THE REPUBLIC OF TURKEY
REPORT ON
THE MINERAL EXPLORATION
OF
KÜRE AREA

CONSOLIDATED REPORT

MARCH 1995

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

THE REPUBLIC OF TURKEY
REPORT ON
THE MINERAL EXPLORATION
OF
KÜRE AREA

CONSOLIDATED REPORT

MARCH 1995

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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 Küre Area, and commissioned its implementation to the Japan International Cooperation Agency (JICA).

The agency, taking the importance of the technical nature of the survey work into consideration, sought the cooperation of the Metal Mining Agency of Japan (MMAJ) to accomplish the task.

The Government of the Republic of Turkey appointed the Etibank to execute the survey as a counterpart to the Japanese team. The survey was carried out from 1992 jointly by experts from both governments.

The cooperative mineral exploration in the Küre has continued for three years. It consisted of geological and geophysical survey, and drilling exploration.

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

We wish to express our sincere appreciation to the officials concerned of the Government of the Republic of Turkey for their close cooperation extended to the team.

March 1995

Kimio FUJITA
President,
Japan International Cooperation Agency

Takashi Ishikawa
President,
Metal Mining Agency of Japan

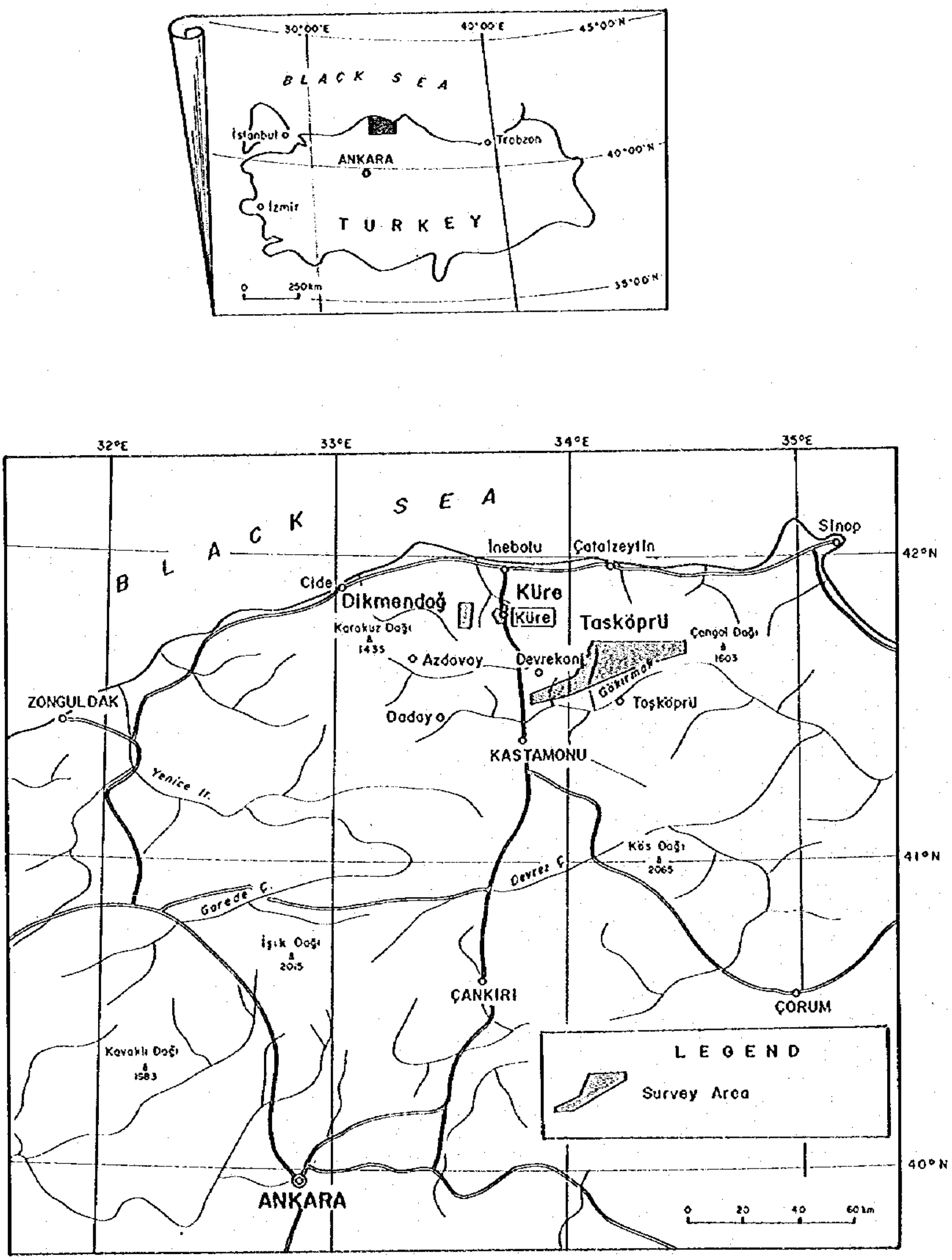


Fig. 1-1 Index Map of the Survey Area

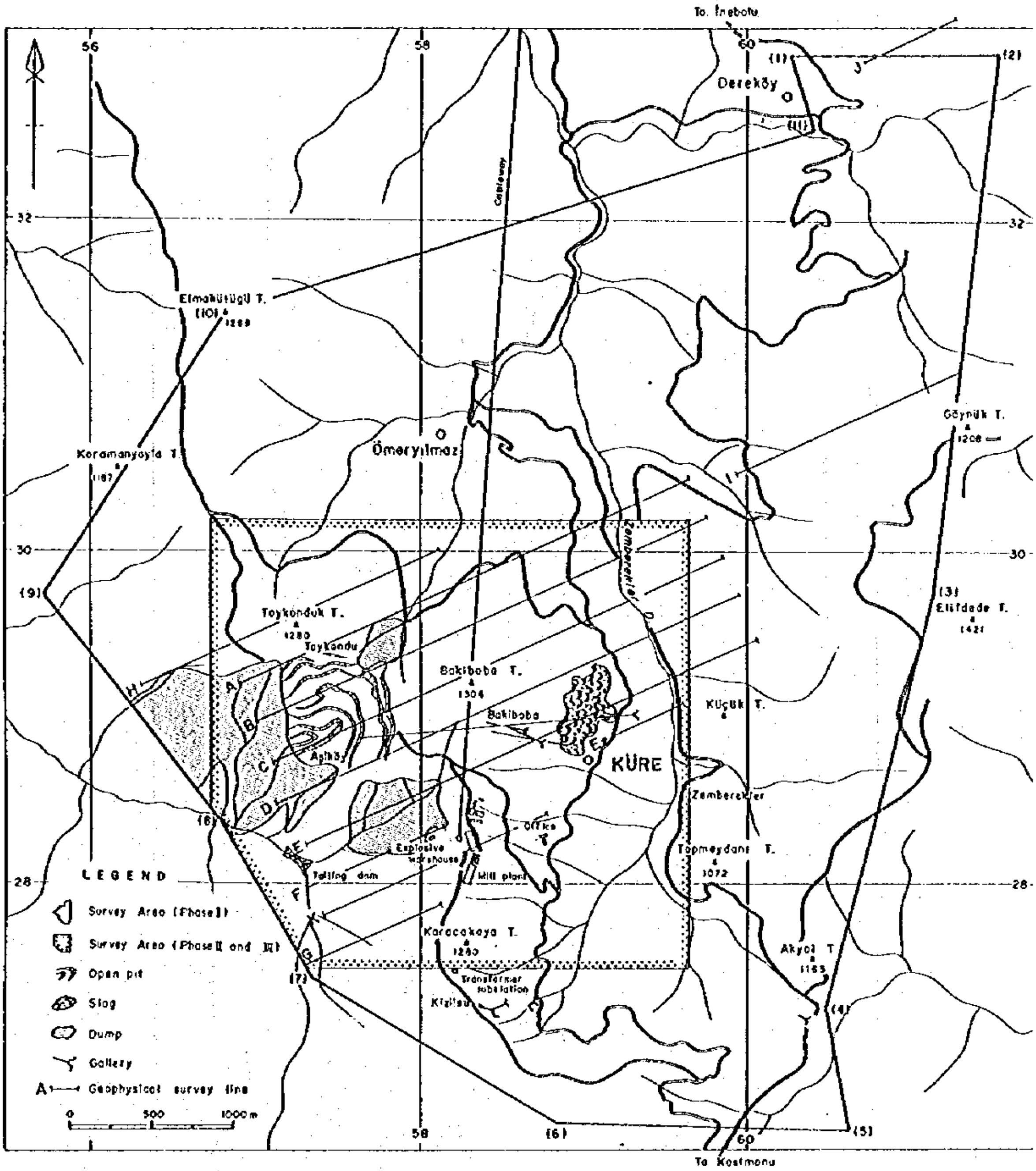


Fig. 1-2 Location Map of the Küre Zone

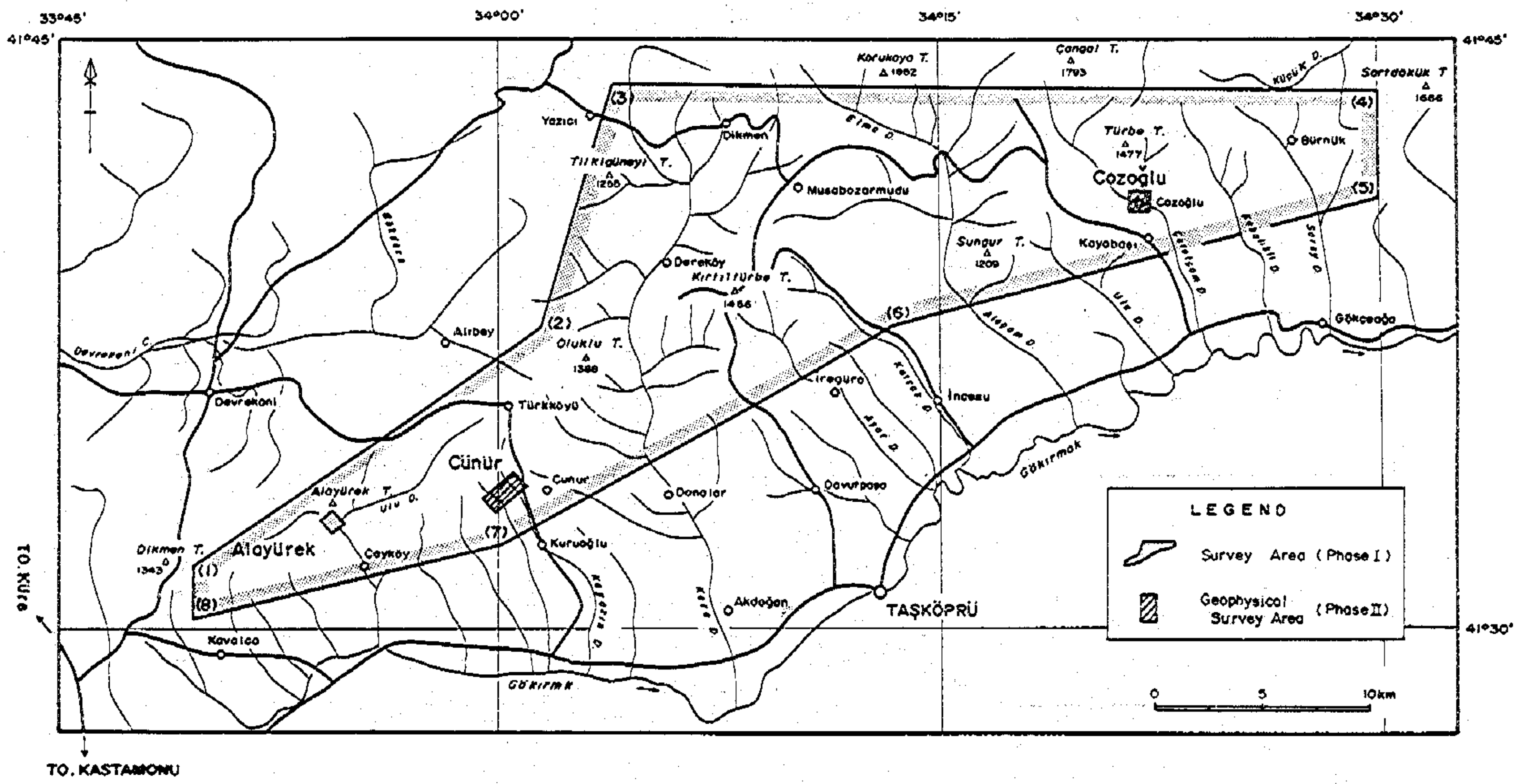


Fig. 1-3 Location Map of the Taşköprü Zone

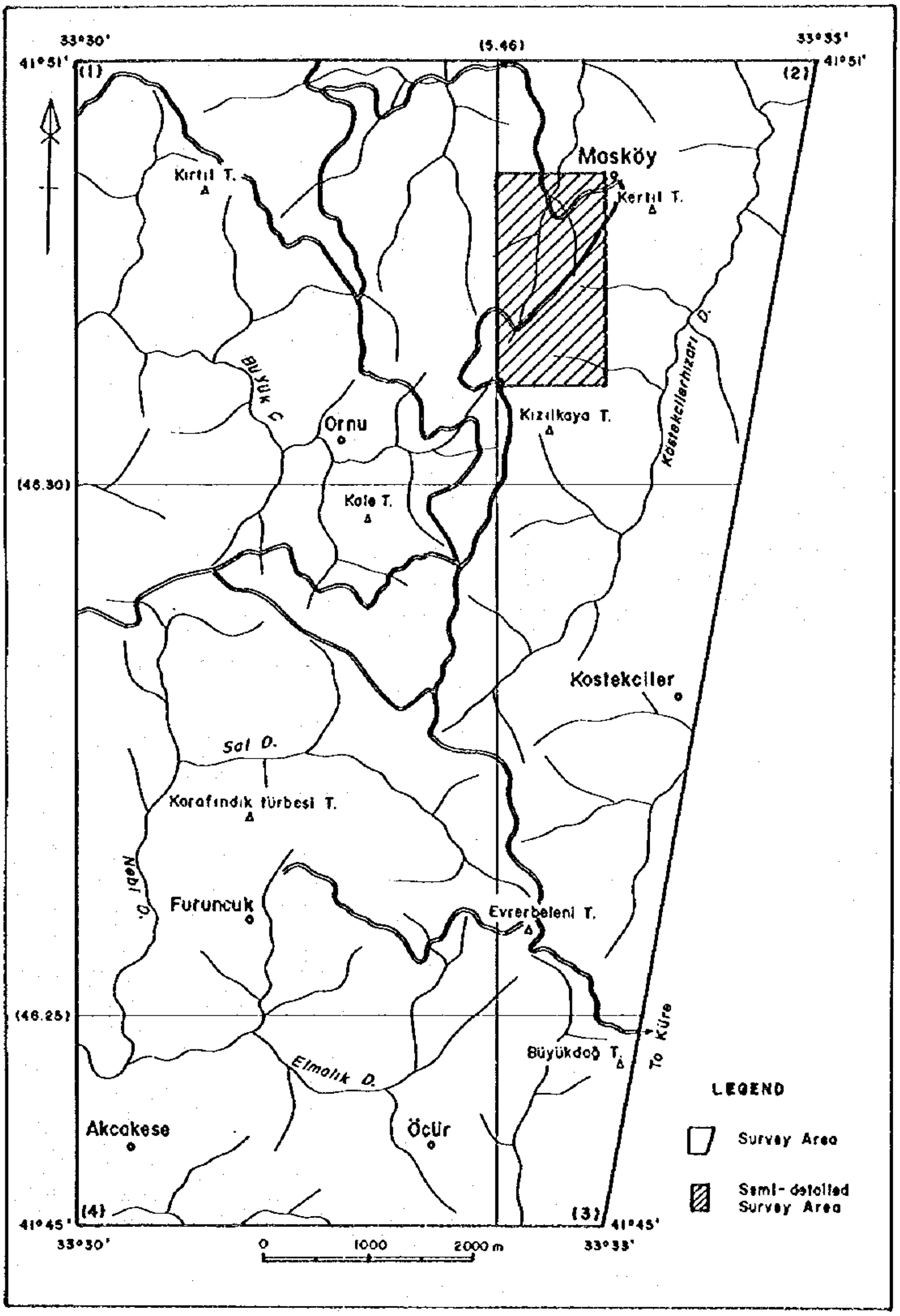


Fig. 1-4 Location Map of the Dikmendağ Zone

SUMMARY

The cooperative mineral exploration has been carried out for three years in the Küre area. The potential of the Cyprus-type ore deposit in the Küre zone was confirmed by the drilling.

Küre area consists of three zones, namely, Küre, Taşköprü and Dikmendağ zones.

The first phase survey of this project was carried out in fiscal 1992. The purpose of the first phase was to clarify the geological environment and thereby understand the occurrence and conditions of ore deposits of the Küre area. The works carried out in the first phase were; compilation of available geological and geophysical information, geological survey of the whole area, and geophysical survey over the Küre zone.

In fiscal 1993, four holes totaling 1,003.55m in length were drilled in the promising areas of the Küre zone, which were delineated by the geological and geophysical surveys during the previous year. Also two holes were electrically logged. Geophysical survey (IP, 21 line-km) was carried out at Cünür and Cozoğlu of the Taşköprü zone since these were concluded to be promising by geological survey during the first year.

In fiscal 1994, drilling exploration comprising four holes totaling 953.70m in length continued on the Küre zone.

Following conclusions are obtained as the results of the above works.

Küre Zone

The geology of the Küre zone consists of pre-Jurassic ultramafic rocks, Jurassic basalt, sedimentary rocks of the Küre Formation, fossiliferous limestone of the Lower Cretaceous Karadana Formation, marl of the Upper Cretaceous Çağlayan Formation, intrusive diorite and dacite.

Basalt of the Küre Formation that occupies the major part of the zone is composed of pillow lava, hyaloclastite and massive basalt.

Sedimentary facies of the Küre Formation is composed of angularly fragmented graywacke and sheared/argillized black shale.

Basalt and brecciated sediments of the Küre Formation are interpreted as a constituent of melange. The period of melange formation is considered to be Middle Jurassic because the intrusion of dacite into the melange is inferred to be later Dogger epoch.

The geologic structure of this zone is characterized by many faults. They are divided into two systems: N-S and E-W.

Basalt is interpreted to constitute the footwall or the horizon of ore deposits. It extends to the N-S and NNW-SSE directions with imbricate structure.

The known ore deposits are categorized as the Cyprus-type deposits. It is expected that deposits of the same type occur in this zone.

Ore deposits has been dislocated by the melange formation and later tectonic movement, but it is inferred that most ore deposits have been displaced with the displacement of footwall mineralized zone and hangingwall pelitic rocks.

On the basis of the results of drilling survey done in the past two years, the low resistivity anomalies by CSAMT are considered to indicate zones dominated by pelitic rock and/or fractured zone aside from some ore deposits. From the results of physical properties measurement in the first and present phase, it has been proved that massive ore, vein network, black shale and some sandstone produce low resistivity anomalies . Therefore, the suitable method for the exploration in this zone is the IP survey. As the size of known massive orebodies is small except Aşiköy Deposit, it is necessary to conduct such IP survey that has the line and station allocation of short distance.

Drilling in third phase resulted in locating a massive ore deposit with the drilled length of 75 cm and 4% Cu grade at the area to the southwest of the Bakibaba Deposit. The location and depth of ore correspond the low resistivity zone defined by CSAMT. The characteristic of the ore is similar to that of the known ore deposits. The potential of the Cyprus-type ore deposit was confirmed by the drilling.

Argillization similar to that observed in the above mentioned drill hole occurs in the other drill hole at the north of the Bakibaba Deposit. So the area in the vicinity of this hole is promising for the future exploration.

Limonite network and dissemination are widely developed near the Bakibaba deposit. The past exploration in this area covered only a limited location and depth. An aggressive exploration covering a wide area is necessary.

Vein network and dissemination occur over the orebody at the Bakibaba Deposit. Overturned structure is inferred in the surrounding area. The main orebody of Kızılsu Deposit is believed to be the vein network in the footwall side of the orebody. On the basis of the above evidence, it is concluded that the gossan which is exposed between Bakibaba and Kızılsu Deposits is most probably the altered products in the footwall side of the mineralized zone. It is recommended that drilling survey should be carried out in this zone in the future.

Taşköprü Zone

Cozoğlu prospect is extracted as a promising area for a new mineral deposit through the first and second phase surveys.

The geology around Cozoğlu prospect is composed mainly of the Çangal meta-ophiolite, the Kızacik Formation of Lower Cretaceous, and the Alaçam Formation of Upper Cretaceous. The meta-ophiolite consists of pelitic schist, massive metabasalt and green schist. The Kızacik Formation consists of grayish white limestone and the Alaçam Formation of quartz arenite and black mudstone.

There are two openings of old adits, a large amount of slag and waste dumps on the surface. They are distributed in the Çangal meta-ophiolite.

The mineralized zone observed in outcrops in this prospect is only a weak dissemination of pyrite.

The results of geophysical survey (IP) in the second phase show that high chargeability anomalies are distributed from the above zones which are covered by slags and waste dumps to the eastern part of this prospect. The shape of these anomalies on cross sections and the geology may indicate that bedded cupriferous pyrite deposits probably occur within these zones.

The other high chargeability anomalies having similar values to the above mentioned anomalies are identified in the southern margin of the prospect, where is covered by the Çangal meta-ophiolite. It is considered that bedded cupriferous deposits may occur in these anomalous zones.

Dikmendağ Zone

Masköy prospect is extracted as a promising area for a new mineral deposit through geological survey conducted in the first phase.

It is considered that geophysical prospecting is necessary for this prospect, but the order of priority for the work is lower than that for above mentioned two zones because the surface manifestation of the mineralization is small.

CONTENTS

PART 2 KÜRE ZONE

PART 3 TAŞKÖPRÜ ZONE

PART 4 DIKMENDAĞ ZONE

PART 5 PREPARATORY INVESTIGATION FOR GEOCHEMICAL PROSPECTING

PART 6 CONCLUSIONS AND RECOMMENDATIONS

FIGURES

TABLES

Appendix Tables

PART 1 OVERVIEW

PART 1 OVERVIEW

CHAPTER 1 Introduction

1-1 Background and Objective of the Survey

The Turkey-Japan Cooperative Mineral Exploration has been carried out in four areas of the Republic of Turkey as an example, Çanakkale (1988-1990). As a result of these works, a large amount of information relevant to metallic mineral resources was obtained.

The Government of Turkey planned to conduct mineral exploration in the Küre area, and requested the cooperation of the Japanese Government. In December 1991, the Japanese Government, complying with the request, sent a mission for project- finding, discussing the Scope of Work and to make a preliminary survey trip to the area. As a result of consultations with Etibank, the counterpart of the Metal Mining Agency of Japan(MMAJ), an agreement was reached for cooperative mineral exploration work in the Küre area on March 11, 1992.

The principal objective of the project is to find a new mineral deposit in the Küre area through the exploration and examination of geology and mineralization. Technology transfer to the counterpart organization is also an important objective of the project.

The first phase survey of this project was carried out in fiscal 1992. The purpose of the first phase was to clarify the geological environment and thereby understand the occurrence and conditions of ore deposits of the Küre area. The works carried out in the first phase were; compilation of available geological and geophysical information, geological survey of the whole area, and geophysical survey over the Küre zone.

In fiscal 1993, four holes totaling 1,003.55m in length were drilled in the promising areas of the Küre zone, which were delineated by the geological and geophysical surveys during the previous year. Also two holes were electrically logged. Geophysical survey (IP, 21 line-km) was carried out at Cünür and Cozoğlu of the Taşköprü area since these were concluded to be promising by geological survey during the first year.

In fiscal 1994, drilling exploration comprising four holes totaling 953.70m in length continued on the Küre zone.

1-2 Outline of the Survey Area

The localities surveyed during the first phase are the Küre, Taşköprü and Dikmendağ zones. The coordinates of each zone are as follows.

Küre Zone (22 km² in area)

	Latitude	Longitude		Latitude	Longitude
1.	41°50.77'N	33°43.58'E	7.	41°47.73'N	33°41.40'E
2.	41°50.77'N	33°44.48'E	8.	41°48.27'N	33°40.98'E
3.	41°49.00'N	33°44.17'E	9.	41°49.00'N	33°40.25'E
4.	41°47.62'N	33°43.68'E	10.	41°49.92'N	33°41.05'E
5.	41°47.26'N	33°43.78'E	11.	41°50.48'N	33°43.67'E
6.	41°47.25'N	33°42.50'E			

Taşköprü Zone (559 km² in area)

	Latitude	Longitude		Latitude	Longitude
1.	41°31.63'N	33°49.63'E	5.	41°40.77'N	34°30.00'E
2.	41°37.50'N	34°01.07'E	6.	41°37.50'N	34°13.27'E
3.	41°43.85'N	34°03.77'E	7.	41°31.55'N	34°00.00'E
4.	41°43.65'N	34°30.00'E	8.	41°30.17'N	33°49.63'E

Dikmendağ Zone (66 km² in area)

	Latitude	Longitude		Latitude	Longitude
1.	41°51.36'N	33°30.36'E	3.	41°45.41'N	33°33.92'E
2.	41°51.34'N	33°35.42'E	4.	41°45.42'N	33°30.31'E

The localities surveyed during the second phase are the Küre and Tasköprü zones. The coordinates of each zone are as follows.

Küre Zone (6 km² in area)

	Latitude	Longitude		Latitude	Longitude
1.	41°49.00'N	33°41.12'E	4.	41°47.58'N	33°41.40'E
2.	41°49.00'N	33°43.04'E	5.	41°47.99'N	33°41.12'E
3.	41°47.55'N	33°43.09'E			

Cünür Prospect in Taşköprü Zone (2 km² in area)

	Latitude	Longitude		Latitude	Longitude
1.	41°34.07'N	33°59.56'E	3.	41°32.97'N	33°59.05'E
2.	41°33.65'N	34°00.08'E	4.	41°33.39'N	33°58.42'E

Cozoğlu Prospect in Taşköprü Zone (1 km² in area)

	Latitude	Longitude		Latitude	Longitude
1.	41°41.18'N	34°21.56'E	3.	41°40.49'N	34°22.27'E
2.	41°41.17'N	34°22.28'E	4.	41°40.49'N	34°21.55'E

The locality surveyed during the third phase is the Küre zone. The coordinates of the zone are as follows.

Küre Zone (6 km^2 in area)

	Latitude	Longitude		Latitude	Longitude
1.	41°49.00'N	33°41.12'E	4.	41°47.58'N	33°41.40'E
2.	41°49.00'N	33°43.04'E	5.	41°47.99'N	33°41.12'E
3.	41°47.55'N	33°43.09'E			

The location maps of each phase survey are shown in Figures 1-2, 1-3 and 1-4.

1-3 Method of Exploration

Methods and amount of work in each phase are summarized in Table 1-1.

1-4 Duration and Survey Team

(1) Mission for Project Finding

From 10 December 1991 to 18 December 1991

Turkish Members

Cumhur YILDIZ	Planning and Coordination Department
Sadik KAFADAR	Planning and Coordination Department
Ahmet ÜNSAL	Mineral Exploration Department

Japanese Members

Nobuyuki MASUDA	Metal Mining Agency of Japan (MMAJ)
Naotaka ADACHI	Metal Mining Agency of Japan (MMAJ)

(2) Mission for Scope of Work

From 7 March 1992 to 17 March 1992

Turkish Members

Taşkin AKDENIZ	General Manager, Etibank
N.Kemal ATALAN	Assistant General Manager
Ergün GÜRCAN	Head of Mineral Exploration Department
Cumhur YILDIZ	Ass. Director of Planning and Coordination Department

Japanese Members

Yasuo NOGUCHI	Metal Mining Agency of Japan
Norio NAKANO	Ministry of Foreign Affairs
Masahiko NISHITOH	Ministry of International Trade and Industry
Masamichi MAEJIMA	Japan International Cooperation Agency

Nobuyuki MASUDA	Metal Mining Agency of Japan (MMAJ)
Tetsuo SUZUKI	Metal Mining Agency of Japan (MMAJ)
Naotaka ADACHI	Metal Mining Agency of Japan (MMAJ)

(3) First Phase

Coordinators of MMAJ

From 11 July 1992 to 18 July 1992 :Nobuyuki OKAMOTO

From 9 September to 17 September 1992 :Takafumi TSUJIMOTO

:Kazuko MATSUMOTO

Survey Team : Geological and Geophysical Surveys:June 30-September 23

Turkish Side

Assistant General Manager Ibrahim BOZAN

Planning and Coordination Department

Director	Ayhan ALP
Mining Engineer	Sadik KAFADAR

Mineral Exploration Department

Director	Ergün GÜRCAN

Küre Mine

General Manager	Kemal Aydın ÇELİK
Deputy Manager	Fuat ATALAY
Deputy Manager	Mehmet ZENGIN
Deputy Manager	Irfan ŞIŞMANOĞLU

Survey Members of Etibank

Coordinator	Ahmet ÜNSAL
Geologist	Latif YIGIT
Geologist	Necmettin ÇELİK
Geologist	Mürsel ÖZTÜRK
Geophysicist	Tayfun AKKUŞ
Geophysicist	Orhan ERSÖZ

Japanese Side

Coordinator	Takafumi TSUJIMOTO (MMAJ)
Coordinator	Kazuko MATSUMOTO (MMAJ)
Coordinator	Nobuyuki OKAMOTO (MMAJ)
Team leader	Hisashi MIZUMOTO (NED)
Geologist	Yoneharu MATANO (NED)
Geologist	Kenji SATO (NED)
Geologist	Kazuyasu SUGAWARA (NED)
Geophysicist	Masao YOSHIZAWA (NED)
Geophysicist	Ikuo TAKAHASHI (NED)

Geophysicist   Shinichi SUGIYAMA (NED)

(4) Second Phase

Coordinators of MMAJ

From November 29 to December 9, 1993   :Atsuhiko MINOWA
:Nobuyuki OKAMOTO

Survey Team : Drilling Survey:August 28, 1993- January 6, 1994
Geophysical Survey:September 20- November 26, 1993

Turkish Side

Assistant General Manager   Ibrahim BOZAN

Mineral Exploration Department

Director	Ergün GÜRCAN
Ass. Manager	Şevket ORHON
Manager	Ekrem UTKUÇAL
Manager	Ihsan DUR

Küre Mine

General Manager	Kemal Aydın ÇELİK
Deputy Manager	Mahir TEZCAN
Deputy Manager	Mehmet ZENGIN
Chief Engineer	Muammer ŞAHİN

Survey Members of Etibank

Coordinator	Ahmet ÜNSAL
Ass. Coordinator	Necmettin ÇELİK
Drilling Engineer	Sadik KELESOGLU
Ass. Manager	Cemalettin SOLAK
Chief Driller	Ahmet TÜNCER
Geophysicist	Tayfun AKKUS,
Geophysicist	Orhan ERSÖZ

Japanese Side

Coordinator	Atsuhiko MINOWA (MMAJ)
Coordinator	Nobuyuki OKAMOTO (MMAJ)
Team leader	Yoneharu MATANO (NED)
Drilling Engineer	Saichi ISHII (NED)
Drilling Engineer	Itsuki HATAZAWA (NED)
Drilling Engineer	Tadateru SUGIBUCHI (NED)
Drilling Engineer	Soji KANNARI (NED)
Drilling Engineer	Mitsuo NOMURA (NED)
Drilling Engineer	Koichi TAMURA (NED)
Geophysicist	Masao YOSHIZAWA (NED)

Geophysicist	Ikuo TAKAHASHI (NED)
Geophysicist	Norikiyo SUGIURA (NED)

(5) Third Phase

Coordinators of MMAJ

From November 29 to December 9, 1993 :Takahisa YAMAMOTO (MMAJ)
:Yoshiaki IGARASHI (MMAJ)

Survey Team: Drilling Survey: September 27, 1994 - January 18, 1995

Turkish Side

Assistant General Manager Ismet SIVRIOĜLU

Mineral Exploration Department of ETiBANK

Director	Suat AYBEK
Ass. Director	Adil SUSOĜLU
Manager	Ahmet ÜNSAL
Manager	Ekrem UTKUÇAL
Manager	Ihsan DUR

Küre Mine

General Manager	Kemal Aydın ÇELİK
Deputy Manager	Mahir TEZCAN
Deputy Manager	Avni SAATÇIOĜLU

Survey Members of Etibank

Coordinator	Necmettin ÇELİK
Drilling Engineer	Sadik KELESOĜLU
Ass. Manager	Cemalettin SOLAK

Japanese Side

Coordinator	Takahisa YAMAMOTO (MMAJ)
Coordinator	Yoshiaki IGARASHI (MMAJ)
Team leader	Yoneharu MATANO (NED)
Drilling Engineer	Saichi ISHII (NED)
Drilling Engineer	Yoshio SASAKI (NED)
Drilling Engineer	Tadateru SUGIBUCHI (NED)
Drilling Engineer	Mitsuo SASAKI (NED)
Drilling Engineer	Mitsuo NOMURA (NED)
Drilling Engineer	Hiromasa INABE (NED)

Table 1-1 Summery of Exploration Work in the Küre Area

Phase	Survey	Area	Amount of Work
First	Study of existing information	Whole area	
	Geological Survey	Küre Zone Taşköprü Zone Dikmendağ Zone	Area: 22km^2 Area: 559km^2 Area: 66km^2 [Lab. Work] Thin Sections 137 pcs Polished Sections of Ore 60 pcs X-ray Diffraction Analysis 12 pcs EPMA 7 pcs Sulphur Isotope Analysis 7 pcs Chemical Analysis Whole Rocks 30 pcs Ore Assay (Au,Ag,Cu, Pb,Zn,Co,S) 124 pcs
	Geophysical Survey	Küre Zone	Area: 22km^2 CSAMT 513 points IP 4 km Rock Properties Measurement 43 pcs
Second	Drilling Exploration	Küre Zone	Area: 6km^2 Drilling (4 Holes) 1,003.55 m [Lab. Work] Thin Sections 28 pcs Polished Sections of Ore 9 pcs X-ray Diffraction Analysis 12 pcs Chemical Analysis Ore Assay (Au,Ag,Cu,Co,S) 22 pcs
	Geophysical Survey	Küre Zone	Area: 6km^2 Electric Logging (2 Holes)
		Taşköprü Zone Cünür Prospect	Area: 2km^2 IP 13.5 km Rock properties Measurement 12 pcs
		Cozoğlu Prospect	Area: 1km^2 IP 7.5 km Rock Properties Measurement 11 pcs
Third	Drilling Exploration	Küre Zone	Area: 6km^2 Drilling (4 Holes) 953.70 m [Lab. Work] Thin Sections 15 pcs Polished Sections of Ore 11 pcs X-ray Diffraction Analysis 9 pcs Chemical Analysis Ore Assay (Au,Ag,Cu,Co,S) 31 pcs Rock Properties Measurement 30 pcs

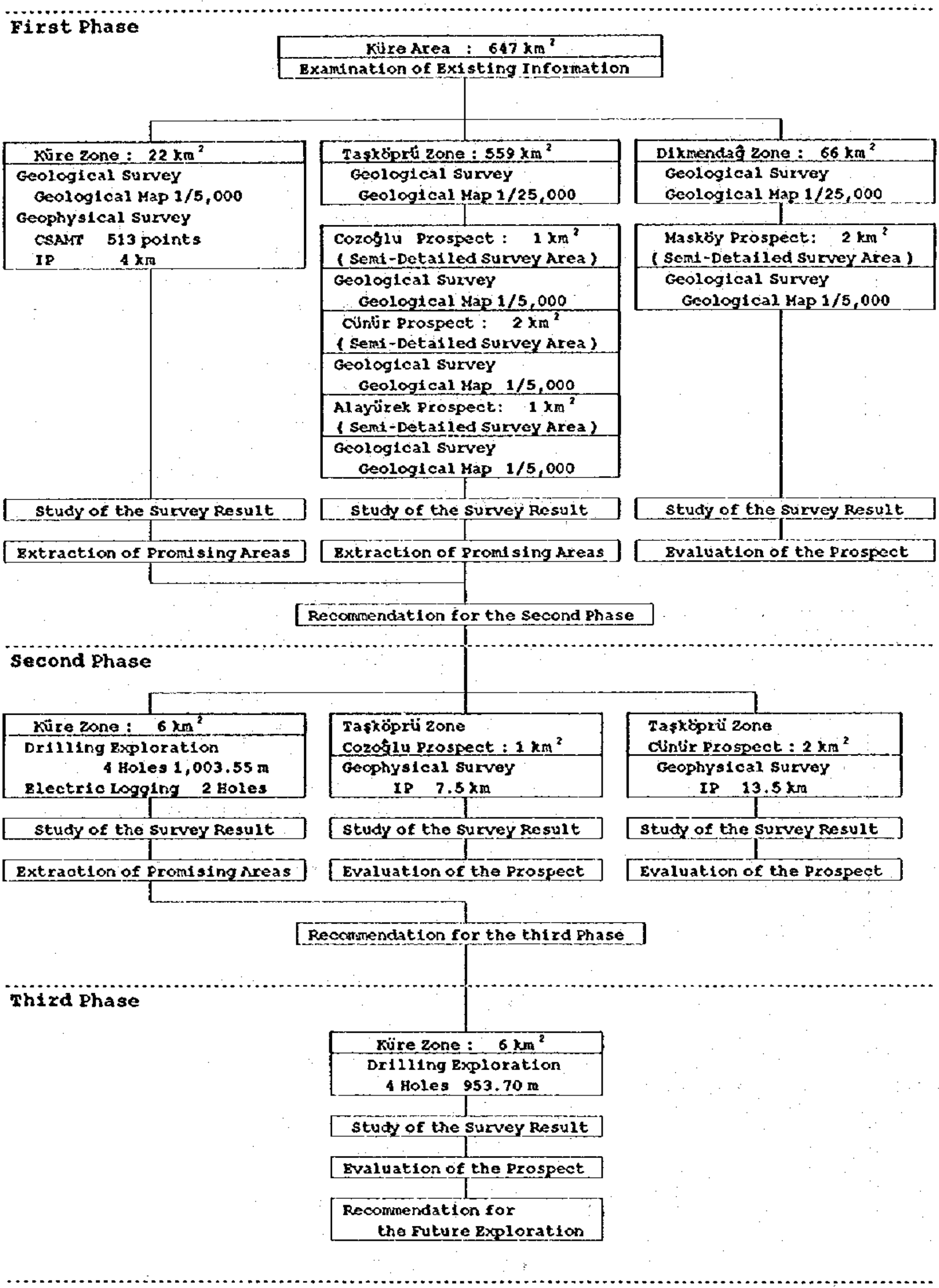


Fig. 1-5 Flowsheet of Survey in the Küre Area

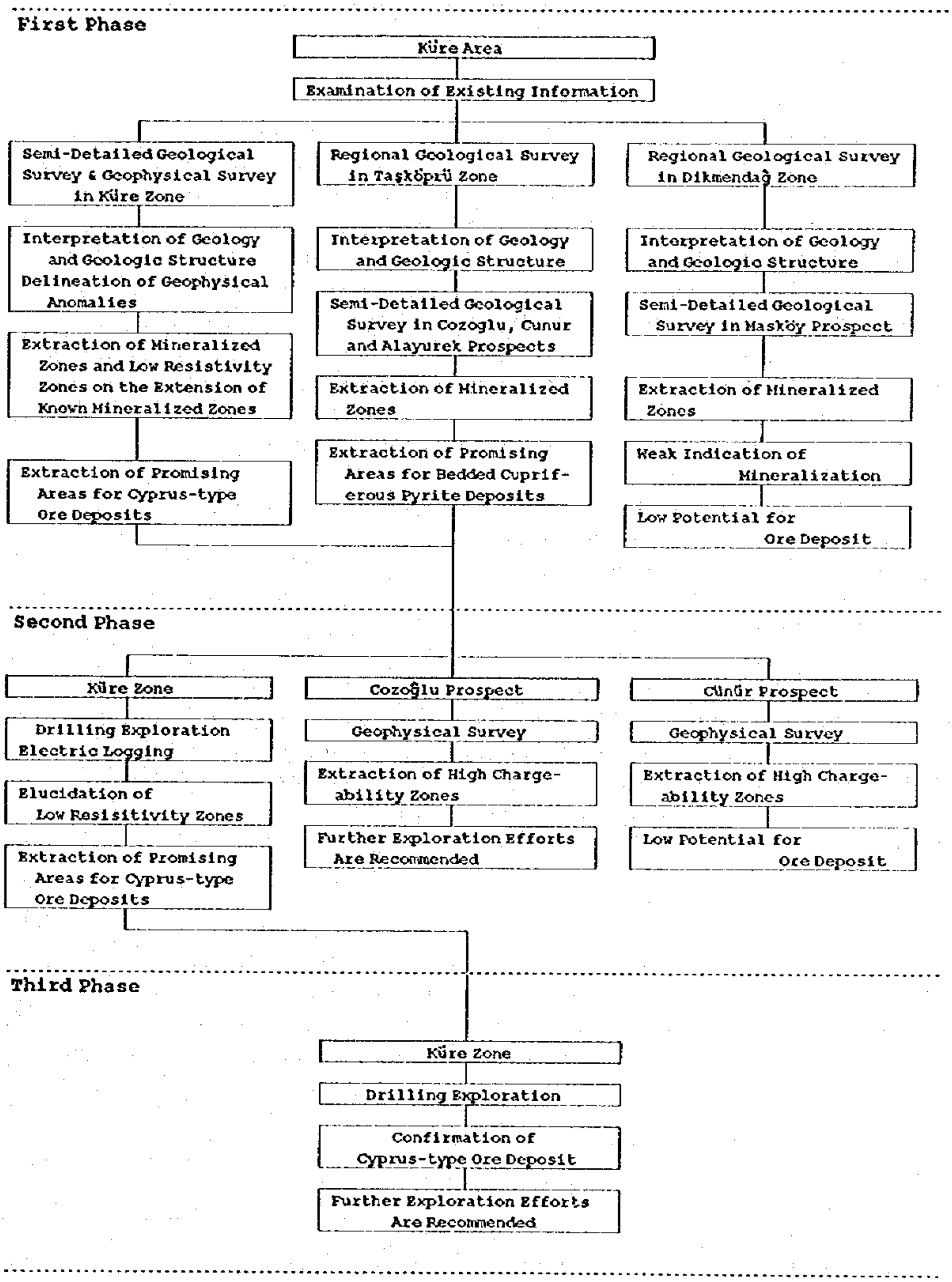


Fig. 1-6 Flow Chart Illustrating the Exploration Step in the Küre Area

CHAPTER 2 Geography

2-1 Location and Access

The Küre mining district is located 50 km north of Kastamonu City, which with a population of 50,000 is the capital of the province and is the largest city in the northern Anatolia. The area is located about 225 km north of Ankara and 400 km east of İstanbul, the largest city in Turkey.

The main road in the area is National Highway 765 traversing Küre area in the north-south direction and also Provincial Highway 30 runs parallel to the Gökırmak River. These roads are almost totally paved. There are also roads connecting the highways and the villages. These are not paved and although is passable in the winter, they are not gravelled and at times become impassable to vehicles particularly in the rainy season. İnebolu-Kastamonu-Ankara road is paved and good, but the bus service is intermittent and inconvenient for the 56 km between Kastamonu and Küre.

The base camp for each phase was established at the Küre Mine.

2-2 Topography and Drainage System

2-2-1 Topography

The Küre area is located in the northern part of the Anatolia plateau. It is bounded to the north by the Black Sea and to the south by the northern Anatolia Fault extending in the E-W direction. Küre Range traverses the survey area in the east-west direction, represented by Mt. Karakuz (1,435 m) in the west and Mt. Çangal (1,605 m) in the east. The topography is relatively rugged and the elevation is about 1,000 m near the Küre mine.

2-2-2 Drainage System

Küre area is located in the upper reaches of Gökırmak River which flows eastward. Küre and Dikmendağ areas are both situated in the upper reaches of Karacehennemboğazı River which flows into the Black Sea. Most of these rivers flow only in the spring thaw. In the Küre Range, streams flow and it drizzles even in the summer.

2-3 Climate and Vegetation

2-3-1 Climate

The annual precipitation and annual average temperature in Küre area are estimated to be more than 600 mm and 10°C respectively, while those of Kastamonu in the inland zone are 400mm and 9.1°C. The survey area is somewhat higher in altitude and the average temperature is estimated to be around 10°C. It is cool in the summer and the winters are quite cold with snowfall amounting to 3 m during December to March.

Along the Gökırmak River from Kastamonu to Taşköprü lies a very fertile flat land with vegetable farms, orchards, wheat growing and cattle raising are flourishing. In the intermontane flats, wheat is grown and forestry is very prosperous.

The monthly average temperature and precipitation recorded by the Kastamonu Meteorological Station is as follows.

Table 1-2 Monthly Temperature of Kastamonu

Month(°C)	Jan	Feb	Mar	Apl	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Max.	17.0	14.2	26.4	23.8	26.0	32.0	35.0	35.0	29.2	29.0	17.0	9.8	
Min.	-8.9	-6.8	-2.4	-2.1	5.2	10.0	11.1	10.5	0.5	4.3	-3.8	-10.0	
Average	-2.5	-0.7	4.7	9.1	12.9	16.9	19.6	19.8	14.8	10.8	4.1	-0.8	9.0

(Data range from 1989 to November 1993)

Table 1-3 Monthly Precipitation of Kastamonu

	Jan	Feb	Mar	Apl	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Ave. (mm)	20	12	18	47	64	96	24	19	24	39	36	37	438

(Data range from 1989 to November 1993)

CHAPTER 3 Geology of the Survey Area

3-1 General Geology of Kastamonu Region

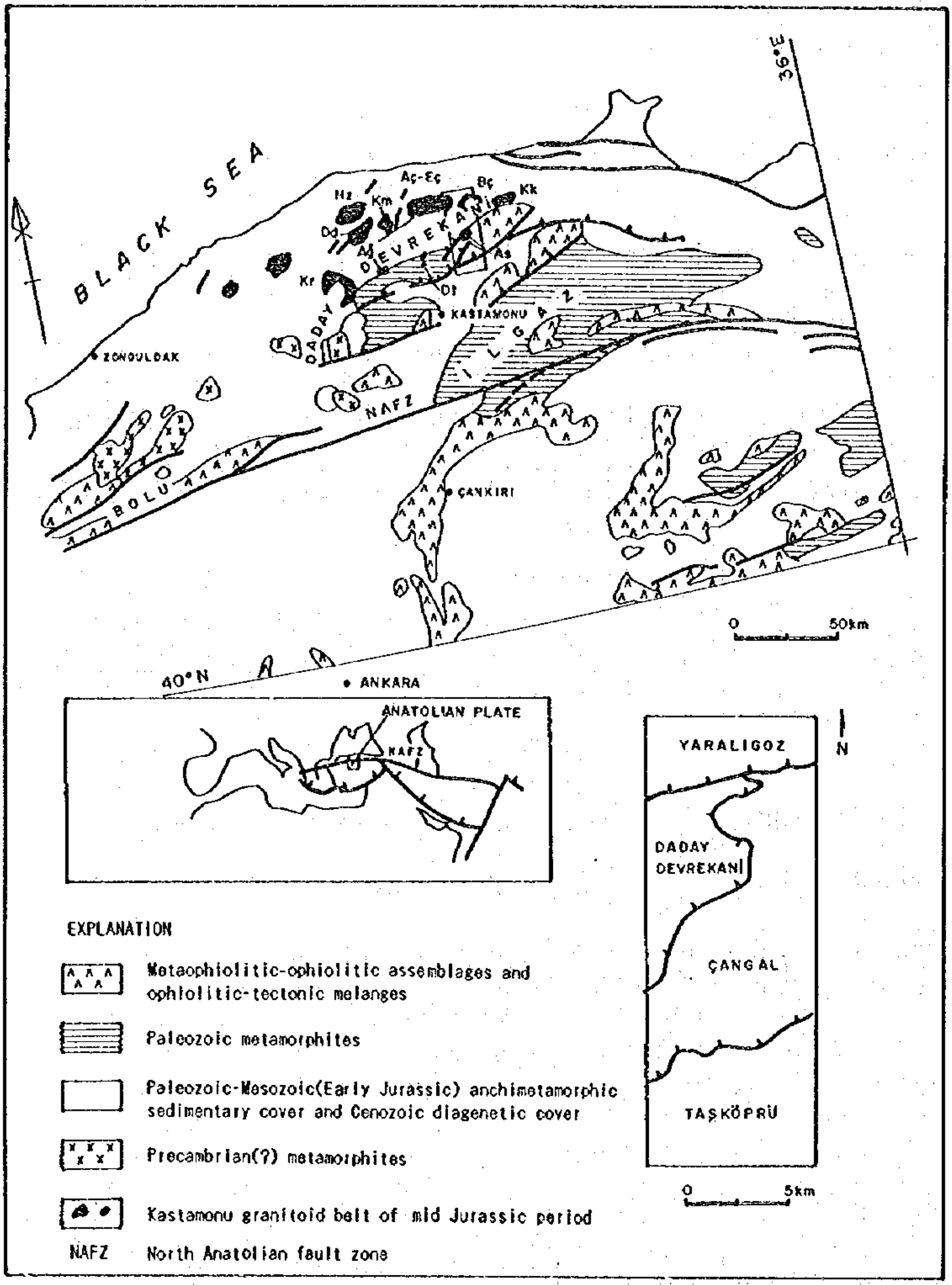
The Kastamonu region, bounded by the Bolu metamorphic massif on the west, covers the Daday-Devrekani metamorphic massif in the central part and the Ilgaz metamorphic massif to the east. It includes granitoid intrusions.

The Bolu massif consists of a metamorphic assemblage of Precambrian period, formed under the middle-pressure amphibolite facies and overlain by Silurian-Devonian age non-metamorphic arkose conglomerate.

The Ilgaz massif consists of metamorphic rocks of Precambrian period, formed under the conditions from glaucophane schist to green schist facies.

Two tectono-stratigraphic assemblages have been identified in the Daday-Devrekani massif. From bottom to top, they are composed of the Daday-Devrekani meta-sedimentary group of Precambrian period and the Çangal meta-ophiolite of pre-Liassic epoch.

Four major formations which are underlain by the above mentioned massif are distributed in the region; Akgöl Formation, Bürnük Formation, Inalti Formation



Structural-geologic map of Kastamonu granitoid belt and surrounding areas, modified after Yılmaz (1979) and Boztuğ et al.(1985). Rectangle outlines: mapped area, enlarged at lower right. Granitoid outcrops: Bç, Büyükçay; Aç-Eç, Ahiçay-Elmaliçay; Kk, Karacakaya; As, Asarcık; Dd, Dikmendağ; Hz, Hayzer; Ağ, Ağlı; Kr, Kürek; Km, Karaman; Dt, Deverkani town.

Fig. 1-7 Structural-Geologic Map of Kastamonu Granitoid Belt and Surrounding Areas

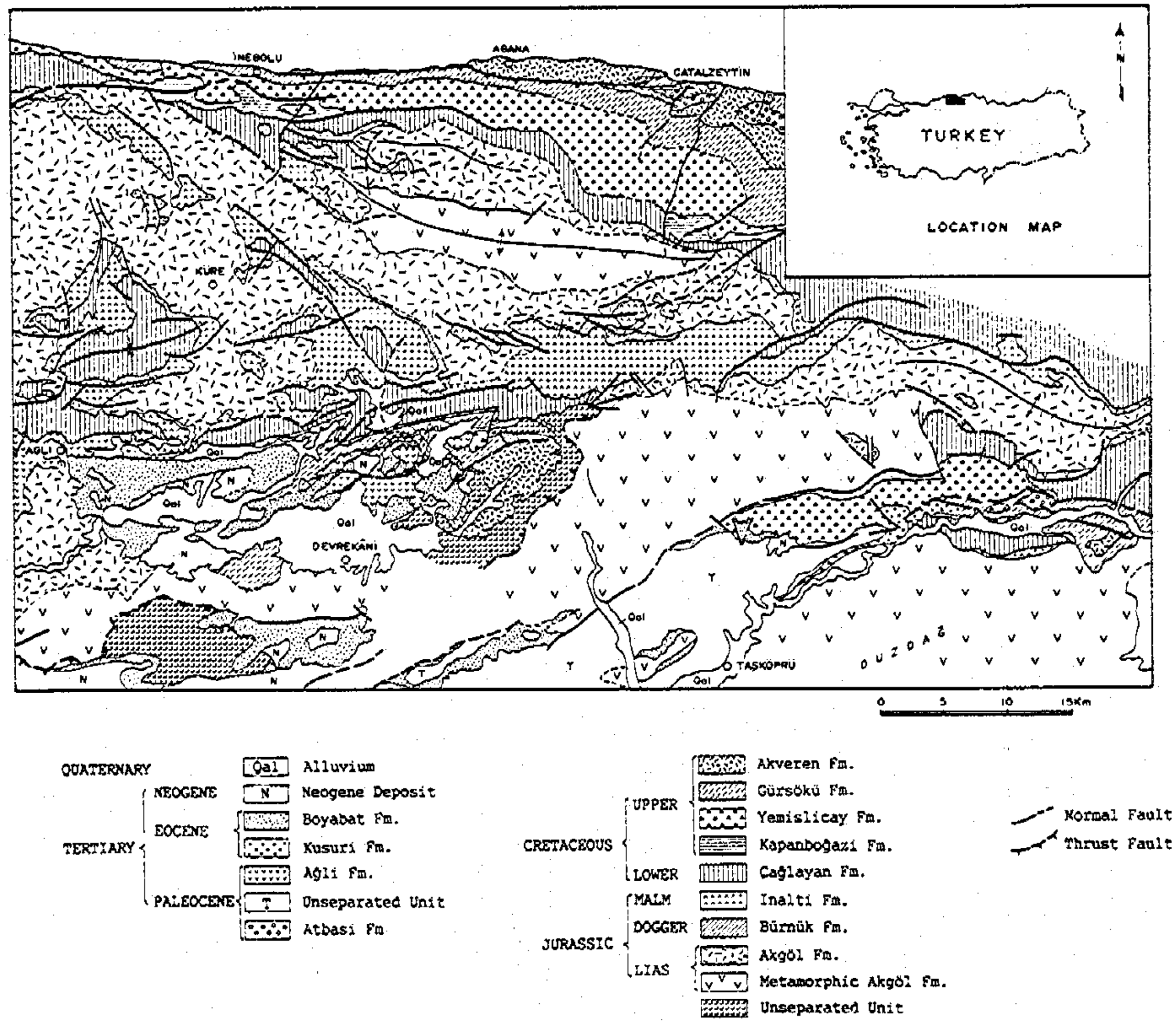


Fig. 1-8 Geologic Map of the Inebolu-Kastamonu Area

and Çağlayan Formation.

The Akgöl Formation is composed of black shale, siltstone, fine-grained sandstone, limestone, spilite, diabase, gabbro and serpentinite. It has a common feature of deep marine environment. Some part of this formation are metamorphosed due to the Early Dogger tectonics and by the Dogger intrusions.

The Bürnük Formation which deposited in intermontane alluvial environment has lithologies such as red colored conglomerate, sandstone, siltstone and sandy limestone of Later Dogger to Early Malm epoch.

The Inalti Formation consists of calcareous rocks and sandstone of shallow marine environment of Malm epoch. It is mostly unconformable with the overlying Cretaceous system.

The Çağlayan Formation of Aptian-Cenomanian epoch consists of turbidity sandstone, conglomerate and carbonaceous shale.

3-2 Geology and Geologic Structure of the Survey area

(1) Küre Zone

The geology of the Küre zone consists of pre-Jurassic ultramafic rocks, Jurassic basalt, sedimentary rocks of the Küre Formation, grayish white fossiliferous limestone of the Lower Cretaceous Karadana Formation, pale brown and white marl of the Upper Cretaceous Çağlayan Formation, talus deposits, intrusive diorite and dacite. The major part of the zone is occupied by the Jurassic Küre Formation. The basalt is composed of pillow lava, hyaloclastite, and massive basalt. Sedimentary facies of the Küre Formation is composed of angularly fragmented graywacke and tectonically sheared/argillized black shale. The matrix consists of pelitic materials.

Basalt and brecciated sediments of the Küre Formation are interpreted as a constituent of melange.

The geologic structure of this zone is characterized by many faults. They are divided into two systems; N-S and E-W. The former system is crosscut by the latter. With the exception of diorite and dacite intrusive bodies and the Karadana Formation, the boundaries of all geologic units, including ultramafic bodies, have been displaced. The surface elongation of the intrusive bodies is harmonious with the strike of faults in the vicinity and with the boundary between sediments and basalt of the Küre Formation.

(2) Taşköprü Zone

The basement of this zone is composed of biotite gneiss of the Devrekani metamorphic rocks. This rock occurs in the northwestern part of the zone.

The Çangal meta-ophiolite has the largest exposure in fault contact with underlying Devrekani metamorphic rocks. The meta-ophiolite is composed of serpentinite, meta-basalt, green schist and pelitic schist.

The Kayadibi Formation occurs in the eastern part of this zone, comprising black shale, siltstone, fine-grained sandstone, limestone and basalt.

The Muzrup Formation of Latest Dogger to Early Malm epoch is distributed in the southern margin of the zone, covering unconformably on the Kayadibi Formation. This formation consists of red conglomerate, sandstone, siltstone and psammitic limestone.

Being underlain unconformably by the Muzrup Formation, the Kızacik Formation occurs in the northern margin of the zone. It is composed of calcareous rock and calcareous sandstone.

The Alaçam Formation consists of turbiditic sandstone, conglomerate and calcareous shale. It is distributed in the southern margin of the zone, and is underlain unconformably by the lower formation.

The Çayköy Formation is exposed in the southern part of the zone, comprising of sandstone, andesite lava and andesitic pyroclastic rocks. This formation has an unconformable relationship with underlying Alaçam Formation.

Granite occurs in the northern and eastern parts of the zone. Dacite is exposed in the central part of the zone.

The geologic structure of the Çangal meta-ophiolite is difficult to interpret because of the metamorphism. It is, however, inferred that the beds are generally steeply dipping and extend in the east-west direction.

(3) Dikmendağ Zone

The geology of the zone consists of Küre Formation, Köstekciler Formation and Satıköy Formation.

Küre Formation is composed of basalt and sedimentary rocks comprising black shale, siltstone and fine-grained sandstone. Sedimentary rocks occupies the major part of this formation.

Köstekciler Formation consists of calcareous rock and calcareous sandstone of Lower Cretaceous.

Satıköy Formation is composed of turbiditic sandstone, conglomerate and calcareous shale of Upper Cretaceous.

Dacite and diorite intrude into Küre Formation and the size of those intrusion is small.

Küre Formation is considered to be a melange same as that of Küre zone.

Köstekciler Formation and Satiköy Formation overlying Küre Formation have a synclinal structure with a NE-SW trending axis.

Köstekciler Formation adjoin with Küre Formation in relation of fault contact in the southern part of the zone.

3-3 Mineralization

(1) Küre Zone

Aşıköy, Toykondu, Bakibaba, and Kızılsu are the known ore deposits in this zone. These deposits occur at the boundary between hyaloclastite and black shale of the Küre Formation. They also occur within hyaloclastite. The other large mineralized zone which is distributed on the surface occurs in Zemberekler.

The Aşıköy deposit is the largest one in this zone. It is composed of many orebodies which have the largest dimensions of 380m east to west, 200m north to south, and 15 to 30m thick.

Ores are classified into massive ore, brecciated ore comprising fragments of massive ore filled in a matrix of chalcopyrite and pyrite, brecciated ore comprising subrounded to subangular massive ore fragments of 10 to 30cm in diameter in black shale, network ore and disseminated ore. The ore contains very large amount of pyrite with smaller amounts of chalcopyrite, sphalerite and marcasite, and minor amount of covelline, tetrahedrite and pyrrhotite. The gangue minerals are quartz with rutile, leucoxene, clay minerals and carbonates.

The ore grade of Aşiköy in drill cores ranges from 1 to 9 % Cu and from 40 to 48 % S.

Hyaloclastite on the footwall side of massive ore is sometimes silicified for a thickness of 1-3 m containing a large amount of quartz and minor sericite. The host rock of network zone is generally green, but it is bleached and silicified where the network is dense and sulfide minerals are strongly disseminated.

The Toykondu Deposit comprises a massive orebody with 200 m x 50 m extension in a locality further north of the northern part of Aşıköy pit and several smaller bodies (50 m x 20 m) nearby.

The orebody to the north of the above pit confirmed by drilling is 3-15 m in core width with Cu 1-4 %, S 32-51 %.

The Toykondu massive ores contain large amount of pyrite, smaller amounts of chalcopyrite and sphalerite, and minor content of bornite, tetrahedrite, marcasite and pyrrhotite. The gangue mineral is quartz.

Hyaloclastite immediately below the massive orebody is leached and silicified (1-2 cm thick), but underlying hyaloclastite does not show signs of alteration except the occurrence of hematite.

Bakibaba Deposit comprises black shale, sandstone and massive orebody emplaced at the boundary of or within hyaloclastite. The massive orebody extends in the dip direction and the lateral section is oblong to circular with size ranging from 40 x 70 - 80 x 80 m. The dip of the orebody id 50-60° SE and extends over 130 m.

The Bakibaba massive ore contains a large amount of pyrite, smaller amounts of chalcopyrite and sphalerite, and minor amounts of covelline and pyrrhotite. The major gangue mineral is quartz. There are locally high grade parts with Cu 4-15 %, and S over 40 %.

Sulfide minerals on the surface have been oxidized to reddish colour within 600 x 500 m of Bakibaba Deposit.

Kızılsu Deposit consists of network and massive orebodies emplaced in hyaloclastite. The lateral extent of the orebodies are in the order of 300 x 150 m. Drilling results confirm that most of the orebodies are network and the massive body is 80 x 40 m in lateral extent and the core width is 15 m. Both massive and network ore contain a large amount of pyrite, smaller amount of chalcopyrite, and minor amount of sphalerite, bornite, covelline, tetrahedrite and marcasite. The major gangue mineral is quartz.

The assay of massive ore shows Cu 4 %, S 40 %. The upper parts of the orebodies are gossan and the host rock hyaloclastite is silicified and leached with a large amount of quartz and some sericite.

The geologic environment, mode of occurrence, and mineral composition of these orebodies show a common feature which is characteristic to the Cyprus-type ore deposits.

(2) Taşköprü Zone

Three types of sulfide mineralization are observed in this zone; bedded, lens-shaped and dissemination. The mineralization with a large amount of pyrite, a small amount of chalcopyrite and a minor amount of sphalerite occurs in the zone which is occupied mainly by metabasalt and green schist. The mineralization is accompanied by silicification and argillization.

There is also a zone where a large amount of slags and abandoned adits occur, but no mineralization has been discovered at the surface outcrops and within waste dumps.

Bedded cupriferous pyrite deposits are possibly expected in this zone.

(3) Dikmendağ Zone

A mineralized zone comprising limonite network and pyrite dissemination over an area of 300x50m occurs in basalt adjoining with dacite intrusion. Pyrite dissemination in basalt appears in two localities of the southern parts in small scale.

Aside from the mineralized zone, slag is discovered at three localities.

It is possible that Cyprus-type copper mineralization is expected to occur in this zone, as basalt similar to that of Küre zone is distributed in the zone

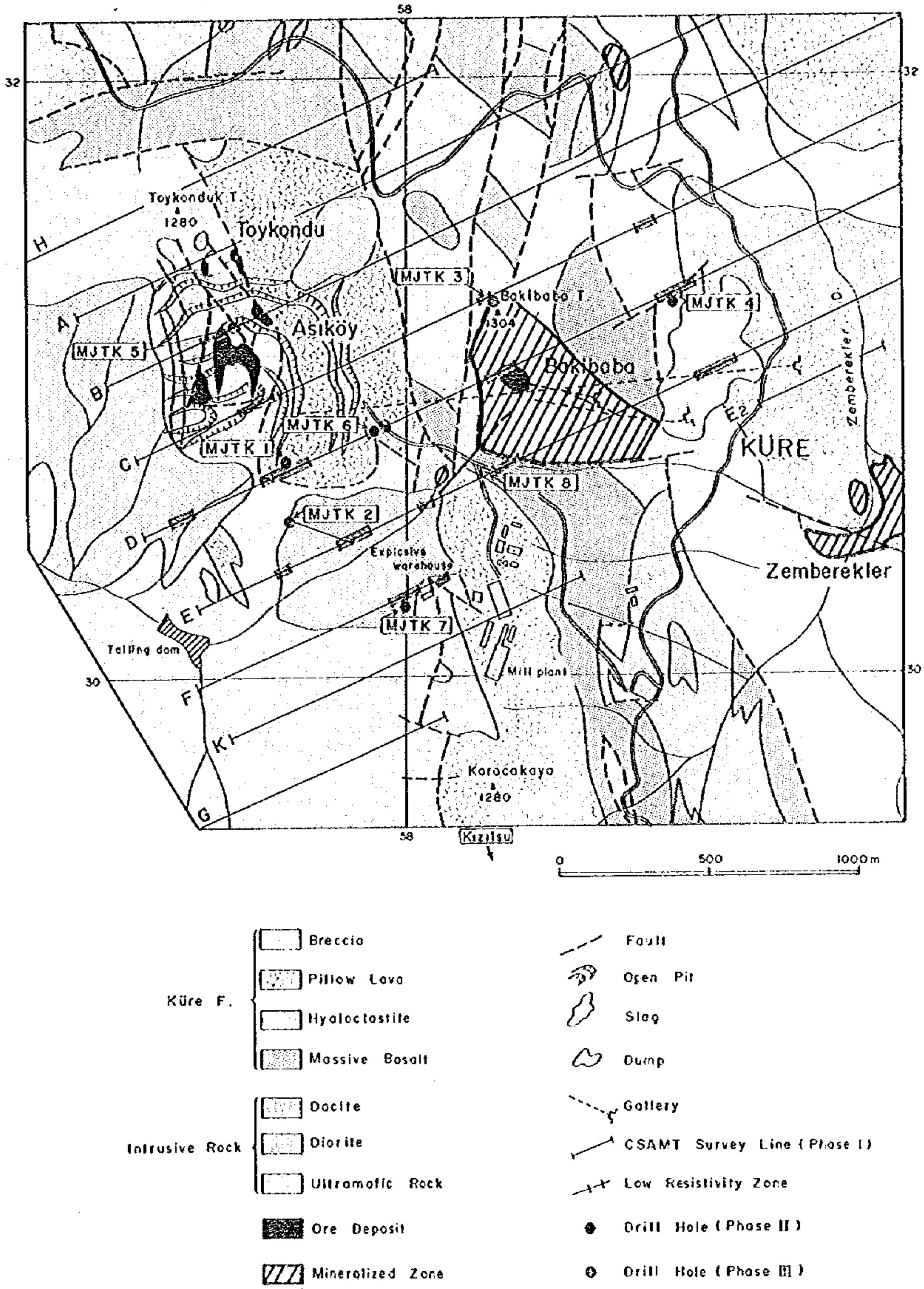


Fig. 1-9 Integrated Interpretation of the Survey Results in the Küre Zone

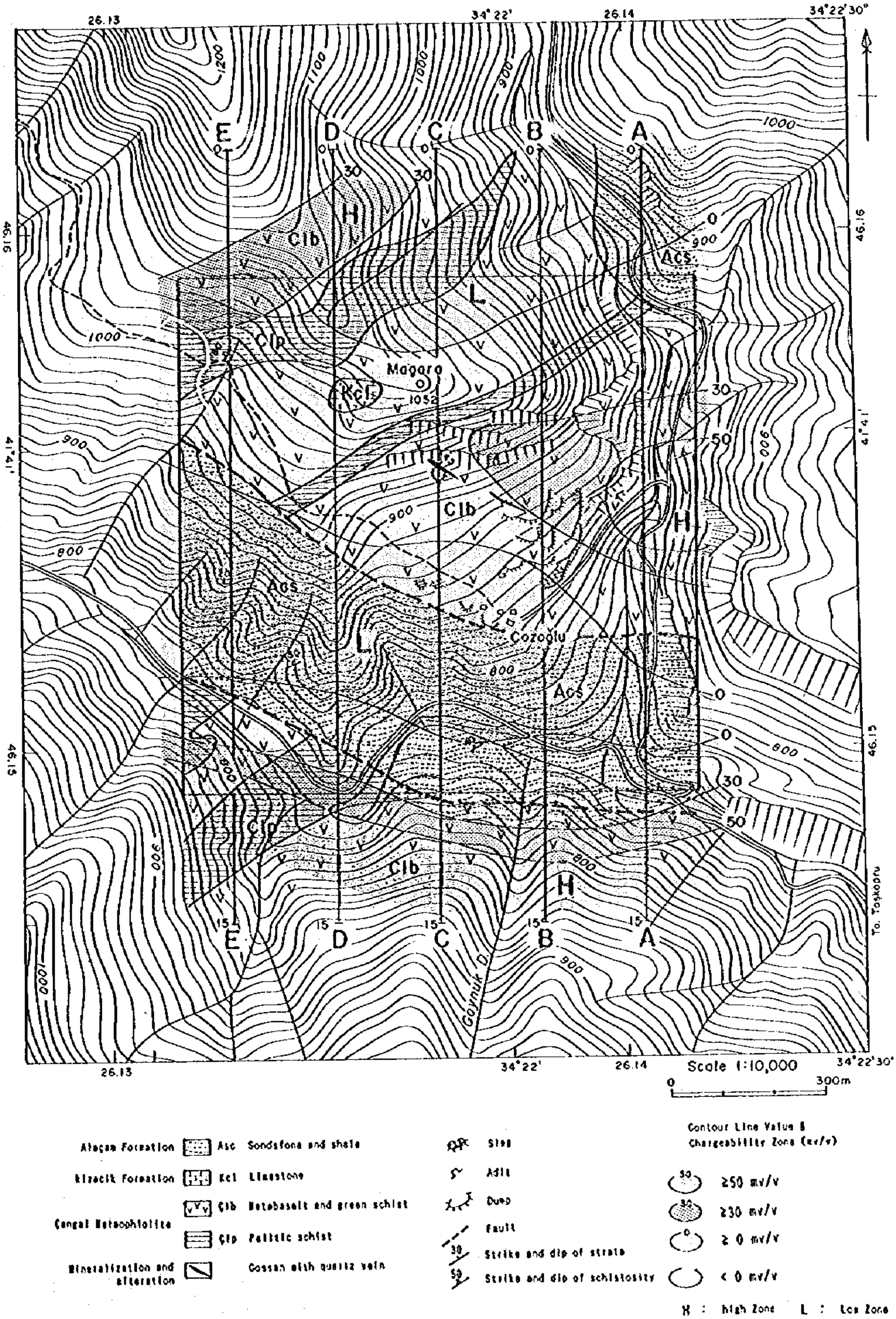


Fig. 1-10 Integrated Interpretation of the Survey Results in the Cozoğlu Prospect in the Taşköprü Zone

CHAPTER 4 Conclusions and Recommendations

4-1 Conclusions

4-1-1 Küre Zone

In the first phase survey, the conducted works were; compilation of available geological and geophysical information, geological survey, and geophysical survey comprising CSAMT and IP.

In the second phase, four holes totaling 1,003.55m in length were drilled in the promising areas of the Küre zone, which were delineated by the geological and geophysical surveys during the previous year. Also two holes were electrically logged.

In the third phase, drilling exploration comprising four holes totaling 953.70m in length continued.

Following conclusions are obtained as the results of the above works.

(1) The geology of the zone consists of pre-Jurassic ultramafic rocks, Jurassic basalt, sedimentary rocks of the Küre Formation, grayish white fossiliferous limestone of the Lower Cretaceous Karadana Formation, pale brown and white marl of the Upper Cretaceous Çağlayan Formation, talus deposits and intrusive diorite and dacite.

(2) The major part of the zone is occupied by the Jurassic Küre Formation. The basalt is composed of pillow lava, hyaloclastite, and massive basalt. Sedimentary facies of the Küre Formation is composed of angularly fragmentated greywacke and tectonically sheared/argillized black shale. The matrix consists of pelitic materials.

Basalt and brecciated sediments of the Küre Formation are interpreted as a constituent of melange. The period of melange formation is inferred to be Middle Jurassic, since intrusion into the melange is inferred to be Later Dogger epoch.

(3) The geologic structure of this zone is characterized by many faults. They are divided into two systems; N-S and E-W. The former system is crosscut by the latter. With the exception of the diorite and dacite intrusive bodies and the Karadana Formation, the boundaries of all geologic units, including ultramafic bodies, have been dislocated. The surface elongation of the intrusive bodies is harmonious with the strike of the faults in the vicinity and with the boundary between sediments and basalt of the Küre Formation.

Basalt is distributed extending to N-S and NNW-SSE direction with imbricate structure.

(4) The known ore deposits are the Cyprus-type deposits. The new ore deposits of the same type are expected to occur in the zone. They occur at the boundary between hyaloclastite and black shale of the Küre Formation and also within hyaloclastite. They consist of massive ore, brecciated ore, network ore and disseminated ore.

(5) Ore deposits together with footwall mineralized zone and hanging-wall pelitic rock are considered to be dislocated by the tectonic movements.

(6) Drilling in this study resulted in locating a massive ore with the drilled length 75 cm long and 4% Cu grade at the area to the southwest of the Bakibaba Deposit. The location and depth of ore correspond a weakly low resistivity zone defined by CSAMT. The characteristic of ore is similar to that of the known ore deposits. The potential of the Cyprus-type was confirmed by the drilling.

(7) A low resistivity zone obtained at the north of Bakibaba Deposit by CSAMT consists of basalt. Veinlets composed mainly of pyrite were observed in this zone. The lithology and mineralization of this hole are considered not to cause this low resistivity. Argillization similar to that observed in the above mentioned drill hole occurs in this hole. Thus, the area in the vicinity of this hole is promising for the future exploration.

(8) Drilling at the northern extension of Zemberekler mineralized zone results in finding a mineralized zone. The zone which is located in the N-S and NNW-SSE extensions from the Zemberekler mineralized zone with low resistivity anomalies, are promising for future exploration.

(9) In the low resistivity zone to the south of Aşıköy Deposit, it was anticipated that massive orebodies would occur in the shallow parts due to displacement by a fault. The results of the survey in the second and this phase indicate that this low resistivity zone represents pelitic rocks and fault fractured zone. Therefore, it is considered that the possibility of the existence of massive orebodies of the scale of Aşıköy is low. The existence of massive orebodies expected to occur in the deep parts could not examine due to the shortness of the drilling length.

(10) Limonite network and dissemination are widely developed near the Bakibaba Deposit. The past exploration of this area covered only a limited location and depth. An aggressive exploration covering a wide area is necessary.

(11) The massive deposit confirmed at the south of Bakibaba Deposit is accompanied by a silicified zone. Noting this characteristic, the silicified zones

of Mt. Bakibaba to the north of Bakibaba Deposit and Mt. Karacakaya between the Bakibaba and Kızılsu Deposits will be targets for exploration.

(12) Vein network and dissemination occur over the orebody at Bakibaba Deposit. Overturned structure is inferred in the surrounding area. The main orebody of Kizilsu Deposit is believed to be the vein network in the footwall side of the orebody.

On the basis of the above evidence, it is concluded that the gossan which is exposed between Bakibaba and Kizilsu Deposits is most probably the altered products in the footwall side of the mineralized zone.

(13) On the basis of the results of drilling survey done in the past two years, the low resistivity anomalies by CSAMT are considered to indicate zones dominated by pelitic rocks and/or fractured zones aside from some ore deposits. From the results of physical properties measurement in the first and third phase, it have been proved that massive ore, sulfide network, black shale and some sandstone cause low resistivity anomalies. Therefore, the suitable method for the exploration in this zone is the IP survey. As the size of known massive orebodies is small except Aşiköy Deposit, it is necessary to conduct such IP survey that has the line and station allocation of short distances.

4-1-2 Taşköprü Zone

In the first phase survey, the conducted works were; compilation of available geological and geophysical information, and geological survey.

In fiscal 1993, geophysical survey (IP, 21 line-km) was carried out at Cünür and Cozoğlu of the Taşköprü zone since these were concluded to be promising by geological survey during the first year.

Following conclusions are obtained as the results of the above works.

(1) The geology of the zone consists of Devrekani metamorphics, Çangal meta-ophiolite, Kayadibi Formation, Muzrup Formation, Kızacik Formation, Alaçam Formation and Çayköy Formation in ascending order.

(2) Mineralization occurs in Cozoğlu, Cünür, Alayürek, Boyalı, Musabozarmut, Sey Yayla, Kepez and East of Cünür.

(3) The geology around the Cünür prospect is the Çangal meta-ophiolite consisting of pelitic schist, massive basalt, and green schist. The mineralized zone in this prospect is composed of eight lenses and bedded gossans in green schist. The gossans consist of quartz-limonite-pyrite network and limonite dissemination in the silicified and argillized parts of mafic rocks.

The results of time-domain IP survey show that resistivities of the zone extended below gossans are similar to those of the surrounding non-mineralized zone, and chargeabilities are lower than those of the surrounding silicified zones. The size of mineralized zones expected to occur below gossans is estimated to be small.

Blind mineralized zones may not be expected below the extensively silicified zone which occurs around gossans, because chargeabilities of the zones below silicified zone are similar to those of surface outcrops.

High chargeability anomalies are identified at the southern margin of the zone. These anomalies are located adjoining to the silicified zone. The shape on cross sections, chargeabilities, resistivities of these anomalies and geology suggest that these anomalies may indicate the existence of disseminated sulphide minerals.

(4) The geology around Cozoğlu prospect is composed mainly of the Çangal meta-ophiolite, the Kızacik Formation, and the Alaçam Formation. The meta-ophiolite consists of pelitic schist, massive metabasalt and green schist. The Kızacik Formation consists of grayish white limestone and the Alaçam Formation of quartz arenite and black mudstone.

There are two openings of old adits, a large amount of slag and waste dumps on the surface. They are distributed in the Çangal meta-ophiolite.

The mineralized zone observed in outcrops in this prospect is only a weak dissemination of pyrite.

The results of geophysical survey in the second phase show that high chargeability anomalies are distributed from the above zones which are covered by slags and waste dumps to the eastern part of this prospect. The shape of these anomalies on cross sections and the geology may indicate that bedded cupriferous pyrite deposits probably occur within these zones.

The other high chargeability anomalies having similar values to the above mentioned anomalies are identified in the southern margin of the prospect, where is covered by the Çangal meta-ophiolite. It is considered that bedded cupriferous deposits may occur in these anomalous zones.

4-1-3 Dikmendağ Zone

In the first phase survey, the conducted works were; compilation of available geological and geophysical information, and geological suıvey.

Following conclusions are obtained as the results of the above works.

(1) The geology of the zone consists of Küre Formation of Lias, Köstekciler Formation of Lower Cretaceous, Satıköy Formation of Upper Cretaceous and, intrusive dacite and diorite.

(2) Masköy mineralized zone is located in the northeastern part of the zone. Aside from this zone, pyrite dissemination in basalt occurs in the north of Furuncuk village and around Ornu village. Slag is also distributed 1 km south and 1.6 km southeast of Ornu, and 1 km south of Furuncuk.

(3) The size of pyrite dissemination is small except of Masköy mineralized zone. The order of priority for the future exploration in these mineralized locations is lower than that of Masköy prospect.

(4) Masköy mineralized zone consists of limonite network and pyrite dissemination over an area of 300x50m. The host rock is basalt and it is silicified to dark gray in the pyrite disseminated part of the zone. Dacite occurs in the vicinity, but it is fresh without evidences of alteration. There is not enough geological data to discuss whether this mineralization is Cyprus-type because surface manifestation of the mineralization is weak.

4-2 Recommendations for the Future Exploration

4-2-1 Küre Zone

It is recommended that drilling exploration should be carried out in the following localities for the purpose of clarifying the conditions of subsurface copper mineralization.

(1) Detailed drilling survey in the vicinity of MJTK-8, the south and the north of Bakibaba Deposit

(2) An area between Bakibaba and Kızılsu Deposits

(3) An area from the east of Bakibaba Deposit to Zemberekler mineralized zone

IP survey is recommended to carry out over the low resistivity zones by CSAMT, where have not been explored by drilling in this study.

4-2-2 Taşköprü Zone

In Cozoğlu prospect, it is recommended that drilling works should be carried out in the geophysical anomalies which are identified in the east of the localities where are occupied by slags for the purpose of clarifying the conditions of subsurface copper mineralization.

4-2-3 Dikmendağ Zone

It is considered that geophysical prospecting is necessary for Masköy prospect for the future exploration, but the order of priority for the work is lower than that for above mentioned two zones because the surface manifestation of the mineralization is small.

PART 2 KÜRE ZONE

PART 2 KÜRE ZONE

CHAPTER 1 OUTLINE OF THE ZONE

1-1 Introduction

Küre zone was extracted as a promising zone for a further study, as Küre Mine, an operating mine is located in this zone and it is expected that similar mineralization as known ore deposits is distributed in this zone.

This zone covers an area of 22 square kilometers and is the mining claim of ETiBANK.

This zone is located in the central northern part of the Küre area. The land consists of steep and well-vegetated mountains. The Bakibaba is the highest peak of the zone, rising 1,304 m above sea level.

Geological and geophysical surveys were conducted in the first phase. Drilling survey and electric logging in the second phase and drilling survey in the third phase were carried out.

The location of this zone is indicated in Figures 1-1 and 1-2.

1-2 Mining Activity of Küre Mine

1-2-1 Investment

Etibank had meetings with Outokumpu Company (Finland) and, evaluated the Küre-Aşıköy ore, it is understood that copper concentrate (15% Cu and 46% S) with 82% productivity can be gained when the concentrator is fed with crude ore with 1.73% Cu and 37% S. An agreement was signed between Etibank and Outokumpu Company in August 1977 to design the concentrator foundation and supply the outer equipment in return for the Finland Government credit and establishment of concentrator foundation which can operate 600,000ton/year ore from Aşıköy open pit; 270,000 ton/year ore from Aşiköy underground mining and 60,000 ton/year ore from Bakibaba underground mining.

It was taken into the Etibank's investment program with "Küre Copper facility investment". It is made up of 5 different units; 1) Aşıköy open pit, 2) Aşıköy underground mining, 3) concentrator facility: a- enrichment, b- concentrate drying, c- heat power station, 4) cable railway facility, 5) Inebolu loading facility.

1-2-2 Aşıköy Open Pit

It was determined that the Aşıköy ore deposit was operated by a open pit from the current level to + 948 ML (meter level) and open pit project was prepared in 1986. By taking care of the general dip angles of 35° and 40° and keeping the 12 m step height constant; step slope angles and step widths were determined to be 72° and 76° and 13m and 11m respectively.

1-2-3 Aşıköy Underground Mining

Because the 948 ML of Aşıköy orebody is the base boundary of the open pit operation, the economical and modern underground mining methods have to be operated from 948 ML to the 756 ML. Detailed engineering works were done and award stage has come through. Ore production and mining transportation will be conducted in two stages.

The crude ores of Bakibaba orebody will be transported to Küre copper-pyrite milling plant and crushed, then 920 ML gallery for main transportation was conducted, and it will be transporting the material, equipment and workers to the underground and to dump the underground water out.

1-2-4 Milling Operation

Enrichment: 90,000 ton/year copper concentrate with 15% Cu grade and 460,000 ton/year pyrite concentrate with 46% S grade will be produced by feeding the concentrator with 930,000 ton/year ore of 1.73% Cu and 37% S grades. The ores supplied from open pit and underground mining, are transported the ore grain-store with 100 m^3. They are crushed to be different sizes like 15 cm, 20 mm. The crushed ore is prepared for the flotation by transporting it to the four different conditioning tanks of 25 m^3. After the flotation, the copper concentrate is cleaned, transported to the filter and to drying circuit.

1-2-5 Cable Railway Transportation

The cable railway transportation was decided to be economical for the transporting of the dried concentrates. Therefore, an agreement between Etibank and West German Company PBH Wesserhutte AG was concluded. PHB company guarantied all the detailed engineering works and the supply of main equipments.

1-2-6 Stripping and Production Activities

Stripping and open pit:Production has been continuing in the open pit since 1985.

1-2-7 Supporting Services

Laboratory equipments have jaw crusher, roller pin crusher, marble mill, pulverization and flotation cell for ore preparation. There are atomic absorption instrument, electrolysis instrument, sulfur analysis instrument, distillation instrument, digital libra and microscope. Chemical analysis of Cu, S, Fe, Co, Zn, CaO and FeS can be conducted. Moisture and density, sieve analysis and measurement of water hardness can be done.

Energy:Electricity is supplied by the T.E.K. (Turkish Electric Power Corporation). 34.5 kilovolt electricity is reduced to 6.3 kilovolt in the power station and used as distribution tension. 6.3 Kilovolt is used in the mills and 0.4 Kilovolt is used in the concentrates, crusher, Aşıköy, water pump, social foundations etc. The reducing power station at each unit ; reduces the 6.3 Kilovolt tension to 0.4 Kilovolt. Two generators of 380 and 200 watt can be able to feeds the places which can stop the process for energy cuttings.

1-2-8 Rationalization of Mine

Aşıköy mine development project was signed between Etibank and Teknomad A.S. on 2 January 1991 concerning engineering services of Aşıköy Orebody. Teknomad handed in the bidding file concerning primary development of Aşıköy underground mine on 4 March 1991.

Automation project of Küre concentrator was signed with Outomec, Amdel and Denver participated in the bidding on 13 August 1992. It will increase productivity by reducing the loses caused by manual control.

CHAPTER 2 GEOLOGICAL SURVEY

2-1 Method of the Survey

Field geological survey was carried out in semi-detail with topographic maps on 1:5,000 and the survey results were compiled into a 1:5,000 geological map. The Aşıköy Deposit was surveyed using 1:1,000 open pit maps.

A geological column, a geological map and geological sections of this zone which were prepared in the course of this project are shown in Figures 2-1, 2-2 and 2-3 respectively.

2-2 Stratigraphy

< Ultramafic Rocks >

The ultramafic bodies are distributed widely in the vicinity of Mt. Koramanyayla, Mt. Elmakütüğü, and Ömeryilmaz Village. They also occur in small bodies to the north and to the south-southwest of Bakibaba.

These rocks are the oldest rocks exposed in the zone and comprise black massive pyroxenite, peridotite and serpentinite. They are holocrystalline and contain serpentinized pyroxene, olivine, and small amount of plagioclase. They

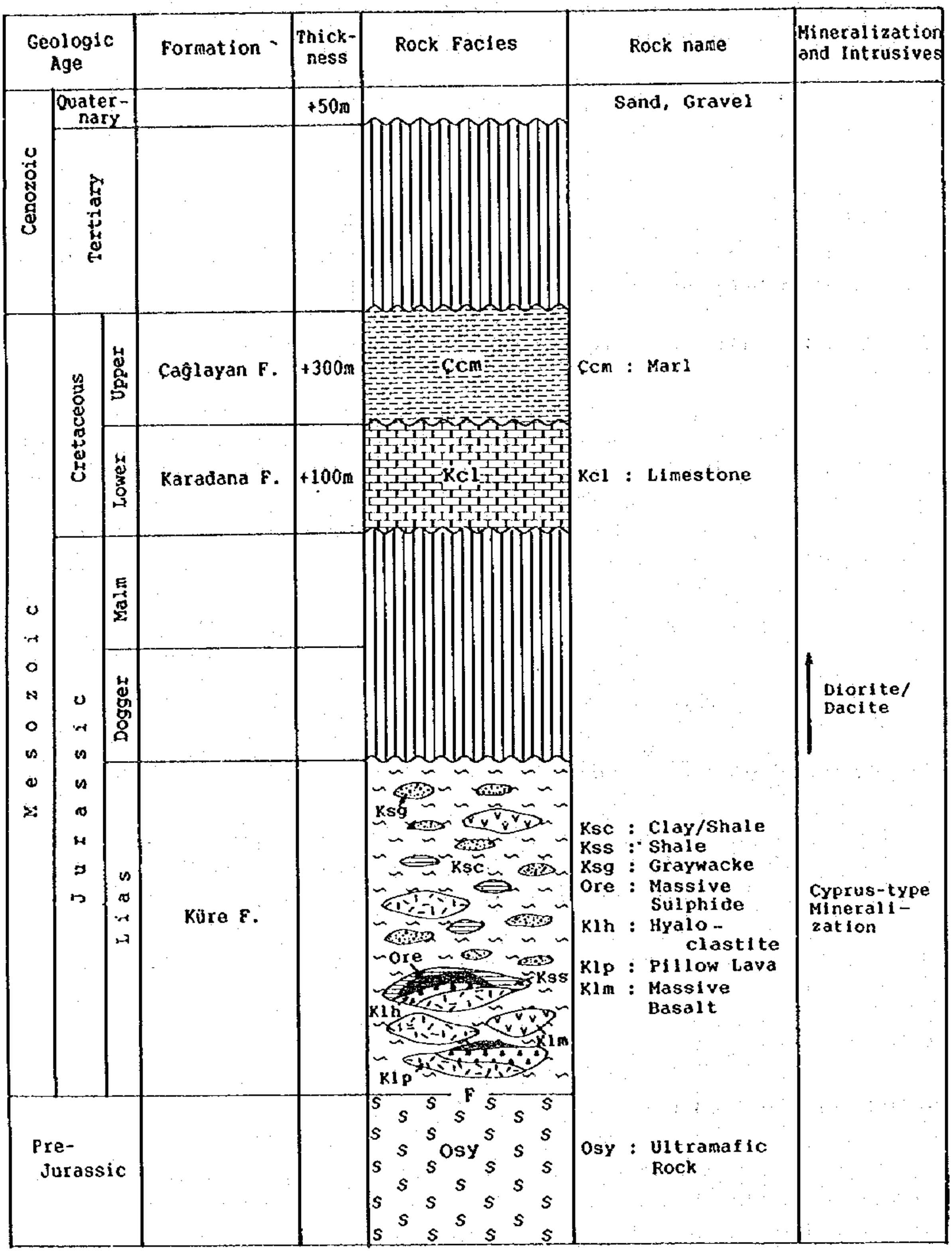


Fig. 2-1 Schematic Geologic Column of the Küre Zone

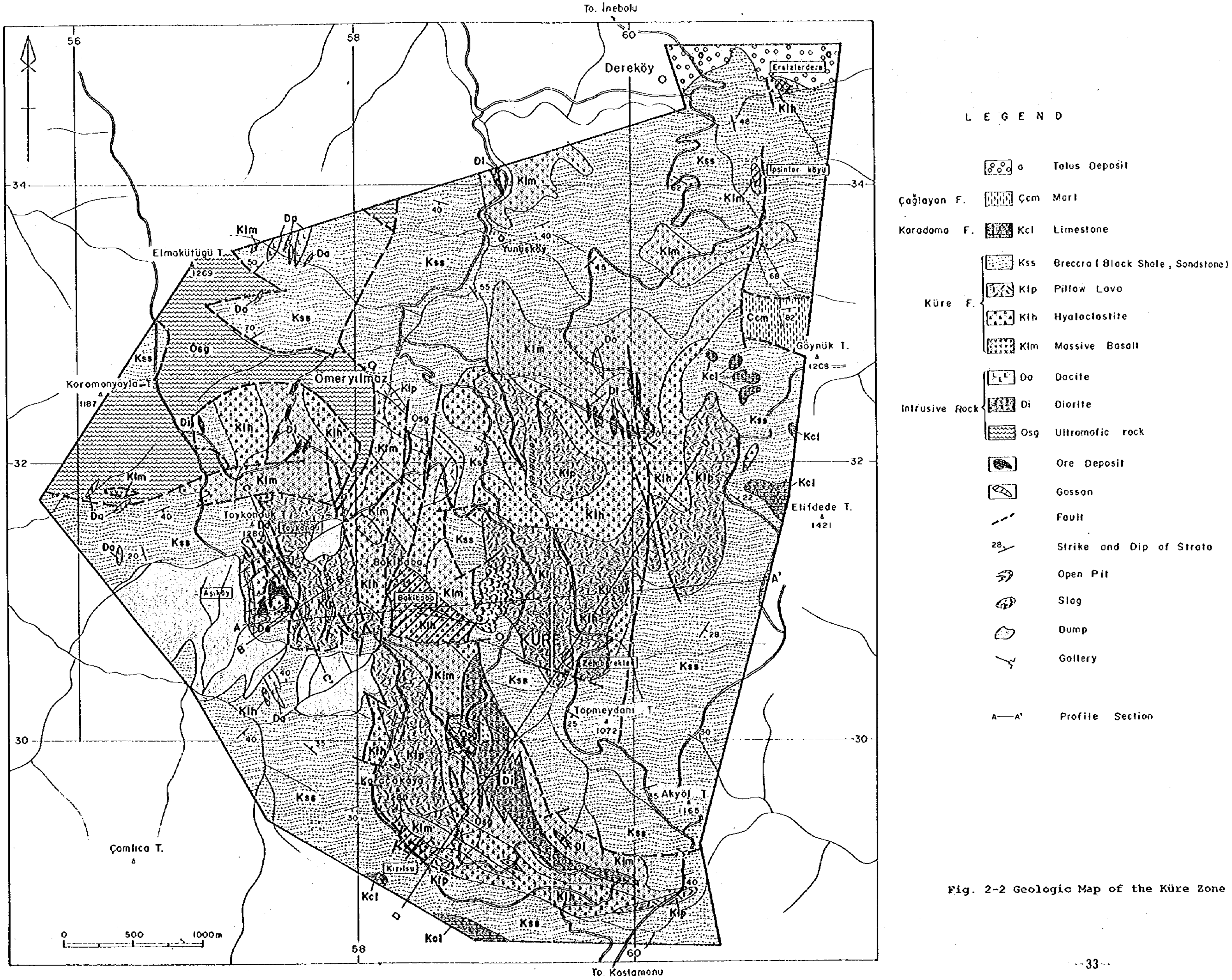


Fig. 2-2 Geologic Map of the Küre Zone

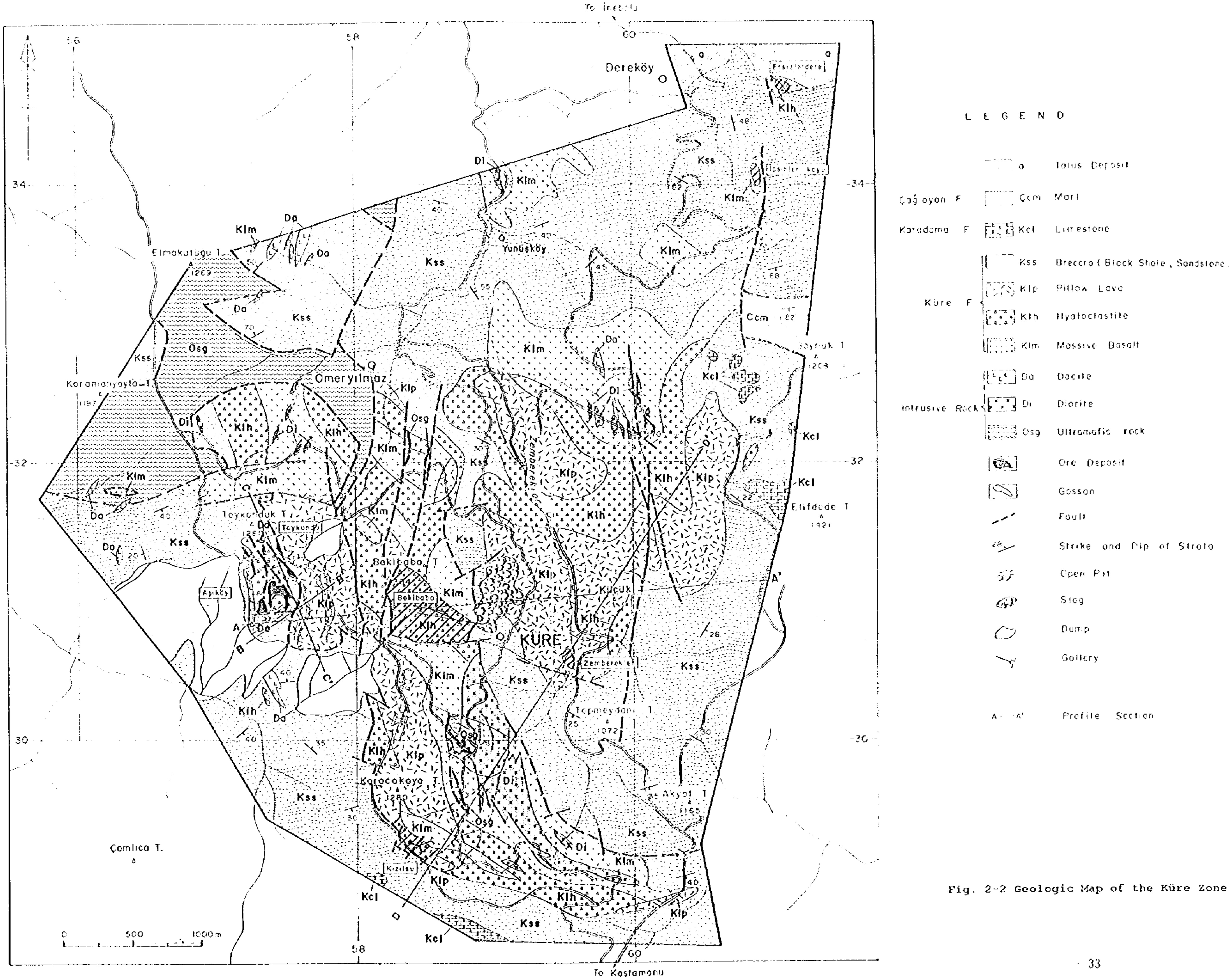


Fig. 2-2 Geologic Map of the Küre Zone

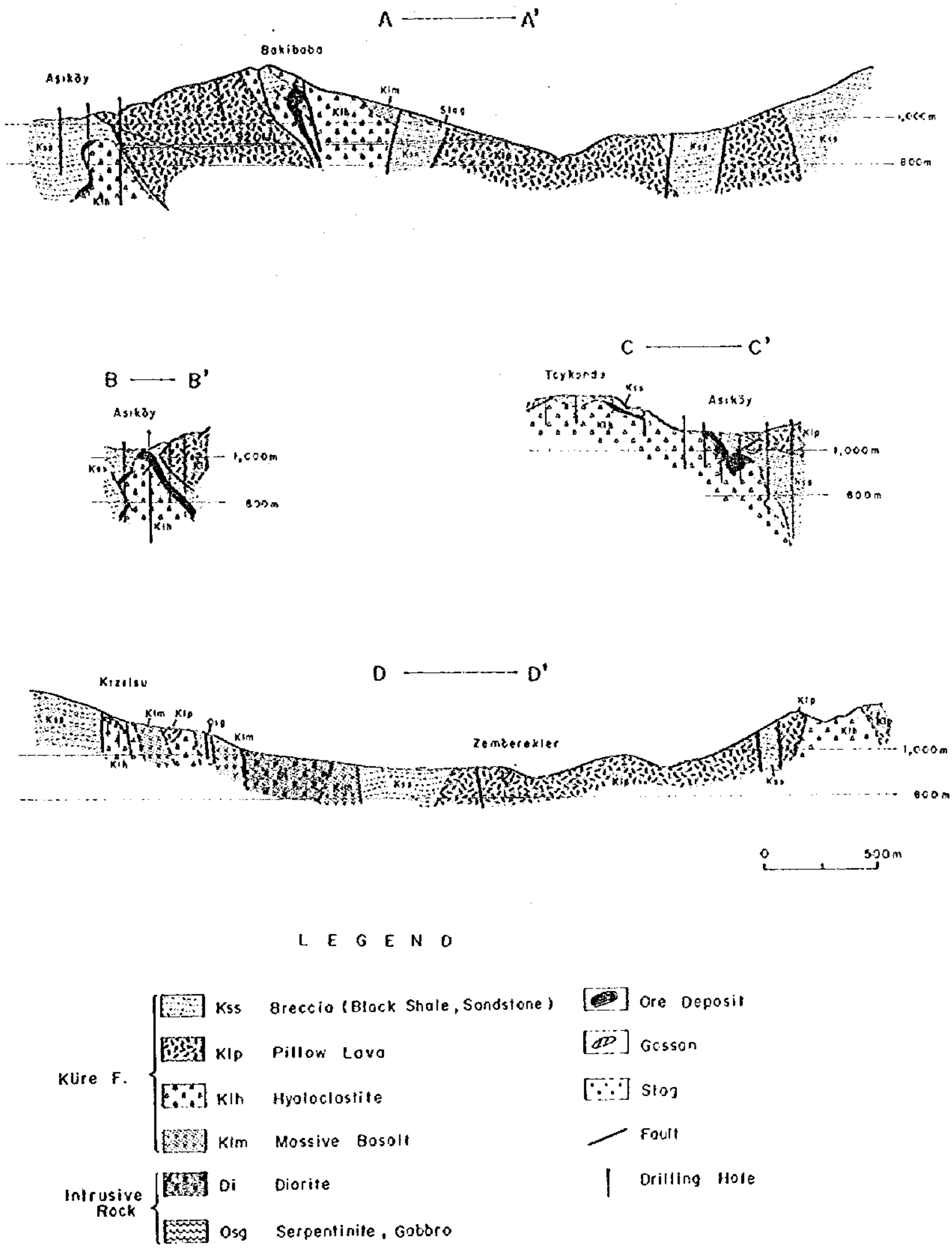


Fig. 2-3 Geologic Cross Section of the Küre Zone

are in fault contact with the Küre Formation. These rocks do not have banded structure and have not exerted thermal metamorphism to the surrounding bodies. Thus they are considered to have intruded in solid state.

< Küre Formation >

Type locality of this formation is the middle to upper reaches of the Zemberekler Stream in the central part of the zone.

This formation occurs in the major part of the zone. This formation is composed of basalts, black shale, and sandstone.

The basalts are largely divided into pillow lava, hyaloclastite, and massive basalt. They are shown separately in the geological map where by the predominant rock type.

The pillow lava is dark gray to dark greenish gray. It occurs as close-packed pillow lava, pillow breccia, or pillow lava. The pillows are oval or spherical and the long diameter is 1.5 - 2m. Where close-packed pillows occur, they are partly accompanied by massive basalt and rarely is associated with hyaloclastite. These are distributed in the upper reaches of the Zemberekler Stream and to the east of Aşıköy Orebody. The pillows of the pillow breccia and pillow lava are often spherical and the maximum diameter is about 1m. These rocks are often accompanied by massive basalt and hyaloclastite and occur in the middle reaches of Zemberekler Stream and near the Mt. Karacakaya.

The hyaloclastite is greenish gray. It contains lapilli-size rock fragments and the matrix is fine-grained. It also includes many fragments of pillows. The lapilli-size fragments are mafic glass and basalts and their color is similar to that of the matrix. It is often accompanied by massive basalt. Peperite with argillaceous matrix is found to the east of the upper part of the Zemberekler Stream.

Massive basalt is dark gray to greenish gray and the outcrops appear homogeneous under observation by unaided eyes.

Although the mode of occurrence of the basalts are distinct as described above, there seems to be no characteristic microscopic texture associated with these types of occurrence. These rocks show various textures with plagioclase and augite phenocrysts and groundmass consisting of plagioclase, clinopyroxenes and opaque minerals. Even those appearing fresh contain alteration minerals such as calcite and other carbonates, sericite, chlorite, epidote and rarely prehnite. Parts of the pillow lava are spilitized.

Sandstone is fine- to medium-grained quartz wacke and it occurs as thick beds, alternation with black shale, or as lenses in black shale.

The black shale often has scaly cleavage particularly when lenses of sandstone are intercalated.

It is interpreted from the observation of drilling cores that sedimentary rocks of this formation consist of breccia containing allochthonous blocks as greywacke, and being filled by pelitic materials. A small block of basalt occurs in pelitic rock on the surface. Pelitic rocks filling breccia have schistose texture and scaly cleavages.

From above facts, it is inferred that these sedimentary rocks constitute a melange. Basalt is also inferred to be a constituent of the melange

Güner(1980) reported on the analytical results of basalt in the Küre zone. He used both major and minor contents of 30 basalt samples and concluded that these were typical ridge-type tholeiite. The following consideration was made referring to the results of Güner and Kosaka (1975).

AFM diagram: The Na_2O+K_2O of the basalts is higher than normal mafic rocks and indicates the strong albitization. It belongs to the calc-alkali rock series.

$Na_2O+K_2O-SiO_2$ diagram: The basalts of this area have high Na_2O+K_2O content because of alteration and many of them plot in the alkali rock series range.

SiO_2-FeO/MgO diagram: Many of the basic rocks fall in the tholeiite range.

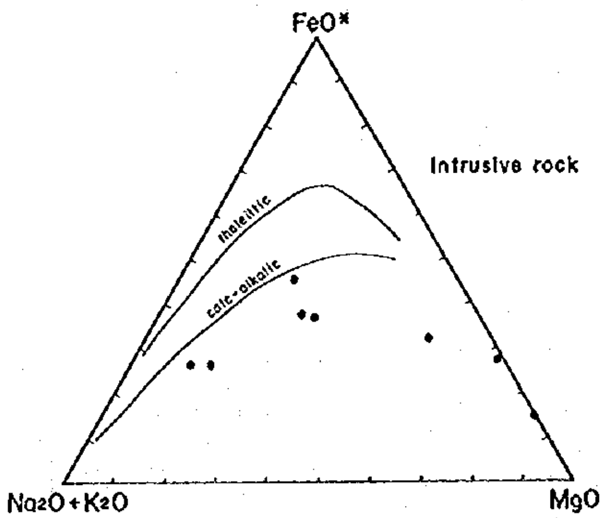
Alkali-alumina-silica diagram: In the basalt classification of Kuno (1960), the rocks of the Küre Area plot in the alkali rock series because of their high alkali content, but some of the low silica basalts are observed to fall in the tholeiite group.

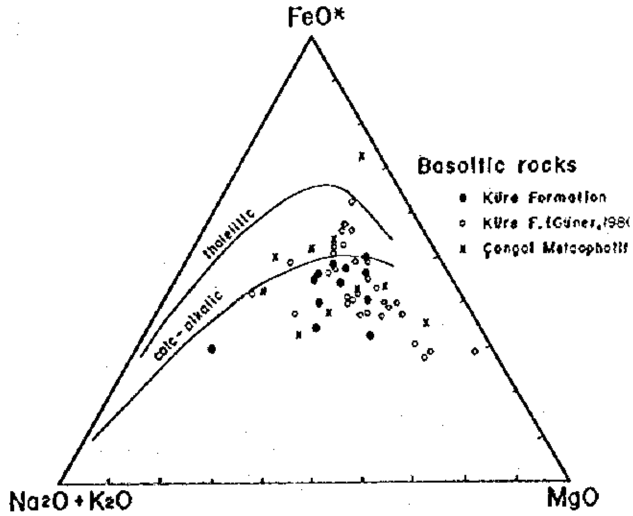
$Al_2O_3-TiO_2$ diagram: In the diagram with average values of ridge-type and ocean island- type tholeiites plotted (Hubbard, 1969), The present rocks plots in the high alumina-low titanium ridge-tholeiite group.

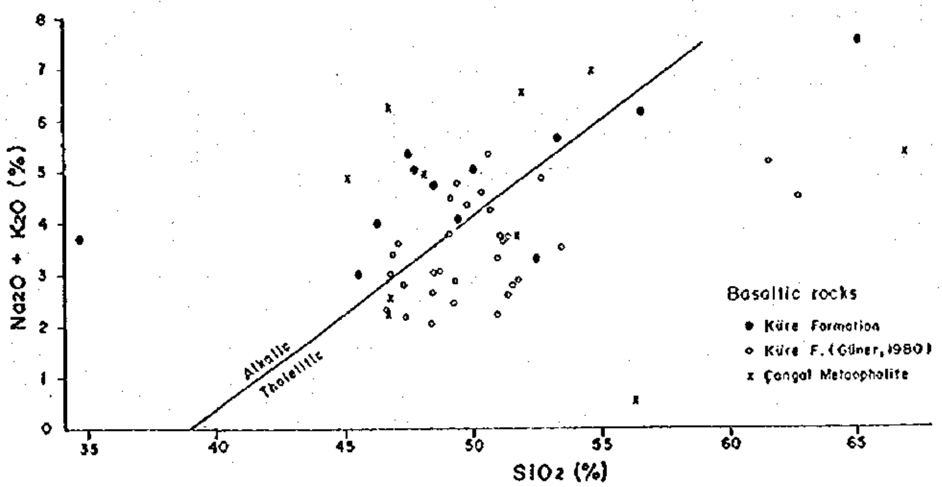
S.I. and titanium-alumina diagram: In the diagram using the solidification index by Kuno (1957), the rocks of the Küre Area plots in the area ranging from the ridge-type to ocean-island-type.

TiO_2-FeO/MgO diagram: In the diagram by Miyashiro (1975) with Güner's plots, the results of the present work plot in the area ranging from ridge to ocean-island-type tholeiite.

$P_2O_5-TiO_2$ diagram: These rocks have low titanium and phosphorus contents and plots in the ridge-type tholeiite range.







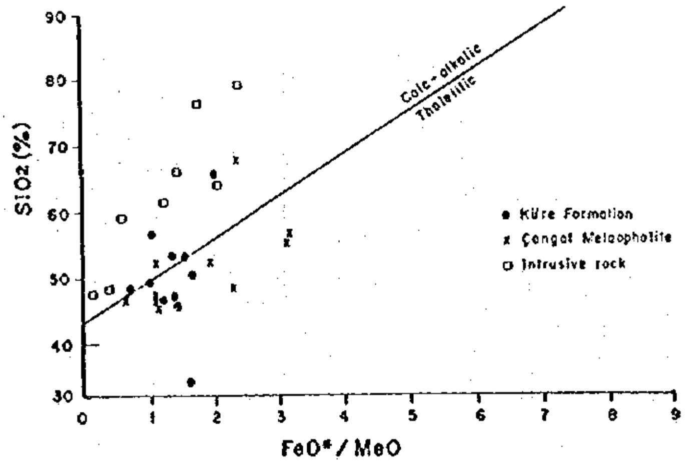


Fig. 2-4 Chemical Composition of basalt in the Küre Zone (1/3)

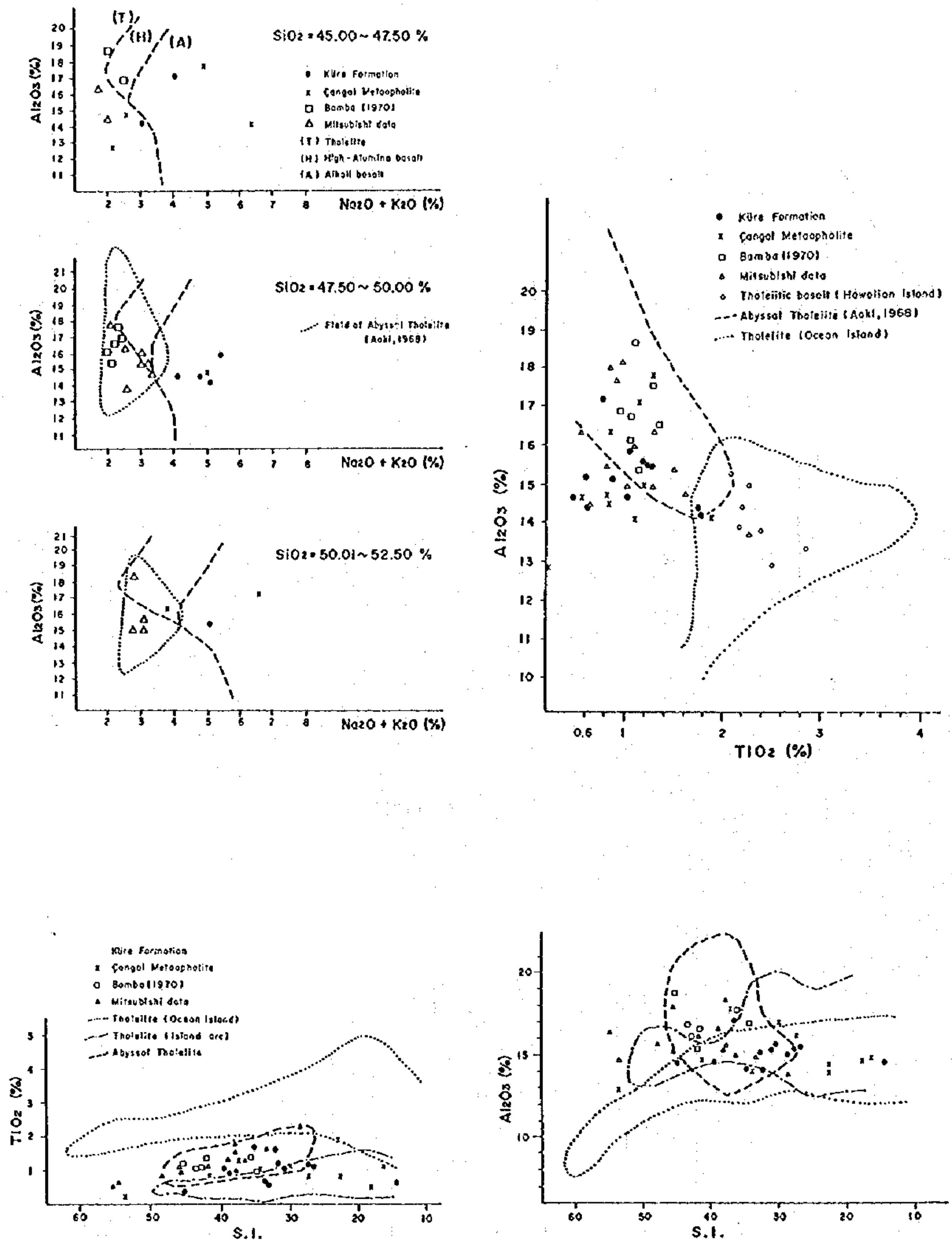
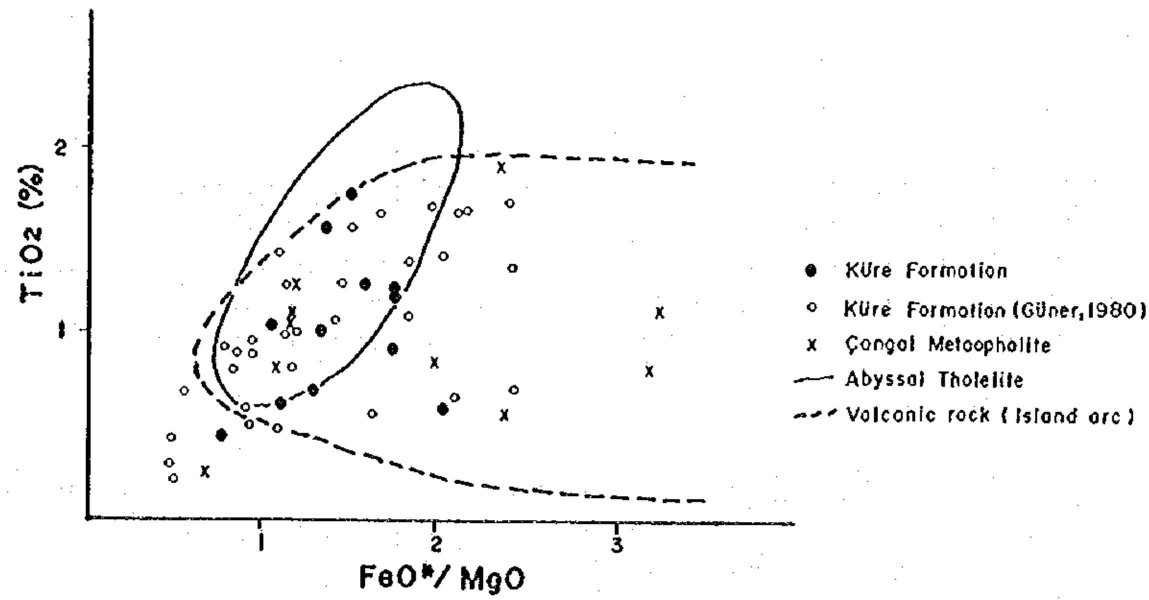


Fig. 2-4 Chemical Composition of basalt in the Küre Zone (2/3)



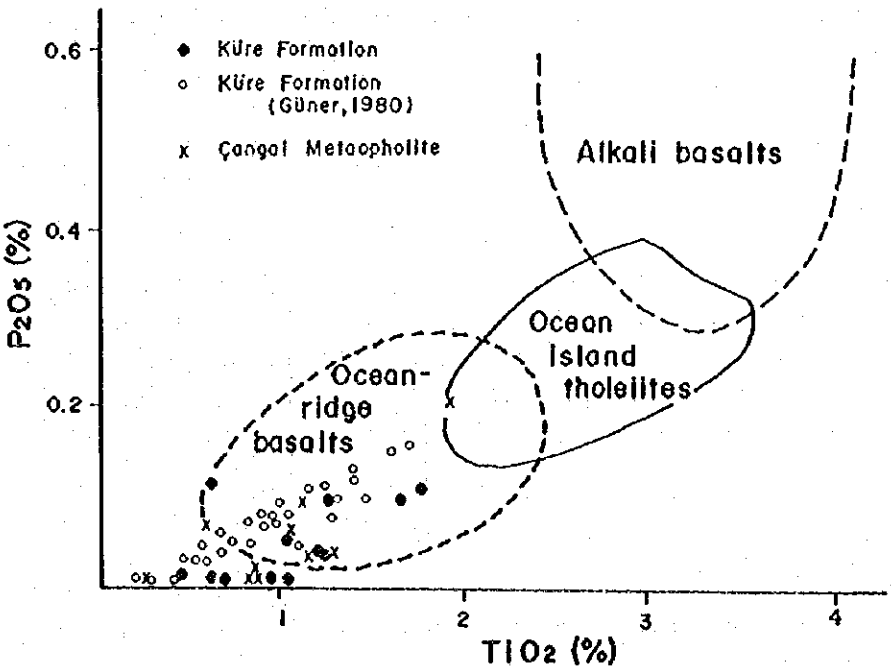


Fig. 2-4 Chemical Composition of basalt in the Küre Zone (3/3)

Minor elements: The contents of rare earths Ba, Nb, Sr, Y. Zr were determined. It is seen that although the alkali contents are high in the altered basalts and they plot in the alkali rock area of the diagrams, the major chemical components and some minor element contents both indicate ridge-type tholeiite as the original rock.

< Karadana Formation >

Type localities the vicinity of Karadana Village to the south of the Küre Mine (outside of the survey area). The thickness is over 100m. This unit occurs unconformably overlying the lower Küre Formation in the vicinity of the Mt. Elifdede in the easternmost part and at the southernmost part of the zone.

The formation consists of grayish white fossiliferous limestone.

< Çağlayan Formation >

Type locality is Çağlayan Village to the east of the Küre Mine (outside of the survey area). The thickness of this formation is over 300m. This formation occurs in small scale on the northwestern side of Mt. Göynük in the eastern part of the zone. It is in fault contact with the lower Küre Formation.

It consists of stratified pale brown marl.

< Talus Deposits >

The talus is developed at the foot of the mountains formed by Çağlayan limestone in the northeastern part of the zone. It contains a large amount of limestone breccias.

2-3 Intrusive Rocks

< Diorite >

Diorite occupies 0.2 x 2km of the eastern part of Mt. Karacakaya and also occur as small bodies in various parts of the zone. It often is intruded into the massive basalt of the Küre Formation. These bodies consist of pale green diorite and dark green gabbro, they are holocrystalline with phenocrysts of plagioclase, hornblende, and augite.

< Dacite >

Dacite bodies occur as relatively thin dikes in the Küre volcanics or in mudstones near Mt. Elmakütüğü in the northwesternmost, in the westernmost parts, to the west of Asıköy, and to the northeast of Bakibaba. Dacite is gray and has porphyritic texture with phenocrysts of quartz, plagioclase, biotite, and matrix consisting of secondary fine-grained quartz and chlorite.

2-4 Geologic Structure

The attitude of the boundary between the black shale and the sandstone of the Küre Formation vary considerably. It can be said from the frequency distribution of the attitude of the boundary that NE-SW and NW-SE and 30°- 60°S would be the most frequent strike and dip throughout the zone. In the northern part of the zone NW-SE strike and southward dip are most common, while in the south NE-SW strike and southward dip are often observed.

Basalt and brecciated sediments of the Küre Formation is interpreted as a constituent of melange. The above attitude of the boundary is harmonious with the strike of the blocks consisted of basalt and sediment.

With the exception of diorite and dacite intrusives and Karadana Formation, the boundaries of all geological units including the ultramafic bodies are displaced. Also displacement is confirmed within the Küre Formation by the scaly cleavages of the black shale.

The faults observed in the Küre Formation are grouped into N-S and E-W systems, the latter intersecting the former system. It is considered from the results of the prospecting at Aşiköy Pit and other points, that the former fault system has a larger vertical displacement. The boundary between the ultramafic and the Küre Formation appears to be a junction of the three fault systems, namely NW-SE, N-S and NE-SW.

The direction of surface elongation of the intrusive bodies is harmonious with the strike of the faults in the vicinity, particularly the boundary of the sedimentary rocks and the basalts of the Küre Formation.

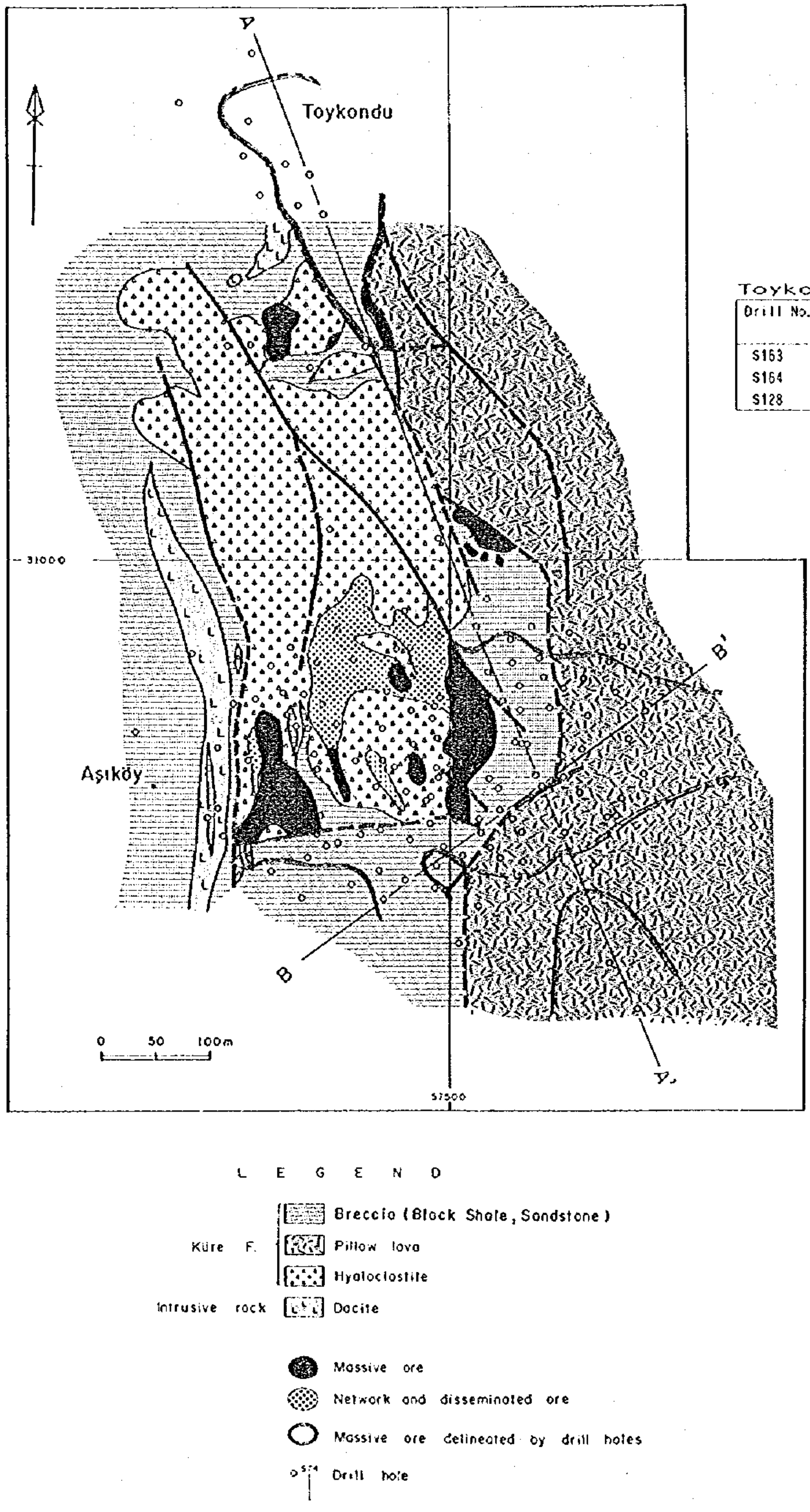
2-5 Küre Ore Deposit

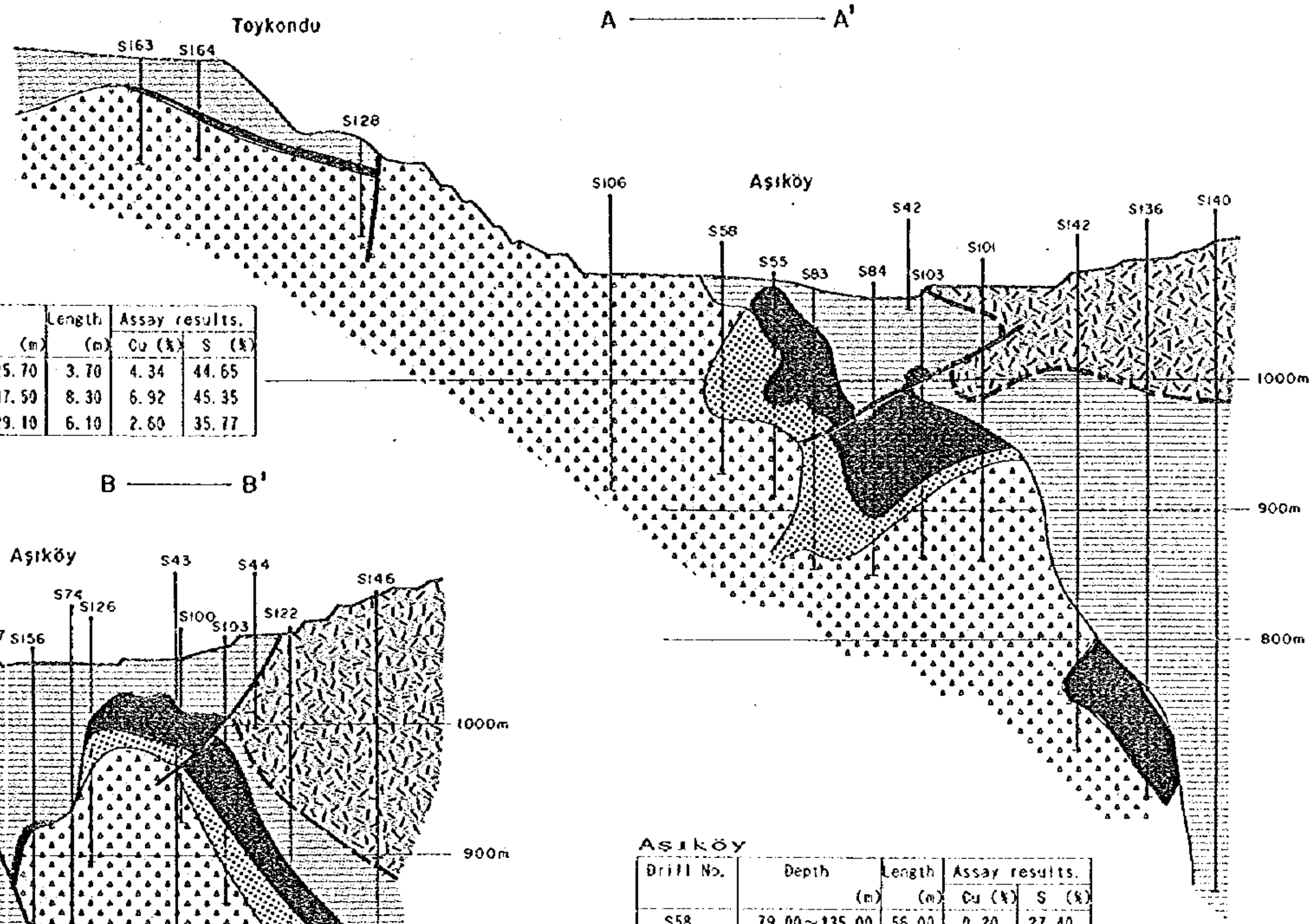
< Aşıköy-Toykondu Deposit >

These orebodies are distributed in an area extending northward from the vicinity of the Aşıköy Pit. The Toykondu Orebody extends to the north from the northern part of the Pit and the Aşıköy Orebody is located from the central part of the Pit to the south. The Aşıköy Orebody is observed at the open pit and the lower and lateral extension is confirmed by drilling. A part of the Toykondu Orebody can be observed at the open pit, but the major part is explored only by drilling.

A planar map and cross section of the Aşıköy Orebody is shown in Figures 2-5.

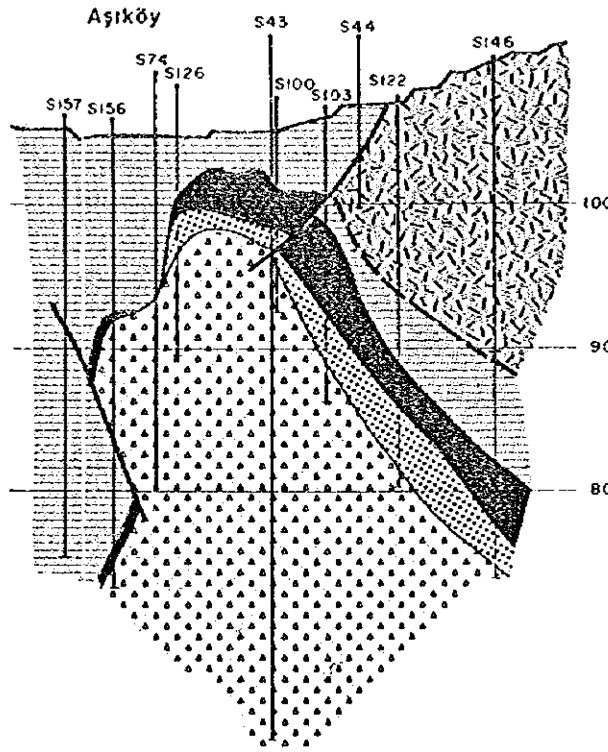
The geology of the vicinity of the Aşıköy Orebody is composed of black shale,





Toykondu

Drill No.	Depth (m)	Length (m)	Assay results. Cu (%)	S (%)
S163	22.00~ 25.70	3.70	4.34	44.65
S164	39.20~ 47.50	8.30	6.92	45.35
S128	23.00~ 29.10	6.10	2.60	35.77



Aşıköy

Drill No.	Depth (m)	Length (m)	Assay results. Cu (%)	S (%)
S156	135.00~142.00	7.00	3.15	28.08
	300.50~313.80	13.30	2.47	26.95
S126	72.35~ 88.10	15.75	1.99	44.62
	88.10~116.25	28.15	0.70	21.66
S43	90.30~138.20	47.90	1.31	48.52
S100	58.00~ 85.40	27.40	1.76	46.32
	85.40~ 99.65	14.25	0.84	18.37
	120.80~144.00	23.20	0.25	8.81
S103	61.50~ 73.40	11.90	1.36	46.44
	86.75~149.00	62.25	1.22	45.15
	149.00~167.50	18.50	0.08	27.51
S122	186.00~209.50	23.50	8.53	42.65
	209.50~234.00	24.50	3.71	26.90
	234.00~258.00	24.00	0.44	10.18
S146	279.00~326.00	47.00	5.00	43.92
	335.50~361.00	25.50	0.36	12.04

Aşıköy

Drill No.	Depth (m)	Length (m)	Assay results. Cu (%)	S (%)
S58	79.00~135.00	56.00	0.20	27.40
S55	10.08~ 42.00	31.92	3.62	44.71
	42.00~ 66.00	24.00	2.48	38.14
	66.00~ 76.00	10.00	1.43	31.05
	76.00~106.50	30.50	0.61	49.94
	106.50~118.50	12.00	0.83	35.02
S83	32.00~ 46.00	14.00	9.40	36.44
	46.00~102.00	55.00	1.85	40.99
	104.00~210.50	106.50	0.37	19.16
S84	103.90~184.60	80.70	3.09	47.02
	184.60~189.70	5.10	0.59	18.15
S103	61.50~ 73.40	11.90	1.39	46.44
	86.75~149.00	62.25	1.23	45.15
	149.00~167.50	18.50	0.08	27.50
S101	127.75~151.80	24.05	2.53	42.03
	151.80~166.10	14.30	1.64	18.42
S142	294.00~295.65	1.65	3.66	38.30
	328.00~357.50	29.50	0.47	42.66
	357.50~397.00	39.50	0.09	35.21
S136	372.50~435.25	62.75	3.19	47.54

Fig. 2-5 Geologic Map and Cross Section of the Aşıköy Deposit

sandstone, hyaloclastite, and pillow basalt of the Küre Formation and of dacite which intruded into the shale and sandstone. Pillow lava occurs to the east of the open pit; orebody, black shale, sandstone, hyaloclastite in the central part of the open pit; and black shale and sandstone and dacite occur elongated in the north-south direction in the western part of the open pit.

The geology of the vicinity of the Toykondu Orebody consists of black shale and sandstone of the Küre Formation and dacite.

Many faults are developed near the Aşıköy-Toykondu Deposits. These are grouped into the following three systems, namely N-S, E-W, and NE-SW systems. The dip is not constant, but is generally steep (50°-80°). There are many scaly cleavages in the black shale, but the shale is massive without cleavages directly over massive ore.

The Aşıköy Orebody occurs at the boundary of black shale and hyaloclastite of the Küre Formation or in the hyaloclastite. The ore occurs as massive, boulder, conglomeratic, and network types. The massive ore is more or less homogeneous to the unaided eyes, the boulder ore is subrounded to subangular ores of 10-30cm and occur in black shale, conglomeratic ore occurs with chalcopyrite and pyrite filling the interstices of the boulder ore, the network ore is emplaced in hyaloclastite.

The Aşıköy Orebodies are composed of a body situated in the central part of the open pit, that on the northern side of the open pit, and another to the southwest of the open pit. The northern orebody consists of massive ore extending 70 x 20m laterally and conglomeratic ore in the black shale adjacent to it to the south. The central body extends 380m east-west and 200m north-south, the ore is of massive and network type. The lateral distribution of the massive ore is convex southward.

The attitude of the boundary between the massive ore in the eastern part of the open pit and the overlying black shale is N-S strike and 50°-70° E and the thickness of the orebody is 15-35m. The grade of the massive ore in the drill cores is Cu 1-9%, S 40-48%. The network ore occurs as 0.1-1cm thick pyrite, chalcopyrite, quartz veinlets in hyaloclastite with dissemination of the sulfide minerals. The host rock of the network ore is generally green, but it is bleached and silicified where the network is dense and strongly disseminated. Most of the altered minerals is quartz with minor amount of sericite.

The hyaloclastite on the footwall side of the massive ore is sometimes silicified for a thickness of 1-3cm with large amount of quartz and minor sericite.

The orebody to the southwest of the open pit consists of massive and network ore confirmed by drilling. The southwestern extent of the body is not yet confirmed.

The massive ores of the Aşıköy Orebody is composed of a large amount of pyrite, smaller amounts of chalcopyrite, sphalerite, marcasite, minor amounts of covelline, tetrahedrite, and pyrrhotite. The gangue minerals are mostly quartz, rarely rutile, leucoxene, clay and carbonate minerals. The constituents of the network and disseminated ores are the same as massive ores.

The Toykondu Orebodies consists of massive orebodies with 200 x 50m lateral extent and several smaller ones of 50 x 20m or less. These are situated to the north of the open pit. The thickness confirmed by drilling of these bodies is 3-15m, the grade of the cores is Cu 1-4%, S 32-51%.

The stratigraphic sequence of these bodies is, from the surface downward, black shale, massive ore, and hyaloclastite. The ore minerals are; large amount of pyrite, small amount of chalcopyrite, sphalerite, minor content of bornite, tetrahedrite, covelline, marcasite, and pyrrhotite. The gangue mineral is quartz. Assay result of massive ore of Drilling B-164 is Cu 6.92%, S 45.35%.

The smaller bodies less than 50 x 20m are massive and boulder ores occurring at the boundary of black shale and hyaloclastite. In some cases, 10- 20cm boulder ores occur in the hyaloclastite. The hyaloclastite is in contact with pillow lava on the eastern side through a fault and the silicification and the amount of ores contained in the hyaloclastite decreases westward from the fault.

The hyaloclastite is silicified and thus bleached to a thickness of 1-2m immediately below the massive orebody. Further down, hematite is observed in the matrix of the hyaloclastite.

< Bakibaba Deposit >

The Bakibaba Deposit is located approximately 900 m east of the Aşıköy Orebody. This is the original deposit of the Küre mine and has been worked sporadically since the Greek times. A large amount of mine waste is dumped near the deposit and it appears that a different deposit near Bakibaba was mined earlier. At present drilling is conducted from the surface. A planar map and cross section of the Bakibaba Deposit are shown in Figure 2-6.

The geology of the vicinity of the Bakibaba Deposit consists of black shale, hyaloclastite, and pillow lava (partly massive basalt). Pillow lava, black shale-sandstone, and hyaloclastite occur elongated in the N-S direction. These rock units are bounded by faults with eastern dip.

The ores occur at the boundary of black shale-sandstone and hyaloclastite and within hyaloclastite. They are massive ores are lenses elongated in the dip direction. The horizontal section of the orebodies are oval to circular with

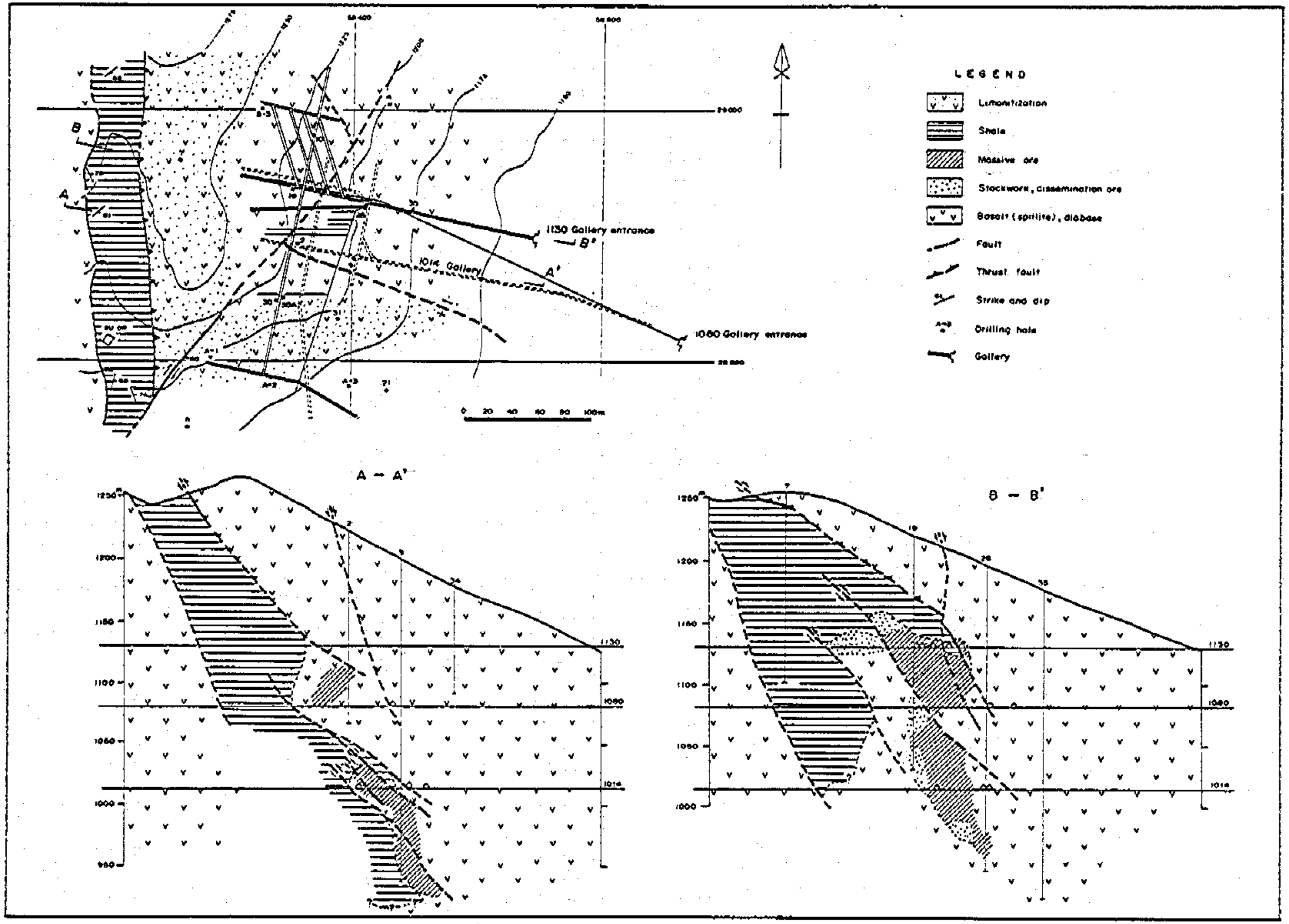


Fig. 2-6 Geologic Map and Cross Section of Bakibaba Deposit (ETiBANK, 1985)

dimensions of 40 x 70m - 80 x 80m. The dip of the orebodies is 50°-60° SE and the extension in that direction has been confirmed up to 130m.

The massive ores of the Bakibaba Deposits is composed of a large amount of pyrite, small amounts of chalcopyrite and sphalerite, minor amounts of covelline and pyrrhotite, and the gangue minerals is quartz. The assay of the ore shows the grade to be Cu 4-15%, S over 40%, indicating locally high-grade copper zones.

Sulfide minerals have been oxidized on the surface near the orebodies and for 600 x 500m the surface is red with limonite.

There are mine slags 600m to the east of the orebodies and these contain minor amounts of chalcopyrite, bornite, covelline, pyrrhotite, magnetite and hematite with grades ranging from Cu 1 to 4%, Co 0.2 to 0.4%.

< Kızılsu Deposit >

Kızılsu Deposit lies 1.7km south of the Bakibaba Deposit, and the high-grade part confirmed by drilling is being mined. Drilling was carried out until recently.

The geology of the vicinity of the Kızılsu Deposit consists of black shale, hyaloclastite, and massive basalt (partly pillow lava) from the southwest northeastward. These units are elongated in the NW-SE direction. The sediments and hyaloclastite are in fault contact.

The orebodies are network and massive type in hyaloclastite. The horizontal extent is 300 x 150m. The results of the drilling indicates that most of the ore is of network type with massive ores occupying 80 x 40m in horizontal extent and about 15m thick. Both types of ores consists of a large amount of pyrite, small amount of chalcopyrite, minor amount of sphalerite, bornite, covelline, tetrahedrite, and marcasite with quartz as the gangue mineral.

The assay result of the massive ore is Cu 4%, S 40% and of gossan is Cu less than 1%, S 1-2%.

The upper part of the orebodies is gossan and the host rock is silicified and contains a large amount of quartz and some sericite.

< Ore Microscopy >

The microscopic characteristics of the ores are summarized as follows.

Pyrite: It is observed abundantly and consist of two types; one of them is euhedral-subhedral, interfingered with cataclastic structure. This type of pyrite which is the oldest sulfide mineral is replaced by the other sulfide minerals. This type of pyrite sometimes show zonation. The other pyrite type is colloform (melnicovite) pyrite. Concentric crusted, kidney-like, grape-like and locally with radial texture melnicovite (colloform) pyrites grew within each other with chalcopyrite and sphalerite. Melnicovite pyrites are generally very minute grains

Chalcopyrite: It is very abundant. Chalcopyrite fills the interspaces and cataclastic fractures of euhedral cataclastic pyrites and sometimes is associated with the concentric crusted kidney-like, radial texture of melnicovite (colloform) pyrites.

Sphalerite and galena: These minerals are observed as small anhedral grains within the chalcopyrite, gangue minerals and pyrites. Sphalerite contains local chalcopyrite exsolutions.

Cobalt minerals: Carrollite has the same crystal structure as pyrite and is a polymorph of linnaeite and bravoite are observed. The former mineral occurs as small grains and the latter as large crystals. There are high cobalt parts in the veins.

Titanium minerals: Leucoxene, rutile, and anatase occur in the ores. These minerals form fine exsolution texture in pyrite. Leucoxene occurs in gangue minerals as an alteration product of mafic minerals. The other two minerals occur as minute crystals in pyrite and gangue mineral.

< Ore Assay >

The assay result of ores except of Cu, Pb and Zn are summarized as follows.

Gold: Although there are high-grade ores such as 8g/t in the Bakibaba samples, most of them contain 1-2g/t. The maximum grade of Toykondu samples is 4g/t. There were samples containing around 1g/t from Kizilsu Deposit, surface gossan at Bakibaba, and slags at Bakibaba.

Silver: The silver content of most of the ores is less than the limit of detection. The maximum value of silver is 25g/t.

Sulfur: The content is high at Küre ranging from 40 to 50%, but is several percent in other localities.

< EPMA >

Four representative ore samples were selected from Aşıköy Orebody and three from Bakibaba for qualitative analysis of minor elements by EPMA. Analysis was made at 21 points for 17 elements. The results are shown in Appendix Table 5-6. The following is the description.

Gold: Microscopic studies failed to identify electrum and native gold. Gold was not detected by EPMA analysis. It is generally below the detection limit. The content in chalcopyrite is 0.08% (max), 0.09% (max) in pyrite, and 0.06% in sphalerite.

Silver: Copper-silver minerals occur together with pyrite. Generally the content is below the limit of detection. Content is 0.03% in chalcopyrite and 0.02% in pyrite.

Manganese: Very minor content is detected in chalcopyrite and pyrite (0.02-0.03%).

Arsenic: Minor content is detected 0.28% in pyrite, 0.10% in undecided minerals existing between chalcopyrite and pyrite, and 0.04% in chalcopyrite.

Antimony: Content is 0.02% in chalcopyrite and pyrite.

Bismuth:content is 0.15%(max) in pyrite, 0.06% in chalcopyrite and 0.03% in sphalerite.

Selenium: Content is 0.08% in undecided minerals existing between chalcopyrite and pyrite, 0.07% in chalcopyrite and sphalerite, and 0.02% in pyrite.

Cobalt: Content is 0.75%(max) in pyrite, 0.41% in undecided minerals existing between chalcopyrite and pyrite, and 0.06% in chalcopyrite.

Nickel: Very minor content is 0.01% in chalcopyrite and 0.1% in pyrite.

< Sulfur Isotope Studies >

Six samples from Aşıköy Orebody and one from Bakibaba were selected for sulfur isotope studies. Samples with large amount of chalcopyrite, those with only pyrite were chosen from both massive and vein ores. Sulfur was extract by Sn-strong phosphoric acid method and Finuigan mat delta-E equipment was used. The result is shown in permil deviation to the CDT values. The accuracy is ± $0.1^{0}/_{00}$.

The delta ^{34}S values range within +5.43 - $+12.72^{0}/_{00}$ and significant difference does not exist between the chalcopyrite and pyrite dominant parts of the massive ores, but the veins have high values of +8 - +12‰.

Although the number of measurements are limited in the present case, the delta ^{34}S values obtained are similar to those of ophiolite. Thus it is inferred that these ores were formed syngenetically without being affected by the deep sea water.

2-6 Other Mineral Showings

Mineral showings and alteration zones are shown in Figure 2-7.

< Ersizlerdere >

This showing is located 4.7km northeast of Bakibaba. The ores are limonite veinlet network and quartz-limonite veins in the massive basalt and hyaloclastite. The horizontal extent of this showing is 100x40m.

< İpsinler >

This is located 4km northeast of Bakibaba. Limonite dissemination in silicified massive basalt and sandstone is observed. The horizontal extent is 150x50 m.

< Northern Yunusköy >

This is located 1.3km southwest of Dereköy Village. The showing consists of 0.4-0.5m thick silicified pyrite zone in dikes along the NW-SE trending fissure in the massive basalt.

< Western Yunusköy >

This is located 2.9km north of the Bakibaba. Limonite dissemination occurs in 2m thick lenses of silicified rock along the NNW-SSE faults in the black shale and along NNE-SSW faults bordering the black shale-sandstone and ultramafic rocks.

< East of Elmakütügü >

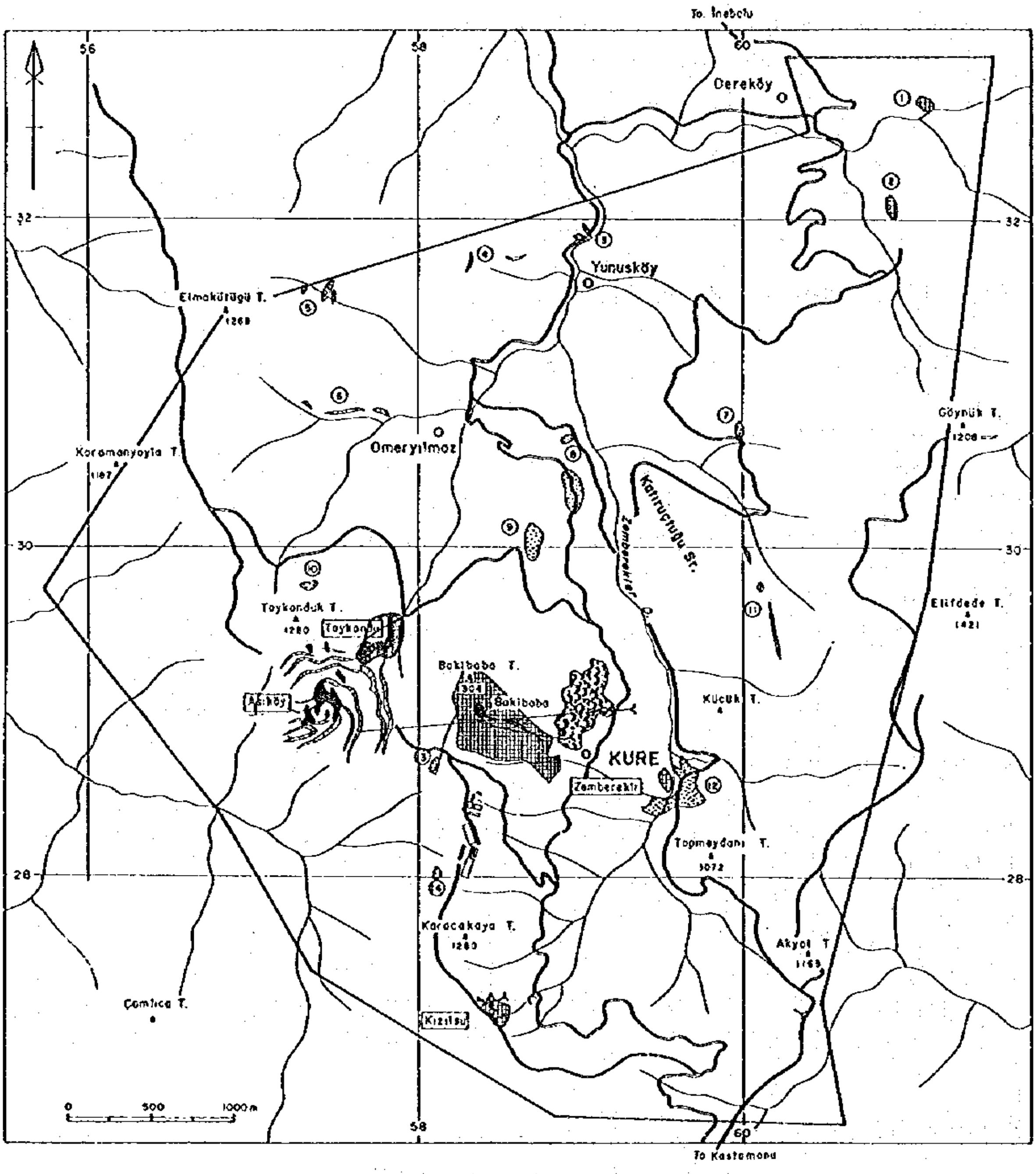
This is located 2.9km north-northwest of Bakibaba. Pyrite dissemination occurs in the silicified parts of massive basalt and dacite.

< Western Ömeryilmaz >

This is located 2km north-northwest of Bakibaba. Limonite dissemination occurs in the silicified dikes along the E-W fault bordering the black shale and ultramafic rocks. The silicified dikes extend 500m intermittently.

< Western Göynük >

This is located 2.4km northeast of Bakibaba. Silicification-pyrite dissemination occurs in the massive basalt. This extends for 100x50m.



L E G E N D

① Ersizlerdere ② İpsinler Köyü ③ North of Yunusköy ④ West of Yunusköy
⑤ East of Elmakütügü ⑥ West of Ömeryılmaz ⑦ West of Göynük T. ⑧ East of Ömeryılmaz
⑨ North of Bakibaba ⑩ North of Toykondu ⑪ East of Bakibaba ⑫ Zemberekler
⑬ Southwest of Bakibaba ⑭ North of Karacakaya

Massive ore Gossan Mineral showing Slag

Fig. 2-7 Mineral Showing Map of the Küre Zone

< Eastern Ömeryilmaz >

There are two mineral showings in the hyaloclastite in contact with the black shale 300m east of Ömeryilmaz Village. The northern one is 2-3m thick silicification-pyrite network in dikes and the southern showing consists of silicification and limonite dissemination of 250-100m scale.

< North of Bakibaba >

This is located 0.6km north-northeast of Bakibaba. Limonite dissemination occurs in parts of the silicified zone of the pillow lava, hyaloclastite, and massive basalt. The zone is 200x100m with quartz, sericite, and chlorite.

< North of Toykondu >

Gossan occurs at the fault contact of pillow lava and massive basalt. It is located 250m north of Toykondu.

< East of Bakibaba >

This is located 2km east of Bakibaba. Limonite dissemination occurs in the silicified dikes along the faults bordering the black shale and basalts and along the faults in the basalts. The altered minerals of the white altered rocks are quartz and minor amount of chlorite.

< Zemberekler >

This is located 1.2km southeast of Bakibaba. There are two showings in the pillow lava. One is the occurrence of gossan over 120 x 50m with mine wastes in the vicinity. The other is partly pyrite dissemination and veinlets in the silicified parts over 400 x 150m to the southeast of the former. The silicified rocks contain quartz with minor amount of pyrite and marcasite.

< Southwest of Bakibaba >

This is located 0.4km southwest of Bakibaba. Limonite dissemination occurs in the altered and bleached black shale.

< North of Karacakaya >

This is located 1km south-southwest of Bakibaba. Limonite dissemination occurs in the silicified parts of hyaloclastite. It covers an area of 50 x 50m.

2-7 Discussion

The geology of the zone consists of pre-Jurassic ultramafic rocks, Jurassic basalt and sedimentary rocks of the Küre Formation, grayish white fossiliferous limestone of the Lower Cretaceous Karadana Formation, pale brown and white marl of the Upper Cretaceous Çağlayan Formation, talus deposits and also intrusive diorite and dacite.

The major part of the zone is occupied by the Jurassic Küre Formation. Basalt consists of pillow lava, hyaloclastite, and massive basalt. Sedimentary facies of the Küre Formation is composed of angularly fragmentated greywacke and tectonically sheared/argillized black shale. The matrix is made up of pelitic materials.

Basalt and brecciated sediments of the Küre Formation are interpreted as a constituent of melange.

The geologic structure of this zone is characterized by many faults. They are divided into two systems; N-S and E-W. The former system is crosscut by the latter. With the exception of diorite and dacite intrusive bodies and the Karadana Formation, the boundaries of all geologic units, including ultramafic bodies, have been displaced. The surface elongation of the intrusive bodies is harmonious with the strike of faults in the vicinity and with the boundary between sediments and basalt of the Küre Formation.

Aşıköy, Toykondu, Bakibaba, and Kızılsu are the known ore deposits in this zone. These deposits occur at the boundary between hyaloclastite and black shale of the Küre Formation. They also occur within hyaloclastite. The other large mineralized zone which is distributed on the surface occurs in Zemberekler. This mineralized zone is composed of three types of mineral showings; gossans, pyrite dissemination and pyrite veinlets in silicified basalt.

The Aşıköy deposit is the largest one in this zone. It is composed of many ore bodies which have the largest dimension of 380m east to west, 200m north to south, and 15 to 30m thick.

Ores are classified into massive ore, brecciated ore comprising fragments of massive ore filled in a matrix of chalcopyrite and pyrite, brecciated ore comprising subrounded to subangular massive ore fragments of 10 to 30cm in diameter in black shale, network ore and disseminated ore.

Ore minerals are composed of a large amount of pyrite with a small amount of chalcopyrite, sphalerite and marcasite, and a minor amount of covelline, tetrahedrite and pyrrhotite.

Gangue minerals are mainly composed of quartz with a small amount of rutile, leucoxene, clay and carbonate minerals.

The ore grade of Aşiköy in drill cores range from 1 to 9 % Cu and from 40 to 48% S.

Hyaloclastite on the footwall side of massive ore is sometimes silicified for a thickness of 1-3 m containing a large amount of quartz and minor sericite. The host rock of network zone is generally green, but it is bleached and silicified where the network is dense and sulfide minerals are strongly disseminated.

fied where the network is dense and sulfide minerals are strongly disseminated.

The geologic environment, mode of occurrence, and mineral composition of these orebodies show a common feature which is characteristic to the Cyprus-type ore deposits. The ore potential of this type may be high in the Küre zone.

CHAPTER 3 GEOPHYSICAL PROSPECTING

3-1 Outline of Geophysical Prospecting (CSAMT and IP Methods)

The object of the survey is to clarify the subsurface structure of the Küre Zone by CSAMT electromagnetic method and also to understand the relation between the geologic structure and mineralization by IP electric method. Geophysical anomalies will be extracted at the same time in order to obtain guidance for future exploration.

The geophysical survey was conducted in Küre Zone in general which was the target for semi-detailed geological survey.

The method used is CSAMT and IP. CSAMT is generally a method used for investigating a specific area. During the present survey, array method for studying a linear profile and random point method for clarifying the resistivity structure of the whole Küre Zone were applied. Ten profiles totaling 20,000m and 400 stations were measured with the array method and 113 stations were measured by random point method. With the IP method, three profiles totaling 4,000m were measured (Figure 2-8).

The lengths of traverse lines and the numbers of stations are as follows.

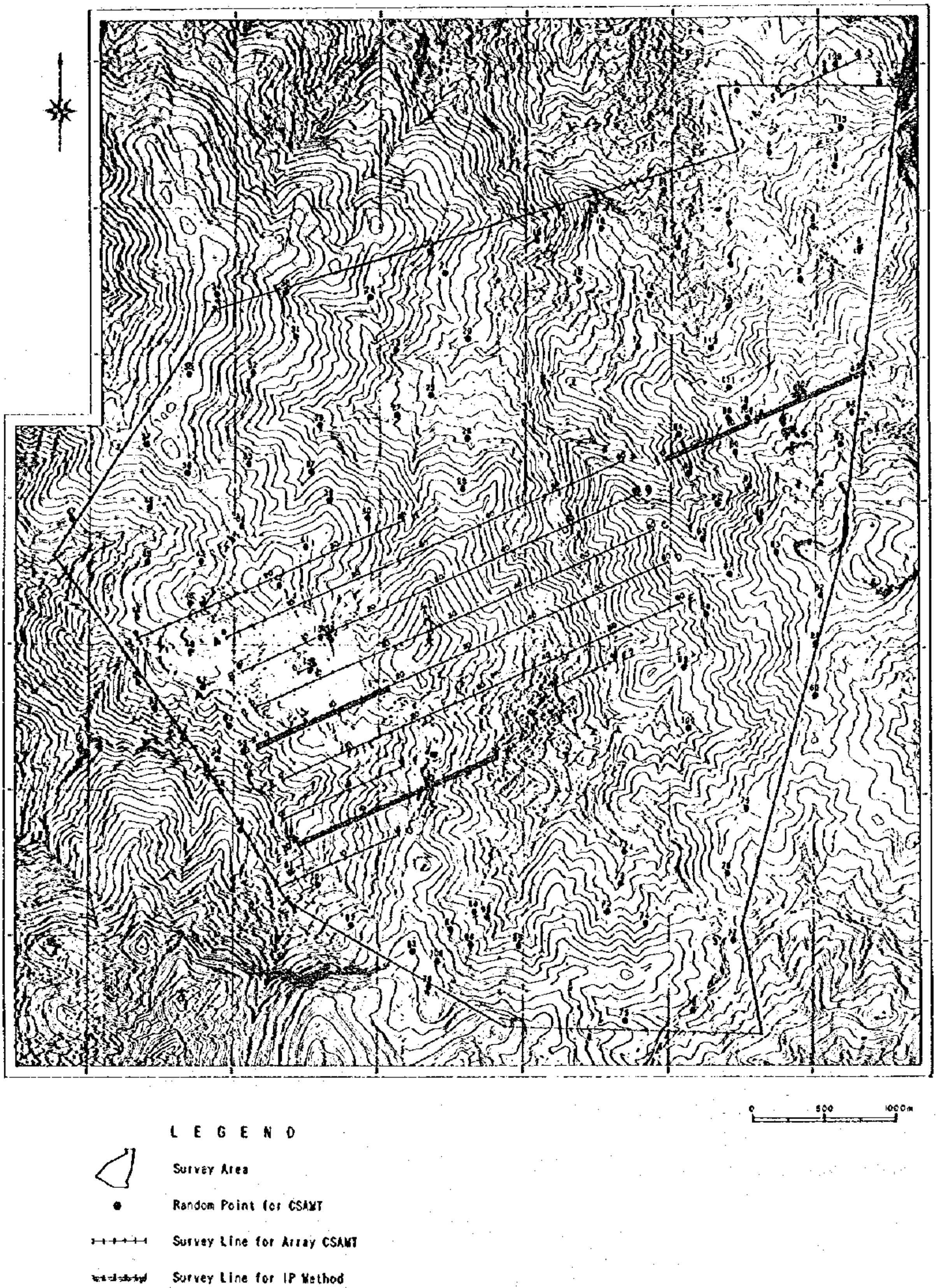
Array CSAMT Method

Line	A	B	C	D	E	F	G	H	I	J	Total
Line length (m)	3000	3000	3000	3000	3000	900	900	2000	600	600	20000
Station No.	60	60	60	60	60	18	18	40	12	12	400
Distance of stations (m)	50	50	50	50	50	50	50	50	50	50	

Line interval : 250 m

Random Point CSAMT Method

Number of station	113 points
Distance of station	200 - 500 m



L E G E N D

Survey Area

Random Point for CSAMT

Survey Line for Array CSAMT

Survey Line for IP Method

Fig. 2-8 Location Map of Survey Points and lines

IP Method

Line	DD	II	K	Total
Line length (m)	1000	1500	1500	4000
Station No.	30	55	55	140

< Selection of Traverse Lines >

The analysis and interpretation of the reports of previous survey indicated that the regional structure of the Küre Zone is not clear. In order to clarify the resistivity structure of the central part of the area and to pursue the relation between the Aşiköy and Bakibaba Deposits, five CSAMT lines at 250m intervals transecting the Aşiköy Orebody at N63°E direction were measured. From the results of this first measurements and the analysis of previous surveys, two lines for southeastern part of Aşiköy and one line for the vicinity of Toykondu were further added. Also 600m array CSAMT measurement was carried out for two anomalies in northeast Küre which were detected by random CSAMT.

With IP method, two lines between the Aşiköy and Kizilsu Orebodies, and one in the northeastern part of Küre were measured in order to determine whether the anomalies detected by the array and random point CSAMT were caused by mineralization or not.

3-2 Methods Employed for Survey and Analysis

3-2-1 CSAMT Method

< Field Operation and Equipment >

The standard configuration is six Ex dipoles and one Hy magnetic field measurements for each of the 10 frequencies, The Ex fields are measured with a dipole using non-polarizable porous pots. The survey traverse line, for the series of equally spaced Ex dipoles, is parallel to the transmitter dipole. A horizontal magnetic sensor coil is placed on the ground, approximately at the center of the series of Ex field. It must be placed several meters away from the Ex dipole line and the receiver console, to avoid interference.

The measurements are performed at each of ten frequencies with a binary step: 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048 Hz, and are three time operations to make sure the repeatability of data.

The equipment manufactured by Zonge in USA is shown in Table 2-1.

The transmitter (powered by a suitable motor generator) sends current into the grounded dipole (distance of two electrodes is about 1900m) located 4 km NNE from the Küre Mine.

The transmitting dipole is at a distance of about 1.9 km in the N63°E direction. The coordinates and conditions are as follows:

Location	Elevation (m)	Orientation	Distance of dipole	Current (Amp)
NE electrode:Lta. 41°46'54"N Long. 33°44'52"E	900	N63°E	1,900m	3.5 - 11
SW electrode:Lat. 41°46'30"N Long. 33°43'39"E	950			

The field conditions of random stations were the same as array system on the survey line with the exception of measurement of one Ex field.

Table 2-1 Equipments of CSAMT Method

Item	Model	Specification
Transmitting System	Chiba Electric Transmitter CH-120A	Output Voltage :400,600,800,1000V Output Current :0.1 ~ 20A Wave Form :Rectangular wave 1 pc Frequency :DC ~ 8192 Hz Weight :40 Kg
	Zonge GGT-20 Transmitter	Output Voltage :400,600,800,1000V Output Current :0.4 ~ 40A Wave Form :Rectangular 1pc Frequency :DC ~ 8,192Hz Weight :120kg
	Zonge XMT-16 Transmitter controller	Frequency :DC ~ 8,192Hz Weight :5.8Kg 1 pc Power Requirement:12 Volt Battery
	Zonge ZMG-20 Engine Generator	Maximum Power :20 KW Frequency :400 Hz 1 pc Output Voltage :115V Power :62Hp
Receiving System	Zonge GDP-16/8 Data Processor	Input Channel :8 cH. Sensitivity :0.03 μ V 1 pc Weight :23Kg Power Requirement:DC 12 Volt
	Toshiba Computer J-3100GT	16 bits 1 pc
	Zonge ANT/1B Antenna	1 Coil 1 pc Weight :6.2Kg
Electrode	Current Potential	Fe Plate 24cm × 36cm 15 Sheets Non-polarizable CuSO4 Porous Pot
Walkie Talkie	Yaesu	Output :5.0 watt 900 MHz 4 pcs

< Data Processing and Interpretation >

The magnitudes of Ex and Hy are measured at the stations, the resistivities and the parameters(the phase differences in Ex-Hy and the standard deviation) are calculated, stored in the RAM of the receiver unit and transferred into the field personal computer at the end of each day. The data were immediately processed at the camp. The field presentation of the results is in the form of a contoured apparent resistivity pseudosection plot and a plane map. The skin depth equation suggests that the data of lower frequencies inform us of deeper characteristics, the CSAMT data can be plotted with frequency as the sounding parameter (vertical axis) and receiver position as the lateral parameter(horizontal axis). This type of plot is called a sounding pseudosection, and the plane maps of each frequency are plotted with the apparent resistivity.

< One-Dimensional Inversion Analysis >

The CSAMT curve, plotted with ten frequencies as X-axis and apparent resistivity as Y-axis, is interpreted for one-dimensional multi-layer structure by computer.

1) The initial models are made by qualitative analysis of the observed CSAMT curve using the Bostick Inversion.

2) The parameters, namely resistivities and thickness of layers, are corrected by the non-liner minimum square method.

3) The theoretical CSAMT curve of the model is compared with the observed CSAMT curve.

4) The procedures 2) and 3) are repeated, the deviation between observed value and the theoretical value of model are minimized.

These data which are analyzed, the resistivities and thickness of layers, are plotted on the cross section of resistivity and plane map on each levels of 100m, 200m, 300, 500m below the ground surface.

< Two-Dimensional Inversion Analysis >

There are two methods of two-dimensional analysis, one is called forward method, the suitable model made from the result of one-dimensional analysis is calculated. The other is called inversion method, the fitness model is obtained directly from observed values. In this report, two-dimension inversion analysis is applied for the CSAMT anomaly zones. The program was prepared by Ogawa and Uchida (1988, GSJ). This program calculates the coefficients of partial differential equation for the parameters of response function when the model is calculated by forward method. The second step is that new parameters are set by the inversion analysis applied numerical solution of singular value. The most fit model of minimum deviation with observed values is selected from these parameters.

3-2-2 IP Method

< Field Operation and Equipment >

The distance between receiver dipole and transmitting dipole is changed in measuring.

The conditions of field work are as follows.

The electrode configuration : dipole - dipole
The distance of electrode : horizontal 100 m
The coefficient of electrode : n= 1 - 5
Frequency : 0.3 Hz and 3.0 Hz

The equipment used for IP survey is shown in Table 2-2.

Table 2-2 Equipments of IP Method

Item	Model	Specification
Transmitter	Chiba Electric Lab. Model 8104T	Output Voltage :200 V ~ 800 V Output Current :0.2 ~ 2.5 Amp Wave Form :Square Wave Frequency :0.1Hz ~ 3 Hz
Engine Generator	McCulloch MK-2	Output :2 KW Frequency :400 Hz Output Voltage :115 V
Receiver	Chiba Electric Lab. Model 8104R	Sensitivity :10 V Frequency Range:0.1 ~ 3 Hz Power Requirement 006Px4 pcs
Electrode	Current Potential	Stainless ϕ 0.6cm, Length 60 cm Non polarizable $CuSO_4$ Porous pot

< The Data Processing and Interpretation >

Apparent resistivity data and FE are illustrated on the pseudosection and plane map.

The terrain effect appear on the pseudosections of apparent resistivity. Correction calculated by computer is performed on the measured values of apparent resistivity.

These pseudosections show analytically the characteristics of apparent resistivity and FE.

Two dimensional model simulations are applied for IP data.

3-3 Results of Geophysical Prospecting

3-3-1 CSAMT Method

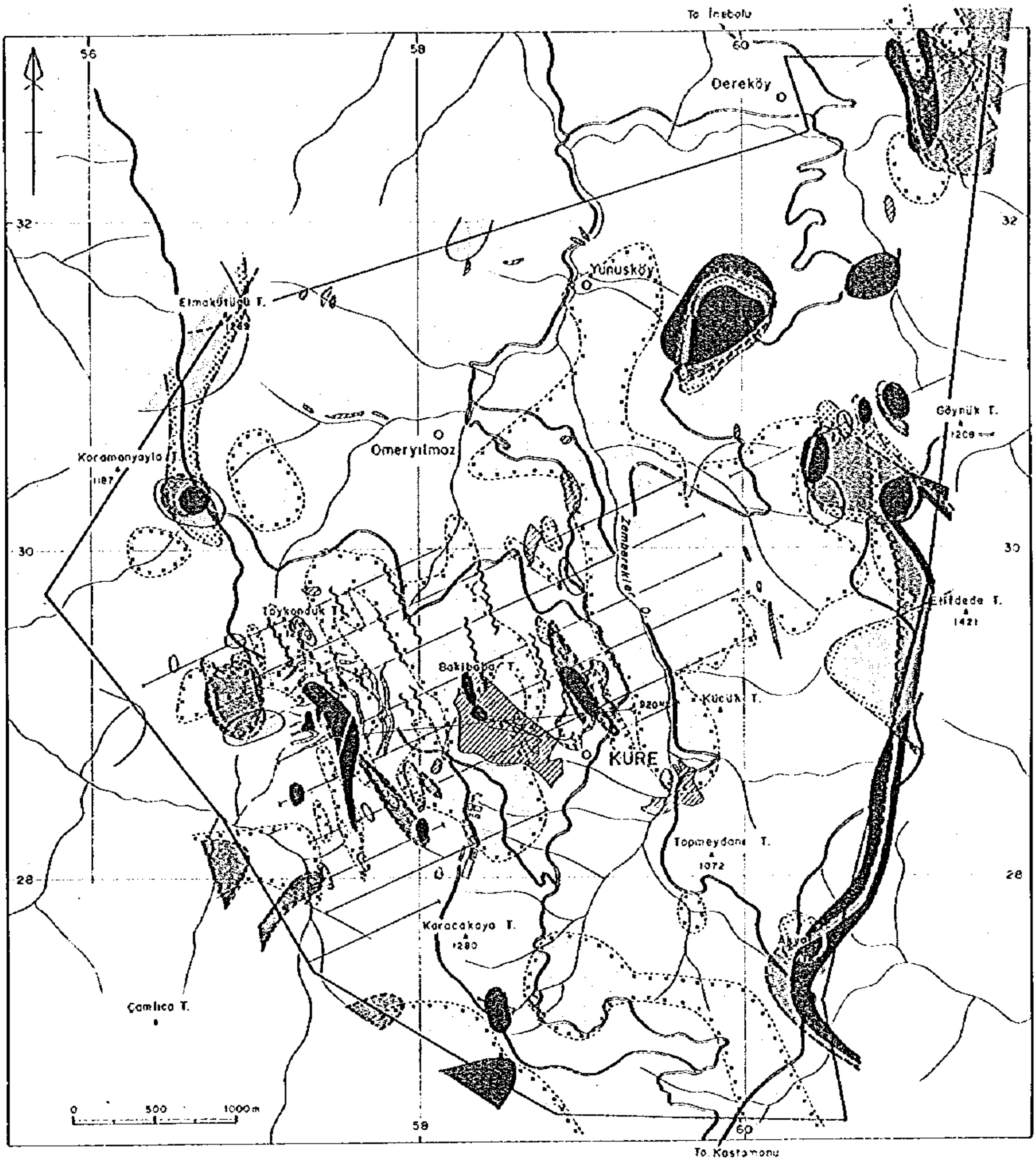
A total of 513 stations, 400 array stations and 113 random points were measured by CSAMT method. For the array anomalies, inversion analysis was made in order to obtain two-dimensional structures which fit the measured values.

The interpretation of the results of CSAMT array and random point surveys one- and two-dimensional analysis are described below. The CSAMT method interpretation map and CSAMT two-dimensional simulation result are shown in Figures 2-9 and 2-10 respectively.

(1) As a whole, the resistivity of the Küre Zone is dominantly of intermediate values, 100-300ohm-m. This intermediate resistivity is distributed quite widely in the vicinity of the area. The high resistivity zones of more than 1000ohm-m are concentrated in the central part of the area and extend in the NW-SE direction. The distribution of these high anomaly zones tend to expand toward the deeper parts and resistivity exceeding 300ohm-m extends throughout the area at 500m depth or more.

(2) Regarding low resistivity anomalies, those related to Aşıköy, Bakibaba, and Kızılsu Deposits are significant. A group of small anomalies to the southeast of Aşıköy Orebody was detected by the present work. Also small but strong low resistivity anomalies are confirmed to the north and south of the Bakibaba Deposit.

(3) Regarding weak anomalies, there is a northeastern Bakibaba weak anomalies which are considered to be related to the mineral showings at northeast of Bakibaba Orebody. Slag from old Bakibaba Mine is dumped widely to the south of these anomalies. Although not recorded as a mineral prospect because of the slag, significant east Bakibaba anomalies extending in the NNW-SSE direction have been identified below the slag heap. This anomaly zone continues for four traverse lines, from Line C to E 2, and is in en echelon position with the northeastern Bakibaba weak anomalies in the north, and the Zemberekler mineralized Zone is in the southern extension of this anomaly zone.



L E G E N D

<30 ohm-m Low Resistivity Zone

- -100m Level
- -200m Level
- -300m Level
- -500m Level

>1000 ohm-m High Resistivity Zone

- at-100m~-500m Levels
- Line of resistivity discontinuity
- Ore body
- Mineral showing
- Slag

Fig. 2-9 Geophysical Interpretation Map of the Küre Zone

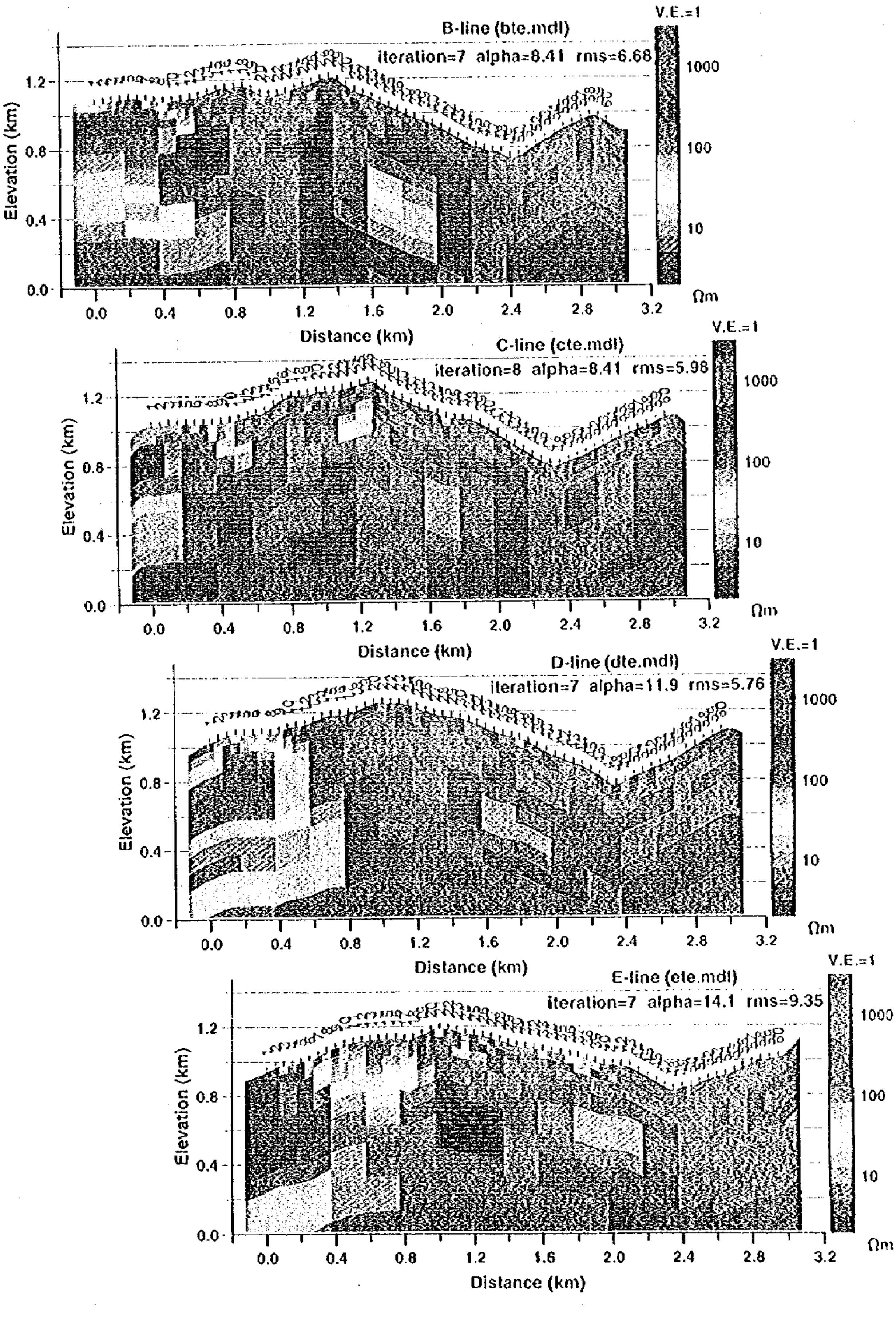


Fig. 2-10 Two-dimensional Interpretation of CSAMT of the Küre Zone

(4) Mineral prospect are known at Ersizlerdere and İpsinler in the northeastern part of Küre Zone. Random CSAMT points were established at these localities for investigation of the prospecting. Some lowering of resistivity was observed, but not to the extent of calling it anomaly. Thus these localities are considered to be not promising.

(5) Although Kızılsu and Zemberekler mineral showings are considered to have high mineral potential, CSAMT random points could not be established because of the noise from the high tension transmission cables.

(6) Significant low resistivity anomalies were identified at 400m north of Ersizler Prospect and 1km south of İpsinler Prospect by CSAMT random point measurements. Array CSAMT measurements were carried out in addition to the original plan, and notable low anomalies were analyzed at both localities. Both anomalies were detected in the talus deposits with tall limestone cliffs in the back. And IP exploration was carried out in order to check whether the anomalies were caused by mineralization or by factors other than mineralization such as groundwater.

(7) The low resistivity anomalies at, the western end of Lines A and B, east-southeast of Yunusköy in the north, and east of Mt. Koramanyayla T., are distributed widely over two or three stations. The former two anomalies occur in shale and sandstone, and the latter in serpentinite and there are no mineral showings in the vicinity. These anomalies are not considered to be important.

(8) It is known that the distribution of the high anomalies agree well with that of basaltic rocks. The high anomalies are distributed with NW-SE to NNW-SSE trend and the line of resistivity discontinuity also trend in the same direction.

3-3-2 IP Method

IP electrical prospecting is a method by which the orebodies are directly detected and confirmed. During the present survey, three lines, namely DD, II, and K were established in order to check the anomalies detected by CSAMT. The results of the measurements and of two-dimensional model simulation are described in the following sections.

FE anomalies of significance have not been detected by IP in the three traverse lines. The low resistivity detected by CSAMT in Line II is believed to be caused by groundwater. Regarding the inability to detect the shallow subsurface anomalies by Line DD, it is not feasible to detect anomalies at depth of 50m or so by electrode interval of a=100m. Shorter interval of 25 to 50m would be more suitable for work of this type.

3-3-3 Laboratory Tests

Forty three representative rocks in the area were sampled for measurement of physical characteristics such as resistivity and FE values by the same equipment used in the field. The samples were roughly shaped at Etibank and reshaped into cubes or rectangles upon return to Japan and then measured.

The following features are noted for the rocks in this area.

(1) Resistivity is generally high in diorite and basalt in the range of 300-4,000ohm-m. On the other hand that of the sedimentary rocks , namely black shale and sandstone are low at 300- 600ohm-m. The value of each rock is scattered in a relatively wide range and they sometimes overlap. The resistivity of shale and sandstone tends to be higher than other rocks.

(2) The rock with the highest resistivity is limestone at 28,200ohm-m followed by serpentinite, hyaloclastite, pillow lava, massive basalt, diorite, sandstone, and black shale. The lowest measured average is 302ohm-m of black shale.

(3) The FE values are more consistent compared to resistivity. They are within normal range.

(4) The rock with the highest FE value is serpentinite at 12.2% followed by black shale, hyaloclastite, sandstone, diorite, massive basalt, pillow lava, and limestone. The lowest average is 0.4% of limestone.

(5) Serpentinite has high resistivity and FE vales, the averages being 20,000ohm-m and 8% respectively. Limestone of this area has high resistivity and low FE within the general range.

(6) The ores of the Aşıköy, Bakibaba, and Kızılsu Deposits have high FE of around 40% and very low resistivity of 7.5ohm-m. Both of these physical properties are significantly different from the host rocks.

(7) The FE of gossan and slag are both unexpectedly low, 4.25 and 17.9% respectively. The resistivity is high for gossan at 964ohm-m similar to the values of diorite and basalt, but that of slag is low at 220ohm-m within the normal range of sedimentary rocks.

3-4 Summary of the Geophysical Prospecting and Discussions

The relation between the resistivity structure and the ore deposits, mineralized zones of the area was investigated by CSAMT method with 400 stations of array measurements and 113 random points. Then 4000m of IP lines were measured for promising anomalies detected by the CSAMT method. The following is the findings of the investigation as well as matters to be considered carefully.

3-4-1 Vicinity of the ore deposits

A group of small anomalies to the southeast of Aşıköy Orebody is not considered to indicate the southern extension of the orebody because the depth of these anomalies is shallow. It is considerably possible that the extensional parts of the orebody were displaced tectonically to the shallow positions from the deep ones.

A strong low resistivity anomaly confirmed to the north of Aşıköy Orebody is possibly interpreted to be network zones of Aşıköy Orebody or to be a massive ore displaced tectonically from other places.

Small low resisitivity anomalies detected to the north and south of the Bakibaba Deposit are possibly considered to imply the existence of ore deposits because the surface of these anomalous areas is covered by gossan.

CSAMT random points could not be established in the vicinity of the Kızılsu Deposit because of the noise from the high tension transmission cables. Therefore it can not be evaluated geophysically.

3-4-2 Other Mineral Showings

Low resisitivity anomalies extending in the NW-SE direction from the northeast of Bakibaba Deposit to Zemberekler mineral showing is located on the boundary of basalt and sediments. Pyrite dissemination occurs in both rocks near the boundary at 920 ML gallery. The northern extension of these anomalies corresponds to a mineral showing, namely North of Bakibaba. These anomalies are considered to be important from above facts.

Ersizlerdere and İpsinler mineral showings are known in the northeastern Küre Zone. CSAMT random points were measured in these localities for determining the existence of anomalies and slight decrease of resistivity was found, but not to the extent of being anomalies. Thus the potential of these two showings is considered to be low.

Low resistivity anomalies by CSAMT random points are not observed in Northern Yunusköy, Western Yunusköy, East of Elmakütügü, Western Göynük and North of Toykondu. The CSAMT array survey in the southwest of Bakibaba does not support to exist low resistivity. These mineral showings are evaluated to have low potentiality.

Any geophysical survey was not conducted in Western Ömeryilmaz, Eastern Ömeryilmaz, East of Bakibaba, Zemberekler, Southwest of Bakibaba and North of Karacakaya.