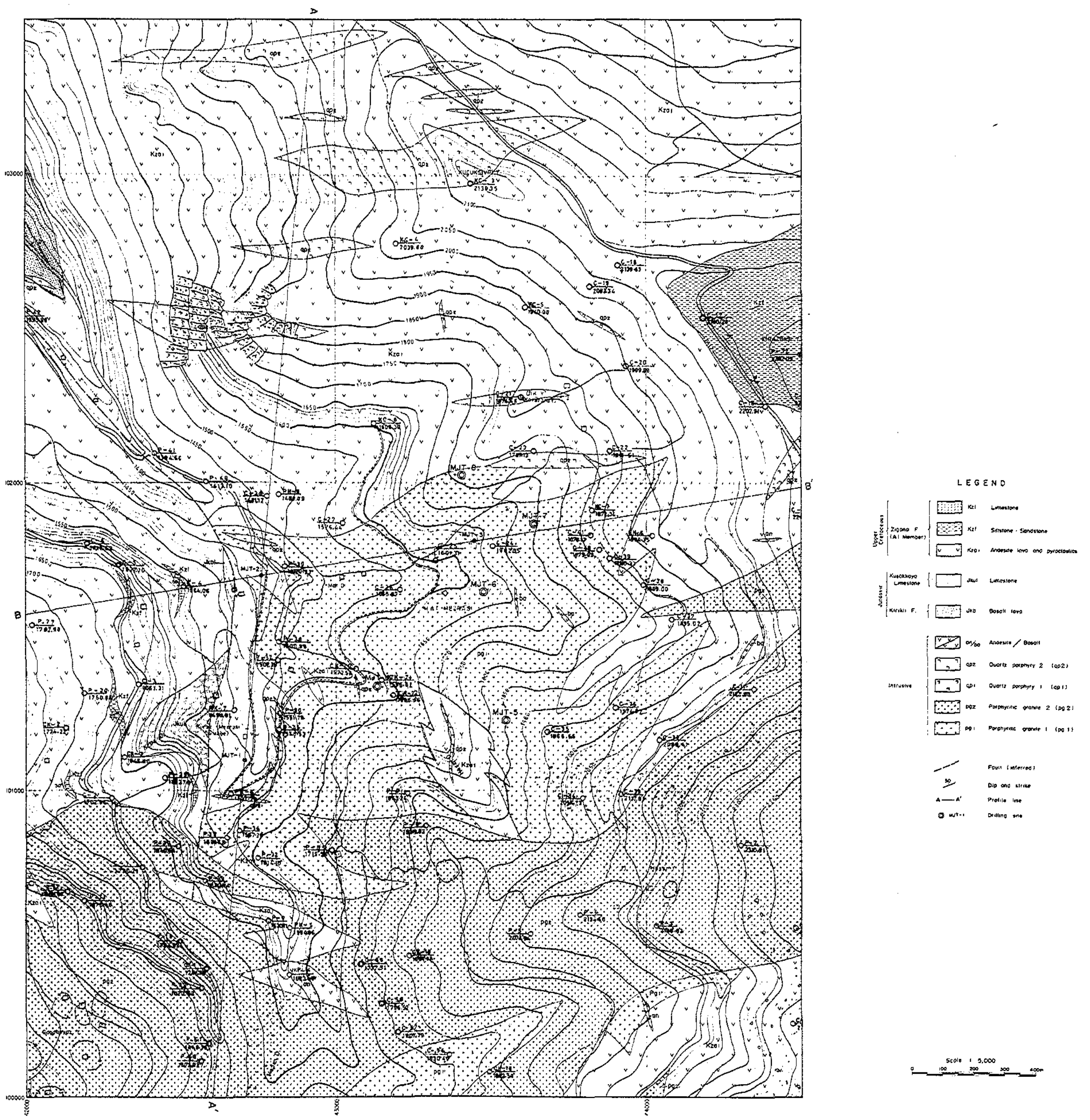
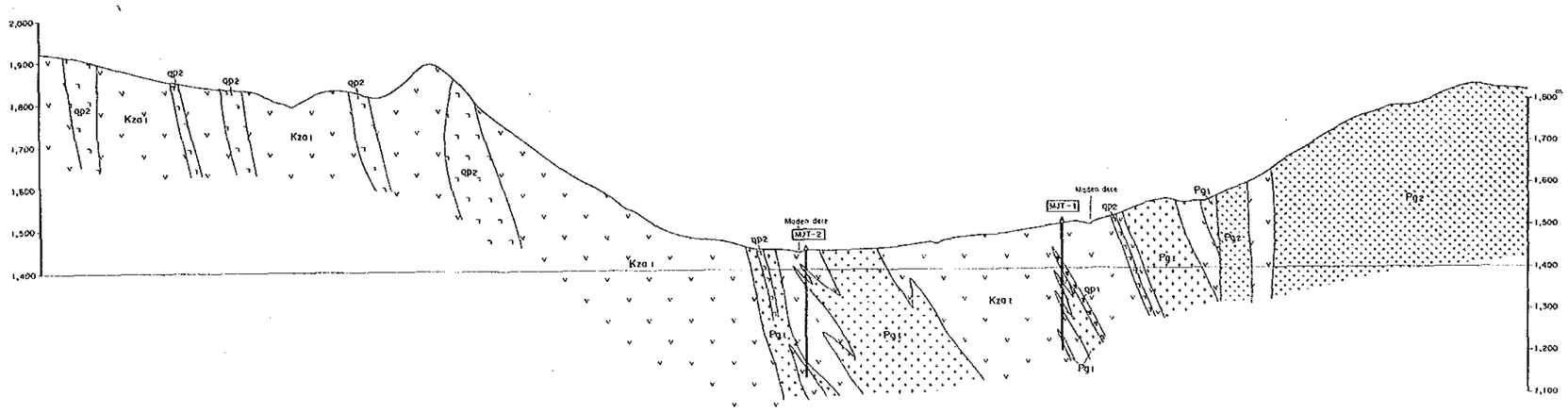
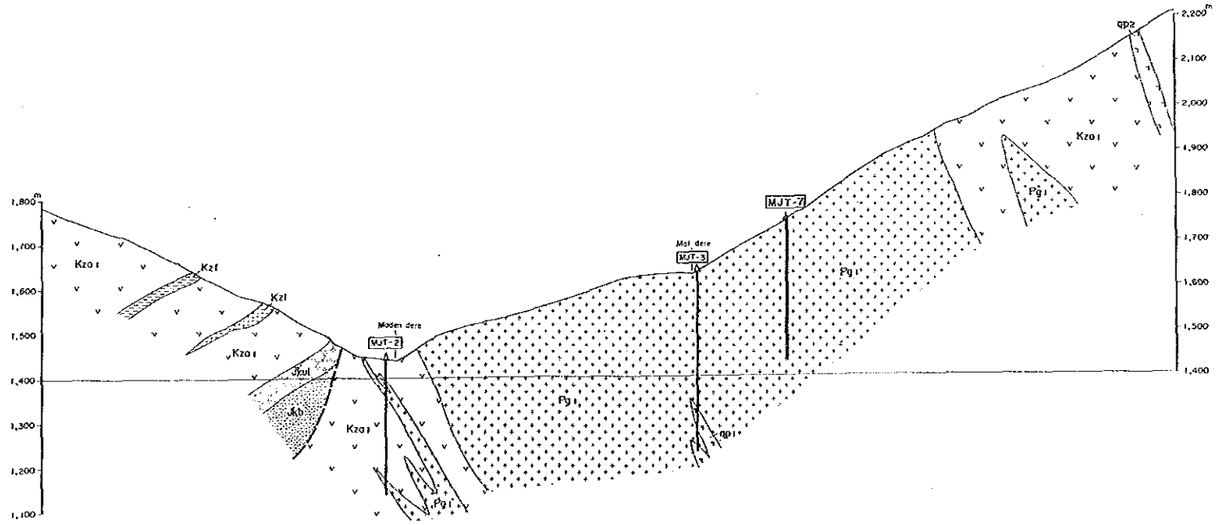


Fig. 6 Geological Map of the Güzelyayla Area

A — A′



B — B′



LEGEND

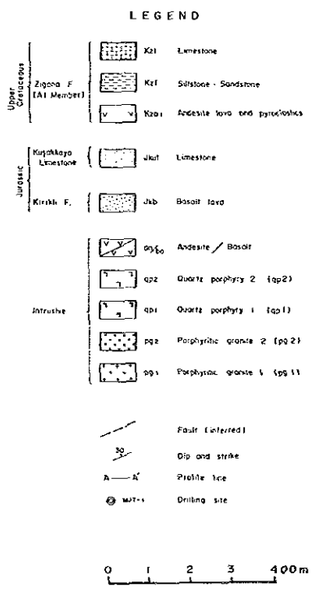


Fig. 7 Geological Profile Maps of the Güzelyayla Area

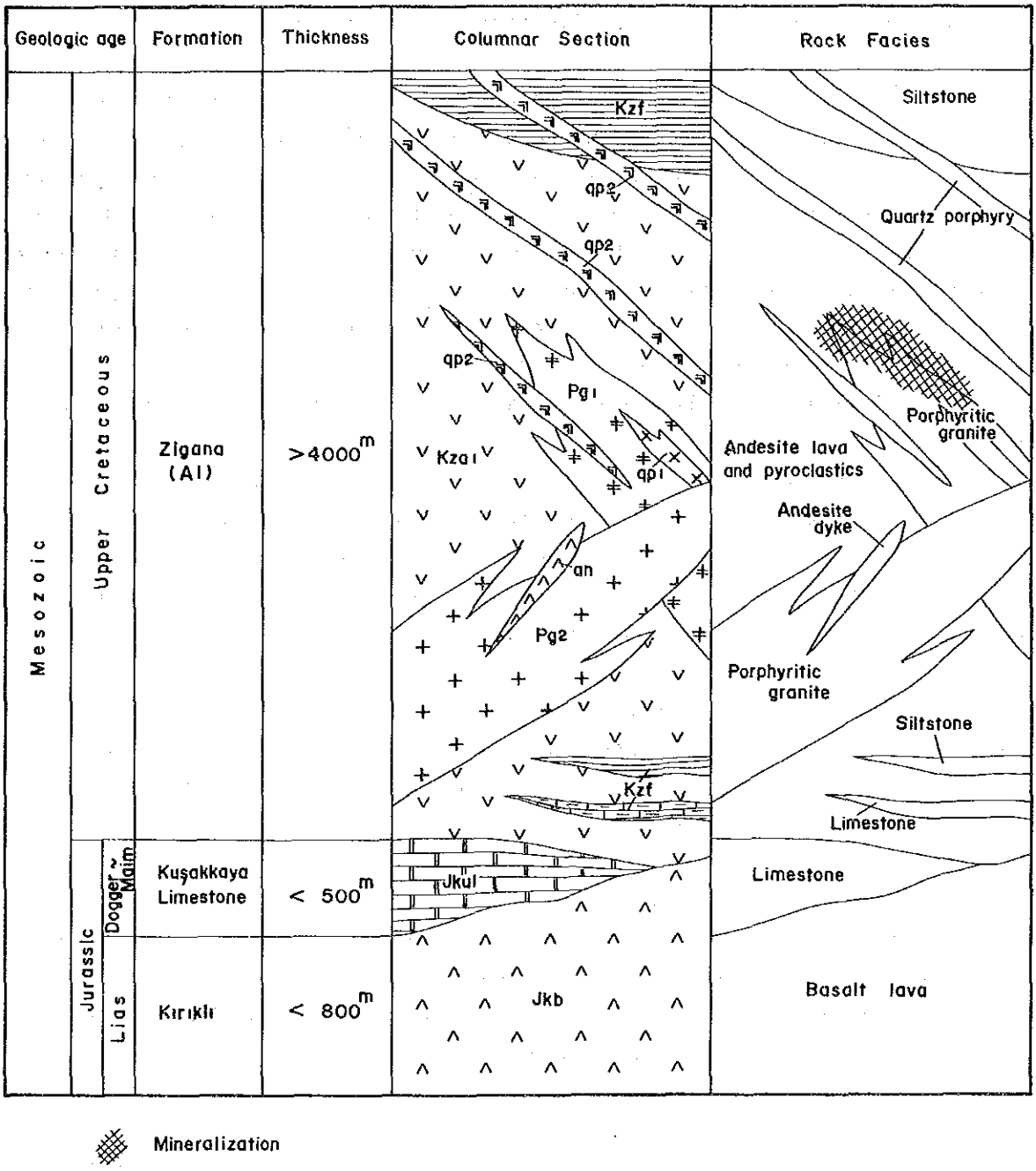


Fig. 8 Schematic Geological Column of Güzelyayla Area

formation and consists of altered andesite accompanied by sulphide ores.

Zigana Formation : This formation has been divided into the Kermutdere, A1, D1, A2, D2 Members in ascending order, but only the A1 Member is widely distributed in the surveyed area. This member consists of andesitic lava, andesitic pyroclastic rocks and thin beds of limestone and siltstone.

Andesitic lava: This rock is a pale green to dark green massive or hyalocrastic basaltic andesite. The rock has been brecciated owing to hyaloclasts, and consists of breccia and matrix of the same material incorporating subangular pebbles of limestone and siltstone. Hyaloclastic basalt changes laterally to a massive lava rock facies. At the fault boundary, running in a north-south direction in the western part of the surveyed area, a remarkable difference in alteration mode is observed. The rock has undergone strong alteration and has developed many cracks and fissures caused by an intrusion on the east side of the fault, whereas weak alteration with only chloritization and epidotization occur on the west side of the fault. This alteration, as will be mentioned later, is sericitization and chloritization distributed around porphyry granite (Pgl). Chalcopyrite-molybdenite-pyrite bearing mineralization is observed along with fissures and quartz veins in cliffs at Maden River or in rock exposures by the forest road. It is very difficult to microscopically identify the rock in this part because of strong alteration.

Andesitic tuff: Well-bedded andesitic tuff is partly intercalated in andesite lava. The tuff is a pale green to reddish green coarse grained rock. The rock may be a member of the hyaloclastite, as it is discontinuous and gradually changes to hyalocrastic lava.

Siltstone-sandstone and limestone: These rocks are intercalated as thin discontinous beds in the andesite lava. Thick, well-bedded alternating beds of siltstone and sandstone are distributed at Kırazbası Mountain in the eastern section of the surveyed area. The limestone is poor, discontinuous, and grades into a siltstone-sandstone bed in the same horizon. It is partly altered to crystalline limestone.

Quarternary : The main Quarternary sediments are conglomerate and travertine, but Quarternary sediments are not indicated on the geological map. Conglomerate sediment is distributed along Maden River. Travertine has been deposited mainly on both banks of the Kıraz River.

2-3 Intrusive Rocks

The main intrusive rocks are porphyritic rock and quartz porphyry with distributions of small andesite and basalt dykes. Porphyritic granite and quartz porphyry are, respectively, classified into two types based on alteration modes.

Altered porphyry granite (Pg1): This rock is distributed in the range of about 1.5 km north-south and about 1.5 km east-west, centered in the area of Hasan Dere and Mat Dere, and is embedded in the andesite of the Zigana Formation. Porphyritic texture of quartz and feldspar is common in the rock, and facies of the rock are similar to those of the unaltered porphyry granite (Pg2, below), but the rock is easily discriminated by noting that Pg1 has undergone strong silicification and argillization consisting of sericite and biotite. Mineralizations accompanied by pyrite,chalcopyrite and molybdenite are embedded along fissures and quartz veins at Hasan Dere, and porphyritic granite, which has been altered to white rock accompanyed by disseminations of pyrite, is partly distributed at the southern part of the surveyed area. Mineralization and alteration are described in the next chapter. Porphyritic granite ranges microscopically from a diorite facies to a granodiorite porphyry facies with porphyritic texture. Alteration and mineralization occurring in the quartz diorite rock are weaker than in others under microscopic observation.

Unaltered porphyritic granite (Pg2): This occurs as a large batholith rock elongated in a ENE-WSW direction and is widely distributed at Turnagöl (outside the surveyed area). This rock is pale green to graysh and commonly contains porphyritic texture consisting of quartz and plagioclase. Some of the mafic minerals are altered to chlorite and epidote, but generally, the rock has undergone little alteration. It may be inferred that the unaltered porphyritic granite is a later intrusion than the altered porphyritic granite, because the former, found close to the latter in the field, is substantially free of alteration by mineralization, although a chronological relationship between the two intrusions was not observed in the field. Although the litholgy of MJT-6 consists of Pg1 and Pg2, the relation between both porphyritic granites could not be clarified because of well-developed crushed cores. The rock is holocrystalline with a porphyritic texture, and alteration of biotite and hornblende to chlorite, epidote, sericite, and calcite can be seen through the microscope.

Quartz porphyry (Qp1): The existence of this rock body was confirmed by MJT-1 and MJT-3. This rock has intruded into andesite of the Zigana Formation at MJT-1, and into porphyritic granite at MJT-3. Both host rocks have undergone sericitization and silicification, and chalcopyrite and molybdenite are embedded along fissures and quartz veins in the rock.

Quartz porphyry (Qp2): This rock is found around Kucuksıvrı Mountain and at Maden River, and has intruded into andesite lava, and partly into the altered porphyritic granite (Pg1). It is inferred that the intrusion activity of the quartz porphyry (Qp2) is later than that of the altered porphyritic granite (Pg1) due to the relationship between both rocks as mentioned above.

Andesite dyke (an): A dark green massive andesite dyke is observed at the conjunction of Maden and Saralim Deres. This dyke cuts the andesite of the Zigana Formation and the unaltered porphyritic granite(Pg2) in a WNW-ESE direction. There are also other small dykes up the Mat Dere cutting altered porphyritic granite and the andesite of the Zigana Formation. This rock is porphyritic in texture, and the constituent minerals of plagioclase, hornblende, and pyroxene have been replaced by chlorite and calcite through weak alteration as seen under microscopic observation. The rock is named quartz bearing andesite.

Basalt dyke (ba): Narrow basalt dykes several meters in width are observed at four places up the Mat Dere and MJT-6. These dykes have varying strike directions, (N-S, NE-SW, NW-SE, etc.) at Mat Dere. Pg1 was intruded by basalt from 289m to 298.40m (real width;7～8m) at MJT-6. The basaltic rock has an interstital texture, and plagioclase, biotite and hornblende of the constituent minerals are slightly altered to chlorite and calcite in thin section.

2-4 Geological Structure

The surveyed area is situated on the wing of an anticlinal structure extending N-S to NE-SW from Hamsiköy to Dikkaya. The geological structure of the area is largly controlled by this anticlinal structure, but some structural disturbances owing to the effects of the porphyritic granite intrusion from the central to western part of the surveyed area and subsequent fault activity occur. The Zigana Formation dips westward on the west side of the fault and northward or eastward on the east side of the fault. The fault, thought to be running along the east side of Maden Dere in a N-S directional system, extends northward out of the surveyed area, while it disminishes at the southern

extention as it is cut off by the intrusion of the unaltered porphyritic granite. Displacement by the fault has raised the western side, judging from

1) the distribution of the Kuşakkaya Limestone formation, which is a lower Formation than the Zigana Formation,

2) the absence of Mo-Cu mineralization or minera-lized alteration on the west side of the fault. The quartz porphyry extends in an east-west direction, differing from the north-south system of the fault.

Chapter 3 Mineralization and Alteration

3-1 Mineralization

The mineralized zone is embedded in the altered porphyritic granite (Pg1) and in the andesite of the Zigana Formation (A1 member) in the vicinity of the granite in an area from Mat Dere to Hasan Dere which are tributaries of the Maden River, situated 4 km south-east of Hamsiköy. As mentioned before, the porphyritic granite consists of Pg1 accompanied by Mo-Cu mineralization along fine fissures and Pg2 undergoing very weak alteration without mineralization. Observed with the naked eye, both porphyritic granites resemble their rock facies, but intruded at sightly different times. The former intruded earlier in a confined area while the latter is exposed south of the former and extends NE-SW.

The mineralized zone is characterized by molybdenite-chalcopyrite-pyrite mineralization emplaced along fine fissures caused by the porphyritic granite (Pg1) instrusion and consists of the following parts ;

① those embedded along fissures with quartz veins (vein type)

② those embedded as filmy veinlets (fissure type)

③ those embedded as disseminations (dissemimnation type)

Vein and fissure type mineralizations are common at Maden, Mat, and Hasan Deres, but mineralization on the ridge of the mountain, being topographically high, is strongly limonitized owing to the effects of rain and snow. Also, due to forest cover, the above mentioned characteristics of mineralization were not observable. In such areas, copper was leached, and surface soil usually contained very low grades of Cu, as seen in the results of the soil geochemical survey, but there is a secondary enrichment zone 1m～10m below the surface.

In MJT-1 and MJT-2 of the drilling survey located in Maden Dere, vein and fissure types are continuously observed from ground surface to hole bottom (301m). Conversely in MJT-3 to MJT-8, located on convex topography, dissemination type is dominant, accompanied by vein and fissure types, except in a section of secondary enrichment consisting of native copper, chalcocite and covelline in fissures and as disseminations from surface to 120 m in depth.

The ore minerals are mainly pyrite, and some chalcopyrite and molybdenite. Chalcocite was found in a boulder at Mat Dere, and malachite along Mat Dere, but no molybdenite was observed at Mat Dere in the area of the Mo geochemical anomaly detected by the soil geochemical survey of the initial phase. Minor amounts of native copper, covelline, galena, sphalerite, magnetite and hematite are observed in drill cores. Pyrite is embedded as disseminations, networks and veins and is associated with other sulphide ores. It occurs throughout the long mineralization stage, from early stages to later stages. Most chalcopyrites co-exist with pyrite along fissures, and is cut by molybdenite-pyrite-quartz veins. This is predominant in MJT-2, but chalcopyrite-pyrite veins exist along fissures of chalcopyrite-pyrite in the disseminated section.

Under microscopic observation, chalcopyrite-pyrite cuts aggregated magnetite. Therefore, paragenesis of ore minerals is: magnetite was crystallized in the first stage, chalcopyrite-pyrite followed magnetite, and molybdenite-quartz occurred, filling in cracks (cavities) around pyrite crystals at a later stage. Very minor amounts of sphalerite may have crystalized with chalcopyrite, since they exist together in exsolution texture.

This fact observed through the microscope reveals that these ore minerals might have crystallized in the following order: magnetite→pyrite→chalcopyrite • sphalerite→molybdenite. This relationship is consistent with field observations. The mineralized zone in the Pgl intrusion is expected in an area of diameter 1.8 km～2.0 km. The area is delineated by Cu anomalous values of more than M+σ (200 ppm), and centers around a high Mo anomalous zone, as found by the geochemical survey conducted by MTA. It covers the stock intrusion of altered porphyritic granite (Pgl) and the surrounding the andesite intruded by Pgl.

In the second phase, chip samples for investigation of the chemical constitution of the ore were collected in the Hasandere Area in which mineralized showings of porphyry copper type are recognized. The assay results indicate that copper exposed on the ground surface was leached owing to much precipitation of rain and snow, and shows very low grade. Molybdenum content values of these samples are also low grade except for samples from the Mo geochemical anomalous area. These chip sample results are of lower grade than that of drilling core. The leached nature of the chip samples may be the

cause of this discrepancy. Good correlation between Cu and Mo values of the chip samples is not recognizable as is the case with the soil geochemical survey.

3-2 Alteration

In the second phase, samples for X-ray diffraction analysis were collected in the area of the Pg1 stock and surrounding andesite at Maden, Mat and Hasan Deres in order to unravel the zoning of alteration by mineralization. The result was compiled in the map of alteration zoning. Together with microscopic observations of thin sections, the alteration zoning map of ground surface is in Fig.54. In the third phase, samples for X-ray diffraction analysis were collected from MJT-4 to MJT-8. These 100 samples were analysed using the X-ray diffraction meter. Results of the X-ray diffraction analysis are presented in Table 22. The alteration zoning map of drilling core is in Fig.55.

Altered clay minerals detected through X-ray diffraction analysis are mostly sericite and chlorite with additional kaoline, pyrophyllite, montomorillonite and mixed-layer mineral. It is difficult to distinguish sericite and biotite by X-ray diffraction analysis. Although diffraction patterns are slightly different between both minerals, this difference does not distinglish the two clay minerals. Thus the potassic zone was defined with the help of microscopic observations of thin sections .

Core samples located at the periphery of the potassic zone contain chlorite and sericite. In this zone, sericite rich white rock is classified into the phyllic zone, while chlorite rich greenish rock is classified into the propylitic zone. The outer parts of the phyllic zone, chlorite rich propylitic zone, and further outer zones tend to decrease in chlorite content while increasing in epidote content.

Pyrophyllite and kaoline also occur locally at the southern end of the Pg1 stock which has been intruded by Pg2.

This pattern of alteration zoning is similar to the Lowell-Guilbert model(1970) of potassic zone → phyllic zone → argillic zone→ propylitic zone outwards from the core. In the case of this surveyed area, the outer limit of the propylitic zone was delineated as an area of 1.7 km × 1.4 km, on the basis of the anomalous area of Cu and Mo as found by the soil geochemical survey of the initial phase conducted by MTA, but the alteration area was expanded into an area of 1.8 km × 1.8 km as a result of an extention of the anomalous area to the north and north west subsquent to an additional soil geochemical survey carried out by MTA (Trabzon branch office).