REPORT
ON
THE MINERAL EXPLORATION
IN
THE ÇANAKKALE AREA
REPUBLIC OF TURKEY

CONSOLIDATED REPORT

FEBRUARY 1991

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

REPORT
ON
THE MINERAL EXPLORATION
IN
THE ÇANAKKALE AREA
REPUBLIC OF TURKEY

CONSOLIDATED REPORT

FEBRUARY 1991

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 Çanakkale Area, and commissioned its implementation to the Japan International Cooperation Agency.

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

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

The collaboration survey for metallic mineral, which lasted three years, consists of geological, geochemical, and geophysical surveys, supported by drilling and laboratory work. This consolidated report hereby submitted summarizes results of the said survey.

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

February 1991

Kensuke Yanagiya

Kensuke YANAGIYA
President,
Japan International Cooperation Agency

Gen-ichi FUKUHARA
President,
Metal Mining Agency of Japan

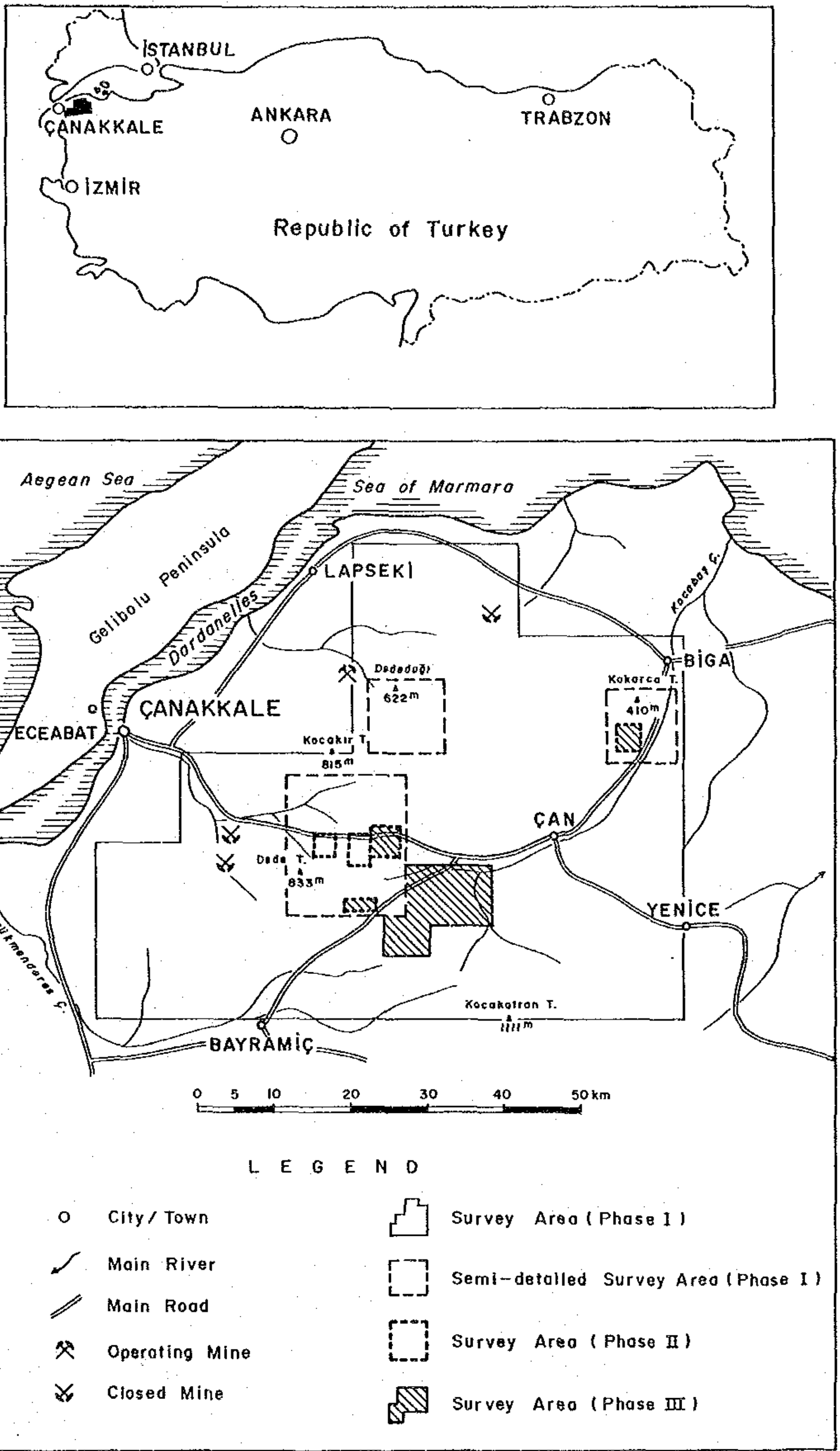

Figure 1-1 Index Map of the Survey Area

Summary

The objective of the present survey was to clarify the mode of occurrence of various metal deposits of the Çanakkale Area.

Prior to the survey of the first phase, Landsat images totaling 3,400km^2 in areal extent were analyzed and interpreted; available data regarding previous work on geology and geochemical prospecting were acquired and studied. From the results, Zones A and B were isolated as warranting investigation for precious metals, and Zone C for metallic deposits.

In addition to the geological survey, systematic collection of rock samples for geochemical prospecting and heavy mineral investigation were carried out. Also, the remainder of the stream sediment samples previously collected by MTA was analyzed for gold and other additional elements. As a result of the survey of the first phase, four localities (Arlık Stream, Karaibrahimler, Kestane Mt. and Piren Hill) in Zone B and one (Dikmen) in Zone C were isolated as promising.

In the second phase, the detailed geological survey, systematic collection of rock samples for geochemical prospecting, and heavy mineral investigation, geophysical prospecting and drill survey were carried out in the above-mentioned localities. On the basis of these results, surveys of the third phase were conducted as follows:

Zone	Geological Survey		Geochemical Prospecting		Drill Survey
	Semi-detail	Detail			
A	100km^2		Rock Samples	138pcs	
B	415km^2	69km^2	Rock Samples	1,625pcs	1,812.10m (12 holes)
			Trenches (1,579m)	508pcs	
C	100km^2	12km^2	Rock Samples	312pcs	150.00m (1 hole)
Total	615km^2	81km^2		2,583pcs	1,962.10m (13 holes)

The results of survey are summarized as follows:

(1) Arlık Stream: Many rock samples bearing gold were found in the silicified zones, and gold mineralization zones of low grade were detected by trench and drill surveys conducted in the Sartaş and Güvemalanı silicified zones.

(2) Piren Hill: Although limonitic gold-bearing argillized zones were intersected by drill hole MJTC-2 in the Davulgılı alteration zones, significant gold mineralization zones on the surface could not be detected by trench survey.

(3) Etili: Many more rock samples containing gold were found in the Hamam and Halilaga silicified zones. The limonitic, porous and brecciated parts of the

former contain gold, the massive parts are mined as brick-sized stone. The latter is limonitic, argillically silicified, of small scale, and extending NE-SW. Auriferous zones of a small scale were intersected by drill hole MJTC-16 near the surface.

(4) Dikmen: A porphyry molybdenum-copper mineralization associated with the intrusion of the Dikmen Granite and porphyry was discovered. The subsurface extent of mineralization from the outcrop downward was shown by delineating the PFE anomalies by geophysical methods. The lithology of MJTC-15 consists of altered rocks of the Emeşe Formation which are strongly silicified and are accompanied with quartz veinlets of various orientations. The content of antimony and mercury is high, indicating the halo of gold mineralization.

The mineralizations of the survey areas are largely divided into epithermal and dissemination (porphyry molybdenum) types. Epithermal-type mineralization is low-grade large-scale gold deposits in Zone B. The dissemination type is found in Zone C. It is associated with the intrusion of Dikmen Granite and porphyry, and also, low-grade (Mo) mineralization is developed in the host rocks.

Concerning the relationship between geologic structure and mineralization, serpentinite and Dikmen Granite, together with the associated porphyry, and epithermal mineralization are arranged in the direction of the major lineaments, NE-SW and E-W. In Zone B, gold mineralization is observed associated with the NE-SW faults near the uplifted basement and with the younger NEN-SWS and NW-SE fractures. As for the geochemical anomalies and mineralization zones, it was concluded that rock samples are more effective indicators, and delineation was carried out using component scores of a multivariate analysis method. This conclusion is based on the analysis of rock samples and the results of the analysis of heavy mineral samples. Gold grains were found in heavy mineral samples about 1-2km downstream of the exposures and this agrees with the results of rock sample analysis.

A comprehensive study of the above work resulted in delineation of the following zones for future prospecting.

Zone B: Geochemical anomalies of gold were discovered in the alteration zones in the Miocene Şapçı Volcanics which are distributed in the vicinity of the basement complex. The basement is composed of the Taşdibek/Sakar Dağı Formation and granites. From the mineralization and extent of the geochemically anomalous zone, three localities (Sartaş and Güvemalanı Hills of Arlık Stream, eastern Piren Hill and Tepeköy of Etili) are expected to bear large-scale low-grade gold deposits.

Zone C: A porphyry molybdenum-copper deposit associated with the intrusion of Dikmen Granite and porphyry was discovered in this zone. Molybdenite, chalcopyrite, pyrite and other sulfide minerals occur in minor amounts and analysis of rocks showed the association of gold, arsenic, and other metals. Thus it is considered that epithermal mineralization occurred after the porphyry molybdenum mineralization, and that the two overlapped. It is supposed that this type of mineralization extends to the lower parts and should prove to be a large-scale low-grade deposit.

The objective of future exploration will be to clarify the subsurface extension of the mineralized zone. It is recommended that a drill survey be conducted in the promising areas delineated above.

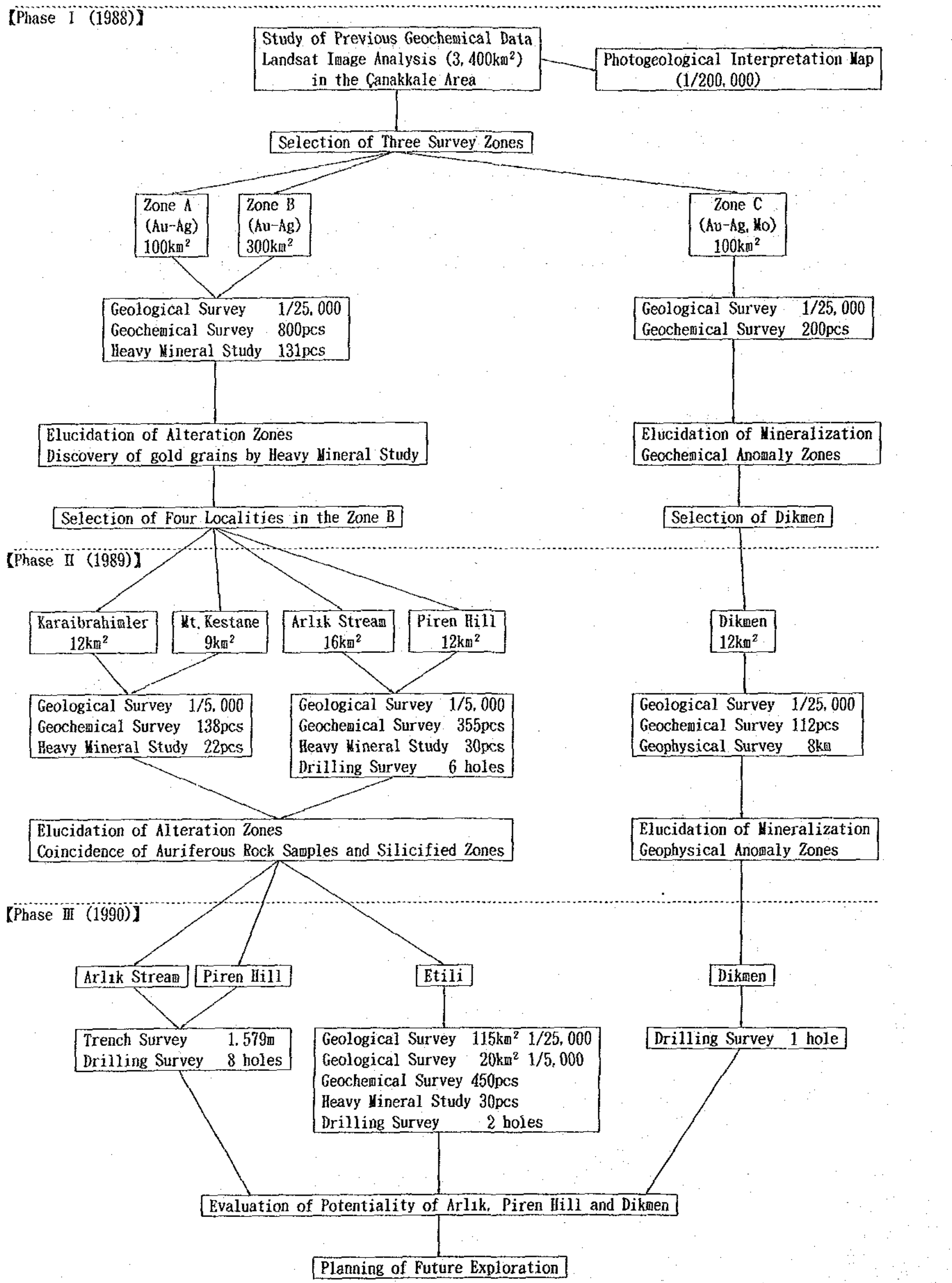

Table 1-1 Flow Sheet of Selection of Promising Area through Survey

CONTENTS

PART I OVERVIEW

PART II REGIONAL CONSIDERATIONS

PART III GEOLOGY AND PROSPECTING OF ZONES A, B AND C

PART IV CONCLUSIONS AND RECOMMENDATIONS

APPENDIX

FIGURES

TABLES

PART I OVERVIEW

PART I OVERVIEW

CHAPTER 1 INTRODUCTION

1-1 Background and Objective of the Survey

The work reported in the following chapters comprises the three year projects on Mineral Exploration of Çanakkale Area in the Republic of Turkey. Prior to the field survey, existing data and information from previous geological surveys and geochemical prospecting were acquired and studied. Also, Landsat images of 3,400km^2 were analyzed and interpreted. From these studies, three zones were extracted for semi-detailed survey. These are Zones A (100km^2), B (300km^2) and C (100km^2), and they were inferred to be promising for metal concentration. The data on which the delineation of the three zones was based are laid out in Table 1-2.

As a result of the first-phase survey, in the four localities of Zone B, epithermal gold mineralization was anticipated from the gold showings of the alteration zones which were identified by geological and geochemical surveys. The hydrothermal gold mineralization is expected to extend both horizontally and vertically. In the second-phase survey detailed geological survey clarified the distribution and extent of the alteration zone, and the investigation of the heavy minerals of the vicinity located the position of the gold mineralization. On the basis of these findings, inclined drilling was carried out in order to clarify the state of subsurface mineralization.

Regarding the Dikmen Granite of Zone C, geophysical prospecting was carried out together with detailed geological survey and geochemical prospecting. The detailed geological survey clarified the distribution and the conditions of gold occurrence, argillized zones and skarnization. The geochemical work clarified the two types of mineralization.

By geophysical methods, the subsurface extent of mineralization from the outcrop downward was shown by delineating the low resistivity zone and FE anomalies by IP, then detailed SIP work provided the necessary information.

The results of the second-phase work in Zone B indicate the possibility of large-scale low-grade gold deposits in the alteration zones near the basement rocks. The porphyry molybdenum deposit in Zone C is also expected to be a large-scale low-grade deposit as this type of mineralization is extensive at depth. This deposit locally contains gold and antimony, and it may turn out to be a very important target if significant gold is found in the overlapping portion.

Table 1-2 Summarized Data for Selection of Semi-detailed Survey Area

		No. ※1	Name of Geochemical Anomaly	Minerals	Geological Environments※2	Remarks※3 1	2	3	4	5	Selected Survey Areas(km²)
MINERALIZATION	Related with younger volcanics	1	Kuştepe	Cu	Kuş with Tsi	A	×				
		2	Çamlıtepe	Cu, Pb, Zn	ditto	A					
		3	Kundakçılar	Cu, Pb, Zn	ditto	A			○	○	
		4	Yaylatar	Pb, Zn	ditto	A			○		100(A)*1
		5	Balcılar	Pb, Zn	ditto	A			○	○	
		12	Sivridag Kocalar	Cu, Pb, Zn	$A_1+T_1$with Tsi/Gd	A	×		○		
		30	Torunlar	Cu, Mo	$A_1+T_1$with Tsi	A		○		○	300(A)*2
		31	Karacaören	Cu, Pb, Zn, Mo	A_1+T_1/nd	A		○	○		
		13	Kavak Dere	Zn	$A_1+T_1$with Tsi	A	×			○	
		27	Karıncalı	Pb	A_1+T_1/nd	A	×	○		○	
		28	Y. Palamut	Cu, Pb, Mo	ditto	A		○		○	120(B)
		34	Doganci	Cu, Mo	nd/Hs	A		○			
		39	Bardakçılar	As, Pb, Zn, Sb	A_1+T_1 with Tsi/Gd/Hs	A	×		○	○	100(B)
		61	Sakardag	Cu	Gn/Gd/Hs	A					
		101	Calılı	Cu	A_1+T_1 with Tsi/Hs	A					
		102	Dibektaş	Cu	ditto	A	×				80(B)
		103	Kızıldam	Cu	ditto	A					
	Related with older v.	6	Kocamusalar	Cu	Efl	B					
		7	Magara Tepe	Pb, Zn	A_1+T_1	B					
		9	Manyasobası	Cu, Pb, Zn, Sb	ditto	B		○		○	
		10	Karadag	Cu, Pb, Zn, Sb	ditto	B		○			80(B)
		11	Dogancılar	Cu, Pb, Zn, Sb	ditto	B					
		14	Üvezdere	Pb	ditto	B	×	○			
		29	Kayalıdag	Mo(Pb, Zn)	ditto	B	×		○		100(B)
		32	Bıyıklı	As	ditto	B		○			
		99	Adatepe	Sb, As	A_1+T_1/ng	B	×				
		100	Çataltepe	Sb, Pb, Zn	A_1+T_1/Ep	B					
	Related with granitoids	8	Sayatepe	Pb, Zn	Gn/Gd	C					
		19	Danapınarı	Pb, Zn, Mo	ditto	C					
		20	Dikmen	Cu, Zn	ditto	A					
		21	Katrancı	Mo, Cu, Pb, Zn	ditto	A					
		22	Cilingitr	Cu	ditto	A					100(A)*3
		23	Okcular	Sb	ditto	A					
		24	Dogaca	As	ditto	C					
		25	Kayacık	Cu	Ep/Gd/A_1+T_1	C					
		26	Kuşçayırı	Cu, Pb, Zn, Sb	Ep/Gd	C		○			
		38	Hacıbekirler	Pb, Zn, Cu	A_1+T_1/mum/Gd	C		○			
		40	Kanlıoba	As, Cu, Pb, Zn	mum/Gd	C	×				
		41	Yesilköy	As	ditto	C	×				
		42	Korucak	As, Sb, Pb	A_1+T_1	C		○			
		43	Tongurlu	Cu	Gd/Hs	C	×				
		58	Sazak	W?	Gn/Gd	C					
		104	Karaeyrek	Cu	Ep/Gd	C					
		105	Susamalan	Cu	ditto	C					
		109	Salihler	Cu, Pb, Zn	ditto	C					

※1 Geochemical Data of Northwest Anadolu Branch of MTA
※2 Symbols are same as Table 1-6. Hs : Hot spring
※3 1:Priority, A, B, C in order
2:Including the concession of private sector
3:Including the concession of MTA
4:Indicating ring structure of TM image
5:Including the siliceous tuff zone
*1: Zone A, *2: Zone B, *3: Zone C

The surveys of the third phase included trench and diamond drill in the Arlık Stream Area, trench in the Piren Hill Area, diamond drill in the Dikmen Area, and geology, geochemistry and diamond drill in the Etili Area in which gold grains were detected by the heavy mineral study.

1-2 Areal Extent and Work Operation of the Survey

Table 1-3 Survey Contents and Laboratory Studies

Survey Area	Reco S.A. km²	Deta S.A. km²	Rock Sample Reco pcs	Rock Sample Deta pcs	X-ray pcs	Whole Rock pcs	Polish Sect. pcs	Thin Sect. pcs	Core Anal pcs	Tren Anal pcs	Heavy Mi.S. pcs
Zone A	100	-	138	34	2	4	2			18	
Zone B	415		1625	100	8	1	8			113	
Arlık		16		282	74	12		12	402	404	15
Kara.		12		98	4	2		2			22
Kestane		9		140	3	2		2			
Piren		12		207	7	2		2		104	15
Etili		20		389	62	13		13	100		5
Zone C	100		312	17	2		2				
Dikmen		12		269	9	10	21	10	50		
計	615	81	2075	1385	310	53	26	53	552	508	188

Reco:Reconnaissance, Deta:Detailed, S.A.:Survey Area, Sect.:Section
Mi.S.:Mineral Study, Ana:Analysis, Kara.:Karaibrahimler

Table 1-4 Location of Drill Holes

Survey Area	No.	Coordinates		Length	Direction	Dip
Piren Hill	MJTC- 1	79150	20760	151.0m	N40°E	-50°
	MJTC- 2	79580	20920	151.0m	S40°W	-50°
Kocataş	MJTC- 5	82620	30220	151.0m	N80°W	-50°
	MJTC- 6	82340	30170	151.0m	S80°E	-50°
	MJTC- 7	82325	29948	151.0m	N10°E	-50°
	MJTC- 8	82726	30548	151.0m	S10°W	-50°
Sarıtaş	MJTC- 3	82980	30790	151.0m	-	-90°
	MJTC- 9	82848	31059	151.0m	S10°W	-50°
	MJTC-10	82971	30796	151.0m	N10°E	-50°
Güvemalanı	MJTC- 4	83400	30790	151.1m	-	-90°
	MJTC-11	83426	30694	151.0m	N10°E	-50°
	MJTC-12	83554	31037	151.0m	S10°W	-50°
	MJTC-13	83597	30497	151.0m	S10°W	-50°
	MJTC-14	83729	30465	151.0m	S10°W	-50°
Dikmen	MJTC-15	13062	41280	150.0m	-	-90°
Etili	MJTC-16	88338	20785	151.0m	N20°E	-50°
(Halilaga)	MJTC-17	88500	20805	151.0M	N20°E	-50°

1-3 Periods and Members of the Survey

The survey periods and members are shown in Table 1-5.

Table 1-5 Survey Term and Members

	Turkey/Japan	Phase I (1988) Period	Phase I (1988) Member	Phase II (1989) Period	Phase II (1989) Member	Phase III (1990) Period	Phase III (1990) Member
Discussion of the New Project	Turkey (MTA)	27/1/88~1/2/88	Sıtık SANCAR Ramiz ÖZOCAK Adnan İNAN Engin ÇUBUKÇU		【MTA Coordinator】 Dr. Orhan BAYSAL Özer ÖLÇER Temel NEBİOĞLU Ramiz ÖZOCAK Asim GÖKTEPELİ Ferit ERDEN Abdullah GÜLGÖR Ercüment GÜRSOYTRAK Mehmet Abid GENÇ Nizamettin ÇETİNKAYA Sinan ASLAN		【MTA Coordinator】 Dr. Orhan BAYSAL Özer ÖLÇER Temel NEBİOĞLU Ramiz ÖZOCAK Asim GÖKTEPELİ Abdullah GÜLGÖR Rıfat BAYBÖLÜ Nizamettin ÇETİNKAYA Sinan ASLAN
	Japan		Hideki FUKUDA (MITI) Masahiro KAMITANI(MFA) Takeshi IZUMI (MMAJ) Hideo HIRANO (MMAJ) Yoshihiro KITA(MMAJ)				
Negotiation and the Agreement on the Survey	Turkey (MTA)	22/6/88~30/6/88	Orhan BAYSAL Atilla AYMAN Ramiz ÖZOCAK Mehmet Abid GENÇ				
	Japan		Takeshi MORIYA(MITI) Hideo HIRANO (MMAJ) Naotaka ADACHI(MMAJ)				
Planning and Coordination	Japan (MMAJ)			17/11/89~26/11/89	Morihiro KURUSHIMA Naoki SATOH	1/9/90~8/9/90	Morohiro KURUSHIMA Hiroshi SHIMOTORI
Turkish Members of Survey(MTA)	Coordinator		Necmi YÜCE		Necmi YÜCE		Necmi YÜCE
	Leader		Ahamet KARA		Necip PEHLİVAN		Necip PEHLİVAN
	Geologist	5/9/88~15/11/88	Hasn BATIK	26/6/89~17/11/89	Abdullah TUFAN	19/6/90~5/11/90	Abudullah TUFAN
	Geologist		Sinan ORBAY		Ahmet ÇETİN		Ahmet ÇETİN
	Geologist		Turhan ALPAN				
	Geophysicist			26/6/89~16/8/89	Kadircan AKTAŞ		
	Drill Engineer			7/8/89~21/11/89	Mustafa CANTÜRK	19/6/90~5/11/90	Muharrem DAĞLU
	Drill Engineer				Hasan Ali ERDAL		Mustafa CANTÜRK
Japanese Members of Survey(NED)	Leader		Hisashi MIZUMOTO		Hisashi MIZUMOTO		Hisashi MIZUMOTO
	Geologist	5/9/88~15/11/88	Ken OBARA	26/6/89~17/11/89	Ken OBARA	18/6/90~8/11/90	Kazuyasu SUGAWARA
	Geologist		Tetsuo SATOH		Kazuyasu SUGAWARA		
	Geologist		Kazuyasu SUGAWARA				
	Geophysicist				Masao YOSHIZAWA		
	Geophysicist			26/6/89~16/8/89	Tsuyoshi YAMAISHI		
	Geophysicist				Tadanori IWASAKI		
	Drill Engineer				Saichi ISHII		Saichi ISHII
	Driller			7/8/89~21/11/89	Tadateru SUGIBUCHI	7/7/90~1/11/90	Tadateru SUGIBUCHI
	Driller				Mitsuo NOMURA		Mitsuo NOMURA

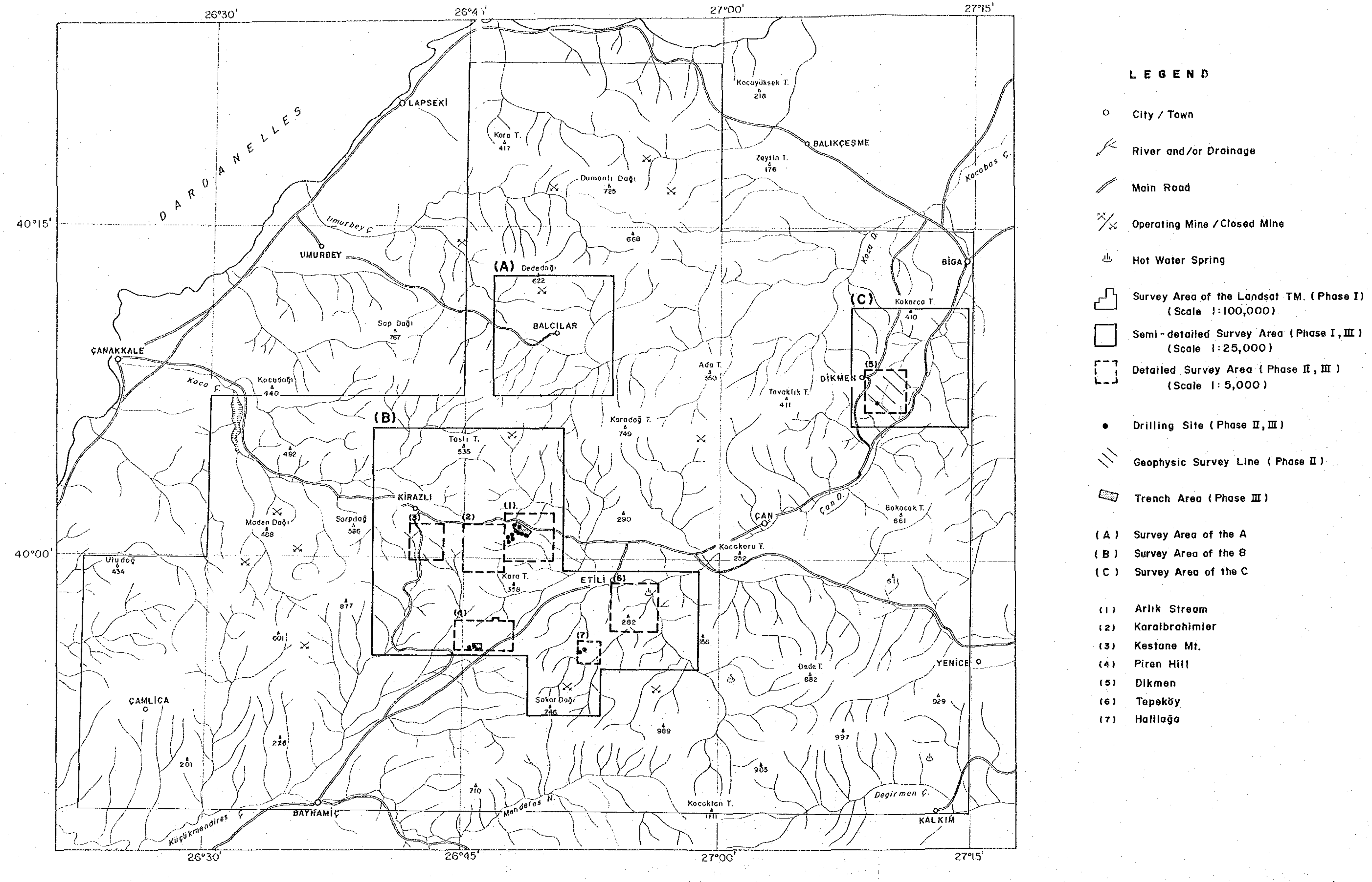

Figure 1-2 Location Map of the Survey Area

CHAPTER 2 OUTLINE OF PREVIOUS WORKS

The stratigraphy of the Çanakkale Area is shown in Table 1-6. This was compiled by Behçet AKYÜREK and Yılmaz SOYSAL of the Geology Division of MTA Ankara in 1980.

The basement of the area consists of pre-Triassic metamorphic rocks-the Kazdağ Group. It is mainly composed of gneiss, metamorphic rocks derived from basic volcanic rocks and recrystallized limestone. This basement is unconformably overlain by Mesozoic sedimentary formations and Miocene intermediate volcanic rocks. Silicified and argillized alteration zones were identified from parts of the area where volcanism was active during Eocene to Miocene, and andesite, dacite, rhyolite and pyroclastic rocks are developed. These are widely distributed in the central part of the survey area. During this period, granodiorite intrusions occurred in many parts of the area and iron, copper, lead and zinc mineralization are found associated with these intrusions.

In 1987, an exploration group of the Turkish Petroleum Co. conducted a geological survey of the whole Biga Peninsula prior to drilling for oil in Edremit Bay (bay at the southern part of the Biga Peninsula). It was shown by this work that the volcanic rock widely distributed in the central part of the area can be grouped into the product of three major volcanic activities: Eocene, Miocene and post-Pliocene. Also there are two stages of granite activities: Triassic and Cretaceous to Eocene. The ages were determined by the study of fossils in the vicinity. The compiled geology of the Çanakkale area is shown in the Figure 1-3.

CHAPTER 3 GENERAL GEOLOGY OF THE BIGA PENINSULA

3-1 Outline of the Western Part of the Biga Peninsula

The geology of Biga Peninsula, as mentioned above, has been investigated by MTA and the Turkish Petroleum Co., as shown in Figure 1-3. Table 1-6 shoes the correlation of the results of the present survey with those of the two previous works. It is seen that the stratigraphy compiled during the three years of geological study agrees with that prepared by the Turkish Petroleum Co.

Table 1-6 Correlation List of Biga Peninsula

Geologic Age		Turkish Petroleum Co. Exploration Group (1987)	Yılmaz SOYSAL Behçet AKYÜREk (1980)	Turkish-Japanese Joint Project (1989-1991) Zone A	Zone B	Etili	Zone C
Cenozoic	Quaternary Holocene	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
	Quaternary Holocene	Taştepe Basalt		Balaban B.	Kocaçakıl B.	Terrace dep	
	Quaternary Pleistocene	Gülpınar F.	Olivine Basalt		Karaköy F. Osmanlar V.		Bakacaklı V.
	Pliocene	Bayramiç F. / Ergene G.	ng/nd Göl Sediment Agps Agglomerate Arag Agglomerate	Dededag V.			Akkayrak V.
	Miocene	Alçıtepe F. Kirazlı F. Gazhanedere F. Küçükkuyu F. / Çan F.	DR Dacite/Rhyolite A_2+T_2 Volcanics Tsi Silicified tuff				
	Miocene	Ezine Volcanics / Hisarlıdag Volcanics	A_2+T_2 Volcanics	Balcılar V.	Şapçı V.	Şapçı V.	
	Oligocene	Yenimu-hacır G.: Osmancık F. Mezardere F.					
	Eocene Middle-Upper	Keşan G.: Volcanics Ceylan F. Soğucak F. Koyunbaba F.	Efl Sandstone & Conglomerate				Kirazlıgecit M. Kızılcık M.
	Eocene Lower	Akçaalan Volcanics Fıçıtepe F. Karaağaç F.	A_1+T_1 Andesite & Tuff	Çamyayla V.	Çamyayla V.	Gicikler V.	
	Palaeocene	Palaeocene					
Mesozoic	Jurassic~Cretaceous	Manyas Melange (Ophiolite & Limestone) Vezirhan F.					Sarısuvat F.
	Jurassic~Cretaceous	Bilecik Limestone Bayırköy F.			Kirazlı Conglomerate		
	Triassic	Granite	Granite				
	Triassic	Karakaya Group: Yalindi F. Arnutcuk M. Çal F. Limestone Spilite Torasan F. Karaasik F. Sazak M.	Hasanlar F. Çınarcık Limestone Karakaya F.		Taşdibek F.	Sakar Dağı Formation	Emeşe F.
Pre-Triassic		Kazdağ Metamorphics	Kazdağ Group				

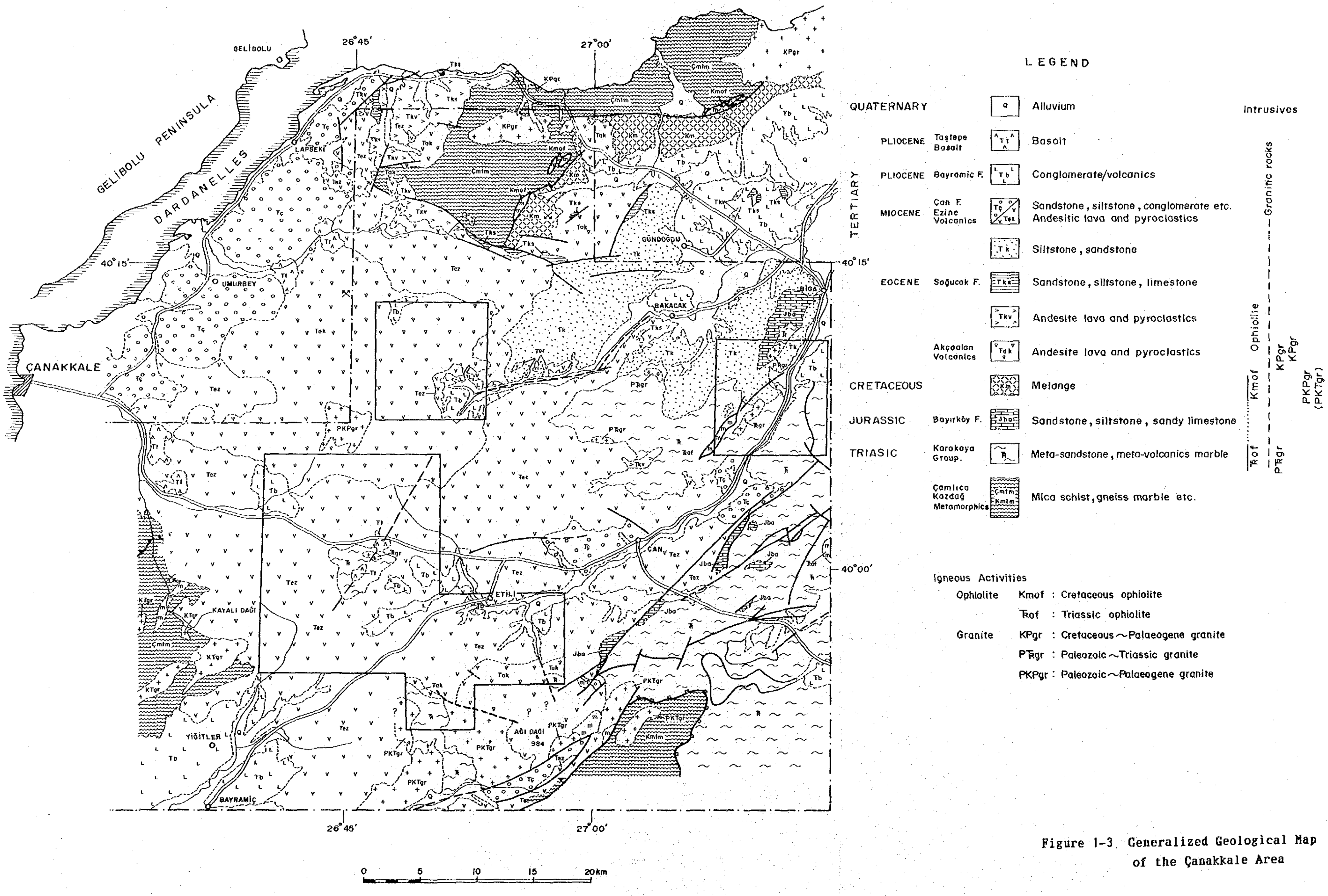

Figure 1-3 Generalized Geological Map of the Çanakkale Area

The lowermost geologic unit of northwestern Biga is the pre-Triassic metamorphics (Kazdag Group) which consists mainly of metamorphic rocks of basic volcanic origin and is distributed to the north of Zone A and west of Zone B, both outside of the present survey area. In Zones B and C, the Triassic Karakaya Group and unconformably overlying Eocene and later intermediate volcanic rocks are widely distributed, while in Zone A, Eocene and later intermediate volcanic rocks occur widely. Most of the geologic units of these zones are Eocene to Miocene andesites and andesitic pyroclastics accompanied by a small amount of Late Tertiary to Quaternary dacite and basalt. The intrusive rocks are Triassic and Cretaceous to Eocene granodiorite, and they are distributed in Zones B and C.

Representative fossils of Biga Peninsula were provided by the Turkish Petroleum Co. They are unpublished material.

3-2 Geology of the Area and its Significance to Mineralization

The geology of the major part of the survey area consists of Eocene and later volcanic rocks. The host rocks of the silicified and argillized zones are Miocene volcanics. These alteration zones have characteristics similar to those at the Madendagı and Kartaldagı mines. They extend into the survey area. The age of the alteration is inferred to be latest Tertiary, and the centre of the Tertiary volcanic activity was very clearly identified.

The geology of Zone C consists of metamorphosed volcanics and sedimentary rocks in which granite and serpentinite intruded along fractures of a NE-SW system. The granite is altered with highly developed fracture zones. The mineralization of porphyry molybdenum type occurs in these zones.

CHAPTER 4 GEOGRAPHY

4-1 Location and Access

Çanakkale is the capital of the province and is the largest city in the Biga Peninsula. It is located approximately 550km west of Ankara and about 250km southwest of the largest city in Turkey, Istanbul. The population of Çanakkale city is about 50,000. Çan is the second largest city of the Çanakkale Province, and its population is more than 20,000. In addition, small villages are scattered throughout the area.

By road, the distance from Ankara to Çanakkale is approximately 600km through Eskişehir and Bursa; long-distance bus takes eleven and a half hours. The survey area is under the jurisdiction of the MTA Balıkesir Office which has the largest staff of all of the MTA regional offices. There is a major highway, National Highway 60, which traverses the central part of the area in an E-W direction. National Highway 2 runs along the Aegean coast from Marmara. They are almost totally paved. There are automobile roads which connect the major highways and the villages. These roads are paved. Other roads accessible but become very bad in the winter because they are gravel roads. During the wet season they become extremely muddy. The major highway between Balıkesir and Çanakkale is paved and the about 250km can be covered by car in about three hours. The base camp during the first- to third-phase surveys was set in Çanakkale and the field work for Zones A, B and C was conducted using jeeps for transport from Çanakkale. The travel time from Çanakkale to Zone A was one and a half hours, to Zone B one hour and to Zone C two hours.

4-2 Topography and Drainage

(1) Topography

The Çanakkale Area located in the northwestern part of Biga Peninsula is bound on the north by the Sea of Marmara, on the west by the Aegean Sea, and on the south by the Kaz Range (highest peak 1,710m) extending in an E-W direction. Within the Landsat images used, the highest peak of the area is Mt. Kocakatran with an elevation of 1,111m, which is located near the southernmost part of the survey area. The area (500km^2) delineated for semi-detailed survey for the following year is located inland with relatively gentle topography with elevation ranging from 200-800m. There are many villages in the flat area below 200m, and vegetables and fruits are actively cultivated. Above 200m in the higher lands, cultivation of wheat and cattle raising are very prominant.

(2) Drainage

Zone A is located in the upstream part of Umurbey River which flows into the Dardanelles, and also of the Kocabaş River which flows eastward into Biga. Zone B is in the upstream part of the Koca River which flows into Çanakkale, and of the Çan Stream which is a tributary of the Kocabaş River. Zone C is along the estuary of Çan Stream. All of these rivers flow during the snow-melting season in early spring, but otherwise are dry.

(3) Climate and Vegetation

The annual precipitation of the survey area amounts to 600mm, and there is a large area of fertile land where cultivation of vegetables, fruits and wheat and breeding cows, sheep and goats among others are very widespread. The annual average temperature is warm at 14.6℃ and is close to a Mediterranean climate, but since it is at a higher latitude, the survey area with fairly high elevation is cool in the summer and quite cold in the winter, with some snowfall. At Çanakkale, the temperature rises above 20℃ during the four months from July to September and during June to November when the field survey was carried out, the climate gradually shifted from the relatively dry season to relatively wet season with the average monthly temperature dropping from 20.0℃ in September to 8.0℃ in November. The average monthly temperature and precipitation published by the Çanakkale Meteorological Station are as follows.

Table 1-7 Average Monthly Temperature of Çanakkale

Month(℃)	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Max	16.7	15.2	18.1	20.7	28.8	32.0	38.8	34.2	30.0	24.2	18.8	17.6	1988
Min	-1.7	-2.2	-0.2	1.4	5.4	12.3	14.6	13.3	11.0	2.0	-2.4	-5.8	
Average	7.9	6.7	9.3	11.5	16.8	22.7	26.8	25.5	20.8	14.8	7.7	6.9	14.8
Max	13.7	17.4	19.5	24.3	26.6	32.2	32.8	33.5	30.0	25.8	21.8	16.0	1989
Min	-4.0	-4.7	2.0	8.0	5.6	12.0	16.4	14.6	13.2	6.4	-2.7	-4.0	
Average	4.4	2.1	10.1	15.2	16.7	21.3	24.6	24.9	21.0	14.8	9.7	7.4	14.4
Max	14.1	19.6	21.3	23.0	30.2	36.0	34.0	34.3	33.6				1990
Min	-4.1	-1.1	-1.3	3.8	3.4	8.6	16.7	15.8	8.7				
Average	4.8	7.3	9.6	13.4	17.0	21.6	25.4	24.6	19.5				

Table 1-8 Monthly Precipitation of Çanakkale

Precipitation	1	2	3	4	5	6	7	8	9	10	11	12	Annual
1988 (mm)	87	51	75	56	1	37	4	-	30	21	202	139	703
1989 (mm)	2	3	58	9	28	19	-	25	33	85	76	94	431
1990 (mm)	5	12	25	37	12	50	7	1	19				

(4) Vegetation

The survey area with relatively high topography has higher precipitation than in the lower areas and is covered by thick vegetation. They are mostly conifers (pines) with some deciduous trees. The former is used for construction and the latter for fuel. The flat areas are cultivated, but other parts are used for grazing.

CHAPTER 5 RESOURCE POTENTIAL OF GOLD AND PORPHYRY MOLYBDENUM DEPOSITS

5-1 Gold Potential

The geologic characteristic of this area is the predominance of Eocene to Miocene intermediate volcanic rocks. In Zone A, Eocene Çamyayla volcanics is developed and small-scale vein mineralization associated with the volcanism of this period is observed, while in Zone B including rhe Etili Area, Miocene Şapçı volcanics is developed, and silicified and argillized zones related to epithermal gold mineralization is widely developed. In the Çanakkale area, there are the Madendagı and Kartaldagı gold mines, and the alteration zone extends from these mines to Zone B including the Etili Area.

It was shown by Landsat image analysis that there are many silicified and argillized alteration zones in the survey area, but the alteration zones are not necessarily accompanied by gold mineralization. Gold occurs only at limited localities.

The major localities where gold mineralization was confirmed by geochemical samples (rock and trench) are shown in Table 1-7. The potential of these areas will be clarified by subsequent surveys. The characteristics known to date are as follows.

(1) In the central part of Zone B, the basement, which consists of the Taşdibek Formation and Akpınar Granite, forms an uplifted zone and gold mineralization is observed in the altered zone surrounding the basement complex. Similar characteristics are found in the Etili Area.

(2) The X-ray diffraction study of samples from the alteration zone showed that gold mineralization occurs in the acidic alteration areas whose products are kaoline, alunite and pyrophyllite with associated cristobalite.

(3) In the silicified zones, the gold content is low in the massive part, but is generally high along the fissures of the brecciated part with limonitic and hematitic clay associations.

(4) Aside from gold, the components with large absolute values of the eigenvector of the principal component analysis are copper, lead, zinc, silver, mercury, arsenic, and molybdenum; these elements are considered to be associated with gold.

From the above, it is anticipated that low-grade large-scale gold deposits occur in the silicified and argillized alteration zones near the basement rocks in Zone B including the Etili Area. Gold-bearing massive silicified bodies are expected from the Sartaş to Güvemalanı Hills in the Arlık Stream Area and Tepeköy in the Etili Area. Further gold-bearing brecciated zones are detected from Güvemalanı to İnkaya Hills.

5-2 Porphyry Molybdenum Potential

Porphyry molybdenum-copper deposits associated with the Dikmen Granite and porphyry intrusion were discovered in Zone C. The mineralization extends from the eastern side of the Dikmen Granite, which is elongated in the NEN-SWS direction to the Emeşe Formation of the Sığırirek Stream. The rocks are decoloured white at Sığırirek, and minor amounts of sulfide minerals such as molybdenite, chalcopyrite, sphalerite and pyrite occur in association with quartz veinlets. Although invisible under the microscope, analysis of drill cores shows the existence of gold, silver, arsenic, mercury and antimony. Sericite and kaoline were identified by X-ray diffraction, indicating epithermal activity after the porphyry mineralization. The two mineralizations may be overlapping. The porphyry-type mineralization extends to the lower horizons and this is expected to be a low-grade large-scale deposit. This deposit locally contains gold. If gold can be found in significant amounts in the overlapped section, it will be an important future target.

5-3 Geologic Structure, Characteristics and Control of Mineralization.

The central part of Zone B consists of the Taşdibek Formation and Akpınar Granite which forms the geological basement. The basement is uplifted. Also, the south of the Etili Area consists of the Sakar Dagı Formation and Çavus Granite which forms the geological basement. The silicified and argillized zones of Şapçı Volcanics occur around the basement. The alteration zone extends further outward, but the gold mineralization is observed near the uplifted zone. In these localities, acidic alteration consisting of cristobalite, alunite, kaoline and pyrophyllite is observed. Analysis of rocks shows copper, lead, zinc, silver, mercury, arsenic and molybdenum together with gold. These elements are considered to be associated with gold mineralization.

Quaternary Kocaçakıl Basalt lava intruded along the fault which extends through the uplifted zone of the basement. This is further evidence that conduits for hydrothermal fluids formed in the vicinity of the basement, and that gold mineralization associated with the acidic alteration occurred.

The Triassic Emeşe Formation is predominant in the southern part of Zone C. There are lineations trending NEN-SWS, parallel to the Dikmen Fault. Serpentinite intruded along these latent faults, and Dikmen Granite and porphyry also intruded in the same direction in latest Cretaceous to Eocene.

Parts of the limestone and metavolcanics of the Emeşe Formation were skarnitized, argillized and silicified by the intrusion of the granitic rocks and porphyry. Molybdenite and other sulfide minerals occur in the quartz veinlets along the fissures formed by the intrusion of Dikmen Granite and porphyry.

The intermediate volcanism became active in the Tertiary, and large amounts of lava and pyroclastic material were deposited during the Eocene to Miocene. The structure with the NEN-SWS trend clearly remained later into the time of silicification, argillization and associated gold mineralization (inferred to be latest Tertiary to Quaternary). Gold-bearing zones are locally observed along this direction, and the range of this mineralized zone is 4 km long and 2-3 km wide elongated in a NEN-SWS direction.

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

6-1 Conclusions

During the three years, geological and geochemical surveys were conducted in Zones A, B and C. Further trench survey was carried out in the Arlık Stream and Piren Hill Areas, geophysical survey (SIP and IP methods) in the Dikmen, and drill survey in the Arlık Stream, Etili and Dikmen. Compiled maps of these areas are shown in Figures 1-4, 1-5 and 1-6, the list of geological and geochemical characteristics in Table 1-9, and the summary of the these areas is below.

(1) Arlık Stream Area

Silicified and argillized zones occur in Şapçı Volcanics and part of the Kirazlı Conglomerate. The Kocataş silicified zones occurring in Şapçı Volcanics were evident to 100m in MJTC-5, 6, 7 and 8, after which Kirazlı Conglomerate was intersected, but the Sartaş and Güvemalanı silicified zones continued for at least 150m in MJTC-3, 4, 9, 10, 11, 12, 13 and 14. Altered zones with limonite are predominant on the outcrops, but pyrites are not observed. Of the results of the drill survey, the following are significant: fine-grained pyrites are developed in the section underneath the surface; limonitic silicified zones with open spaces (caves) were found by drill hole MJTC-4 and 10; and the low-grade auriferous zones continued from near surface to bottom in holes MJTC-4, 13 and 14. Therefore, it is considered that the potential for gold deposits is high. Generally, auriferous mineralization in the silicified body did not extend further downward, and silicified veins were observed in the periphery of the silicified zones. Thus it is considered that their shapes are "jellyfish-like" in geologic section.

(2) Piren Hill Area

The geology consists of Şapçı Volcanics in this vicinity. The original rocks cannot be distinguished in the altered zones. The volcanic rocks become thicker with distance from the geologic basement. Altered zones with limonite and hematite are predominant on the outcrops, and pyrites are not observed because of oxidation.

Gold anomalies were detected in the silicified zones located in the southern part of the large alteration zone. The zones extend in an E-W direction in the vicinity of Piren Hill. The auriferous zones, which occur in limonitic clay such as those in fault zones, were detected by drill hole MJTC-2. As a result of the trench survey, gold-bearing zones on the surface were small scale and the content of gold was low.

(3) Etili Area

Silicified and argillized zones occur in Şapçı Volcanics. The Halilaga silicified zones occurring in Şapçı Volcanics were evident as thin near the surface in MJTC-16 and 17, after which weakly altered andesites were intersected, but the Tepeköy silicified zones are inferred to continue for at least 150m because of large-scale silicified bodies. Altered zones with limonite are predominant on the outcrops, but pyrites are not observed.

Of the results of the drill survey, the following are significant: fine-grained pyrites are developed in the section underneath the surface, limonitic silicified-argillized zones were found by drill hole MJTC-16 and the low-grade auriferous zones continued from 2.80m to 16.65m in hole MJTC-16. Therefore, it is considered that the potential for gold deposits is low.

In the Tepeköy alteration zones, auriferous mineralization in the silicified body extend further downward, and silicified veins are expected to be found in the central portion of the silicified zones. Thus it is considered that their shapes are "mushroom-like" in geologic section, as in the Kestane Mt. Area.

(4) Dikmen Area

Geophysical prospecting was carried out together with a detailed geological survey and geochemical prospecting. The detailed geological survey has clarified the distribution and conditions of gold occurrence, argillized zones and skarnization. The geochemical work has revealed two types of mineralization. By geophysical methods, the subsurface extent of mineralization from the outcrop downward was shown by delineating the low-resistivity zone and FE anomalies by IP.

A porphyry molybdenum-copper deposit associated with the intrusion of the Dikmen Granite and porphyry was discovered. The mineralization extends from the eastern side of the Dikmen Granite in a NW-SE direction to the Emeşe Formation in the Sığırirek Stream. The Emeşe Formation is altered, and minor amounts of sulfides such as molybdenite, chalcopyrite, wolframite, sphalerite and pyrite occur in the quartz veinlets. *The analytical results show the* existence of gold, arsenic, mercury and antimony. This shows that epithermal mineralization occurred after the porphyry molybdenum mineralization, and they *now overlap spatially.*

The porphyry molybdenum deposit mentioned above is expected to be a large-scale low-grade deposit as this type of mineralization is extensive at depth. It contains gold and antimony locally and may turn out to be a very important target.

The results of the Çanakkale Project work summarized in (1)-(3) above, indicate the possibility of large-scale low-grade gold deposits in the alteration zone near the basement rocks. The porphyry molybdenum deposit mentioned in (4) also is expected to be a large-scale low-grade deposit as this type of mineralization is extensive at depth. It locally contains gold and antimony, and significant gold is expected to be found in the overlapping portion.

6-2 Recommendations for Future Exploration

It is recommended that the following work be conducted in the promising areas delineated above (Figure 1-7). In the three localities of Zone B, epithermal gold mineralization is anticipated because of the gold showings of the alteration zones which were identified by geological and geochemical surveys. The hydrothermal gold mineralization is expected to extend both horizontally and vertically. Here, detailed geological survey clarified the distribution and extent of the alteration zone, and heavy mineral investigation in the vicinity located the position of the gold mineralization. On the basis of these findings, inclined drilling should be carried out in order to clarify the state of subsurface mineralization.

(1) Arlık Stream Area

The auriferous zones have been detected in Sartaş, Güvemalanı and İnkaya Hills; these localities belong to the concession of MTA. The drilling survey should be continued in these localities since auriferous zones were intersected by drill holes MJTC-4, 10, 13 and 14.

(2) Piren Hill Area

Gold anomalies were detected in the silicified zones located in the southern part of the large alteration zone which extends in an E-W direction in the vicinity of the Piren Tepe. The auriferous zone was detected by drill hole MJTC-2 in the Davulgılı silicified zones belonging to the concession of MTA. This zone was small and the content of gold was low on the surface. Further drilling survey should be carried out in the southeastern part of the Piren silicified zones, which corresponds to west of Muratlar Village.

(3) Etili Area

The auriferous zones have been detected in Hamam Hill of southern Tepeköy Village. Although this locality does not belong to the concession of MTA, the drilling survey should be continued here because the auriferous zones were found through study of many rock samples.

(4) Dikmen Area

Geophysical prospecting was carried out along with detailed geological survey and geochemical prospecting. By geophysical methods, the subsurface extent of mineralization from the outcrop downward was shown by delineating the mineralization zones corresponding to geophysical anomalies, and was intersected by drill hole MJTC-15. Further drill survey should be conducted in the mineralized zone of the localities distributed in the Dikmen Granite and porphyry.

Table 1-10 Geological and Geochemical Characteristics

Characteristics of Geology and Geochemistry	Survey Area			
	Arlık Stream	Etili	Piren Hill	Dikmen
Type of Mineralization	Epithermal Type			Porphyry Mo
Country Rock of Ore Horizon	Şapçı Volcanics			Dikmen G. Porphyry
Clay Minerals	Kaoline, alunite, pyrophyllite			Sericite
Silicified Zone:Massive	○	○	○	-
Vein	×	×	×	○
Scale(km^2)	1.5	0.8	4.7	-
Au (max) ppb (Rock Sample)	3050	3660	2060	4600
Au>100ppb (Trench Sample)	29pcs	-	-	-
Au>100ppb (Rock Sample)	27pcs	56pcs	18pcs	22pcs
Au>100ppb (Core)	74pcs	5pcs	10pcs	-
Mo>100ppm (Core)	-	-	-	10pcs
Heavy Mineral Study	●	●	●	-
Detection of Gold Grains	common	abundant	few	-
Potential	high	high	low	high
Gold-bearing m sil Ore	□	□	□	
Gold-bearing Brecciated Ore	□			
Gold-gearing Quartz Vein				□
Porphyry Molybdenum				□

○ : predominant × : not observed ● : collected samples □ : expected ore m sil:massive silicified

Gold-bearing massive silicified ore : During the process of copper smelting, the iron component of the copper concentrates must be precipitated in the slag. Silicified ore is used for this purpose. The ratio of iron to silicified ore is 1.2. Kasuga Mine (Kyushu island) is operated as an open pit; ore grade is 2-3g/T Au and more than 88% SiO_2.

Gold-bearing brecciated ore : Gold extraction is easy with this type of ore because a sodium cyanide solution can be passed through the cracks to dissolve the gold. Gold extracted by the heap-leaching method is absorbed in active carbon. Generally, the location of the mine should be in a depopulated area with dry climate and a small amount of precipitation. Picacho Mine (California, USA) is operated as an open pit, ore grade is 0.9g/T Au, cut-off limit is 0.3g/T.

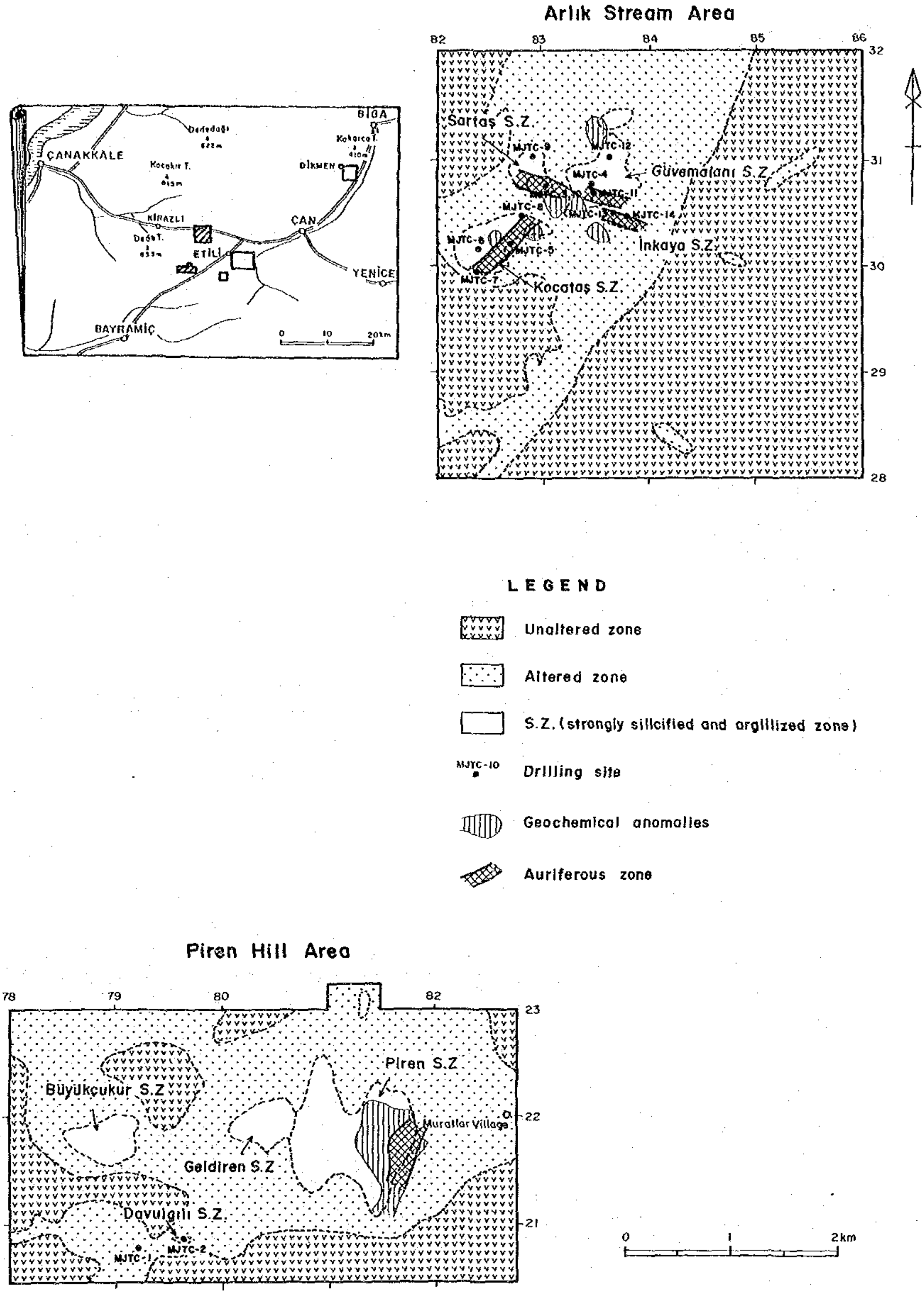

Figure 1-4 Compiled Map of Arlık Stream and Piren Hill Areas

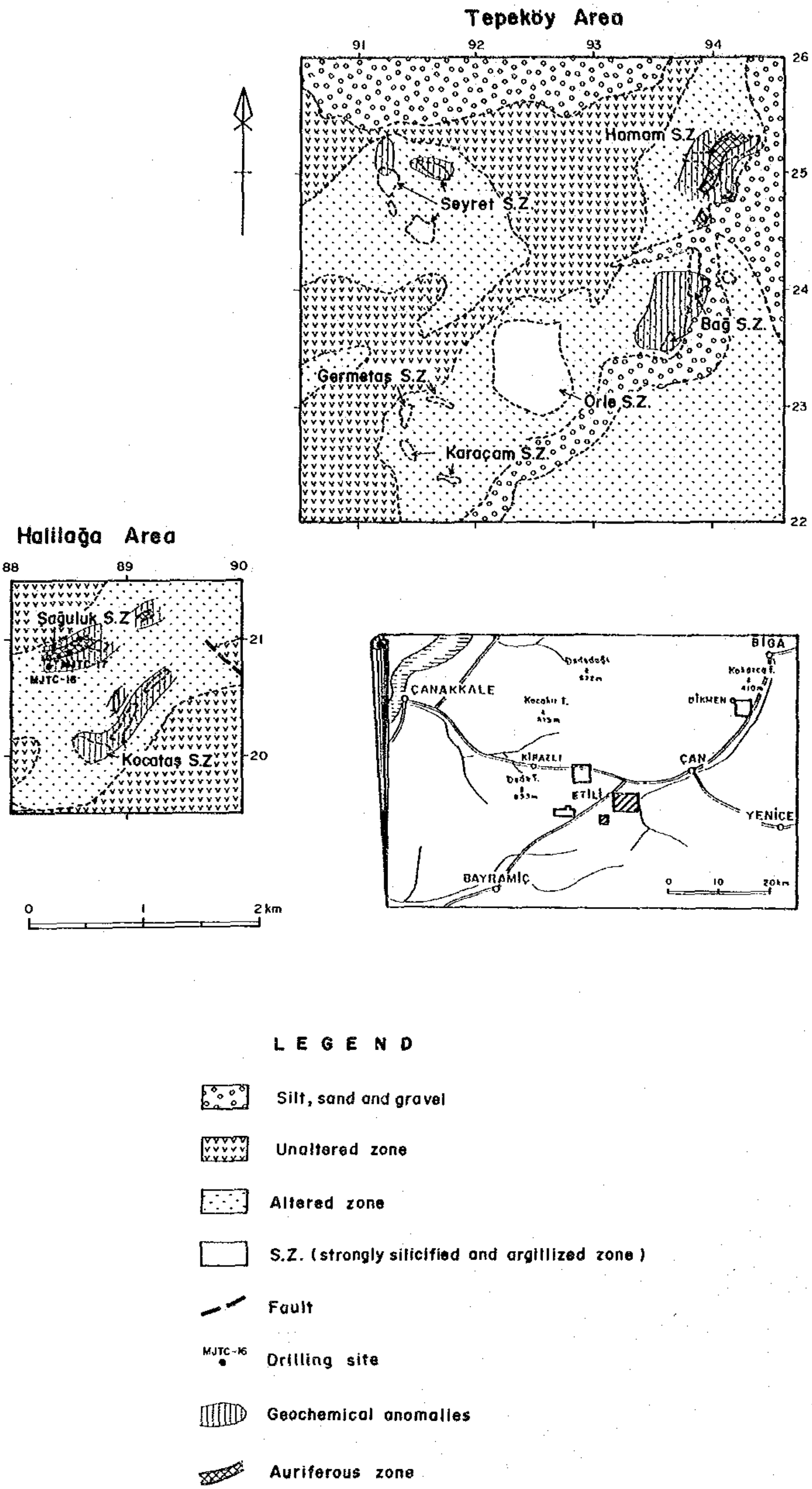

Figure 1-5 Compiled Map of the Etili Area

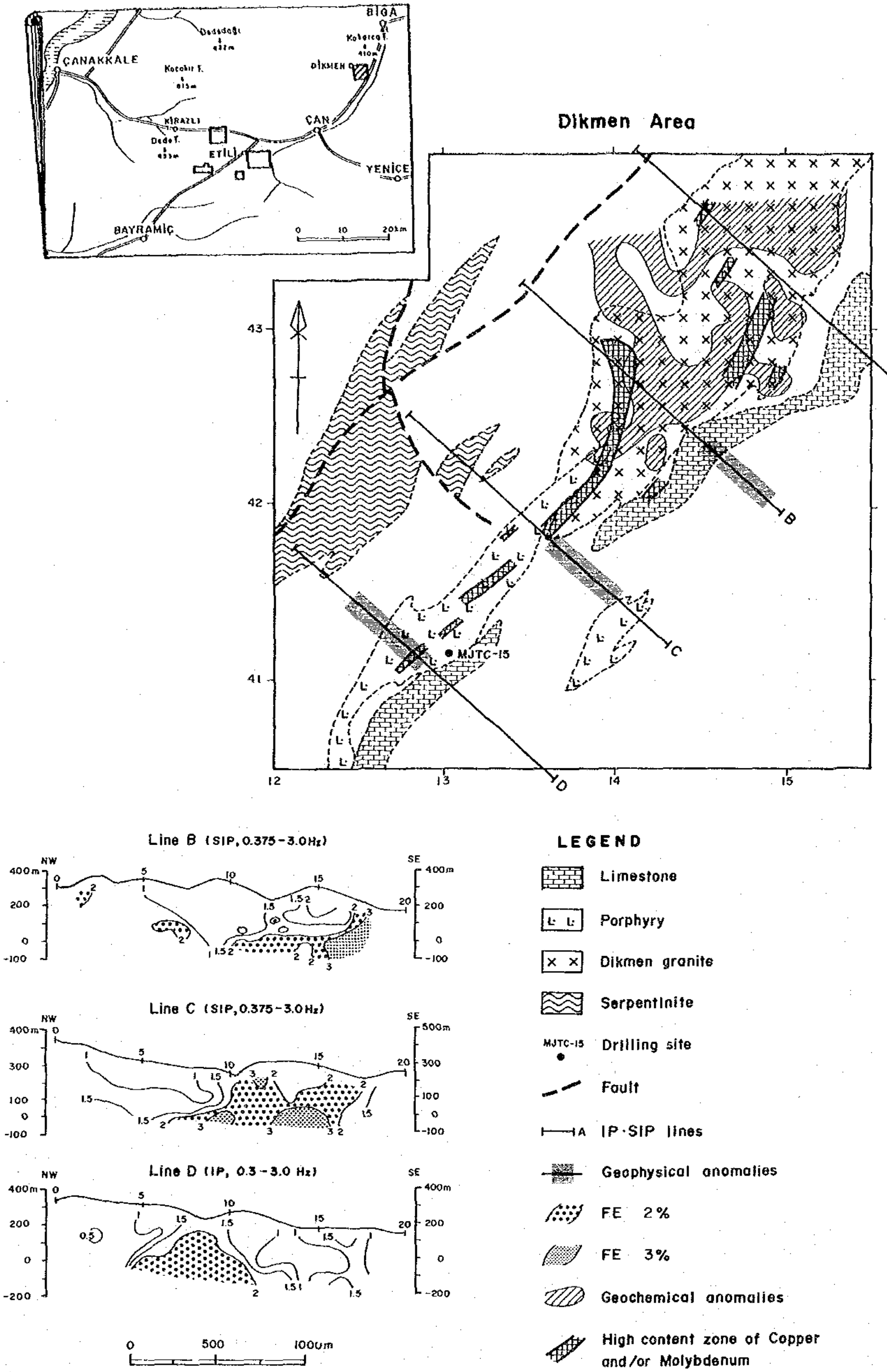

Figure 1-6 Compiled Map of Dikmen Area

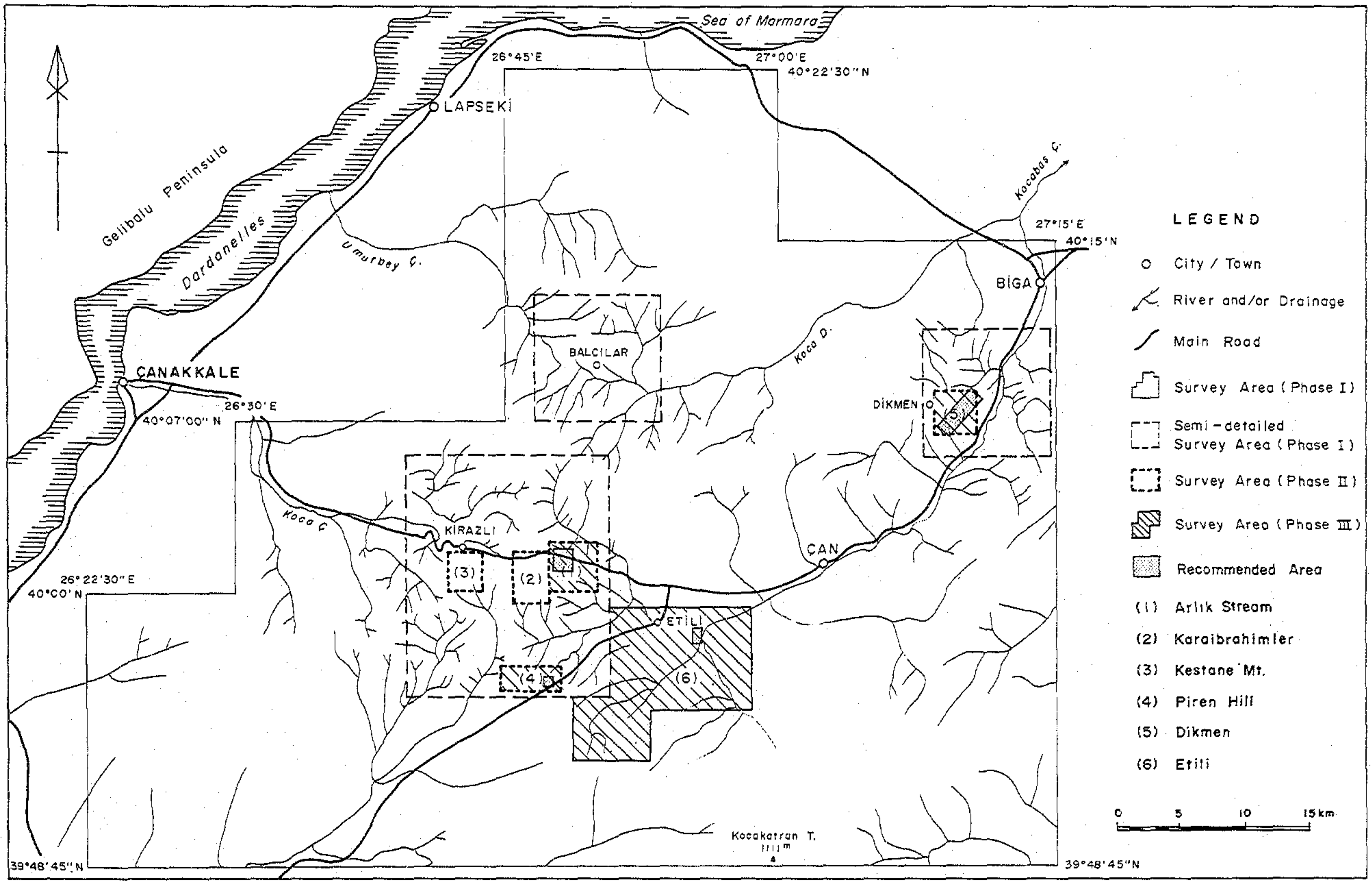

Figure 1-7 Recommendation Map of the Çanakkale Area

PART II REGIONAL CONSIDERATIONS

PART II REGIONAL CONSIDERATIONS

CHAPTER 1 LANDSAT IMAGE ANALYSIS

1-1 Landsat Images-Location and Data

The areal coverage of the Landsat images used is shown in Figure 2-1. They cover mainly the Biga Peninsula and Gelibolu Peninsula in the western part of the Republic of Turkey and also include parts of the Aegean Sea and the Sea of Marmara.

The image data used for this analysis are one CCT (computer compatible tape) scene which was acquired by the thematic mapper (TM) on Landsat 5. The scene is very clear without cloud or snow.

Path	Row	Observation Date	Cloud Cover	Identification No.	Sun Direction	
					Angle of Elevation	Azimuth
181	32	May 5, 1987	0 %	Y5116608154X0	56°	124°

Table 2-1 Characteristic of TM Bands

Band	Wavelength Range	Characteristics	Major Application	Remarks
TM 1	0.45 ~ 0.52 μm	Efficient for distinguishing coastal and marine zones; and also deciduous and conifer trees. Susceptible to atmospheric scattering due to short wavelength.	Atmospheric information. Marine environment.	Corresponds to blue-green visible range.
TM 2 TM 3	0.52 ~ 0.60 μm 0.63 ~ 0.69 μm	Absorbed by pigments consisting mainly of chlorophyll.	Classification of vegetation. Delineation and activity of vegetation.	TM 2 corresponds to visible green and TM 3 to visible red. High correlation to bands 4 (0.5 ~ 0.6 μm) and 5 (0.6 ~ 0.7 μm) respectively.
TM 4	0.76 ~ 0.90 μm	High reflectance from plants. Effective for quantitative survey of plants. Radiance of sea and land clearly different.	Topographic classification. Land use classification (soil, vegetation, geology).	Near infrared zone.
TM 5 TM 7	1.55 ~ 1.75 μm 2.08 ~ 2.35 μm	TM 5: Estimation of water content of plants and soils. Discrimination of clouds and snow. TM 7: Delineation of hydrothermal alteration zones.	Water content of earth's surface. Delineation of vegetation.	Intermediate infrared zone.
TM 6	10.4 ~ 12.5 μm	Responds to radiated heat from the earth's surface. Higher the temperature of the surface, greater the radiance of the image.	Distribution of geothermal heat. Thermal nature of rocks and soils. Characteristics of natural environment.	Far(thermal) infrared zone. Instantaneous range of view four times wider than that of other bands.

TM data, compared to those of MSS, have higher resolution, larger number of bands, wider range of wavelengths and generally higher quality. For example, the nominal resolution is 80m for MSS while that for TM is 30m, therefore, greater detail can be read from the TM images than from the MSS. Also MSS contains four band data while TM has seven bands with greater spectral information (Table 2-1).

In order to prepare colour images for analysis, however, three bands must be selected from the above seven. During the course of the present work, the combination of the three bands was chosen by considering the characteristics of each band and the infrared information together with the results of recent studies. This will be reported later in section 2-3.

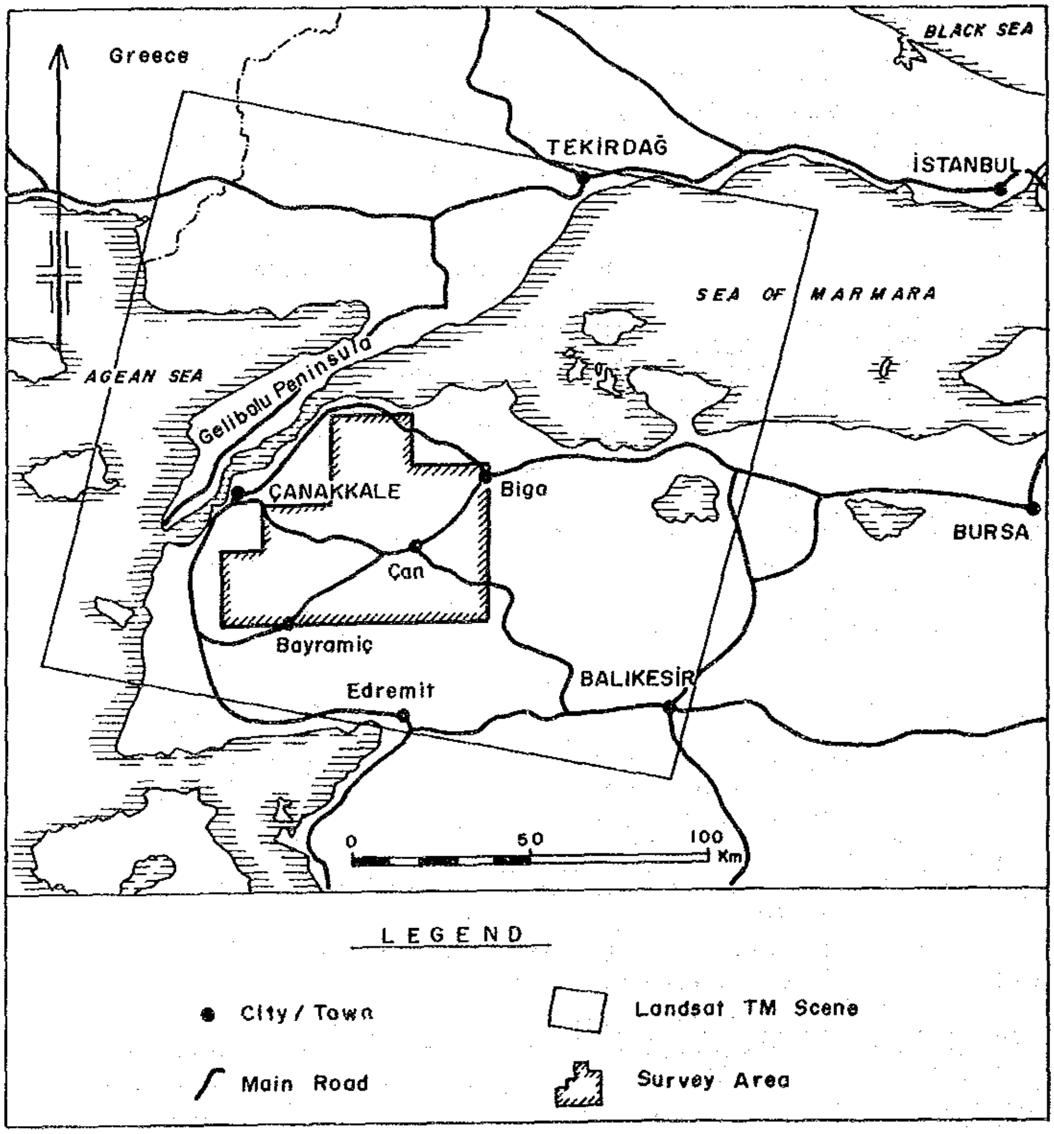

Figure 2-1 Location Map of Landsat Image

1-2 Methods for Processing, Preparation and Analysis of Landsat Images

1-2-1 Data Processing

There are two types of data processing, namely conventional processing and optional processing. The objective of the conventional processing is to prepare false colour images which are the basic instruments in all stages of analysis. On the other hand, optional processing is carried out for preparing images which provide useful information for geological interpretation or for areas which are difficult to interpret by false colour images alone. In the present survey, ratio processing was used as the nonconventional procedure.

Conventional Processing

(1) Selection of the Bands

As mentioned in section 1-1, the TM data have larger number of bands and the wavelength range is wider than the conventional MSS data. Thus three bands are selected from the seven for preparing the false colour images. In actual practice, however, the resolution and the wavelength range of band 6 (thermal infrared) are considerably different from these of other bands and thus the selection is made from the other six bands. In selecting the three bands from six, *there are* ${}_6C_3=20$ *combinations without considering the assignment of* colour to each band.

For the present work, the method which evolved through the research project of the Metal Mining Agency of Japan (MMAJ) and Earth Resources Satellite Data Analysis Center of Japan (ERSDAC) was used for identifying alteration zones related to mineralization. The combination of TM bands 4, 5, and 7 was concluded to be the best for the preparation of the false colour images.

(2) Edge Enhancement Processing

This processing is used in order to facilitate the extraction of lineaments and other topographic information from the images. The procedure is to apply a suitable high-pass filter over the preprocessed images, and clearer, sharper images are obtained.

(3) Contrast Enhancement Processing

The contrast of the output image is very weak and the difference of the radiance cannot be distinguished when the original values are used. It is necessary to convert the distribution of radiance to that which corresponds to the dynamic range of the output device. This conversion process is called contrast stretching and images with good contrast can be obtained. There are several methods of contrast stretching such as histogram equalization, hybrid, and linear stretching methods. Here, it was concluded from the shape of the histogram after edge enhancement that linear stretching would be best suited and it was applied.

Optional Processing (Ratio Processing)

The purpose of this process is to decrease the effect of the topography on the reflection of the sun from the surface and to produce an image composed of spectral information from the earth's surface without topographic information. As for the combination of the bands for obtaining the ratios, 3/1, 5/4 and 5/7 bands in the shorter wavelength infrared zone were selected. The reason is that the spectral information of the rocks is more important in the shorter wavelength infrared zone (1.5~2.5μm).

1-2-2 Types of Images

The following images were prepared and used.

① Edge enhanced false colour image from CCT(F/C): combination of bands and filters: 4(blue)・5(green)・7(red)………………scale, 1:100,000

② Ratio processed image A from CCT(R/C_1): combination of bands and filters: 5/7(blue)・5/4(green)・3/1(red)………………scale, 1:100,000

③ Ratio processed image B from CCT(R/C_2): combination of bands and filters: 5/7(red)・5/4(green)・3/1(blue)………………scale, 1:100,000

④ Ratio processed image C from CCT(R/C_3): combination of bands and filters: 5/7(black and white)………………scale, 1:100,000

1-2-3 Method of Analysis

Methodology regarding the analysis of resource satellite data for prospecting purposes has been actively pursued by MMAJ and ERSDAC since 1982. One of the achievements of this study is the extraction of alteration zones from images prepared by processing the Landsat TM data. It was expected during the present survey that images prepared by similar processes would enable the extraction of the argillized and other altered zones which are closely related to gold mineralization.

For the analysis, close attention was focused on photogeological characteristics such as tone and texture, as well as on drainage patterns, drainage density, rock resistance, existence of bedding and other topographic features. Then geologic units (lithology) were delineated, and lineaments, annular (ring) structures, folds and other structural features were read and interpreted.

The lineaments are topographic features which suggest fractured zones, and the main basis for the interpretation is as follows.

a) Existence of fault scarps.
b) Existence of linear valleys (fault valleys).
c) Rivers with very linear flow pattern.
d) Existence of kerncols and kernbuts.
e) Linear arrangement of break points of mountain slopes.

These topographic features are affected by the geology, geologic structure, and the age of the rocks. Thus, there is considerable areal variation in their development, but most of the lineaments can be understood by empirical interpretation of these topographic features.

1-3 Results of Analysis

1-3-1 Geological Interpretation

Four geological units, A~D, were delineated from these images (Fig.2-2). The interpretation of these units from the images are shown in Table 2-2 and their major features are as follows.

(1) Unit A

This unit is distributed in the northern and the southern zones and also in the part extending from the eastern to the southern part of the survey area. It occupies a very large portion of the survey area (approximately 37%), second to that of Unit B. It is distributed in relatively elevated regions.

Table 2-2 Photogeological Interpretation Chart for Landsat TM Images

Units	Tone			Texture	Drainage※		Rock Resistance	Bedding	Geological Environment
	F/C※¹	R/C_1※²	R/C_2※³		Pattern	Density			
D	blue, chrome yellow	red, greenish blue	yellow, royal purple	fine, speckled	meandering	very low	very low	-	mainly Quaternary sediments(Al, Ta, Qd), and Pliocene sediments(n)
C	lilac, chrome yellow	light blue	yellow green	fine	-	-	very high	-	mainly Miocene siliceous tuff(Tsi), and Eocene andesite·tuff(A_1+T_1)
B	bluish purple chrome yellow	orange, light blue	royal purple emerald green	coarse	dendritic	medium	moderate to high	-	mainly Eocene andesite·tuff(A_1+T_1), and Pleistocene volcanic ash(Pt)
A	bluish purple chrome yellow	pink, blue	royal purple, yellow	coarse, banded	dendritic	high, low	high to very high	very thin	mainly Pre-Tertiary rocks (Ep, Gn, SPO, DPO), and Eocene granodiorite(Gd)

※ Geologic symbols are shown in the Table 1-5.

※¹ F/C_1(False colour image) : Bands 4(blue)· 5(green)· 7(red)

※² R/C_2(Ratio colour images): Band ratio 3/1(blue)· 5/4(green)· 5/7(red)

※³ R/C_3(Ratio colour images): Band ratio 3/1(red)· 5/4(green)· 5/7(blue)

The drainage system, an important topographic feature, generally shows a dense dendritic pattern, but in the southern part of the survey area, a dense parallel pattern at right angles to the lineaments is observed. In the southwestern part of this area, a sparse dendritic pattern is also observed. The resistance of the rocks is high to very high. Also, the texture suggests the existence of bedding or schistosity.

This unit is distributed in the localities of, according to existing data, pre-Tertiary rocks, namely the weakly metamorphosed schists (EP) and Bozağaç dağ Formation (Gn) of the Triassic Kazdag Group, meta-spilites (SPO) and detrital rocks (DPO) of the lower Triassic and the Eocene granodiorites (Gd).

(2) Unit B

This unit is distributed in the central part of the survey area and is surrounded by Unit A. This unit occupies the largest portion of the area (approximately 42%). It occurs in various topographic environments from high to low.

The drainage system has a medium-density dendritic pattern and the resistance of the rocks is medium to high.

This unit is distributed in the part consisting mainly of Eocene andesite, tuff (A_1+T_1) and Pleistocene Gevşek volcanic ash.

(3) Unit C

This unit is distributed near the central part of the survey area in localities of Unit B distribution. It occupies topographically the highest part and the smallest portion (about 3%) of all delineated units.

The distribution of this unit, according to existing data, is in Miocene siliceous tuff and Eocene andesite, tuff (A_1+T_1) localities.

(4) Unit D

This unit is distributed from the northeast to the southwestern part of the survey area. It occupies 18% of the survey area in topographiclly low parts along the major rivers.

The drainage meanders in this environment. The resistance of the rocks is very low.

The distribution of this unit, according to existing data, is in Holocene alluvium (Al), terrace deposits (Ta), talus deposits (Qd) and Pliocene Göl sedimentary rock (n) zones.

1-3-2 Alteration Zones

Attempts were made to extract alteration zones from the prepared images, but the entire survey area is covered by vegetation and thus it was not possible to identify colour tones characteristic of alteration from any of the Landsat images. Good examples of alteration zones in satellite images are the pale greenish tone indicating the ore deposits of the Goldfield, Escondida※[1], and other mines.

As reported in section 1-2-1, however, Unit C has high resistance, forms rounded to protruded ridges and the relief is quite large. These are characteristics different from other units and the locations coincide with those of the siliceous tuff (A_1+T_1) reported in previous work. From these facts, it is inferred that Unit C might contain silicified zones or siliceous dike-like bodies such as those seen in the gold-producing areas of southern Kyushu, Japan.

1-3-3 Interpretation of Geologic Structures

(1) Fold Structures

Folding is usually identified by tracing the bedding. The bedding or schistosity of the survey areas as mentioned in section 2-1 Unit A, however, are observed in Unit A in the southwestern part, and they extend in a NE direction with monoclinic structure dipping NW. The foldings cannot be identified in this area by tracing schistosity or bedding.

On the other hand, curved drainage patterns and ridges arranged parallel in the NE-direction are observed in two localities of Units A and B in the eastern part of the area. These are interpreted to be synclinal structures with NE trending axes. Thus focusing attention on drainage patterns can yield relevant structural information in many cases.

(2) Lineaments

Two hundred and ten lineaments were extracted and interpreted. The density of distribution is higher from the northeast to the southern parts.

Rose diagrams of the number, lengths and a histogram of the lengths of the lineaments of the survey area are shown in Figure 2-4. It is seen that the prevailing direction is, in general, NE, but the number and the length of lineaments do not coincide in some directions.

※[1] The alteration zones related to the gold mineralization at Goldfield mine (Nevada, USA) and of the auriferous porphyry copper mineralization of the Escondida mine (northern Chile) are expressed in a pale greenish tone in the false colour images prepared by applying blue, green and red to bands 4, 5, and 7, respectively. The spectra for iron oxide in the visible, near-infrared zone is shown in shorter wavelength for clay minerals. Then, the alteration zone near the Goldfield mine shows the highest reflectivity for band 5, and it contains clay minerals which absorb band 7 spectra. The pale greenish tone reflects the effect of band 5.

Direction	Number	Length	Remarks
N45~75°E	38%	54%	Many long lineaments, in northeastern to southern parts, indicate direction of major geologic structures.
N15~35°E	22	17	Many short lineaments in the northern part.

(3) Annular Structure

A total of 17 annular structures were extracted and interpreted from the images prepared.

Annular form	Number	Geology				Size(diameter)
		Unit A	B	C	D	
Nearly complete	10	-	7	-	3	3~6 km
Incomplete	7	1	6	-	-	1~2.5

These annular structures are observed in parts where the lineament density is relatively low, but the overall trend of their distribution is NE, similar to the prevailing direction of the lineaments.

It is not possible to determine the relation between the annular structure and Unit C because the size of the individual bodies of the unit is very small. These structures occur near Unit C and in some localities, the unit occur within the annular structure.

1-3-4 Discussions

As reported above, the outline of the geology and the geologic structure of the survey area were clarified by the analysis of Landsat data. The information considered to bear important significance regarding mineral exploration, particularly for gold exploration, is summarized as follows.

(1) Unit C has high resistance, forms rounded or protruding ridges and has strong relief, and its distribution coincides mostly with that of siliceous tuff (A_1+T_1). It is inferred from the above that this unit consists of silicified zones and/or siliceous bodies such as dikes, such as these that occur in the gold-producing area in southern Kyushu, Japan.

It is considered that the relation between this unit and the "low temperature gold mineralization associated with Late Tertiary acidic volcanism and Quaternary hot spring activity," which is one of the known mineralizations of this area, is one of the most important aims of further work.

(2) The genesis of annular structures is not clear, but it is observed that they often occur in Unit B which is surrounded by the geologic basement of the survey area, Unit A. Some of the annulars contain Unit C and this unit also

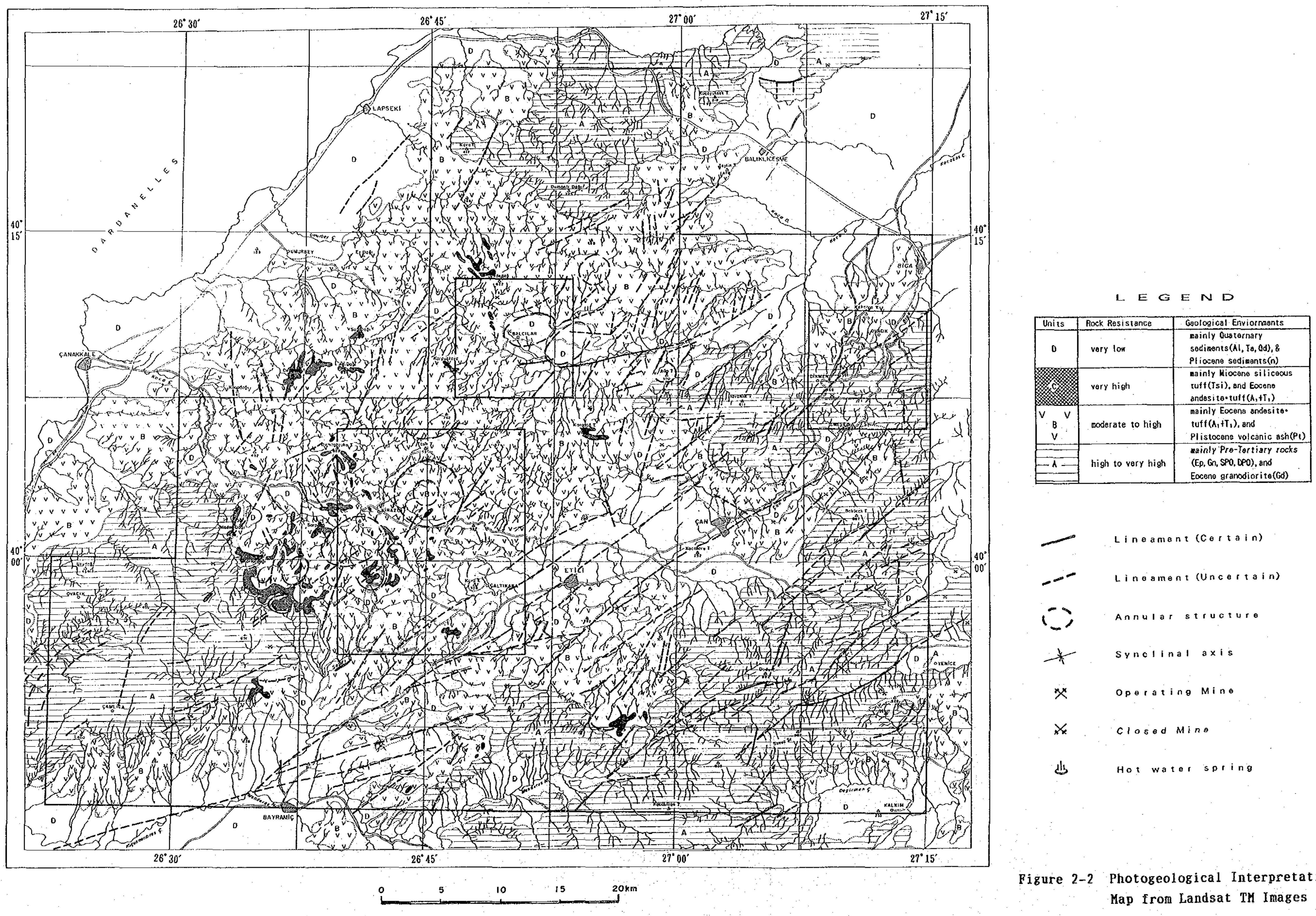

Figure 2-2 Photogeological Interpretation Map from Landsat TM Images

occurs near these structures. Two or three annulars are observed in the younger Unit D. The overall trend of these annular structures is NE which coincides with the prevailing direction of the lineaments. If these structures are related to igneous activities, they may have acted as conduits for mineralization.

(3) Of the lineaments of the area extracted from the images, those of Unit B in the western part of the area have N-S or NW trends and there are annular structures and Unit C nearby. These features are different from other parts of the area.

(4) As to the relationship among the lineations, it seems that those of the NE system are transected by the E-W system along the Koca Çay River, and in western Yenice, the NE and E-W lineament seem to be cut by a N-S system.

There is a large NW trending fracture (joining Çanakkale and Eceabat) at right angles to the Dardanelles Strait (Çanakkale Strait) outside of the survey area. If the lineaments with this trend are faults, they would be younger than those of the NE system, but there are very few lineaments with this trend in the area. If the mineralization in the area is related to younger activities, these lineaments or fractures should be carefully studied during the field work.

(5) Attempts were made to extract silicified and argillized zones by false colour images, but the "pale greenish tone" which is characteristic of alteration could not be observed because of vegetation. Also, alteration zones could not be identified by ratio images for the same reason.

From the above reasoning, the zones relevant to mineral prospecting in this area are considered to be:

① Vicinity of Unit C which possibly contains iron silicification and alteration, together with Unit B nearby.

② Annular structures and vicinity.

③ Unit B zone in the western part where there is a unique lineament distribution pattern (N-S and NW direction).

From the above studies and the results of geological survey, the major points of the Landsat image analysis are summarized as follows.

(a) The geologic units inferred to be the silicified zones by remote sensing are silicified rock bodies, and kaolinized alteration zones were found near these bodies. The distribution of silicified zones read from the