No. 86

THE REPUBLIC OF TURKEY

REPORT ON THE COOPERATIVE MINERAL EXPLORATION

OF

GÜMÜŞHANE AREA

PHASE II

FEBRUARY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

THE REPUBLIC OF TURKEY REPORT ON THE COOPERATIVE MINERAL EXPLORATION OF GÜMÜŞHANE AREA PHASE II FEBRUARY 1988 JAPAN INTERNATIONAL COOPE METAL MINING AGENCY O

314
GJ
MIN

MPN
C R(3)
86-27

THE REPUBLIC OF TURKEY

REPORT ON THE COOPERATIVE MINERAL EXPLORATION

OF

GÜMÜŞHANE AREA

JICA LIBRARY
1029320[7]

PHASE 2

FEBRUARY 1986

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

国際協力事業団

受入月日 61. 8. 12	314
	66.1
登録No. 15146	MPN

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 second phase of the collaboration survey consists of geological and geophysical surveys, and diamond drilling for metallic mineral exploration.

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

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

February , 1986

Keisuke ARITA

President,

Japan International

Cooperation Agency

Masayuki NISHIIE

President,

Metal Mining Agency of Japan

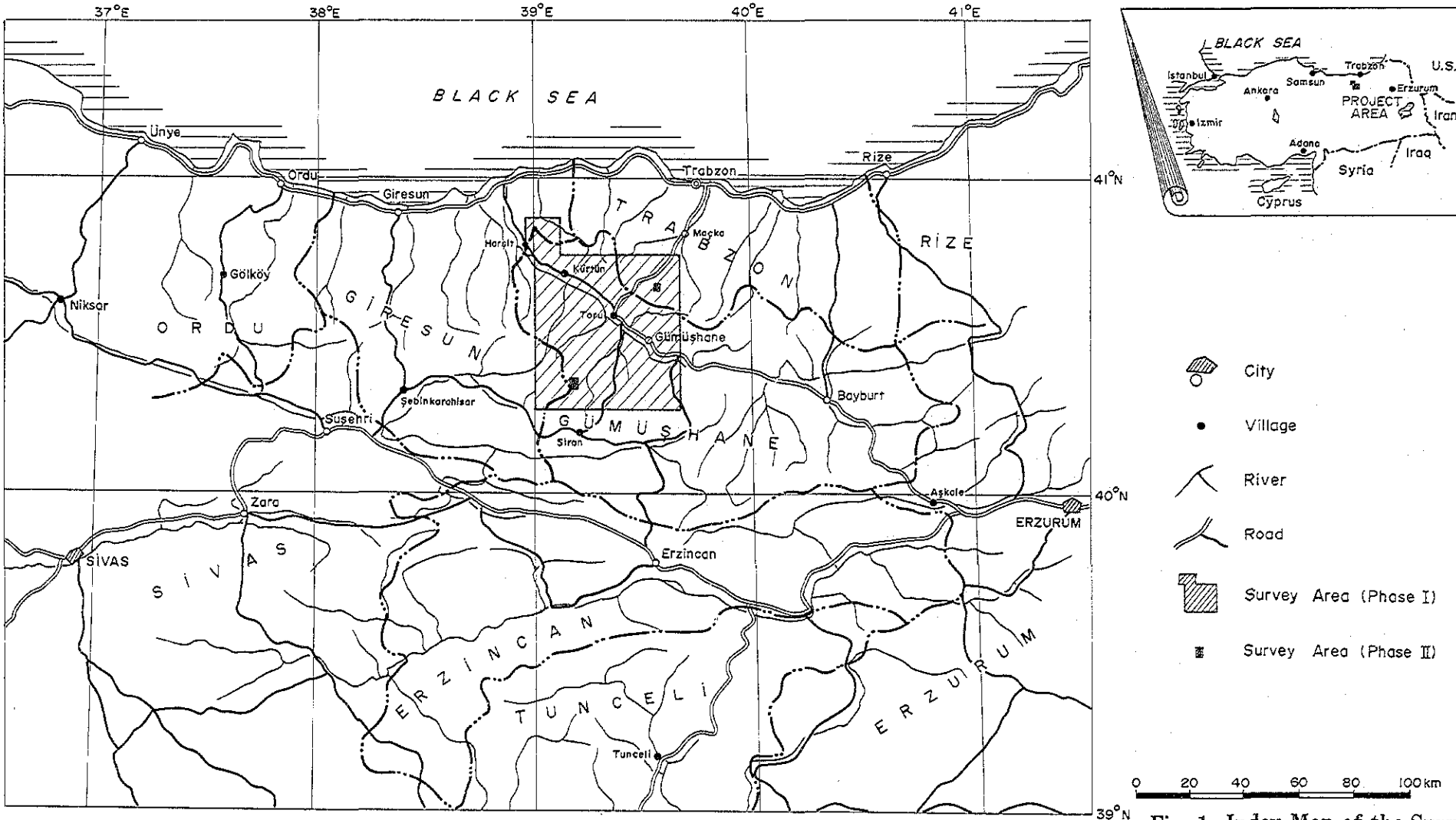


Fig. 1 Index Map of the Surveyed Area

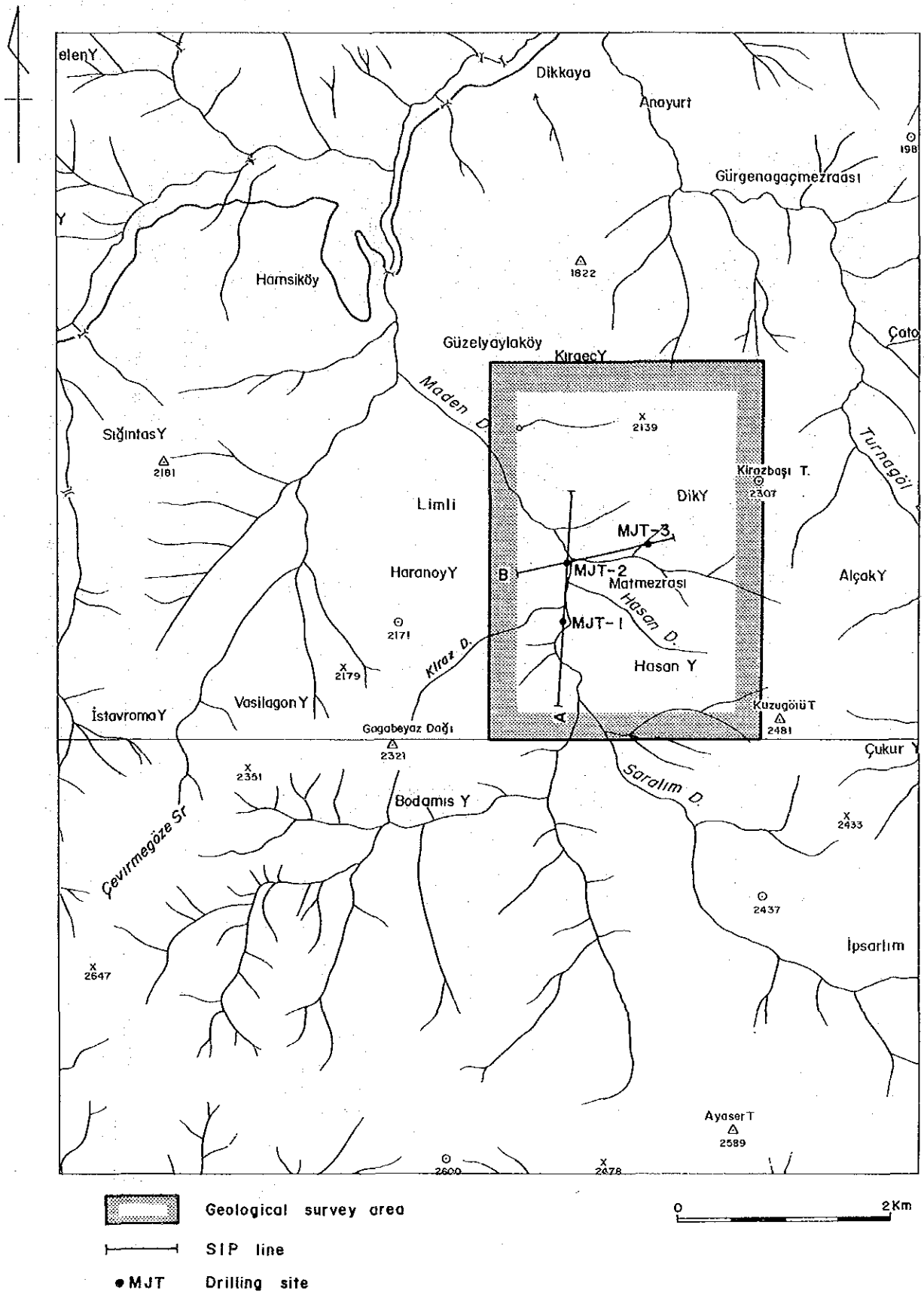


Fig. 2 Location Map of the Hasandere Surveyed Area

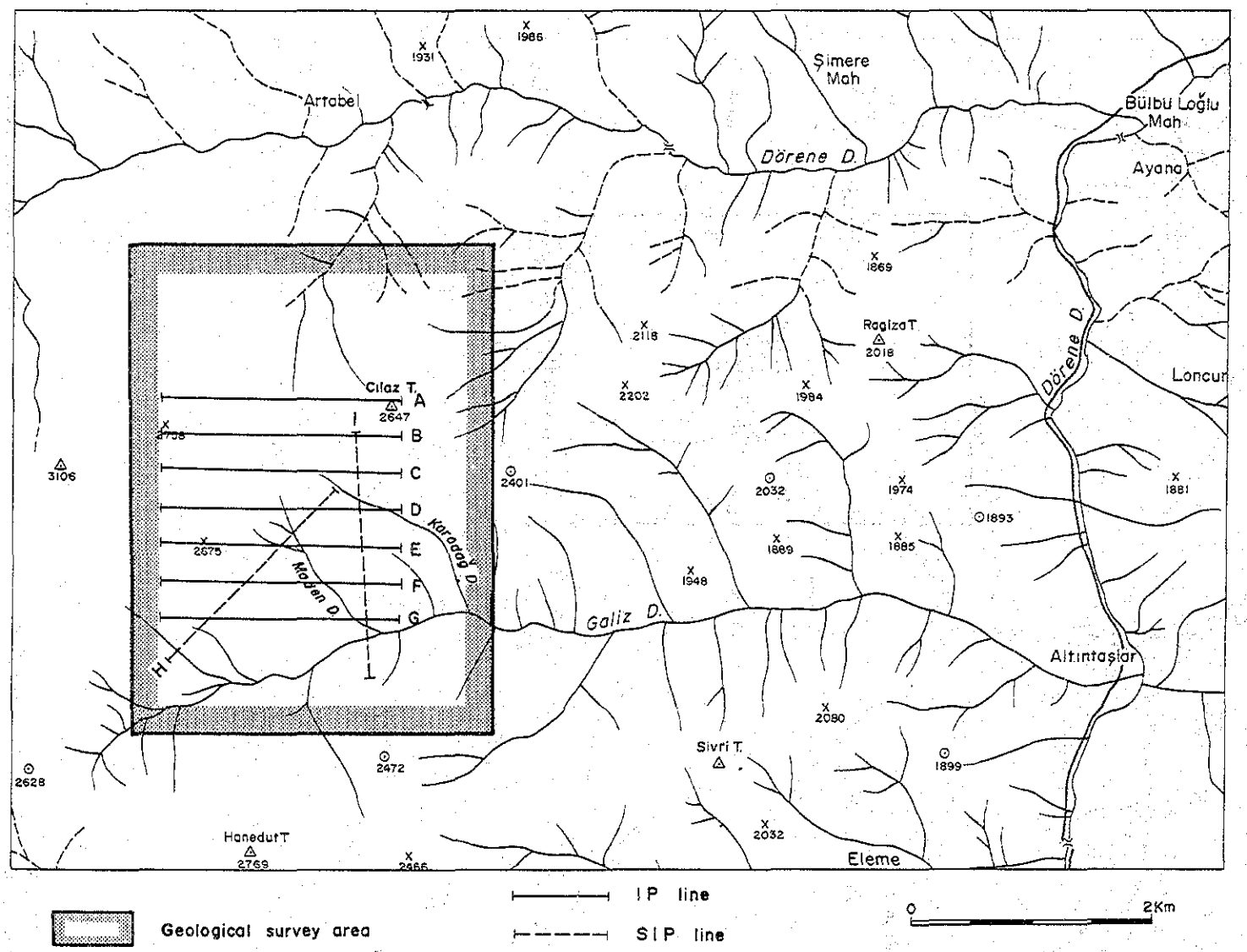


Fig. 3 Location Map of the Karadağ Surveyed Area

SUMMARY

The initial survey on the Cooperative Mineral Exploration Survey of the Gümüşhane Area of the Republic of Turkey was conducted with an aim at unravelling 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 km^2. As a result, the following two areas were isolated as promising, andthe second phase survey consisting of geological, geophysical and drilling surveys was performed as follows :

1. Hasandere Area	:	Semi-detailed geological survey	8.75 km^2
		Geophysical survey (SIP method)	3.50 km
		Drilling survey (3 holes)	1,003.00 m
2. Karadag Area	:	Semi-detailed geological survey	12.00 km^2
		Geophysical survey (IP method)	14.00 km
		Geophysical survey (SIP method)	4.00 km

These survey results are summarized as below.

1. Hasandere Area

The initial survey indicated that geochemical anomalies of Ag, Cu, Mo, Pb, Zn, Sn and W were found, and emplacement of a porphyry copper-type mineralized zone was expected through geological survey. In the second phase, distribution of porphyry copper type mineralization caused by intrusion of altered porphyritic granite (Pgl) was delineated by geological and geochemical surveys. Drilling survey was conducted in the area of intrusive rock and andesite of the Zigana Formation accompanying by mineralization, and a promising copper and molybdenum mineralized area was obtained. Results of the drilling survey are as follows :

MJT-1 ; The hole was drilled up to 301.00 m in depth through low grade copper-molybdenite mineralization in the andesite of Zigana Formation which was intruded by altered porphyritic granite stock at depth. The mineralization contains a grade of 0.091 % copper equivalent at the range

from 9.90 m to 301.00 m, and is embedded in propylitic zone of alteration.

MJT-2 ; The hole was also drilled up to 301.00 m through andesite of Zigana Formation. The drilling found low grade copper-molybdenum zones bearing mineralization as good as MJT-1. The mineralization has a grade of 0.257 % copper equivalent with a range from 9.50 m to 301.00 m in depth, and is embedded in propyltic zone of alteration.

MJT-3 ; The hole was drilled up to 401.00 m through the copper-molybdenite mineralized zone in altered porphyritic granite (Pgl). The mean ore grade is 0.345 % copper equivalent with in the range from 0.00 m to 401.00 m in depth, and alteration in the mineralized area varies from the phyllic to potassic zones.

The geophysical survey (SIP method) connecting each drill hole reveals that there is strong mineralization accompanied by pyrite, and the mineralized area and unmineralized area are divided by a fault. The data obtained are very encouraging for further exploration work of the mineralization.

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 of these three are expected to be dissemination-type mineralization embedded in quartz porphyry, the granodiorite stock and the andesite of the Zigana Formation, 200 m to 300 m below the surface. The other one 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 mined ore in the vicinity of the abovementioned 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 Hasandere and the Karadağ Areas, promising ore deposits are expected: namely a

copper and molybdenite ore deposit in the former, and a copper, lead and zinc ore deposit in the latter. Further exploration is requested in the areas.

CONTENTS

FIGURES

TABLES

PLATES

Part 1 INTRODUCTION

Part 1 INTRODUCTION

Chapter 1 Outline of the Survey

1-1 Introduction

The present survey was conducted with the objective of clarifying the occurrence of non-ferrous (silver, copper, lead, zinc etc.) ore deposits of the Gümüşhane area. Geological survey and geochemical prospecting were conducted over an area of 2,800 km^2. As a result, the following two areas were isolated as promising.

1. Hasandere area where molybdenum-copper dissemination deposits can be expected.
2. Karadağ area where copper-zinc dissemination deposits can be expected.

The geological basement of this area is comprised of the Kurtoğlu Metamorphic Complex consisting of gneiss and biotite schist considered to be of Carboniferous-Permian age and Gümüshane Ganite. These rocks are unconformably overlain byJurassic-Eocene basic-acidic volcanic and pyroclastic rocks. Limestone, mudstone, sandstone and others are intercalated, representing the dormant stage of volcanism. These sedimentary units are classified by fossils into; Lower Jurassic Kırıklı Formation, Upper Jurassic Kuşakkaya Limestone Formation, Upper Cretaceous Zigana Formation and Eocene Venk Yayla Formation in stratigraphically ascending order. Gavur Dağı Volcanics which are considered to be Upper Eocene overlies the above formations.

The intrusive rocks are old granite, the Gümüşhane Granite, which intruded during the Paleozoic, and young granodiorite, quartz porphyry and dolerite which intruded during the Late Cretaceous to Eocene.

Structually, the area can be divided into northern and southern parts with the E-W trending Gümüşhane Thrust as the boundary. Gümüşhane Granite and Lower Jurassic basalt are developed in the south while Upper Cretaceous andesite is widely distributed in the northern part. Young intrusive bodies are more abundant in the northern part.

The mineralization of this area is largely grouped into skarn, vein(fissure-filling) and dissemination(porphyry copper) types. Skarn type mineralization occurs at the contact of andesite and limestone of the Zigana Formation with iron minerals sometimes accompanied by chalcopyrite, sphalerite and galena. This type is more abundant in the northern part. Vein type deposits are small in scale but have high grade. They occur in the Kırıkh, Zigana and Venk Yayla Formations. Dissemination mineralization is associated with young intrusives, developed in and near granodiorite bodies, and forms low grade molybdenum-copper, copper-zinc, pyrite-molybdenum mineralized zones. There are veins which contain unique minerals such as the vein consisting mainly of stibnite which occurs in the Zigana Formation at Avliyana. It is thin but extends, off and on, for more than 500 meters. Also, there are barite veins which occur only in Gümüşhane Granite.

The ore minerals are, in skarn type: specularite, magnetite, chalcopyrite, sphalerite, and galena ; in vein(fissure-filling) type: chalcopyrite, sphalerite,and galena ; in dissemination type: mostly pyrite, but in some cases combinations of molybdenite, chalcopyrite, pyrite and chalcopyrite, and sphalerite occur and they are noted. In the surveyed area as a whole, the major intrusive bodies were intruded in a ENE-WSW to NE-SW direction while many of the vein type mineralization occurred along ENE-WSW to E-W trending fissures. E-W trending folds and faults are prevalent in the geological structure of Turkey and the area under consideration probably has a large number of E-W trending fissures.

The results of the geochemical work of the following samples were taken into consideration in dealing with the problem of geochemical anomalies and mineralization. Approximately 2,000 stream sediment samples from Zone B were collected by the UNDP project of 1970-1974, 942 soil samples were collected from Hasandere by MTA in 1984, and 406 stream sediment samples from Zone A and 504 from Zone B collected by the present work. Through the analysis and interprtation of the combined results of the geochemical and geological work, 50 geochemically anomalous zones have been delineated. From these zones we have selected two geochemically anomalous zones which warrant further investigation. They are the Hasandere(Mo, Cu) and Karadağ (Ag, Cu, Pb, Zn) zones.

1-2 Duration and Organization of the Survey

The survey of the second phase was carried out during the period from 31 August 1985 to 16 November 1985. The field survey and the organization of the survey team were as follows.

(1) Duration of the Field Survey

Geological survey : From 4 September 1985 to 10 October 7 1985

Geophysical survey : From 4 September 1985 to 4 November 1985

Drilling survey : From 12 September 1985 [starting date] to 10 October 1985 [completed date]

(2) Member of Survey Team

Superviser of Planning and Coordinating

Japan (MMAJ)	Turkey (MTA)
Takeshi IZUMI	Orhan ÖZKOCAK
Hideki OKAMOTO	Ramiz ÖZOCAK
Ichizo MORIKAWA	Ömer T. AKINCI
Yoshiyuki KITA	Temel Y. NEBİOĞLU

Geological, Geophysical and Drilling Surveys

Japanese Survey Team (NED)	Turkish Survey Team (MTA)
Hisashi MIZUMOTO	Dr. Yusuf Z. ÖZKAN
(Leader, Chief Geologist)	(Coordinator)
Geological Survey	
Hiroshi KANBARA (Geologist)	İsmail H. GÜVEN (Geologist)
	Murat ER (Geologist)
	Kemal ÖZDOĞAN (Geologist)
	Hüseyin YILMAZ (Geologist)
	Ali İ. ERÇİN (Geologist)

Geophysical Survey (IP.SIP Method)

Masao YOSHIZAWA (Geophysicist)	Mustafa DEMIRHAN (Geophysicist)
Shinichi SUGIYAMA (Geophysicist)	Asım ÖZMEN (Geophysicist)
Tsuyoshi YAMAISHI (Geophisicist)	Kadircan AKTAŞ (Geophysicist)
	Faik SARAÇ (Geophysicist)
	Ethem OFLU (Geophysicist)

Drilling Survey

Saichi ISHII (Drill. Eng.)	Cemal ÖZSOY (Ass.Drill. Eng.)
Tadao SUGIBUCHI (Drill.Eng.)	Levent MEHEMET (Ass.Dril.Eng.)
Mitsuo NOMURA (Drill.Eng.)	

MMAJ: Metal Mining Agency of Japan

MTA : Mineral Research and Exploration Institute

NED : Nikko Exploration and Development Co. Ltd.

1-3 Survey Method and Amount of Work

(1) Geological Survey (Semi-detailed Survey)

	Surveyed area	Surveyed route length
Hasandere Area	8.75 km^2	29.50 km
Karadağ Area	12.00 km^2	43.00 km

(2) Geophysical Survey

Hasandere Area	SIP method	(Survey length, 3.50 km Survey station, 135 stations)
Karadağ Area	IP method	(Survey length, 14 km)
	SIP method	(Survey length, 4.0 km Survey station, 160 stations)

(3) Drilling Survey

Hasandere Area	MJT-1	301.00 m
	MJT-2	301.00 m
	MJT-3	401.00 m
	Total	1,003.00 m

(4) Laboratory Works of Samples Collected

Analysis Item and element		Amount
Rock thin section		30 pieces
Ore polished specimen		30 pieces
Chemical analysis		
Hasandere Area	Geological survey(Cu, Mo)	102 samples
	Drilling survey(Cu, Mo)	301 samples
	Drilling survey(Cu, Mo, Au, Sn, W)	33 samples
Fluid inclusion(Homogenization temperature and salinity)		100 samples
X ray diffraction analysis		55 samples
Physical property measurement of rock samples for SIP		60 samples

Chapter 2 Outline of the Survey Area

2-1 Hasandere Area

The Hasandere area is located at Güzelyayla of Hamsiköy village, approximately 50 km 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 1,400 m to 2,400 m above sea level. It takes about an hour by car from Trabzon to Hamsiköy, the location of the base camp for in the second phase survey.

On the Trabzon side, situated at the north side of the Zigana Mountain Range which runs in on

east - west direction, the climatic condition is very humid, and there are very many rainy days during all seasons. Average precipitation reachs 700 - 1,000 mm per year. As Hasandere area is close to the north side of the pass of the mountain range, it is usually foggy and there are few fine days throughout the year. Geological surveys can be performed during the period from April to October.

The Hasandere 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 distributed along Route 65 at the foot of the mountain from Hamsiköy to Dikkaya.

2-2 Karadağ Area

The Karadağ Area is located approximately 40 km south-east of Torul and 5 km 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 2,700 m 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 survey.

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 Kırkpavlı in Eski Gümüşhane. *Kovenvo(1937) reported that Hazine Mağara is a*

silver replacement deposit in calcareous sediment overlaying Paleozoic Granite (Gümüşhane Granite), and that Kırkpavlı 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 Menders 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 Merzifon-İspir area, of which 8 anomalies are concerned with the Gümüşhane area. The Gümüşhane area is a 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, namely Pontids, Anatolids, Taurids and Border Folds from north to south. These belts generally extend in an E-W direction. The surveyed area belongs to the Pontids, consisting of the Ordovician to Oligocene.

The Pontids is characterized by extensive volcanic activities, including calc-alkaline basalt-andesite-dacite series in the Upper Cretaceous-Tertiary period. This violent volcanism is accompanied with emplacement of granitic rocks. Most of the ore deposits in the Pontids 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, to the north of the surveyed area, dacite series are mainly distributed, according to the results of the collaboration mineral exploration programme in 1974 ~1976 (Trabzon area).

The great majority of the massive sulfide deposits are located along the Black Sea Coast, and stockwork sulphide deposits are located in the 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, 55g/t Ag) is planned to be developed by Eti Bank 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.

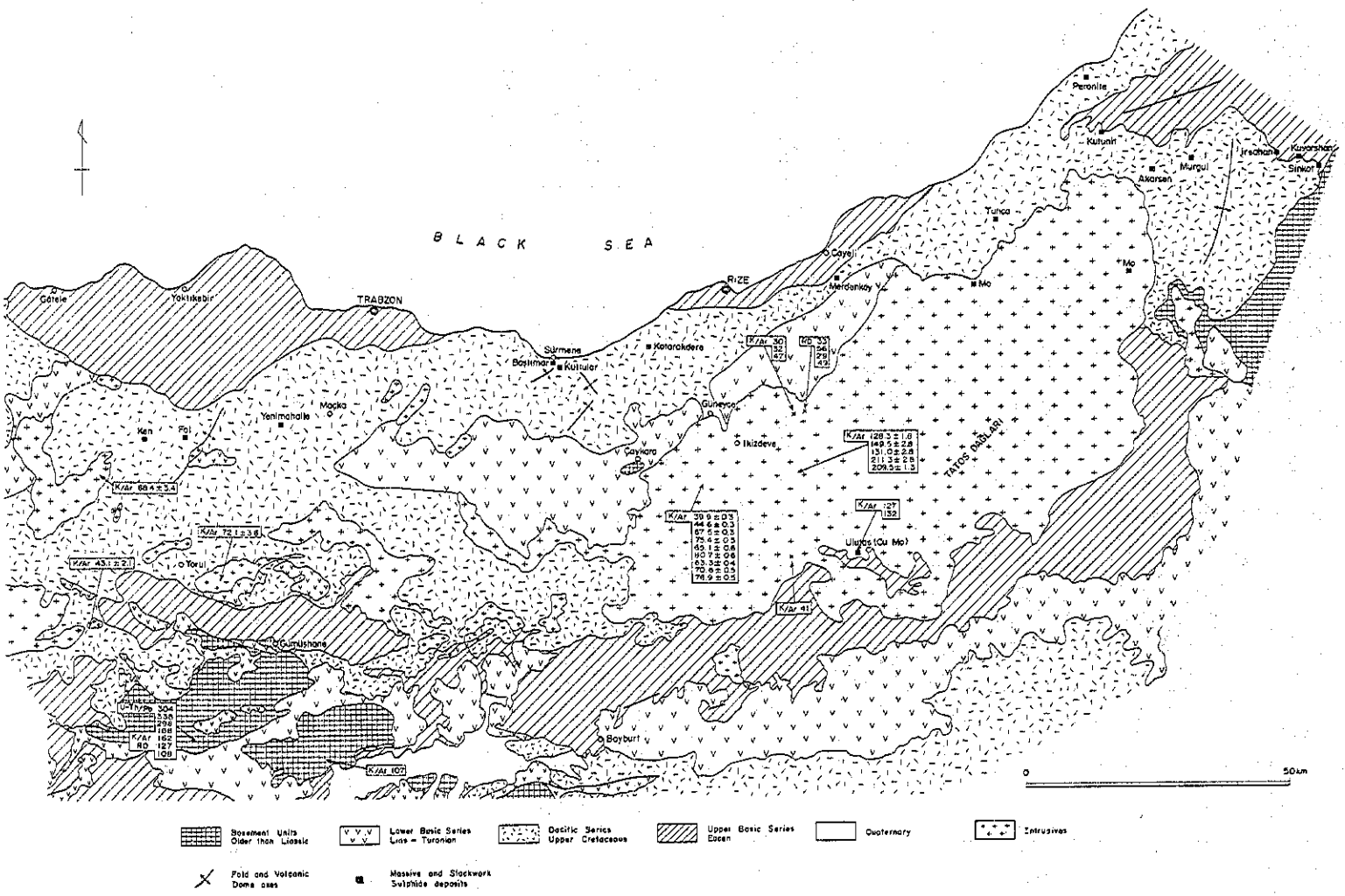


Fig. 4 Generalized Map of the Surveyed Area (Geology compiled from AKINCI'85)

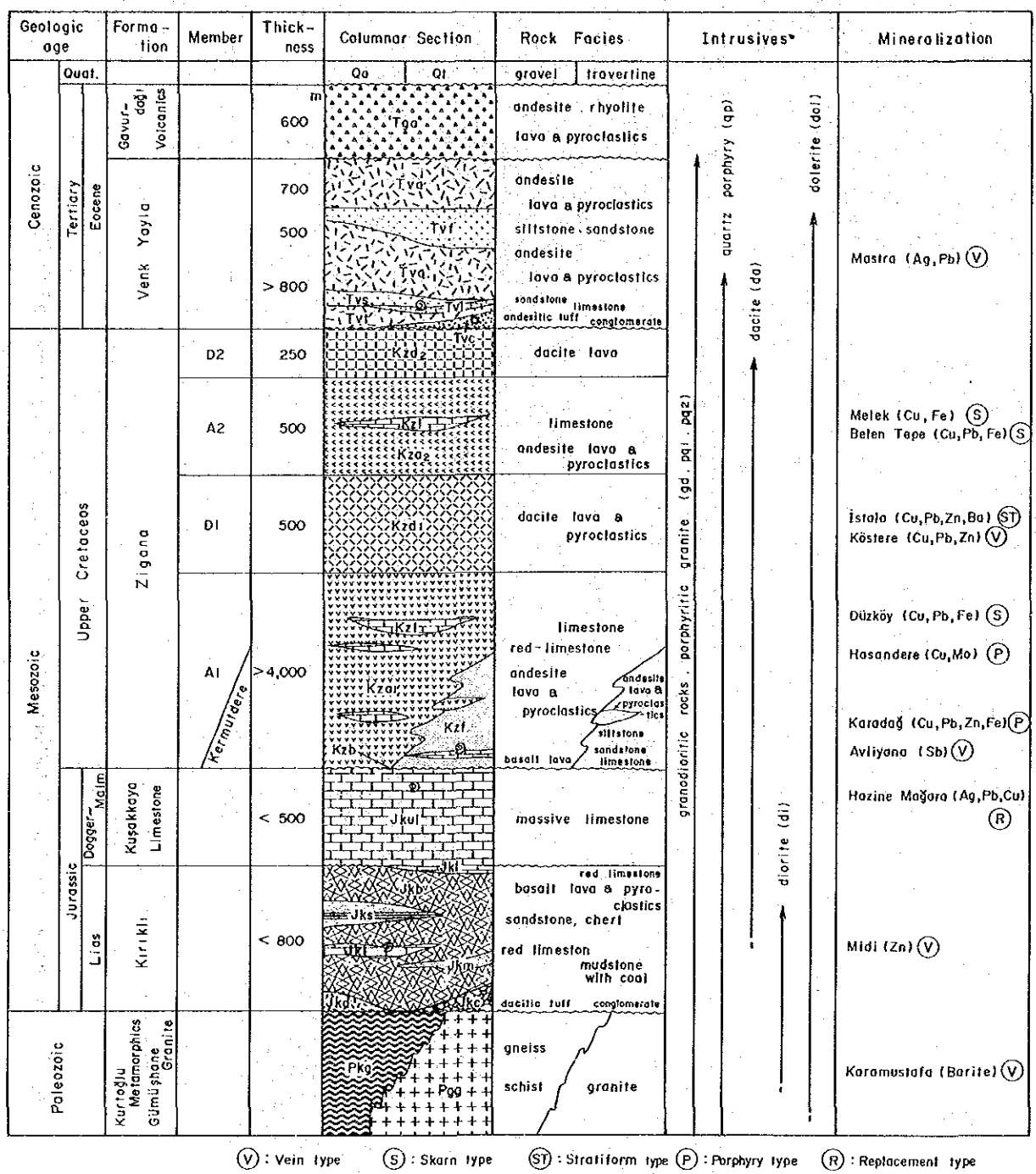


Fig. 5 Schematic Geological Column of Gümüşhane Area

Part 2 RESULTS OF SURVEY

Part 2 RESULTS OF SURVEY

Chapter 1 Hasandere Area

1-1 Outline of Survey

1-1-1 Summary of Initial Phase Survey

The surveyed area is situated in the Pontids Belt, and is characterized by plutonic intrusion activity 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 Formtion consists of andesite, andesitic pyroclastic rocks and intercalations of thin limstone and siltstone beds. The Zigana Formation is correlative with A1 Member divided by initial phase survey. Distributed in the area from Maden Dere to Tulmagol River, the porphyritic granite was so named by the initial phase survey because of predominant existence of a porphritic texture with quartz and plagioclase, even though partly equigranular texture occur. The porphyritic granite is classified into two types on the basis of their mode of alteration, namely altered porphyritic granite and unaltered granite. 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 initial phase survey that the former had intruded into the latter although the intrusion times of both are unclear.

Results of the geochemical survey on stream sediments of the initial phase revealed predominant geochemical anomalies of seven elements, namely Ag, Cu, Mo, Pb, Zn W, and Sn. Especially high anomalies of Cu (780 ppm maximum) and Mo (28 ppm maximum) associated with W are especially noticeable. MTA also found Mo and Cu anomalies though soil geochemical surveys in the same area. The anomalous area measureed 1.7 km x 1.4 km, and probably extends further to the north and north east.

1-1-2 Purpose of Second Phase Survey

The second phase survey aims at unravelling distribution of porphyritic granite related with Cu-Mo mineralization, characteristics of the mineralization, alteration patterns in the Hasandere area (surveyed area : 8.75 km^2) with a promising porphyry type ore deposit, and also estimating emplacement conditions and scale of the ore deposit.

1-1-3 Survey Methods and Amount of works

The topographic maps of 1:2,000 scale are those enlarged from 1:5,000 scale maps produced by the Mineral Research and Exploration Institute, The Republic of Turkey, for field survey, and the survey route map was compiled on these maps. At Mat and Hasan Deres of the central surveyed area, topograph maps of 1:2,000 scale were ensmalled from 1;1,000 scale maps and were used for detailed survey. The geological map was compiled on a 1:5,000 scale map.

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

1-2 Geology

1-2-1 General Geology

The geology of the Hasandere 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 units, namely the Kermutdere, A1, D1, A2 and D2 Members in ascending order as determinbed 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 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.

1-2-2 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 down stream of the Kıraz Dere. However, it is widely distributed around Dikkaya Village in 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. At 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 formation and consists of altered andesite accompanied by sulphide ores.

Zigana Formation : This Formation has been divided into 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 pale green to dark green massive or hyalocrastic basaltic andesite. The rock has been brecciated owing to hyaloclast, and consists of breccia and matrix of the same

material, incorporating the subangular pebble 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 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 mention later, is sericitization and chloritization distributed around porphyry granite (Pgl). Chalcopyrite-molybdenite-pyrite bearing mineralization is observed along with fissures and quartz veins at cliffs in Maden River or rock exposures of forest road. It is very difficult to microscopically identify the rock in this part because of strong alteration.

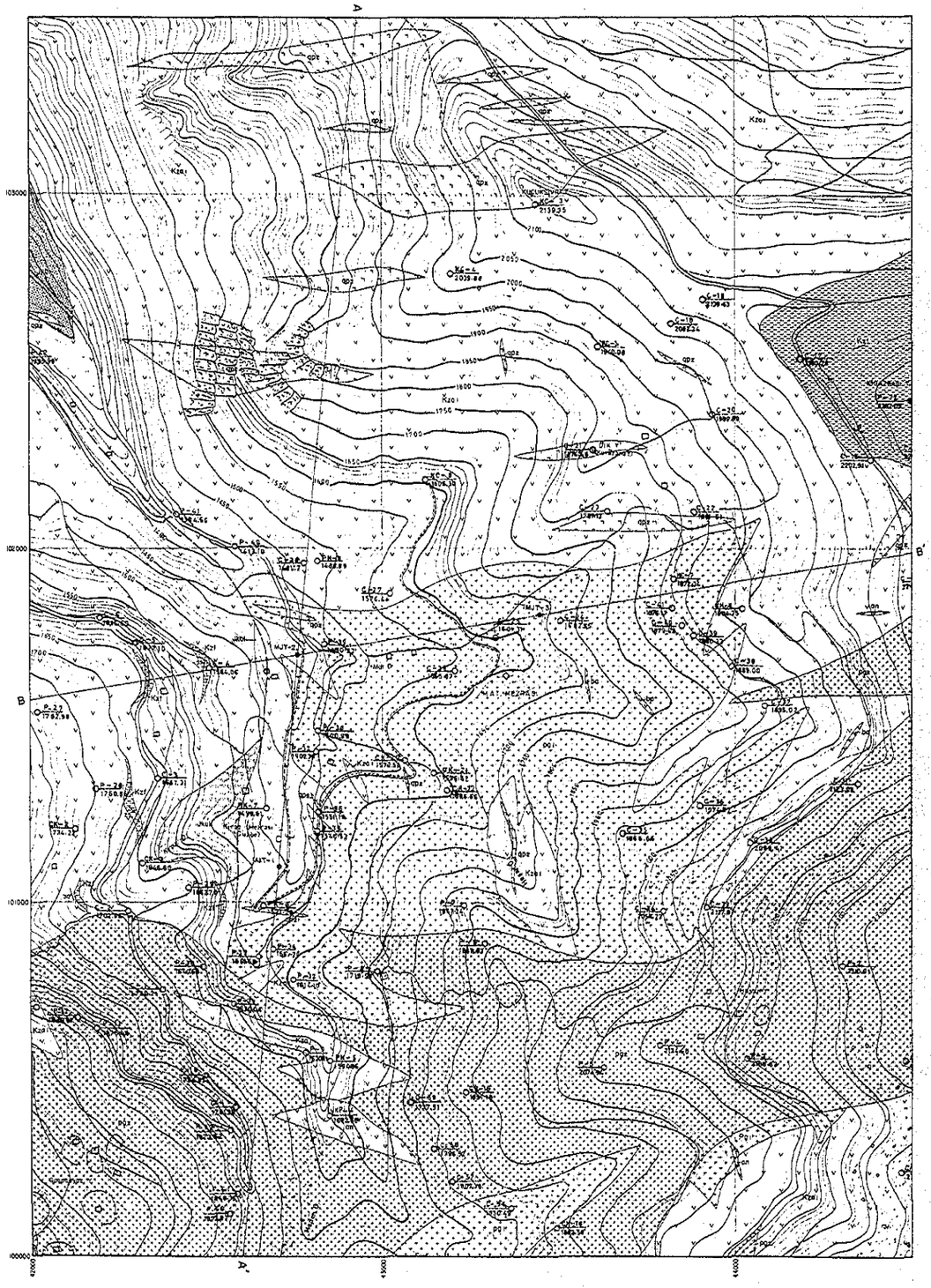
Andesitic tuff: Well-bedded andesitic tuff is partly intercalated in andesite lava. The tuff is a pale green to reddish green coarse grained rock. The rock may be a member of the hyaloclastite, as it is discontinuous and gradually changes to hyalocrastic lava.

Siltstone-sandstone and limestone: These rocks are interclated as thin discontinous beds in the andesite lava. Well-bedded and thick alternating beds of siltstone and sandstone are distributed at Kırazbası Mountain in the east 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 crystallined limestone.

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

1-2-3 Intrusive Rocks

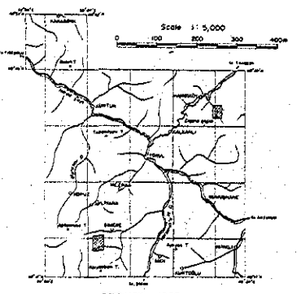
The main intrusive rocks are porphyritic rock and quartz porphyry with distributions of small andesite dykes. Porphyritic granite and quartz porphyry are respectivery classified into two types based on alteration modes.



PL. 1

REPORT ON THE MINERAL EXPLORATION
OF GÜMÜŞHANE AREA, THE REPUBLIC OF TURKEY

GEOLOGICAL MAP OF THE
HASANDERE AREA



FEBRUARY 1986

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

LEGEND

Upper Cretaceous
- Kzl — Limestone
- Kzf — Siltstone, Sandstone
- Kza — Andesite lava and pyroclastics

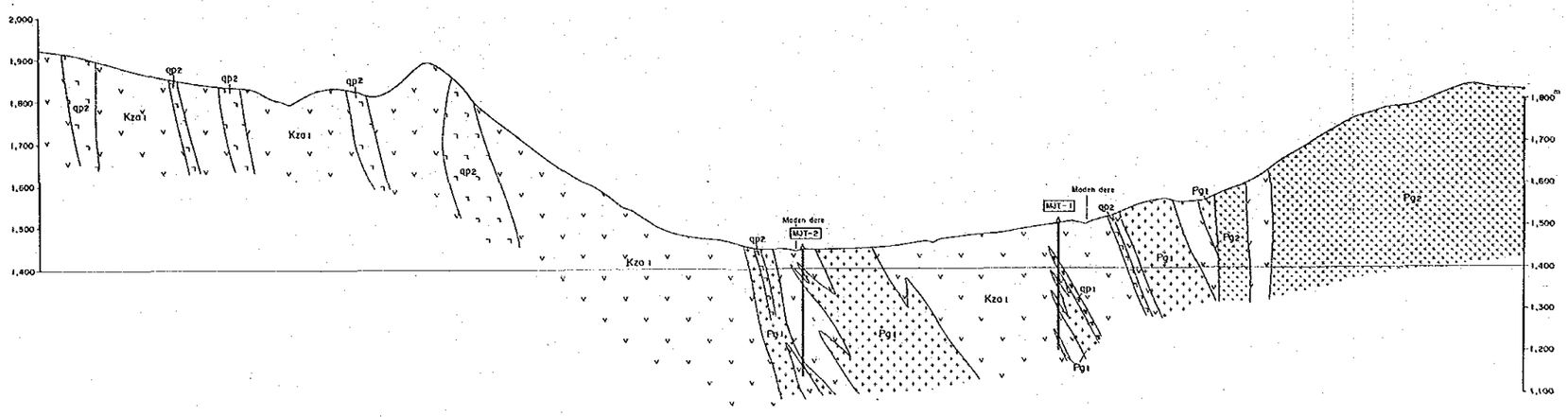
Jurassic
- Jkul — Limestone
- Jkb — Basalt lava

Intrusive
- dy, dg — Andesite / Basalt
- qp2 — Quartz porphyry 2 (qp2)
- qp1 — Quartz porphyry 1 (qp1)
- pg2 — Porphyritic granite 2 (pg2)
- pg1 — Porphyritic granite 1 (pg1)

- Fault (inferred)
- 30 — Dip and strike
- A — A' — Profile line
- MJT-1 — Drilling site

Fig. 6 Geological Map of the Hasandere Area

A — A′



B — B′

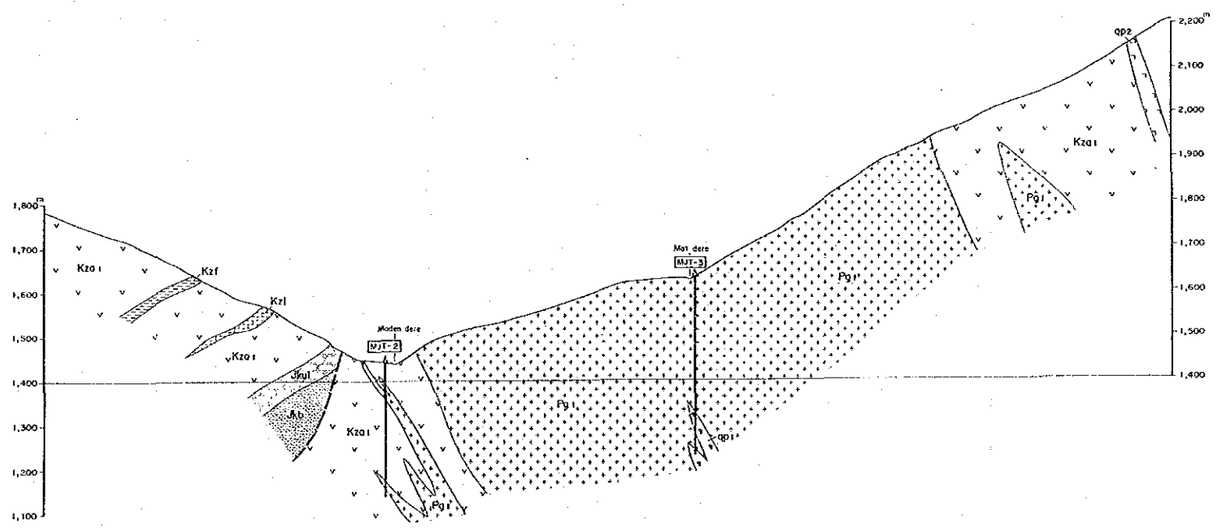
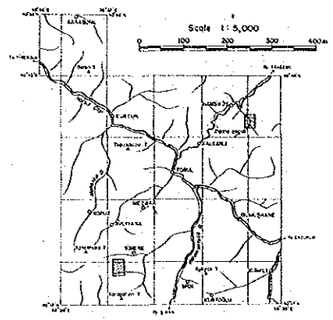


Fig. 7 Geological Profile Maps of the Hasandere Area

PL. 2

REPORT ON THE MINERAL EXPLORATION
OF GÜMÜŞHANE AREA, THE REPUBLIC OF TURKEY

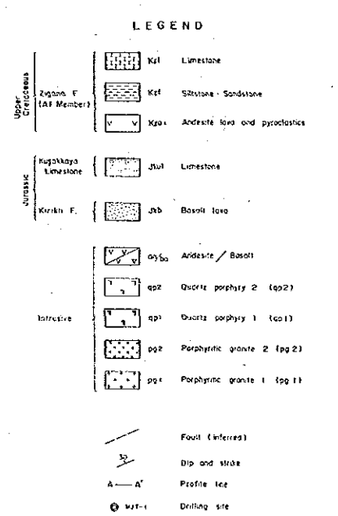
GEOLOGICAL PROFILE MAPS OF THE
HASANDERE AREA



FEBRUARY 1986

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

LEGEND



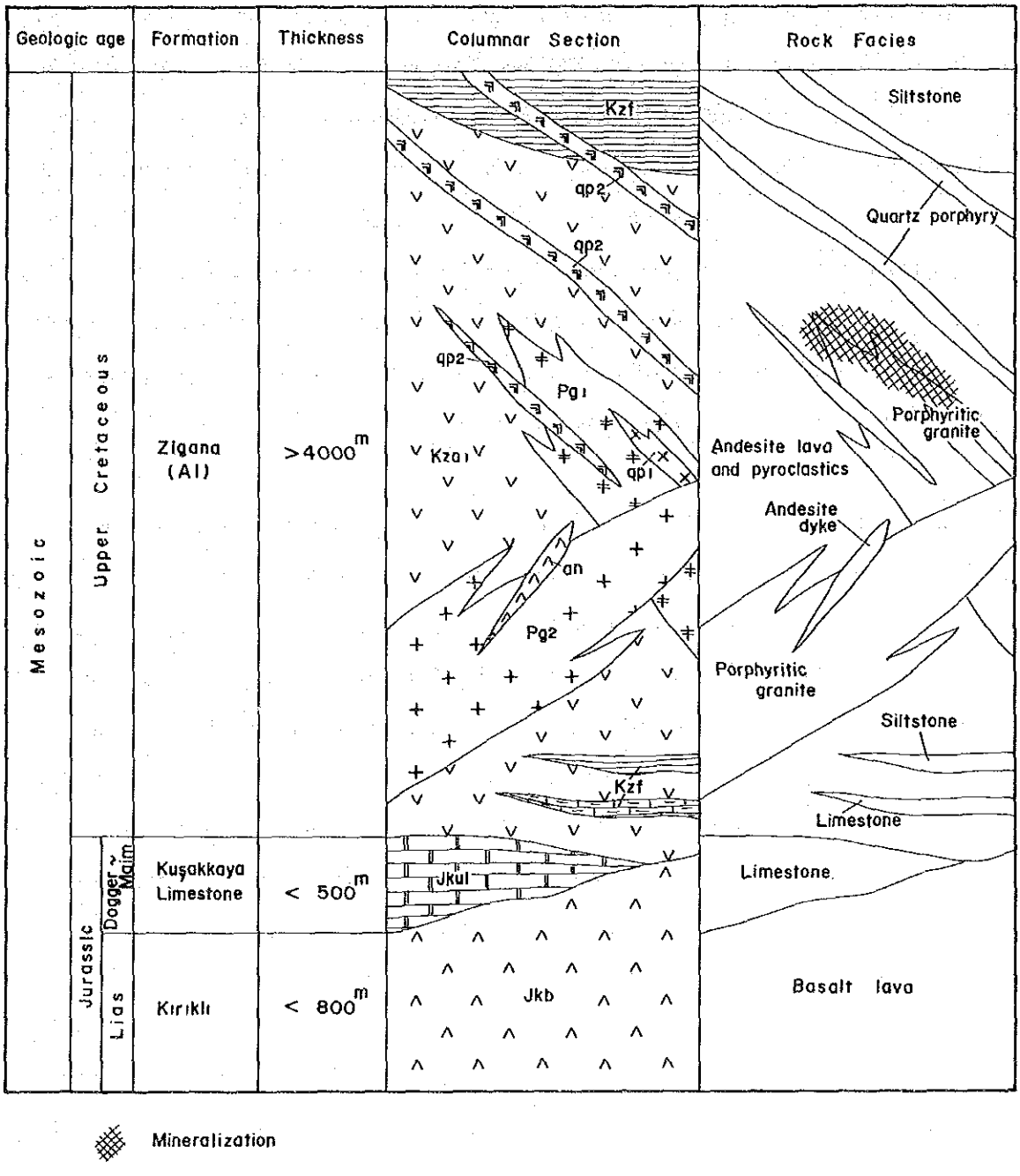


Fig. 8 Schematic Geological Column of the Hasandere Area

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 has embedded in the andesite of the Zigana Formation. Porphyritic texture of quartz and feldspar is common in the rock, and facies of the rock is similar to 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 granodiorite 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 next chapter. Porphyritic granite ranges microscopically from a diorite facies to a granodiorite porphyry facies with porphyritic texture. And 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 Turnagol (outside of 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 geneally, the rock has undergone little alteration. It may be inferred that the unaltered porphyritic granodiorite 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. The rock is holocrystaline with 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. The 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 with fissures and quartz veins in the rock.

Quartz porphyry(Qp2): This rock is found around Küçüksiviri Mountain and at Maden River, and

has intruded into andesite lava, and partly into the altered porphyritic granite(Pgl). It is inferred that the intrusion activity of the quartz porphyry(Qp2) is later than that of the altered porphyritic granite(Pgl), due to the relationship between both rocks as mentioned above.

Andesite dyke(an): A dark green massive andesite dyke is observed at conjunction of Maden and Salalim Deres. This dyke cuts the andesite of the Zigana Formation and 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. These dykes have varying strike directions,(N-S, NE-SW, NW-SE and etc). The basaltic rock has with an intersertal texture, and plagioclase, biotite and hornblende of the constituent minerals are slightly altered to chlorite and calcite in thin-section.

1-2-4 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 strucutural 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 Medan Dere in a N-S direction system, extends northward out of the surveyed area, while it disminishes at the southern extention due to cutting off by the intrusion of unaltered porphyritic granite. Displacement by the fault has rised the western side, judging from the distribution of the Kuşakkaya Limestone Formation, which is a lower Formation than the Zigana Formation, and the absence of Mo-Cu mineralization or mineralized 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.

1-3 Mineralization and Alteration

1-3-1 Mineralization

The mineralized zone is embedded in the altered porphyritic granite (Pgl) and andesite of the Zigana Formation (A 1 member) in the vicinity of the granite in an area from Mat Dere to Hasan Dere, tributaries of the Maden River, situated 4 km south-east of Hamsiköy. As mentioned before, the porphyritic granite consists of granite (Pgl) accompanied by Mo-Cu mineralization along fine fissures and granite (Pg2) undergoing very weak alteration without mineralization. Observed with the naked eye, both 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 (Pgl) instrusion and consists of the following parts ;

① those embedding along fissures with quartz vein (vein type)

② those embedding as filmy veinlets (network type)

③ those embedding as disseminations (dissemimnation type)

Vein① and network② type mineralizations are common in Maden, Mat, and Hasan Deres, but mineralization on the ridge of the mountain, being topographycally 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. In MJT-1 and MJT-2 of the drilling survey locating in Maden Dere, vein① and network② types are continuously observed from ground surface to hole bottom (301m). Conversely in MJT-3, located on convex topography, dissemination type③ is dominant, accompanied by vein① and network② types, except in a section secondary enrichment consisting of native copper and chalcocite in poor fissures from surface to 16 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. Pytite is embedded as disseminations, networks and veins and is associated with other sulphide ores. It occurs throughtout 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-(quartz) veins exist along fissures of chalcopyrite-pyrite in the dissemination section.

Under microscopic observation, chalcopyrite-pyrite cuts aggregated magnetite. Therefore paragenesis of ore minerals is: magnetite was crystalized 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 mincrals might have crystallized in the following order: magnetite→pyrite→chalcopyrite・sphalerite→molybdenite. This relationship is consistent with field observations. The mineralized zone is expected in the Pgl intrusion in an area of diameter 1.8 km～2.0 km. The area is delineated by Cu anomalous values of more than $M+\sigma$(200 ppm), and centers 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 surrounding andesite intruded by Pgl.

Chipped samples for investigation of the chemical constitution of the ore were collected in the Hasandere Area in which such mineralized showings of porphyry copper type are recognized. The number of samples is 39 pieces from Maden Dere, 37 pieces from Hasan Dere area, and 26 pieces from Mat Dere area, totalling 102 pieces. Assay results of these samples are shown in Table 1. 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. Namely, 70% of the samples are less than 0.1% Cu in grade, and 80% of samples are of less than 0.015 % Mo in grade. These chipped sample results are of lower grade than that of drilling core. The leached nature of the chipped samples may be the cause of this discreapancy. Two samples, collected

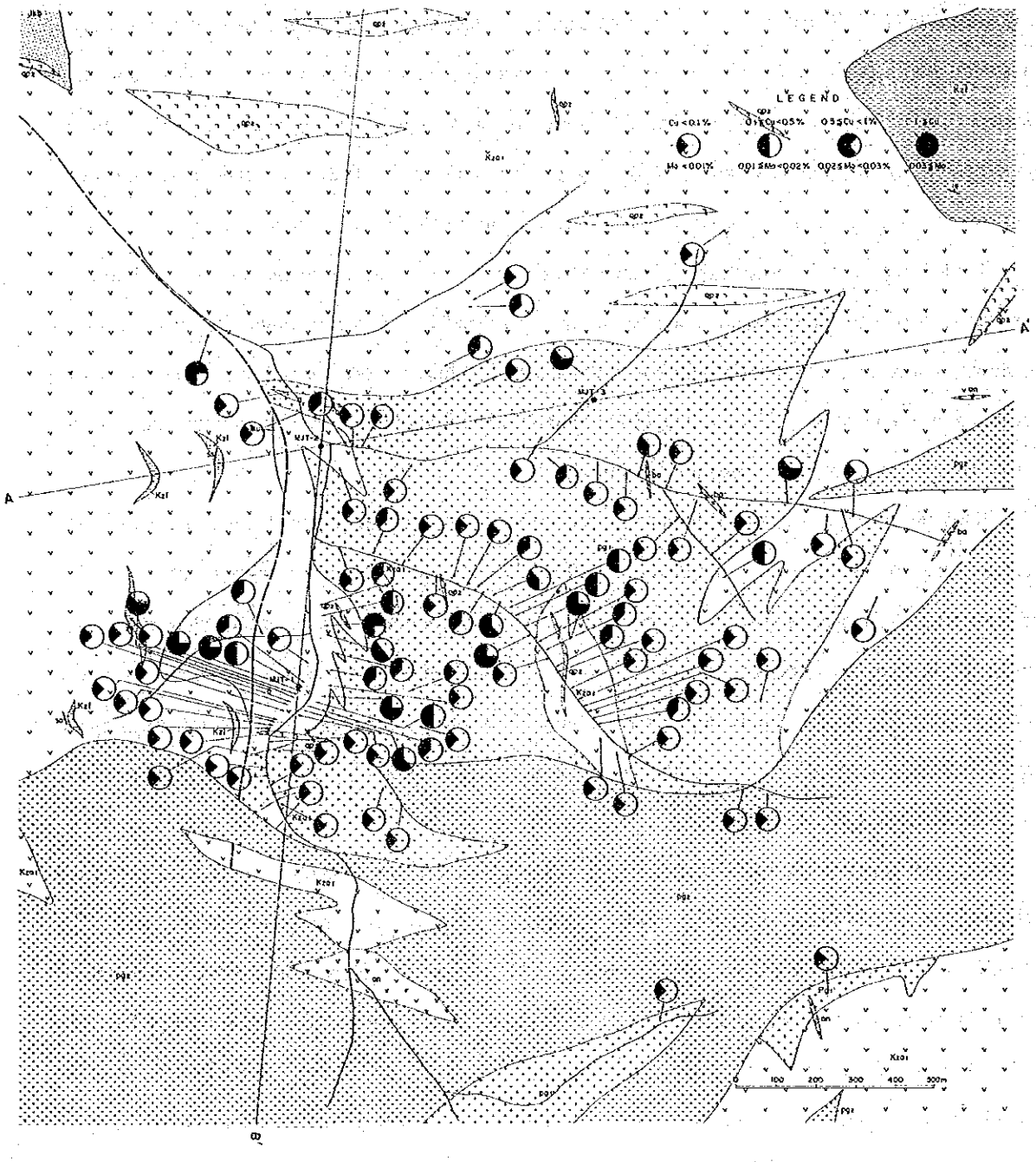


Fig. 9 Chemical Analysis Result (Chipped Sample) Map of the Hasandere Area

Table 1 List of Chemical Analysis Results of Ores of the Hasandere Area (1)

No 1

Sample No	Description	Location	Cu %	Mo %
AE- 8	Pgl with Qz-vein	Maden dere	0.04	tr
AE- 9	Pgl with Py-diss	Maden dere	0.02	tr
AE-10	Pgl with Py-diss	Maden dere	0.01	tr
AE-11	Pgl with Py-Qz vein	Maden dere	0.01	tr
AE-12	Pgl with Py-diss	Maden dere	0.01	tr
AE-13	ditto	Maden dere	0.02	tr
AE-14	Andesite with Mo-Py-Qz vein	Maden dere	0.02	0.001
AE-15	Andesite with Py-Qz vein	Maden dere	0.01	tr
AE-16	ditto	Maden dere	0.01	0.001
AE-17	Andesite with Py diss	Maden dere	0.02	tr
AE-18	Andesite with Py-Qz vein	Maden dere	0.01	0.002
AE-19	Andesite	Maden dere	0.02	tr
AE-20	Andesite with Py-Qz vein	Maden dere	0.01	0.001
AE-21	ditto	Maden dere	0.02	0.007
AE-22	Andesite with Mo-Py-Qz vein	Maden dere	0.03	0.002
AE-23	ditto.	Maden dere	0.07	0.003
AE-24	Andesite with Mo-rich Py-Qz vein	Maden dere	0.10	0.072
AE-25	ditto.	Maden dere	0.35	0.065
AE-26	Andesite with Mo-Py-Qz vein	Maden dere	0.18	0.011
AE-27	Andesite with Py-diss	Maden dere	0.10	0.001
AE-28	ditto.	Maden dere	0.04	0.002
AE-30	Andesite with limo-Qz vein	Maden dere	0.01	0.001
AE-31	Andesite with Mo-Py-Qz vein	Maden dere	0.12	0.020
AE-32	Andesite with Py-Qz vein	Maden dere	0.17	0.008
AE-33	Andesite with Mo-Py-Qz vein	Maden dere	0.10	0.012
AE-34	Andesite with Mo-Py-Qz vein	Maden dere	0.13	0.154

Ditection Limit : Mo 1 ppm , Cu 10 ppm

Analytical method : Atomic Absorption and Common Assay

Table 1 List of Chemical Analysis Results of Ores of the Hasandere Area (2)

No 2

Sample No	Description	Location	Cu %	Mo %
AE-35	Andesite with Py-diss	Maden dere	0.02	0.002
AE-36	ditto	Maden dere	0.13	0.001
AE-37	Andesite with Py-(Mo)-Qz vein	Maden dere	0.16	0.003
AE-38	Andesite with Qz-vein	Maden dere	0.04	0.026
AE-39	Andesite with Py-Mo-Cp-Cc-Qz vein	Maden dere	1.30	0.017
AE-40	Andesite with Py-Mo-Qz vein	Maden dere	0.12	0.011
AE-41	Andesite with Py-Qz vein	Maden dere	0.16	0.001
AE-42	Andesite with Py-Qz vein	Maden dere	0.96	0.11
AE-43	Pgl with Mo-Py vein	Maden dere	0.04	0.005
AE-44	Andesite with Mo-Py vein	Maden dere	0.09	0.001
AE-45	Pgl with Qz-veinlets	Maden dere	0.02	tr
AE-60	Andesite with Py-diss	Maden dere	0.04	0.001
YY- 5	Andesite with Mo-Qz vein	Mat dere	0.41	0.007
YY- 6	Pgl with Mo-Py-Qz vein	Mat dere	0.07	0.004
YY- 7	Pgl	Mat dere	0.01	tr
YY- 9	Pgl with Qz vein	Mat dere	0.01	0.009
YY-11	Qz-vein,limonitization.	Mat dere	0.01	0.002
YY-12	Unaltered pgl (no-mineralization)	Mat dere	0.03	tr
YY-13	Limonite-Qza vein	Mat dere	0.02	0.017
YY-15	Pgl with limonite-Py-Qz vein	Mat dere	0.02	0.001
YY-16	Pgl with stili-limo	Mat dere	0.01	0.002
YY-18	Unaltered pgl	Mat dere	0.05	0.034
YY-19	Sili.-limonitized pgl	Mat dere	0.01	0.006
YY-21	Andesite with Py-diss	Mat dere	0.03	0.001
YY-22	ditto.	Mat dere	0.03	0.001
YY-23	Unaltered pgl	Mat dere	0.01	tr
YY-26	Pgl with Py-Qz vein	Mat dere	0.04	0.003
YY-27	ditto.	Mat dere	0.03	0.002
YY-28	Altered Pgl	Mat dere	0.11	0.012
YY-29	Pgl.	Mat dere	0.01	tr

Ditection Limit :Mo 1 ppm ,Cu 10 ppm

Analytical method :Atomic Absorption and Common Assay

Table 1 List of Chemical Analysis Results of Ores of the Hasandere Area (3)

Sample No	Description	Location	Cu %	Mo %
HY- 1	Andesite with Mo-Qz vein	Maden dere	0.02	0.054
HH- 7	Andesite with Py-diss	Hasan dere	0.04	tr
HH- 8	ditto.	Hasan dere	0.01	tr
HH- 9	Andesitewith Qz-vein	Hasan dere	0.02	tr
HH-13	Pg2 with Py-diss	Hasan dere	0.01	tr
HH-15	ditto	Hasan dere	tr	tr
HH-19	Wht-alt pgl sili-limonitized	Hasan yayla	tr	tr
HH-22	Wht-alt pgl	Hasan yayla	tr	tr
HH-24	Bi-alt pgl with Qz-vein	Hasan dere	0.07	0.001
HH-25	Bi-Alt pgl with Py-diss	Hasan dere	0.06	0.001
HH-26	Pgl with Mo-Py-Qz vein	Hasan dere	0.15	0.005
HH-27	alt Pgl with Qz vein	Hasan dere	0.01	0.003
HH-28	Andesite with strong Py-diss.	Hasan dere	0.15	0.002
HH-46	wht pgl with Qz-vein	South Hasan	0.01	0.001
HH-47	Pgl with Qz-vein & Py-diss	South Hasan	0.01	tr
HH-53	Pgl with limo vein	South Hasan	0.01	tr
HH-54	ditto	South Hasan	0.01	tr
KY- 1	Andesite with Py-Qz vein	Hasan dere	0.14	tr
KY- 3	Andesite with Py-diss	Hasan dere	tr	tr
KY- 5	ditto	Hasan dere	0.07	tr
KY- 7	Andesite with Py-Qz vein	Hasan dere	0.04	tr
KY- 9	ditto	Hasan dere	0.02	0.003
KY-11	Andesite	Hasan dere	0.01	tr
KY-14	Andesite with Py-diss	Hasan dere	0.04	tr
KY-15	ditto	Hasan dere	0.12	0.001
KY-16	ditto	Hasan dere	0.05	0.001
KY-17	ditto	Hasan dere	0.16	0.001
KY-18	Andesite with Py-Mo-Qz vein	Hasan dere	0.09	tr
KY-19	Pgl with Py-Mo-Qz vein	Hasan dere	0.41	0.038
KY-20	ditto	Hasan dere	0.15	0.178

Ditection Limit :Mo 1 ppm ,Cu 10 ppm

Analytical method :Atomic Absorption and Common Assay

Table 1 List of Chemical Analysis Results of Ores of the Hasandere Area (4)

No 4

Sample No	Description	Location	Cu %	Mo %
KY-21	Pgl with Mo-Py-Qz vein	Hasan dere	0.32	0.016
KY-22	ditto	Hasan dere	0.13	0.018
KY-23	Pgl with Mo-Qz vein	Hasan dere	0.10	0.027
KY-24	ditto	Hasan dere	0.06	0.015
KY-25	Pgl with Qz vein	Hasan dere	0.13	0.006
KY-26	Pgl	Hasan dere	0.12	0.003
KY-27	Pgl with Qz veivlets	Hasan dere	0.05	0.001
KY-28	Pgl with Qz veinlets	Hasan dere	0.01	tr
KM- 3	Pgl with Cp diss	Mat dere	0.13	tr
KM- 4	Pgl with Cp diss. & qz veinlets	Mat dere	0.07	tr
KM- 5	White altered pgl	Mat dere	0.01	0.001
KM- 7	Andesite	Mat dere	0.18	0.002
KM- 9	ditto	Mat dere	0.11	tr
KM-10	Altered and.with qz veinlets	Mat dere	0.01	0.007
KM-13	Magnetite-actionolite skarn	Mat dere	tr	0.001
MM- 7	Limonitized pgl	Mat dere	0.01	0.061

Ditection Limit : Mo 1 ppm ,Cu 10 ppm

Analytical method : Atomic Absorption and Common Assay