REPORT
ON
THE MINERAL EXPLORATION
IN
THE ESPiYE AREA,
THE REPUBLIC OF TURKEY

SUMMARY

MARCH 1998

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

The Government of Japan, in response to the request of the Government of Republic of Turkey, decided to conduct a mineral exploration project in Espiye area, Republic of Turkey.

The Japanese Government entrusted the survey to the Japan International Cooperation Agency (JICA), and JICA in turn sought the cooperation of the Metal Mining Agency of Japan (MMAJ) to accomplish the survey, considering the importance of technical nature of the work.

The survey was performed in a period of three years commencing from 1995. The field survey in Turkey was carried out successfully with cooperation of the Turkish Government authorities, and General Directorate of Mineral Research and Exploration.

This report is summary of the results of survey carried out through three years.

We wish to express our deep appreciation to the officials of the Government of Republic of Turkey and to the Embassy of Japan in Turkey concerned for their close cooperation extended to the survey mission.

March, 1998

Kimio Fujita
President
Japan International Cooperation Agency

Hiroaki Hiyama
President
Metal Mining Agency of Japan

To The Late

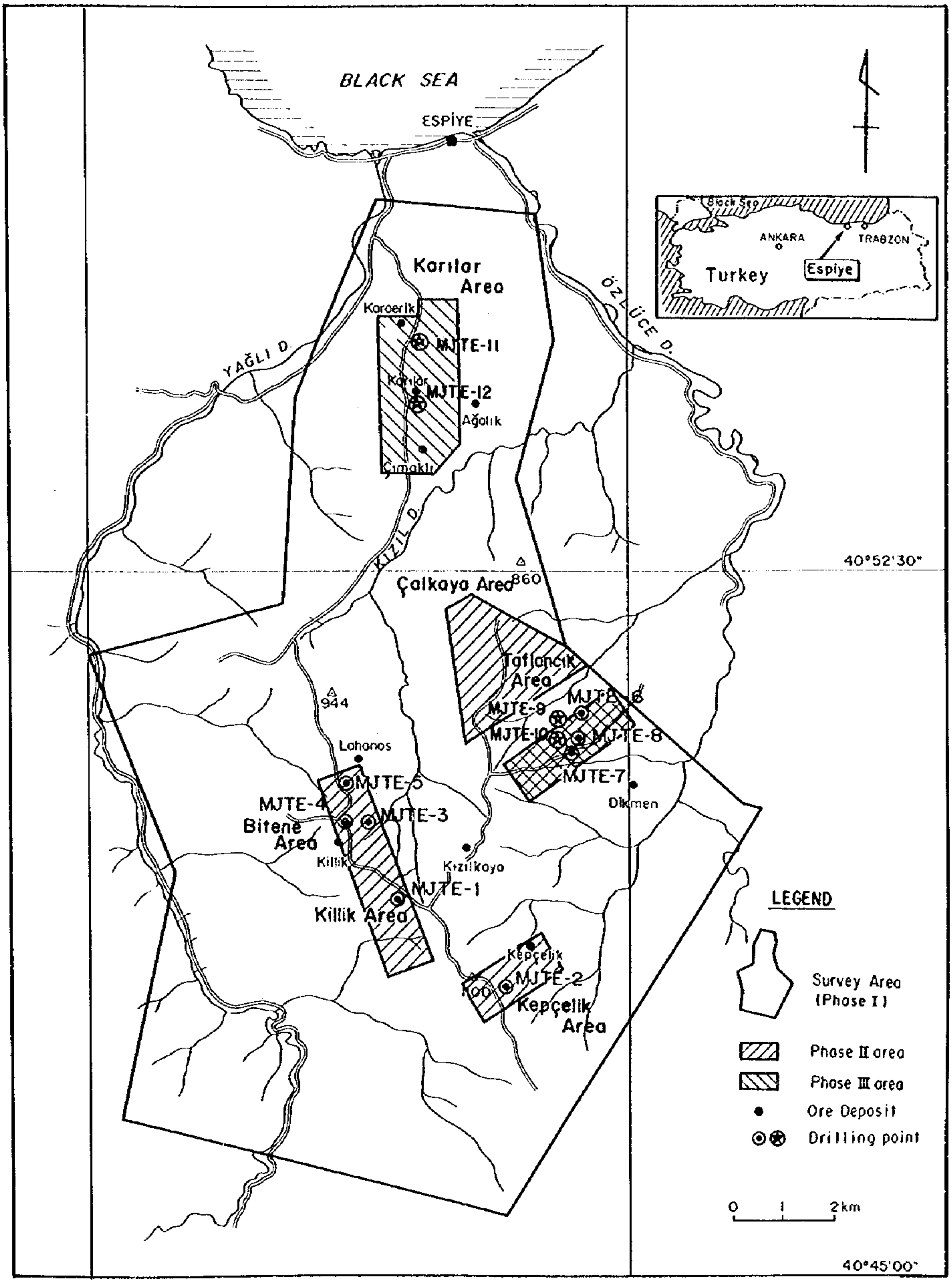
Dr. Kemal ÖZDOĞAN

In loving memory of Dr. Kemal ÖZDOĞAN whom we lost

in a terrible traffic accident on the first day (18. SEP. 1995)

of the field studies of Joint TURKISH - JAPANESE Project.

May he rest in peace. This Report is gratefully dedicated.



Location Map of the Survey Area

Abstract

This report is the final report on the mineral exploration project in the Espiye Area, Republic of Turkey, including the results of survey in phase I to phase III.

This survey has been carried out in order to study the geological frame work and to discover new ore deposits of massive sulfide in the Espiye area and also to pursue technology transfer to the Turkish counterpart.

The employed survey methods are existing data analysis, geological survey (including geochemical survey), geophysical survey (gravity, IP and CSAMT method), drilling survey.

The results of the survey are summarized as below.

- The Ore showings in this area include the massive sulfide type, as well as the network-vein type mineralization of late stage (younger than the massive sulfide). The representatives of massive sulfide type are Lahanos mine, Kızılkaya deposit (300,000 tons of remaining reserves) and Killik deposit (90,000 tons of remaining reserves) etc. The exploration for those deposits has been performed since old times, but those deposits are closed now except Lahanos mine. On the other hand, network-vein type mineralization is identified in some place, which is supposed to has been operated in old times. Because a considerable amount of slugs remained around those deposits.

- The survey area geologically consists of, in ascending order, the Çatak Formation containing andesitic volcanics, the Kızılkaya Formation mainly containing dacitic lava accompanied by dacitic pyroclastics and the Çağlayan Formation mainly composed of dacitic-rhyolitic volcanics accompanied by a lot of intrusive rocks. The massive sulfide type ore deposits, as represented by Lahanos ore deposit, are hosted on the top of the Kızılkaya Formation and are covered with the tuff of the Çağlayan Formation and hematite dacite.

- The footwall dacite has undergone argillic alteration with remarkable sericite accompanied by kaolinite occasionally. The main part of this alteration zone including Lahanos mine, Killik deposit and Kızılkaya deposit, continues to extend in a northeast direction of Çalkaya~Taflancık area. Such alteration also continues to hanging wall in some place.

- Through the drilling survey, partially predominant stock work mineralization was detected at each drilling hole. A dissemination zone of copper (25cm thick, Cu 4.88%) in MJTE-1 of Killik area, massive yellow ore of 20cm thick (Cu 12.58%, Au 2.06ppm) in MJTE-3 of Bitene area, fragments of yellow ore in MJTE-6 of Taflancık area were detected respectively, but it was concluded that there was little possibility of the existence of large-scale massive ore deposits.

- Because of the IP anomaly reflected the presence of a widespread stockwork mineralization in the footwall, the IP method will be applicable even for the survey in the area covered with the hanging wall in the Black Sea area.

- It can be considered that NE-trending structure is predominant around this area, and so it can also be considered that the mineralized zone of NE-direction including the Lahanos-Kızılkaya ore deposits indicates a high potential zone of massive sulfide type ore deposits.

Based on the survey results, the following surveys will be proposed.

- Drilling survey and IP survey for deep level in the Çalkaya area which extending in NE direction of Lahanos mine.

- Reviewing of the ore showings related with the massive sulfide ore deposits in the East Black Sea Region as well as detailed survey for footwall dacite.

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PART I General Remarks

Part 1 General Remarks

Chapter 1 Introduction

1-1 Surveyed Area

The Espiye area is an area of about 150km^2, extending in the south from Espiye Town, and is situated in the northeastern part of the Republic of Turkey along the coast of the Black Sea as shown in location map.

There are a number of ore showings including currently operating Lahanos mine of massive sulfide type, and the mines have been explored over many years since old times.

1-2 Purpose of the Survey

The Espiye region is that of high potentiality concerning the existence of the massive sulfide type ore deposits including a number of metallic elements, but the survey and the development of survey technique applicable to such ore deposits have not been sufficient, and thus the earlier execution of the exploration and evaluation of such ore deposits have been urged. Therefor, the Government of the Republic of Turkey has requested the Government of Japan to conduct the mineral exploration in the Espiye area. The Government of Japan in response to the request, decided to conduct the joint technical cooperation survey, and to transfer the survey technology to the Turkish side.

1-3 Survey Method and Contents of the Survey

Flow Sheet of the survey and Flow Chart of Selection for the Promising area are shown in Fig. I-1-1 and Fig. I-1-2.

Method and specifications of the survey in each phase are shown in Table I-1-1.

1-4 Survey terms and member of the survey

Survey terms and member of the survey in each year are shown in Table I-1-2.

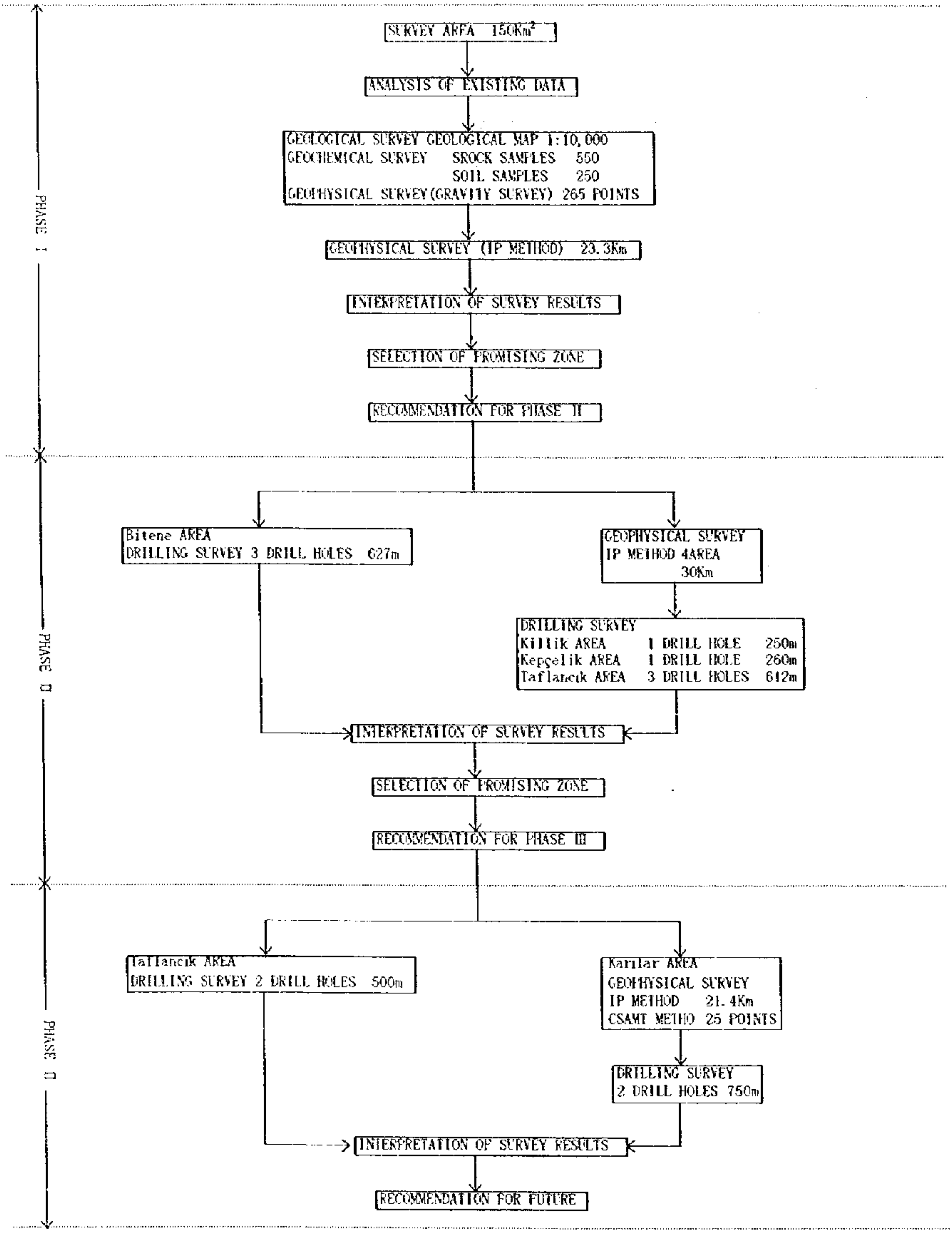


Fig.I-1-1 Flow Sheet of the Survey

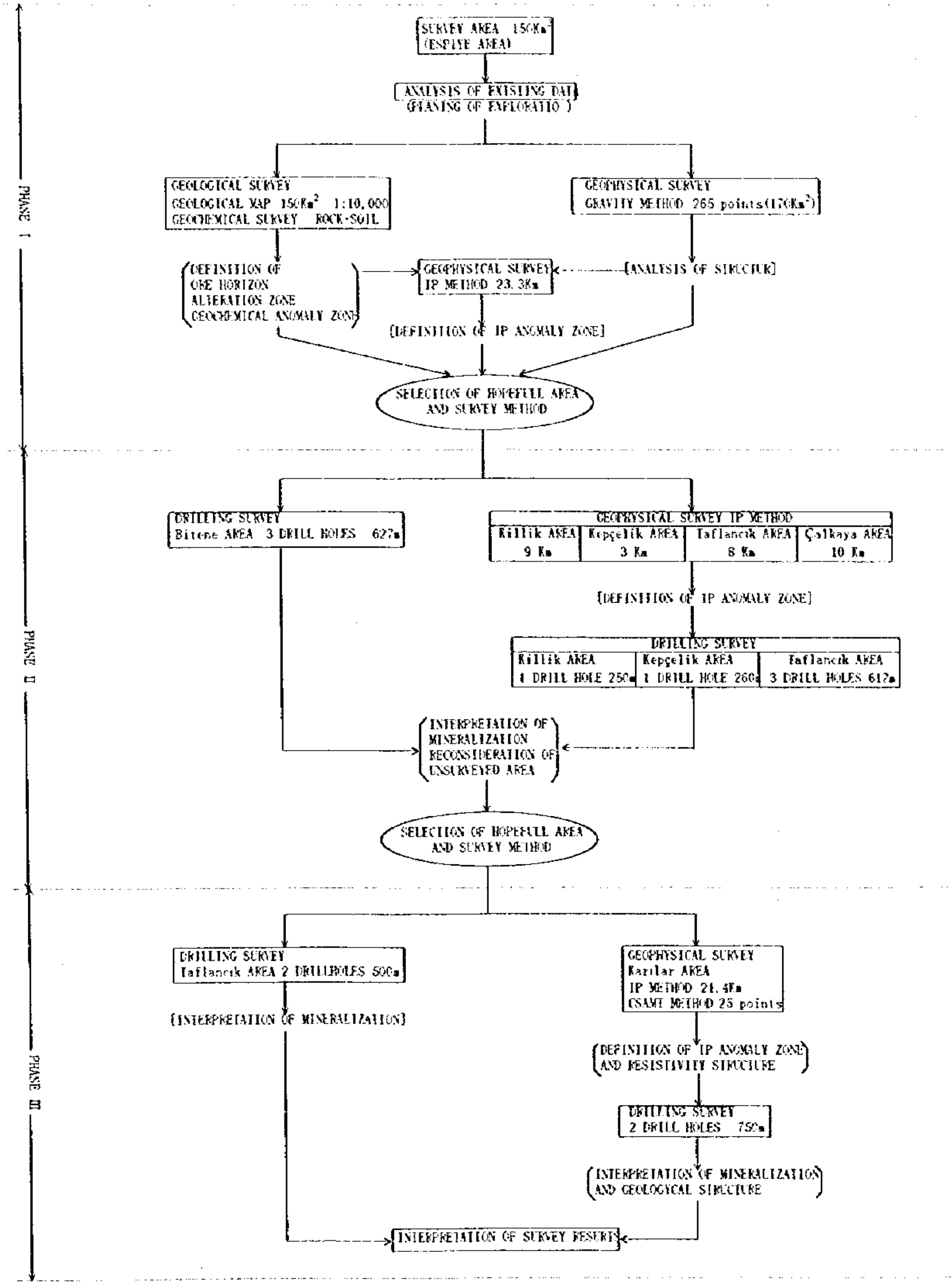


Fig.I-1-2 Flow Chart of Selection for the Promising Area

Table I-1-1 Contents of the Survey

Stage	Survey Method	Specifications			
Phase I (1995)	Existing Data Analysis	Analysis and Collection of Data		1 set	
	Geological Survey	Survey Area	$150\ Km^2$		
		Survey Rout	100 Km		
		Thin Section	20 samples		
		Polished Section	30 samples		
		Chemical Analysis of Ore	50 samples	(Au,Ag,Cu,Pb,Zn,As,Sb,Fe,Mn,Mo, Ba,La,Ce,Nd,Sm,Eu,Tb,Yb,Lu,U,Th)	
		Chemical Analysis of Rock	550 samples	(Au,Ag,Cu,Pb,Zn,As,Sb,Fe,Mn,Mo, Ba,SiO_2,TiO_2,Al_2O_3,Fe_2O_3,Cr_2O_3,MnO, CaO,MgO,Na_2O,K_2O,P_2O_5,LOI)	
		Chemical Analysis of Soil	250 samples	(Mn,Fe,Cu,Zn,As,Ag,Mo,Sb,Ba,Au,Pb)	
		X-ray Diffraction	200 samples		
	Geophysical Survey	Gravity Survey	Survey Area		
			Measuring Point	265 points	
			Measurement of Density	112 samples	
		IP Method	Survey Line	23.3 Km	
			Measuring Point	1,031 points	
			Measurement of Resistivity and Chargeability	45 samples	
Phase II (1996)	Geophysical Survey	IPMethod(Killik,Kepçelik,Taflancık,Çalkaya ar		$170\ Km^2$	
			Suevey Line	30.0 Km	
			Measuring Point	1220 points	
		Measurement of Resistivity and Chargeability		42 samples	
	Drilling Survey	8 holes	Total depth	1,749.0 m	
			Thin Section	15 samples	
			Polished Section	15 samples	
			X-ray Diffraction	40 samples	
			K/Ar Dating	2 samples	
			Chemical Analysis of Ore	43(Au,Ag,Cu,Pb,Zn,Fe,S)	
Phase III (1997)	Geophysical Survey	Karılar Area			
		IP Method	Suevey Line	21.4 Km	
			Measuring Point	370 points	
		CSAMT Method	Measuring Point	25 points	
		Measurement of Resistivity and Chargeability		23 samples	
	Drilling Survey	Taflancık Area		Thin Section	12 samples
			2 holes Totai depth 500m	Polished Section	10 samples
		Karılar Area		X-ray Diffraction	31 samples
			2holes Totai depth 750m	Chemical Analysis of Ore (Au, Ag, Cu, Pb, Zn, FeS)	33 samples

Table I-1-2 Terms and Member of the Survey

Stage	Terms of the survey	Japanese Members		Turkish Members	
Phase I	Aug-29-1955 | Mar-1-1996	**Planning and negotiation**			
		Junichi TMINAGA	(MMAJ)	Mehmet BALCI	(MTA)
		Kenichi TAKAHASHI	(JICA)	Yavuz ULUTÜRK	(MTA)
		Naoki SATO	(MMAJ)	Ramazan DOĞAN	(MTA)
		Takashi OKAMOTO	(MMAJ)	Murat ER	(MTA)
		Survey Team			
		Jiro DATE	(DEC)	Murat ER	(MTA)
		Yukio KINRYU	(DEC)	Nevzat KARABALIK	(MTA)
		Hiroshi MIYAMOTO	(DEC)	Huseyin YILMAZ	(MTA)
		Junichi ISHIKAWA	(DEC)	Kemal ÖZDOĞAN	(MTA)
		Shigeo MORIBAYASHI	(DEC)	Mustafa K : KURUÇE	(MTA)
		Kuraei IWAKI	(DEC)	Ali Faik ALTINBAŞ	(MTA)
		Norikiyo SUGIURA	(DEC)	Turgut ÇOLAK	(MTA)
				Mustafa DEMİRHAN	(MTA)
				Hasan UĞURLU	(MTA)
				Hasan SOYLU	(MTA)
				Kadir DEMİR	(MTA)
				Ömer DUMAN	(MTA)
				Etem OFLU	(MTA)
				Erdem ÖZBAYRAK	(MTA)
		Supervisor in Turkey			
		Haruhisa MOROZUMI	(MMAJ)		
Phase II	Jul-15-1996 | Feb-28-1997	**Survey Team**			
		Shigehisa FUJIWARA	(DEC)	Nevzat KARABALIK	(MTA)
		Saichi ISHII	(DEC)	Huseyin YILMAZ	(MTA)
		Kinichiro ITO	(DEC)	Mustafa K : KURUÇE	(MTA)
		Ryoichi SUDO	(DEC)	Ali Faik ALTINBAŞ	(MTA)
		Kuraei IWAKI	(DEC)	Turgut ÇOLAK	(MTA)
		Norikiyo SUGIURA	(DEC)	Hasan YEMEN	(MTA)
		Masatoshi MAEKAW	(DEC)	Kadir DEMİR	(MTA)
				Hasan SOYLU	(MTA)
				Ömer DUMAN	(MTA)
				Mustafa DEMİRHAN	(MTA)
				Hurşit ASLANOĞLU	(MTA)
				Ersin KARABULUT	(MTA)
				Avni AKDENIZ	(MTA)
				Etem OFLU	(MTA)
				Erdem ÖZBAYRAK	(MTA)
		Supervisor in Turkey			
		Toyo MIYAUCHI	(MMAJ)		
		Katsuhisa OHONO	(MMAJ)		
Phase III	Jun-5-1997 | Feb-27-1998	**Survey Team**			
		Shigehisa FUJIWARA	(DEC)	Nevzat KARABALIK	(MTA)
		Tatuhiro AOYAMA	(DEC)	Huseyin YILMAZ	(MTA)
		Kuraei IWAKI	(DEC)	Mustafa K : KURUÇE	(MTA)
		Norikiyo SUGIURA	(DEC)	Ali Faik ALTINBAŞ	(MTA)
		Masatoshi MAEKAW	(DEC)	Turgut ÇOLAK	(MTA)
				Kadir DEMİR	(MTA)
				Ömer DUMAN	(MTA)
				Mustafa DEMİRHAN	(MTA)
				Hurşit ASLANOĞLU	(MTA)
				Avni AKDENIZ	(MTA)
				Etem OFLU	(MTA)
		Supervisor in Turkey			
		Tadashi ITO	(MMAJ)		
		Eishi ENDO	(MMAJ)		

Chapter 2 Previous works

This area is said to have been one of the places of mining from old times (from the time of the Ottoman Empire), but the start of the modern exploration and mining date back to the time after 1930's. The mines leaving the evidences of the mining operation in the old time are the mines of Karaelik, Karılar and Ağalık in the northern district, mines of Lahanos, Killik and Kızılkaya in the central district and some others, the evidence being the slag left in these mines, amounting to several ten thousand to several hundred thousand tons. In later years, after modernization of the country, geological surveys, geophysical surveys (mainly by electrical prospecting such as the IP method), drilling survey and underground exploration were carried out mainly by the government agencies such as MTA, Etibank, etc.

For example, for the Lahanos mine which is only under operation, the survey by MTA was started from 1936, and the survey, including the geological survey, geophysical survey ,drilling survey and tunnel exploration, has been conducted until 1960. This survey was followed by the underground exploration and drilling by K.B.I. and Etibank, and, as a result, the inferred reserves was estimated the amount of 2.3 million tons (Cu average grade of 3.6% and Zn average grade of 2.39%). Later, Demir Export A.Ş. one of Turkish business conglomerates, who acquired the mining right, conducted the geological detailed survey, geophysical survey and drilling survey reaching total length of 1,315.5m, at 14 sites, and confirmed the ore reserves amounting to 1,124,000 tons (Cu average grade of 4.23%, Zn average grade of 3.31%) in 1989, and started its mining operation from 1995.

The regional geological maps of Turkey, scaled in 1/500,000, are covering the whole territory of the Republic of Turkey. The data about geology and ore deposits of the East Black Sea Region including the surveyed area, have been accumulated by the geologists of the Black Sea Branch (Trabzon) of MTA. Especially, the massive sulfide ore deposits are the most important sources of the copper resource, and thus the ore showings in the form of the massive sulfide type ore deposits have been well explored. It was reported that the ore deposits of this area were formed relating to the acidic volcanism during the late Cretaceous period, and the metallogenic province has been traced from Murgul (near the northeastern border) to Giresun in the west of the Espiye area along the coast of the Black Sea.

Chapter 3 General Geology

3-1 Outline of Geology

Turkey is geologically divided into three areas of Pontides in the north, Anatolides in the middle, and Taurides in the south (Kormaz et al. 1992). The survey area is located in the north-east of the Pontides area. The basement in the Pontides area consists of metamorphic rocks and granitic rocks, and six stratigraphical units are distributed over it. They are Paleozoic, early Jurassic system-early Cretaceous system, late Cretaceous system-early Paleocene series, middle Paleocene-late Eocene series, Miocene series-Pliocene, and Pliocene series-Quaternary system in this order from the lowest layer.

Volcanic rocks belonging to the late Cretaceous system-early Paleocene are continuously distributed along the cost of the east Black Sea including this area and they are accompanied by massive sulfide type mines represented by Murgul, Çayeli, Lahanos, etc.

Güven et al (1992) classified the late Cretaceous system-early Paleocene into the Çatak Formation mainly composed of andesitic-basaltic volcanics, the Kızılkaya Formation mainly composed of dacitic volcanics, and the Çağlayan Formation composed of andesite-basaltic lava, pyroclastics, and part of dacitic volcanics from the lowest layer. In addition, an intermittent distribution of granitic rocks which are thought to belong to the Tertiary period is observed in this zone.

From a structural point of view, the area along the coast of the Eastern Black Sea including this area is located in the north of the northern Anatoria Fault (WNW-ESE) which is a right-lateral transform fault and is classified as a Pontides orogenic zone as mentioned above.

It is thought that a deep fracture of an E-W~NE trending is related to the magmatism after Cretaceous period along the coast of the eastern Black Sea (Çagatay, 1993).

3-2 Mineralization and Mineralization Zone

The eastern Black Sea area is a major metallogenic province in the Republic of Turkey (see Fig.I-3-1) and is accompanied by many ore deposits of copper, lead, zinc, iron sulfide, gypsum, etc. Among others, it is said that this area produces about 70% of the domestic yield of copper.

Various types of ore deposits are known in this metallogenic province. As a general tendency, a zonal arrangement is observed in order of porphyry Cu type, skarn deposits, network-vein copper/iron sulfide deposits, massive-lenticular iron/copper/lead/zinc sulfide ore deposits, and manganese-hematite ore deposits from the mountain ridge toward the coast of the Black Sea. Among these, it is thought that a zone of the massive-lenticular iron/copper/lead/zinc sulfide ore deposits crosses the boarder into Georgia.

Among these ore deposits, a massive sulfide ore deposit is particularly important. Murgul and Çayeli, a typical ore deposit, have the following features. Both ore deposits are formed in dacite lava of upper part of the Kızılkaya Formation and the ore deposits are covered with relatively thick hematite dacite through a thin tuff of the hanging wall in Murgul. The ore deposit in Çayeli is covered with tuff and basaltic lava.

Ores in Murgul have the characteristics of stringer and dissemination. The aggregate of veinlets containing copper is the subject of the opencut mining. Zinc and gypsum exist only in the upper part of an ore body. An ore body in Çayeli is a steep lenticular form, and clastic ores rich in sphalerite, massive black ore, and yellow ore are found in this order from the top. Ores in the Lahanos ore deposit existing in the survey area resemble Çayeli ores, except that the distribution form of the Lahanos ore deposit is almost horizontal.

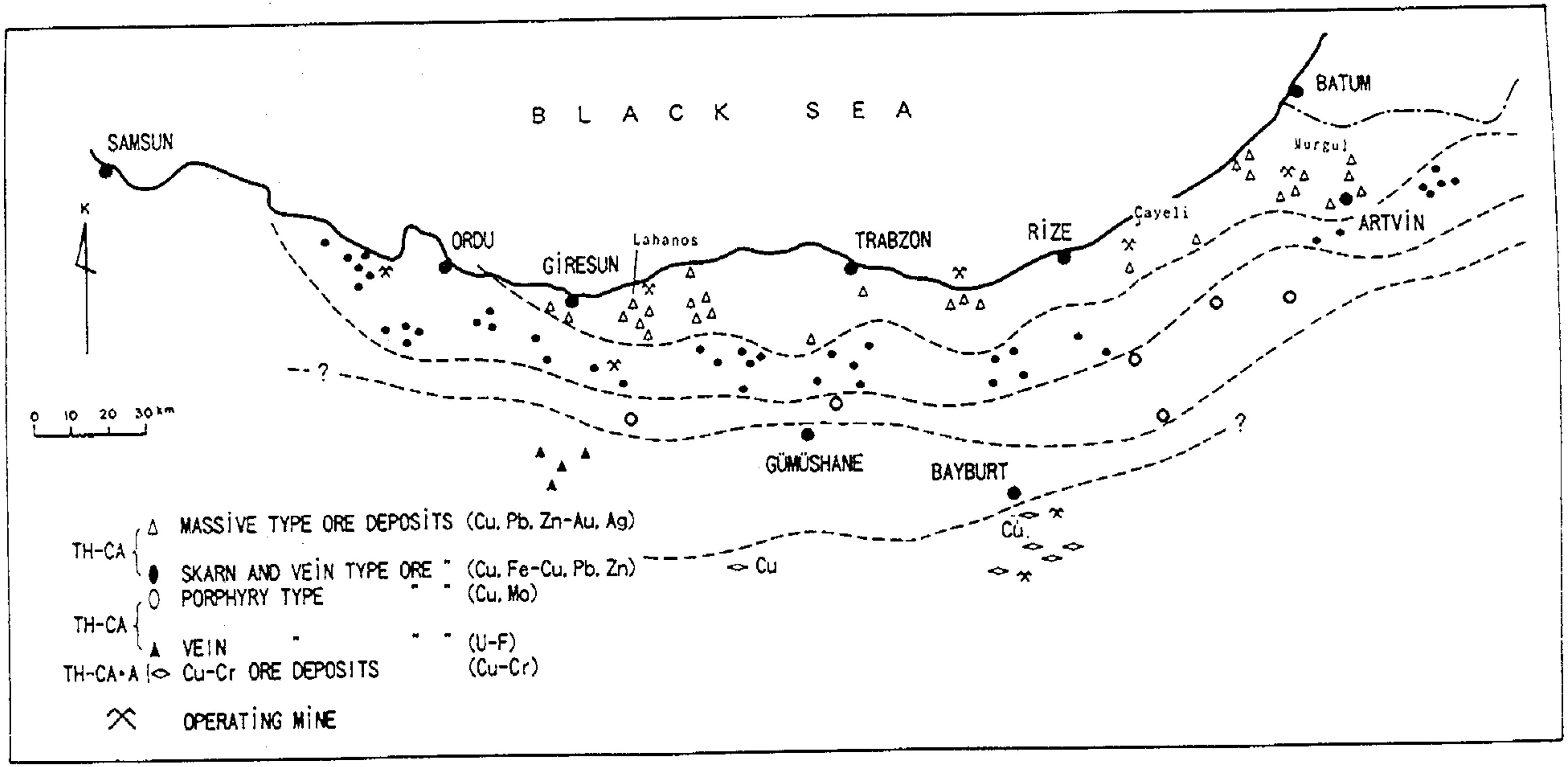


Fig.I-3-1 Metallogenic Province of East Black Sea Region

Chapter 4 Geography in the Survey Area

4-1 Location and Transportation

The Espiye area is an area of 150km ^{2} extending south from Espiye Town(population of about 10,000) located about 100km west of Trabzon City, a major city along the cost of the Black Sea, in the north-east area of the Republic of Turkey. It takes about one hour from Ankara, the capital, to Trabzon by air and less than two hours are required by car from Trabzon to Espiye through a paved road along the Black Sea.

This region belongs to Giresun Prefecture of which center is Giresun City located 30km west of Espiye Town in terms of administrative division.

The survey area is a hazelnut-producing area and is dotted with small villages. Unpaved roads in bad condition lead to each village. However, they are often closed to traffic during the rainy season. It takes about two hours by car with four-wheel drive from Espiye Town, a base town, to the southern end of this year's survey area.

4-2 Physical Features

4-2-1 Topography and Drainage

Within this survey area belonging to the Black Sea coast part, a fold mountain range(Inoue, 1970) formed in the beginning of the Alpine orogenic cycle, called as the East Black Sea Mountain Range falls sharply into the vicinity of the coast, and there is little flat land. For this reason, the area is tens of meters to about 1,500meters high above the sea level and its land form is steep and relatively rich in undulations.

The survey area is divided into two by a dividing ridge running from north to south in the center. That is, the eastern part belongs to the upper reaches of the river system of Kızıl Dere and Karadona Dere, a branches of Özlüce Dere. The western part corresponds to the upper reaches of branch streams of the Yağlı Dere system. These streams form a steep V-shaped valley.

4-2-2 Climate and Vegetation

This area which has the heaviest rainfall and snow in the Republic of Turkey belongs to a Black Sea type climate (MMAJ, 1970) because a warm and wet wind from the Black Sea blows against the Black Sea Mountains. For this reason, the vegetation grows thick. Rainfall is plentiful from September through March and the average rainfall for October in Trabzon reaches 300mm. In November rain turns to snow. The average temperature in August reaches the maximum, 24 ℃, and that in February falls to the minimum, 6 ℃.

Since this area is a hazelnut-producing area, even a steep mountainous slopes are covered with these trees in many places. Particularly, this tendency is significant in the northern part. Natural plants can be often seen in high elevation area of the southern part and shrubs such as rhododendrons grow thick with some evergreen oak trees and beech trees.

Chapter 5 Conclusion and Recommendation

5-1 Conclusion

After the existing data was analyzed, the surveys such as geological survey (including ore showing survey and geochemical survey), geophysical survey (gravity method, IP method and CSAMT method) and drilling survey were carried out. Comprehensively analyzing the results of these surveys, the following conclusions are obtained.

In the surveyed area, there are a number of ore showings and ore deposits including the Lahanos mine (under operation). Before this project, all of these existing ore deposits and ore showings were considered relating to the massive sulfide type mineralization, but it has been clarified that at least the ore deposits located in the north part were formed by the newer stockwork mineralization like the cases of Karılar and Karaerik ore deposits.

The massive sulfide type ore deposits such as that of Lahanos were formed relating with acidic volcanism in late Mesozoic. The massive sulfide type ore deposits are hosted in the top of the Kızılkaya Formation and covered with the tuff and hematite dacite of the Çağlayan Formation. The massive sulfide ore body is accompanied by intense argillic alteration, mainly the sericitization and frequently accompanying the kaolinite. Such alteration was continued to the hanging wall even after the formation of the ore body in the cases of Killik and Lahanos ore deposit. The K/Ar age of the sericite from the alteration zones around Kızılkaya and Karaerik ore deposits is 77Ma.

Based on the result of the geochemical survey of the rock, it is considered that the high score zones of the second principal component reflected well the mineralization.

Through the sub-regional gravity survey, it was clarified that, the gravity trend in NE-SW or ENE-WSW directions was predominant around this area, and the bouguer anomaly rises towards the Black Sea, and many of the existing ore deposits distribute in the surrounging areas of the high gravity zone.

It is considered that the IP method is the effective method for the area covered with hanging wall. That is, new anomaly zone reflecting mineralization was found in Taflancık area. And also in the Karılar area, the observed anomaly reflected well the form of ore body.

Resistivity structure (ENE-WSW trending) related to mineralization was found by the CSAMT method in Karılar area.

The drilling survey was carried out at 12 sites of selected promising area during the second year and third year surveys. As the results of these drilling surveys, a massive yellow ore (Cu 12.58%, Au 2.06ppm) of 20cm thick was found at MJTE-3 in Bitene area, and yellow ore fragments were encountered at MJTE-6 in Taflancık area. Further, in other drilling sites too, pyrite dissemination zone and stockwork mineralization zone including chalcopyrite, pyrite and sphalerite were observed, and a wide distribution of mineralization zone relating to the massive sulfide ore deposit was also clarified. The major mineralization zone is a zone including Lahanos and Kızılkaya ore deposits and is considered extending to the northeastern direction.

5-2 Recommendation in the future Projects

1. Survey at greater depth by IP method and drilling survey in Çalkaya area.
2. Detail study for footwall dacite and reexploration (checking) of the massive sulfide type ore showings in the Black Sea Region.

PART II Details of the Survey

PART II Details of the Survey

Chapter 1 Analysis of Existing Data

1-1 Survey Method

The survey area was very famous of their mining potentiality for a long time. But it is difficult to find out the documents written before 1939. After 1939 MTA, Etibank(including KBI) and Demir Export company performed geological survey, geophysical survey and drilling survey vigorously in this area, and results of these surveys were summarized in their reports. Analysis and collection of data were carried out chiefly in Ankara and Trabzon through MTA.

1-2 Results of the Survey

Results of the survey are shown in Fig.II-1-1 and Table II-1-1.

1-2-1 Geology

The regional geological maps of Turkey, scaled in 1/500,000, are covering the whole territory of the Republic of Turkey and this area is included in the map of SAMSUN. The data about geology and ore deposits of the East Black Sea Region including the surveyed area, have been accumulated by the geologists of the Black Sea Branch(Trabzon) of MTA. Geological map of the eastern Black Sea Region (on a scale of 1:500,000) was mapped by geologists of MTA Black Sea Branch office based on regional geological corelation. Also geological map on a scale of 1:25,000 covered whole of the area.

According to Güven et al, in the survey area, the Çatak, Kızılkaya and Çağlayan Formations(in ascending order) lie on underlying Formations conformably and they are thought to be formed in late Cretaceous to Palaeocene.

The Çatak Formation composed of andesite, basalt, their pyroclastics, sandstone, siltstone and limestone exists on the Berdiga Formation conformably, and its thickness is around 1,500m. It developes in southern part of the survey area.

The Kızılkaya Formation lies on the Çatak Formation, and is composed of dacite, rhyolite and their pyroclastics. Its thickness is around 500m and distributes in central part of the survey area. The uppermost layer of the Kızılkaya Formation is thought to be the horizon containing massive sulfide ore deposits that is correlated to Kuroko deposits in Japan.

The Çaglayan Formation lies on the Kızılkaya Formation conformably and is composed of mudstone, dacite lava, its pyroclastics, andesite and basalt. It developes in northern part of the survey area and its thickness is around 1,000m.

In north-eastern area from the survey area, the Kabaköy Formation composed of andesite, basalt and their pyroclastics developes with 750m thickness unconformably on underlying Formation. It is thought to be formed in Eocene.

Regarding intrusive rocks, granite formed in late Cretaceous, diorite and quartz diorite formed in Eocene are recognized in and around the survey area.

1-2-2 Ore Deposits

Beside Lahanos mine, there are many old mines and ore showings in this area, and also many kind of explorations have been carried out for them recentry. Survey method is consists of geological detail survey, geophysical survey(mainly electric survey such as IP) and drilling survey around ore showings. Origin of these mines and ore showings was believed to be a massive sulfide type.

Lahanos mine is located around 15km south from Espiye town and is also a working mine. In 1958~1960, MTA mined 2 tunnels, drilled 10 holes in tunnels and also drilled 67 holes outside. Consequently 2,300 thousand tons(Cu 3.59%, Zn 2.34%) was estimated as probable ore reserves. Afterwards, Demir Export company(mining division of a Turkish plutocracy) obtained the mining right of this mine, and in 1989 they drilled 14 holes (total length;1315.5m) consecuently about 1,500,000 tons (Cu 4.25%, Zn 3.31%.) was estimated finally as ore reserves. At April of 1995, they started to produce 500t/day(Cu 3.8%, Zn 3.2%) as crude ore, 70t/day(Cu 22%, Zn 4%, Pb 2%) as copper concentrated ore and 10t/day(Zn 50%, Cu 5%) as zinc concentrated ore. They send copper concentrated ore to the refinery of KBI in Samsun and sell zinc concentrated ore to a Germany company (Metalgesellshaft). Total employees in all sections such as prospecting, mining, mineral dressing and maintenance sections are around 100 persons. As capacity of mining section is over that of mineral dressing, mining personnel is shifted to mineral dressing section when stock of crude ore increases.

Ore deposits are composed of massive yellow ore that contains abundant pyrite and chalcopyrite, with a little sphalerite. In underlying dacite lava, argillization, silicification, brecciation, disseminated pyrite and networks of pyrite are recognized. Thickness of massive ore bodies is 15m as maximum and 3~5m in average. Several massive ore bodies are contained lenticularly in the same stratigraphical layer as the others.

Killik ore deposit is located in a south of Lahanos mine and has been explored by MTA and Demir Export co. etc. Ore reserves are calculated as 170,000 tons (Cu 5.2%, Zn 5.6%). But it is now closed.

Kızılkaya ore deposit is located in a south east of Lahanos mine and has been explored by MTA, Etibank and KBI for a long time. They confirmed existence of 3 ore bodies which probable ore reserves were calculated as 300,000 tons.

1-2-3 Geophysical Data

Existing gravity data around the survey area acquired from regional survey that was performed by MTA over whole Turkish territory for a long time were available for this survey. The survey by MTA was a kind of rough survey, because they adopted 5~10km as interval of measuring points. But it is still useful to study the regional trend of gravity. However, gravity data as well as topographical maps are treated as military secrecy, and then raw data can not be obtained and contour maps on gravity can be obtained through MTA. The obtained contour maps regarding the survey area are bouguer anomaly maps, residual gravity maps and others which were drawn on around 1 to 500,000 scaled map in range of 60km × 70km.

Some electric surveys such as IP, CSAMT, SP, EM have been carried out for ore showings. For instance, results of the IP survey on the Lahanos mine revealed IP anomaly zone reflecting ore body of 30mV/V. But the other cases showed that the exploration depth was shallow and obtained data was not analyzed enough (eg. 2-D analysis was not performed).

Table II-1-1 List of the Analyzed Existing Data

Document Number	Author	Age	Title
01	Unidentified	1939	Electro-magnetic Data in Giresun-Espiye-Gol Area.
02	Unidentified	1939	Geophisical Data In Giresun-Espiye-Karilar Area.
03	Eksper Muh and Breusse, J.J.	1940	Esbiye-Israil Mintakasinda Yapilan Elektrik Prospeksiyonuna Muteallik Ikinci Rapor.
04	Muh. Jeol V. Kovenko	1940	Aglikmaden(Esbiye) Ocaginin M) Topografya Noktasi(Rakim Takriben 326m) Altinda Cevher Mevcudiyeti Imkanlarina Muteallik Not.
05	Ragib Gencer	1940	Aglik(Espiye) P.S. Etudu Hakkinda Not.
06	Unidentified	1943?	Geophysical Data in Giresun-Espiye-Agalik Area.
07	Ahmet Acar	1960	Lahanos Ile Killik Arasindaki Sahanin Rezistivite Etudu.
08	Unidentified	1960	Electro-magnetic Data in Giresun-Espiye-Karilar Area.
09	Unidentified	1961	Electro-magnetic Data in Giresun-Espiye-Kozkoy Area.
10	Unidentified	1967	Eti Bank Espiye Santiyesi Giresun Vilayeti Lahanos Maden Kizilkaya Sahasi Jeofisik Etudu Raporu.
11	Ugur Kaynak	1969	Karaerik Bakirli Pirit Zuhuru Induced Polarization Etudu Hakkinda Rapor
12	Sinasi Apaydin	1970	Giresun-Espiye-Kizilkaya Bakir Aramalari Jeofizik I.P. Etudu Raporu.
13	Ugur Kaynak	1970	Eti Bank 1970 Kepcelik I.P. Etudu Raporu.
14	Ugur Kaynak	1970	Eti Bank 1970 Kizildere I.P. Etudu Raporu.
15	Ugur Kaynak	1970	Eti Bank Giresun Espiye 1970 Kizildere I.P. Etudu Raporu.
16	Ugur Kaynak	1970	Eti Bank Maden Aramalar Subesi Agalik 1970 IP Etudu Raporu.
17	Ugur Kaynak	1970	Eti Bank Maden Aramalar Subesi Espiye Karilar Pirit Maden 1970 I.P. Etudu Raporu.
18	Unidentified	1975	Geophysical Data in Giresun-Espiye-Dikmen area.
19	Karaman, I.	1981	Geologic Research Front Report of Giresun-Espiye area.
20	Fain Kokelekli and Recai Boynukalin	1982	Israildere-Karilar-Karaerik-Killik Madeni Dogal Potansyel Calismalari.
21	Mustafa Cakir and Yusuf Cekic	1982	Giresun-Espiye Killik Yoresinin Jeoloji Raporu.
22	Seyran Sardar and Mustafa Demirhan	1987	Giresun-Espiye-Killik-Sahasi Bakir-Kursun-Cinko Aramalari Jeofizik Induklem Polaizasyon(I.P.) Etudu.
23	Mustafa Demirhan	1989	Giresun-Espiye-Cimakli-Karilar Sahasi Bakir-Kursun-Cinko Aramalari Induklenmis Polarizasyon(IP) Etudu.
24	Demir Export A.S.	1990	16.03.1988 Tarihli Anlasma Kapsaminda Giresun-Espiye Guneyi Sahala-rinda 1989 Yilinda Yapilan Arama Calismalariyla Ilgili Faaliyet Raporu.
25	Demir Export A.S.	1990	Lahanos Bakir-Cinko Yataginda Yapilan Arama ve Degerlendirme Calismalari.
26	Demir Export A.S.	1992	16.03.1988 Tarihli Anlasma Kapsaminda Giresun-Espiye ve Tirebolu Sahalarinda 1991 Yilinda Yapilan Arama Calismalariyla Ilgili Faaliyet Raporu.
27	Demir Export A.S.	1993	Giresun-Espiye-Kizilkaya Cu-Zn Yataginin Jeoloji Raporu.
28	Demir Export A.S.	1994	16.03.1988 Tarihli Anlasma Kapsaminda Giresun-Espiye ve Tirebolu Sahalarinda Yapilan Arama Calismalariyla Ilgili Faaliyet Raporu.
29	Demir Export A.S.	1995	16.03.1988 Tarihli Anlasma Kapsaminda Giresun-Espiye Sahalarinda Yapilan Arama Calismalariyla Ilgili Faaliyet Raporu.

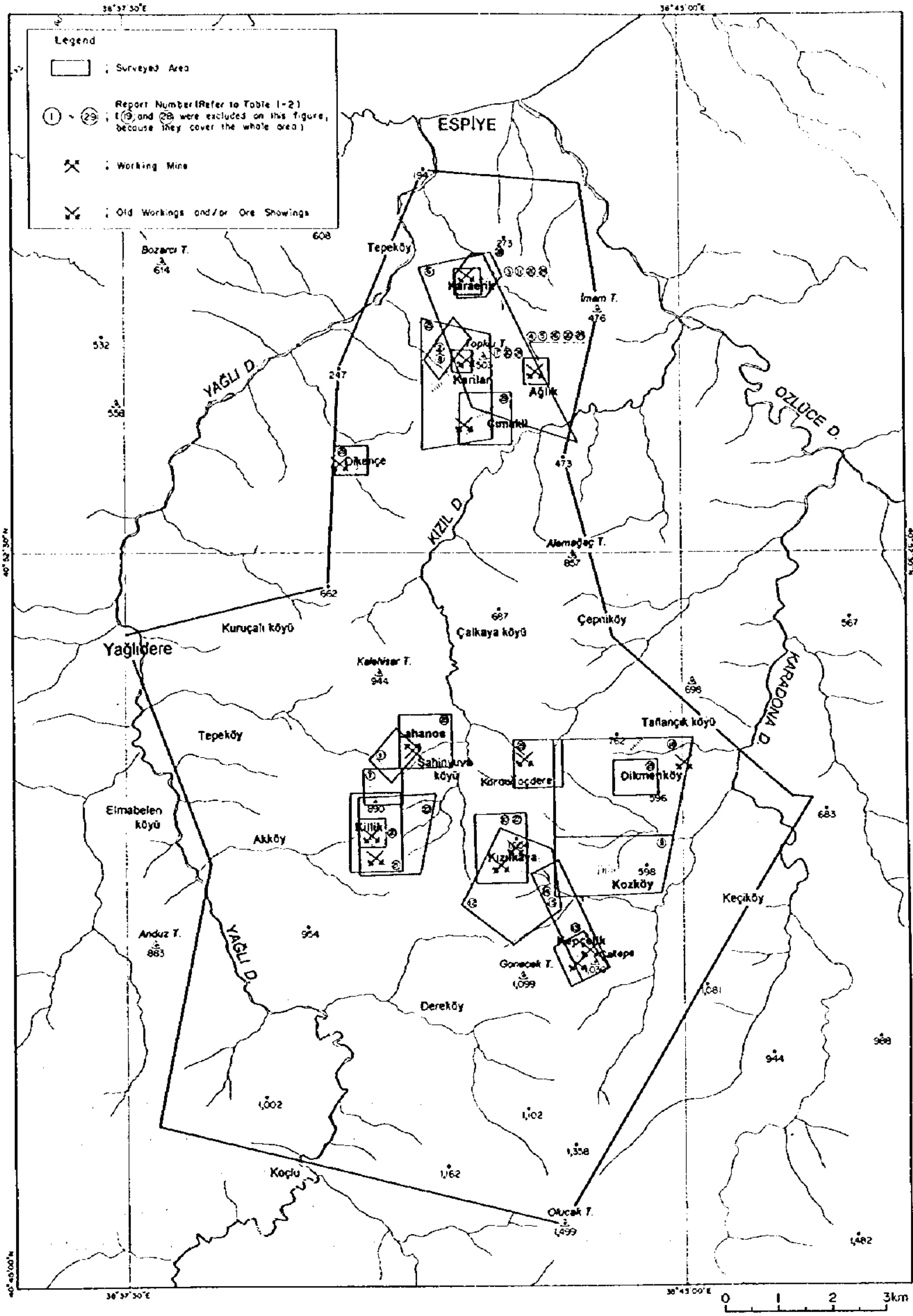


Fig.II-1-1 Summary of Previous Works

Chapter 2 Geological Survey

2-1 Survey Method

In this project, geological and geochemical surveys were performed by geologists group. The map on a scale of 1 to 10,000 was obtained by enlarging from the 1 to 25,000 scaled map and it was used in the field. Survey routes were selected from the existing documents and most suitable routes were decided to be surveyed.

Massive sulfide ore deposits here were considered to be contained in special stratigraphical layer, therefore special attention was paid on distinguishing special stratigraphic units from others. Because both hanging wall and footwall of massive ore deposits here were composed of dacitic in composition, muddy rocks(fine tuff) lying just on the ore horizon was pursued on geological survey as key bed.

2-2 Results of the Survey

Geological map and schematic lithostratigraphy are shown in Fig.II-2-1 and II-2-2.

2-2-1 Outline of Geology

The Çatak, Kızılkaya and Çağlayan Formations besides intrusive rocks in ascending order compose the geology of this survey area and they were formed in late Cretaceous. Names of each Formations in this report are cited chiefly after Güven et al.(1992).

2-2-2 Stratigraphy

1. Çatak Formation

This Formation is mainly composed of autobrecciated andesite lava(abbreviated form;Çad) and its pyroclastics(Abb. form;Çtf) with intercalation of muddy~calcareous rock. It developes widely along Yağlı river that flows in western and southern part of the area, and its thickness is over 1,000m. Chloritization and epidotization are recognized characteristically, and regional hydrothermal and/or low grade metamorphic alteration are also observed, but strong metamorphism can not be seen.

Andesite lava(Çad) shows dark green to light green in color, and intercalates thin beds of dacitic pyroclastics somewhere. Plagioclase with diameter of 1~2mm are seen commonly and plagioclase of 5~10mm diameter are seen rarely by naked eye. Most of mafic minerals are replaced by chlorite. Zeolite and epidote are observed in groundmass and cavities. According to result of microscopical observation, phenocrysts are composed of plagioclase and common hornblende, and groundmass are done of glass, plagioclase and iron minerals. Hydrothermal alteration minerals such as, quartz, pyrite, chlorite, sericite, calcite, epidote have occurred.

Andesitic pyroclastics(Çtf) show dark green to light green in color, and tuff to tuff breccia in rock facies. Bedding planes are very clear in tuff, and pyroclastic rocks are composed of only essential andesite breccias. Their thickness is less than 200m. Under microscope, glass and plagioclase are observed in groundmass, and quartz, clay minerals and calcite were seen because of alteration.

Muddy rocks(Çms) show grayish green to grayish brown in color, and also clear bedding planes. Their thickness is less than 50m. Calcareous rocks(Cms) show gray to grayish white in color,

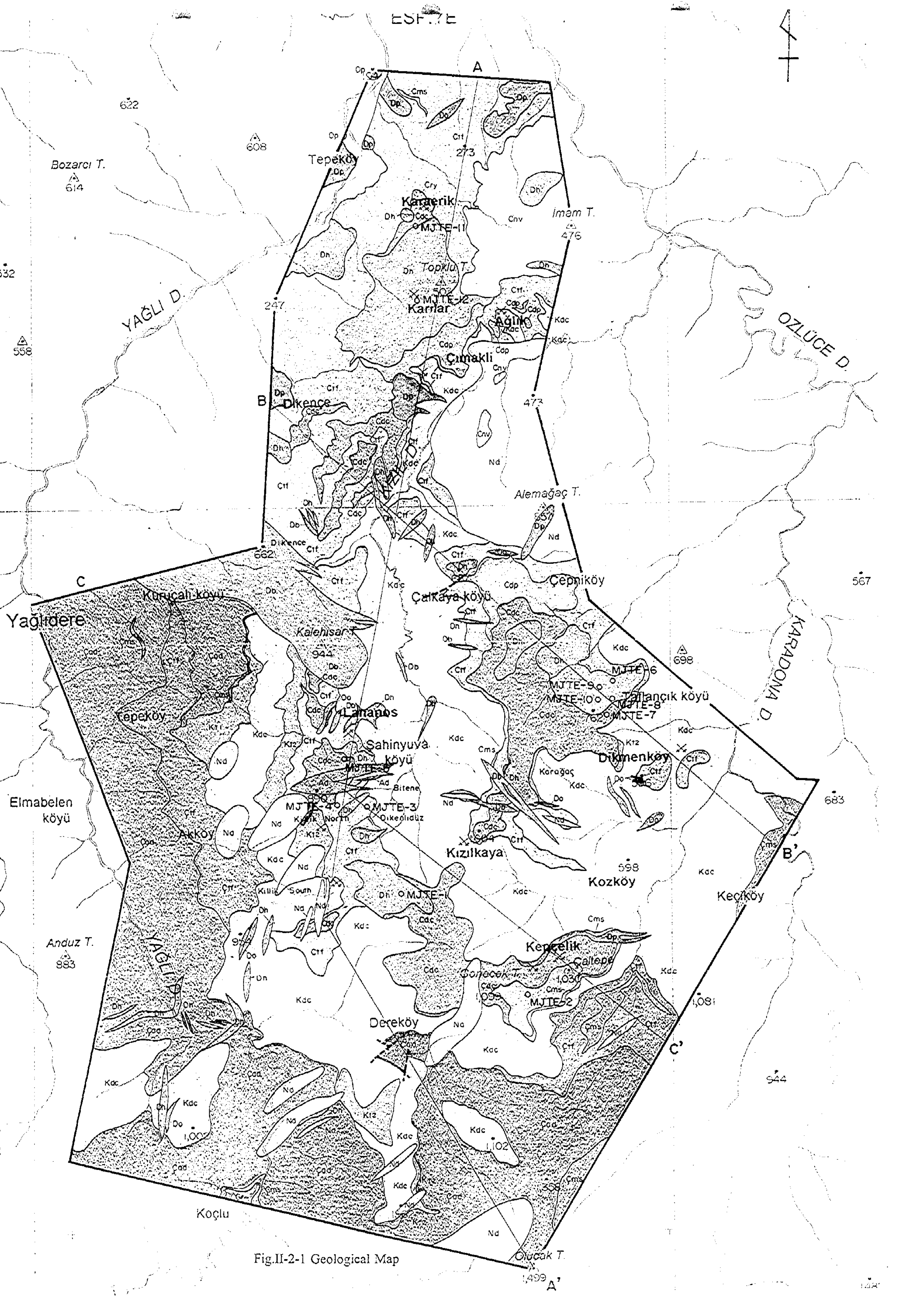


Fig.II-2-1 Geological Map

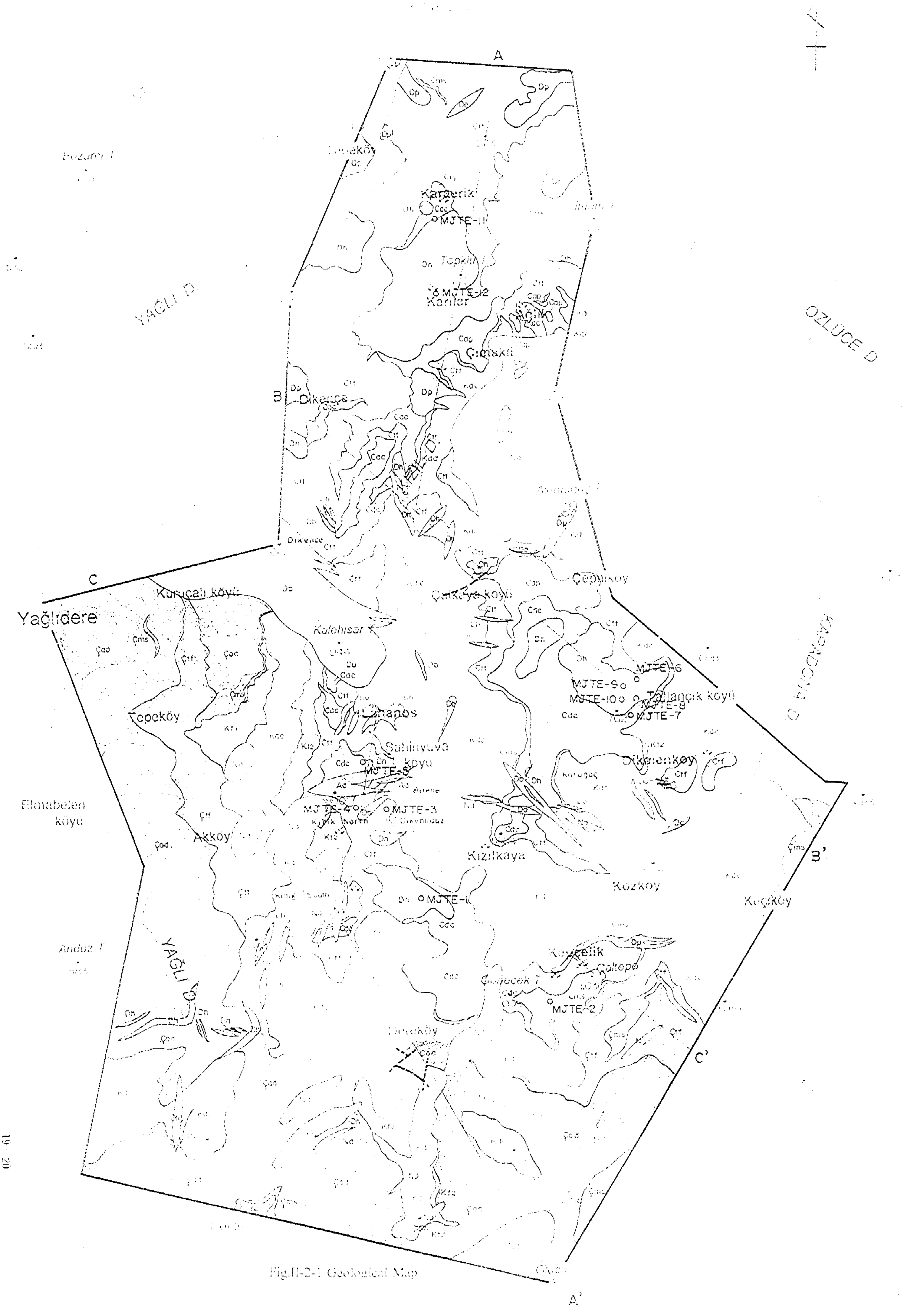


Fig.II-2-1 Geological Map

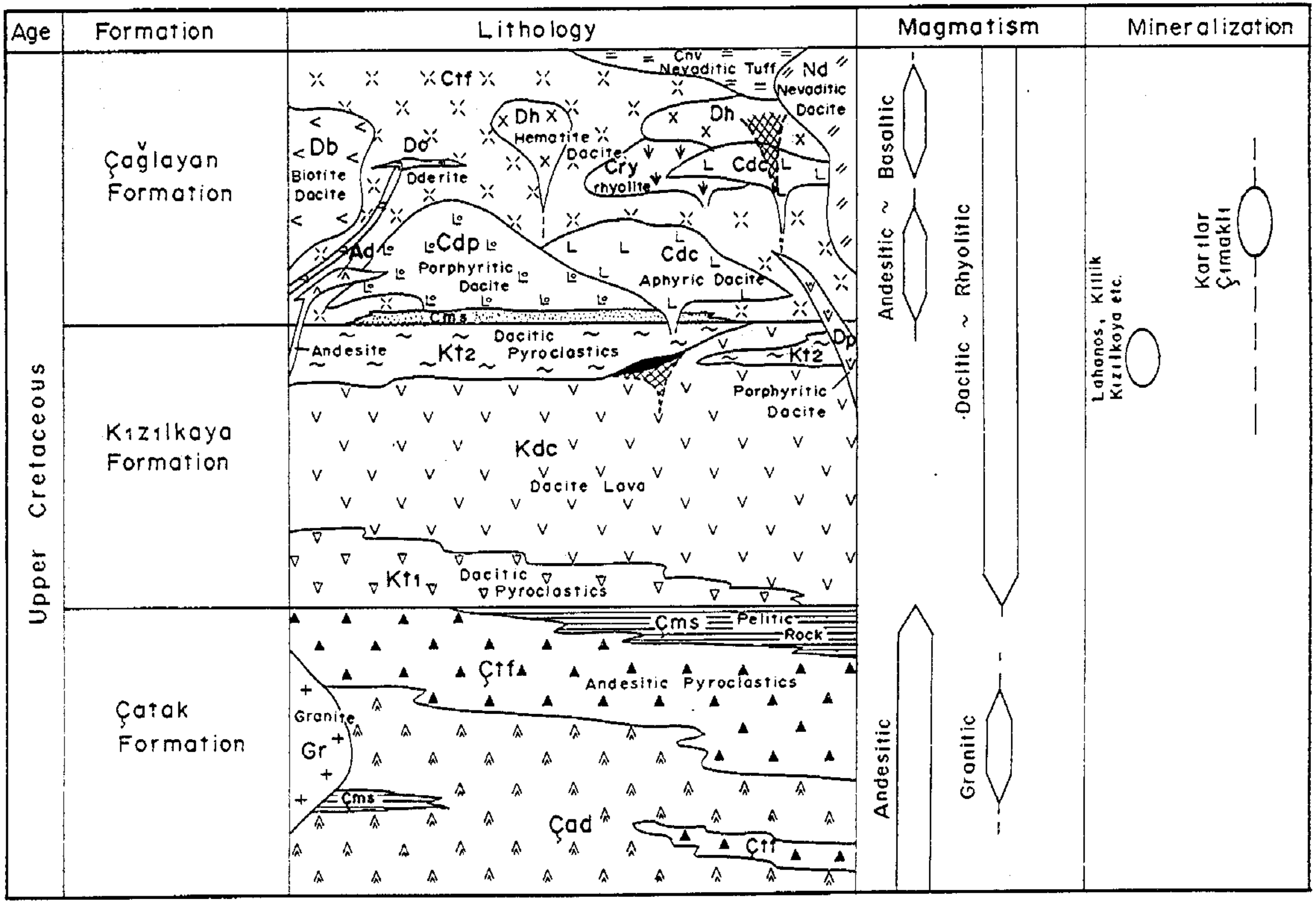


Fig.II-2-2 Schematic Lithostratigraphy

and are changed to be marble around intrusive bodies of granite after recrystallization.

2. Kızılkaya Formation

This Formation is composed of autobrecciated dacite lava(Abb.form;Kdc) and its pyroclastic rocks (Abb.form;Kt1 & Kt2). It is usually exposed on surface in central to eastern part of the area and covered by overlying Çağlayan Formation in northern part of the area.

Massive sulfide ore deposit such as Lahanos ore deposit(in central part), Killik South ore deposit (in central part) and Ağalik ore deposit(in northern part) are contained in upper-most layer of this Formation, and thickness of this Formation attains to more than 1,000m around Lahanos ore deposit and Çalkaya area.

In this Formation, chloritization, sericitization and regional hydrothermal alteration are observed commonly, but metamorphism can not be seen. Specially white argillization accompanied by mineralization is recognized besides regional hydrothermal alteration, around massive sulfide ore deposits.

Dacitic pyroclastic rocks(Abb.form;Kt1) compose lowest layer of this Formation and show green to light green in color. They are composed of well bedded tuff and tuff breccia, and their breccia are including quartz and plagioclase commonly. Under microscope, glass, plagioclase, pyroxene and opaque minerals are seen as groundmass, and quartz, pyrite, chlorite, clay minerals and calcite seem to be formed by alteration.

Dacitic lavas(Abb.form;Kdc) show green to light green in color and sometimes intercalate thin bed of its pyroclastic rocks. Rock facies change in this rock unit is observed, that is, dacitic rock around Ağalik and Killik South ore deposits contains quartz more than dacitic rock around Lahanos ore deposits. Microscopic observation indicates that phenocrysts are composed of quartz and plagioclase, that groundmass are composed of glass, plagioclase, pyroxene and opaque minerals, and that alteration produced quartz, pyrite, calcite, chlorite, sericite and other clay minerals.

Dacitic pyroclastic rocks(Abb.form;Kt2) form uppermost layer in this Formation and is mainly composed of green to light green tuffaceous rocks that contain massive sulfide ore deposits excluisively. Ferruginous chert is seen at same horizon as massive sulfide ore deposits, and then it is thought to be formed at same time as massive sulfide ore deposits.

Microscopic observation shows that phenocrysts such as quartz and feldspar are poor, that groundmass are composed of glass, quartz, plagioclase, opaque minerals such as iron minerals and others, and that alteration formed quartz, pyrite, epidote, chlorite and other clay minerals.

3. Çağlayan Formation

This Formation is composed of autobrecciated~massive dacite lavas(Abb.form;Cdp& Cdc), dacitic pyroclastic rocks(Abb.form;Ctf), nevaditic pyroclastic rocks(Abb.form;Cnv) rhyolitic rocks (Cry) and muddy rocks(Abb.form;Cms). This Formation is distributed widely in northern part of the area and covers the Kızılkaya Formation in high elevation zone of central part. Its thickness increases northwards. Diagenetic alteration such as montmorillonitization is recognized widely and red to reddish brown hydrothermally altered zone accompanied by networks-type mineralization is also seen around intrusive rocks.

Dacite lavas show generally light gray to light green in color, and can be divided into two types, that is, one is porphyritic dacite lava(Cdp) that includes big phenocrysts such as quartz and plagioclase with 1~2mm diameter, the other is aphyric dacite lava poor in phenocrysts(Cdc). Porphyritic dacite is distributed in lower part of the Çağlayan Formation and it shows white~light green in altered parts. In strongly hematitized zone, it shows red to brown in color.

Dacitic pyroclastic rocks(Ctf) show pale green to light yellow in color. Those tuffs which are distributed in Lahanos-Killik area, are composed of fine tuff- lapilli tuff with graded bedding in part. But in Karılar area dacitic tuffs are rich in glass and show loose property in general.

Nevaditic pyroclastic rocks(Cnv) show light green~light yellow~light gray in color, and include commonly phenocrysts of quartz and plagioclase with 3~5mm diameter. They show also low solidification and weakly bedded plane. The main constituents of dacitic tuffs are quartz, plagioclase, essential-accessary fragments and glassy matrix. Alteration minerals such as quartz, Fe minerals are observed.

Rhyolite lava-tuffs(Cry) show grayish green in color, and intersected by drilling(MJTE-11 and MJTE-12), also crops out in the noth of Karaerik. It consists of euhedral quartz, plagioclase, hornblende and perlitic matrix. It forms lava dome or mass of crystal tuff. No mineralization was observed.

Muddy rocks(Cms) show white to grayish green in color, and is composed of well bedded mudstone, tuffaceous mudstone and tuff. Their thickness is less than 30m and exists at lowest level in this Formation.

4. Intrusive Rocks

Granitic rock(Abb.form;Gr), andesite(Abb.form;Ad), dolerite(Abb.form;Do) and dacitic rocks indicating various facies can be recognized as intrusive rocks. Then dacitic rocks are subdivided based on result of field survey as follows; hematite dacite(Abb.form;Dh), porphyritic dacite(Abb.form;Dp), nevaditic dacite(Abb.form;Nd) and biotite-dacite(Abb.form;Db).

(1) Granitic Rock(Gr)

It developes at southern end of the survey area, forming a small stock with around 1km diameter. It shows whitish gray in color and is composed of equigranular quartz grains, feldspar and mafic minerals. By thermal alteration from this granitic rock, muddy rocks of the Çatak Formation were changed to be hornfels at contact zone with this rock and limestone of the Çatak Formation was changed to be marble at contact zone with this rock.

(2) Andesite(Ad)

In south of Lahanos mine, it developes forming a small body whose size in planis 1.8km (east-west) × 0.4km(north-south). It intruded into the Çağlayan Formation and hematite dacite(Dh). It shows dark gray in color, and includes phenocrysts of plagioclase and pyroxene with 1mm diameter. It shows also columnar joints and no alteration.

Microscopic observation indicates existence of plagioclase, augite and common hornblende as phenocrysts, and those of glass, plagioclase and opaque minerals as groundmass. Quartz, chlorite and calcite are thought to be formed by alteration.

(3) Dolerite (Do)

It distributes forming small bodies in eastern, northern and south-western parts of the survey area. This rock intruded into the Çağlayan Formation and it is cut by nevaditic intrusive rock (Nd). The rock bodies in eastern part are inclined to extend in east-west and north-northwest direction, and those in northern and south-western parts are inclined to extend in north-northeast direction. Long diameters of the rock bodies are less than 1km and short diameters are less than 300m. It shows black to dark green in color. It shows more weathering than alteration, and consequently it shows sometimes an appearance like sandstone.

Under microscope, plagioclase, augite and olivine are observed as phenocrysts and glass, plagioclase, pyroxene and opaque minerals are done as groundmass.

(4) Hematite Dacite (Dh)

This rock developes in central part of the survey area. It intruded into the Çağlayan Formation and was intruded by andesite (Ad). This rock which developes around Lahanos and Killik ore deposits intruded concordantly to host rocks at boundary zone between the Kızılkaya and Çağlayan Formations, and at boundary zone between dacite lava and its pyroclastics in the Çaglayan Formation.

This rock forms lava domes and small intrusive bodies. Lava domes develope in southern part of Lahanos area and in Çalkaya area, and their diameter in plan are less than 1km. Small intrusive bodies mainly show slender forms, and mainly extend towards north-east direction, but sometimes towards north-northeast or north-northwest direction.

Generally it shows reddish gray to reddish brown in color and contains rather amount of iron oxidized minerals (around 5%). It shows also massive in shape and well developed columnar joints. Quartz and feldspar can not be observed by naked eye, but sometimes feldspar crystals in size of 1mm diameter can be seen. Microscopic observation indicates that phenocrysts are composed of plagioclase, common hornblende and iron minerals, and that groundmass is composed of glass. Quartz, pyrite, hematite, chlorite and other clay minerals are considered to have been formed during alteration.

White to gray argillized zones are formed by strong alteration and such zones sometimes show reddish brown in color because of impregnated hematite.

(5) Porphyritic Dacite

This rock distributes mainly in northern part of the survey area, forming small intrusive bodies whose sizes are less than 1km in long diameter and less than 300m in short diameter. It intruded into the Çağlayan Formation and nevaditic dacite (Nd). It shows grayish white to grayish brown in color, and characteristically contains quartz and feldspar with 1~2mm diameter. It is fine and hard rock, and shows well developed columnar joints. It did not accompany hydrothermal alteration.

Under microscope, phenocrysts is composed of quartz, plagioclase, biotite and iron minerals, and groundmass is composed of glass, quartz and iron minerals. Quartz, chlorite and sericite were revealed to have been formed during alteration.

(6) Nevaditic Dacite(Nd)

This rock developes in southern and north-eastern parts of the survey area, forming big to small intrusive bodies. It intruded into the Çağlayan Formation and was intruded by porphyritic dacite(Dp). In north-eastern part of the survey area(Çalkaya area), it composes a part of big intrusive body which occupies more than 5km in plan, and in central and southern parts it composes many small bodies. These small bodies are inclined to extend usually towards north-east direction, but in some cases towards north-northeast direction.

It shows grayish white to gray in color, and contains commonly big crystals of quartz and plagioclase as big as 5mm diameter. It is generally fine grained, hard and massive.

Microscopic observation revealed that phenocrysts were composed of quartz, plagioclase, biotite and iron minerals, and that groundmass were composed of glass, plagioclase and opaque minerals. Alteration is thought to have formed quartz, chlorite, sericite and epidote.

Alteration such as argillization and hematitization is recognized at contact zone between Çağlayan Formation and this rock in Çalkaya area, but in other parts of the survey area strong alteration can not be observed.

(7) Biotite Dacite(Db)

This rock exists mainly in central part of the survey area as big to small bodies. These bodies show 5km as maximum long diameter and 1km as maximum short diameter, and less than 1km as minimum long diameter and less than 200m as minimum short diameter. It intruded into the Çağlayan Formation, extends towards north-west or north-northeast direction, and contains xenolith of hematite dacite(Dh). It shows gray to grayish black in color, and feldspar and biotite in 1~2mm diameter can be seen commonly. It is fine grained and hard, and flow banding structure are also commonn. It is generally fresh, but at boundary zones with the Çağlayan Formation white argillization and reddish brown hematitization are observed, and in some places it seems sandy due to weathering.

Microscopic observation tells that phenocrysts are composed of quartz, plagioclase, common hornblende and apatite, and that groundmass are composed of glass, plagioclase and opaque minerals. Quartz, pyrite, chlorite and other clay minerals are presumed to be formed during alteration.

2-2-2 Geological Structure

Generally the Çatak Formation shows north-east strike and dips south-westwards in south-eastern part of the survey area, and shows north-northeast strike and dips east-northeastwards in south-western and western part. Therefore, the Kızılkaya Formation was controlled by north-east and north-northwest structure and were deposited in structural basin opened northwards.

In western part where lowest members of the Kızılkaya Formation develope, they show north-northwest strike and dip east-northeastwards as well as the Çatak Formation. In central part where upper members of the Kızılkaya Formation develope, they show north-northwest or north-norteast strike and dip gently east-northeastwards or west-northwestwards. Strikely speaking, basin structure in the Çatak Formation was filled by volcanic effusive materials in age of the Kızılkaya Formation.

In central part, the Çağlayan Formation shows same dip and strike as the Kızılkaya Formation, but in northrn part it shows east-northeast strike and dips gently north-northwestwards. On overlooking from the Çatak to Çağlayan Formations, the more northern part they exist in, the steeper they dip. And then it is concluded that the southern part was raised relatively in these geological duration.

Intrusive rocks also were controlled by same geological structure as the Çatak to Çaglayan Formations. Namely in southern part where the Çatak Formation is predominat, intrusive rocks usually intruded north-eastwards equally as principal structure. In central to northern part where the Kızılkaya and Çağlayan Formations develope predominantly, they intruded north-northwestwards and north-northeastwards, besides north-eastwards and north-westwards.

In the survey area, no big faults can be found, but in southern part, faults extending north-westwards and north-eastwards are recognized. These faults are high angled and reverse faults. Furthermore dextral faults with north-east strike are seen in the Çağlayan Formation that exists in Çalkaya area, central part of the survey area, and reverse faults with north-northwest strike are seen in the Çağlayan Formation that developes in northern part.

2-2-3 Ore deposits and Ore Showings

As existing ore deposits and/or ore showings in the survey area, Lahanos, Killik, Kepçelik, Kızılkaya, Dickmen, Ağalık, Çımaklı, Karılar, Karaerik and other ore deposits or ore showings are well known. Lahanos mine is only one working mine and all of others were closed or have not been mined. Details of each ore deposits are explained as follows,

(1) Lahanos Ore Deposit

The ore deposit is located in central part of the survey area. At this moment, Demir Export company is mining underground. Demir Export company (1990) says that they estimated 1,500 thousand tons (average Cu 4.23% and average Zn 3.31%) as probable ore reserves.

The ore deposits are massive sulfide ore deposits which are contained in uppermost member of the Kızılkaya Formation, that is, dacite lava (Kdc). In ore horizon tuff (Kt2) that is defined as tuffaceous rocks exclusively including massive sulfide ore deposits, ferruginous chert zone are recognized in less thickness than 1m. As hanging wall of ore deposits, muddy rocks (Cms), dacite lava (Cdc) and pyroclastic rocks (Ctf) of Çağlayan Formation are observed. In some places, hematite dacite (Dh) intruded along boundary between ore deposits and overlying rocks. According to the result of chemical analysis are shown as follows, Au 0.4~6.3g/t, Ag 7~490g/t, Cu 0.28~24.20%, Pb < 0.01~3.64%, Zn 0.31~20.00%, Fe 9.61~45.80%, Mn < 0.01~0.08%, Ba 0.01~21.60%, La < 1~3ppm, Ce 1~13ppm, Nd < 5ppm, Sm < 1~7ppm, Eu < 1ppm, Tb < 1~2ppm, Yb 1ppm, Lu < 1ppm, U < 1~10ppm, Th < 1~1ppm.

Ore deposits are composed of massive to brecciated yellow ore and semi-black ore, and sometimes accompany siliceous ore and pyrite ore. Their maximum thickness in massive part is 15m and average thickness is 3~5m. Yellow ore contains rather much amount of Au, Ag and Cu, and semi-black ore shows high contents of Au, Ag and Zn. In pyrite ore, contents of these metals are low. Ba is contained more than 10% in parts of yellow and semi-black ores. According to microscopic observation, yellow ore consists of pyrite, chalcopyrite, sphalerite and barite as main components, and sometimes accompanies galena, tetrahedrite, bornite and arsenopyrite. Semi-black ore consists of pyrite, sphalerite and chalcopyrite as main components, and sometimes includes galena, tetrahedrite and barite. Pyrite ore consists mainly of pyrite, and includes small amount of sphalerite, chalcopyrite, galena and tetrahedrite. As gangue minerals,quartz, sericite and carbonate minerals besides barite are recognized. In massive ore,colloform texture made from pyrite, chalcopyrite and sphalerite are observed and framboidal pyrite is also seen.

The Kızılkaya Formation around ore deposits shows strong and white argillized alteration, and in some places shows silicification and disseminated pyrite. The Çağlayan Formation(hanging wall of massive ore deposit) also shows argillization and hematitization by later hydrothermal alteration than formation of massive sulfide ore deposits.

(2) Killik North and Killik South Ore Deposits

Killik North ore deposit is located at 2km south from Lahanos mine and Killik South ore deposit is located at 3km south from Lahanos mine. Probable ore reserves of 172 thousand tons(average Cu 1.1%, Zn 2.5%, Pb 0.7%) were estimated after 27 drilling holes(total length;2,440m), and they were stopped to work in spite of remained ore reserves of 90 thousand tons.

The type of both ore deposits is massive sulfide type. In Killik North ore deposit, dacitic pyroclastic rocks of the Kızılkaya Formation(Kt2) underlie, and muddy rocks(Cms) and dacitic pyroclastic rocks(Ctf) of the Çaglayan Formation overlie ore deposit. Andesite intruded into various parts of ore bodies.

In Killik South ore deposit, dacite lava(Kdc) and its pyroclastic rocks(Kt2) underlie, and muddy rocks(Cms) and dacitic pyroclastic rocks(Ctf) overlie ore deposit. Dacite lava below ore deposit seems porphyritic because of their phenocrysts such as quartz and plagioclase with 2~3mm diameter, and it is clearly different from dacite lava below Lahanos ore deposits that is aphyric.

According to chemical analysis, elemental contents of ore samples here are shown as follows,
Au 0.4~6.3g/t, Ag 7~490g/t, Cu 0.28~24.20%, Pb < 0.01~3.64%, Zn 0.31~20.00%, Fe 9.61~45.80%, Mn < 0.01~0.08%, Ba 0.01~21.60%, La < 1~3ppm, Ce 1~13ppm, Nd < 5ppm, Sm < 1~7ppm, Eu < 1ppm, Tb < 1~2ppm, Yb 1ppm, Lu < 1ppm, U < 1~10ppm, Th < 1~1ppm.

Ore deposits are composed of massive to brecciated yellow ore, semi-black ore and pyrite ore, and networked siliceous ore. Yellow ore shows high contents of Au, Ag, Cu and Zn, and in siliceous ore these elements are contained poorly. Ba is contained more than 10% in parts of pyrite and yellow ores. Under microscope, chalcopyrite, pyrite and sphalerite are observed as main components, and galena, tetrahedrite and barite are observed as subsidiary components in yellow ore. Semi-black ore consists of pyrite, barite, sphalerite and chalcopyrite. Pyrite ore mainly consists of pyrite and barite, and subsidiarily consists of sphalerite, chalcopyrite and tetrahedrite. As gangue minerals, quartz, sericite and carbonate minerals besides barite are seen. Colloform texture composed of pyrite is observed very often in ore.

(3) Kızıkaya Ore Deposits

The ore deposits exist in central part of the survey area. They were mined in rather big scale in the past. MTA surveyed in latter half of 1960's and Demir Export company followed exploration works. Demir Export company calculated 320 thousand tons (Cu 3.5%, Zn 2.8%, Pb 0.7%, Ag 77g/t) as remained ore reserves after they drilled 37 holes (total length;1,741m).

Disseminated ore, networked ore and dacite lava (Kdc) in the Kızılkaya Formation underlie, and muddy rocks (Cms) and dacitic pyroclastic rocks (Ctf) overlie massive sulfide ore deposits here. Disseminated~networked ore body shows rather large distribution range such as 1km × 1km in plan, and shows strong silicification, argillization and hematitization. Affect of mineralization is clearly and strongly attained to the Çağlayan Formation. At some spots in disseminated~networked ore body, sulfide minerals are reported to be concentrated.

Chemical analysis of ore samples show their result as follows,

Au 0.09~3.71g/t, Ag 2~212g/t, Cu $<$ 0.01~0.08%, Pb $<$ 0.01~14.7%, Zn $<$ 0.01~4.26%, Fe 1.20~33.20%, Mn $<$ 0.01%, Ba 0.01~33.90%, La $<$~6ppm, Ce $<$ 1~13ppm, Nd $<$ 5~5ppm, Sm $<$ 1~1ppm, Eu $<$ 1ppm, Tb $\leqq$ 1ppm, Yb $<$ 1ppm, Lu $<$ 1~2ppm, U $<$ 1~2ppm, Th $<$ 1~2ppm.

Ore deposits consist of massive black ore, pyrite ore and networked siliceous ore. Under microscope, in black ore sphalerite and galena are observed as main components, and pyrite, chalcopyrite and tetrahedrite are observed as subsidiary components. In pyrite ore, pyrite and barite are seen as main components, and sphalerite and chalcopyrite are seen as subsidiary components. As gangue minerals, barite, quartz, carbonate minerals (siderite, ankerite, rhodochrosite) and sericite are observed. In oxidized zone, secondary minerals such as limonite, hematite, bornite and covelline are recognized. Colloform texture made from pyrite is also seen commonly.

Black ore shows high contents of Au, Ag, Pb and Zn, but contents of these elements in pyrite ore and siliceous ore are not so much. In some parts of black and pyrite ores, Ba is included more than 30%.

(4) Kepçelik Ore Showing

The ore showing is located in south-eastern part of the survey area. They said that massive sulfide lens was found in exploration tunnel. Although two drill holes were performed by Etiank, any economical ore body could not be discovered. The old tunnel is located at the boundary of porphyritic dacite (Dp) and aphyric dacite (Cdc).

Dacitic pyroclastic rocks (Kt2) of the Kızılkaya Formation underlie, and muddy rocks (Cms) and pyroclastic rocks (Ctf) of the Çağlayan Formation overlie ore horizon. Porphyritic dacite (Dp) and hematite dacite (Dh) intruded between hanging wall and ore zone.

Result of chemical analysis from ore samples here are shown as follows,

Au 0.01~3.75g/t, Ag 2~281g/t, Cu 0.02~24.50%, Pb < 0.01~10.50%, Zn 0.44~31.20%, Fe 7.75~32.2%, Mn < 0.01~0.03%, Ba 0.02~1.07%, La < 1ppm, Ce < 1~7ppm, Nd < 5ppm, Sm < 1ppm, Eu < 1ppm, Tb ≦ 1ppm, Yb < 1ppm, Lu < 1ppm, U < 1~4ppm, Th < 1ppm.

Obtained samles are composed of semi-black ore, yellow ore, pyrite ore and siliceous ore. Microscopic observation shows that semi-black ore consists mainly of sphalerite, pyrite and chalcopyrite, and subsidiarily of galena, tetrahedrite and quartz. In some parts of this ore, colloform texture made by pyrite is recognized. Siliceous ore consists mainly of quartz and pyrite, and in several spots consists of sphalerite,quartz and sericite.

In yellow ore, Au, Ag, Cu, Pb and Zn are contained highly, and in siliceous ore these elements are not contained so much.

(5) Dikmen Ore Showing

The ore showing is located in eastern part of the survey area.

The ore showing is massive sulfide type which is included in upper-most members of the Kızılkaya Formation. Dacite lava (Kdc) and dacitic pyroclastic rocks (Kt2) underlie, and muddy rocks (Cms) and dacitic pyroclastic rocks (Ctf) overlie ore zone.

Chemical analysis from ore samples here show their result as follows,

Au 0.01~0.17g/t, Ag 1~30g/t,Cu < 0.1~1.28%, Pb < 0.01~0.62%, Zn < 0.01~7.51%, Fe 2.91~23.10%, Mn < 0.01%, Ba 0.01~0.08%, La < 1~5ppm, Ce 2~10ppm, Nd < 5ppm, Sm < 1ppm, Eu < 1ppm, Tb < 1ppm, Yb < 1ppm, Lu < 1ppm, U ≦ 1ppm, Th ≦ 1ppm.

The ore consists of massive to brecciated pyrite ore and networked siliceous ore. Under microscope in pyrite ore, pyrite is seen as main component, sphalerite is seen as subsidiary component, and tetrahedrite, quartz and carbonate minerals are reported as accessory minerals.

Siliceous ore shows high contents of Zn partly, but contents of metallic elements are usually low in pyrite ore and siliceous ore. Contents of Ba are also less than 1% in these ores.

(6) Ağalik Ore Deposit

The ore deposit is located in northern part of the survey area. MTA and Etibank performed exploration works, and 1,400 thousand tons (Cu 0.6%, Zn 2.0%, Ag 96g/t) were estimated as probable ore reserves.

The ore deposit is massive sulfide ore deposit which is contained in uppermost members of the Kızılkaya Formation. Dacite lava (Kdc) of the Kızılkaya Formation underlie and dacitic pyroclastic rocks (Ctf) of the Çağlayan Formation overlie ore deposits. Dacite lava below ore deposit here contains commonly big crystals of quartz and plagioclase with 2~4mm diameter, and is porphyritic as same as dacite lava below Kepçelik ore deposit. It is different from aphyric dacite lava below Lahanos ore deposit.

Chemical analysis of ore samples here show their result as follows,

Au 0.72~0.78g/t, Ag 16~31g/t, Cu < 0.01~0.05%, Pb 0.02%, Zn 0.08~0.18%, Fe 44.2~44.5%, Mn < 0.01%, Ba 0.10~0.93%, La < 0.1ppm, Ce 2~3ppm, Nd < 5ppm, Sm < 1ppm, Eu < 1ppm, Tb < 1ppm, Yb < 1ppm, Lu < 1ppm, U < 1ppm, Th < 1ppm.

Ore deposit is composed of massive to brecciated pyrite ore. Microscopical observation shows that pyrite ore consists of mainly pyrite and sphalerite, and includes barite and chalcopyrite as subsidiary minerals.

In pyrite ore, contents of Au, Ag, Cu, Pb, Zn and Ba are low and those of Fe are high.

(7) Çımaklı Ore Showing

The ore showing is located in northern part of the survey area. MTA and Etibank drilled 5 holes (total length;845m).

The mineralization zone is hosted in upper most of the Kızılkaya Formation. White argillized zone has occurred in dacite of the Kızılkaya Formation. Dacite lava (Kdc) of the Kızılkaya Formation underlie and dacitic pyroclastic rocks (Ctf) of the Çağlayan Formation overlie ore deposits. Dacite lava just under ore deposits contains commonly crystals of quartz and plagioclase with 2~4mm diameter, and is porphyritic as same as dacite lava below Kepçelik and Ağalık ore deposits. Hematite dacite (Dh) is reported to intrude between hanging wall and ore deposits.

Ore deposit is mainly composed of siliceous ore and pyrite ore. Microscopic observation shows that main mineralogical components are pyrite, chalcopyrite and sphalerite, and subsidiary components are tetrahedrite, galena and silver minerals. Quartz, barite, sericite and carbonate minerals are observed as gangue minerals. In some spots of dacite lava (Kdc), strong argillization with kaolinitization is seen.

(8) Karılar Ore Deposit

The ore deposit is in northern part of the survey area. MTA and Etibank drilled 3 holes (total length;325m), and afterwards they estimated 100 thousand tons (Cu 0.5~1.1%, Zn 0.7~2.5%, Pb 1.0%, Ag 50~69g/t, Fe 46.2%) as probable ore reserves.

The ore deposit is dissemineted~networked ore deposit which is contained in hematite dacite (Dh) and dacitic pyroclastic rocks (Ctf) of the Çağlayan Formation. Pyrite ore that looks like massive ore is reported in a small area of networked ore body.

Chemical analysis of ore samples here show their result as follows,

Au 0.07g/t, Ag 1~2g/t, Cu < 0.01~0.05%, Pb < 0.01%, Zn 0.02~0.03%, Fe 44.60~46.50%, Mn < 0.01%, Ba ≦ 0.01%, La ≦ 1ppm, Ce 3~6ppm, Nd < 5ppm, Sm < 1ppm, Eu < 1ppm, Tb < 1ppm, Yb < 1ppm, Lu < 1ppm, U < 1ppm, Th < 1ppm.

Ore deposit is mainly composed of disseminated to networked siliceous ore and massive pyrite ore. Under microscope, pyrite ore includes mainly pyrite and sphalerite, and subsidiarily chalcopyrite and quartz. Barite and carbonate minerals besides quartz are reported as gangue minerals.

Pyrite ore shows low contents of Au, Ag, Cu, Pb, Zn and Ba, and high contents of Fe.

(9) Karaerik Ore Deposit

The ore deposit is located in northern part of the survey area. MTA and Etibank have been explored for a long time but economical ore body was not confirmed yet.

The ore deposit is disseminated to networked ore deposit which is contained in dacite lava(Cdc) and dacitic pyroclastic rocks(Ctf) of the Çağlayan Formation. In some spots of disseminated ore body, pyrite ore that seems massive is reported. The mineralizaition is also observed in Porphyritic dacite(Dp) intrusive.

Ore deposits are composed of disseminated to networked siliceous ore and partly of massive pyrite ore. Under microscope, pyrite and sphalerite are observed as main components, and chalcopyrite, quartz, barite and carbonate minerals are observed as subsidiary components. Around marginal zone of intrusive rocks, small veins filled with manganese oxidized minerals are reported to exist. Around networked ore bodies, silicification, sericitization and limonitization due to alteration can be observed.

Chemical analysis from ore samples here show their result as follows,

Au 0.55 g/t, Ag 2g/t, Cu 0.025%, Pb < 0.01%, Zn 0.01%, Fe 46.6%, Mn < 0.01%, Ba < 0.01%,La < 1ppm, Ce < 1ppm, Nd < 5ppm, Sm < 1ppm, Eu < 1ppm, Tb < 1ppm, Yb < 1ppm, Lu < 1ppm, U 1ppm, Th < 1ppm.

Pyrite ore shows low contents of Au, Ag, Cu, Pb, Zn and Ba, and high contents of Fe.

(10) Dikence Mineralized Zone

This mineralized zone is located between Lahanos and Çımakli ore showing. The small mineralized zone was recognized by ground survey peformed by MTA.

Mineralized zones exist in dacite lava(Cdc) and dacitic pyroclastic rocks(Ctf) of the Çağlayan Formation, and hematite dacite(Dh) and biotite-dacite(Db) intruded around mineralized zones. Ore zone is presumed to be composed of massive and networked ore in small scale. Pyrite, sphalerite and chalcopyrite are reported as ore minerals, and quartz, sericite barite are also reported as gangue minerals.

(11) Bitene Area

This area is located between Lahanos mine and Killik ore deposit. MTA has surveyed this area, but real exploration works have not been performed yet.

Mineralized and altered zone developes widely along a branch of kızıl river, and floating ore were confirmed. Field survey for the ore showings here suggest the expectence of massive sulfide ore deposits that are contained in uppermost member of the Kızılkaya Formation. Dacite lava(Kdc) of the Kızılkaya Formation is presumed to underlie and dacitic pyroclastic rocks(Ctf) of the Çağlayan Formation is presumed to overlie the ore deposits. Dacite lava here presumed to underlie ore deposits is aphyric as same as footwall dacite lava in Lahanos area. Hematite dacite intruded between ore showings and hanging wall in some places. Andesite(Ad) also intruded into various parts of surrounding rocks and ore showings.

Floating ore is composed of semi-black ore showing banded structure, pyrite ore and siliceous ore. Under microscope, pyrite, sphalerite and barite were observed as main components in semi-black ore. Framboidal pyrite is also seen, and quartz and sericite are reported as gangue minerals.

Result of chemical analysis from floating ore samples is shown as follows,
Au $<$ 0.01~0.20g/t, Ag 1~3g/t, Cu $<$ 0.01~0.06%, Pb $\leqq$ 0.01%, Zn $\leqq$ 1%, Fe 5.22~31.20%, Mn $<$ 0.01%, Ba 0.04~0.58%, La 2~5ppm, Ce 5~8ppm, Nd $<$ 5ppm, Sm $<$ 1~2ppm, Eu $<$ 1ppm, Tb $<$ 1~2ppm, Yb 2ppm, Lu $<$ 1ppm, U 3~13ppm, Th 3~4ppm.

Au, Ag, Cu, Pb, Zn and Ba are contained poorly in pyrite ore and siliceous ore.

(12) Çalkaya~Taflancık Area

This area is in eastern part of the survey area and real exploration works have not been performed before this survey.

In this area, mineralized and altered zones were recognized at exposures of dacite lava(Kdc)of the Kızılkaya Formation and dacitic pyroclastic rocks(Ctf) of the Çağlayan Formation. Strongly argillized alteration, silicification and disseminated pyrite were also seen together in these rocks. But where the Kızılkaya Formation is thickly covered by dacite lava(Cdc) of the Çağlayan Formation and was intruded in its various parts by intrusive dacite(Dh), ore showings in the Kızılkaya Formation could not be confirmed directly from the surface.

Chemical analysis of ore samples here show as follows, Au 2.74g/t, Ag 21g/t, Cu 0.01%, Pb 0.09%, Zn 0.08%, Fe 9.05%, Mn $<$ 0.01%, Ba 0.01%, La 4ppm, Ce 8ppm, Nd $<$ 5ppm, Sm $<$ 1ppm, Eu $<$ 1ppm, Tb $<$ 1ppm, Yb $<$ 1ppm, Lu $<$ 1ppm, U 1ppm, Th $<$ 1ppm. Analized sample shows rather high contents of Au.

(13) Karaağç Area

This mineralized zone is located at 1.5km north from Kızılkaya ore deposit. Two mineralized zone are found. One is located in the weast slope of the ridge and the other is located in the east side of it. The former zone shows a mineralization of network- dissemination of sulfide. The later shows a land slide deposit(reworked) of massive pyrite ore accompanying chalcopyrite. MTA and Demir Export have investigated for this area but they could not catch any massive sulfide ore deposits.

(14) Others

The Çağlayan Formation and intrusive rocks develope between Lahanos and Killik ore deposits, and between Killik and Kepçelik ore deposits. In these areas, mineralized zones can be seen. Dissemination of pyrite and sphalerite can be observed commonly in altered zone showing silicification, argillization and hematitization.

In central part of the survey area where the Kızılkaya Formation developes widely along Kızıl river, and around Kozköy area in eastern part of the survey area, disseminated to networked mineralized zones composed of pyrite and sphalerite can be seen in dacite lava(Kdc) of the Kızılkaya Formation. Chemical analysis of ore samples here show as follows,

Au 0.01~0.05g/t, Ag 1g/t, Cu < 0.01%, Pb < 0.01%, Zn < 0.01%, Fe 20.70~36.40%, Mn < 0.01%, Ba 0.02~0.04%, La < 1~16ppm, Ce 2~38ppm, Nd < 5~20ppm, Sm < 1~2ppm, Eu < 1ppm, Tb < 1~2ppm, Yb < 1ppm, Lu < 1ppm, U 1ppm, Th ≦ 1ppm.

Any concentration of these elements can not be observed in analized samples.

2. Alteration

Alteration in this survey area can be divided into two types, that is, one is regional alteration and the other is mineralized alteration. Distribution patterns of alteration and details of altered zones are explained below. The distribution map of alteration zone is shown in Fig.II-2-3.

(1) Regional Alteration

The Çatak Formation mainly consists of andesite lava and its pyroclastic rocks, and generally shows green in the field. Feldspar, mafic minerals and glass of this Formation in southern part were replaced by alterration minerals. As altered minerals, quartz, albite and chlorite can be observed as main altered minerals, and calcite, montmorillonite, pyrite and zeolite(stilbite and laumontite) as subsidiary minerals. Sericite also can be seen around mineralized zones.

In northern part, the Çatak Formation shows weaker alteration than in southern part. Namely, albitization in plagioclase does not advanced so much, and montmorillonite and montmorillonite-sericite mixed layered mineral were formed mainly, and quartz, pyrite, albite, calcite and mordenite were formed subsidiarily.

The Kızılkaya Formation mainly consists of dacite lava and dacitic pyroclastic rocks, and contains massive sulfide ore deposits in its uppermost members. This Formation distributes in central to northern parts widely, and shows middle~strong regional alteration. It shows light green to grayey white in color. Most of original feldspar and glass were changed to altered minerals. Main altered minerals are quartz, albite, sericite and chlorite accompanying pyrite, montmorillonite and carbonate minerals such as siderite.

The Çağlayan Formation that developes in northern part of the survey area is mainly composed of dacite lava and dacitic pyroclastic rocks. Lava parts of this Formation usually show original colors due to very poor alteration, but pyroclastic parts show light yellow, light green and light blue in color because of weak alteration. Most of feldspar and glass existing far away from mineralized zones are remained to be unaltered. Montmorillonite is seen as main altered mineral, and montmorillonite-sericite mixed layered mineral, cristobalite and tridymite as subsidiary minerals.

The Çağlayan Formation that developes rather thinly in central part shows lower grade alterarion than in northern part, and usually shows light green in color, probably due to existence of Lahanos ore deposits in underlying the Kızılkaya Formation. Feldspar and glass were also more altered than those in northern part Albite, montmorillonite, montmorillonite-sericite mixed layered mineral and cristobalite can be observed as altered minerals.

Marginal zones of intrusive rock bodies were highly altered by mineralized alteration in some places, but generally they have very weak affect from regional alteration. Therefore only montmorillonite can be observed very rarely as altered mineral.

(2) Mineralized Alteration

In this survey area, alteration by mineralization can be recognized in various locations, besides regional alteration above mentioned. In the parts where the Çatak Formation developes mineralized alteration can not be observed in large scale. In mineralized area along intrusive bodies, strongly altered zone rich in sericite developes narrowly in albite-chlorite altered zone.

The Kızılkaya Formation includes many strongly altered zones around ore deposits, because it contains exclusively massive sulfide ore deposits. Specially in altered zones around Lahanos ore deposits and their neighboring Bitene mineralized area in central part of the survey area, and around Çalkaya~Taflancık area in eastern part, quartz, sericite, kaolinite dickite and pyrite were formed as main altered minerals, and alunite, pyrophyllite and sericite-montmorillonite mixed layered mineral were done as subsidiary altered minerals. Around Killik and Kızılkaya ore deposits in central part, around Kepçelik and Dickmen ore showings in south-eastern part, and around Ağalık, Çimaklı and other known ore deposits, quartz, sericite, pyrite and barite which are products under neutral acidity can be observed very commonly, and altered mineral formed in acidic condition such as kaolinite can not be observed.

Around disseminated to networked ore bodies contained in the Çağlayan Formation, strongly altered zones can be seen. In the areas between Lahanos and Killik, and between Killik and Kepçelik where the Çağlayan Formation developes, disseminated to networked ore bodies distribute intermittently and strongly altered zones were formed around them. In these altered zones, quartz, sericite and pyrite are observed usually, and kaolinite occasionally.

Around Çalkaya~Taflancık area in eastern part and around Karaerik and Karılar ore deposits in northern part, the Çağlayan Formation was altered by mineralization to produce quartz, sericite and pyrite in much quantity, and kaolinite and hematite in small amount.

In strongly altered zones around intrusive rock bodies, quartz, kaolinite and hematite were produced, but their distributing range is so small.

The K/Ar age of the sericite from the alteration zones around Kızılkaya and Karaerik ore deposits showed 77Ma. Which indicated late Cretaceous age.

Characteristics of regional alteration and mineralized alteration for each stratigraphical units are summarized as follows,

Stratigraphical units	Type of Alteration	Products by Alteration
Intrusive rocks	① Regional alteration;	No alteration~weak alteration ・Montmorillonite
	② Mineralized alteration; Around intrusive bodies White and red altered zones	Middle~strong alteration Acidic alteration ・Quartz ・Kaolinite ・Hematite/pyrite
Çağlayan Formation	① Regional alteration Light green altered zones	Weak alteration ・Montmorillonite ・Cristobalite ・Mordenite
	② Mineralized alteration White and red altered zones Disseminated to networked ore deposits	Middle~strong alteration Acidic~neutral alteration ・Quartz ・Kaolinite ・Sericite ・Pyrite/hematite
Kızılkaya Formation	① Regional alteration Light green altered zones	Middle~strong alteration Neutral alteration ・Sericite ・Chlorite
	② Mineralized alteration White altered zones Massive sulfide ore deposits	Strong alteration Neutral~acidic alteration ・Quartz ・Sericite ・Kaolinite ・Magnesite
Çatak Formation	① Regional alteration Green altered zones	Weak~middle alteration Neutral~alkaline alteration ・Chlorite ・Epidote ・Zeolite

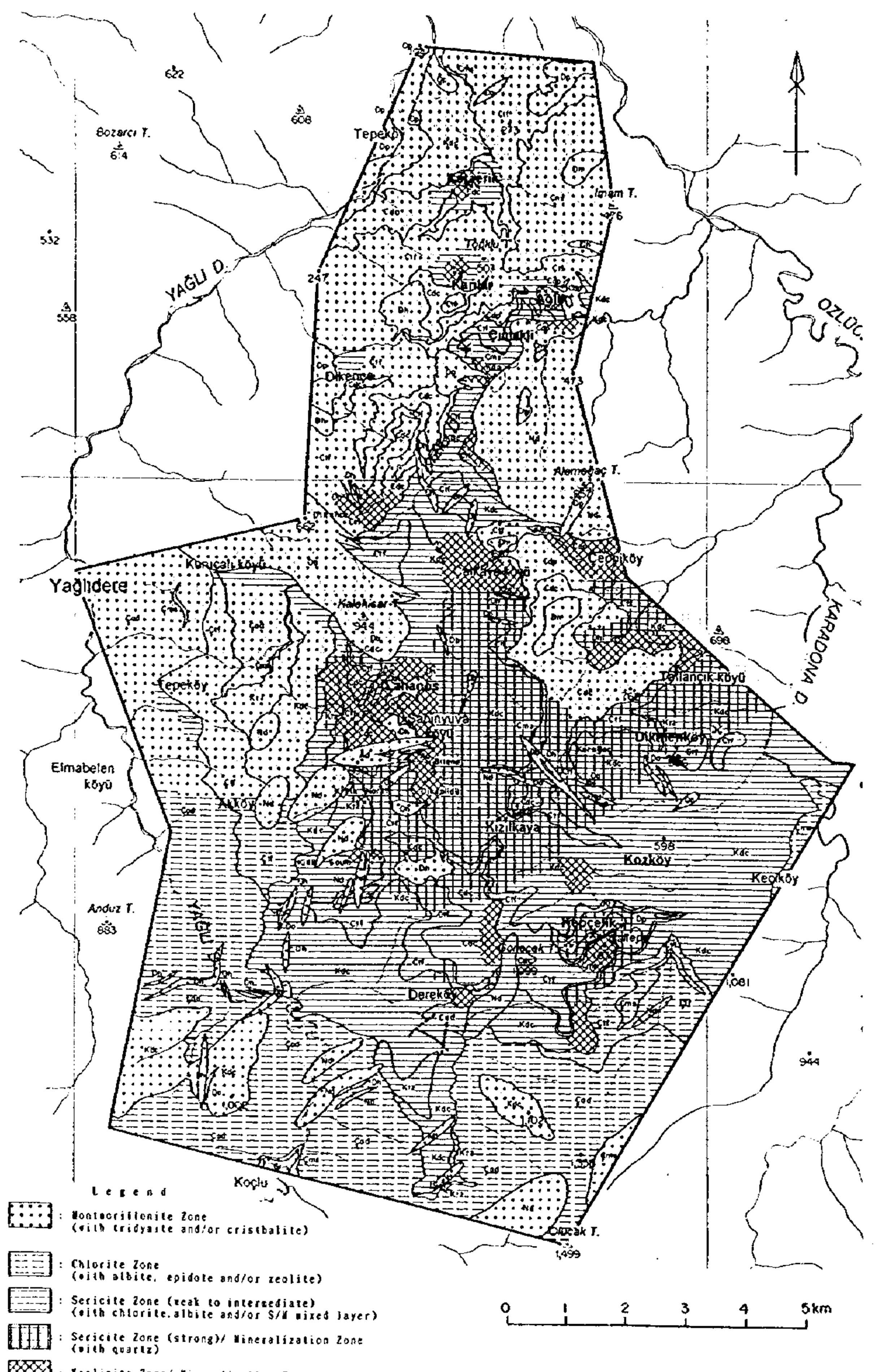


Fig.II-2-3 Distribution Map of the Alteration Zones

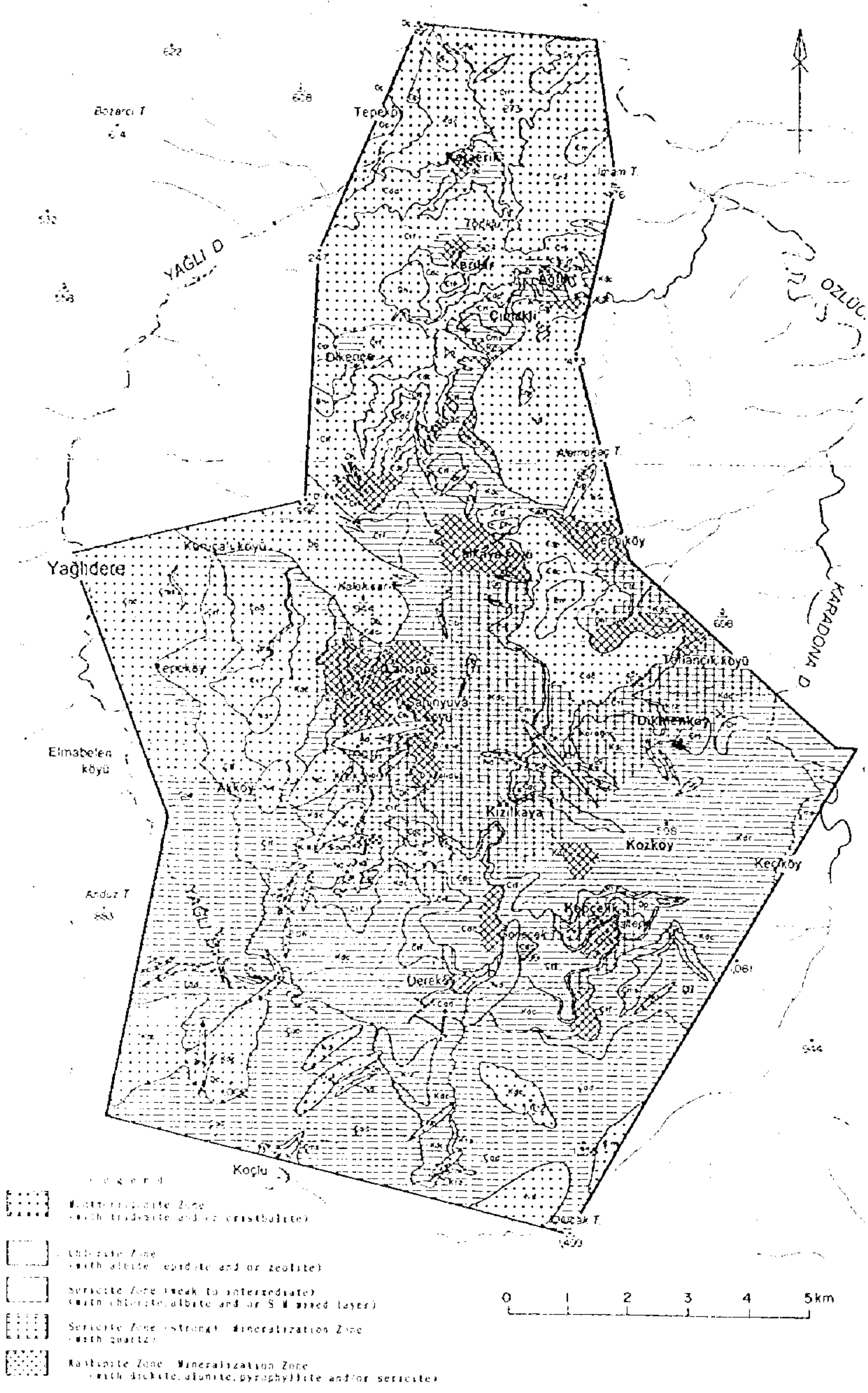


Fig.II-2-3 Distribution Map of the Alteration Zones

2-2-4 Geochemical Survey

Totally 560 rock samples were taken and analized elements are as follows, Au, Ag, Cu, Pb, Zn, As, Sb, Mn, Fe, Mo, Ba, SiO_2, Al_2O_3, TiO_2, Fe_2O_3, Cr_2O_3, CaO, MgO, MnO, Na_2O, K_2O, P_2O_5 and LOI (total 23 elements). For some samples in these 560samples, 10 more elements such as rare earth elements and others were analized additionally and these 10 elements are as follows, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, U and Th.

Totally 255 soil samples were analized for 11 elements as follows, Au, Ag,Cu, Pb, Zn, As, Sb, Mn, Fe, Mo and Ba.

After chemical analysis, basic statistics were calculated for each elements and principal components analysis, that is one of multi variables analysis, were performed for rock samples and soil samples. The results of the survey are shown in Table II-2-1~3 and Fig.II-2-4.

1. Geochemical Survey by Rock Samples

Contents of each elements are varying depend on rock facies, mineralization and alteration. According to their behaviours in the survey area, the elements were divided as follows,

① The elements considered to be added to host rocks during mineralization.

Au, Ag, Cu, Pb, Zn, As, Sb, Mo and Ba.

② The elements considered to indicate difference of rock facies(may be, added to host rocks during mineralization)

SiO_2, K_2O, P_2O_5 and LOI.

③ The elements considered to indicate difference of rock facies(may be, depleted from host rocks during mineralization)

TiO_2, CaO, U, Th, La and Ce.

④ The elements considered to indicate difference of rock facies(may be, added to or depleted from host rocks during mineralization)

Mn, Fe, Al_2O_3, MgO and Na_2O.

Massive sulfide ore deposits such as Lahanos, Killik, Kepçelik and others, and disseminated to networked ore deposits such as Karılar, Karaerik and others develope in the geochemical survey area using rock samples. Massive sulfide ore deposits are contained in uppermost members of the Kızılkaya Formation, but disseminated to networked ore deposits are contained in both the Kızılkaya and Çağlayan Formations because of their genetical relation with volcanic activities in the age of the Çağlayan Formation.

Among elements added during mineralization, Au, Cu, Pb, Zn, As, Sb and Mo are inclined to be concentrated around both massive sulfide and disseminated to networked ore deposits. Specially, As shows its concentration around all of known ore deposits in the survey area. Among elements added during alteration, SiO_2 and K_2O concentrate around known ore deposits, and their concentrating ranges are inclined to show a little wider than those of just above mentioned metallic elements. Among elements depleted during alteration, Na_2O and CaO are depleted around known ore deposits, and their depleted zones develope widely same as the additional SiO_2 and K_2O zones. The just above mentioned facts can be observed easily in the Kızılkaya Formation, but in the Çağlayan Formation too it can be observed.

SiO_2, K_2O, P_2O_5 and LOI have inclination to be contained poorly in neutral acidity rocks (Çatak Formation), to be contained abundantly in acidic rocks (Kızıkaya and Çağlayan Formations), and to be added to host rocks during alteration such as silicification and argillization (sericitization and montmorillonitization).

Among Mn, Fe, MgO and Na_2O, generally neutral acidity rocks (Çatak Formation) show much amount of Mn, Fe and MgO, and acidic rocks (Kızılkaya and Çatak Formations) include high contents of Na_2O. But the Çatak Formation shows rather high amounts of Na_2O besides Mg and Fe because of pyritization, chloritization and albitization by alteration. And in some parts of the Kızılkaya and Çağlayan Formations where manganese oxidized minerals, pyrite, chlorite and albit are formed by alteration, they show high amounts of Mn, Fe and MgO besides Na_2O.

Concentrated parts of these element show their own directions. For examples, Au concentrated parts around Lahanos, Kepçelik and Killik ore deposits are arranged in north-northwest and north-northeast directions. Concentrated parts of Cu, Pb, Zn, As and Mo are arrayed in north-west and north-east~east-northeast directions.

Result of principal components analysis for rock samples, that is one of multivariables analysis, is shown in Table 4-3. Principal components analysis were performed on 23 elements except rare-earth elements from 557 rock samples, and then contribution rate of 1st and 2nd principal components are calculated as 29%and 16% respectively. But that of 3rd component is less than 7%. Therefore, 45% of relations between each elements can be explained by 1st and 2nd principal components.

First principal component shows high factor loading on Al_2O_3, TiO_2, Na_2O, CaO,MgO, P_2O_5, LOI,Cu, Pb, Zn, Mn and Fe, and low factor loading on As, Sb, Mo, Ba,SiO_2 and K_2O. Second component shows high factor loading on Au, Ag, Cu, Pb, Zn, As, Sb, Fe and Mo, and low factor loading Mn, SiO_2, Al_2O_3, Na_2O, CaO and MgO. Namely 1st component indicates that most of rock forming elements and a part of metallic elements increase or decrease in their amounts together. Second component indicate that most of metallic elements behave together against rock forming elements.

High scored zones of 1st component develope in the Çatak Formation areas of southern and western parts of the survey area, and in the Çağlayan Formation areas of northern part, and low scored zones develope in the Kızılkaya Formation areas and around known ore deposits. Then, high scored zones of 1st component correspond very well to distribution patterns of weak mineralized zones in the Çatak and Çağlayan Formations.

High scored zones of 2nd principal component develope around known ore deposits in central and northern parts of the survey area. Therefore, high factor loaded elements as 2nd component are considered to be added to host rocks during mineralization, in spite of a slight difference in elemental assemblages in each ore deposits.

Away from known ore deposits, high scored zones of 2nd component are recognized in Bitene area south from Lahanos mine, between Lahanos and Killik, between Çalkaya and Taflancık, between Killik and Kepçelik, and between Lahanos and Dikence. Therefore new ore deposits like as Lahanos can be expected to be discovered in these areas. In central part of the survey area high scored zones of 2nd component show north-west to north-northwest and north-east to east-northeast direction as centers of each zones arranged around Lahanos ore deposits, and in northern part they show north-west and east-northeast direction as centers of each zones arranged around Karaerik ore deposits.

Fifty rock samples taken from Lahanos~Bitene area were chemically analized for 33elements, that is, rare earth elements such as La and Ce, and U and Th, besides above mentioned rock forming elements and metallic elements. And then principal components analysis were performed on these 50 samples. Contribution ratios of 1st and 2nd components are 19% and 15% respectively, and that of 3rd component is less than 10%. Therefore, 34% of elemental behaviours between each elements can be interpreted by 1st and 2nd components.

First principal component shows high factor loading on SiO_2, Na_2O, K_2O, CaO, MgO, U and Th, and rare earth elements such as La and Ce, and shows low factor loading on metallic elements such as Cu,Pb and Zn. In other words, rock forming elements behave with rare earth elements together, and metallic elements such as Cu, Pb and Zn behave against them. Namely 1st component shows high scores in weakly mineralized zones and shows very low scores in strongly mineralized zones. Low scored zones of 1st component are observed in the Kızılkaya Formation around Lahanos ore deposits and Bitene area, then these zones are presumed to be anomaly due to mineralization.

Second principal component shows high factor loading on SiO_2, Mo and Ba, and shows low factor loading on metallic elements such as Pb, Zn and Mn, rock forming elements such as CaO and MgO, and rare earth elements. Namely 2nd component shows high scores in strongly silicified zones and mineralized zones containing much barite.

High scored zone of 2nd component extends from Lahanos ore deposits to Killik Tepe in north-eastern direction. This zone is considered to be anomaly due to silicification and barite mineralization.

2. Geochemical Survey by Soil Samples

In the geochemically surveyed area using soil samples, there are massive sulfide ore deposits such as Lahanos and Killik South ore deposits, and networked ore deposits such as Killik North ore deposits. This survey was carried out between Kuruculu, Lahanos and Killik in central part.

Massive sulfide ore deposits are contained in uppermost members of the Kızılkaya Formation. But networked ore deposits are contained in both the Kızılkaya and Çağlayan Formations, because they seem to have genetical relations with volcanic activities in the time of the Çağlayan Formation..

In this area containing two types of ore deposits, Pb, Zn, As and Ba are concentrated in soils only on the Kızılkaya Formation, but Au, Ag, Cu, As and Mo are concentrated in both soils on the Kızılkaya and Çağlayan Formations. As mentioned just before, kinds of elements concentrated in soils on each Formations are different from each other.

Each concentrated zones has each characteristics in extending directions on distribution patterns and in assemblages of elements. For examples, in Lahanos North and Lahanos South areas all elements except Mn compose the concentrated zones extending east-northeastwards. Cu, Zn and Ba concentrated zones in Killik North~Bitene area extend north-eastwards. Au, Ag, Cu, Mo, Fe and Mn concentrated zones in Lahanos~Killik North area extend north-northeastwards. Au and Ag concentrated zones in Dikenlidüz~Güzlek area extend north-northwestwards. Sb concentrated zone in Killik North~Mizuran area extends north-northeastwards.

From above mentioned characteristics of metallic concentrations, the following interpretations can be obtained. Both mineralizations derived from massive sulfide ore deposits and from networked ore deposits are considered to be overlapped in Lahanos North and South areas, relating with geological structure(fracture zones) extending east-northeastwards through the age of the Kızıkaya and Çağlayan Formations. Mineralization from massive sulfide ore deposits show north-eastwards extension in the Kızılkaya Formation of Bitene~Killik areas, and mineralization from networked ore deposits show north-northwestwards and north-northeastwards extension in the Çağlayan Formation of Bitene~Killik areas.

Results of principal components analysis regarding soil samples are showm in Table. According this table, contribution ratios of first and second principal components are 38% and 16% respectively, but that of third component is very low and less than 8%. Therefore, 54% of whole behaviour of these elements can be explained by first and second principal components.

First principal component shows high factor loading on Au, Ag, Cu, Pb, Zn, As, Sb, Mn, Mo and Ba, and these elements are inclined to increse and decrease their contents together. Group of Cu, Fe and Mn contribute highly to second principal component.

High scored zones of first principal component are observed in the Kızılkaya Formation of Lahanos North, Lahanos South, Killik North, Bitene and Dikenlidüz areas, and specially high scored zones are confirmed around known massive sulfide ore deposits such as Lahanos and Killik ore deposits. And then first principal component can be concluded to be showing geochemical anomalies due to massive sulfide ore deposition. From the result of geochemical survey by soil samples, existence of massive sulfide ore deposits in the Kızılkaya Formation covered by the Çağlayan Formation such as Lahanos ore deposits can be expected in high scored zones of first principal component which extend north-eastwards in Lahanos South~Killik North areas and extend east-northeastwards in Killik South~Bitene areas.

High scored zones of second principal components are recognized in the Çağlayan Formation of Mizuran, Güzlek and Toroman Tepe areas, and in the Kızıkaya Formation of Lahanos North, Lahanos South and Killik North areas. Specially, second principal component shows high score around networked ore deposits in the Çağlayan Formation of Güzlek and Toroman Tepe areas. And then second principal component can be concluded to be geochemical anomaly due to networked ore deposition in the Çağlayan Formation that is younger than the Kızılkaya Formation. Therefore, from the points of soil geochemistry, networked ore deposits younger than massive sulfide ore deposits can be expected in high scored zones of second principal component which extend north-northeastwards in Toroman~Güzlek areas.

Table II-2-2 Correlation Coefficient of Geochemical Data (1)

Soil

	Au	Ag	Cu	Pb	Zn	As	Sb	Mn	Fe	Mo	Ba
Au	-										
Ag	0.29	-									
Cu	0.32	0.30	-								
Pb	0.42	0.37	0.56	-							
Zn	0.19	0.16	0.57	0.54	-						
As	0.44	0.36	0.46	0.74	0.36	-					
Sb	0.25	0.30	0.33	0.60	0.30	0.56	-				
Mn	-0.05	-0.05	0.10	-0.01	0.46	-0.11	-0.01	-			
Fe	0.33	0.18	0.41	0.52	0.50	0.34	0.31	0.31	-		
Mo	0.23	0.24	0.24	0.37	-0.01	0.39	0.31	-0.28	0.11	-	
Ba	0.29	0.28	0.29	0.34	0.10	0.41	0.24	0.00	0.21	0.22	-

Rock(1)

	Au	Ag	Cu	Pb	Zn	As	Sb	Mn	Fe	Mo	Ba
Au	-										
Ag	0.13	-									
Cu	0.24	0.25	-								
Pb	0.27	0.21	0.51	-							
Zn	0.05	0.22	0.50	0.60	-						
As	0.31	0.20	0.32	0.28	0.09	-					
Sb	0.28	0.21	0.31	0.33	0.15	0.63	-				
Mn	-0.24	0.05	0.03	0.08	0.42	-0.33	-0.30	-			
Fe	0.05	0.12	0.36	0.37	0.47	0.10	-0.01	0.50	-		
Mo	0.30	0.15	0.21	0.14	-0.09	0.47	0.41	-0.42	-0.14	-	
Ba	0.01	0.05	-0.05	-0.02	-0.16	0.17	0.15	-0.24	-0.41	0.20	-

Rock(2)

	SiO2	Al2O3	TiO2	Na2O3	K2O	CaO	MgO	Fe2O3	Cr2O3	MnO	P2O5	LOI
Au	0.01	-0.19	-0.10	-0.26	-0.04	-0.20	-0.21	0.05	0.13	-0.23	0.00	-0.01
Ag	-0.11	-0.08	0.04	-0.08	-0.03	0.00	-0.02	0.12	0.06	0.01	0.14	-0.02
Cu	-0.36	0.00	0.08	-0.15	-0.13	0.05	-0.05	0.36	0.03	0.00	0.16	0.24
Pb	-0.43	0.09	0.24	-0.14	-0.12	0.10	0.11	0.37	0.00	0.06	0.28	0.33
Zn	-0.45	0.20	0.27	0.11	-0.16	0.28	0.25	0.47	-0.06	0.40	0.25	0.35
As	0.06	-0.20	-0.07	-0.40	0.18	-0.36	-0.30	0.10	0.03	-0.33	0.01	-0.02
Sb	0.09	-0.42	-0.15	-0.33	0.08	-0.28	-0.27	-0.01	0.09	-0.30	-0.14	-0.07
Mn	-0.49	0.35	0.36	0.43	-0.18	0.62	0.57	0.50	-0.11	0.96	0.39	0.18
Fe	-0.70	0.21	0.38	0.11	-0.36	0.42	0.34	1.00	-0.16	0.47	0.47	0.46
Mo	0.17	-0.34	-0.18	-0.43	0.16	-0.39	-0.25	-0.14	0.06	-0.43	-0.16	-0.17
Ba	0.37	-0.14	-0.12	-0.12	0.61	-0.27	-0.14	-0.41	-0.02	-0.19	-0.16	-0.21

Rock(3)

	Au	Ag	Cu	Pb	Zn	As	Sb	Mn	Fe	Mo	Ba
La	-0.24	-0.22	0.03	-0.17	0.16	-0.41	-0.20	0.09	-0.09	-0.14	0.14
Ce	-0.03	-0.11	0.15	-0.12	-0.14	-0.26	-0.08	-0.02	-0.14	-0.02	0.05
Nd	-0.14	-0.21	0.16	-0.15	-0.10	-0.28	-0.13	0.29	0.02	-0.16	0.06
Sm	0.07	-0.16	-0.02	-0.24	-0.25	-0.21	-0.23	0.16	0.13	-0.14	0.07
Eu	0.00	-0.02	0.07	0.01	0.03	-0.05	-0.15	0.06	0.10	-0.12	-0.09
Tb	-0.03	-0.06	-0.21	-0.12	-0.14	-0.06	-0.05	0.06	-0.16	0.11	0.26
Yb	-0.23	-0.19	-0.28	-0.13	0.04	-0.35	-0.40	0.08	-0.28	-0.15	0.03
Lu	0.03	-0.08	0.05	-0.10	-0.02	-0.05	0.04	0.08	0.07	-0.31	0.09
Th	-0.10	-0.03	0.08	0.00	-0.07	-0.21	0.05	-0.34	-0.12	-0.05	0.33
U	0.09	0.06	0.05	0.13	0.21	-0.04	0.10	-0.05	-0.18	0.02	0.09

Table II-2-1 Statistical Values of Geochemical Data

Soil

	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)	Sb (ppm)	Mn (ppm)	Fe (%)	Mo (ppm)	Ba (ppm)
No. of Samples	255	255	255	255	255	255	255	255	255	255	255
Arithmetric Min.	< 0.01	< 0.01	9	54	17	4	< 1	29	0.89	< 1	52
Arithmetric Mean	0.13	2.06	136	252	125	70	5	436	3.25	3	304
Arithmetric Max.	8.79	175.00	3,600	10,100	799	4,000	313	2,670	13.40	65	3,330
Arithmetric σ	0.64	12.06	343	957	102	298	29	363	1.71	6	330
Geometric Mean	0.02	0.22	64	133	104	22	0.2	319	2.93	1	239
Geometric 0.5σ	0.05	0.84	106	184	138	38	0.4	480	3.64	2	325
Geometric σ	0.14	3.27	176	254	184	64	1.0	722	4.51	4	444
Background Value	0.002	0.1	15	17	36	7.5	2	320	2.10	2.5	300

Rock(1)

	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)	Sb (ppm)	Mn (ppm)	Fe (%)	Mo (ppm)	Ba (ppm)
No. of Samples	557	557	557	557	557	557	557	557	557	557	557
Arithmetric Min.	< 0.01	< 0.01	5	18	8	< 1	< 1	12	0.08	< 1	10
Arithmetric Mean	0.04	1.37	78	110	120	25	2	517	2.65	1	332
Arithmetric Max.	1.69	57.10	7,860	1,360	3,020	3,640	134	8,030	31.62	46	3,630
Arithmetric σ	0.11	2.90	373	102	252	162	8	764	3.06	4	378
Geometric Mean	0.01	0.56	31	94	71	6	0.3	229	1.74	0.2	210
Geometric μ+0.5σ	0.02	1.60	50	120	110	12	0.6	447	2.76	0.5	346
Geometric μ+1.0σ	0.05	4.60	82	154	171	26	1.4	874	4.39	1.1	568
Background Value	0.002	0.04	12	18	51	2.1	0.2	390	1.42	1.3	840

Rock(2)

	SiO2 (wt%)	TiO2 (wt%)	Al2O3 (wt%)	Fe2O3 (wt%)	Cr2O3 (ppm)	MnO (wt%)	CaO (wt%)	MgO (wt%)	Na2O (wt%)	K2O (wt%)	P2O5 (wt%)
No. of Samples	557	557	557	557	557	557	557	557	557	557	557
Arithmetric Min.	19.10	0.04	1.72	0.11	< 1	< 0.01	0.02	< 0.01	0.04	0.01	< 0.01
Arithmetric Mean	69.53	0.42	12.76	3.79	141	0.07	1.34	1.83	2.12	1.76	0.07
Arithmetric Max.	94.94	1.66	30.86	45.21	4,144	1.04	29.20	15.91	8.18	7.29	0.42
Arithmetric σ	11.20	0.25	3.30	4.37	273	0.10	2.98	2.20	1.93	1.33	0.06
Geometric Mean	68.44	0.36	12.27	2.48	67	0.02	0.30	0.95	1.25	1.09	0.05
Geometric μ+0.5σ	75.23	0.48	14.25	3.95	135	0.05	0.70	1.82	2.20	2.02	0.08
Geometric μ+1.0σ	82.70	0.68	16.55	6.29	273	0.13	1.63	3.52	3.88	3.75	0.13

Rock(3)

	LOI (wt%)	La (ppm)	Ce (ppm)	Nd (ppm)	Sm (ppm)	Eu (ppm)	Tb (ppm)	Yb (ppm)	Lu (ppm)	U (ppm)	Th (ppm)
No. of Samples	557	50	50	50	50	50	50	50	50	50	50
Arithmetric Min.	0.66	3	18	1	< 1	< 1	5	< 1	< 1	< 1	< 1
Arithmetric Mean	5.75	11	32	6	3	< 1	13	0.6	0.8	2	3
Arithmetric Max.	24.98	24	49	17	17	1	34	3	3	6	7
Arithmetric σ	4.21	5	8	55	3	< 1	6	0.9	0.8	2	1
Geometric Mean	4.55	10	31	3	2	< 1	12	0.2	0.4	1	2
Geometric μ+0.5σ	6.39	13	35	7	4	< 1	15	0.5	0.7	2	4
Geometric μ+1.0σ	8.98	16	39	13	8	< 1	17	0.9	1.1	3	6
Background Value	-	55	57	-	-	-	-	-	-	3.9	20

Table II-2-2 Correlation Coefficient of Geochemical Data (2)

Rock(4)

	SiO2	Al2O3	TiO2	Na2O	K2O	CaO	MgO	Fe2O3	Cr2O3	MnO	P2O5	LOI
La	0.07	0.22	0.00	0.07	-0.04	0.30	0.14	-0.09	-0.01	0.21	0.15	0.15
Ce	0.01	0.36	0.06	0.07	-0.02	0.22	0.05	-0.14	-0.05	0.11	0.12	0.16
Nd	0.01	0.28	0.04	0.13	0.01	0.46	0.27	0.02	-0.05	0.31	0.42	0.19
Sm	-0.02	0.07	0.23	0.12	0.04	0.27	0.16	0.13	0.22	0.18	0.19	0.01
Eu	-0.16	0.18	0.24	-0.06	0.02	-0.05	0.15	0.10	-0.02	0.12	-0.05	0.26
Tb	0.20	-0.31	0.14	-0.09	0.15	0.08	0.08	-0.16	0.03	-0.02	-0.03	-0.29
Yb	0.07	0.24	0.25	0.27	0.17	0.29	0.32	-0.28	-0.09	0.09	-0.16	0.07
Lu	0.12	-0.08	0.13	-0.03	0.10	-0.10	0.02	0.07	0.15	0.19	-0.21	0.08
Th	0.06	0.30	0.09	-0.12	0.07	-0.15	-0.05	-0.42	0.01	-0.20	-0.33	-0.10
U	-0.10	0.10	0.43	-0.06	0.40	0.01	0.26	-0.17	-0.10	-0.07	-0.36	0.01

Rock(5)

	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	Th	U
La	1.00									
Ce	0.81	1.00								
Nd	0.68	0.67	1.00							
Sm	0.14	0.26	0.26	1.00						
Eu	0.20	0.09	0.15	0.15	1.00					
Tb	-0.07	-0.15	-0.05	0.21	-0.06	1.00				
Yb	0.28	0.14	0.18	-0.02	0.23	-0.03	1.00			
Lu	0.28	0.18	0.06	-0.02	0.18	-0.03	0.17	1.00		
Th	0.42	0.38	0.07	-0.10	0.16	0.02	0.25	0.25	1.00	
U	0.13	0.04	-0.05	-0.09	0.20	0.06	0.40	0.18	0.51	1.00

Table II-2-3 Principal Components Values of Geochemical Data

1. Soil Sample

	Ratio	Factor Loading										
		Au	Ag	Cu	Pb	Zn	As	Sb	Mn	Fe	Mo	Ba
First Component	0.38	0.57	0.51	0.61	0.81	0.67	0.71	0.88	0.62	0.08	0.44	0.50
Second Component	0.16	-0.15	-0.23	0.62	-0.22	-0.13	0.19	-0.02	0.41	0.83	-0.55	-0.19

2. Rock Sample

	Ratio	Factor Loading										
		Au	Ag	Cu	Pb	Zn	As	Sb	Mn	Fe	Mo	Ba
First Component	0.29	-0.17	0.06	0.22	0.33	0.55	-0.28	-0.30	0.79	0.77	-0.45	-0.44
Second Component	0.16	0.54	0.37	0.68	0.67	0.43	0.72	0.67	-0.24	0.38	0.52	-0.01

	Ratio	Factor Loading											
		SiO2	Al2O3	TiO2	Na2O	K2O	CaO	MgO	Fe2O3	Cr2O3	MnO	P2O5	LOI
First Component	0.29	-0.82	0.57	0.59	0.38	-0.41	0.70	0.63	0.77	-0.17	0.76	0.55	0.54
Second Component	0.16	-0.27	-0.24	0.05	-0.50	-0.08	-0.21	-0.21	0.38	0.03	-0.27	0.13	0.27

3. Rock Sample(with rare earth elements)

	Ratio	Factor Loading										
		Au	Ag	Cu	Pb	Zn	As	Sb	Mn	Fe	Mo	Ba
First Component	0.19	-0.54	-0.67	-0.68	-0.63	-0.45	-0.76	-0.62	0.29	-0.71	-0.21	0.56
Second Component	0.15	0.00	-0.14	-0.26	-0.39	-0.51	0.09	0.17	-0.65	-0.32	0.35	0.26

	Ratio	Factor Loading											
		SiO2	Al2O3	TiO2	Na2O	K2O	CaO	MgO	Fe2O3	Cr2O3	MnO	P2O5	LOI
First Component	0.19	0.58	0.14	0.19	0.48	0.34	0.24	0.49	-0.71	0.02	0.27	-0.30	-0.57
Second Component	0.15	0.50	-0.51	-0.49	-0.38	-0.34	-0.65	-0.61	-0.32	0.24	-0.67	-0.26	-0.51

	Ratio	Factor Loading									
		La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	Th	U
First Component	0.19	0.37	0.25	0.27	0.19	0.03	0.20	0.44	0.11	0.26	0.12
Second Component	0.15	-0.35	-0.32	-0.50	-0.24	-0.29	0.18	-0.29	-0.12	0.09	-0.16

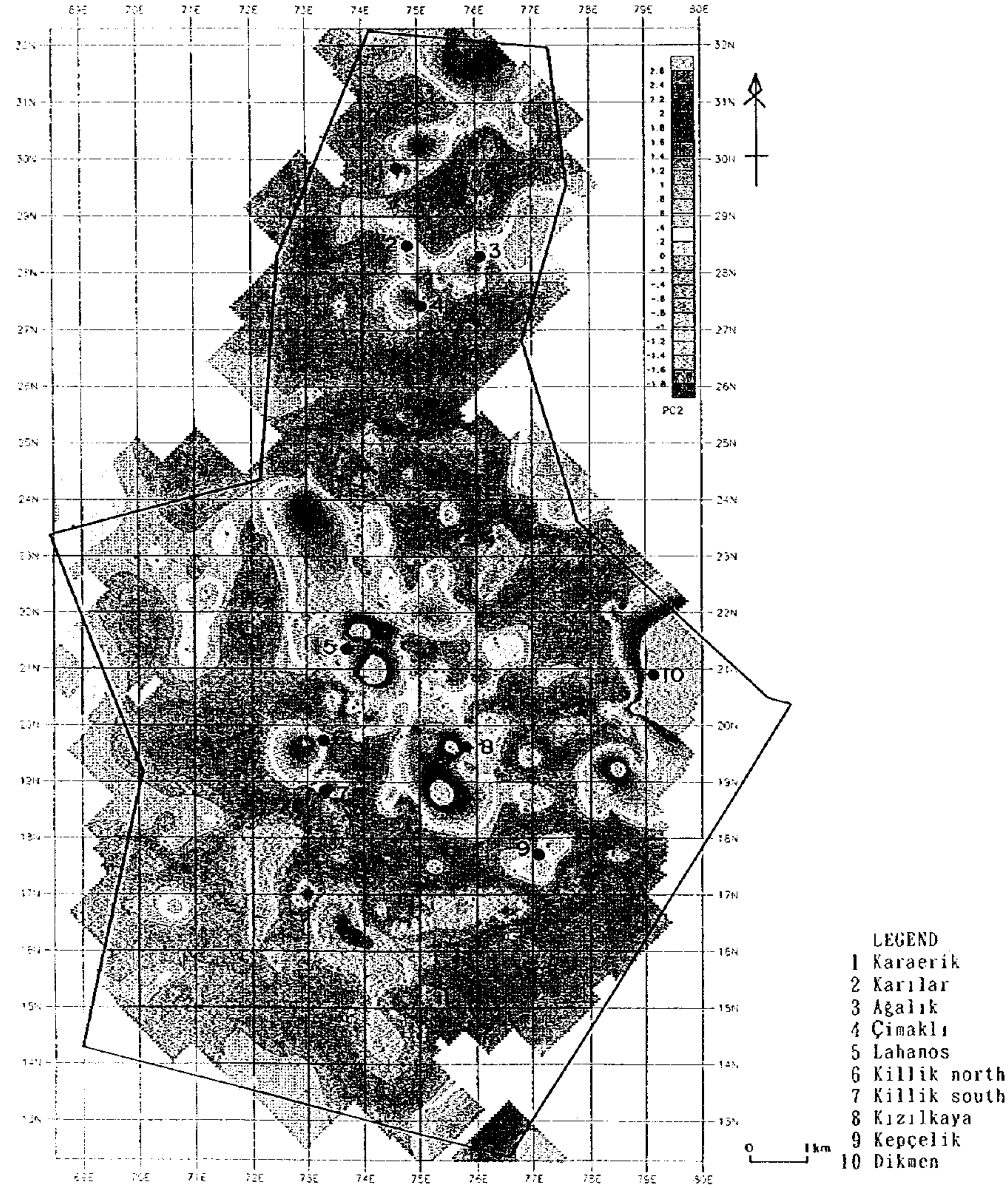


Fig.II-2-4 Results of the Geochemical Survey (2nd Principal Component of Rock Samples)

Chapter 3 Geophysical Survey

3-1 Gravity Survey

The flow chart of gravity survey is shown in Fig. II-3-1.

3-1-1 Method of the survey

For the survey area of 170Km^2 including Espiye area, gravity survey was carried out for 265 points in total. And, 112 samples for density measurement were collected.

Two sets of La Coste G gravity meter were used for the gravity survey and the base point (No.1000) of gravity survey was placed at the central part of the survey base, Espiye.

Gravity value of the base point was determined by measurement at the point between MTA gravity points Nos. 187 and 193 located close to Espiye.

Leveling measurement was conducted by referential positioning using GPS (Global Positioning System) static survey. The GPS base point was placed on a roof of a 5 stories building at central Espiye. Elevation of the point was determined by measurement conducted between the base point and Imam Tepe triangulation point (El. 476m) in northeast part of the survey area.

3-1-2 Results of the survey

1. Density Measurement of Rocks

The results of density measurement are shown in Table II-3-1.

The following characteristics are noted.

- In general, the lower Formation has the higher average density.
- Density difference between the Kızılkaya and Çatak Formations is rather great and that between the Çağlayan and Kızılkaya Formations is rather small.
- In the Çatak Formation, density of andesite lava and andesite tuff-breccia is high, but density of sandstone is relatively low.
- Density of intrusive rocks vary considerably and granitic rocks and biotite dacite show high values.

2. Relationship between Gravity Anomalies and Geological Structure.

The survey results are shown in Fig. II-3-2 to II-3-7.

In the proximity of survey area including Espiye area, regional gravity trend along NE-SW~ENE-WSW direction is dominant and Bouguer anomaly gradually increases towards the Black Sea. As for regional residual gravity map, distribution of high and low gravity anomalies as well as another distribution of pairs of rather small high and low gravity anomalies that diagonally crosses the former anomaly distribution are observed.

Relationship between short wavelength gravity anomaly (less than 7 Km anomaly scale) and geology thereof can be summarized as following.

High gravity anomalies occupied at eastern part of Karaerik deposit in northern area, northern part of Lahanos deposit in central area and southern part of Gonecek mountain in southern area. Among those, the anomaly at northern Lahanos corresponds to distribution of biotite dacite intrusive, and high gravity anomaly in the southern area corresponds to distribution of the Çatak Formation but cause of the anomaly in the northern area is not known (probably concealed intrusive).

Low gravity anomaly zones covered the northern part of Dikence district and eastern part of Çimaklı district in northern area, and coincides with distribution area of the Çağlayan Formation in Dikence district and nevadite dacite intrusive rocks in eastern part of Çimaklı district.

In the central area, the low gravity anomaly zone distributed between Taflancık-Kızılkaya-Killik as if the anomaly surrounds the high gravity zone at northern Lahanos district and, in here, corresponds to distribution area of the Çağlayan and Kızılkaya Formations and partially to tuffs of the Çatak Formation. Apart from the stratums, influence by argillization accompanying to mineralization can be possibly imagined to exist, in the whole vicinity area.

In the south area, the low gravity anomaly zone distributed in small zone reflecting the distribution of the Kızılkaya Formation.

3. Relationship between Gravity Anomaly and Ore Showings

The ore showings in this area concentrated in northern part and central part. Four ore showings of northern part tend to distribute around high gravity zone or transition part to low gravity zone. Among these ore showing at least Karaerik and Karılar deposits, are considered to belong to the stockwork type in origin, formed later than the massive sulfide type. The cause of generation of high gravity zone is unknown but there is some possibilities of concealed intrusive rocks that is related to those new mineralization.

In the central area, ore showings of Kepçelik and Dikmen tend to closely located to the high gravity zone, Also, as the ore showings located at the transition part from high gravity zone to low gravity zone, Lahanos, and Killik south mine, and Taflancık and Çalkaya can be indicated. As the ore showings located at low gravity zone, Killik north and Kızılkaya deposits and Karaağç district can be indicated.

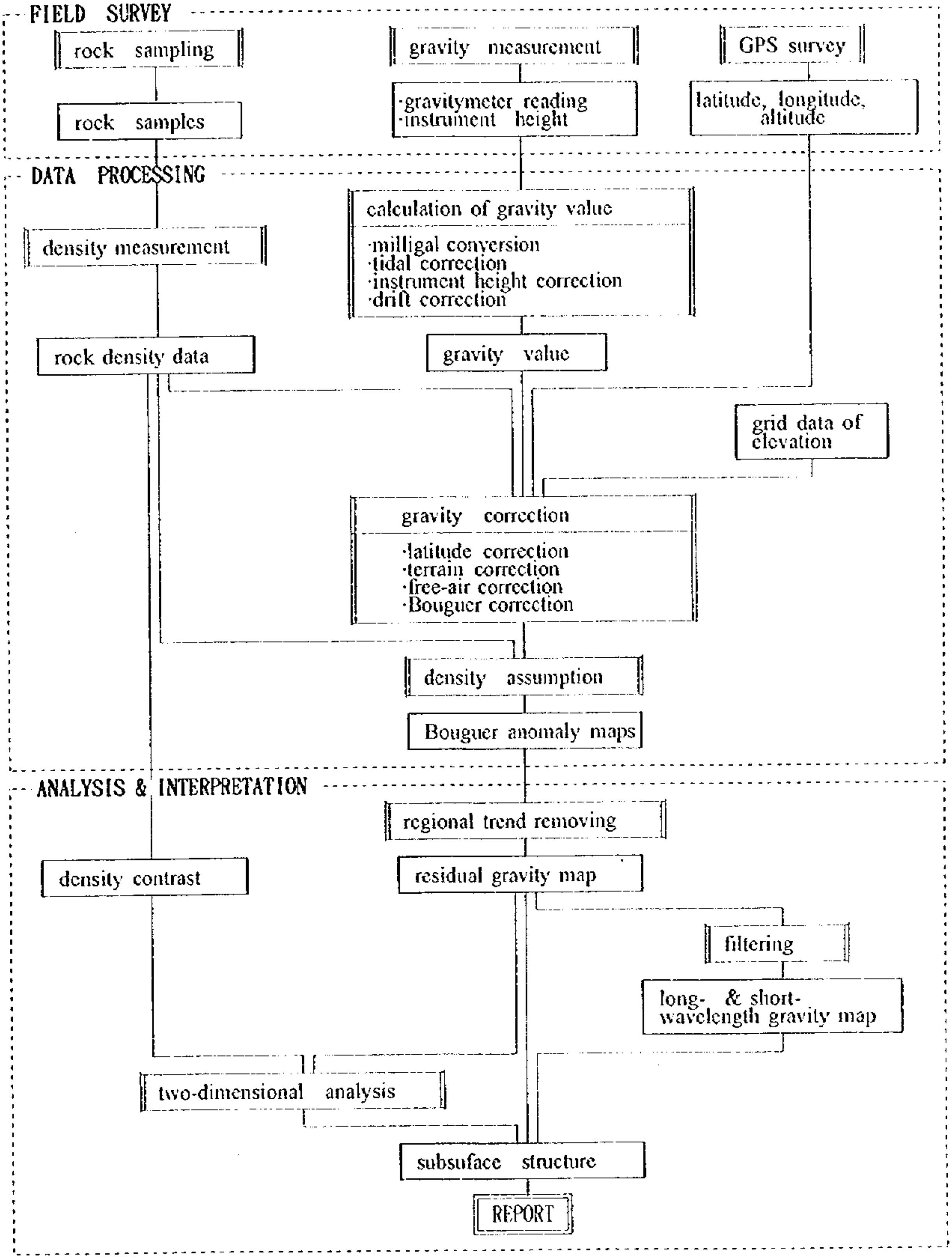
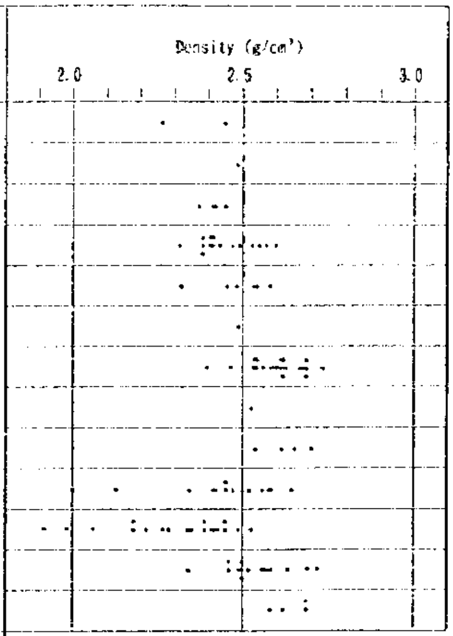


Fig.II-3-1 Flow Chart of Gravity Survey

Table II-3-1 Average Density Values of Rock (in wet)

Age	Startigraphic units	Rock name	Number	Average density (g/cm³)		Density (g/cm³)
MESOZOIC	Çağlayan Formation	Acidic Lapilli Tuff	2	2.35	2.41	
		Hematic Dacite	1	2.49		
		Dacite Lava	4	2.41		
	Kızılkaya Formation	Dacite Lava	15	2.46	2.47	
		Hematic Dacite	6	2.49		
		Dacitic Tuff Breccia	1	2.49		
	Çatak Formation	Andesite Lava	22	2.61	2.61	
		Sandstone	1	2.53		
		Andesitic Tuff Breccia	4	2.63		
	Intrusive Rocks	Nevaditic Dacite	11	2.44	2.43	
		Hematic Dacite	19	2.30		
		Dacite	15	2.54		
		Granitic Rock	4	2.65		
Average			108	2.48		

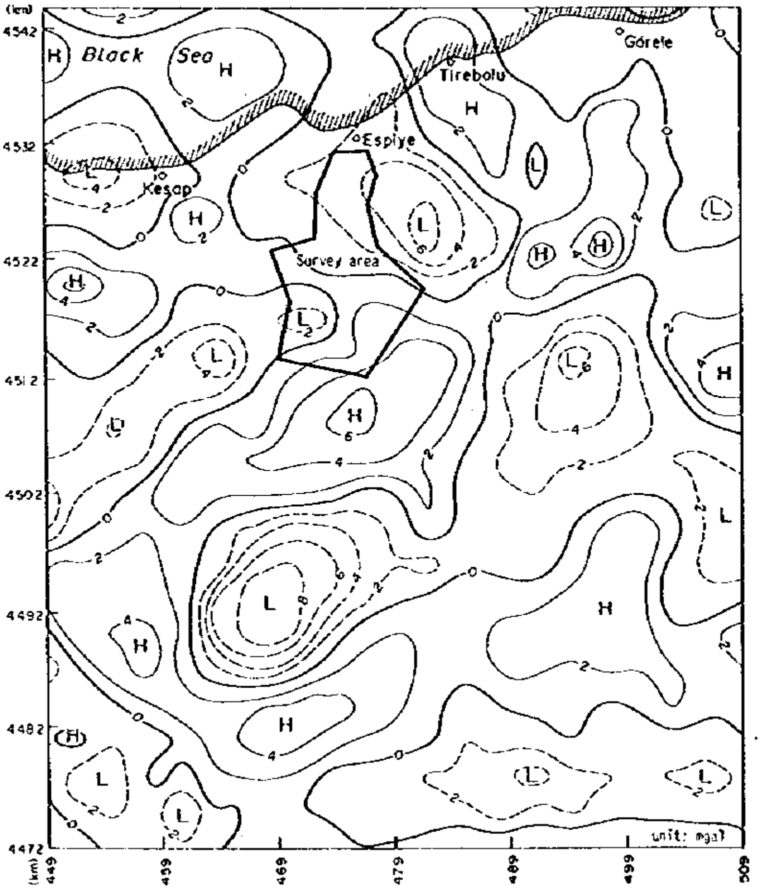


Fig.II-3-2 Regional Residual Gravity Map

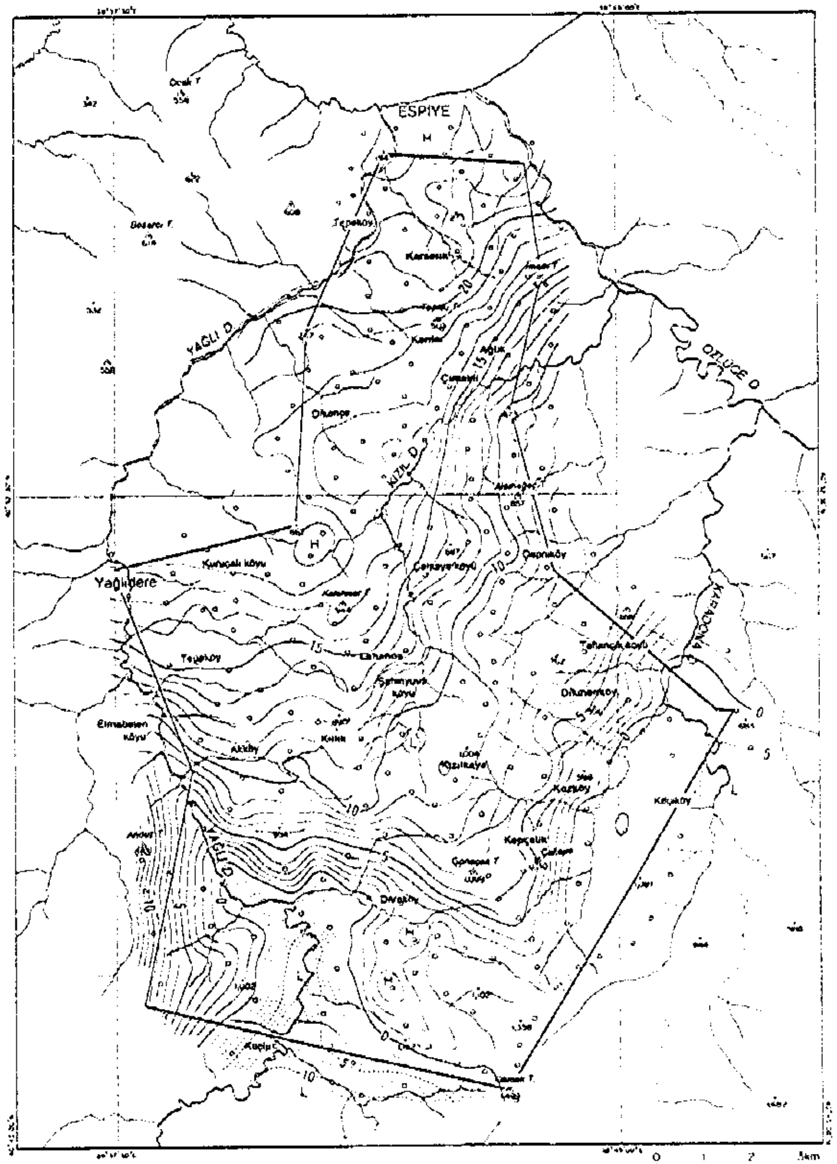


Fig.II-3-3 Bouguer Anomaly Map (ρ=2.40g/m³)

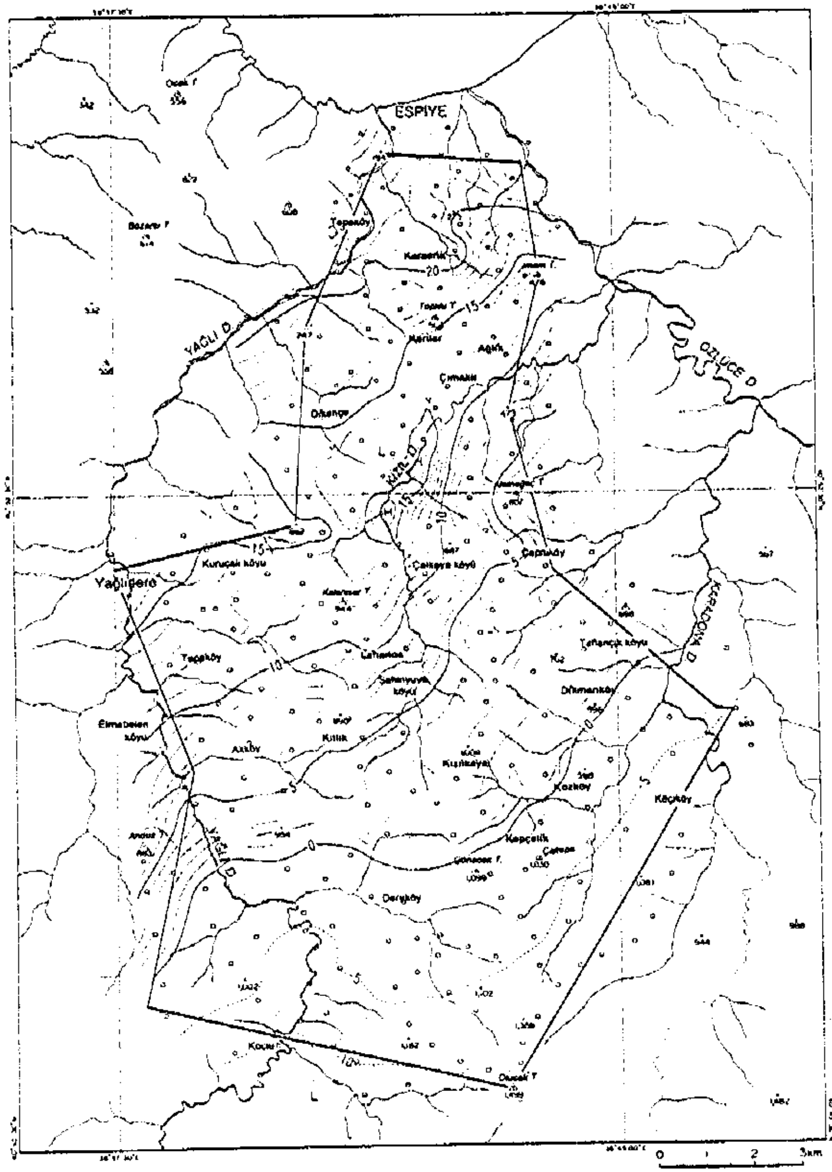


Fig.II-3-4 Bouguer Anomaly Map (ρ=2.60g/m³)

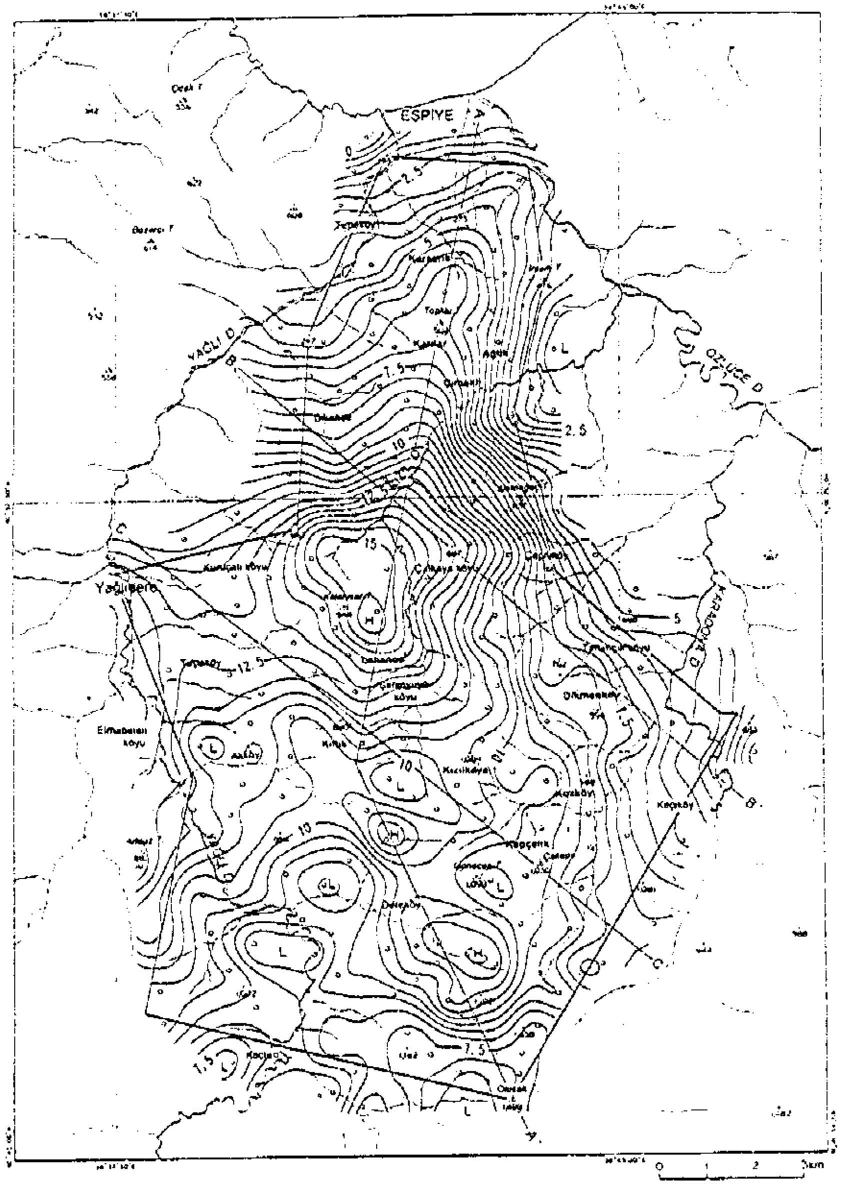


Fig.II-3-6 First Order Residual Gravity Map (Variable Density)

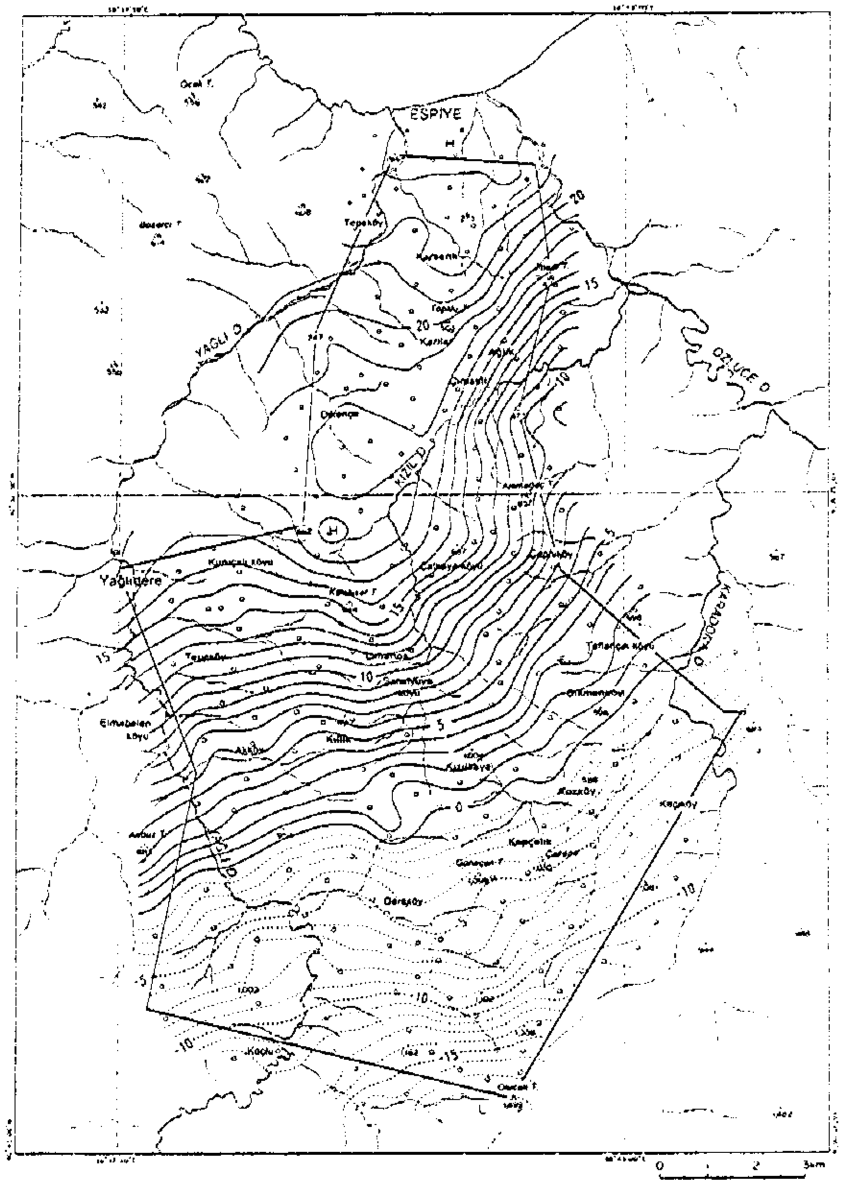


Fig.II-3-5 Bouguer Anomaly Map (Variable Density)

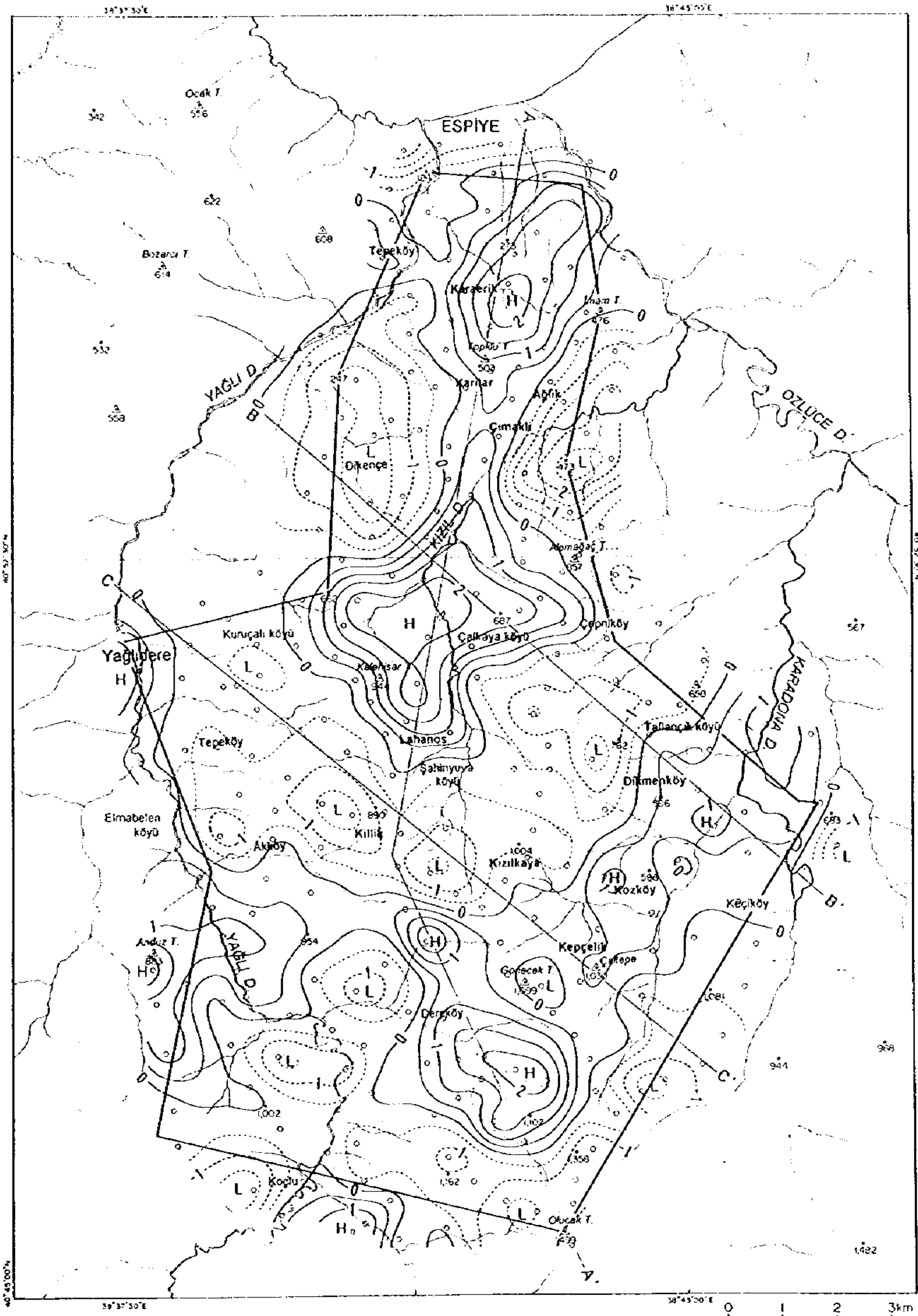


Fig.II-3-7 Short Wavelength Gravity Map

3-2 Electrical Prospecting (IP Method, CSAMT Method)

The survey programs were established by analysis of existing documents, geological and geophysical survey.

3-2-1 Content of the Survey

Survey method and specificatins are shown in Table II-3-2.

Table II-3-2 Specifications of the Geophysical Survey

	Method	Specifications
Phase I	Method	Induced Polarization Method
	Detection method	Time Domain
	Electrode arrangement	Dipole-Dipole Array
	Separation of electrode arrangement	a=100m
	Coefficient of electrodes separation	n=1-5
	Number of survey line	8
	Total length of survey line	23.3km
	Tests of physical property of rocks and ores (laboratory test)	45 specimens for chargeability and resistivity
Phase II	Method	Induced Polarization Method
	Detection method	Time Domain
	Electrode arrangement	Dipole-Dipole Array
	Separation of electrode arrangement	a=100m
	Coefficient of electrodes separation	n=1-5
	Number of survey line	14
	Total length of survey line	30.0km
	Tests of physical property of rocks and ores (laboratory test)	42 specimens for chargeability and resistivity
Phase IIII	Method	Induced Polarization Method
	Detection method	Time Domain
	Electrode arrangement	Dipole-Dipole
	Separation of electrode arrangement	a=200m, 100m
	Coefficient of electrodes separation	n=1-4
	Number of survey line	7
	Total length of survey line	21.4km
	Tests of physical property of rocks and ores (laboratory test)	23 specimens for chargeability and resistivity
	Method	CSAMT
	No. of Measuring points	25points
	No. of Frequency	12Frequency (1,2,4,8,16,32,64,128,256,512,1024,2048Hz)
	Length of Transmitter Antenna	1,500m
	Direction of Signal Source	N4° E
	Length of electric potential	50m

3-2-2 Operation of the Measurements

1. Measuring Method of the Survey

1) IP Method

The measurement had been carried out by the time-domain method. This method (abbreviation symbol T.D. method, transient IP method) sends an intermittent direct current (on/off 2.0sec) into the ground through a couple of current electrode C1,C2. After that, we get two date from a couple of potential electrodes P1,P2. One is the primary potential difference (Vp) just before switching off an electric current, the other is the secondary potential difference (Vs) during T time (T time is from 60msec to 1,590msec) after switching off an electric current.

In this survey, we had measured Vs during T time after switching off an electric current.

The concept of operation is shown in Fig.II-3-8. The concept of the method of measurement is shown in Fig.II-3-9 and the list of sampling time is shown Table in II-3-3.

IP effective measurement value is generally called with chargeability, expressed with Vs/Vp[mV/V].

The data of secondary potential difference in this survey has not received an influence of the effect of electromagnetic coupling. At this investigation, the chargeability adopted 820-1,050msec data.

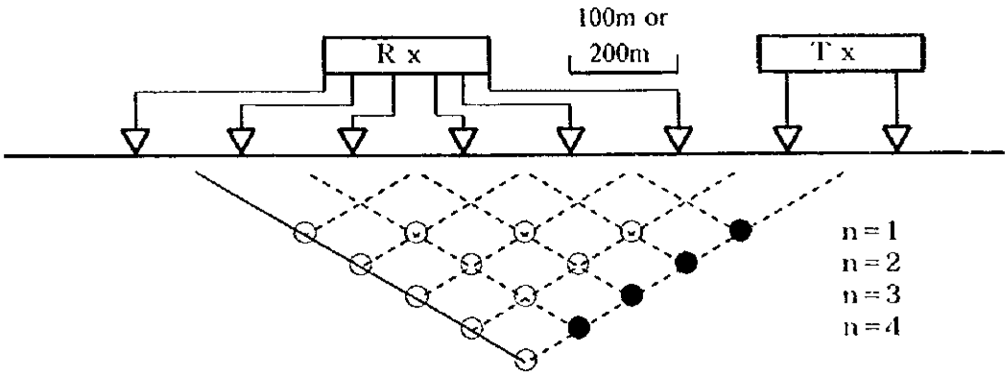


Fig.II-3-8 Concept of IP Operation

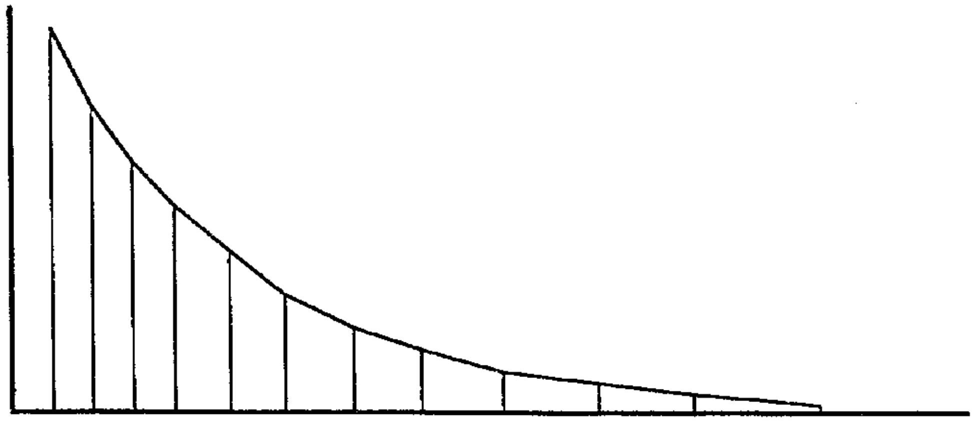


Fig.II-3-9 Concept of IP Method of Measurement

Table II-3-3 List of Sampling Time

Slice #	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14
Mid-Point	60	90	130	190	270	380	520	705	935	1230	1590 msec
Width	20	40	40	80	80	140	140	230	230	360	360 msec

2) CSAMT Method

Survey points were planned to start from the well known IP Survey Linens or corner of road. Open traverse method was adopted to locate exact length of electric potential. Transmitter Antenna was seting rever side of Yağlı Dere, it is about 4km from the survey area.

CSAMT Method (Controlled Source Audio Frequency Magneto-telluric Method) is a kind of MT Method. While MT Method is a deep sounding method with natural magnetic field as its signal source, CSAMT method is a MT method using artificial signal source which is often adopted for vertical sounding of the place whose depth is less than 1km.

This survey was performed by letting periodic (harmonic) current in the fields of audio frequency run continuously through a wire of 1.5km long whose both ends were grounded and magnetic field orthogonal to the electric field parallel to the signal source (grounded wire) at measuring points. Fig.II-3-10 is a conceptual chart of measurement. In measuring electric fields, copper electrodes were used as potential electrodes and electrode spacing was 1,500m. For measuring magnetic fields, induction coil magnetic antenna was used. The distance between the signal source and a measuring point should be three times (3δ) or more as large as the skin depth (δ) where the signal (electromagnetic wave) would become almost the same as plane wave. In the area nearer than this (called "near field") the assumption of the plane wave cannot be made and it is difficult to analyze the data.

Skin depth is the depth to which the electro-magnetic wave entered to homogeneous earth (resistivity: ρ) decays to 1/e (approx. 37%), and this depth is used as a standard. Skin depth can be obtained by applying the following formula and approx. 70% to the skin depth is considered as the sounding depth.

$$\delta = 503\sqrt{(\rho / f)}$$

δ : Skin Depth (m)

ρ : Resistivity of homogeneous medium ($\Omega \cdot$m)

f : Frequency (Hz)

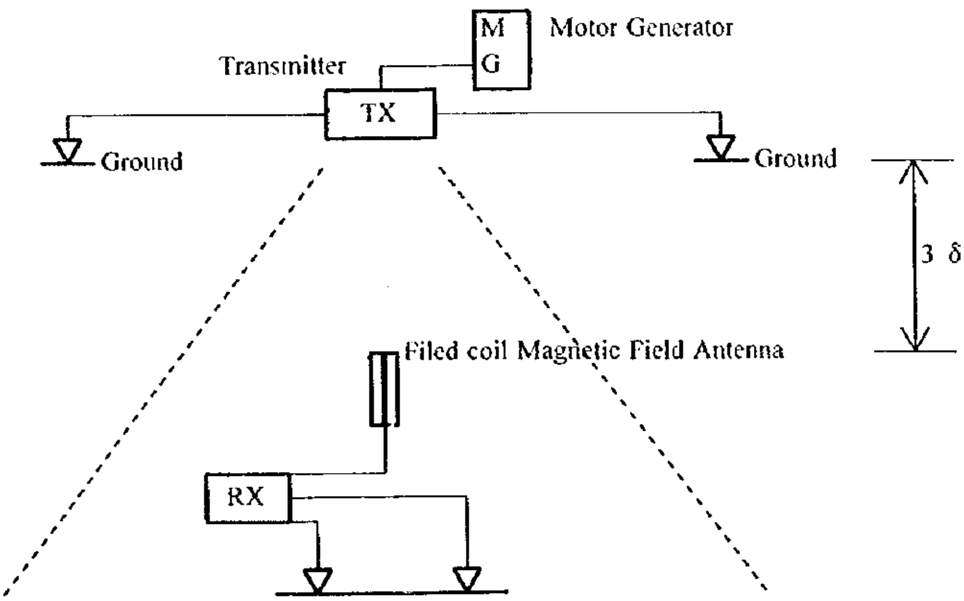


Fig.II-3-10 Conceptual Chart of CSAMT Measurement

2. Measuring Equipment and Materials

The measuring equipment and materials are shown in Table II-3-4.

Table II-3-4 List of Equipment and Materials

IP Method

Equipment	Maker	Type	Specification
*Transmitter	SCINTREX PHOENIX	TSQ-3 IPT-2	max putput; 1500V,10A 3KW maxoutput 1000V,15A 15kw
*Engine Generator	WESTINGHOUS ELECTRIC	10DE	220V 400Hz 30KW 2 cylinder 4 cycle
*Receiver	SCINTREX	IPR-12	8channel, 14window Input Range:50uV to 14V
Electrode		Current Potential	stainless steel CuSO4
Cable	FUJIKURA		VSF1.25mm ^{2} cable
Measuring compass	USHIKATA		Pocket compass 100m Esron tape
* Communication device	KENWOOD	TH-45G	Output:600mAhW Battery:12V

CSAMT Method

Equipment	Maker	Type	Specification
Transmitter	PHOENIX	LPT-2	max output: 1,000V 15A, 15Kw
Engin Generator	WESTINGHOUS		max output: 220V 30KW
Receiver	ZONG	GDP-16	16ch.Minimum detectable signal: 0.03 μ V
Transmitter controller	ZONG	XMT-12	Frequency range: 0.001-8kHz
Electrode			Stainless steel
Cable	FUJIKURA		VSF1.25mm ^{2} cable
Measuring compass	USHIKATA		Pocket compass, 100m Esron Ttape
Communication device	KENWOOD	TH-45G	Output 600mAhWk

* provided by MTA

Laboratory Test

Equipment	Maker	Type	Specification
Transmitter	IRIS	IP-L	Output:1uA - 100mA Max 10V
Receiver	SCINTREX	IPR-12	8channel, 14window Input Range:50uV - 14V
Electrode			Pt

3. Method of Analysis

1) IP Method

Phase I,II Survey (1995,1996)

Simulation analyses of resistivity and pseudo cross section of IP were carried out using infinite elemental program of 2nd dimension by Coggon(1971) and Rijo(1977). After data and modification were input in dialogue style and calculations were repeated several tens times, result was obtained approximately almost same as the presumed model on pseude cross sections.

Phase III Survey (1997)

For the analyses of the resistivity and the IP pseudosection, the 2-dimensional inversion program (Zong Corp.) was used.

Calculation was performed by every unit of 100m(Horizontal) × 50~70(Vertical).

The metal factor (hereinafter referred to as MF) was determined by a formula, that is, 100 × analyzed resistivity [Ω·m]/analyzed chargeability [mV/V].

2) CSAMT Method

1-D analysis

In order to obtain underground resistivity models, 1-D analysis was made on the assumption that the underground resistivity structure was of a horizontal multi-layered structure.

In the analysis, the data which had been obviously under the influence of noise were excluded. Apparent resistivity value was calculated for initial models of each frequency with parameters of the number of layers of horizontal multi-layered structure, thickness of layers and resistivity values. Then simulation technique was used to correct the parameters of the models so that they might become near to the values of actual measurement (the values obtained after near field correction based on the method of Yamashita and Hallof (1985).

2-D analysis

2-D analysis was conducted using 2-D inversion analysis program of Uchida and Ogawa (1993). In the analysis, the data under the influence of near field were excluded.

3-2-3 Results of the Survey

1. IP Method

1) Phase I (1995)

(1) Results of the Survey

Survey lines and locations are shown in Fig.II-3-22.

Results of the survey are summarized as shown in Fig.II-3-11~12 and Table II-3-5.

Table II-3-5 Results of IP Survey (Phase I)

Survey Line	Apparent Resistivity (Ω·m)	Chargeability (mV/V)	Characteristics of IP Distribution Pattern
A	40~2,675	-0.4~12.1	Weak IP anomaly around Nos. 6~7, 29.
B	7~1,432	0.9~10.1	Weak IP anomaly at depth of Nos.19~20.
C	14~798	-0.5~5.8	No anomaly.
D	6~8,306	-11.0~18.3	Clear anomaly at depth of No. 11 & weak anomaly around No. 63.
E	43~4,559	-0.7~14.8	Clear IP anomaly around Nos. 23~25 & weak IP anomaly at No. 14.
F	38~246	0.4~7.9	The deeper, the higher IP.
G	80~386	1.8~18.3	Clear IP anomaly around Nos. 3~10
H	19~1,267	0.9~15.7	High chargeability in high resistivity area.

(2) Results of Analysis

Results of analysis are summarized as shown in Fig.II-3-13~14 and Table II-3-6.

Table II-3-6 Summary of IP Survey (phase I)

Survey Line	Estimated Resistivity & Chargeability of Origin of IP Anomaly	Estimated Distribution Pattern of Origin of IP anomaly
A Lahanos area	120 Ω·m & 14mV/V 140 Ω·m & 17mV/V	· IP anomaly zone is expected to develop widely in depth. On surface it is thought to be flat. Geologically it distributes over the Kızılkaya to Çağlayan Formations.
D Çalkaya area	2 Ω·m & 42mV/V 35 Ω·m & 20mV/V 2 Ω·m & 40mV/V	· It is flat at deeper place than 200m. · It is flat at deeper place than 100m. · It is flat at depper place than 100m. Geologically it developes in both the Kızılkaya and Çağlayan Formations.
E Lahanos area	180 Ω·m & 10mV/V 30 Ω·m & 20mV/V	· It extends from surface to deeper places. · It developes from surface to depth. Geologically it developes in the Kızılkay Formation.
G Lahanos area	200 Ω·m & 15mV/V 20 Ω·m & 32mV/V	· It exists horizontally at deeper place than 100m. · It is the same anomaly that just above mentioned, but inclined. Geologically it exists in the Kızılkaya Formation.

(3) Consideration

Result of IP survey was summarized and was shown in Fig.II-3-22.

Higher resistivity area than 500 Ω·m was concluded to correspond very well to the distribution area of intrusive rocks. But in the area of around 200 Ω·m resistivity, correspondence of resistivity to rock facies could not be recognized clearly because of argillization and mineralization.

Low resistivity area like as around 50 Ω·m correponded very well to argillization relating with superficial alteration.

Regarding physical properties of samples, high grade ore showed low resistivity and high chargeability, but low grade ore showed low resistivity and variable chargeability.

Higher chargeability than 200 Ω·m in itrusive rock area was due to the existence of magnetite.

Anomalous chargeabilities were observed in A, D, E and G survey lines. In depth of F and H survey lines, weak IP anomalous zones were estimated to exist.

After simulative analysis on A, D, E and G survey lines, shallow IP anomaly in A line was expected to have derived from depth where intrusive rock showed high chargeability or dacitic pyroclastics were slightly mineralized.

IP anomaly in D line was concluded to have shown the effect from deeply existing mineralized zone in the Kızılkaya and Çağlayan Formations.

IP anomalies in E and G lines were considered to have shown the effect from mineralized zone in dacite lava of the Kızılkaya Formation.

IP anomalies in D, E and G lines were concluded to have derived from mineralized zones, therefore further detailed surveys are requested to be performed in these areas and to clarify them.