No. 17

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JAPAN [illegible] AGENCY

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

PHASE I

FEBRUARY 1989

JAPAN INTERNATIONAL COOPERATION AGENGY
METAL MINING AGENCY OF JAPAN

PREFACE

In response to the request of the Government of the Republic of Turkey, the Japanese Government decided to conduct a Mineral Exploration Project in the Çanakkale Area and entrusted the survey to Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Republic of Turkey a survey team headed by Mr. Hisashi Mizumoto from 5 September to 21 November, 1988.

The team exchanged views with the officials concerned of the Goverment of the Republic of Turkey and conducted a field survey in the Çanakkale area. After the team returned to Japan, further studies were made and the present report has been prepared.

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

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

February, 1989

Kensuke Yanagiya

Kensuke YANAGIYA
President,
Japan International Cooperation Agency

Junichiro Sato

Junichiro SATO
President,
Metal Mining Agency of Japan

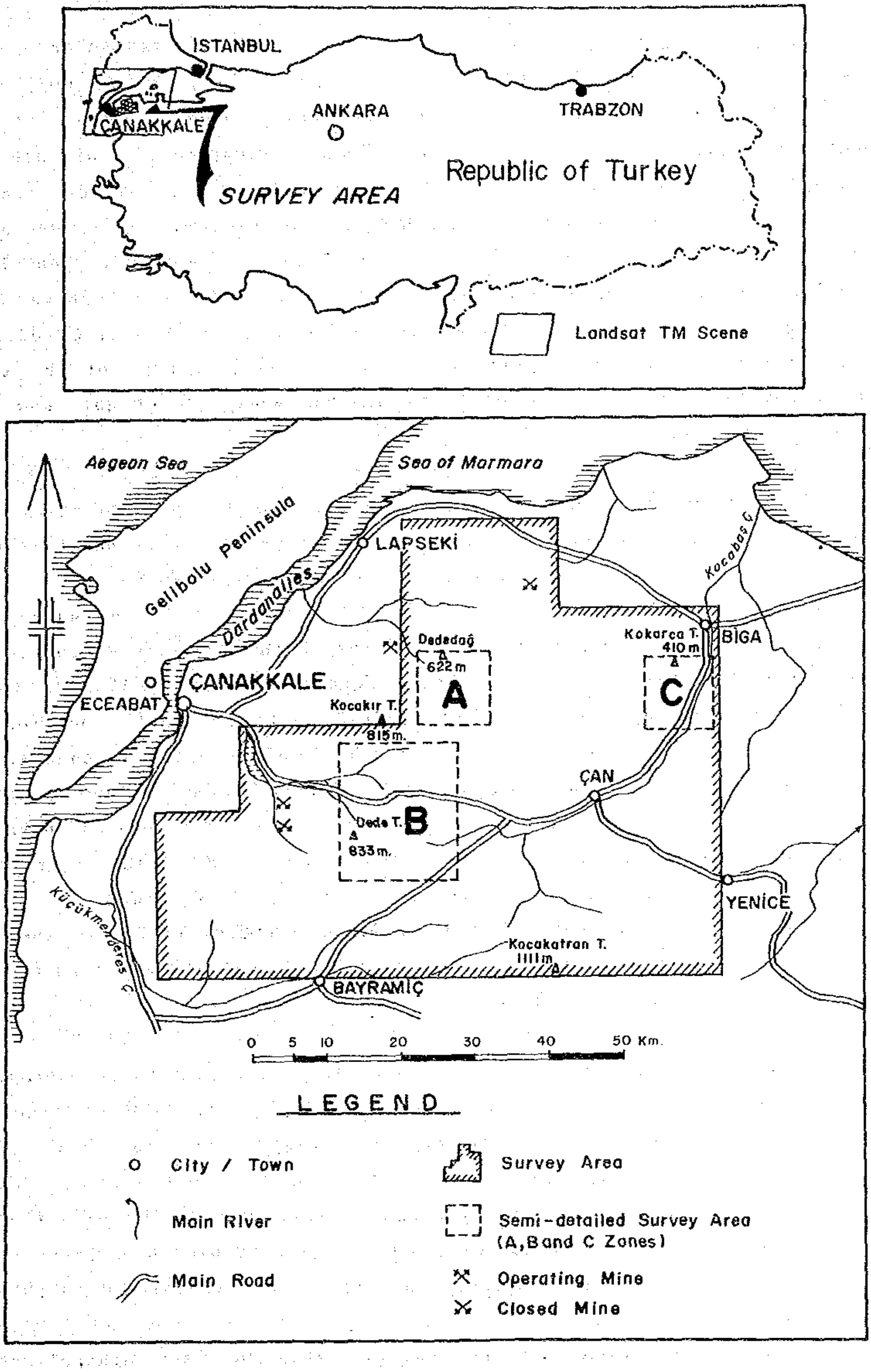

Fig. 1-1 Index Map of the Survey Area

Summary

The objective of the present survey was to clarify the mode of occurrence of various metal deposits (gold, silver, copper, lead, zinc, molybdenum, etc.,) of the Çanakkale Area. Prior to the survey, Landsat images totaling 3,400km² in areal extent were analyzed and interpreted, available data regarding previous work on geology and geochemical prospecting were acquired and studied. From the results, A and B Zones were extracted as warranting investigation for precious metals, and C Zone for metallic deposits - particularly porphyry molybdenum - . Together with geological survey, chip samples were systematically collected for geochemical prospecting and heavy mineral investigation were carried out. Also, the remainder of the stream sediment samples previously collected by MTA was analysed for gold and other additional elements.

The lowermost geologic unit of the Çanakkale Area is pre-Triassic Kazdağ Group which consists mainly of metamorphic rocks derived from basic volcanic rocks. This group is distributed outside of the present survey area, namely north of Zone A and west of Zone B. The lowermost unit of the survey area consists of Triassic Taşdibek Formation in Zone B and Emeşe Formation in Zone C which unconformably overlie the Kazdağ Group and are correlated to the Karakaya Group. Eocene and later intermediate volcanic rocks unconformably overlie the two formations. The basement rocks do not occur in Zone A. The Tertiary volcanics rock are Eocene and Miocene andesite and andesitic pyroclastic rocks and also there are small occurrences of dacite and basalt of Late Tertiary to Quaternary. As for intrusive rocks, Triassic and Late Cretaceous to Eocene granodiorites are distributed in Zones B and C.

Regarding geologic structure, the major NE-SW trending parallel lineaments represented by Dikmen Fault are transected by E-W lineaments which in turn are cut by younger fractures of N-S system.

The mineralization of the survey area is largely divided into epithermal and dissemination (porphyry molybdenum-copper) types. There are two groups of epithermal type mineralization, namely the high grade but small scale auriferous silver-lead-zinc-copper-barite veins which are observed in Zone A, and the 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 the low grade (molybdenum-copper) mineralization is developed in the host rocks.

Conscerning the relation 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 to E-W, while in Zone B, gold mineralization is observed associated with the NE-SW faults near uplifted basement and with the younger NNE-SSW and NW-SE fractures.

As for the geochemical anomalies and mineralization zones, it was concluded that stream sediments are not very effective for investigation of gold mineralization because the dispersion of the metal is not wide and rock chips are more effective. This conclusion is based on the analysis of 304 stream sediment samples, 1,010 chip samples and the results of the study of 131 heavy mineral samples. With heavy minerals, gold grains were found about 1~2km downstream of the exposures and this agrees with the results of rock chip analysis.

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

Zone A: Eocene Çamyayla and Miocene Balcılar Volcanics are developed and small scale copper, lead, zinc vein mineralization occur in those bodies. The ores contain significant amount of silver and are of high grade. The veins are thin and short. The deposits of this zone are of small scale.

Zone B: Geochemical anomalies of gold were discovered in the silicified and argillized alteration zones in the Miocene Şapçı Volcanics which is distributed in the vicinity of the basement complex. The basement is composed of Taşdibek Formation and granites. From the mineralization and extent of geochemically anomalous zone, the following localities are expected to bear large scale, low grade gold deposits.

(1) Arlık Dere
(2) Karaibrahimler
(3) Kestane Dagı
(4) Piren Tepe

Zone C: Porphyry molybdenum-copper deposit associated with the intrusion of Dikmen Granite was discovered in this zone. Molybdenite, chalcopyrite, wolframite, sphalerite, pyrite and other sulfide minerals occur in minor amounts and analysis of rocks showed the association of gold, arsenic, mercury, antimony and other metals. Thus it is considered that epithermal mineralization occured after the porphyry molybdenum mineralization, and the two overlapped. It is expected that this type of mineralization extends in the lower parts and prove to be a large scale low grade deposit. If gold could be found to be contained in significant amounts in the overlapped part, this would be a important future target.

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PART I OVERVIEW

CHAPTER 1 INTRODUCTION

1-1 Background and Objective of the Survey

The work reported in the following chapters comprises that of the first year (first phase) of 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 3,400km² were analysed and interpreted. From these studies, three zones were extracted for semi-detailed survey. These are Zones A (100km²), B (300km²) and C (100km²) and they were inferred to be promising for metal concentration. The data on which the above delineation of the three zones were based are laid out in Table 1-1. Geological survey and geochemical prospecting were carried out in the above three zones during two and a half months from 5 September to 21 November 1988.

The survey area belongs to the West Pontids Belt of the tectonic division of Turkey and the geology is similar to that of the Trabzon area of the East Pontids Belt which has been surveyed geologically three times in the past. The geologic units are; basement composed of Triassic metamorphic rocks, unconformably overlying Tertiary intermediate volcanic rocks and the granodiorite and serpentinite intrusive bodies which are distributed in the parts where Triassic basement is developed. The predominance of intermediate volcanic and pyroclastic rocks during Eocene to Miocene is noted and associated small scale vein type mineralization is observed as well as silicification and argillization.

Thus, porphyry molybdenum-copper, small scale high grade copper-lead-zinc veins and gold deposits in silicified zones are the three types which can be anticipated to occur in this geologic environment. Gold veins associated with silicified zone are known in two localities in the western part of this area. The details of these deposits are not known, but they have been worked in the past, and subsequent discovery of new veins by MTA has been reported (Higgs, 1962). Silicified zones similar to these occur widely in the eastern part and thus the survey in Zones A and B was focussed on gold prospecting. Geochemical anomalies have been detected in Zone C. These anomalies, however, are considered to be due to copper-lead-zinc-molybdenum mineralization associated with granodiorite intrusion and the survey was oriented for the investigation of porphyry molybdenum-copper mineralization.

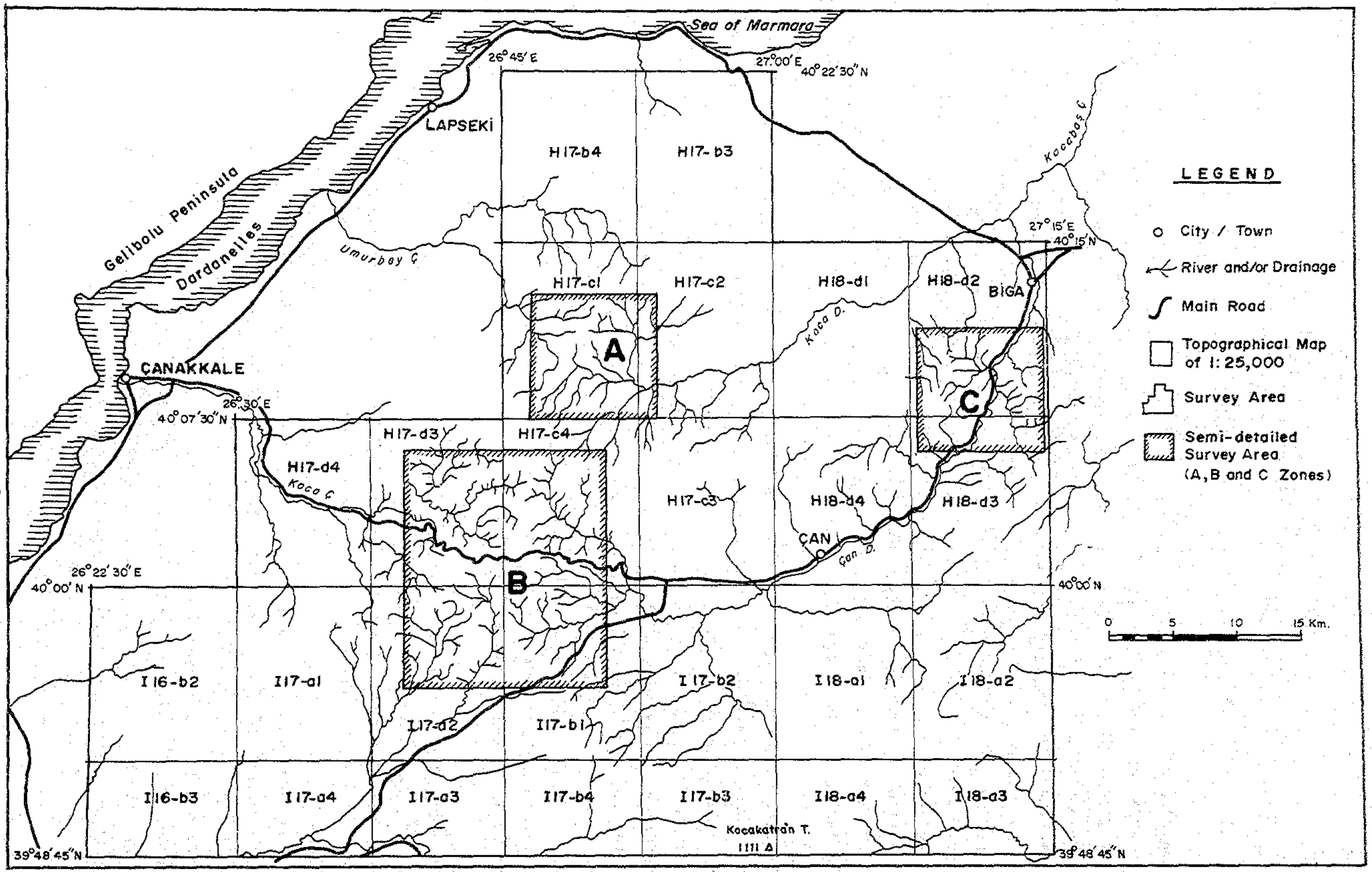


Fig. 1-2 Location Map of the Survey area

Table 1-1 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	A	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	Sivridağ 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	Doğancı	Cu,Mo	nd/Hs	A		○			
		39	Bardakçılar	As,Pb,Zn,Sb	A_1+T_1 with Tsi/Gd/Hs	A	×		○	○	100(B)
		61	Sakardağ	Cu	Gn/Gd/Hs	A					
		101	Calılı	Cu	A_1+T_1 with Tsi/Hs	A					
		102	Diboktaş	Cu	ditto	A	×				80(B)
		103	Kızıldam	Cu	ditto	A					
	Related with older v.	6	Kocamusalar	Cu	Efl	B					
		7	Mağara Tepe	Pb,Zn	A_1+T_1	B					
		9	Manyasobası	Cu,Pb,Zn,Sb	ditto	B		○		○	
		10	Karadağ	Cu,Pb,Zn,Sb	ditto	B		○			80(B)
		11	Dogancılar	Cu,Pb,Zn,Sb	ditto	B					
		14	Üvezdere	Pb	ditto	B	×	○			
		29	Kayalıdağ	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	Yeşilköy	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] Simboles are same in Table 1-2. 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

1-2 Areal Extent and Work Operation of the First Phase Survey

The area surveyed during the period of this report is 3,400km² bounded by the following four coordinates (Fig. 1-2).

Latitude	Logitude
40° 22′ 30″	26° 22′ 30″
40° 22′ 30″	27° 15′ 00″
39° 48′ 45″	27° 15′ 00″
39° 48′ 45″	26° 22′ 30″

1-2-1 Priority Activities of the Survey

As reported in the preceding sections, the major geologic constituents of this area are Tertiary intermediate volcanics and pyroclastics, and mineralization within these host rocks occur in many localities. As the study of the existing geochemical data and the Landsat images indicated the existance of notable alteration zones, the following problems and items became the priority activities during the first phase survey.

(1) Geologic structure analysis of volcanic and pyroclastic zone. (clarification of volcanic centres, fractured zones, fault structures etc.)
(2) Collection of geochemical chip samples with emphasis on delineated altered zones.
(3) Subdivision of alteration zones by X-ray diffraction.
(4) Detailed surface survey of fractured zones inferred from TM image.
(5) Relationship between geochemical anomalies and mineralization.
(6) Extension of mineralization to the deeper parts.
(7) Extraction of geochemically anomalous zones and clarification of their characteristics.

1-2-2 Survey Methods

(1) Extraction of alteration zones by TM image interpretation

Geology of the Çanakkale Area (3,400km²) was analysed by Landsat TM data. The extraction of altered zones by ratio processing the various TM bands and thereby preparing the ratio images was decided to be effective. Blue, green, red were selected for the ratio processed data of 5/7, 5/4, 3/1 bands ratio and ratio images and false colour images (both 1:100,000) were prepared for altered zone extraction and lineament interpretation. During this procedure, the results of the analysis of the mineralized areas of North and South Americas were useful references.

(2) Geological Survey

The general geology of the survey area is known through the geological survey conducted by MTA and also by cooperative work with Federal Republic of Germany. During the first phase survey, the results of the above surveys formed the basis of the work and empasis was laid in the investigation of the alteration zones of the volcanic belt extracted from Landsat image analysis. Almost all of the geochemically anomalous zone occurrences are limited to the belt of volcanic rock distribution and thus the relation between volcanism and mineralized zone and alteration were investigated in detail.

(3) Geochemical prospecting

Chip samples were collected together with geological survey in the 500km² area for semi-detailed survey delineated from the study of Landsat data and existing geological information. The sampling density was two samples per 1km². Silicified and argillized zones were developed and in some parts hot spring activity was found. Sampling was conducted with these zones in mind.

(4) The Scope of geological survey and geochemical prospecting

Surveyed area (Landsat image analysis)	3,400km²
Area of semi-detailed survey	500km²
Length of survey route	750km
Thin section	15pcs
Polished section	16pcs
Chip samples (Au,Ag,As,Hg,F,Tl,Se,Sb,Ba,Cu,Pb,Zn,Mo,Bi,Cd)	1,009pcs
Stream sediment samples (Au,Ag,As,Hg,F,Tl,Se,Sb)	304pcs
Ore analysis (Ag,Cu,Pb,Zn,Mo,Sb,W)	16pcs
Whole rock analysis	15pcs
X-ray diffraction analysis	150pcs
Heavy mineral collection	131pcs

1-3 Member of the First Phase Survey

(1) Mission for Project Finding (From 27 January 1988 to 1 Feburary 1988)

【Turkish memberes】

Sıtkı SANCAR	General Director, General Directorate of Mineral Research and Exploration of Turkey (MADEN TETKİK ve ARAMA GENEL MÜDÜRLÜĞÜ, M.T.A.)
Dr.Ramiz ÖZOCAK	Director of Metallic Mineral Department,M.T.A.
Dr.Ünal ARTAN	Deputy Director of Metallic Minerals Department, M.T.A.
Adnan İNAN	Deputy Director of Metallic Minerals Department, M.T.A.
Engin ÇUBUKÇU	Coordinator of Oversea Planning, M.T.A.
Mehmet Abid GENÇ	General Manager of Northwest Anadolu Branch, M.T.A.
Nizamettin ÇETİNKAYA	Deputy Manager of Northwest Anadolu Branch, M.T.A.

【Japanese memberes】

Takeshi IZUMI	Metal Mining Agency of Japan
Hideki FUKUDA	Ministry of International Trade and Industry
Hideo HIRANO	Metal Mining Agency of Japan
Masahiro KAMITANI	Ministry of Foreign Affairs
Yoshiyuki KITA	Japan International Cooperation Agency

(2) Mission for Scope of Work(From 22 June 1988 to 30 June 1988)

【Turkish memberes】

Orhan BAYSAL	General Director, General Directorate of Mineral Research and Exploration of Turkey (MADEN TETKİK ve ARAMA GENEL MÜDÜRLÜĞÜ, M.T.A)
Atilla AYMAN	Deputy General Director,M.T.A.
Ramiz ÖZOCAK	Director of Metallic Mineral Department,M.T.A.
Unal ARTAN	Deputy Director of Metallic Minerals Department, M.T.A.
Adnan İNAN	Deputy Director of Metallic Minerals Department, M.T.A.
Engin ÇUBUKÇU	Coordinator of Oversea Planning, M.T.A.
Mehmet Abid GENÇ	General Manager of Northwest Anadolu Branch, M.T.A.
Nizamettin ÇETİNKAYA	Deputy Maneger of Northwest Anadolu Branch, M.T.A.

【Japanese Members】

Hideo HIRANO	Metal Mining Agency of Japan
Takeshi MORIYA	Ministry of International Trade and Industry
Yoshiyuki KITA	Japan International Cooperation Agency
Naotaka ADACHI	Metal Mining Agency of Japan

(3) Survey Team

The survey of first phase was carried out during the period from 2 August 1988 to 21 November 1988. The field survey and the organization of the survey team were as follows.

Duration of the Field Survey: From 10 September 1988 to 15 November 1988

【Turkish Team】

Necmi YÜCE	M.T.A.(Coordinator, Chief Geologist)
Ahmet KARA	M.T.A.(Leader, Chief Geologist)
Hasan BATIK	M.T.A.(Geologist)
Sinan ORBAY	M.T.A.(Geologist)
Hakan SAKA	M.T.A.(Geologist)
Turhan ALPAN	M.T.A.(Geologist)
Nuri SALTA	M.T.A.(Geochemist)

【Japanese survey Team】

Hisashi MIZUMOTO	Nikko Exploration and Development Co.Ltd. (NED)

(Leader, Chief Geologist)

Satoshi OBARA	NED (Geologist, Analysis and Interpretation of Landsat image)
Tetsuo SATO	NED (Geologist)
Kazuyasu SUGAWARA	NED (Geologist)

CHAPTER 2 GEOGRAPHY

2-1 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 Çanakkle Prcovince, and its population is more than 20,000. Besides, small villages are scattered in the area.

By road, the distance from Ankara to Çanakkale is approximately 600km through Eskişehir and Bursa, long-distance bus takes 11 hours. The survey area is under the jurisdiction of MTA Balıkesir Office which has the largest member staff in all of the MTA regional office. There is a major highway, National Highway 60, which traverses the central part of the area in E-W direction, National Highway 2 runs along the Aegean coast from Marmara. They are almost totally paved. There are automobile roads which connects the major highways and the villages. These roads are paved, accessible but become very bad roads in the winter because they are not gravel roads, in 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 from the first phase survey was set in Çanakkale and the field work for Zones A, B and C was conducted by using jeeps for transport from Çanakkale. The travel time from Çanakkale to Zone A was one and half hours, to Zone B one hour and to Zone C two hours.

2-2 Topography and Drainage

2-2-1 Topography

The Çanakkale Area located in the northwestern part of Biga Peninsula is bound to the north by Sea of Marmara, to the west by Aegean Sea, and to the south by the Kaz Range (highest peak 1,710m) extending in E-W direction. Within the Landsat images used, the highest peak of the area is the Mt.Kocakatran with elevation of 1,111m which is located near the southernmost part of the survey area. The area ($500km^2$) delineated for semi-detailed survey in 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 elevation and vegetables and fruits are actively cultivated. Above 200m in the higher lands, cultivation of wheat and cattle raising are very active.

2-2-2 Drainage

The Zone A is located in the upstream part of Umurbey River which flows into the Dardanelles and also of the Kacabaş 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 tributery 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.

2-3 Climate and Vegetation

2-3-1 Climate

The annual precipitation of the survey area amount to 600mm and there is a large area of fertile land where cultivation of vegetables, fruits, wheat and breeding cows, sheep, goats among others are very active. The annual average temperature is warm at 14.6℃ and is close to Mediterranean climate, but since it is in higher latitude, the survey area with fairly high elevation is cool in the summer and quite cold in the winter with some snow fall. At Çanakkale the temperature rises above 20℃ during the four months from June to September and during September to November when the field survey was carried out, the climate gradually shifted from the relatively dry season to relatively wet season and the monthly average temperature dropped from 19.7℃ in September to 11.8℃ in November. The monthly average temperature and precipitation published by the Çanakkale Meteorological Station are as follows.

Temperature	Jan	Feb	Mar	Apl	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
℃	5.9	6.5	8.0	12.3	17.2	21.8	24.6	23.9	19.7	15.6	11.8	8.1	14.6

Precipitation	Jan	Feb	Mar	Apl	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
mm	98	72	67	40	29	23	11	8	24	46	86	105	609

2-3-2 Vegetation

The survey area in 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 parts are cultivated, but other parts are used for grazing.

CHAPTER 3 RESULTS OF PREVIOUS WORKS

3-1 Outline of Previous Works in the Area

The stratigraphy of the Çanakkale Area is shown in Table 1-2. This was compiled by Behçet AKYUREK 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 crystalline limestone. This basement is unconformably overlain by Mesozoic sedimentary formations and Miocene intermediate volcanic rocks. Silicified and argillized alteration zones were extracted 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 intrusion occured in many parts of the area and iron, copper, lead and zinc mineralization are found associated with this intrusion.

In 1987, exploration group of the Turkish Petroleum Co.,conducted geological survey of the whole Biga Peninsula prior to drilling for oil in the 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 activites; Triassic and Cretaceous to Eocene. The ages were determined by the study of fossils (Table 1-3) in the vicinity(Fig. 1-3).

3-2 General Geology of the Western Part of the Biga Peninsula

The geology of Biga Peninsula as mentioned above, has been investigated by MTA and Turkish Petroleum Co., as shows in Fig. 1-4. Table 1-4 lays out the correlation of the results of the present survey with those of the two previous work. It is seen that the stratigraphy compiled during the present study agrees with that prepared by Turkish Petroleum Co.

Lowermost geologic unit of the northwestern Biga is the pre-Triassic metamorphics(Kazdağ 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, 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 small amount of Late Tertiary to Quaternary dacite and basalt. The intrusive rocks are Traissic and Cretaceous to Eocene granodiorite and they are distributed in Zones B and C.

Representative fossils of Biga Peninsula provided by the Turkish Petroleum Co. are listed in Table 1-3. These are unpublished material.

Table 1-2 Stratigraphy of Biga Peninsula *

Era	Period	Epoch	Units
Cenozoic	Quaternary	Holocene	Alluvium(Al) Terrace(Ta) Tals sediment(Qd)
		Pleistocene	Olivine Basalt(Boh) Gevşek Volcanic Ash(Pt)
	Neogene	Pliocene	Göl Sedimentary Rocks(n) — Killi Limestone(ng); Pyroclastics(nd)
		Miocene	Aggromerate(Agps, Arag) Silicious tuff(Tsi) Dacite-Rhyorite(DR) Pyroclastics(A_2+T_2) Ignimbrite, Rhyolite, Rhyodacite, Andesite, Tuff
	Palaeogene	Oligocene	
		Eocene	Sandstone-Conglomerate(Efl)-Limestone(Ekkçl) Andesite, Tuff(A_1+T_1) Granodiorite(Gd) Contact Metamorphic Rocks(KMK)
		Palaeocene	
Mesozoic	Cretaceous		Alancık F.(Kçisy)
	Jurassic		Terzialan Sandy F. — Sandstone(Kkır); Sandy Limestone F.(Kkçt)
	Triassic	Upper	Hasanlar F.(Kon-Tkır)
		Middle	Çınarcık Limestone F.(Tkçt)
		Lower	Karakaya F. Gabbro(Ga)-Spilitic Basalt(Dz) Metaspilite(SPO), Pyroclastics(DPO)
Pre-Triassic	Kazdağ Group		Epimetamorphic Schist(Ep) Sarıkız F.(Mr) Bozagaç Tepesi F.(Gn) Tozlu F.(mum) — Kozburun Member(Af); Boluca Member(MGa); Babadağ Member(MD)

* Behçet AKYÜREK and Yılmaz SOYSAL (1980)

3-3 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 of the Madendagı and Kartaldagı mines. They extend into the survey

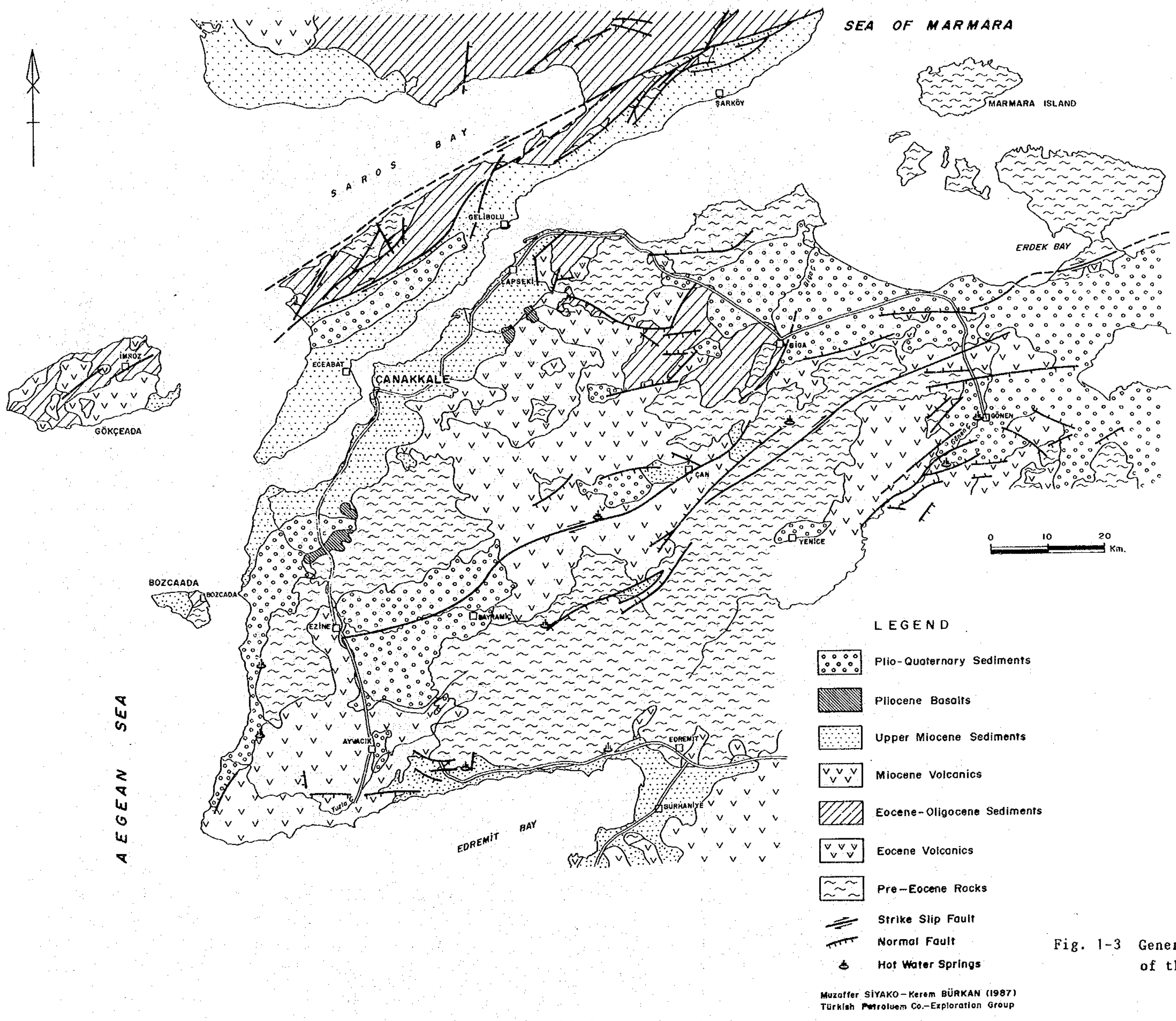


Fig. 1-3 Generalized Geologcal Map of the Western Biga Peninsula

area. The age of the alteration is inferred to be latest Tertiary and the centre of the Tertiary volcanic activity was very clearly identified.

Table 1-3 Fossil Occurrence of the Biga Peninsula

Formation	Geologic Age	Location (Map No.)	Name of Fossils
Karakaya Group	Carboniferous~ Permian	South of Çan (I18-a)	Textularia sp. Valvulina sp. Schwagerinidae:Upper Permian Codonofusiella ? sp.:ditto Geinitzinaceae:ditto
Bayırköy Formation	Upper Jurassic	South of Çan (I18-a)	Protopeneroplis striata Miliolidae (shows lagoon environment)
Manyas Melanjı	Cretaceous	West of Beypınarı (H17-b)	Hedbergella sp.
Çan Formation	Middle Miocene	Northeast of Kızıldam (H17-b)	Lindarina sp. Globigerina sp. Discocyclina sp. Bryozoa Red algea
		West of Şevketiye (H17-b)	Nummulites spp. Asterigerina spp. Bryozoa Red algea
Ezine Volcanics	Middle Miocene	North of Kazmalı (H17-c)	Eoannularia eocenica Red algea Bryozoa
Kirazlı Formation	Middle~ Upper Miocene	South of Çanakkale Erenköy (H16-c)	Pityosporites microalotus Compositae type pollens Tricolpopollenites gramineoides Periporopollenites cf. stigmosus Triatriopollenites sp. Subtripropollenites sumplex
Alçıtepe Formation	Upper Miocene	Southwest of Lapseki (H17-a)	Triatriopollenites spp. Casinipollenites cf. beulus noctis Subtriporopollenites sumplex Inaperturopollenites undulosus Zonalapollenites sp.

3-4 Outline of Mining in the Survey Area

The Biga Peninsula including the Çanakkale Area is considered to be the most important lead-zinc metallogenic province of the Republic of Turkey. Also antimony, gold, silver, mercury, iron and other matallic deposits as well as ceramic material resources have been found in the peninsula. Thus, this

Table 1-4 Correlation List of the Biga Peninsula

Geologic Age			Turkish Petroleum Co. Exploration Group (1987)	Yılmaz SOYSAL Behçet AKYÜREK (1980)	Turkish-Japanese Joint Project (1989) Zone A	Zone B	Zone C
Cenozoic	Quaternary	Holocene	Alluvium Taştepe Basalt	Alluvium	Alluvium Balaban B.	Alluvium Kocaçakıl B.	Alluvium
		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			
			Ezine Volcanics / Hisarlıdag Volcanics	A_2+T_2 Volcanics	Balcılar V.	Şapçı V.	
	Oligocene		Yenimuhacır G.: Osmancık F. Mezardere F.				
	Eocene	Middle-Upper	Keşan G.: Volcanics Ceylan F. Soğucak F. Koyunbaba F.	Efl Sandstone & Conglomerate			Kirazlıgeçit M. Kızılcık M.
		Lower	Akçaalan Volcanics Fıçıtepe F. Karaagaç F.	A_1+T_2 Andesite & Tuff	Çamyayla V.	Çamyayla V.	
	Palaeocene						
Mesozoic	Jurassic~Cretaceous		Manyas Melange (Ophiolite & Limestone) Vezirhan F. Bilecik Limestone Bayırköy F.			Kirazlı Conglomerate	Sarısuvat F.
	Triassic		Granite Karakaya Group: Yalindi F., Armutçuk M., Çal F., Limestone Spilite, Torasan F., Karaaşik F., Sazak M.	Granite Hasanlar F. Çınarcık Limestone Karakaya F.		Taşdibek F.	Emeşe F.
Pre-Triassic			Kazdag Metamorphics	Kazdag Group			

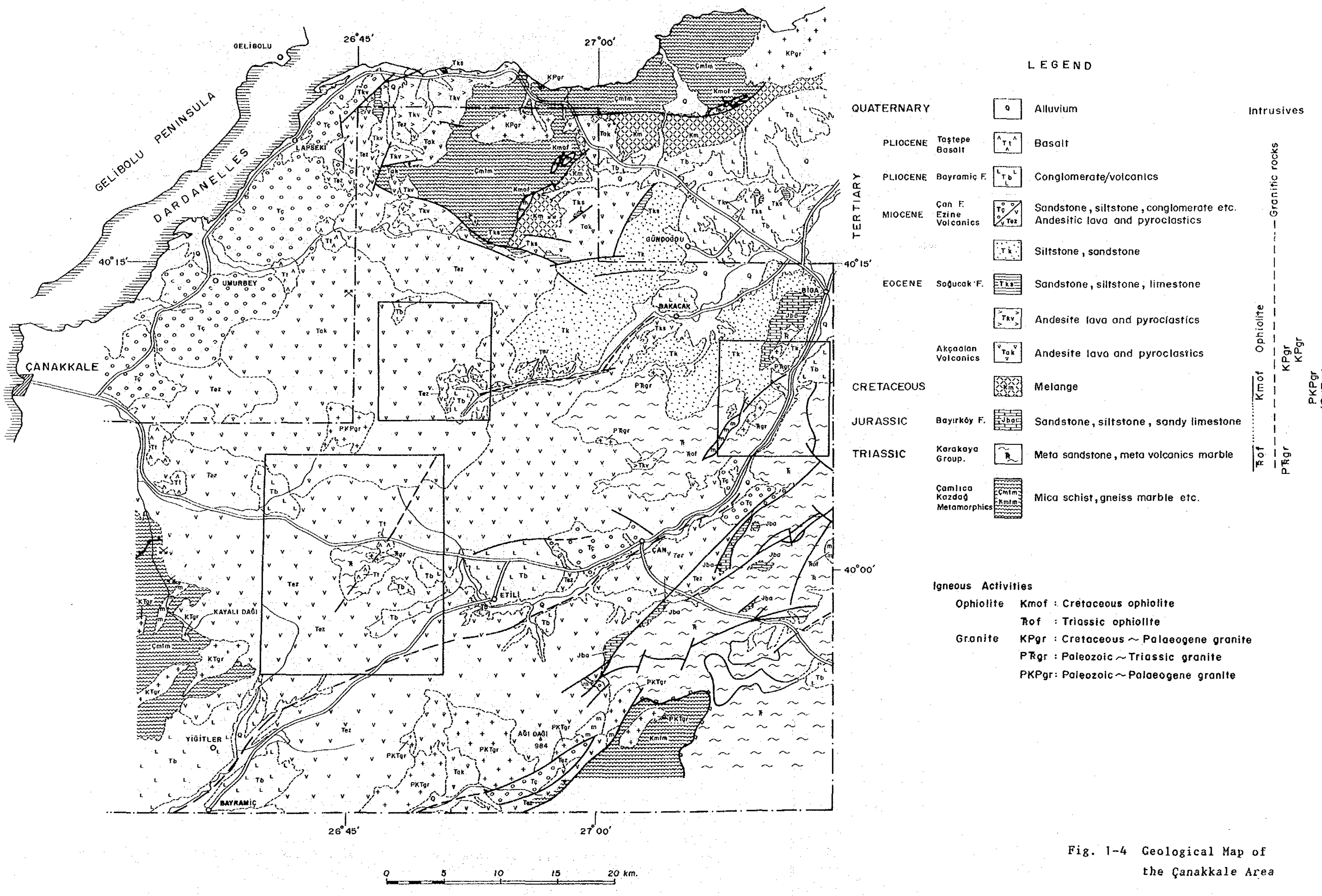


Fig. 1-4 Geological Map of the Çanakkale Area

peninsula has been the target of geological survey, geochemical prospecting, mining study and other various MTA projects.

The area has been the site for Turkey/Federal Republic of Germany Cooperative Project which resulted in the discovery of promising lead-zinc deposits.

Within the 3,400km² area analyzed by Landsat images, there are well known gold deposits of Madendagı and Kartaldagı mines. Also, although presently closed and operated at very small scale, Çataltepe mine (lead-zinc veins) is in the above area. In Zone C, a porphyry molybdenum deposit (Dikmen mineralized zone) was discovered during the present survey. Immediately outside of the Landsat image, there are the presently operating Koru Köyü mine and Yenice gold deposit which is now being explored.

Madendagı mine: It is located 50km southwest of Çanakkale. The mine was operated by British company Astyra Gold Mining Co. during 1914-1918 (Molly, 1958). It had been worked prior to 1914, but the situation is not clear. MTA, during 1960-1962, conducted geological survey, tunnelling and drilling and delineated a small ore reserve of 15,000t (Au,5.8-6.8g/t). At present, Turkey-West Germany joint venture Tüprag Co., is exploring the silicified zone in the Miocene andesitic pyroclastics to the west of the old mine. They are using trenching and drilling.

The old deposit of this mine is quartz veins in the pre-Triassic brecciated schist. These quartz veins are considered to have formed in association with the Tertiary andesitic volcanism. The brecciated zone is strongly silicified, the main vein is that along the fracture with N60°～70°W trend and southward dip. It is accompanied by limonitic clay forming a bonanza and fissures were formed during this process in N20°～30°E and N60°E direction. The quartz veins spread out along these subsequently formed fissures. In this locality, network of quartz veins are also developed, pyrite dissemination is observed and forms low grade gold mineralized zone. The locality, presently being explored by this project, is in the Miocene andesitic rocks where silicification-limonitization (oxidation of sulfides)-argillization and pyritization are significant. Silicified zones are highly fractured. Trenching at 50m interval, grid drilling and other exploratory work is being carried out here for epithermal gold. The heavy mineral study of the soil of the silicified and argillized zone revealed the existance of large amount of gold grains during the present survey.

Kartaldagı mine: It is located 55km southwest of Çanakkale. This mine was also operated by the British Astyra Gold Mining Co., during 1914-1918 (Molly, 1958). This mine was operated prior to 1914, but the details are unknown. Stone mortars which were probably used for crushing gold ores and also used as conduits for concentrates in the very old days are found scattered in the vicinity. MTA conducted geological survey, trenching, drilling and other exploration of this prospect during 1960-1962 and delineated a small amount of reserves of 50,000t (Au; trace to 5.5g/t). Since August 1987, Çanakkale Mining Co. is in the process of reopening the old adits by seven workers. As of mid-November, 1988, the work has progressed to 130m below the ground level. In the mine area, andesite lava is widely distributed and E-W, NE-SW trending faults occur in the lava. Silicified alteration zone is developed along these faults. The old orebody occurs lens-shaped within the fault with N20°-30°E strike and dips NW70°. There are significant amount of pyrite in the gold-rich zone and kaolinization is very strong in the vicinity (MTA, 1970). It is considered to be a deposit similar to the Madendağı from the fact that significant amount of gold grains are found from the stream sands and soil near the mine and also that the kaolinized zones also contain gold.

Yenice gold deposit: It is located in the southern part of the Yenice Village. Etibank holds the mining rights and requested MTA to undertake prospecting. MTA is undertaking geological survey, geochemical prospecting (including panning), trenching and other exploratory activities since 1987. The dimensions of the deposit, grade and other factors are not yet clear, but panning proved the existence of a considerable amount of gold grains of 10～500μm.

The geology near the deposit consists of widely distributed andesite lava and pyroclastics near Kayatepe which lie at the centre of gold mineralization, silicification, argillization and pyritization are strong extending in E-W direction. Silica cap was formed as a result of the above alteration. Thus the deposit is considered to be epithermal gold.

Koru Köyü mine: It is located northwest of Koru Village, and is a small lead-zinc vein deposit presently worked by Çanakkale Mining Co. The company employs 70 workers and produces 100～150t of massive crude ore monthly, separates them at the mine, sends to dressing plant at the suburbs of Çanakkale, then shipped to Italy as lead and zinc concentrates.

Çataltepe mine: It is located 20km east of Lapseki and was operated on small scale by Çanakkale Mining Co., but was recently closed. Details are not known.

Other deposits: Resources known in this area include kaoline deposits and lignite seams.

Table 1-5 Main Ore Deposits of the Çanakkale Area

Name	Kind of Ore Deposits	Host Rocks	Type of Ore Deposits	Age of Mineralization
Madendagı Kartaldağı	Au	Breccia zones of schist(Pre-Triassic)/ Andesite lava & pyroclastics(Miocene)	Epithermal	Tertiary
Karapınar	Cu	Schistose marbles (Pre-Triassic)	Hydrothermal (Shear zones)	Miocene
Kuşçayırı	Fe-As	Ayrışmış andesitic tuff(Miocene)		Upper Miocene
Kundakçı-larobası	Pb-Zn-Ab	Andesitic lava & pyroclastics(Eocene)	Epithermal (Vein)	Tertiary
Koru Köyü	Pb-Ba-Ag	Andesitic lava pyroclastics(Eocene)	Meso-epithermal (Vein)	Tertiary
Çamyurt	Cu	Schist(Pre-Triassic)/ Qz diorite	Meso-epithermal (Qz vein)	Tertiary
Çataltepe	Pb-Zn-Cu	Andesitic lava & pyroclastics(Eocene)	Epithermal (Vein)	Tertiary
Nusretiye	Pb-Zn-Cu	Andesitic lava pyroclastics(Eocene)	Epithermal	Tertiary
Balcılar	Ag-Pb-Zn	Andesite (Miocene)	Epithermal (Vein)	Tertiary
Kocalar	Pb-Zn	Andesitic lava pyroclastics(Eocene)	Epithermal (Vein)	Tertiary
Kocayayla	Zn-Pb-Cu	Volcanic rock(Miocene)/ phyllic schist(Triassic)	Mesothermal (Brecciated zone)	Miocene
Doğancılar	Cu-Pb-Zn	Block-faulted volcanic rocks	Qz vein/veinlet	

CHAPTER 4 REVIEW OF THE SURVEY RESULTS

4-1 Geochemical Nature of Mineralization

Stream sediments and mineralization: The stream sediment samples collected previously by MTA were analized for gold, silver, fluorite, mercury, thallium, selenium, arsenic and antimony. These were elements not previously analyzed and deemed significant for gold prospecting. Most of the samples were selected from Zones A, B and C, with addition of those from adjoining areas. The total number samples analyzed amounted to 304, those exceeding 20 ppb gold were 14, three from Zone A, three from B, one from C and seven from outside. The localities are as follows (Table 1-6, Plate 16).

Zone A: Down stream of Balcılar vein deposit and locality considered to be a part of the halo of Kundakçılarobası mine area.

Zone B: Stream on the western side of Mt. Kestane and southeastern part of Karaibrahimler.

Zone C: Along the Dikmen fault in the southeastern part of Ovacık.

In Zone A, considerable amount of gold and silver was detected in the samples from near lead-zinc veins. These veins, however, are very small deposits and thus this is not included in the geochemical anomalies. In Zone B, there are arsenic, mercury, antimony and barium minerals, aside from the gold concentration. Considering the X-ray diffraction results together with other data, the mineralization in this zone is the so-called acidic-sulfate epithermal mineralization. In Zone C, evidences for mineralization was the Dikmen anomaly (copper, lead, zinc, molybdenum), which was already extracted by MTA.

Chip composition and mineralization: One thousand samples were collected from the semi-detailed survey area and ten samples from the MTA prospects outside of the above. The analyzed elements are, gold, silver, fluorite, mercury, thallium, selenium, antimony, arsenic, copper, lead, zinc, molybdenum, cadmium, bismuth and barium. The samples were collected from the alteration zones -silicification, argillization- in Zones A and B, Dikmen Granite and the mineralized zone near this intrusive body were sampled in Zone C. The localities with samples exceeding 50 ppb gold and 100 ppm molybdenum are as follows (Tables 1-7～1-9, Plates 3, 7 and 10).

Zone A: From this zone, 135 rock samples were analyzed. Of these, 15 samples contained gold in excess of 50 ppb, these are gold associated with vein-type mineral of Kundakçılarobası and Balcılar veins as seen in the Table 1-7.

Zone B: From this zone 664 chip samples were analyzed. It is noted that almost all of these samples contained small amounts of copper, lead, zinc while the content of arsenic, mercury, antimony, bismuth, barium were relatively higher together with gold (Table1-8). The localities of the samples are Karaibrahimler, Arlık River, Mt. Piren and the Mt. Kestane. There are samples from other localities which contained significant metals, but these occur isolated and the minerals have not been confirmed by heavy mineral investigation, thus they are considered to be of smaller scale mineralization.

Zone C: From this zone, 200 chip samples were analyzed. Most of the samples were collected from the Dikmen Granite and the alteration zones in the vicinity. There is porphyry molybdenum-copper mineralization in the quartz veinlets in and near the Dikmen Granite. Elements of lower temperature mineralization such as gold, mercury, antimony and barium were detected, and it is inferred that two different types of mineralization occurred in the same locality at different times.

Other zones: Ten samples from the MTA prospect south of Zone B were analyzed, but noteworthy results were not obtained.

Heavy minerals and mineralization: Heavy minerals were studied for obtaining information useful for gold prospecting. The mineral samples were collected from the silicified and argillized zones in the vicinity of Madendağı and Kartaldağı mines and in the A and B Zones. Most of the sampling was done in the downstream part of the silicified bodies. Those samples which might indicate the existence of gold mineralization in the upstream areas were selected from Table 6 of the appendix and listed by their localities (Table 1-10). The localites of major interest are as follows.

Zone A: This will not be treated as geochemical anomaly, because it is near vein type deposit.

Zone B: The vicinity of Karaibrahimler Village and Sarp River which flows on the westernside of the above silicified body, Kestane Dağı, Kocataş Tepe, Arlık Dere and Karacaören Tepe.

The localities outside of the semi-detailed survey area are Madendağı and Kartaldağı mines and Dededag which is located to the north of Zone A.

4-2 Resource Potential of Gold and Porphyry Molybdenum Resources

4-2-1 Gold Potential

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

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 acompanied by gold mineralization. Gold occurs only in limited localities. The geochemical prospecting and X-ray diffraction results of the work on samples from Zones A, B and Madendağı, Kartaldağı mines are laid out in Table 1-11.

The mineralization of Zone A is gold-silver veins, the extent in the strike direction is short and the veins are thin veinlets, indicating the small scale of the deposits.

The major localities where gold mineralization was confirmed from geochemical samples are shown in Table 1-11. 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 the B Zone, the basement which consists of Taşdibek Formation and Akpınar Granite forms an uplifted zone and gold mineralization is observed in the altered zone surrounding the basement complex.
(2) The X-ray diffraction study of samples from the alteration zone showed that; gold mineralization occurs in the acidic alteration whose products are kaoline, alunite, 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 association.
(4) The components with large absolute values of eigenvector of the principal component analysis are aside from gold, copper, lead, zinc, silver, mercury, arsenic, cadmium, and antimony, 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.

4-2-2 Porphyry Molybdenum Potential

Porphyry molybdenum-copper deposits associated with Dikmen intrusion were discovered in Zone C. The mineralization extends from the eastern side of the Dikmen Granite which is elongated in NE-SW direction to Emeşe Formation of the Sıgırirek Stream. The rocks are decloured white at Sıgırirek and minor amounts of sulfide minerals such as molybdenite, chalcopyrite, sphalerite and pyrite occur associated with quartz veinlets. Although invisible under microscope, analysis (Table 1-9) shows the existence of gold, arsenic, mercury and antimony. Sericite and kaoline were identified by X-ray diffraction which indicates epithermal activity after the porphyry mineralization. The two mineralizations could be overlapping.

The porphyry mineralization extends to the lower horizons and this is expected to be low grade large scale deposit. This deposit locally contains gold and antimony. If gold could be found to be contained in significant amounts in the overlapped part, this would be a important future target.

4-3 Geologic Structure, Characteristics and Control of Mineralization.

Zone A: The geology of this zone consists of Eocene Çamyayla Volcanics and Miocene Balcılar Volcanics. As these volcanic rocks are predominant in this zone, significant and unique geologic structure was not observed. Vein-type copper-lead-zinc mineralization was observed in these volcanics.

The characteristics of the mineralization is the association of barite, and it is a high grade epithermal gold silver deposit. Acidic alteration associated with cristobalite and kaoline, alunite and pyrophyllite do not occur. This is contrary to the silicification and argillization of Zone B, here the alteration is weak argillization with sericite, chlorite, epidote with minor amount of kaoline. This kaoline is believed to be the product of weak kaolinization which occured widely in the region.

Zone B: The central part of this zone consists of Taşdibek Formation and Akpınar Granite which forms the geological basement. The basement is uplifted. 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 zones, acidic alteration consisting of cristobalite, alunite, pyrophyllite is observed. Analysis of rocks shows the content of copper, lead, zinc, silver, mercury, arsenic, cadmium, antimony together with gold. These elements are considered to have been associated with gold mineralization.

Quaternary Kocaçakıl Basalt lava intruded along the fault which extend through the uplifted zone of the basement. This is another evidence that the vicinity of the basement forms the conduits of hydrothermal fluids, and gold mineralization occured associated with the acidic alteration.

Zone C: Triassic Emeşe Formation is predominant in the southern part of this zone. There are lineations trending NE-SW parallel to the Dikmen Fault. Sepentinite intruded along these latent faults and Dikmen Granite also intruded in the same direction in latest Cretaceous to Eocene. Parts of the limestone and metavolcanics of the Emeşe Formation were skarnized, argillized and silicified by the intrusion of the granitic rocks and molybdenite and other sulfide minerals occur in the quartz veinlets along the fissures formed by the intrusion of Dikmen Granite.

The intermediate volcanism became active in Tertiary and large amount of lava and pyroclastic material were deposited during Eocene to

Table 1-6 Significant Analytical Results of Stream Sediments

Area	Location	Sample No.	Au (ppb)	Ag (ppm)	As (ppm)	Hg (ppb)	Sb (ppm)	Se (ppm)	F (ppm)	Tl (ppm)
Zone A	Kundakçılarobası (Vein-type)	153: JT 153	25	0.1	25	100	1.0	0.2	360	0.3
	Eastern part	155: JT 155	40	0.3	33	270	3.2	1.0	360	0.3
	Balcılar Vein-type	158: JT 158	375	0.1	17	110	0.1	0.2	400	0.1
Zone B	Kestane Dağı	3: JT 003	205	0.5	2100	260	26.0	0.2	250	2.1
	Kestane Dağı	4: JT 004	30	0.1	1000	180	18.4	0.2	240	1.3
	Southwest of Karaibrahimler	65: JT 065	20	0.1	36	60	0.4	0.2	310	0.5
	Denizgözüken Tepe	39: JT 039	40	0.1	14	210	0.7	0.2	480	0.1
Zone C	Southeast of Ovacık	298: JT 298	30	0.1	23	90	1.2	0.2	560	0.4
Out of Area	South of Zone B	131: JT 131	40	0.1	29	90	2.4	0.2	570	0.6
	Southeast of Zone B	144: JT 144	400	0.1	25	430	0.1	0.2	360	0.8
	Between Zone A and C	258: JT 258	20	0.1	10	60	0.2	0.2	470	0.2
	ditto	263: JT 263	200	0.3	140	270	2.8	0.2	400	0.4
	ditto	264: JT 264	30	0.7	520	120	5.8	0.2	340	0.5
	ditto	275: JT 275	50	0.2	16	90	1.1	0.2	440	0.5

Table 1-7 Significant Analytical Results of Chip Samples in the Zone A

Name of Mineralization	Sample No. No.	X	Y	Au (ppb)	Cu (ppm)	Mo (ppm)	Pb (ppm)	Zn (ppm)	Ag (ppm)	Cd (ppm)	As (ppm)	Se (ppm)	Hg (ppb)	Sb (ppm)	Bi (ppm)	F (ppm)	Ba (ppm)	Tl (ppm)
Kundakçılarobası (Cu-Pb-Zn)	387: HS213	8530	5084	60	10000	1	196	470	3.30	1.50	16	0.20	90	1.30	0.80	70	70	0.5
	997: TS252	8518	5075	65	750	4	2350	980	1.60	0.90	46	0.40	20	1.20	0.30	370	1200	1.5
	388: HS215	8530	5084	375	10000	1	1250	3000	12.80	16.00	19	0.20	50	1.30	0.90	180	180	0.4
	389: HS216	8530	5084	590	10000	1	1350	4300	16.30	23.00	9	0.20	30	1.20	0.70	200	50	0.2
Balcılar Vein (Pb-Zn-Barite)	1009: TS299	8586	4725	2150	385	1	10000	10000	10.30	148.00	19	0.20	4600	3.80	0.10	150	440	0.1
	1010: TS300	8595	4701	1070	243	1	390	9300	0.70	43.00	7	0.20	540	0.40	0.10	60	580	0.1
Others (Vein Type with Alteration	414: HS267	8604	4840	100	1000	21	10000	10000	8.00	170.00	260	2.40	2100	39.00	0.10	110	10000	0.2
	415: HS268	8604	4840	100	88	1	10000	730	19.00	6.50	9	0.40	220	8.20	0.10	40	660	0.1
	392: HS224	8410	5127	50	34	1	580	54	0.10	0.10	6	0.20	130	0.30	0.10	70	510	0.8
	400: HS250	8548	5020	320	10000	1	900	2850	11.00	15.00	14	0.20	30	0.40	2.20	7400	30	1.4
	1004: TS276	8210	4934	525	10000	24	830	45	2.30	0.10	19	1.20	30	0.50	0.60	220	180	0.2
	416: HS283	8460	4846	50	19	1	590	16	0.10	0.10	12	7.00	30	0.60	0.20	340	330	0.7
	781: NY168	8166	4642	210	55	10	1850	5	74.00	0.10	260	0.20	840	17.40	0.90	80	130	0.2
	782: NY169	8169	4647	65	900	8	10000	92	36.00	0.10	700	0.20	3900	175.00	0.20	110	310	0.2
	783: NY170	8177	4653	90	37	13	900	19	25.00	0.10	46	0.60	940	13.40	0.70	100	200	0.2

Table 1-8 Significant Analytical Results of Chip Samples in the Zone B (1)

Name of Mineralization	Sample No. No.	X	Y	Au (ppb)	Cu (ppm)	Mo (ppm)	Pb (ppm)	Zn (ppm)	Ag (ppm)	Cd (ppm)	As (ppm)	Se (ppm)	Hg (ppb)	Sb (ppm)	Bi (ppm)	F (ppm)	Ba (ppm)	Tl (ppm)
Karaibrahimler	461: KB065	8071	2751	80	7	1	10	2	0.10	0.10	25	1.00	150	1.20	1.60	780	70	0.1
Arlık Dere	83: HB057	8367	3045	65	5	9	14	4	0.10	0.10	6	0.20	20	0.60	0.30	120	30	0.2
	84: HB060	8350	3065	240	17	36	31	19	0.10	0.10	30	0.20	10	0.20	0.80	140	110	0.2
	85: HB061	8349	3068	95	6	1	53	2	0.10	0.10	4	0.20	10	0.30	1.10	110	70	0.2
	86: HB062	8331	3085	50	2	1	3	2	0.10	0.10	11	0.20	10	0.20	0.10	70	50	0.1
	475: KB081	8248	3017	65	14	1	74	6	0.10	0.10	12	0.20	40	0.40	0.30	80	140	0.1
	481: KB088	8347	2953	3050	7	1	34	7	0.10	0.10	5	0.20	30	4.00	0.60	80	30	0.5
	626: KS132	8425	3051	170	6	25	37	11	0.10	0.10	14	0.20	50	0.60	0.20	300	690	0.4
	627: KS133	8405	3052	55	3	1	26	3	0.10	0.10	5	0.20	40	0.60	1.80	370	270	0.2
	628: KS134	8380	3088	60	4	1	3	3	0.10	0.10	4	0.20	30	0.40	0.10	320	30	0.1
	645: KS186	8010	2975	225	6800	41	10000	9000	100.00	8.00	630	0.40	950	65.00	200.00	140	20	0.1
	660: KS205	8271	3038	145	3	2	68	3	2.20	0.10	9	0.40	40	2.40	5.00	60	90	0.2
	663: KS210	8318	3004	130	28	1	67	6	1.00	0.10	32	6.00	430	1.40	24.00	350	200	0.1
	670: KS217	8307	3054	70	25	7	120	24	0.10	0.10	50	0.40	20	0.50	8.00	110	990	0.3
	671: KS218	8279	3069	50	7	3	22	6	0.10	0.10	11	0.20	20	0.20	0.50	120	50	0.1
	820: SR127	8539	2941	200	7	1	5	2	0.10	0.10	5	0.20	60	3.80	0.20	90	90	0.1
Piren Tepe	91: HB072	8212	2143	630	6	4	11	2	0.10	0.10	79	0.20	110	7.80	0.20	60	50	0.1
	92: HB073	8212	2143	2060	3	1	9	1	0.10	0.10	80	0.20	70	13.20	0.20	60	70	0.1
	93: HB075	8208	2152	115	12	1	12	5	0.30	0.10	130	0.20	660	28.00	8.50	50	180	0.1
	94: HB076	8208	2152	175	10	2	12	6	0.50	0.10	140	0.20	110	22.00	3.70	60	70	0.2
	95: HB077	8208	2152	135	11	1	27	2	0.20	0.10	530	0.20	50	38.00	13.00	50	1420	0.1
	96: HB078	8174	2139	55	21	1	3	12	0.10	0.10	4	0.20	20	0.60	0.10	40	310	0.1
	545: KB180	7922	2084	140	12	2	20	6	0.10	0.10	110	2.20	500	4.80	3.50	820	550	0.3
	546: KB181	7925	2083	100	57	2	12	14	0.10	0.10	370	4.20	100	1.00	8.50	1600	490	0.3
	547: KB182	7947	2085	470	70	5	200	21	1.00	0.10	1600	1.20	290	17.00	66.00	200	880	1.1
	552: KB187	8033	2119	50	20	15	76	8	0.10	0.10	24	4.00	30	1.60	0.90	580	380	0.2
	555: KB190	8065	2102	260	25	1	10	7	1.80	0.10	110	4.00	2400	21.00	5.50	60	1680	0.1

Table 1-8 Significant Analytical Results of Chip Samples in the Zone B (2)

Name of Mineralization	Sample No. No.	X	Y	Au (ppb)	Cu (ppm)	Mo (ppm)	Pb (ppm)	Zn (ppm)	Ag (ppm)	Cd (ppm)	As (ppm)	Se (ppm)	Hg (ppb)	Sb (ppm)	Bi (ppm)	F (ppm)	Ba (ppm)	Tl (ppm)
Kestane Dağı	363: HS176	7562	2952	110	33	1	492	20	6.10	0.10	240	4.40	4200	34.00	18.00	70	710	0.4
	366: HS179	7566	2905	75	148	3	4600	15	0.10	0.10	120	6.20	80	10.00	2.80	760	310	0.2
	370: HS183	7584	2875	65	8	2	71	10	0.10	0.10	16	2.40	140	1.00	0.90	1700	130	0.1
	371: HS184	7584	2875	60	8	3	80	4	0.10	0.10	6	0.20	160	1.80	1.80	450	310	0.1
	372: HS185	7600	2872	170	150	32	830	14	0.10	0.10	70	7.00	80	54.00	9.60	1300	360	5.0
	374: HS187	7613	2896	60	5	2	186	3	0.10	0.10	33	0.20	230	4.40	12.00	2000	600	5.2
	378: HS194	7530	2966	100	29	3	26	13	0.10	0.10	36	0.80	80	2.20	1.80	840	30	0.2
	758: NY116	7493	2850	90	10	1	20	103	0.20	0.10	150	0.20	20	0.70	1.20	320	90	0.6
	767: NY128	7419	3008	115	108	3	1	8	0.10	0.10	60	26.00	20	0.40	3.70	670	400	0.4
	886: TS099	7503	2815	75	32	1	5	13	0.40	0.10	63	5.00	30	21.00	5.00	160	110	0.4
	887: TS100	7484	2831	50	47	1	7	42	0.10	0.10	60	2.20	20	1.20	2.20	340	180	1.2
	929: TS156	7511	2776	1430	158	1	1000	16	40.00	0.10	60	82.00	28800	105.00	82.00	70	470	0.3
	950: TS158	7517	2763	50	85	5	41	53	0.10	0.10	12	5.00	90	1.00	2.20	700	110	2.1
	931: TS159	7516	2753	100	30	330	145	9	0.10	0.10	370	7.00	30	8.20	9.70	1700	250	4.9
	932: TS160	7512	2745	200	265	94	29	11	0.30	0.10	35	3.60	60	2.80	0.80	640	180	1.8
Others (Au Mineralization of smale scale)	933: TS161	7517	2733	200	44	43	930	8	2.00	0.10	480	12.60	40	67.00	8.80	380	250	1.5
	935: TS163	7522	2707	120	22	33	9	5	0.30	0.10	15	1.40	130	5.00	3.80	920	380	3.1
	941: TS169	7480	2790	50	38	6	14	10	0.30	0.10	80	6.20	20	17.60	1.20	350	290	1.6
	947: TS175	7373	2721	440	740	13	77	20	0.10	0.10	1000	6.40	50	5.20	4.20	170	660	0.1
	948: TS176	7367	2717	300	273	22	41	17	0.30	0.10	390	7.40	660	0.50	1.40	320	510	2.0
	128: HB127	8080	2530	120	3	1	30	1	0.20	0.10	35	0.20	140	8.40	9.60	80	220	0.2
	198: HM047	7155	3880	140	66	11	50	83	0.40	0.40	210	0.20	70	2.40	1.70	250	110	0.4
	245: HM134	7124	3071	65	8	1	3	8	0.10	0.10	210	1.00	220	4.20	0.50	110	50	0.1
	269: HM209	7118	3197	50	28	1	87	4	17.80	0.10	110	9.00	2300	210.00	16.00	170	2600	0.1
	309: HS089	7125	2450	60	8	8	72	9	0.10	0.10	60	5.00	370	3.00	4.10	110	70	0.1
	313: HS093	7229	2510	100	950	1	430	7	0.80	0.10	220	0.20	140	2.20	6.00	1380	310	0.2
	326: HS119	7836	2342	100	43	6	443	48	0.80	0.10	1900	19.00	50	16.60	4.30	100	360	0.4
	466: KB072	8091	3029	50	51	21	750	93	1.50	0.20	1000	4.00	1900	60.00	2.80	220	1000	3.9
	565: KB209	8316	2575	50	21	4	1	7	0.10	0.10	9	0.60	90	0.40	0.10	60	70	0.2
	639: KS167	7813	3015	70	216	1	1600	235	1.90	0.70	150	0.20	1800	18.40	2.00	70	30	0.1
	716: NY059	7355	3756	150	750	1	472	48	1.00	0.10	270	0.20	120	330.00	34.00	120	550	0.1
	717: NY060	7354	3756	70	12	1	59	2	0.10	0.10	9	0.20	30	2.80	2.80	970	90	0.1

Table I-9 Significant Analytical Results of Chip Samples in the Zone C

Name of Mineralization		Sample No.	X	Y	Au (ppb)	Cu (ppm)	Mo (ppm)	Pb (ppm)	Zn (ppm)	Ag (ppm)	Cd (ppm)	As (ppm)	Se (ppm)	Hg (ppb)	Sb (ppm)	Bi (ppm)	F (ppm)	Ba (ppm)	Tl (ppm)
Dikmen	Au	63: HB008	1479	4325	65	21	8	4	27	0.10	0.10	4	0.20	40	2.20	0.10	270	690	1.1
		66: HB016	1435	4204	600	10000	35	360	3800	28.00	59.00	4200	0.40	2300	49.00	0.30	60	530	0.1
		67: HB017	1435	4204	120	3000	4	263	1700	2.90	81.00	500	0.20	430	180.00	4.30	270	380	1.5
		280: HS049	1402	4094	50	18	1	23	228	0.10	0.40	110	0.20	530	10.00	0.30	270	290	0.6
		429: KB020	1460	4342	3100	90	13	94	13	8.00	0.60	19	0.20	5200	55.00	1.30	80	380	0.1
		433: KB026	1430	4165	530	50	1	8	114	0.10	0.10	240	0.20	140	13.80	0.20	320	140	0.3
		440: KB035	1480	4323	120	40	2	255	20	0.90	0.10	25	0.20	3300	77.00	0.40	320	110	0.4
		599: KS036	1284	4124	55	207	28	50	76	0.10	0.50	70	0.20	17000	64.00	2.20	1350	90	0.5
		700: NY033	1395	4296	100	19	59	182	69	1.50	0.50	15	0.20	600	40.00	0.10	240	470	0.3
		835: TS025	1417	4153	560	29	1	7	100	0.20	0.10	60	0.20	90	6.40	0.10	100	200	0.1
		836: TS026	1418	4161	90	46	1	11	90	0.40	0.40	39	0.20	70	3.60	0.10	150	220	0.5
	Au & Mo	193: HM032	1330	4163	350	498	140	1200	498	10.50	6.40	80	2.00	2900	250.00	3.20	380	30	0.6
		617: KS060	1277	4106	400	10000	144	50	1200	13.80	10.70	8900	0.20	43000	1000.00	28.00	90	50	0.4
		699: NY032	1383	4301	1000	730	500	10000	150	100.00	69.00	2500	0.20	61000	1000.00	0.10	160	2900	1.3
	Mo	60: HB005	1308	4151	5	5	1000	5	5	0.10	0.10	4	0.20	140	0.80	0.10	60	50	0.2
		62: HB007	1495	4331	5	12	600	15	9	0.10	0.10	5	0.20	230	1.10	0.30	70	70	0.2
		69: HB020	1449	4197	5	19	130	6	17	0.10	0.20	23	0.20	230	3.80	0.10	60	30	0.2
		70: HB022	1505	4194	15	26	140	3	10	0.10	0.20	10	0.20	130	1.20	0.10	50	30	0.2
		78: HB039	1470	4344	<5	10	120	2	2	0.10	0.10	6	0.20	40	0.40	0.10	40	20	0.1
		188: HM026	1311	4139	<5	105	270	18	135	0.10	0.30	50	0.20	890	16.60	2.10	320	30	0.3
		190: HM029	1319	4155	<5	172	9	3	52	0.10	1.30	60	0.20	2800	11.80	0.10	410	250	0.5
		192: HM031	1327	4161	<5	326	150	1	35	0.10	0.20	90	0.20	510	16.00	0.10	370	70	0.2
		194: HM034	1342	4169	<5	105	110	8	103	0.10	0.60	22	0.20	2000	31.00	0.30	330	140	0.3
		595: KS032	1301	4128	<5	24	130	29	104	0.10	0.10	19	0.20	910	5.00	0.80	80	110	0.1
		702: NY035	1400	4276	<5	62	500	16	52	0.10	0.10	16	0.20	840	65.00	0.50	840	220	1.5
		706: NY039	1383	4227	10	16	240	6	6	0.10	0.10	19	0.20	2800	18.80	0.40	180	420	0.3
		707: NY040	1379	4205	<5	64	108	4	104	0.10	0.20	38	0.20	300	20.00	0.10	300	290	0.2
Others		426: KB017	1564	4300	50	22	1	158	2100	1.40	2.90	290	0.20	7600	32.00	8.50	220	30	0.2
		582: KS007	1496	4449	65	640	1	295	4200	5.60	73.00	9	0.20	390	11.00	40.00	100	50	0.2
		791: SR018	1129	4132	100	29	1	13	42	0.80	0.10	130	0.20	190	1.40	0.10	100	90	0.8

Table 1-10 Summary of Heavy Mineral Study(1)

Name of Area	Sample No.	Gold No.	Size of Gold Grain					Heavy Minerals																		Anomaly	Distance from Outcrops
			A	B	C	D	E	Ba	Gr	Ep	Bi	Px	Mz	Ci	Il	Zr	Mg	Hm	Py	Sp	Ga	Sc	Sh	Ru	Ch		
Karaibrahimler	TA069D*[1]	22			9		13	◎	○			□	△	1	△	□	□	□	◎				□			Au-Ba	1.5km
	TA099D	5	2	2	2	1		○		△		△		○			△	□	□		△				○	Au-Pb-Hg	
	TA113D	57	51	2	1	1	2	◎	•			△						□	□							Au-Ba	0.5km
	TA114D	6	6					◎				○		1			△	△	□							Au-Ba	0.5km
	TA115D	74	70	2	1	1		□	○								□	□	○	△		△	△		□	Au-Ba	0.5km
	TA116T*[2]	27	20	4	1	1	1	◎										△	△							Au-Ba	0.5km
Kestane Dagı	TA026D	16	7	7	2			□								□	△	◎	□			△				Au	2km
	TA075D	16	6				10	△		○					◎	•	○	□	○						○	Au	1.5km
	TA076D	20	16		2	1	1	□					•		□			□	○		□				□	Au-Pb	1km
	TA111D	8	3	2	2		1	□	◎	○			□	□			○	□	○			○	△			Au-Pb-Hg	2.5km
	TA112D	13	1	2	2	4	4	□									○	◎	□		□	△			○	Au-Pb	2km
Kocataş Tepe	TA083D	65	48	5	5	3	4	△	○	◎							□	△	○		•				○	Au	2km
Arlık Dere	TA037D	25	22	2		1		○			○	◎				•	□	□		△		△			□	Au	1, 4km
South of	TA039D	9	1	8				◎			○	◎	□				◎	◎	△							Au-Ba	2km
Karacaören Tepe	TA095D	10	8	2				△								△	•	□	□							Au	
Kirazlıçamtepe	TA009D	9	9					○				△					□	○	○			△				Au	
Armutcuk	TA013D	13	12		1			△			○	◎					□	△	△							Au	1, 3km
Karacalar	TA014D	13	13						△	△							○	□	△						□	Au	1km
Çesmetepe	TA049D	6	2	1	1	1	1	△								□	□	◎								Au	1km
Caltıkara	TA066D	16	12	2	2			○	□		○		△					◎								Au-Ba	
Madendagı ∫ Kartaldagı	TA006D	14		4	5	5			□								□	□	□							Au-W	
	TA007D	18	11	7				△										△	○					•		Au	
	TA010D	16	11		4	1		□	○	○		◎				△	◎	◎								Au	
	TA011D	109	102	3	1	1		△					△			•	◎	◎	△							Au	2km~
	TA012D	59	46	10	1			○	□			□	△			□	◎	◎	□							Au	2, 5km
	TA016D	4	2			1		△								△	□	◎	○	△						Au	
Dededag	TA091D	10	9		1			◎				◎			△		◎		△						○	Au-Ba	2km

Qualitative amount Abundant ◎, Common ○, Few □, Rare △, Trace • *[1]:Stream sediment *[2]:Soil sample

Size of gold grain : A:50μ>, B:50-100μ, C:100-150μ, D:200-300μ, E:300μ<

Hevey mineral:Ba:barite, Gr:garnet, Ep:epidote, Bi:biotite, Px:pyroxine, Mz:monazite, Ci:cinnabar
Il:ilmenite, Zr:zircone, Mg:magnetite, Hm:hematite, Py:pyrite, Sp:sphalerite
Ga:galena, Sc:specularite, Sh:sphane, Ru:rutile, Ch:chlorite

Table 1-10 Summary of Heavy Mineral Study(2)

Name of Area	Sample No.	Coordinates	Locality	km² ※1	Conditions of Sample※2 SD	KD	S	IC	AC	TS	Geology	Weight※3 -2mm	-1mm	Gravel Li	Si	Ar	Py	He	Remarks
Karaibrahimler	TA069D	8070 2719	S.Karaibrahimler	3.5	×			×			Şapçı V.	7	100		□	□	△		2C izabe
	TA099D	7800 2696	Sarp D.	3.0		×		×			Şapçı V.	5	50			□			
	TA113D	8095 2765	NE.Karaibrahimler	0.5			×			×	Şapçı Vol.	3	60		△	○	△		
	TA114D	8060 2770	N.Karaibrahimler	0.5			×			×	Şapçı Vol.	3	35			○			
	TA115D	8030 2765	Köse D.	1.0		×				×	Şapçı Vol.	3	90		△	○	△		
	TA116T	8070 2760	Karaibrahimler	-							Şapçı Vol.	3	30		○	○	△		
Kestane Dagı	TA026D	7682 3229	N.Karakuz T.	2.0			×		×		Şapçı V.	8	45	□	□	□	□		
	TA075D	7408 2990	Hacıkar D.	2.0							Şapçı V.	6	105	□	△				
	TA076D	7412 3000	W.Kestane Dagı	1.5		×		×			Şapçı V.	6	50	□	□		□		2A izabe
	TA111D	7825 3091	Karakoz D.	3.0	×				×		Şapçı V.	6	130	□	○	△			Spinel△, Pb□
	TA112D	7802 3100	Topallar D.	2.0		×		×			Şapçı V.	6	105	□	○				
Kocataş Tepe	TA083D	8297 2946	İncirlık D.	1.0		×		×			Şapçı V.	5	50		□				Scheelite・
Arlık Dere	TA037D	8447 3265	Arlık D.	4.0		×		×			Şapçı V.	6	65						1A izabe
South of Karacaören Tepe	TA039D	7810 2410	S.Gökyakan D.	2.0			×			×	Şapçı V.	5	165		○		△		1A izabe
	TA095D	7524 2596	Egri D.	2.5	×			×			Şapçı V.	6	55		□	□	□		
Kirazlıçamtepe	TA009D	7302 3195	Kirazlıçamtepe D.	5.0		×		×			Şapçı V.	5	75			□			
Armutcuk	TA013D	7054 3413	Armutcuk Çay	13		×		×			Out of area	8	95						
Karacalar	TA014D	7390 3621	Kavgımaç D.	30		×			×		Çamyayla V.	8	90						
Çesmetepe	TA049D	7170 1990	E.Çesmetepe	1.5		×		×			Out of area	6	60	□	□			□	1E 500μ
Caltıkara	TA086D	8350 2538	S.Taşagıl T.	0.5			×			×	Şapçı V.	4.5	40		□	△			2B izabe
Madendagı ∫ Kartaidagı	TA006D	6810 3197	N.Sarp D.	2.0		×			×		Out of area	5	65	○		○	○		Scheelite○
	TA007D	6858 3160	N.İsret T.	2.0		×			×		Out of area	5	35			□	□	□	
	TA010D	6280 3488	Koca D.	3.5		×			×		Out of area	10	265						1A izabe
	TA011D	6252 3422	Kocaçay D.	7.0		×		×			Out of area	12	115						2B izabe
	TA012D	6590 3321	Ekşiçay	18	×				×		Out of area	10	445		□		□		2B izabe
	TA016D	6670 3038	S.Pırnallı T.	9.0		×			×		Out of area	8	130		◎	◎	◎	○	1A izabe
Dededag	TA091D	8317 5533	Asi Dere Yanı	3.0		×		×			Out of area	7	120	□		□			Diopsite◎

※1 Area of stream

※2 SD ; stream sediment (sulu dere), KD ; dray stream sediment (kuru dere), S ; flood sediment (sellenmeli)
IC ; fine-grained sediment (iyi kansantre), AC ; coarse-grained sediment (orta kansantre), TS ; blend sediment of stream and soil (topraklı kansantre)

※3 weight of sample

Qualitative amount ; Abundant ○, Common □, Few △

İzabe: melted gold

Miocene. The structure with NE-SW trend clealy remained later into the time of silicification, argillization and associated gold mineralization (inferred to be latest Tertiary to Quaternary). High gold 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 NE-SW direction.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5-1 Conclusions

The survey was conducted with the purpose of clarifying the metal deposits and of assessing the metallic resources potential of the Çanakkale Area. Prior to the field survey, data related to geoscientific work conducted previously were studied and Landsat image analysis of an area of 3,400km^2 was carried out. As a result of these studies, three promising Zones A, B and C were delineated for field work of the first phase. Geological survey and geochemical prospecting were conducted in these zones.

Geological survey was carried out over a total area of 500km^2 consisting of Zones A 100km^2, B 300km^2 and C 100km^2. The mineralized zones and alteration zones were located, and the dimensions and the nature of mineralization were clarified. Regarding geochemical prospecting, data from both previous MTA work and the present survey were analyzed. The results revealed the scale, grade of the mineralization and the promising anomalies. Four localities in Zone B and one in Zone C were extracted as promising. The geologic environment and the extent of the geochemical anomalies indicate that these localities have high resources potential and warrant further detailed survey.

These localities are listed below.

(1) Arlık Dere	epithermal gold mineralization
(2) Karaibrahimler	epithermal gold mineralization
(3) Kestane Dağı	epithermal gold mineralization
(4) Piren Tepe	epithermal gold mineralization
(5) Dikmen	porphyry molybdenum – copper mineralization and epithermal gold mineralization

The above four localities (1)~(4) are located in the Şapçı Volcanics, and gold anomalies have been delineated in the alteration zones during the present survey. They are:

(1) Arlık Dere: Significant amount of gold grains was found from the heavy mineral samples collected from Arlık Dere. Also fairly large silicified and argillized zones were found in the upstream parts of this Arlık Dere and many rock samples from the silicified zone also contained gold.

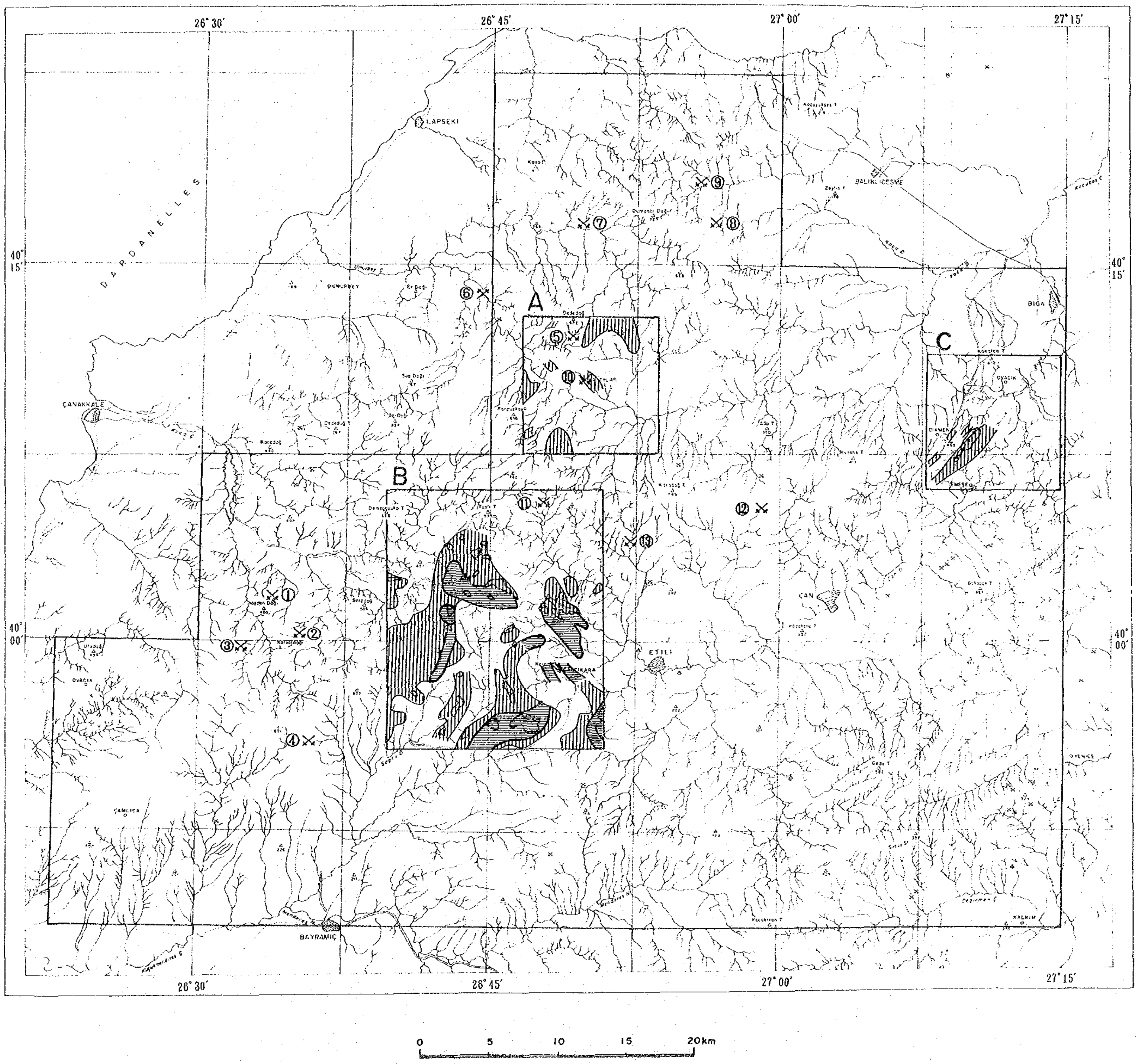
(2) Karaibrahimler: Significant amount of gold was detected in all samples collected the from down stream section of Karaibrahimler Village, a locality where the three streams join in the upstream part of the village and from the silicified, argillized alteration zones nearby. The Şapçı Volcanics have suffered hydrothermal alteration in the vicinity. The gold grains are in some cases as large as over 300μm, but most of them are smaller than 50μm. The shape is irregular, amoebic and they are presumed to have been transported from 1～2km upstream. Gold grains were also found in Şarp Stream to the west of the silicified body. At two localities here, the ore is accompanied by barite.

(3) Kestane Dagı: Gold grains were found from five localities, two from the western stream and three from west of Kestane Dagı. Large grains exceeding 300μm were found. These gold grains are inferred, from the shape, to have been transported from 2～3km upstream. Here also the Şapçı Volcanics have suffered silicification and argillization. Galena is the associated heavy mineral.

(4) Piren Tepe: Gold anomalies were detected in the silicified zone which is located to the south of the large alteration zone. The zone extends in E-W direction in the vicinity of the Piren Tepe.

(5) In Zone C, a porphyry molybdenum-copper deposit associated with the intrusion of the Dikmen Granite was discoverd. The mineralization extends from the eastern side of the Dikmen Granite which extends in NW-SE direction to the Emeşe Formation in the Sıgırirek 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 .

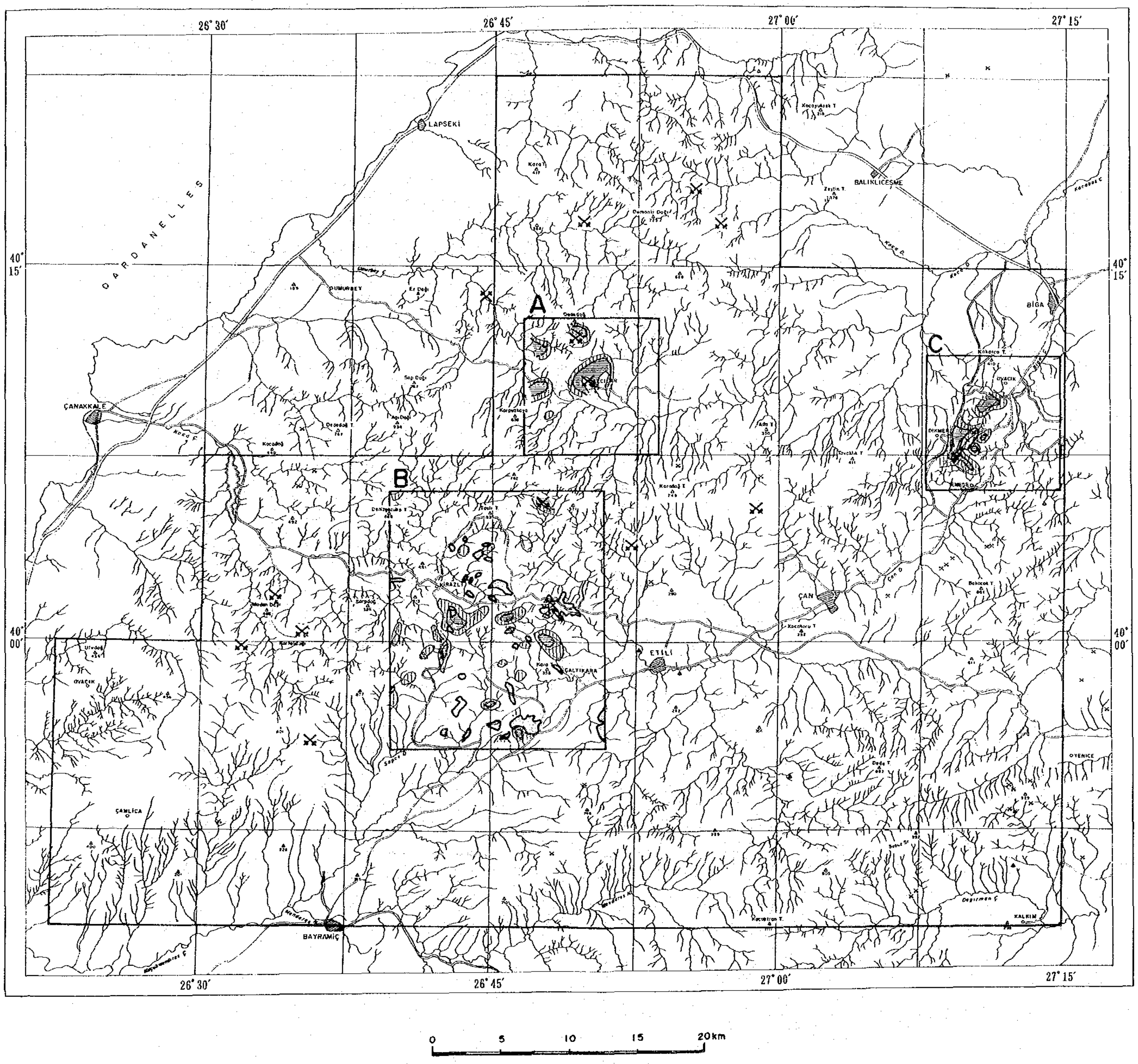
The results of the present work summarized above in (1)～(4), indicate the possibility of large scale low grade gold deposits in the alteration zone near the basement rocks. The porphyry molybdenum deposit mentioned in (5) also is



Location of Ore Deposits

No.	Name	Kind of Ore Deposits	Host Rocks
①	Madendagı	Au	Breccia zones of schist(Pre-Triassic)/
②	Kartaldagı		Andesite lava & pyroclastics(Miocene)
③	Karapınar	Cu	Schistose marbles (Pre-Triassic)
④	kuşçayırı	Fe-As	Ayrışmış andesitic tuff(Miocene)
⑤	Kundakçı-larobası	Pb-Zn-Ab	Andesitic lava & pyroclastics(Eocene)
⑥	Koru Köyü	Pb-Ba-Ag	Andesitic lava pyroclastics(Eocene)
⑦	Çamyurt	Cu	Schist(Pre-Tliassic)/ Qz dicrite
⑧	Çataltepe	Pb-Zn-Cu	Andesitic lava & pyroclastics(Eocene)
⑨	Nusretiye	Pb-Zn-Cu	Andesitic lava pyroclistics(Eocene)
⑩	Balcılar	Ag-Pb-Zn	Andesite (Miocene)
⑪	Kocalar	Pb-Zn	Andesitic lava pyroclastics(Eocene)
⑫	Kocayayla	Zn-Pb-Cu	Volcaric rock(Miocene)/ phyllic schist(Triassic)
⑬	Dogancılar	Cu-Pb-Zn	Block-faulted volcanic rocks

Fig. 1-5 Distribution Map of Mineral Occurrences and Alteration



LEGEND

- Silicified Zone
- Dikmen Granite
- Component Score is more than 1
- Component Score is more than 2
- Operating Mine
- Closed Mine
- Hot water spring

Fig. 1-6 Significant Anomaly Map

expected to be a large scale low grade deposit as this type of mineralization is extensive in the lower parts. This contains gold and antimony locally, and it may turn out to be a very important target if significant gold is found in the overlapping portion.

5-2 Recommendations for the Second Phase

It is recommended that the following work be conducted in the promising areas delineated above (Fig.4-1).

In the four localities of Zone B, epithermal gold mineralization is anticipated in 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 would clarify the distribution and extent of the alteration zone and the investigation of the heavy minerals of the vicinity will locate the position of the gold mineralization. On the basis of the findings of these work, inclined drilling should be carried out in order to clarify the state of subsurface mineralization.

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

By geophysical methods, the subsurface extent of mineralization from the outcrop downward would be shown by delineating the low resistivity zone and FE anomalies by IP, then detailed SIP work is expected to provide the necessary information.

PART II LANDSAT IMAGE ANALYSIS

PART II LANDSAT IMAGE ANALYSIS

CHAPTER 1 LANDSAT IMAGES-LOCATION AND DATA

1-1 Locality

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.

1-2 Data

The image data used for this analysis are one CCT (Computer Compatible Tape) scene which was acquired by Thematic Mapper (TM) on Landsat 5. The scene is very clear without cloud or snow. The data were obtained through EOSAT (Earth Observation Satillite Company. c/o EROS Data Center, Sioux Falls, South Dakota 57198, USA). The data are as follows.

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 chlorophyl.	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. Defination 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. Instantaneouos range of view four times wider than that of other bands.

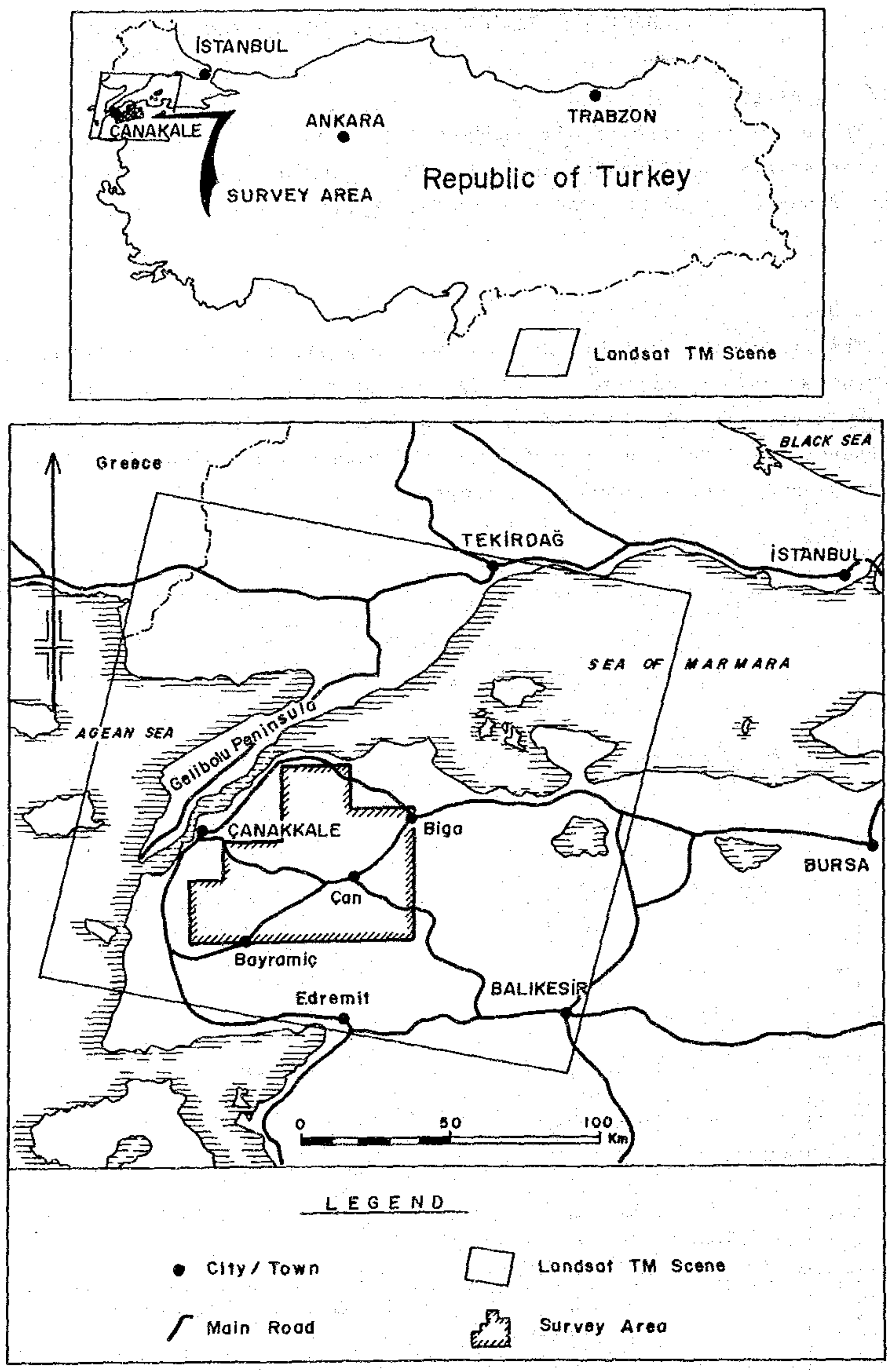


Fig. 2-1 Location Map of Landsat Image

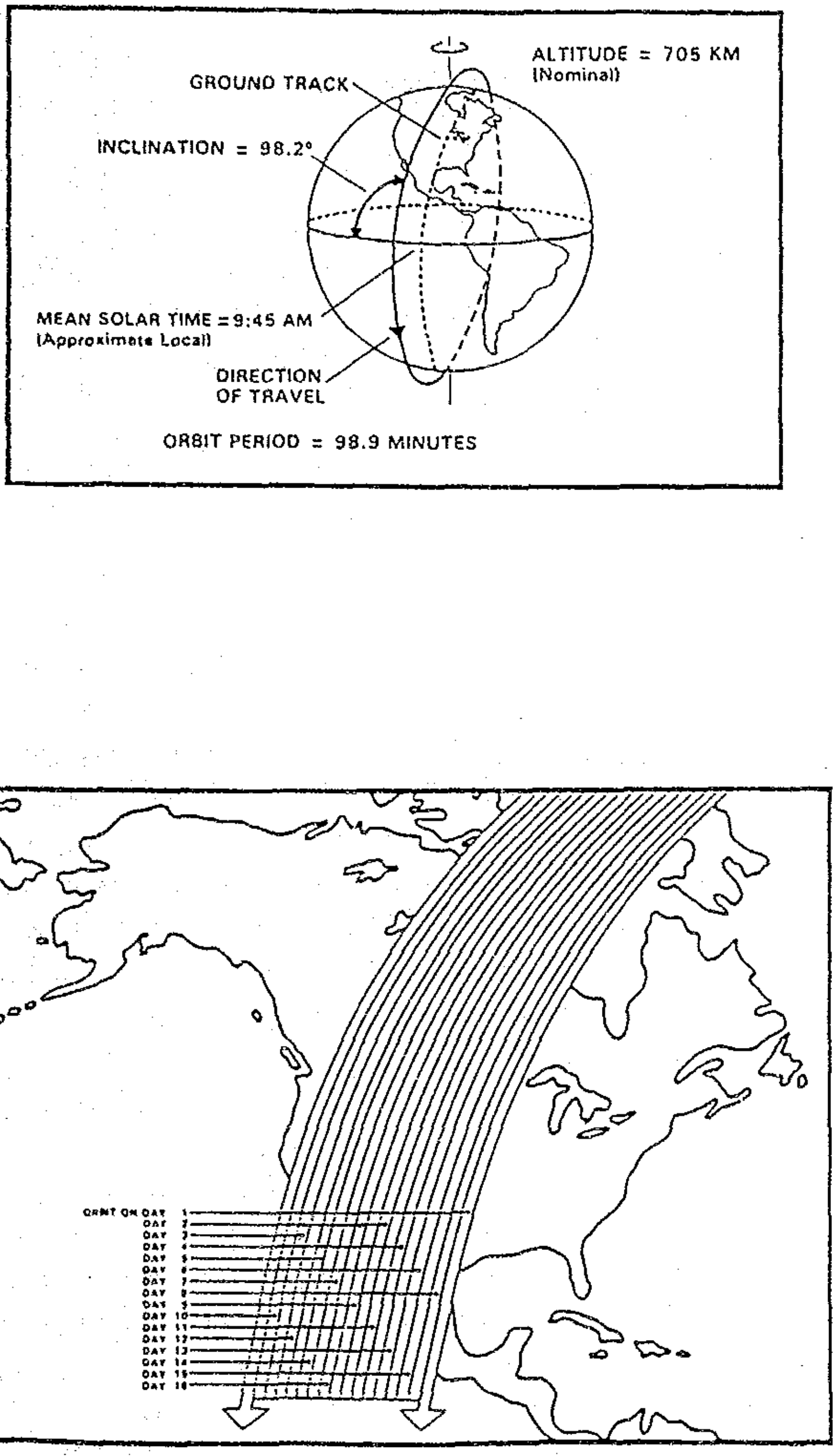


Fig. 2-2 Orbit and Ground Coverage Pattern of Landsat, No.5

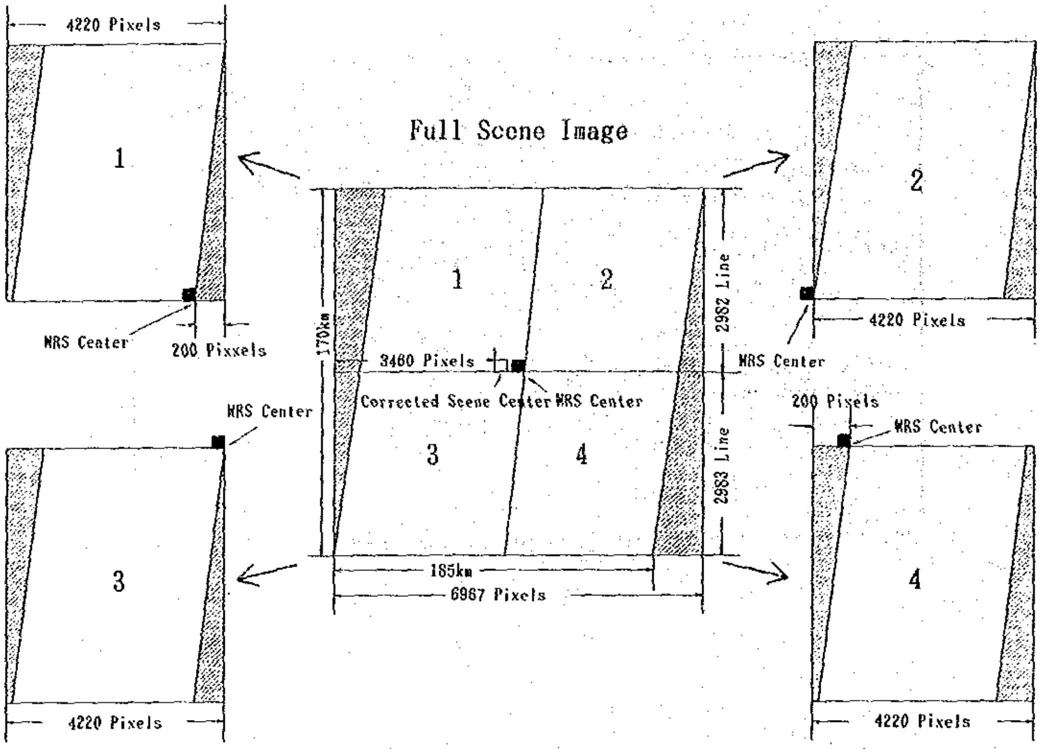


Fig. 2-3 Division of Corrected Image into Subscenes.

Landsat 5 was launched on March 18, 1984 and is on a sun synchrous orbit at a height of approximatly 700km. Its cycle is 16 days (Fig.2-2) and carries TM as well as MSS (Multispectral Scanner) which has been used since Landsat 1.

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 were 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.

One TM scene is divided into four subscenes with the centre of the division at the WRS (World Reference System) coordinate. The WRS is the system for coordinating the Landsat data (Fig.2-3). The data used for the analysis are recorded on each subscene by radiometrically and geometrically corrected BSQ (band sequential) format. The projection of the images is SOM (space oblique Mercator).

CHAPTER 2 METHODS FOR PROCESSING, PTRPARATION AND ANALYSIS OF LANDSAT IMAGES

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 would provide useful information for geological interpretation or for areas which is difficult to interpret by false colour images alone. In the present survey, ratio processing was used as the non-conventional procedure.

A flow chart of the data processing method is laid out in Figure 2-4. The details are as follows.

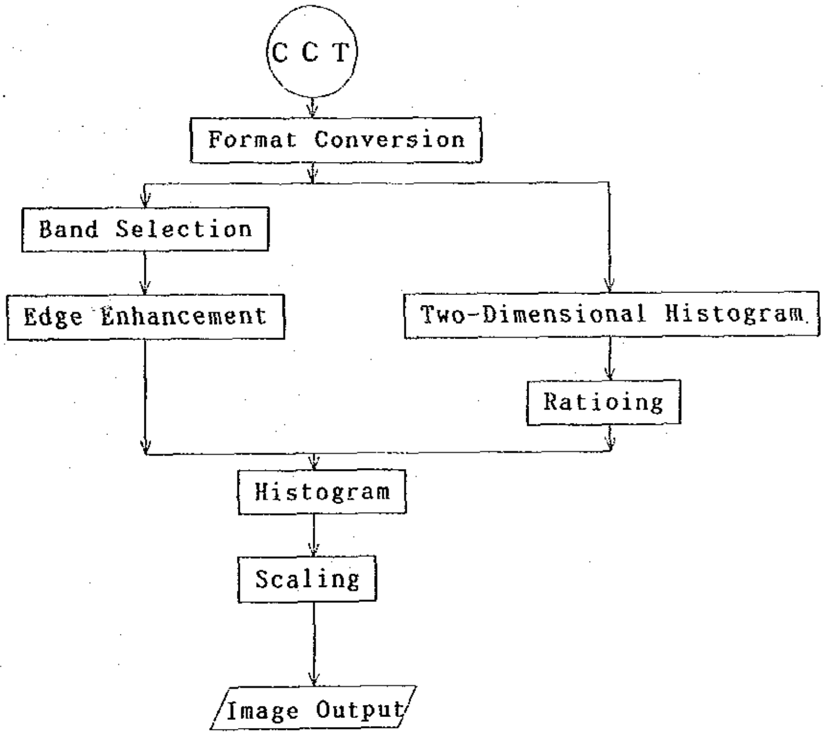


Fig.2-4 Flow Chart of Image Processing

2-1-1 Format Conversion

The remote sensing data are recorded in several formats compatible with the method of acquisition and the computor system. During the present work, the BSQ format data (Fig.2-5) acquired from EOSAT were converted to JPX format (Fig.2-6) which is the format of JGII (JAPEX Geoscience Institute Inc., 2-17-22 Akasaka, Minato-ku, Tokyo 107, Japan) format for processing remote sensing data.

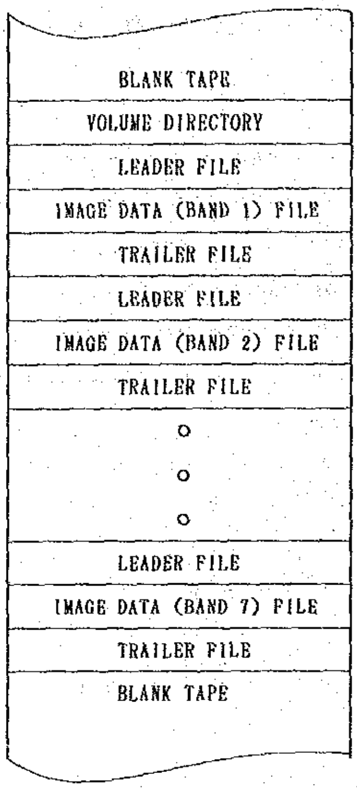


Fig. 2-5 BSQ Format

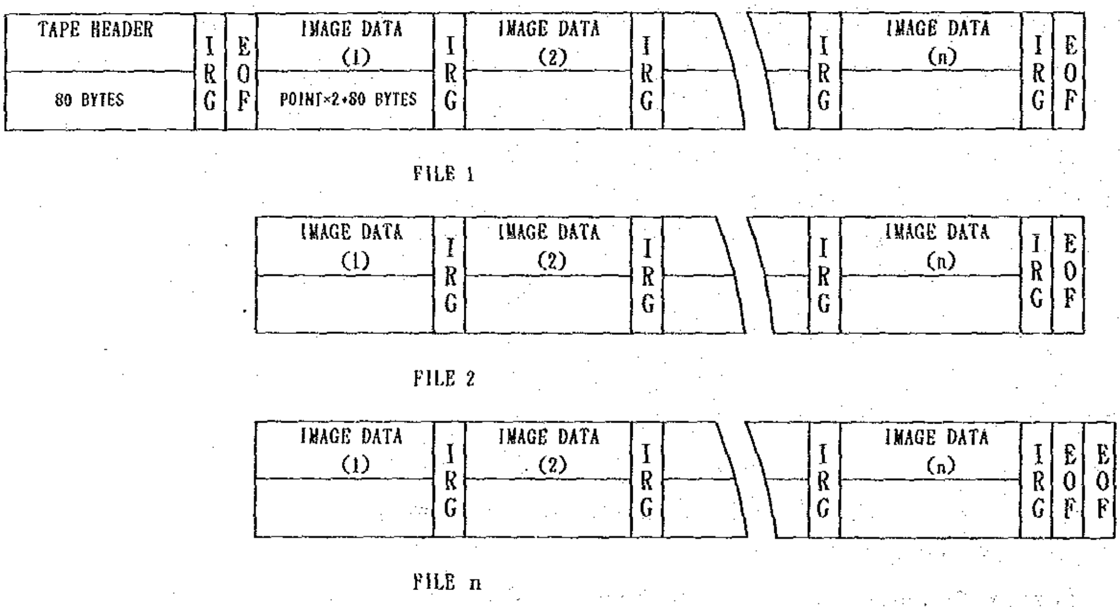
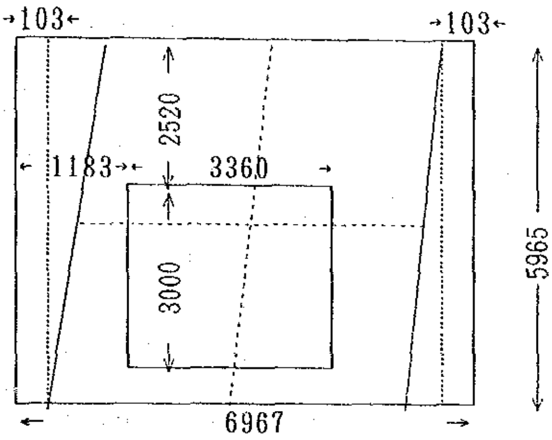


Fig. 2-6 JPX Format

2-1-2 Connection of Subscenes to a Full Scene

The present survey area comprises parts of four subscenes and connective processing of the subscenes to a full scene was applied. This connective processing was done on the basis of the number of supplementary pixels on both sides of the images which are recorded in Field Nos.10 and 11 of the image data records of the subscenes.



The size after the connection is 5965 lines x 6967 pixels, but 103 pixels on the left and right margins were deleted in the output full scene.

2-1-3 Conventional processing

(1) Selection of the Bands

As mentioned in section 1-2, 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 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. And the combination of the TM bands 4, 5, 7 was concluded to be 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 pre-processed images and more clearer and sharper images are obtained.

	1	
1	-4	1
	1	

Fig.2-7 Laplacian Operator

As for the spacial operator, a differentiated Laplacian operator which is a typical quadric differentials was used. This is widely used because it is

	0				1				-1	
0	1	0	−	1	-4	1	=	-1	5	-1
	0				1				-1	

Unit Operator — Laplacian Operator — Edge Enhancement Operator

Fig.2-8 Edge Enhancement Operator

isotropic and small. However, the information of the pre-processed images will be distorted when this operator is used in the original form. Thus an edge enhancement operator was prepared by subtracting the Laplacian operator from the unit operator of the edge enhanced image (Fig.2-8). This edge enhancement operator and the pre-processed image were convoluted. This enhanced the high frequency components and thus topographic information such as the detailed structure of the plains and lineaments has become clearer and sharper.

The histograms of the bands after the edge enhancement of the full scene is shown in Figure 2-9. The highest peaks are observed near radiance 6 in all the bands. These are the spectra containing information from the marine areas. And for the present purposes, it is desireable to eliminate these spectra.

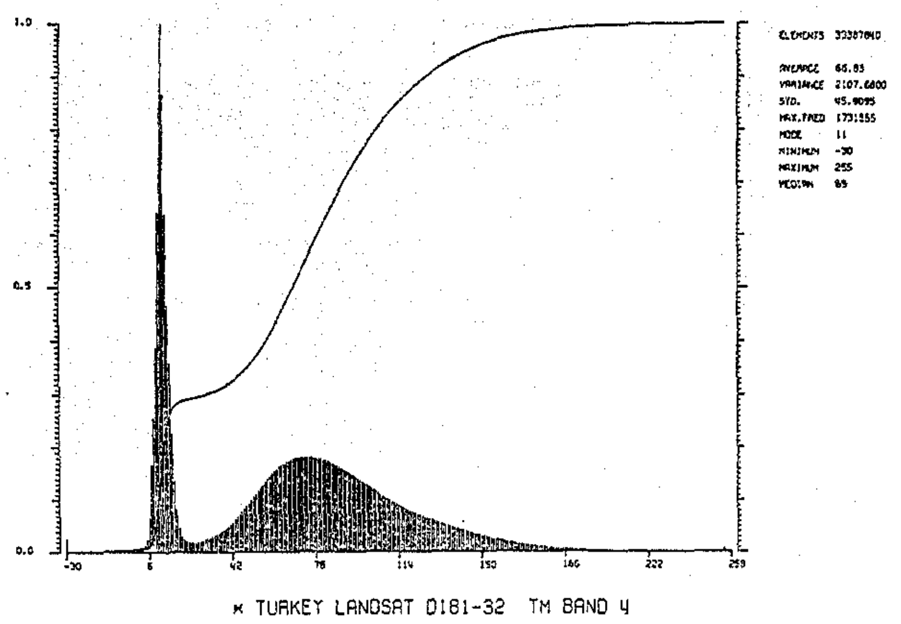
(3) Contrast Enhancement Processing

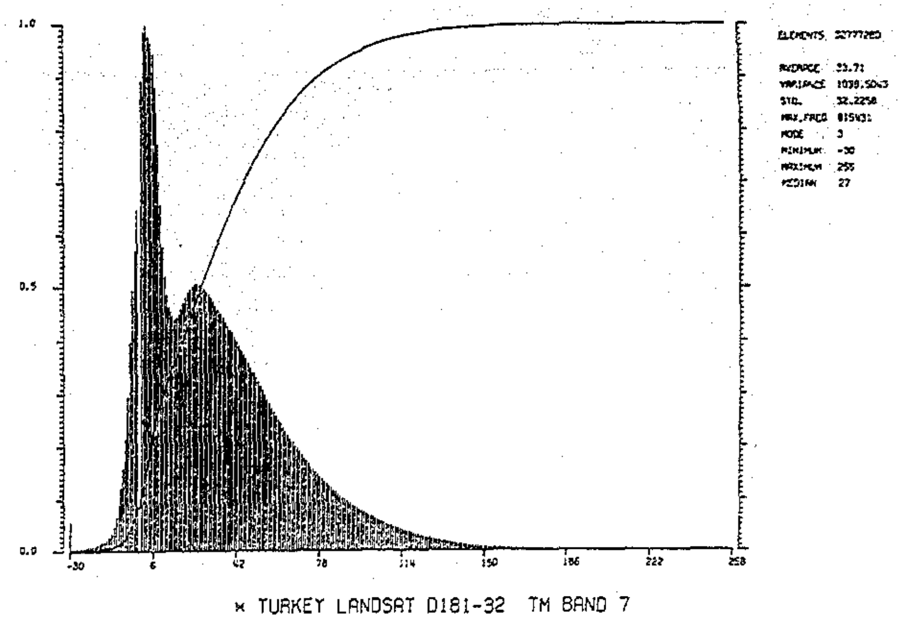
The contrast of the output image is very weak and the difference of the radiance cannot be distinguished when the original values are used. It is necessary to convert the distribution of radiance to that which corresponds to the dynamic range of the output device. This conversion process is called contrast stretching and images with good contrast can be obtained. There are several ways 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.

Histograms of each band after edge enhancement based only on information of the land areas are shown in Figure 2-10.

2-1-4 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





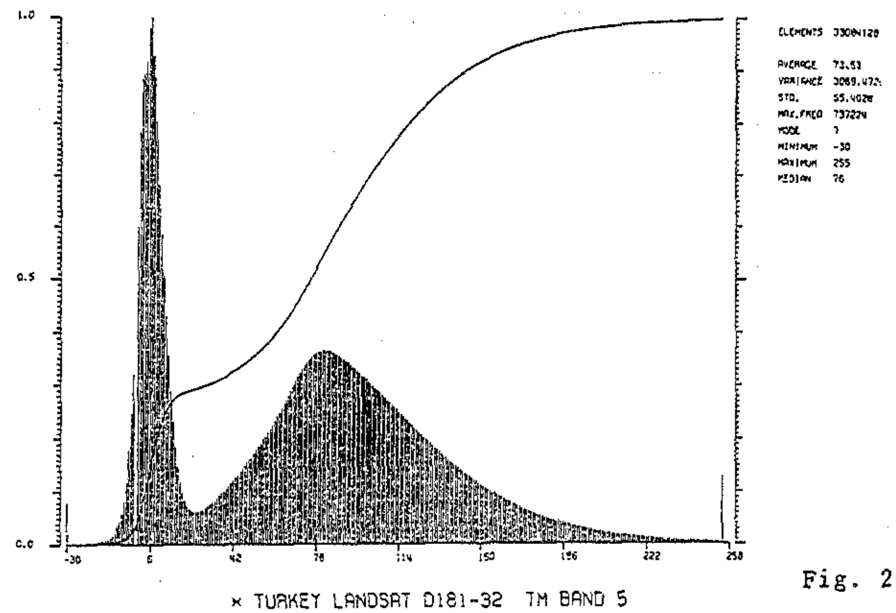


Fig. 2-9 Histograms of Bands after Edge Enhancement of Full Scene

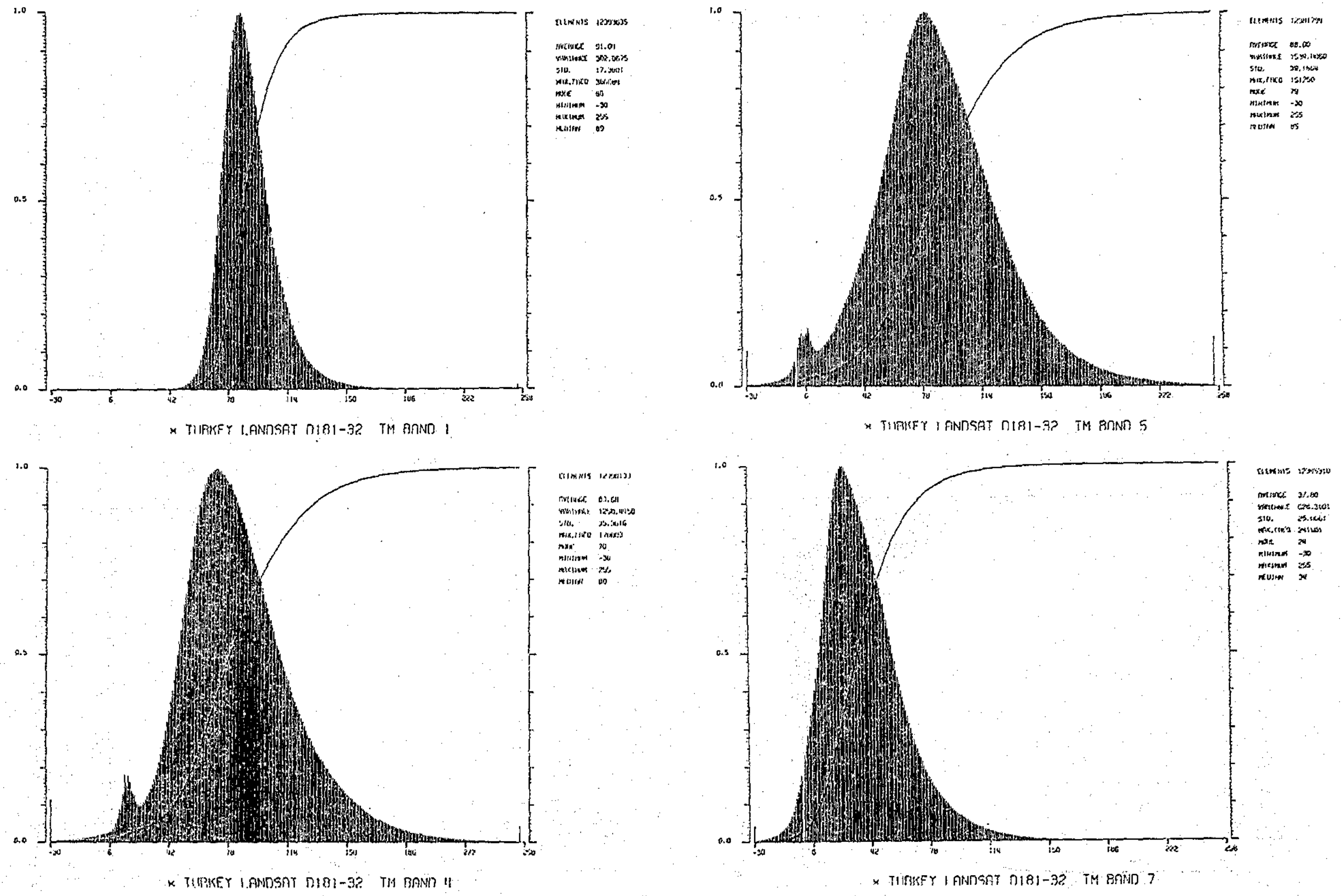


Fig. 2-10 Histograms of Bands after Edge Enhancement of Land Area

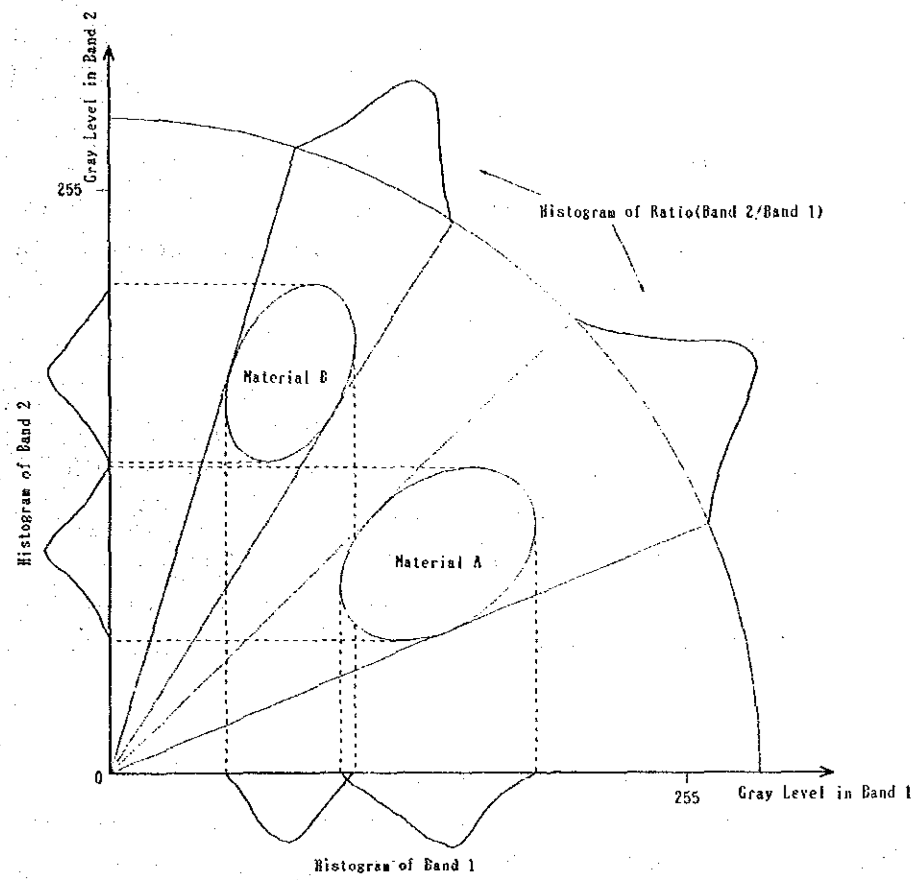


Fig.2-11 Generalized Map of the Ratio

(Fig.2-11). The ratio of the radiance values of two arbitrary bands of the TM multi-band data is calculated.

The ratio Z is generally defined as follows.

$$Z=f\left(\frac{x-a+1}{y-b+1}\right)$$

Where x, y are the radiance of the two bands; a, b, the minimum radiance values of x and y; and f an appropiate function. In this working model, the values a and b represent factors related to atmospheric scattering and the information from the surface is obtained by subtracting the a and b from the apparent radiances.

Since these values are affected by the atomosphere, the shorter wavelength radiation takes larger values, i.e., the shorter wavelength radiation are more scattered.

The following three functions are commonly used for f.

$f(\xi)=A\xi+B$ (direct ratio)

$f(\xi)=A\log\xi+B$ (log ratio)

$f(\xi)=A \arctan\xi+B$ (arctangent ratio)

$$\xi=\frac{x-a+1}{y-b+1}$$

Of the above ratios, when Z is not 1, log and arctangent ratio functions have better symmetry of distribution compared to direct ratio function and thus are more often used. In this present work, arctangent ratio function was used. The equation is as follows.

$$Y=A \times \arctan((X_1-B_1)/(X_2-B_2))-C$$

X_1, X_2 are the radiance of the bands and A, B_1, B_2, C are parameters.

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).

Two dimentional histograms of all bands are shown in Figure 2-12. The wide distribution of the histograms for TM bands 5 and 4 is believed to indicate vegetation.

These data are the basis for the histograms drawn after ratio processing (Fig.2-13). This was done by adding the stretching values after the ratio processing. The parameters and the tangent angles for the ratio processing are as follows.

Band ratio	Parameters				Tangent angle(°)	
	A	B_1	B_2	C	Minimum	Maximum
3/1	471	0	510	271	33	64
5/4	265	0	0	973	21	76
5/7	503	0	0	448	51	80

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

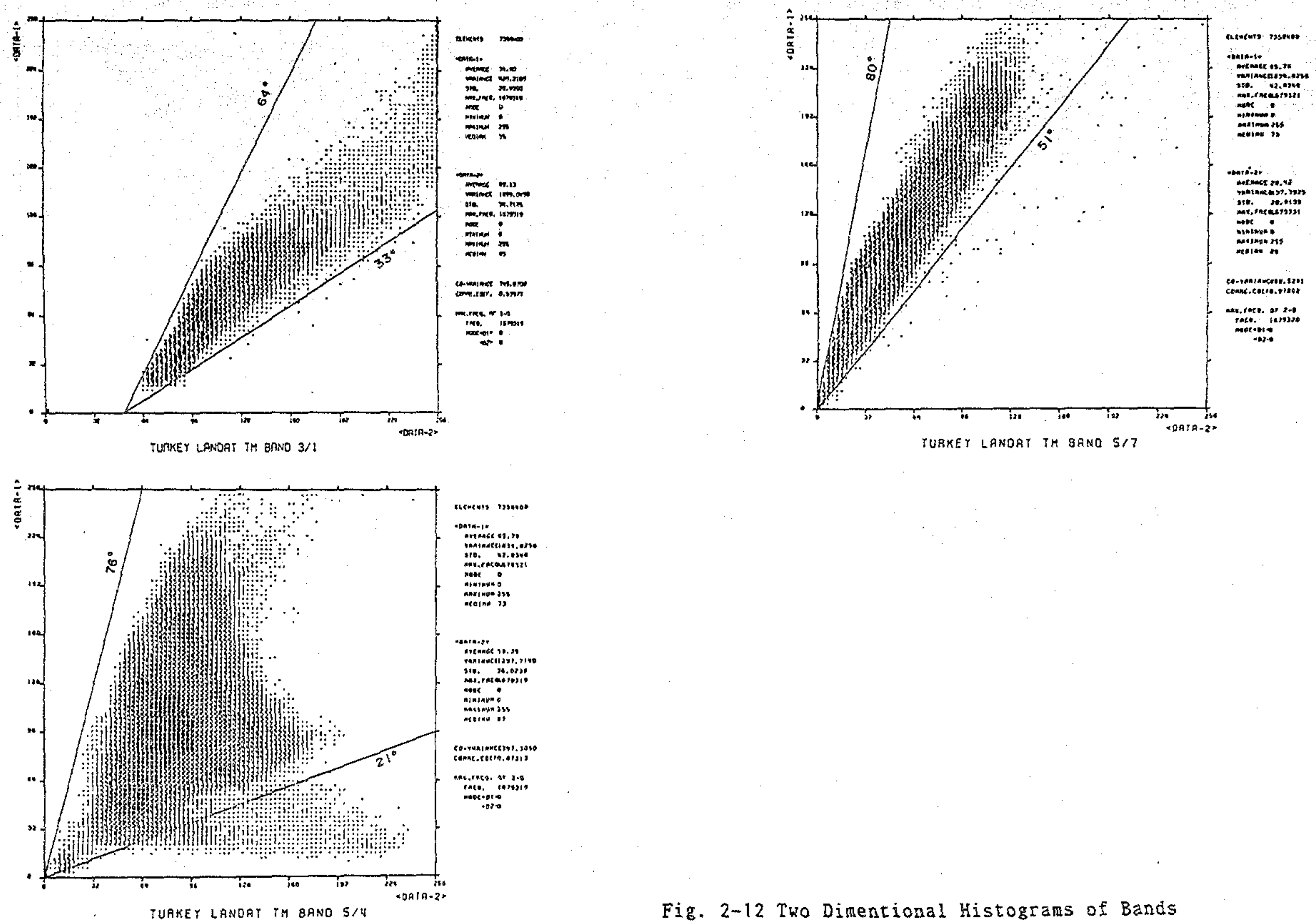
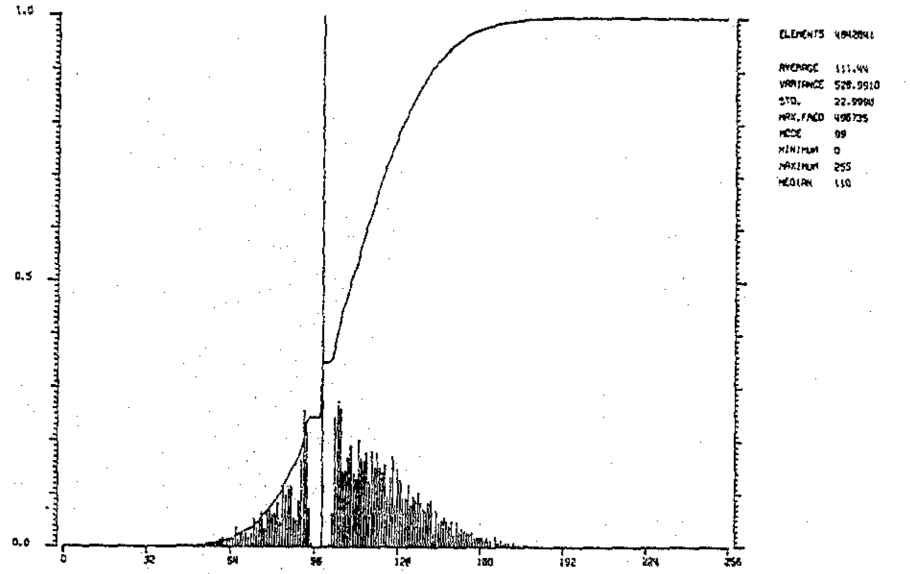
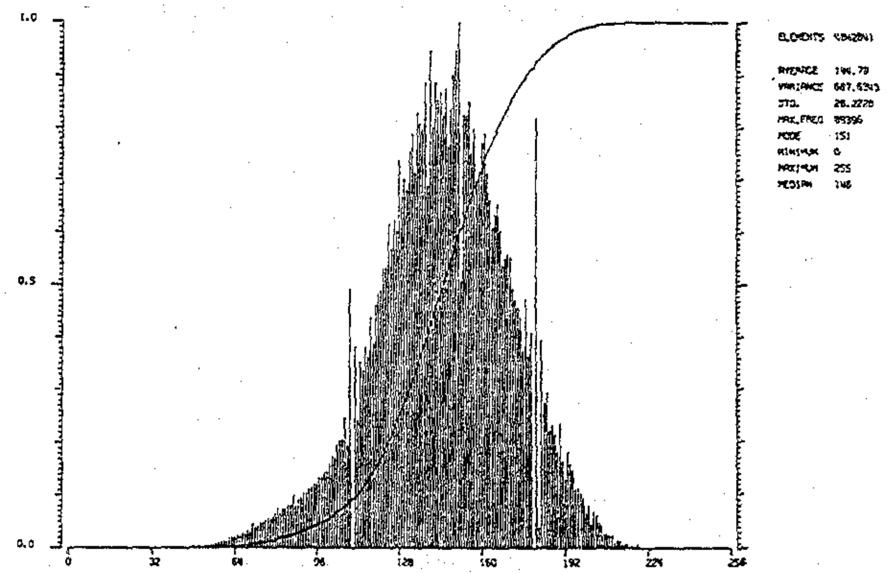


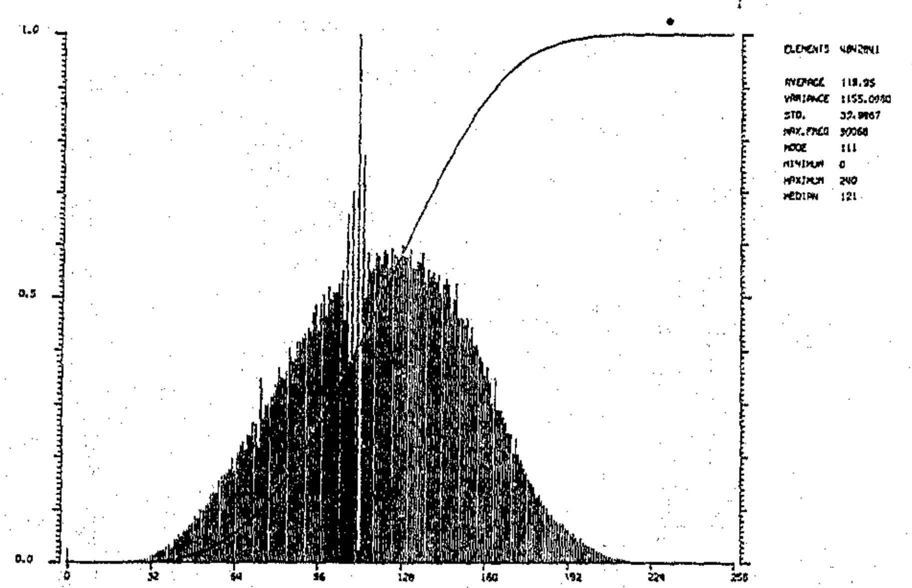
Fig. 2-12 Two Dimentional Histograms of Bands



TURKEY LANDSAT D181-32 TM RATIO BAND 3/1



TURKEY LANDSAT D181-32 TM RATIO BAND 5/7



TURKEY LANDSAT D181-32 TM RATIO BAND 5/4

Fig. 2-13 Histograms of Bands after Ratioing

2-3 Method of Analysis

Methodology regarding the analysis of resources 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,lineaments, annular (ring) structures, foldings and other structural features were read and interpreted.

The lineaments are topographic features which suggest fractured zones and the main basis for the interpretation are 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 are considerable areal variation in their development, but most of the lineaments can be understood by empirical interpretation of these topographic features.

CHAPTER 3 RESULTS OF ANALYSIS

3-1 Geological Interpretation

Four geological units, A~D, were delineated from these images (Fig.2-14). 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, the southern zone 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 parts.

The tone of colour is bluish purple to chrome yellow in F/C, pale red and blue in R/C_1, and royal purple and yellow in R/C_2 images. The texture is generally coarse-grained and banded texture is observed in some of the southwestern part of the area.

Table 2-2 Photogeological Interpretation Chart for Landsat TM Images

Units	Tone			Texture	Drainage		Rock Resistance	Bedding	Geological Enviornment
	F/C※[1]	R/C₁※[2]	R/C₂※[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 Plistocene 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)

※[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 dense dendritic pattern, but in the southern part of the survey area, dense parallel pattern at right angles to the lineaments is observed. In the southwestern part of this area, sparse dendritic pattern is also observed. The resistance of the rocks are 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 Bozagaç dag Formation (Gn) of the Triassic Kazdag Group, meta-spilites (SPO) and detrial rocks (DPO) of lower Triassic and the Eocene granodiorites (Gd).

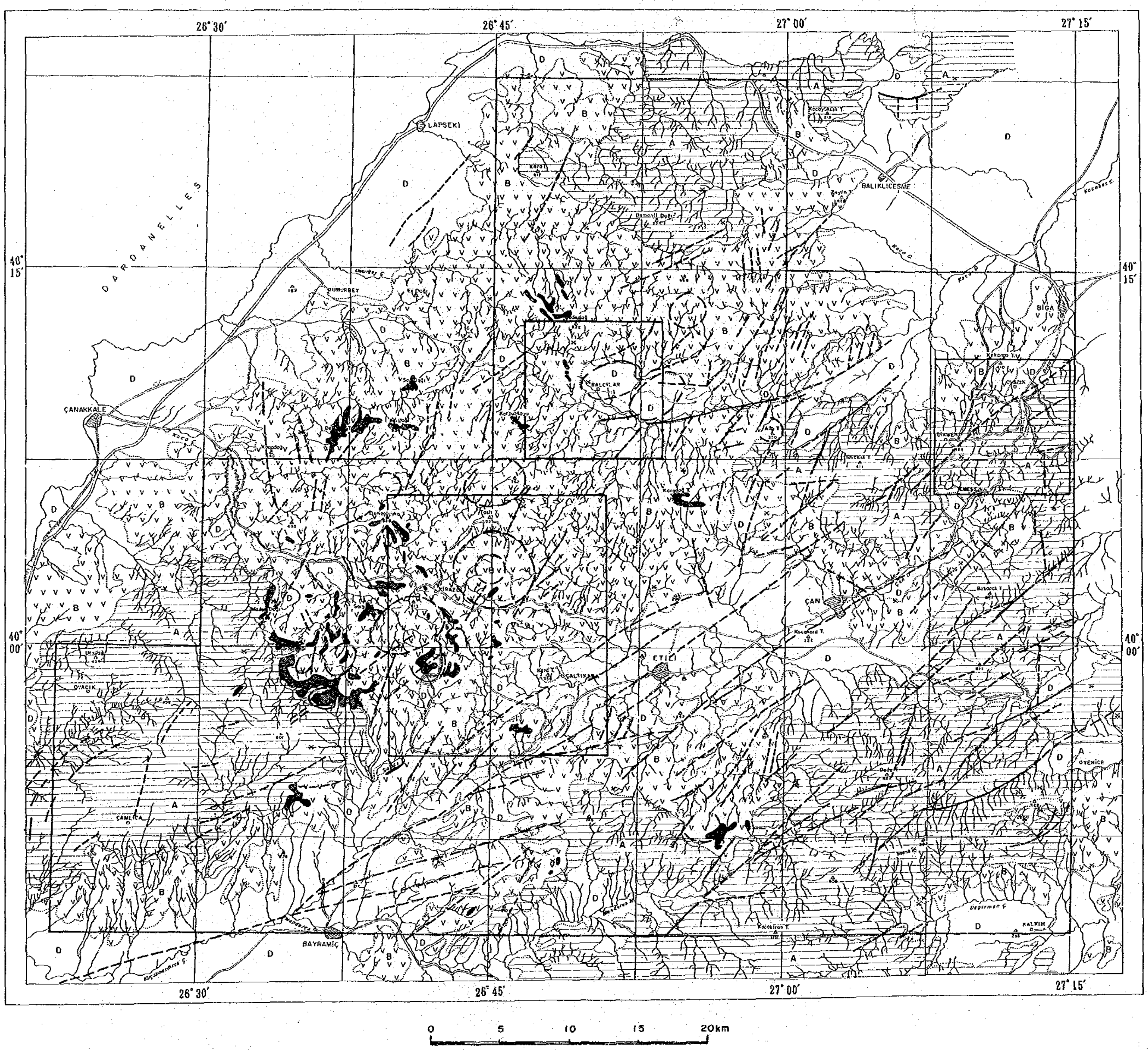
(2) Unit B

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

The tone of colour of the F/C image is bluish purple and chrome yellow, the same as Unit A, for R/C_1 image orange and light blue, for R/C_2 image royal purple and emerald green. The texture is generally coarse-grained.

The drainage system has 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,



LEGEND

Units	Rock Resistance	Geological Enviornments
D	very low	mainly Quaternary sediments(Al, Ta, Qd), & Pliocene sediments(n)
C	very high	mainly Miocene siliceous tuff(Tsi), and Eocene andesite·tuff(A_1+T_1)
V V B V	moderate to high	mainly Eocene andesite·tuff(A_1+T_1), and Plistocene volcanic ash(Pt)
A	high to very high	mainly Pre-Tertiary rocks (Ep, Gn, SPO, DPO), and Eocene granodiorite(Gd)

- Lineament (Certain)
- Lineament (Uncertain)
- Annular structure
- Synclinal axis
- Operating Mine
- Closed Mine
- Hot water spring

Fig. 2-14 Photogeological Interpretation Map for Landsat TM Images