No. 6

REPUBLIC OF TURKEY

REPORT ON GEOLOGICAL SURVEY OF TUNCELİ AND KOPDAĞ DISTRICTS, EASTERN TURKEY

(CONSOLIDATED REPORT)

FEBRUARY, 1981

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 the Republic of Turkey, decided to conduct a geological survey for mineral exploration in Tunceli and Kopdağ district, eastern Turkey, and commissioned its implementation to the Japan International Cooperation Agency.

The Agency, taking into consideration such specific nature of the survey work as geological and mineral resources exploration, requested the Metal Mining Agency of Japan for its cooperation to accomplish the task within a period of four years.

This survey has been carried out for four years from 1977 to 1980, and it was able to accomplish on schedule under close collaboration with the Government of the Republic of Turkey and its various authorities.

This report submitted hereby summarizes the results of the various survey performed during four years.

We wish to take this opportunity to express our heartfelt gratitude to the Government of the Republic of Turkey and the other authorities concerned for their kind cooperation and support extended to the Japanese survey team.

February 1981

Keisuke Arita

Keisuke ARITA
President
Japan International Cooperation Agency

Masayuki Nishiie

Masayuki NISHIIE
President
Metal Mining Agency of Japan

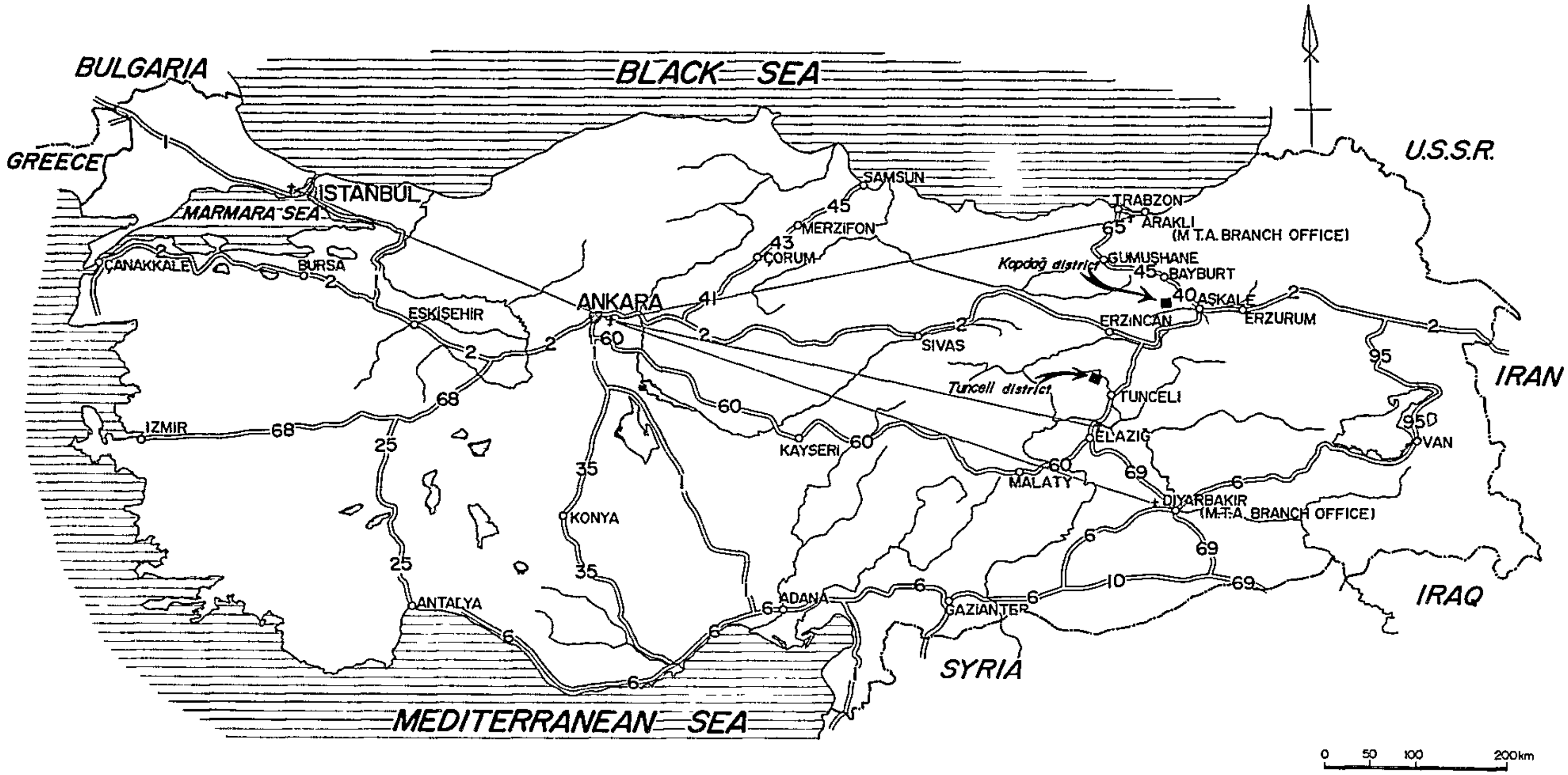

Fig. 1-1 Location Map of Tunceli and Kopdağ District

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1. RÉSUMÉ

(1) Basic survey for mineral resources development was conducted during the period of four years from 1977 to 1980. The surveyed areas were in Tunceli and Kopdağ districts which are located about 600 km east of Ankara at the eastern part of the Republic of Turkey. In the Tunceli district, copper, lead and zinc were the target commodities and geological survey, geochemical survey, geophysical survey (IP), and drilling were carried out for the project. In the Kopdağ district, the objective was chromium and geological survey, survey of abandoned adits and trenches, stripping, and drilling were conducted.

(2) Tunceli was a geologically virgin area, and thus the work started from geological analysis of aerial photographs during the first year of the project. The geology of the area was classified into some geological units, faults inferred, and the altered zones were extracted by this photogeological work. During the second year, geological reconnaissance and geochemical survey were conducted on the basis of the results of the photogeological analysis, the stratigraphy was clarified, and also the altered zones investigated. The Mamlis and Sin areas were delineated as being the most promising from these investigations and were geologically surveyed in detail. The activities of the third year were aimed at obtaining information from the deeper subsurface zones. These included geophysical prospecting (IP) at Mamlis and Sin areas, and semi-detailed

geological survey at the central part of the Tunceli district. During the fourth (the last) year, the promising IP anomalies were drilled. Meterisler, Sincik, and Ağtaş areas were surveyed in detailes and supplementary geochemical samples were collected. These three areas were selected from the anomalies obtained from the geochemical survey.

(3) Basic geological investigation had not been conducted in the Kopdağ district in spite of the existence of the Ezan and Coşan mines which operate during the summer season and many remnants of old mine workings in the district. During the first year of the project, aerial photographs were analysed geologically and the distribution of the ophiolite group was outlined. The work during the second year clarified the stratigraphy and mineralization of the area through geological studies and investigation of old adits and trenches. It became clear through these work that the ore deposits of the Ezan and Coşan mines were of large scale and that the mine area had high mineral potential and detailed geological investigation was conducted in the area of the two mines. Work was conducted in the third year with the purpose of determining the three dimensional extent of the ore bodies. It included stripping and drilling in the Ezan mine area as well as detailed geological studies near the ore deposit, also detailed geology was investigated near the deposits of the Coşan mine. It was shown that stripping was a very effective

prospecting method under the conditions prevailing near the mines, and therefore, stripping was conducted near the two mines during the last project year.

(4) The amount of operations conducted during the period of four years is as follows:

Tunceli district

Geological analysis of aerial photographs (1:25.000)	760 km^2
Geological reconnaissance survey (1:250.000)	640 km^2
Semi-detailed geological survey (1:10.000)	155 km^2
Detailed geological survey (1:2.000)	22 km^2
Number of stream sediment samples collected	225 pcs
Number of soil samples collected	2,279 pcs
Geophysical prospecting (IP)	53.6 km
Drilling (5 holes)	1,175.7 m

Kopdağ district

Geological analysis of aerial photographs (1:25.000)	820 km^2
Geological reconnaissance survey (1:25.000)	320 km^2
Semi-detailed geological survey (1:10.000)	120 km^2
Detailed geological survey (1:2.000)	10 km^2
Detailed geological survey (1:1.000)	2 km^2
Adits investigation	950 m
Stripping	2,570 m^3
Drilling (14 holes)	1,004.15 m

(5) The geological basement of the Tunceli district in the Paleozoic Munzur Formation which is unconformably overlain by Eocene Atadoğdu, Bentepe, Kamışlık Formations. These Eocene strata are, in turn, unconformably overlain by Miocene Düzpelit, Tırnas, Cevizlik, and Savular Formations. The relation is conformable among the Miocene formations. The Munzur Formation which forms the geological basement of this area has been considered to be Permian in age and the lithology is mainly crystalline limestone, pelitic schist, and green schist. Mesozoic strata are lacking, and Eocene Atadoğdu Formation overlies the Paleozoic Munzur Formation unconformably. The Tertiary Atadoğdu, Bentepe, and Kamışlık Formations are flysch type sedimentary rocks deposited in relatively stable deep marine environment under the influence of the basement, namely Paleozoic Munzur Formation. Later, dacitic igneous activity started in Miocene age and Düzpelit Formation was formed under shallow marine conditions. Tırnas Formation was deposited during dormant period of the volcanoes, dacitic volcanic activity became active again and Cevizlik Formation was formed. After this was the period of andesitic activity and Savular Formation was deposited over a wide area. Göktepe Formation was deposited in Pliocene after the volcanic activity ceased.

(6) The Munzur Formation in the Tunceli district underwent regional metamorphism and then block faulting in E-W direction in the Eocene age.

This formation is widely distributed to the east of the Munzur River which flows in the N-S direction and also in the southern part of the area. There are no Mesozoic sediments in the area, but small bodies of ophiolite which was formed towards the last phase of the Alps orogeny crop out in the northern part of the surveyed area. The Tertiary sediments consist mainly of Eocene calcareous mudstone. This is affected by the structure of the basement and gradually shows wavy structure with southward dip along the Büyük River from the south to the western part of the area. From the central to the northern part, this formation is distributed in semi-dome structure around the block faulted Munzur Formation. Marine regression occurred in this area at one stage from late Eocene to Miocene. The uplifted part between the Mount Karataş and the Kakbil Village, a precursor of Miocene volcanism, was heavily eroded. This uplift became the centre of shallow marine dacitic volcanism in Miocene. And the whole area became a depositional site of dacitic pyroclastics and of dacite volcanic rocks.

During this period, Sin dacite and other dacitic bodies intruded into the uplifted Kakbil-Karataş zone, and somewhat later, quartz diorite intruded into the periphery of the uplifted zone. Then, following the above, intrusion of dikes occurred in parts around the uplifted zone.

(7) The centre of the volcanic activity in the Tunceli district was the uplifted part between Karataş and Kakbil. Volcanic rocks with somewhat different lithology have intruded widely along the uplifted zone. The dip of the formations is northward on the north side of the uplift and southward to the south. Quartz diorite-diorite which intruded after the dacitic rocks are distributed at some distance from the uplift. Mineralization is not found to the south of the uplift where dacite and diorite are intruded. It is found only in the uplifted zone in the south and to the north. The major types of the mineralization are Sin mineralized zone which is associated with dacite and Mamlis and Kört mineralized zones associated with quartz diorite. The former type is dissemination in the igneous bodies while the latter types are network and veins in the peripheries of the igneous bodies and in Kamışlık and Düzpelit Formations which are in contact with these bodies.

Sin mineralized zone occurs in the uplifted part, and the mineralization is especially strong at the periphery of the Sin dacite body. Mamlis and Kört mineralized zones are related to the intrusion of quartz diorite and the veins are developed along the fissures of N-S system while the network mineralization occurs along the E-W trending fissure system.

(8) In the Tunceli district, the alteration at Sin and Mamlis areas was noted as the result of geological and geochemical surveys, and the IP anomalies were drilled. It was shown by the drilling that in the Sin area, although of low grade, network type copper-zinc mineralization occurred

widely in strongly altered dacite~andesite bodies. In the Mamlis district, only the pyrite-bearing silicified zone was drilled.

The above results show that further prospecting is warranted in the Sin area. It should be conducted on the basis of the results of the studies where malachite stains are found on the surface, IP anomalies, and the drilling work. The prospecting should be extended into the Meterisler area as further drilling results become available. In the Mamlis area, only the localities near the mineralized zone have been prospected. It will be necessary to construct roads, and drill locations where IP anomalies are extracted and gossans observed on the surface.

(9) The sedimentary formations of the Kopdağ district consists of Meyramdağ limestone which ranges in age from the uppermost Jurassic to lower Cretaceous, Kopdağ limestone of Miocene to Pliocene, and quaternary and later sediments. These formations other than the quaternary deposits, strike approximately in ENE ~ WSE direction and dip gently northward monoclinally.

The Kopdağ district is in an ophiolite zone, and the intrusive bodies consist of sheets of ultramafic to mafic-intermediate igneous rocks. This ophiolitic group is distributed widely with ENE~WSW strike - same as the sedimentary formations. This group intruded into the lower Meyramdağ limestone and is unconformably overlain by the Kopdağ limestone. The intrusion of the ophiolitic group is believed to be Cretaceous to Paleogene and is classified into three zones, namely southern harzbergite, northern dunite, and northern harzbergite zones.

(10) The ultramafic and associated rocks of the Kopdağ district forms intrusive sheets piled northward in the ophiolite cumulative sequence. The sequence is harzburgite · pyroxenite - dunite · pyroxenite - gobbro-diorite - basalt. Cumulating structure is often observed in chromite ores. At the northern end of the mafic body, harzburgite zone is repeated in the pile. This position of harzburgite in the intrusive body is inferred to be the result of E-W structural faults.

The faults and folds of this district were formed during and after the igneous intrusion. The major faults of the region are of N-S and E-W systems. Small faults and small folds in the limestone at the boundary with the ultramafic bodies have random directions. The N-S fault system comprises faults of NE-SW, N-S, and NW-SE strike and the horizontal displacement is less than 400 m. The faults of this system occur frequently near the Ezan mine and the ultramafic rocks are cut into blocks. The faults of the E-W system are not clearly confirmed in this district. These faults are older than those of the N-S system and their direction is approximately parallel to the elongation of the ultramafic bodies, namely ENE~WSW.

(11) The Coşan and Ezan mine areas are in the ophiolite zone and the northern dunite zone. Sepentinite derived from dunite is predominant in these two areas and the serpentinite is grouped from field evidences into massive serpentinite, foliated serpentinite and serpentinized dunite. It is seen at the surface that the ore deposits occur in the foliated serpentinites, the continuity can be traced, and the direction of the extension of the deposit agrees with that of the serpentinized dunite.

There are many faults near the Ezan deposit and they comprise the ENE-WSW system which is the same as the elongation of the ore deposit and the N-S system which is normal to this direction. On the other hand, the ore deposit of the Coşan mine is displaced by faults of irregular directions, but it has been confirmed that there is only one ore horizon. At the Ezan mine, however, at least three ore horizons have been confirmed.

Most of the ore deposits are of disseminated type, but the ore shoots are massive and they are observed frequently at Batı Ezan and other ore bodies. In these ore shoots, faults and fractured zones are developed and Kämmererite and uvarovite occur along these disturbed zones. Cumulite structure is developed in the disseminated ores.

(12) In the Kopdağ district, the emphasis of the work was at the Ezan and Coşan mine areas. Stripping was done and the horizontal extension and the relationship of the ore bodies were clarified. In the Ezan mine area,

the downward extension of the Batı Ezan, B Kafa, C Kafa ore bodies were confirmed by drilling. It was shown by the past work that stripping is very effective for investigating the horizontal outline of the ore bodies, and it will be necessary as the next step to determine the downward extent by drilling.

The host rock of the ore body is dunite, and it is intensely serpentinized near the ore deposits, and hydrothermal kämmererite and uvarovite are abundant near the ore shoots. These zones are intensely fractured. Vegetation is lacking on the surface, the climate is continental and arid, resulting in intense weathering. Also there are many faults near the ore deposits. And therefore, will be necessary to use low viscosity mud water, oversize bit, oversize casing, and to take measures for preventing lost circulation during drilling operation. It is expected that the ore reserves of the two mines will increase greatly by careful prospecting as described above.

2. INVESTIGATION ACTIVITIES

The basic survey of the Tunceli and Kopdağ districts was started in October 1977 with the purpose of providing basic data for the development of mineral resources. The target commodities for the Tunceli district were copper, lead, and zinc. That for the Kopdağ district was chromium. Both districts were geologically virgin areas, and the first step was to extract the promising areas from photogeological analysis. Field work was started in 1978.

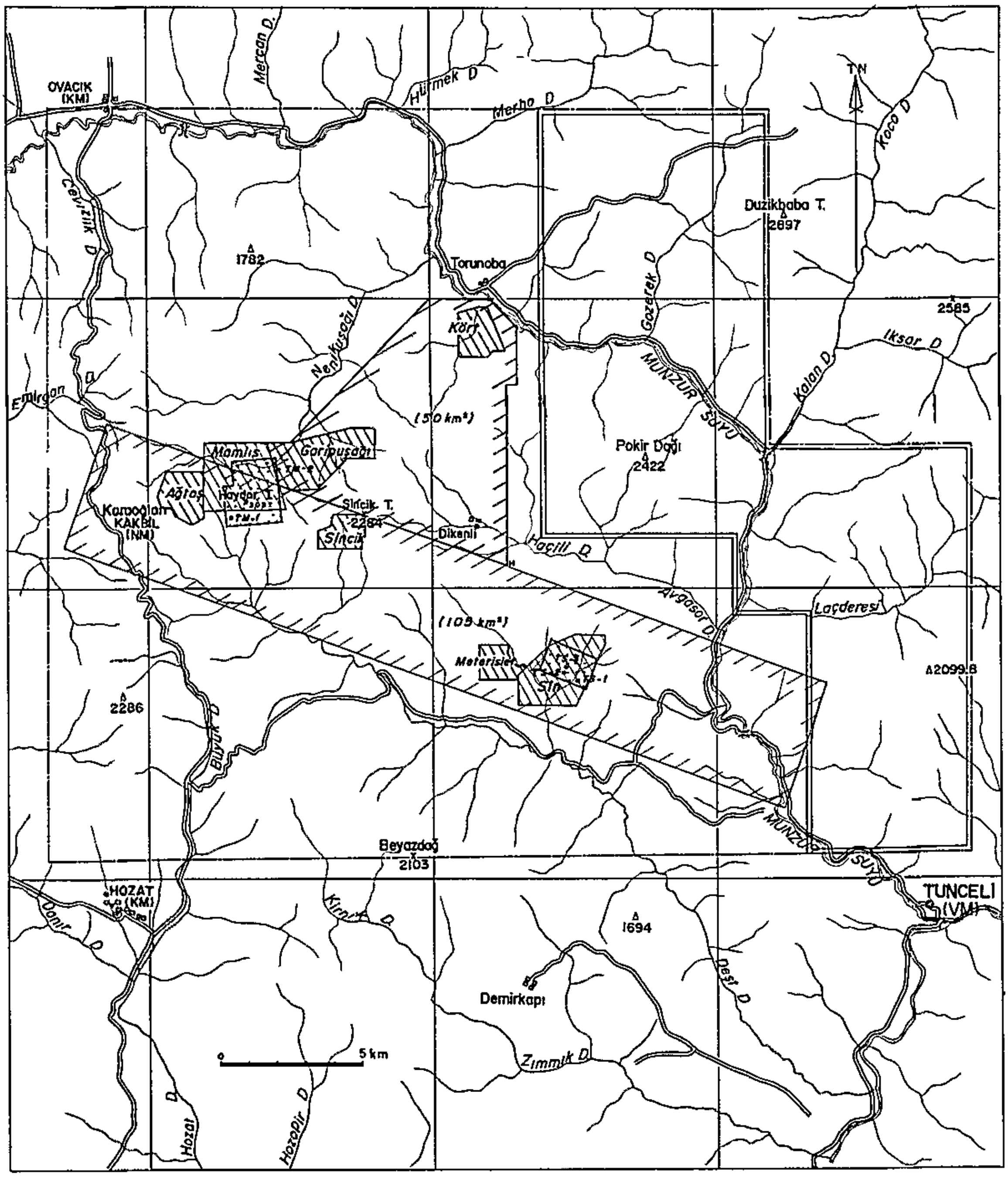
In consultation with the Mineral Deposits Division of MTA Ankara, it was decided that the work be carried out under the jurisdiction of the Diyarbakır Office (later changed to Malatya Office) of MTA for the Tunceli district and Black Sea Office for the Kopdağ district.
Base camp was established at the suburb of Tunceli City for the field work in the district. As the surveyed area was large, forward camp was used when necessary. In the Kopdağ district, a housing facility was constructed at the Sicankale Village which is located at the centre of the surveyed area. It was used as the base for field survey. In the case of the Kopdağ district, the field is located in high country, the access is bad, and the field season is only from June to September. Also roads must be repaired every year after snow-melt in order to construct the camp. These factors shortened the duration of the field work.

The field work in the Tunceli district started from geological reconnaissance survey, and semi-detailed (1:10.000) and detailed geological survey (1:2.000) were carried out for areas where mineralization and alteration were observed. Soil sampling was done together with the above investigation. As a result, Mamlis and Sin areas were closed up, and the IP anomalous localities of these areas were drilled.

Geological reconnaissance was also the first step of field work in the Kopdağ district and it became clear, as the survey progressed, that there were chromite deposits in the ultramafic dunite zone. Many abandoned old adits and trenches were found and semi-detailed (1:10.000) and detailed (1:2.000) geological investigation were conducted in these areas. In Coşan and Ezan areas which were particularly promising, the overburden was stripped and the continuity of the ore bodies were ascertained. In the Ezan area, several localities were drilled to see the downward extension of the ore shoots.

The geology and the mineralization and alteration of these two areas were clarified by the work described above. The activities of the project are listed in Table 2-1, the names of the Japanese and Turkish technical personnel who participated in the Tunceli and Kopdağ project are shown in Table 2-2, and the MTA officials who were concerned with the project are listed in Table 2-3.

Fig. 2-1 Location Map of the Survey Area in Tunceli



LEGEND

		1977	1978	1979	1980
	Photogeological survey area	760 km	–	–	–
	1:25,000 Geological survey area	–	640 km²	–	–
	1:10,000 Geological survey combined with geochemical survey area	–	105 km² 1,561 pcs.	50 km² 620 pcs.	– 100 pcs.
	1:2,000 Geological survey area	–	10 km²	7 km²	5 km²
	Geochemical survey area (streem sediments)	225 pcs.	–	–	–
	Geophysical survey area	–	–	53.6 km	–
●	Drill hole	–	–	1,175.70 m	–

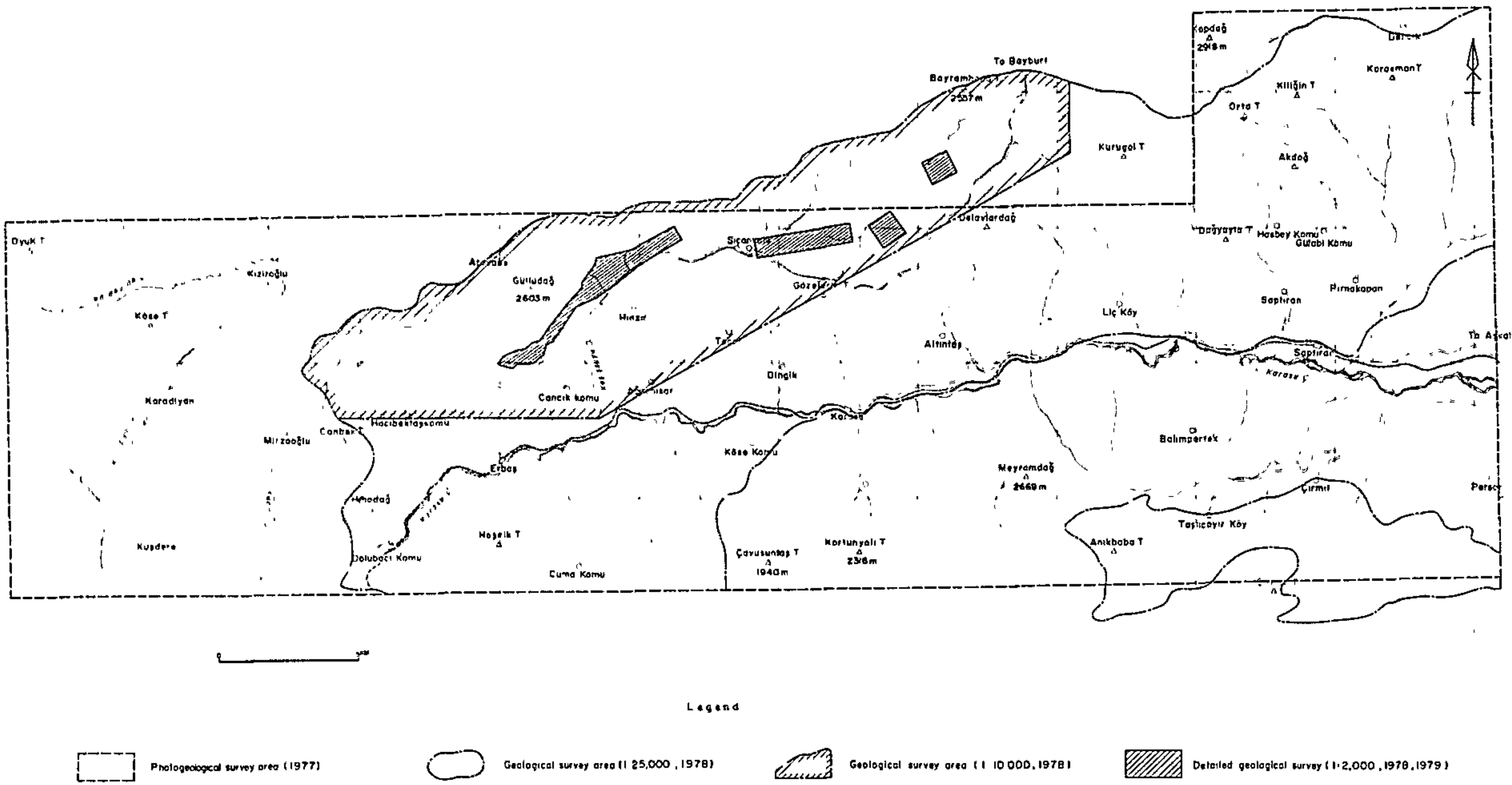


Fig 2-2 Location Map of the Survey Area in Kapdağ

Table 2-1 Summary of the Surveys (1977 - 1980)

	Applied Surveys	Survey Area	Amount of Work	Number of Members	Period of Survey (Interpretation, Report)
1977	Photogeological survey	Tunceli	760 km^2	JAPAN TURKEY Geologist 2 3	Oct. 22, 1977 - March 31, 1978
		Kopdağ	820 km^2		
1978	Geological survey	Tunceli	Reconnaissance 640 km^2	JAPAN TURKEY Geologist 8 8	June 23, 1978 - Nov. 27, 1978
		Kopdağ	" 320 km^2		
		Tunceli	Semi detailed 105 km^2		
		Kopdağ	" 120 km^2		
		Mamlis & Sin	detailed 10 km^2		
		Kopdağ	" 10 km^2		
	Geochemical survey	Tunceli	Soil sample 1,561 pcs		
		Tunceli	Stream sample 225 pcs		
	Sketch of trench & gallery	Kopdağ	15,000 m^3, 950 m		
1979	Geological survey	Tunceli	Semi detailed 50 km^2	JAPAN TURKEY Geologist 4 6	May 19, 1979 - Nov. 30, 1979
	"	"	detailed 7 km^2	Geophysicist 3 3	
	"	Kopdağ	detailed 2 km^2	Drilling Engineer 1 1	May 27, 1980 - Oct. -, 1980
	Geochemical survey	Tunceli	Soil sample 620		
	Geophysical survey	Mamlis & Sin	I. P. line 53.6 km		
	Trench	Kopdağ	Ezan & Coşan 525 m^3		
	Diamond drilling	Kopdağ	Ezan 542.6 m		
			Ezan 461.55 m		

	Applied Surveys	Survey Area	Amount of Work	Number of Members	Period of Survey (Interpretation, Report)
1980	Geological survey	Tunceli	detailed 5 km^2	JAPAN TURKEY Geologist 2 4	May 27, 1980 - Nov. 31, 1980
	Geochemical survey	Tunceli	Soil sample 98 pcs	Drilling Engineer 4 3	
	Trench	Kopdağ	Ezan & Coşan 2,045 m^3		
	Diamond drilling	Tunceli	Mamlis & Sin 1,175.7 m		

Table 2-2 List of the Technical Staffs Participated to the Project

	1977	1978	1979	1980
Coordinator & Administrator	YOSHIHIRO SEKINE HIROYASU KAWAGUCHI EIICHI ASANO HISAMITSU MORIWAKI	KAZUHIRO CHIMURA HISAMITSU MORIWAKI HIROSHI OKANO	KYUZOH TADOKORO TETSUHIRO NAKANOMORI KAZUNORI KANOH HISAMITSU MORIWAKI	SHOZO SAWAYA KAZUNORI KANOH YOZO BABA KENJI ISHII
Leader of Japanease Team	HAJIME TAKAHASHI	HAJIME TAKAHASHI	HISASHI MIZUMOTO	HISASHI MIZUMOTO
Member & Counterpart Geologist	KEN OBARA	HISASHI MIZUMOTO KAZUYOSHI MASUBUCHI YOSHIHIRO WATANABE MASAHARU MARUTANI SHIGEHISA FUJIWARA HIDEO SUZUKI KAZUYASU SUGAWARA	KAZUYOSHI MASUBUCHI HIDEO SUZUKI NOBUYUKI GOTOH	HIDEO SUZUKI
	SUNA HACALOĞLU İNCİ SOYSAL SERPIN INAL	YILMAZ ALTUN MİTHAT KAYAALP TORUN YILMAZ HAYATI YAVUZ SADIK ACAN MAHIR IZMIR IBRAHIM KOÇ NECDET ÜDOŠEK	MİTHAT KAYAALP TORUN YILMAZ ERDEN YAZICI İBRAHIM KOÇ NECDET ÜDOŠEK	MİTHAT KAYAALP TORUN YILMAZ ERDEN YAZICI ÖSKAN BAŞTA
Prospecter		REFİK ÖNAL HALUK DİKMEN SINAN ORBAY	İBRAHİM KONAK	
Geophysicist			MASAYOSHI YOSHIZAWA TADASHI NYUI NORIYUKI SUGIURA	

	1977	1978	1979	1980
Geophysicist			DOĞAN YILDIRIM NECDET PAKER SEYRAN ŞARDAĞ	
Drilling Engineer			NOBUHIKO YAMAMOTO GÜNER AYTAÇ	MICHIYOSHI KIMAZUKA KOHICHI KAWAKAMI KANEO SHITAGAKI HISASHI SUZUKA SALİH ATUĞ SÜHA AKSOY CEMAL KUMRU

Table 2-3 The Head of MTA Related to the Project

	1977	1978	1979	1980
General Director	SADRETTİN ALPAN	SADRETTİN ALPAN NEZİHİ CANITEZ	NEZİHİ CANITEZ EROL İMRE	SITKI SANCAR
Deputy General Director	ORHAN ÖZKOÇAK	ORHAN ÖZKOÇAK	ESEN ARPAT	ORHAN ÖZKOÇAK
Director of Mineral Exploration Dept.	RECAİ KUTLU	RECAİ KUTLU TANDOGAN ENGIN	HÜSEYİN CETİN	MEHMET C. YILDIZ
Deputy Director of Mir. Exp. Dept.	TANDOĞAN ENGİN	RAMIZ ÖZOCAK	METE TEŞREKLİ	RAMİZ ÖZOCAK ÖMER AKINCI
Chief of Copper Sect.	ÖMER AKINCI	ÖMER AKINCI	RUHİ ÇALGIN	YILMAZ ALTUN
Deputy Ch. of Co. Sec.	Mete TEŞREKLİ			
Chief of Chro. Sec.	TANDOĞAN ENGİN	ÜNAL ARTAN	ÜNAL ARTAN	ÜNAL ARTAN
Director of Geoph. Dept.	-	-	SIRRI KAVLAKOĞLU	
Chief of E. Em. Sec.	-	-	IŞIK TURGAY	
Director of Drill. Dep.	-	-	ERSİN UNCU	TEOMAN ÖZGÜVEN

	1977	1978	1979	1980
Deputy Director of Drill. Dept.	-	-	BEKİR SEZGİN	BEKİR SEZGİN
Director of East Black Sea	TEMEL NEBİOĞLU	TEMEL NEBİOĞLU	MİTHAT KAYAALP	TEMEL NEBİOĞLU
Director of Diyarbakır	RAŞİT OSMANÇAVUŞOĞLU	RAŞİT OSMANÇAVUŞOĞLU OSMAN TAŞAN	OSMAN TAŞAN	ÜZEYİR KESER
Director of Malatya	-	-	-	KEMAL YÜMLÜ

3. GEOLOGICAL SURVEY OF TUNCELİ DISTRICT

3-1 Geology of Tunceli District

3-1-1 General Geology

In the Tunceli area, the Paleozoic Munzur Formation is the lowermost formation, and the Eocene Series comprised of the Atadoğdu, the Bentepe and the Kamışlık Formations overlie the Paleozoic Formation unconformably. They are overlain by the Miocene Series, which is composed of the Düzpelit, the Tırnas, the Cevizlik, the Savular, and the Göktepe Formations deposited conformably on one another.

The Munzur Formation, the basement of this area, is considered to be correlated with the Permian System, and consists mainly of metamorphosed crystalline limestone, pelitic schist, and green schist, and is widespread along the Munzur river and to the east of it. The Mesozoic Erathem is absent, and the Atadoğdu Formation comprised of the lowermost Eocene Series overlies the Munzur Paleozoic Formation unconformably. The sediment of the Atadoğdu, the Bentepe, and Kamışlık Formations indicate stable sedimentation, and appear to have been deposited in a deep marine environment control by the paleotopograph, which was influenced by structure of the Paleozoic Formation. During the Miocene Series, early submarine volcanic activity resulted in the deposition of the Düzpelit Formation. The Tırnas Formation was formed during a pause in volcanic activity. The Cevizlik and the Savular Formations accumulated as a result of widespread repeated volcanic activity. After the termination of the volcanism the Göktepe Formation was deposited. Each formation is described as follows:

3-1-2 Munzur Formation

The Munzur Formation forms the basement of the Tunceli district and is widely distributed to the north of Tunceli city. The formation consists mainly of bluishgray to black crystalline limestone, pelitic schist, green schist, and conglomerate. Outcrops of the formation are divided into roughly five blocks, they are the northwestern, the northern, the central, the eastern, and the southern blocks.

The formation of the northwestern block consists of crystalline limestone, pelitic schist, and green schist. Pelitic schist is predominant in the southern part of the block and green schist in the northern part, respectively. Crystalline limestone is bluish gray to brack, and shows banded or massive structure. Pelitic schist is dark green to grayish-black and green schist is light green to dark green. In both schists schistosity, microfolding and segregation film of calcite are developed. Both pelitic schist and green schist gradually grade into each other. Crystalline limestone occurs in schist, forming lenses. Massive green rock occurs near Mt. Görrek (1,673 m). This rock is compact and dark green in color. Crystals of amphibole can be observed with a naked eye. The basic rocks of the Paleozoic era are metamorphosed.

Distribution of the metabasic rock is correlated with the eastern prolongation of greenschist zone.

The structure of the block is monoclinal, striking N60° - 70°E and dipping 30° - 40° north. The northern end of the block is in contact with basic to ultrabasic rocks (mainly - composed of serpentinite) along the Ösik fault. The southern part is in contact with the strata of Neogene along the Yaylagünü fault.

The northern block is composed of gray to bluish gray massive crystalline limestone, forming a steep mountains, Mt. Duzikbaba (2,897 m), which is the highest mountain in the block. In the east of Dumantepe hamlet, conglomerate occurs between the crystalline limestone and mudstone of the Paleogene. It is massive and compact, composed mainly of subangular or subrounded grains of black, gray, and red crystalline limestone. The structure of the block couldn't be observed in detail owing to the massive nature of the limestone, but an anticlinal axis may be on the western slope of the Duzik dağı.
The block was uplifted by movement of the Duzik fault. In the northern block, the lower part of the Munzur Formation could be observed, judging from the rock facies.

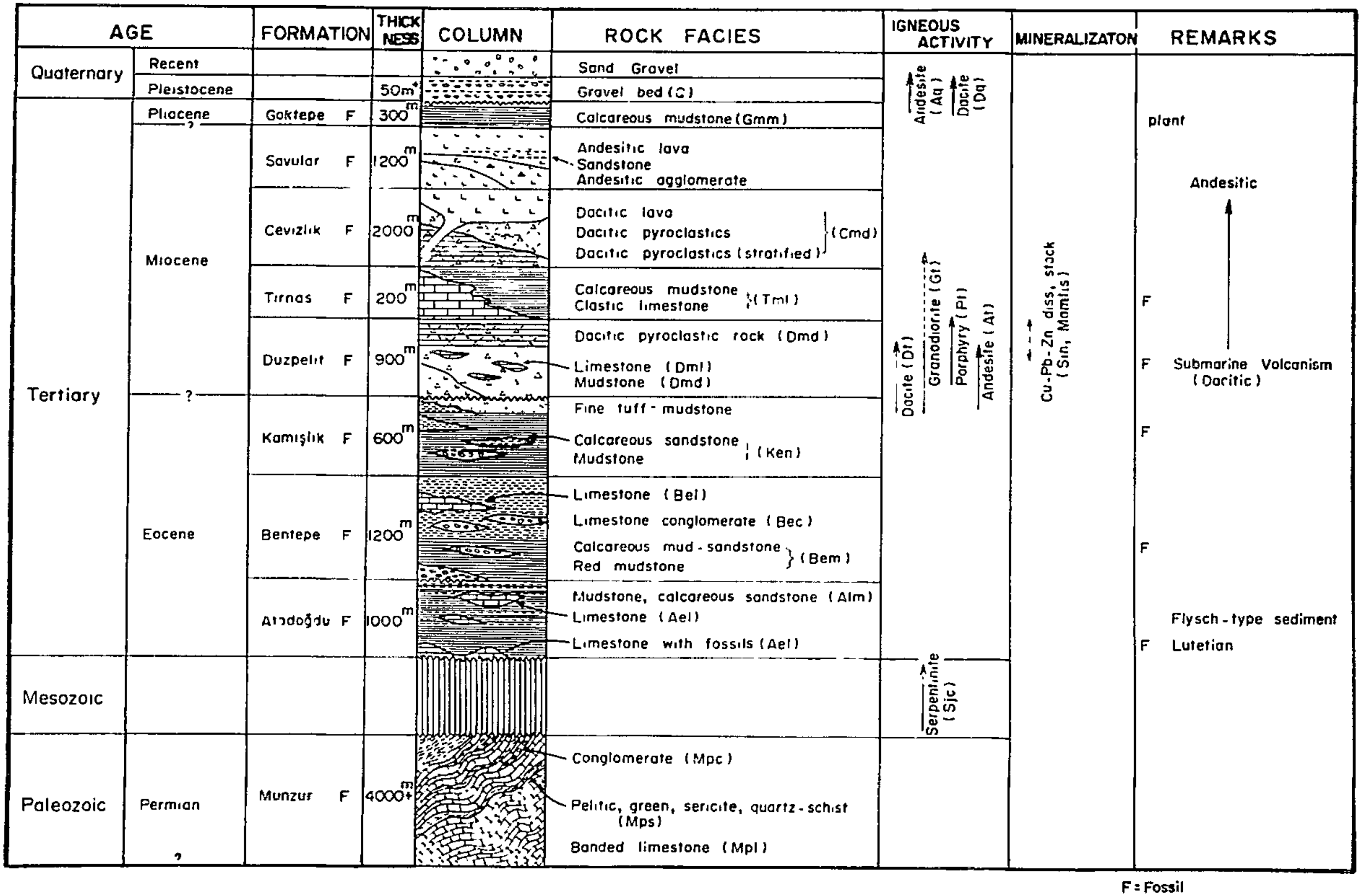
The central block is the type locality of the Munzur Formation. It consists of black to bluish black banded crystalline limestone, gray massive crystalline limestone, pelitic schist, green schist, and conglomerate. Limestone and schists are in units of 10 meters. Crystalline limestone is composed of calcite and shows compact texture. Undulose extinction of calcite crystals suggests metamorphic deformation.

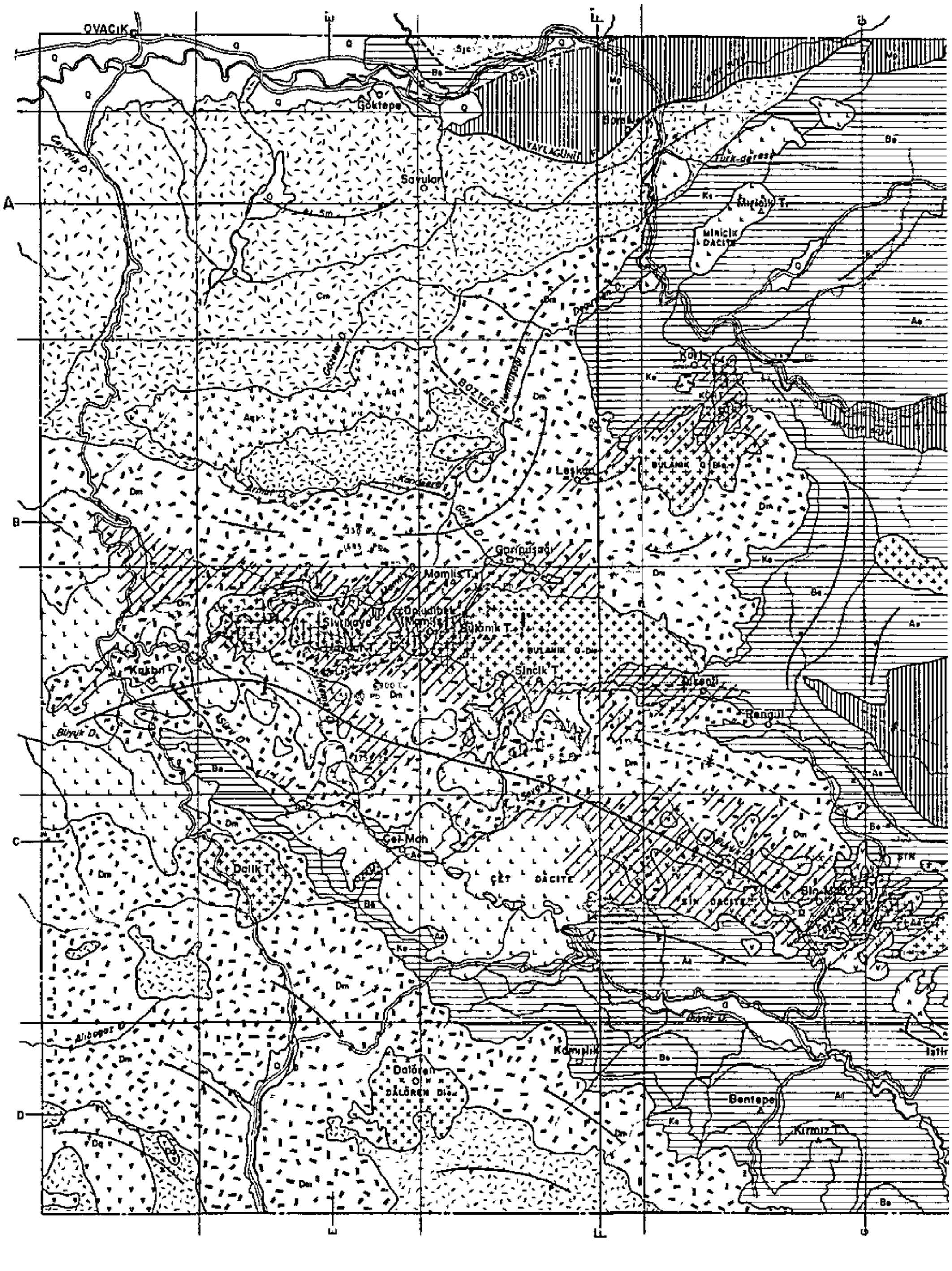
The Venk fault runs NE-SW and divides the block into the northern and southern parts. The structure of the northern part of the block consists of a gentle anticline, the axis of which runs along the Munzur river and plunges to the north. From the lower to the upper part, the rock facies could be observed to vary from conglomerate, banded limestone, massive limestone, and banded limestone to conglomerate.

In the southern part of the block, anticlinal structures lie along the Munzur river, the Avgasor, and the Laç valley, they plunge dip to the north. In this area banded limestone, massive limestone, pelitic schist, and green schist could be observed, there is alternation of limestones and schists.

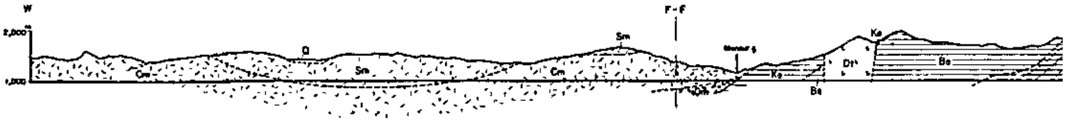
The rock of the eastern block is distributed around Mt. Meydan (2,284 m). It consists of bluish black to gray banded crystalline limestone and pelitic schist. A part of this schist gradually changes into quartz-sericite schist or green schist. The structure of the block is an anticline running along the Katran valley.

Fig. 3-1 Geological Succession of Tunceli District




OVACIK
Göktepe
Savular
A
B
C
D
Minicik T.
MINICIK DACITE
Kört
Leşkan
BULANIK
Garipuşağı
Momlis T.
Sivrikaya
Bulanık T.
Sincik T.
Kokbil T.
Büyük D.
Çel Mah.
ÇET DACITE
SIN DACITE
Dalik T.
Rengul
Dalören
DALÖREN
Kamışlık
Bentepe
Kırmızı T.
Alibağaz D.

A – A'


W
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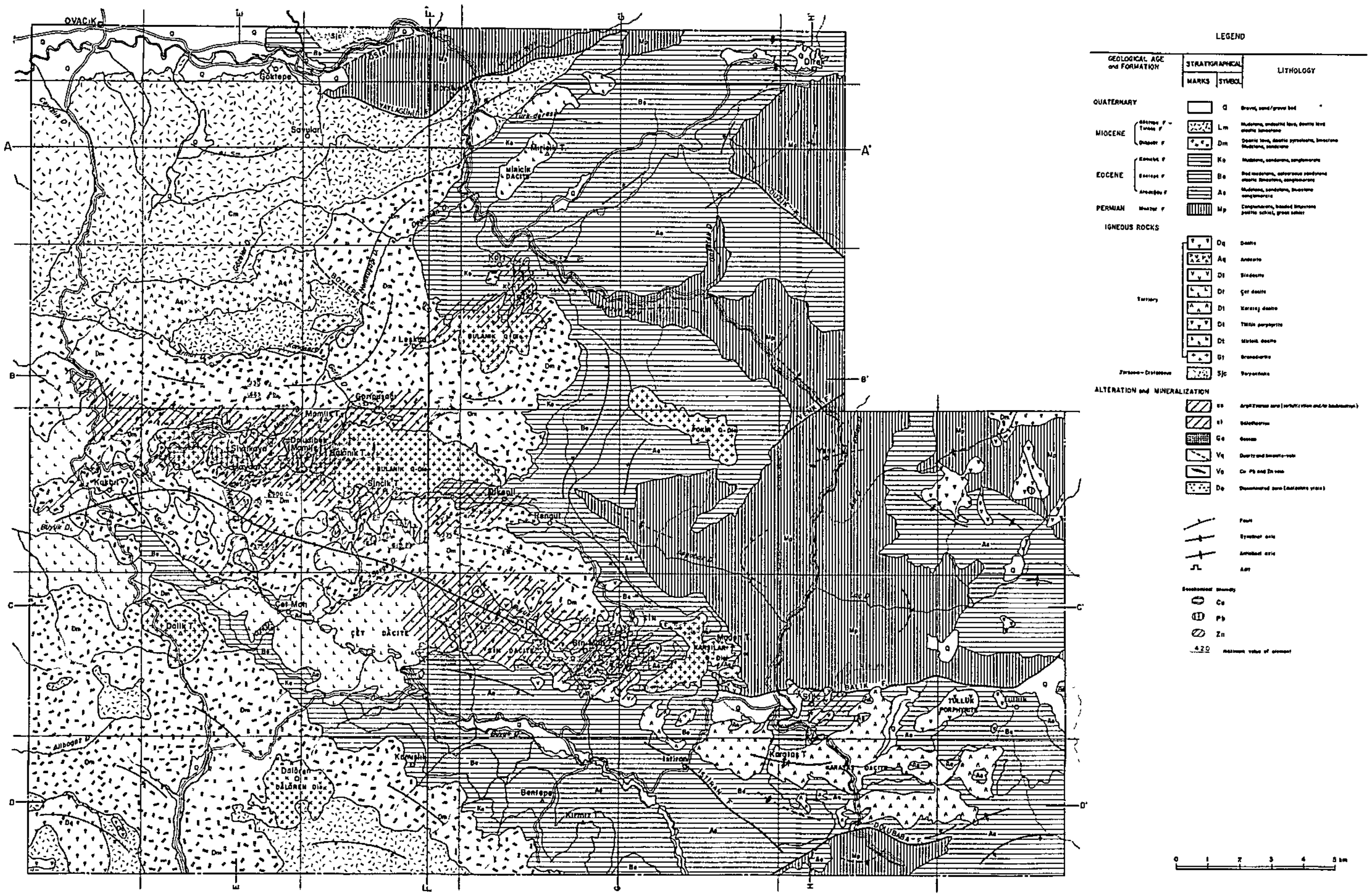


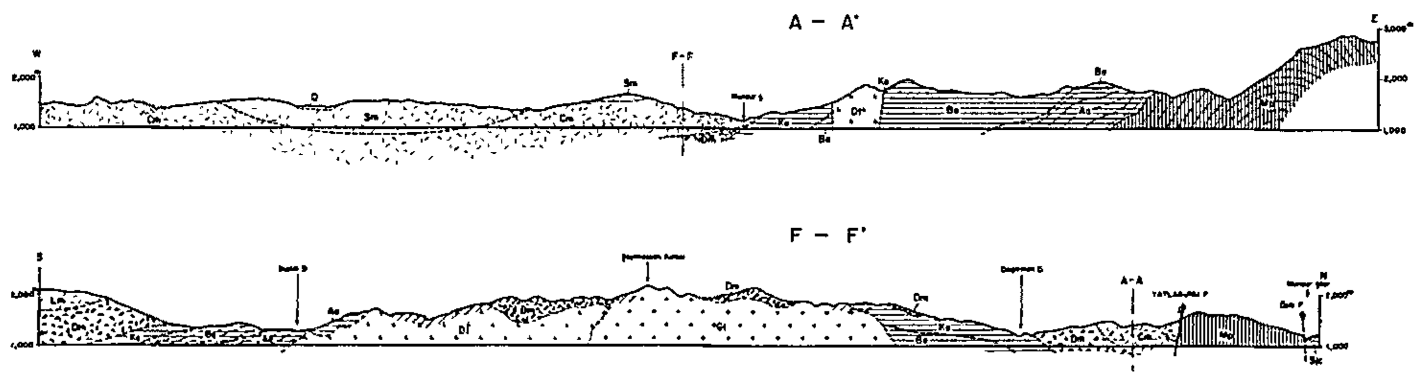


Fig. 3-2 Geological Map of Tunceli District

Rocks of this block crop out in the southeast of the Babaocağı hamlet. They consist mainly of bluish banded crystalline limestone and pelitic schist. Along the western side of the Munzur river, a gentle anticlinal structure plunges to the south. The most northern part of the block is in contact with the Atadoğdu Foundation along the Dolubaba fault.

Although fossils were not found in the Munzur Formation during the geological survey, AFSHAR, T.A. (1965) discovered "Neoschwagerina carticulifera" in crystalline limestone, which crops about 20 km to the west of the Tunceli area. Based on this evidence, the Munzur Formation is correlated with the Permian System.

3-1-3 Atadoğdu Formation

The Atadoğdu Formation overlies the basement of the Paleozoic Munzur Formation unconformably. This formation is the lowermost formation of the Paleogene. It is overlain by the Bentepe Formation conformably. It is distributed around the blocks of the Paleozoic formation and in a wide belt along the Büyük river.

The formation consists mainly of mudstone, accompanied with sandstone and limestone. According to the rock facies, it is divided into three members: the lower member consists of limestone with fossils, the middle one consists of a clastic limestone, calcareous sandstone and mudstone, and the upper one is rhythmical alternation between calcareous mudstone and sandstone.

The lower member is characterized by limestone, sandstone, and mudstone containing Nummulities. Fossil bearing rocks occur here and there. Limestone containing Nummulites is brownish-black to bluish-black in color, massive, and compact.

The middle member occurs in three areas, that is, from Mt. Meydan to the Çıralı hamlet, from the Zımayık hamlet to the Munzur river, and about 3 km to the south of the Tüllük hamlet. This member is characterized by non-fossiliferous clastic limestone, accompanied by alternations of calcareous mudstone and sandstone.

The upper member overlies the above-mentioned middle member, and is distributed widely along the Büyük river. It is formed by rhythmical alternation of mudstones and sandstones.

Distribution of the Atadoğdu Formation is influenced by the structure of the basement. The sediments of the formation are characterized by rhythmical alternation between calcareous mudstone and sandstone, except the lower member. Although the strata vary in strike and dip near intrusive rocks, the are stable around the type locality. This indicates that the facies of the formation are flysh type deposits.

3-1-4 Bentepe Formation

This formation is widely distributed throughout the investigated area. It overlies the Atadoğdu Formation conformably and is conformably overlain by the Kamışlık Formation. This formation is composed mainly of alternation of conglomerate and sandstone, and partly calcareous mudstone and limestone. The fine sandstone of the lower part of this formation, generally characterized by red tinge, is called "Reddish sandstone" or "Reddish mudstone". The reddish parts are composed of mudstone, sandstone, and partly conglomerate. Facies of this formation vary laterally, so that, the distribution of this formation is divided into the following portions:

(1) Bentepe portion lies in the southern part of the investigated area, extending from the east to the west.

(2) Center portion extends from Dikenlitarla hamlet northwards to Kört hamlet. It shows influence of the paleo-topography of the Paleozoic formation.

(3) Northern portion extends in a NE direction in the north of the survey area. It is composed mainly of limestone.

Bentepe portion is the type locality of Bentepe Formation, and a continuous outcrop can be observed from the lower part of the Atadoğdu Formation to the upper part of the Kamışlık Formation. It has monoclinic structure dipping 5° - 10° to the south. In this area, it is composed mainly of coarse reddish sandstone overlying the Atadoğdu Formation conformably, and partly of conglomerate and reddish sandstone alternating with mudstone in the lower part. The middle part consists of calcareous mudstone, the upper part is composed of calcareous conglomerate and sandstone.

Central portion is distributed around Karşılar, Siliç, Bakocağı and Tüllük hamlets. In the north, this formation directly overlies the Paleozoic Munzur Formation along the Balık fault, the Atadoğdu Formation is absent. In the central and western part in the Sin Mah and Siliç hamlet, an alteration zone was formed under the influence of the Sin dacite. Althouth the Sin dacite and the Karşılar diorite extend to the west, for a distance of about 3 km, from İstiran hamlet to Bentepe area, alteration zone does not continue, due to the absence of the Bentepe Formation.

The formation of northern portion lies around Sin, Dikenlitarla, Kört, and Ağaçpınar hamlets, following the outline of the Paleozoic Munzur Formation, and changes strike from NW to NE, and to NW again, dipping at 30° - 50° to the west.

Conglomerates are predominant in the lowest part of the formation, in the lower part reddish sandstone alternates with conglomerate and sandstone between the Sin and Kört hamlets. In the upper part alternation of calcareous sandstone and conglomerate is also found, but gradually sandstone becomes predominant.

The Bentepe Formation surrounds and partially covers the dome like structures of the Paleozoic Formation along the Munzur river and the Laç stream. It was removed by erosion on the south-west side of the İstiran fault. It reappears in Bentepe area and continues west, forming a south dipping monocline. The limestone of this formation is thick in the north, but thin southwards.

3-1-5 Kamışlık Formation

This formation is correlated with the upper Eocene, overlies the Bentepe Formation, and is overlain unconformably by the Düzpelit Formation. The formation is composed mainly of sandstone and mudstone, lower part is mudstone, and upper part is calcareous sandstone and tuffaceous sandstone. This formation extends from the north of Dikenli hamlet to Çayüstü hamlet as a sinuous belt, following the outline of the dome like structures of the Paleozoic Munzur Formation along the Munzur river and Laç stream, south-west of the Istiran fault, it forms an east-west belt dipping gently to the south.

Type locality is around the Kamışlık hamlet in the southern area. This area is composed mainly of mudstone, which gradually changes from mudstone to tuffaceous mudstone westward. This formation changes strike to north-east, forms an anticlinal structure, and disappears near Mt. Bayır (1,854 m). Near Sacak hamlet, it is composed of alternation of sandstone and lapilli tuff. The mudstone is black or gray in color and has bedding. The lower part of the formation shows alternation of conglomerate and mudstone in the south, but gradually changes to bedded mudstone forming the base of the formation in the north. The upper part of the formation is composed of mudstone and sandstone in the south, but in the north, it gradually changes to tuffaceous sandstone with intercalations of calcareous mudstone and sandstone. Fossils occur in sandstone and mudstone.

3-1-6 Düzpelit Formation

The Düzpelit Formation is developed in the mountain area from Mt. Kortan (1,321 m) to Mt. Sürübaba (2,182 m) in the central part of the investigated area, and extends to Mt. Gelin in the north, with a little change in rock facies. In the south part, this formation is developed widely on the west side of Düzpelit hamlet, which is mentioned above as a type locality. This formation is mainly composed of dacitic pyroclastic rocks which are partly intercalated with muddy-sandy sedimentary rocks and limestones.

This formation overlies the Kumışlık Formation unconformably, and is overlain by the Tırnas Formation conformably. On the north side of the Boztepe fault, the Düzpelit Formation is overlain by the Cevizlik Formation unconformably. Based on the distribution and the nature of rock facies, this formation can be divided into three areas, as follows, the southern part, the central part, and the northern part.

The southern part: The Düzpelit Formation is developed widely on the west side of Düpelit hamlet. The area around this hamlet belongs to Büyük drainage system and is formed by comparatively flat topography, although there are mountains with flat summits and very steep slopes. From the south side to the west side of Düzpelit hamlet on the steep slopes, it's very easy to observe the nature of this formation and the conformable contact between the Düzpelit Formation and the Kamışlık Formation. The lower part of the formation consists of non-bedded dacitic tuff breccia - volcanic breccia, and is also accompanied by autobrecciated lava. The amount and the size of lithic fragments decrease gradually in upwards. Due to this vertical change, the Düzpelit Formation becomes intercalated with sandy beds, and sedimentary structures can be observed. Near the boundary between this formation and the Tırnas Formation, the sandy beds become predominant and constitute alternation of lapilli tuff and tuffaceous sand. Generally this formation strikes NW-SE and dips gently to the south.

The central part: The central part is located in the northern part of the uplifted belt which extends from SEE to NWW in the south of the investigated area. This uplifted belt has been intruded by intermediate to felsic igneous rocks called Karataş quartz diorite, Sin-dacite, and Çet dacite, etc.

In this area, the Atadoğdu Formation, the Bentepe Formation, and the Kamışlık Formation had been eroded out before these igneous rocks were intruded, and the Düzpelit Formation overlies the Atadoğdu Formation and the Bentepe Formation unconformably. Dacitic tuff breccia and lapilli tuff which the lower part of this formation is composed of, are also the main constituents in this area, where they are intercalated with muddy tuff and show sedimentary structures. Autobrecciated dacite lavas, and limestone lenses also occur.

This formation was subjected to intense argillization and silicification, seems to have been subjected to mineralization and alteration related to the intrusion of the Sin dacite and the Bulanık quartz-diorite, in Sin area, Mamlis area, etc. The lower part of this formation develops widely in the central part, but shows unstable dip and strike due to the effect of the intrusive rocks.

Northern part: The upper part of the formation occurs from the north of Mamlis mine to the Gelin. The main constituent rocks in this area are composed of dacitic tuff breccia partly intercalated with limestone lenses, lapilli tuff, and tuffaceous sandstone, and often show clear sedimentary structures. The amount of sandy - muddy part increases near the Tırnas Formation. The Düzpelit Formation is pinched out on the north side of Mt. Gelin and overlies the Kamışlık Formation unconformably in the northeast area, where dacitic tuff breccia, characteristic of the lower part of the Düzpelit Formation, is present.

From the above data it is indicated that, the Düzpelit Formation has the character of shallow submarine pyroclastic rocks, and the central area where the lower part is predominant, was the center of the volcanic activity. It is intercalated with sandy-muddy rocks towards the north and the south.

3-1-7 Tırnas Formation

This formation is situated between Mt. Tırnas and Reşo hamlet which are 10 km apart, in the northwest of the investigated area, and between Beyaz Dağ (2,102 m) at the edge of the southern part of the investigated area and Mt. Hızandağı (2,102 m) at the edge of the southwestern part. Though the thickness is in the order of a few hundred meters, due to its continuity it can play the role of the key bed which clarifies geological structure.

The Tırnas Formation consists mainly of calcareous sedimentary rocks which include fossil shells and corals. In the area between Mt. Tırnas and Reşo hamlet, this formation is composed of limestone (containing shells) interbedded with calcareous mudstone, mudstone, and alternation of clastic limestone, impure lime stone and calcareous mudstone, and also with partly tuffaceous mudstone. Towards the east, the thickness of this formation decreases and the rock-facies gradually change to alternations of muddy limestone - clastic limestone, calcareous sand - mudstone, tuff, etc.

This formation is dislocated a little by a few faults between Mr. Tırnas and Reso hamlet and it is pinched out by the Boztepe fault in the north of Reso hamlet. Generally, the strike is EW ∿ NE-SW and dip 20 - 40° to the north. In the southwest area, this formation is located around a high elevation area which exceeds 2,000 m on the south side of Mt. Beyaz and forms table land inclined gently to the south.

This formation is also seen at the top of Mr. Sarısaltık (2,286 m) and Mt. Sivri (2,121 m) in the southwest area. In these areas, calcareous part is more abundant than in the northern area.

Generally, the lower part consists of clastic limestone and the upper part is composed of calcareous sandstone and mudstone. Large number of fossils (shells and corals) are found in the limestone. It strikes NW-SE and dips gently to the south. Fossils of the Miocene were found in the Tırnas Formation. From the geological evidence mentioned above, the environment of deposition seems to have been shallow sea: the north side of Reso hamlet was above sea level.

3-1-8 Cevizlik Formation

The Cevizlik Formation is located on the north side of Mt. Tırnas in the northwest of the investigated area and extends from here to Çayüstü hamlet crossing the Munzur river in the north-east area. In the northwest area the formation overlies the Tırnas Formation conformably and is overlain by the Savular Formation. In the east the formation overlies both the Düzpelit and the Kamışlık Formations unconformably north of the Boztepe fault and in the northeast the formation has a contact with the Munzur Formation along the Yaylagünü fault.

The lower part extends from Dağ yayla in the west end to Reşo hamlet and pinches out north of Reşo hamlet. This part consists of the same kind of pyroclastic rocks as the upper part of the Düzpelit Formation. This dacitic pyroclastic rock has greenish-gray ∿ purple-grey color. Matrix is greenish grey, and includes large amount of plagioclase and small amount of hornblende. The main constituents consist of fragments of purple-gray dacite with abundant plagioclase and dark-grey glassy dacite.

The middle part crops out between Göl hamlet north of Mt. Tirnas and the Çayüstü hamlet beyond the Munzur river. This part is composed of dacitic pyroclastic rocks which are more acidic than those in the lower part. The pyroclastic rocks consist of tuff breccia and lapilli tuff, partly intercalated with tuff ∿ muddy tuff. This matrix is pale-green ∿ pale-purple grey and sometimes contains pale-green ∼ white pumice. The main lithic fragments are white ∿ pale-grey dacite and grey glassy dacite.

The upper part is located between Göl hamlet and the lower Cevizlik creek. Dacitic lava is predominant and is partly intercalated with lapilli tuff. This lave is considered to be of the same composition as the rock in the middle part and is the composite rocks composed of intrusive part and lava part.

3-1-9 Savular Formation

The Savular Formation is distributed from the Ovecler hamlet to Sorsivenk mine in the northwestern part of the survey area. It overlies the Cevizlik Formation conformably, and is overlain by the Göktepe Formation conformably. It is correlated with the upper formation of Miocene. The formation consists mainly of porphyritic andesite lavas in which autobrecciated texture is partly observed. There are occurrences of agglomerate in the south of the Savular hamlet, and of coarse to fine sand in the western part. Andesite is composed mostly of phenocrysts of plagioclase, quartz and magnetite were observed. It is characterized by the fact that phenocrysts of hornblende are locally predominant, and that andesite gradually changes to dacite in the western part, due to increasing number of quartz phenocrysts.

The structure of the formation is monoclinal dipping to the north. At the northern periphery, it is overlain by the Göktepe Formation and Quaternary sediments, and partly in contact with the Paleozoic Manzur Formation along the Yaylagünü fault. On the other hand there isn't a clear boundary between this formation and the Cevizlik Formation at the southern periphery.

3-1-10 Göktepe Formation

The Göktepe Formation is distributed around Mt. Göktepe. Its range is very small, this is 3 km in the E-W and 1 km in the N-S direction. It overlies the Savular Formation conformably in the south, and it is in contact with the limestone and the calcareous mudstones of the Bentepe Formation along the Ösik fault in the north. The formation consists of calcareous mudstones, it is white or pale brown in color and contains fossil plant. The formation has monoclinal structure, striking E-W and dipping gently to the north. It may be correlated with the Pliocene, because it indicates submarine sedimentation, following volcanic activities.

3-1-11 Quarternary

Andesite lavas are distributed from Mt. Belbaba (2,142 m) to Mt. Kantar (1,736 m) in the northwestern part of the investigated area, and overlie the Düzpelit Formation. Andesitic rocks are divided into a lava flow and autobrecciated lava or volcanic breccia, the former is predominant in the east of Mt. Kantar, the latter is dominant around Mt. Barikan (2,184 m). Lava is compact, dark brown in color, and develops joints. Autobrecciated parts are purplish gray to violet in color and are associated with a network and amygdales of limonite.

Dacite lavas are distributed around Mt. Karakaya east of Çaytaşı hamlet. They are whitish gray, and composed dominantly of phenocrysts of plagioclase, biotite, and hornblende, and a matrix of quartz associated with magnetite. They have porphyritic texture.

The Tırnas Formation is intruded by dacite at Mt. Karakaya (2,100 m) and Mt. Kale (2,086 m), and lava flows overlie the gentle southern slopes of the Tirnas, and the Cevizlik Formation around the Çaytaşı hamlet.

Conglomerate is distributed widely enough to form terrace deposits in the Ovacık area. It is assumed that conglomerate resulted from tektonic movement along a Yaylagünü fault. Talus deposits are distributed locally in east of the Karşılar hamlet, Dedeağaç hamlet and east of the Tüllük hamlet.

3-2 Outline of Intrusive Rocks

The intrusive rocks which are located in the investigated area, were intruded during the Miocene epoch, particularly along the uplifted zone which has a trend of NWW-SEE in the south of the investigated area. Dacitic intrusive rocks, partially including porphyry, are predominant. Though the main intrusive rocks are dacitic, quartz diorite ∿ diorite stocks and a few porphyries, andesite dykes, which were intruded subsequently are also observed.

The facies of dacitic and dioritic rocks are different, according to the distribution, as follows:

Karataş dacite, Sin dacite, Çet dacite, Miricik dacite, Tüllük porphyry. Dioritic rocks.

Karşılar quartz diorite, Bulanık quartz diorite, Dalören diorite, Pokir quartz diorite, Dirik quartz diorite.

Ultrabasic rocks are observed in the north of the investigated area.

3-2-1 Serpentinite

Serpentinite is distributed around the north side of Çolaklar hamlet in the north of the investigated area. It covers 5 km^2 in the above area, but this rock also extends widely to the north, covering an area of 200 km (in the east-west direction) by 30 km (in the north-south direction) on the Erzrun geological map (scale of 1/500,000) where this rock is described as an ophiolite of Jurasic-Cretaceous age.

This rock does not weather easily because of the presence of serpentine, and as a result the grass does not grow well on its surface, and the soil is reddish brown - brownish red. In the south from Anakomu hamlet to the Munzur river, serpentinite is in contact with the Munzur Formation along the Armutlu fault, and is overlain by the Bentepe Formation unconformably in the west of Ösik hamlet.

Though this rock is almost serpentinized, gabbro and pyroxinite are partially ovserved in the float. A weak mineralization of chromite is known in this ophiolite.

3-2-2 Dacitic Rocks

Karataş dacite: The rock is located between Seyhömerler mezraasi (east of Sin hamlet) and the south side of Tüllük hamlet. The western part is a composite rock of brecciated lava and intrusive rock, the central part shows partly hypabyssal rock facies, and the eastern part consists of volcanics. On the hand specimen, in the eastern part and the western part, mineralization and alteration were not observed, however in the central part, chloritization, weak siliciflication, and pyritization were observed, especially around the marginal part.

Sin dacite: Sin dacite extends from the east side of Sepertek, through Sin, to Siliç hamlets. This dacite forms stock-dome like shape, cutting the Atadoğdu Formation, the Bentepe Formation and the Düzpelit Formation. It has sheet-like structure. Autobrecciated structure which is limited to a small portion dacite, is sometimes observed. A large part of Sin dacite was subjected to alteration, intensity of which was varied, and which also altered the country rocks. Generally, silicification and mineralization are observed especially in the marginal parts of the dacite intrusive body. Plagioclase is pervasively replaced by calcite and epidote, and sericite as altered a mineral is also observed.

Çet dacite: Çet dacite is located between the west margin of the investigated area and Sepertek in the central part of the area. This intrusive rock forming stock- dome, cuts the Düzpelit Formation. Because autobrecciated parts are sometimes observed and the composition of this rock changes from dacite to andesite, Çet dacite is considered to be a composite rock, the activity of which continued for a long time.

Tüllük porphyry- porphyrite: This rock is widely scattered southeast and north of Tüllük hamlet. This rock whose composition varies from dacitic to andesitic, intrudes as a dome and dyke, cutting the Munzur Formation, the Atadoğdu Formation and the Bentepe Formation. This rock shows different facies in the south part and in the north part, and andesitic rock is observed in the marginal part.

Miricik dacite: This rock is located around Mt. Miricik. It forms a dome like intrusion cutting the Bentepe Formation, the Kamışlık Formation, and the Cevizlik Formation.

3-2-3 Granodioritic Rocks

Karşılar quartz diorite: This rock is distributed between Mt. Maden and Mt. Ahmet in the south part of the central area. This rock intruded as a dome, penetrating the Atadoğdu Formation and the Bentepe Formation. The marginal part of this rock is chilled and the country rock shows effects of thermal metamorphism and argillization to width of a few meters. In hand specimen, chlorite and epidote are partly observed as altered minerals.

Bulanık quartz diorite: This rock is located between Mamlis area and Mt. Kula in the central area and Yenisöğüt hamlet in the north area. This rock intrudes dacitic pyroclastic rocks and dacitic intrusive rocks, and seems to form a batholith like mountain chain in the central area. Alteration and mineralization are observed especially in the marginal parts of the intrusive body. The alteration is mainly argillization and siliciflication, and dissemination or veinlets of lead, zinc and copper are principal types of mineralization.

Dalören diorite: Dalören diorite located around Mt. Sultanseyit (2,173 m) in the southwest area, has a dome structure, which intrudes the Düzpelit Formation and Tırnas Formation. Alteration is not common in the hand specimen.

Pokir quartz diorite: This rock extends from the east side of Bulanık quartz diorite through Mt. Pokir to the east. It seems to be dome-like body intruding the Atadoğdu Formation. Alteration is not observed on the hand specimen scale. Most of the country rocks are not disturbed and some boundaries between the Pokir quartz diorite and the country rock show a weak thermal effect.

Dirik quartz diorite: This intrusive rock has a dome like shape, and intrudes dacitic pyroclastic rocks, which are located around Mt. Dirik in the southwest area.

3-2-4 Porphyry

Most porphyritic rocks are located in the same area as the Cet dacite. These rocks, which are usually small scale, about 100 m in width, have N-S, NW-SE and NE-SW trends, and almost vertical dips, they intrude the Düzpelit Formation. These rocks show the same facies as the porphyritic part of the Çet dacite, which are dark gray - greenish gray in color and have noticeable phenocrysts of plagioclase and hornblende. Alteration was not observed.

This geological evidence indicates that the porphyry rocks are closely related to the Çet dacite. In the Mamlis area, small amount of porphyry rocks intruding Bulanık quartz diorite and Düzpelit Formation were observed. These rocks, having conspicuous phenocrysts of plagioclase and green ground mass, extend NE-SW and dip almost vertically, and are called feldspar porphyry. The distribution area of this feldspar porphyry limited to the Mamlis area, is smaller than that of the porphyry rocks mentioned above.

3-2-5 Andesite Dyke

Andesite dyke with nearly N-S trend and 100 m in width was observed on the west side of the Dalören diorite. This rock is dark-gray, compact, and intrudes the Düzpelit Formation. This rock is limited to the area around the Dalören diorite, and seems to be related to the Daloren diorite.

3-3 Geological Structure

3-3-1 Geological Structure

The basement of the Tunceli area is formed by the Paleozoic Munzur Formation, distributed widely along the Munzur river and throughout the eastern area. The metomorphic grade is equivalent to a low grade of epidote amphibolite facies, that is occurrence of biotite in pelitic schist, and epidote and common hornblende in green schist. It is assumed that the metamorphism may have been regional metamorphism, which took place after the deposition of the Paleozoic Munzur Formation, which is correlated with the Permian.

Prior to the Eocene epoch, the metamorphosed Paleozoic Munzur Formation was divided into blocks by faults resulting from tectonic movements. Five blocks crop out in the Tunceli area. The lower member of the formation occurs in two areas: one of the two areas is located in the area between the Venk and the Balik faults and the other is north of the Duzik fault. Crystalline limestone is predominant in both areas.

In the Tunceli district, Mesozoic sediments were not observed except for serpentinite distributed in the north. The serpentinite forming ophiolite intruded at the later stage of the Alpine orogeny.

During the Eocene epoch Flysh-Type sediments were deposited and resulted in forming of the Atadoğdu, the Bentepe and the Kamışlık Formations. The rock facies of these formations indicate the typical flysh sedimentation. The Atadoğdu Formation, composed of mainly calcareous mudstone, may represent the stable deep-sea sediments. The Bentepe Formation, formed by alternating conglomerate, limestone, and calcareous mudstone may be considered to be shallow sea sediments. The Kamışlık Formation may represent deep-sea sediments, but volcanic fragments have been observed in the upper part. The sediments of the Eocene Series assume undulated structure dipping to the south along the Büyük river and to the south of it. In the central and northern parts of the area, these sediments form a half-dome structure, surrounding the Paleozoic Formation. In the investigated area marine regression took place during the interval form the late Eocene to Miocene epochs. At that time, the area from the Kakbil hamlet to Mt. Karataş, was lifted up, forming the leading structure resulting from igneous activities in the Miocene. After extensive erosion, the Kakbil-Korataş lift zone was submerged and submarine volcanic activity took place. The Duzpelit Formation was formed by this activity.

At the Düzpelit stage, Sin dacite, Çet dacite and other dacites intruded along the Kakbil-Karataş lift zone, and granite rocks followed around the perimeter of the zone. The volcanic cycle was terminated by intrusion of porphyry. At the end of the stage, the area became a sedimentary environment. Mainly limestone and calcareous mudstone were deposited and formed the Tırnas Formation to the north and the south of the lift zone.

Submarine volcanic activities took place again at the Cevizlik stage. Violent activity resulted in deposition of dacitic pyroclastics of the Cevizlik Formation. Composition of pyroclastic rocks changed into andesitic one at the Savular stage. Both the Cevizlik and Savular Formations are distributed in the northern area.

3-3-2 Relation Between Mineralization-Alteration and Geological Structure

In Tunceli district, basement is formed by the Munzur Paleozoic Formation correlated with the Permian System, Eocene Series consists of Flysch-Type deep sea sediments and overlies the basement unconformably. Marine regression took place during the interval from the late Eocene to Miocene. At that time, the area from the Kakbil hamlet to Mr. Karataş was lifted up, forming the leading structure resulting from igneous activities in the Miocene. After extensive erosion, the Kakbil-Karataş lift zone was submerged and submarine volcanic activity took place. The Düzpelit Formation was formed by this activity. Mineralization and alteration were observed from the centre of up-lift zone to the north wing of uplift zone. The mineralization consists of network or vein type related to the Bulanık quartz diorite and disseminated type related to dacitic lava dome. The former is represented by mineralization of the Mamlis and Kört mines and accompanies E-W and N-S fissure pattern, the latter is represented by mineralization of the Sin mine, which accompanies NW-SW trending of geological structure.

3-4 Mineral Deposits and Alteration Zone

3-4-1 Sin Mine

The Sin mine is located at a distance of about 1 km, southeast of Sin hamlet, which is at a distance of about 20 km from Tunceli city. It takes about 1 hour by car from Tunceli city to Sin hamlet, and about 20 minutes to the mine on foot.

The rocks of this area consist mainly of the Atadoğdu Formation, Bentepe Formation and Düzpelit Formation. These formations are intruded by the Sin dacite, and this fact complicates the geology. The Sin dacite is distributed from the Sepertek to Siliç hamlets with about 12 km east-westward extension (about 4 km wide). The silicification, argillization, and pyritization were observed in the neighborhood of the Sin dacite.

The alteration is especially strong around Sin and Siliç hamlets. Geochemical anomaly was found by Bilfer corporation in the Sin area, and therefore soil samples were collected at an interval of 100 m and a detailed geological investigation on a scale of 1 : 2,000 was carried out in the Sin area, in 1978.

The mineralization which was observed to occur along a sheared zone of NEE or EW trend, contains disseminated Cu-Zn-pyrite ore. Malachite stains were often observed in the shard zone (E-W) of the Sin dacite near the Sin mine, and also a network of sphalerite, weak quartz veins, malachite, and secondary azurite were found in the strong silicification zone. The silicification zone extends from the Sin mine to Sin hamlet. It covers an area of about 500 by 300 m around the Sin mine.

The malachite stains are composed of two types, one occurs along joints and is weak, but the other forms a network and is conspicuous.

The another mineralization in this area, was found to occur in mudstone of the Atadoğdu Formation near the Sin dacite. It is a Cu-Zn-quartz vein with silicification. It is different from the Sin mine placed in the dacite.

The veins are strike N40°E and dip at 70° - 80° to the west. The width is less than 1 m, and so the mineralization is a small scale one. Though the alteration observed in the Sin area is white argillization, characterized by chlorite (and probably sericite), the mineralization is weak in the strong argillization zone, and predominant in the silicification zone.

3-4-2 Mamlis Mine

Mamlis mine is situated in the west part of the investigated area, and is located about 5 km west of Mt. Sincik (2,384 m). It takes two hours to the Çeper hamlet from Tunceli City by jeep, via Ovacık town, and ten minutes to the Mamlis mine on foot. The mine is situated at about 1,300 m distance to the south of the Çeper hamlet.

The rocks of Mamlis area are composed of dacitic pyroclastic rocks of the Düzpelit Formation and Bulanık quartz diorite intruded into the formation.

Dacitic pyroclastic rocks around the quartz diorite are strongly altered and it is difficult to clarify the original structures and textures.

However, the pyroclastic rocks about 1.5 km to the north of the Çeper hamlet were not subjected to the alteration and generally have bedding dipping to the north.

Dacitic pyroclastic rocks in the area of 1 km (north-south) by 1.4 km (east-west) centering around Mt. Sivri Kaya, are remarkably altered, that is silicification, white argillization and limonitization (the last originated from sulfide minerals). Especially strongly silicified zones trend N-S on the northern slope of Mt. Sivri Kaya and in the eastern part of Mt. Haydar (along the upper part of the Gezik creek). The silicified zones range from 5 m to 10 m in width and are over 100 m in length. Topographically, these zones form protruded ridges.

The Mamlis mine is situated about 1,850 m above sea level, along a branch of the Maden stream between Mt. Gözerek and Mt. Haydar, to the south of the Çeper hamlet. Wastes lie on the slope and slags were found here and there.

The mineralization is composed of vein and stockwork type, the former is a chalcopyrite-quartz vein, the latter is a stockwork with galena and sphalerite around the peripheries of quartz diorite intrusions.

Mineralization is found not only in Mamlis mine, but also in a wide area from the east to the northeast of the mine. Numerous limonite-quartz veins were observed in a region from the north side of Mt. Haydar to the branches of the Gezik creek.

Five or six outcrops of gossan containing much limonite were found on the western and the eastern ridges of Mt. Haydar, and on the eastern ridge of the Peak 1,947 m. These gossan strike N60° - 80°E and are about 10 m in width.

Floats of silicified rock containing sphalerite were found along the Gezik creek, and in this region geochemical anomalies were obtained by the Bilfer Co. from stream sediments, with Zn as the indicator element. Chemical analysis in the 1978 and 1979 is shown in Table 3-1.

3-4-3 Kört Mine

Kört mine is located about 700 m southeast of Kört hamlet, which lies at about 1,300 - 1,350 m above sea level. There are two galleries in Kört mine. No. 1 gallery is about 200 m southwest of Mt. Nişan (1,397 m) and its elevation is 1,350 m. No. 2 gallery is about 100 m to the west from No. 1 gallery, elevation of which is 1,300 m. This mine was explored in late 1960's and No. 1 gallery is connected with No. 2 gallery in the underground. The ores which were produced are stocked around No. 1 and No. 2 galleries, and also around the suspension bridge across the Munzur river at the foot of Mt. Değirmen. Total ores produced are estimated at over 300 tons. The country rocks are composed of siliceous conglomerate of the Bentepe Formation and siliceous mudstone of the Kamışlık Formation.

Ore bodies are composed of quartz veins accompanied Cu-Pb-Zn minerals. Ore minerals are sphalerite, bornite, and chalcopyrite, secondary azurite and chrysocolla were also observed. It is assumed that an outcrop had been discovered and excavated, forming No. 1 gallery, No. 2 gallery was excavated later and connected to gallery No. 1. Now it is impossible to enter these galleries. Secondary copper minerals accompanying quartz-pyrite vein and malachite stain in the altered country rock, were observed at an outcrop near No. 1 gallery. The ores which are stocked, are mostly secondary minerals and only small amounts of primary minerals (chalcopyrite and sphalerite) were found. This is considered to indicate that the prospecting was located in the oxide zone of ore bodies. The country rocks are almost brecciated, and mineralization and alteration is developed along sheared zones. Judging from this geological evidence, Kórt mine seems to be a small scale vein type ore deposit composed mainly of copper minerals.

The Kamıslık Formation along the Bulanık quartz diorite in the south of Kórt mine was subjected to strong alteration, and in this area, many floats of stained malachite and magnetite which are also observed at Yayla creek, were found. The area extending from Aynalıpozvenk to Leşkan hamlet is also strongly altered.

Table 3-1 Results of Chemical Analysis
(Rock Samples)

Sample No.	Locality	Coordinates		Rock Name	Analysis (ppm)				
		N	E		Au	Ag	Cu	Pb	Zn
TAR 118	Mamlis	^{43}43 300	^{5}24 200	Sili-R	< 0.2	< 2		623	114
TAR 119	Mamlis	^{43}43 300	^{5}24 200	"	"	3		52	1,040
TAR 120	"	^{43}43 300	^{5}24 200	"	"	< 2		75	583
TAR 231	"	^{43}43 550	^{5}24 050	Dacitie Tuff diss. Pb. Zu	"	3		8,659	191
TMR 317	Garipuşağı	^{43}44 650	^{5}27 200	Dacitic Tuff	"	< 2		81	66
TSR 347	Mamlis	^{43}42 750	^{5}23 350	Go	"	4		526	1,608
TWR 239	"	^{43}44 450	^{5}22 700	Sili-R	"	< 2		224	868
TER 224	"	^{43}43 950	^{5}25 950	Go		4	40	37	120
TSR 590	Doludibek	^{43}43 800	^{5}25 850	Sili-R		11	630	2,500	225
TSR 802	Meterisler	^{43}36 985	^{5}33 370	Dacite			100	6,700	50
TSR 804	"	^{43}37 880	^{5}31 910	"			60	30	13
TSR 806	"	^{43}37 730	^{5}32 520	"			940	55	13
TSR 807	"	^{43}37 695	^{5}32 380	"			5,850	430	37
TSR 830	Sincik T.	^{43}42 370	^{5}27 600	Quartz vein			280	770	2,560
TSR 835	Ağ+aş	^{43}40 030	^{5}21 660	Go			35	70	112
M-1	Doludibek	^{43}42 950	^{5}24 650	Go		3	60	87	535
M-2	"	^{43}42 900	^{5}24 500	Go		7	50	56	3,300
M-4	"	^{43}42 850	^{5}24 100	Go		5	70	68	375
M-5	"	^{43}42 800	^{5}23 900	Go		26	300	787	45
M-9	"	^{43}42 750	^{5}23 400	Go		6	20	187	490
M-11	"	^{43}43 300	^{5}23 550	Dacitic Tuff		2	55	37	60
M-21	Gözerek T.	^{43}42 700	^{5}22 850	Go		6	20	25	620
M-33	"	^{43}42 800	^{5}23 100	Go		6	30	25	790
S-4	Sin	^{43}37 000	^{5}35 000	Dacite		3	400	56	150
S-5	"	^{43}37 000	^{5}34 950	"		5	2,250	56	610
S-6	"	^{43}37 100	^{5}34 950	"		3	7,850	37	180
S-7	"	^{43}37 150	^{5}34 900	"		3	60	87	535
TAR 009	Kört	^{43}39 100	^{5}31 850	ore			4.73%	0.14%	5.55%
TSR 016	Sorsivenk	^{43}54 900	^{5}30 100	ore			1.15	0.01	0.06
TSR 356	Mamlis	^{43}43 250	^{5}20 800	ore			0.15	36.70	0.02
M-50	"	^{43}43 250	^{5}20 800	ore			1.17	25.47	0.70

Go: Gossan

In this area, the geochemical exploration of Bilfer company was done, and its results show a Zn-Cu anomaly around this area. The alterations and mineralizations mentioned above are considered to have accompanied the intrusion of the Bulanık quartz diorite.

3-4-4 Mineralization and Alteration except the Mine Described Above

Sorsivenk mine: The Sorsivenk mine is located about 300 m northeast of Sorsivenk hamlet, in the northwestern part of the investigated area. The ore is a barite-calcite-quartz vein with azurite and malachite. This vein occurs in a calcareous siliceous rock of the Paleozoic Formation and is thin and was observed in the hanging wall of a colapsed gallery.

Maden tepe mine: The old adit is situated about 1.3 km to the north-northeast of the Karşılar hamlet, and about 400 m to the southeast of Mt. Maden is 1,640 meters above sea level. The rocks around the mine area are composed of green schist and crystalline limestone. Green schist has gentle folds, striking N30°E, and dipping 10° to the west. Crystalline limestone is banded bluish black in color. A open pit was found, it is 10 m x 15 m, and is filled with slag and waste. There is a waste dump 3 m in height. Ore body occurs along the boundary between crystalline limestone and green schist, where the former corresponds to a foot wall and the latter to a hanging wall.

Gossan which crops out is compact and massive, and composed of limonite and hematite. The skarn minerals of diopside and epidote form the gangue. Magnetite and sulfide minerals of lead and zinc were not observed with a naked eye, the ore body may not be large and may be a pocket-like concentration. It is considered that the ore deposit may have formed during the Miocene epoch, provided that the intrusion of Karşılar quartz diorite is related to the formation of the ore deposit.

Venk mine: The Venk mine, which is situated 500 m southwest of the Venk hamlet, is located at 1,450 m above sea level. The ore body occurs in pelitic schist intercalated with green schist. The structure of schist strikes N50°W and dips 30° to the north. Ore is porous and massive. Limonite, hydrous iron and quartz were observed with naked eye. They form shell structures. Galena (0.5 x 1 cm) is rare and fragments of schist are sometimes found in the ore, and are altered to brownish clay minerals.

Igneous rocks, presumed to be related to the mineralization, were not found around the mine. Though Pokir quartz diorite crops out about 2 km to the west, doesn't show alterations. The Paleozoic Munzur Formation is steadily stable and gossan doesn't occur except around the mine. It is considered that the ore deposit may be an ore pocket resulting from small dykes of igneous rock intruded into the Paleozoic Formation, the formation of the ore deposit took place during the Miocene epoch.

Alteration and mineralization in Garipuşağı area: Mineralization in this area was observed in dacite, which forms lava domes in the Düzpelit Formation. The dacite has E-W strike and lies 400 - 500 m away from the Bulanık quartz diorite. Silicification, pyritization and network of hematite were found in the dacite, which covers an area of 2 km x 0.5 km (maximum). Partially, network of hematite was also found in an area, west of Garipuşağı hamlet, which corresponds to the west side of the dacite lava. Pyritization, silicification, and argillization were observed throughout the dome. An especially large quantity of pyrite is present in the Garipuşağı hamlet, east of Garipuşağı hamlet, and the area along Garip stream. No network type ore deposits were found although they were expected based on geochemical anomaly east of Garipuşağı. The south dacite lava of the Düzpelit Formation was subjected to intense silicification related to the intrusion of the Bulanık quartz diorite.

Konak Dere mineralizated zone: A dacitic lave dome is located south of Kört mine along Konak Dere, it is 700 meters by 400 meters large. Though it is intrusive in the north part of the dome, it is formed by lava in the south part of the dome. Mineralization consists of pyrite dissemination and malachite stain, all of the dacitic lava is the strongly altered.

Dacitic lava is in contact with the Bulanık quartz diorite south of the Kört mine, and the mineralization may therefore be considered to be related to the Bulanık quartz diorite, but a mineralization related to dacite is different from the one related to the Bulanık quartz diorite. Dacite lava is completely altered, and accompanied by fine-grained pyrite and hematite.

Siliç alteration zone: The alteration developing around Silic hamlet area is accompanied by the Sin dacite. This alteration zone is mainly composed of white argillized part containing weak pyrite dissemination. The earth surface around this area is pained reddish brown due to oxidation of pyrite. This alteration zone is not large and is limited only to the Sin dacite and the country rock (calcareous mudstone of the Bentepe Formation).

Fortunately a new car-road connecting Siliç hamlet with the main road along the Munzur river, was finished at the time of the survey. Through detailed observation of this new outcrop, it became clear that the intensity of alteration and mineralization decreases abruptly with depth. A Cu-Zn-Mo anomaly was found by Bilfer Company. However, due to the reason mentioned above, a detailed investigation was not undertaken, and this area is considered to have low potential.

Mehmet alteration zone: The alteration was observed around Mehmet hamlet, which is located in the center of the investigated area. The alteration area is narrow. The north side is limited by the Bulanık quartz diorite and the south side is also limited by the unaltered Duzpelit Formation. The country rock is the Bentepe Formation composed of calcareous mudstone, limestones, etc. This alteration zone looks similar to the zones which extend from Kört mine to Leşkan hamlet and also extend from Kört mine southward. Both of them occur around the Bulanık quartz diorite.

3-5 Geochemical Prospecting in the Tunceli District

Since porphyry copper was assumed to be the type of deposit which was expected to occur in the altered areas delineated by photo-geology copper, lead, zinc, and molybdenum were selected as indicators for the geochemical prospecting. The collected samples were stream sediments and soil. The stream sediments were collected from the 220 km^2 at the eastern part of the geologically reconnoitred area which had not been sampled previously. The soil samples were collected from the uplifted zone (WNW-ESE direction) between Karataş and Kakble which is the centre of Tertiary volcanism and in the zone of Bulanık quartz diorite distributed to the north.

The stream sediments were collected from the major rivers on the basis of one sample per square kilometre. The soil samples were collected by Ridge and Spur method. Sampling intervals were kept as constant as possible, 100 m in Mamlis, Sin and Siliç areas where mineralization and alteration was evident and 300 m in other areas. The collected geochemical samples were as follows.

Table 3-2 Geochemical Prospecting in Tunceli District

Year	Sample	Area	Locations	Average
1978	Stream Sediments	220 km^2	225	1/km^2
1978	Soil	115 km^2	1.561	13/km^2
1979	Soil	50 km^2	620	12/km^2
1980	Soil	5 km^2	98	15/km^2

High geochemical anomalies of rank A and B could not be found from the stream sediments and noteworthy alteration was not discovered from the geological survey. The soil samples were collected over a period of two field seasons of 1978 and 1979, and the number of samples processed totaled 2279. The resulting geochemical anomaly map is shown in Fig. 3-2. The comulative frequency distribution is shown in Fig. 3-3, background, threshold values, and deviation is laid out in Table 3-3. The correlation coefficients of the four elements are shown in Table 3-4 and correlation curve in Fig. 3-4.

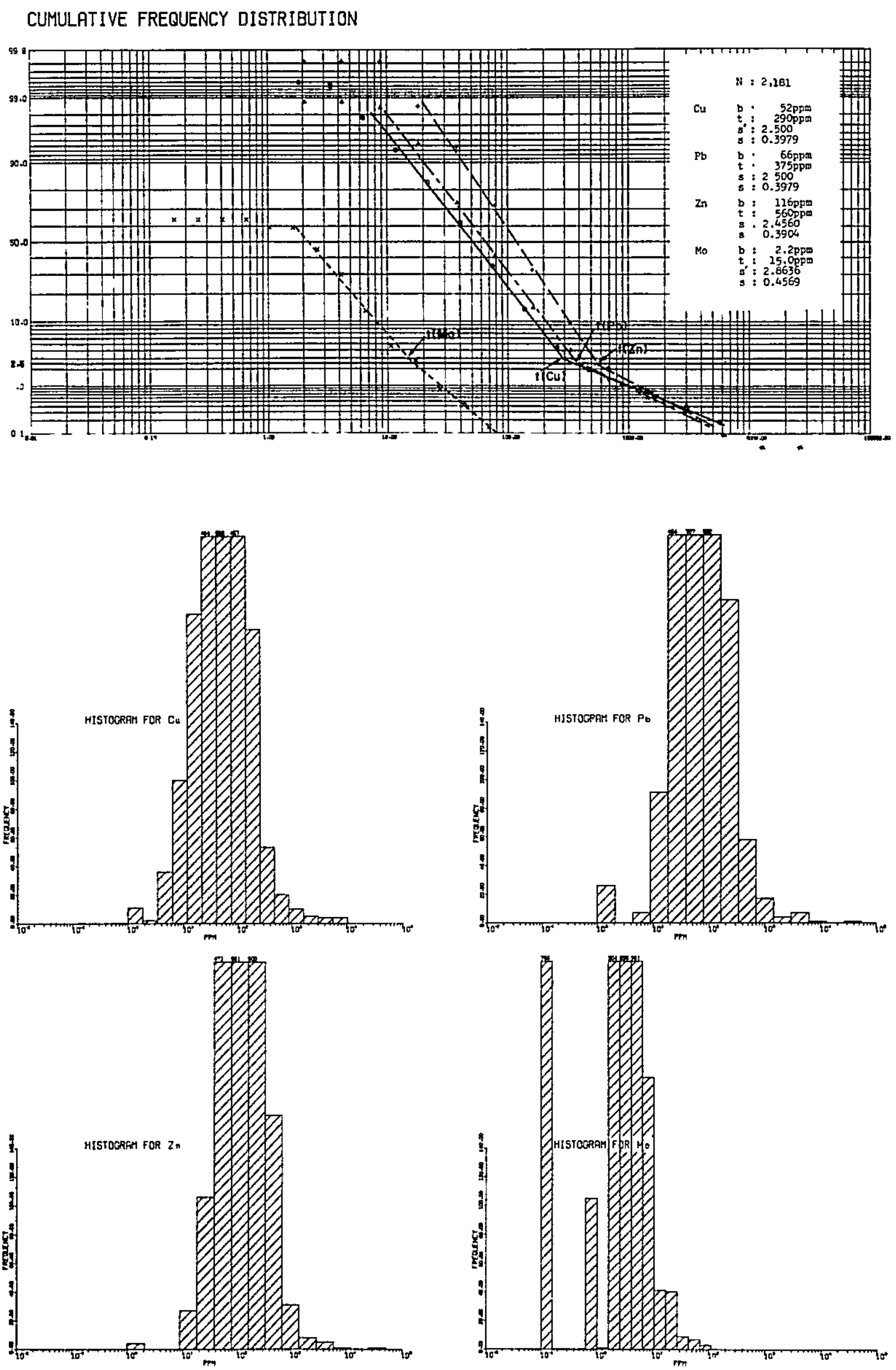
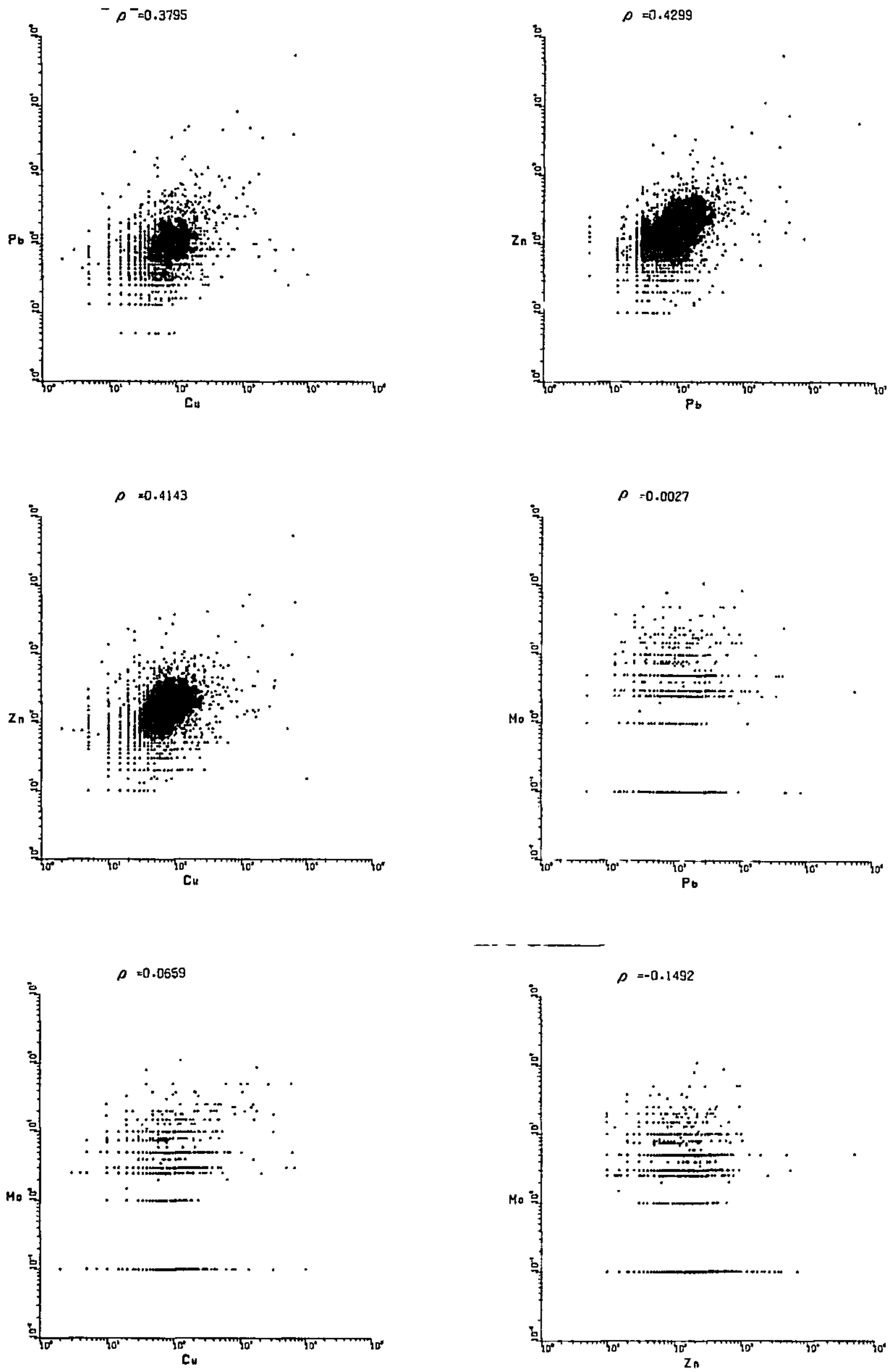


Fig. 3-3 Cumulative Frequency Distribution and Histogram of Geochemical Contents



ρ: Coefficient of correlation

Fig. 3-4 Correlation of Geochemical Contents

Table 3—3 Background and Threshold Value

	Population (N) 2.181			
	Cu ppm	Pb ppm	Zn ppm	Mo ppm
Background value (b)	52	66	116	2.2
Geometric diviation (s')	2.500	2.500	2.456	2.863
Standard diviation (s)	0.397	0.397	0.390	0.456
Threshold value (t)	290	375	560	15.0
Supplementary*1 threshold value (t')	150	185	295	6.8
Supplementary threshold value (2t)	580	750	1,120	30.0

*1: t' is the value either equal to or less than 10% of cumulative frequency percentage of "t value" or corresponds to less than 16% of the highest value of total number of cumlative frequency.

Table 3—4 Correlation Coefficient of Geochemical Elements

	Cu	Pb	Zn	Mo
Cu				
Pb	0.3795			
Zn	0.4143	0.4299		
Mo	0.0659	0.0027	0.1492	

The results of the geochemical prospecting by soil samples agree well with those of geological survey. The anomalies associated with quartz diorite near Kört and Mamlis mines, and those associated with dacite near the Sin mineralized zone are of rank A. In 1980, the especially interesting anomalies extracted from the geological and geochemical survey of 1978 were checked. Ninety eight (98) soil samples were collected from three localities totaling 5 km^2. The interesting alteration and associated mineralization were confirmed by this check at Metrisler which is located to the West of the Sin mineralized zone.

The following is the results obtained from the work described above.

(1) The geochemical anomalies obtained from soil samples are in Sin dacite and Çet dacite in the uplifted zone between Karataş and Kakbil, and in the peripheries of Bulanık quartz diorite bodies.

(2) The rank A anomalies were found in Sin, Mamlis, and Kört. Anomalies were for copper, lead, and zinc.

(3) The centres of geochemical anomalies of this area are Sin, Mamlis, and Kört, and rank B anomalies were found in the vicinity. These rank B anomalies were mainly associated with intrusive bodies distributed near the uplifted zone.

3-6 Geophysical Survey of Mamlis and Sin Areas (Induced Polarization Method)

3-6-1 Introduction

In the Mamlis and Sin areas, promising mineralized zones have been discovered by the 1978 preliminary geological and geochemical surveys. In the Mamlis area, the Vein-type mineralization was found in quartz diorite, and the network-type mineralization was found in dacitic pyroclastic rocks (Düzpeliz Formation) surrounding quartz diorite, outcrops of the network are fully limonitized due to the strong oxidation, it is considered to be primary sulfide minerals underneath the surface. In the Sin area, field evidence has suggested some mineralization of the Sin dacite and the alternative sedimentary environment accompanied with the dacite intrusion. A promising mineralized zone including chalcopyrite, sphalerite and pyrite has been recognized around an open pit of the Sin Mine about one km southeast of Sin hamlet.

On the basis of the above survey results, an Induced Polarization (IP) survey has been planned for exploring the further extension of the mineralized zone and for presuming ore-mineral content. This survey covers an area of about 6 km^2 including 28 survey lines. The total length of the lines amounts to 53.6 km.

The field work has been launched in June 19, 1979, and performed in Sept. 27, 1979. Field data processings have been carried out at both the Tunceli Camp and the Araklı Branch, while computations of terrain correction for apparent resistivity, laboratory IP tests of rock specimens, and simulation analyses have been completed in Tokyo, Japan.

3-6-2 IP Measurement and Survey Apparatus

There are two types of IP field survey: frequency domain method and pulse method. The former has been adopted as the present survey method. For expressing IP characteristics, the following variables are taken into account: FE (frequency effect), AR (apparent resistivity) and MF (metal conduction factor). FE is expressed as a different between apparent resistivities measured at a low and a high frequency in percentage, which Wait (1959) defined as

$$FE = \frac{\rho(\infty) - \rho(0)}{\rho(0)} \times 100\%, \qquad (1)$$

where $\rho(\infty)$ and $\rho(0)$ indicate ARs when the frequency f becomes infinity and zero respectively. In the present survey, the measurements have made at frequencies of 0.3 and 3 Hz instead of $f = 0$ and ∞, respectively. Then Eq. (1) becomes

$$FE = \frac{\rho(0.3\ Hz) - \rho(3\ Hz)}{\rho(3\ Hz)} \times 100\% \qquad (2)$$

AR for a dipole-dipole electrode configuration is calculated from the following formula:

$$\rho = \pi a n\ (n+1)\ (n+2) \frac{V}{I} \qquad (3)$$

in the unit of ohm - m, where "a" is the electrode spacing (m), "n" the electrode-separating coefficient, "V" the input voltage of a receiver (volt), "I" the output current of a transmitter (amp.) and π the circular constant (= 3.14159). In the present survey, ρ(3 Hz), AR at a frequency of 3 Hz, is calculated.

Most of sulfide ore deposits indicate a high FE and a low AR. In order to emphasize such characteristics, MF is defined by taking Eqs. (2) and (3) into account, i.e.

$$MF = \frac{FE}{\rho\,(3\ \text{Hz})} \times 1,000 \qquad (4)$$

The followings are specification of the present IP survey.

	Mamlis area	Sin area
Direction of traverse line	N 6.5°W	N 66.5°W
Direction of baseline	N 83.5°E	N 23.5°E
Method of measurement	frequency domain method	
Transmitting frequencies	3.0, 0.3 Hz	
Electrode configuration	dipole - dipole	
Electrode separations	100 m, 50 m*1	100 m
Spacing of traverse lines	200 m	100 m
Electrode separating coefficient	n = 1 ∿ 5	n = 1 ∿ 5
Shifting of measuring stations	100 m, 50 m*1	100 m

	Mamlis area	Sin area
Number of survey lines	12 lines	16 lines
Total length of survey lines	26.6 km	27.0 km
Number of measured points	1,150	1,030

*1 Note: Used for Line W_3 (8-18) and Line W_4 (8-18)

Survey apparatus

The field apparatuses used in the present survey are as follows:

Mamlis area

Transmitter

Type	:	IP square-wave generator Model T2800
Manufacturer	:	Geotronics Co., USA
Input Voltage	:	95 - 120 V, 400 Hz
Output Voltage	:	95 - 800 V
Output Current	:	0.05 - 2.0 A
Frequency	:	0.1, 0.3, 1, 3 and 10 Hz

Receiver

Type	:	Phase Lock IP Receiver Model 5280
Manufacturer	:	Geotronics Co., USA
Input Voltage	:	10μV - 1 V, 11 steps
Input Impedance	:	10 M ohm
Time Constant	:	2, 6, 15, 60, 150, and 600 sec.

Electrode

Current Electrode	:	Stainless steel stick
Potential Electrode	:	Porous electrode pot saturated with copper sulfate solution

Engine Generator

Type	:	Mark II - 400
Manufacturer	:	McCullch, USA
Output	:	115 V, 400 Hz, 2 kW

Sin area

Transmitter

Type	:	IP square-wave generator Model T 2800
Manufacturer	:	Geotronics Co., USA
Input Voltage	:	95 - 120 V, 400 Hz
Output Voltage	:	95 - 800 V
Output Current	:	0.05 - 2.0 A
Frequency	:	0.1, 0.3, 1, 3 and 10 Hz

Receiver

Type	:	IP Receiver Geomite Model R401
Manufacturer	:	Geotronics Co., USA
Input Voltage	:	9.0 μV - 10 V, 6 steps
Input Impedance	:	10 M ohm
Time Constant	:	2, 6, 15, 60, 150 and 600 sec.

Electrode

Current Electrode	:	Stainless steel stick
Potential Electrode	:	Porous electrode pot saturated with copper sulfate solution

Engine Generator

Type	:	Mark II-400
Manufacturer	:	McCullch, USA
Output	:	115 V, 400 Hz, 2 kW

3-6-3 Survey Results of Mamlis Area

Results of rock sample tests

FE and Resistivity laboratory tests are made with 33 rock specimens sampled in the Mamlis area (see the sampling location map in Fig. 3-5). The results are given in Fig. 3-6.

The statistical distribution ranges of FE and Resistivity together with the mean values except for both the maximum and minimum values are given below.

(Rocks)	FE (%)	Mean	Resistivity (ohm-m)	Mean
Ore	18.7 - 49.2	(35.0)	10 - 64	(37)
Gossan	3.8 - 5.2	(4.5)	525 - 1,910	(1,010)
Diorite	2.6 - 4.3	(3.2)	634 - 3,850	(1,750)
Dacite	2.5 - 3.1	(2.8)	142 - 493	(318)

(Rocks)	FE (%)	Mean	Resistivity (ohm-m)	Mean
Siliceous rock	1.1 - 2.3	(1.5)	192 - 673	(336)
Tuff	0.8 - 1.7	(1.2)	76 - 332	(162)
Porphyry	4.9		3,470	

The followings can be inferred from the results of rock sample tests.

FE:

(1) The mean FE of ore specimens is 35%, very high as compared with the other kinds of specimens.

Even in case of a granodiorite sample including Cu-Pb veinlets, the mean FE is not higher than 20%.

(2) The FE percentage of gossan is relatively low, ranging 2.6 - 5.2%, but slightly higher than those of host rocks.

(3) The mean FE of diorite is 3.2%, high relatively to the other kinds of host rocks. The pyrite dissemination of diorite samples may give rise to such a high FE.

(4) Specimens of widely distributed tuff indicate FEs ranging 1 - 2%.

(5) Only one specimen of porphyry indicates a 4.9% FE, relatively high. The siliceous dacite specimen, which was sampled at the site of the above porphyry specimen was sampled, also

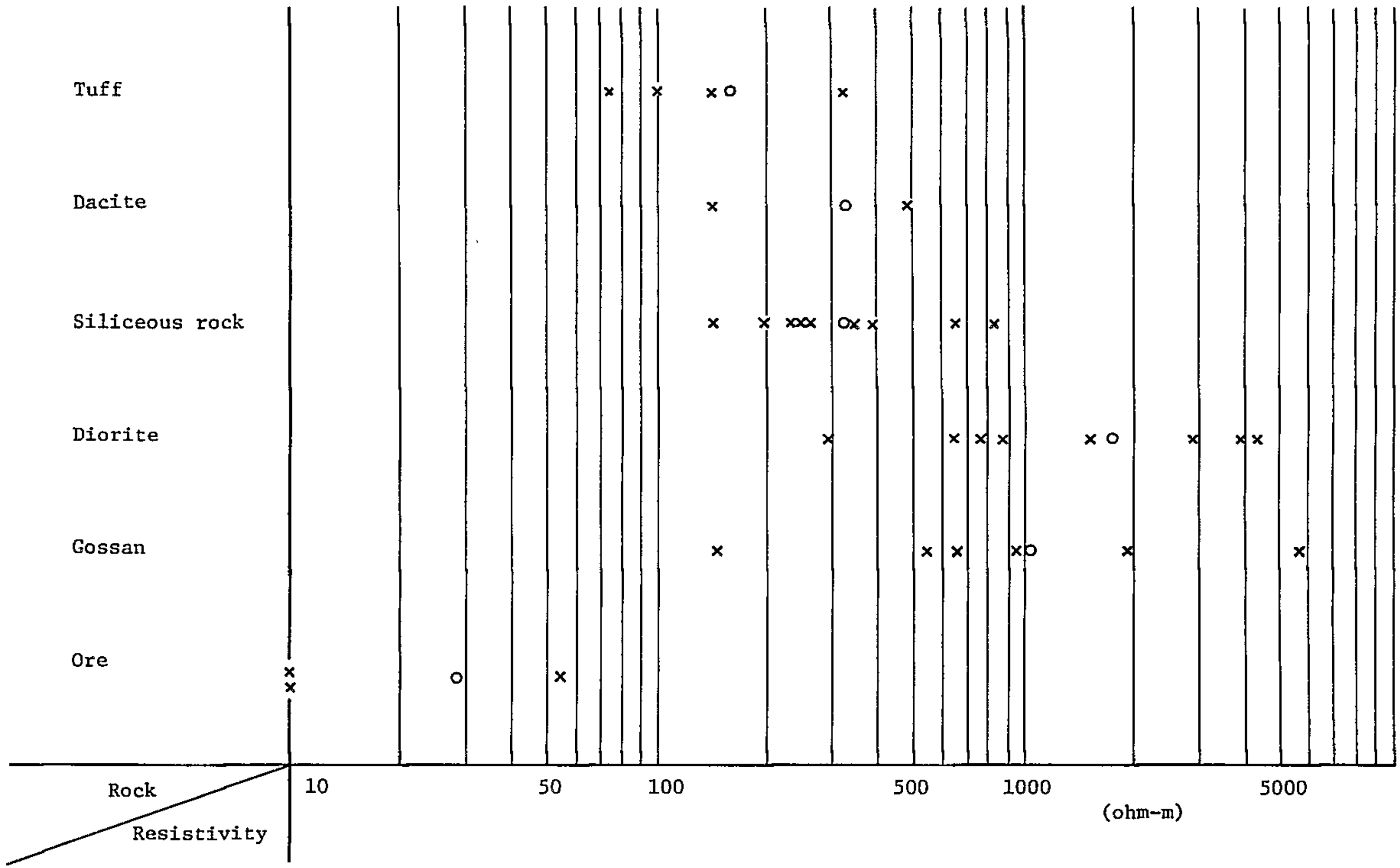


Fig. 3-5 Distribution Range of Resistivity in Laboratory Measurements (Mamlis Area)

Fig. 3-6 Interpretation Map of Mamlis Area

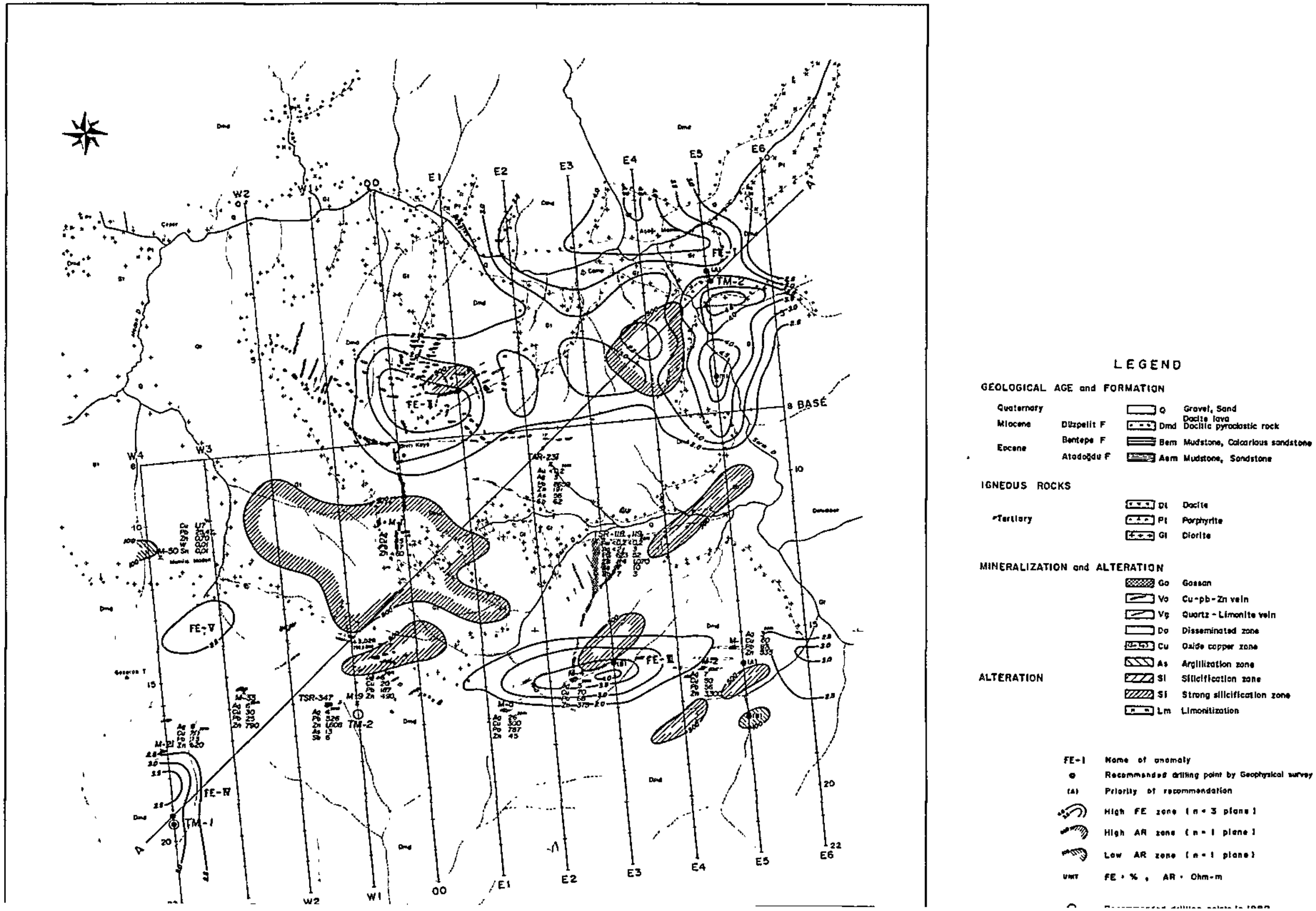
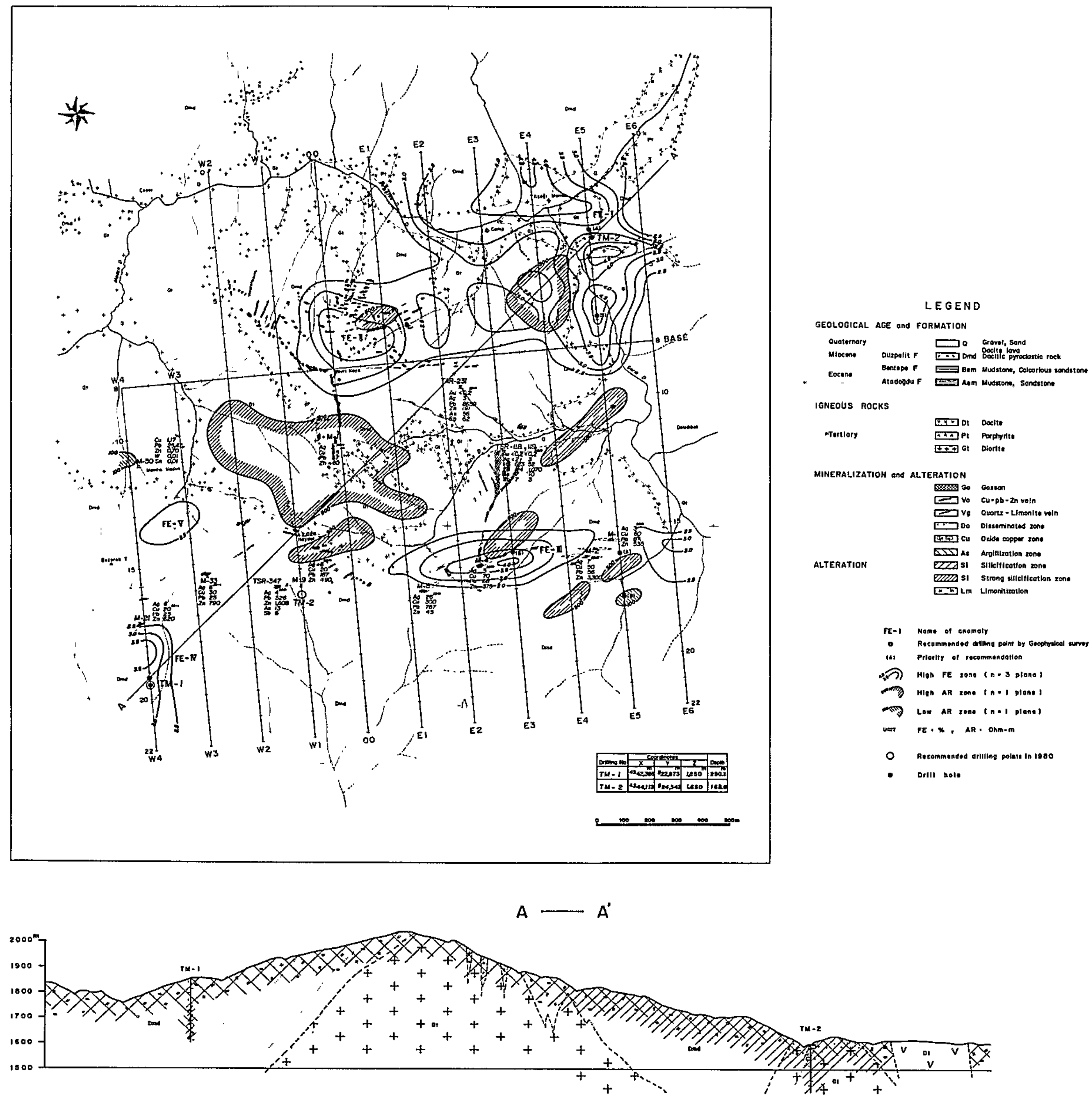


Fig. 3-6 Interpretation Map of Mamlis Area



has a high FE amounting to 3.1%, and slightly higher than the other siliceous dacite specimens. This fact may imply that the mineralization was occurred around the sampling site.

Resistivity:

(1) As shown in Fig. 3-6, resistivities of the ore specimens have lower than 50 ohm-m, as compared with the other kinds of specimens having resistivities ranging 75 - 5,600 ohm-m.

(2) The mean resistivities of gossan and diorite are 1,010 and 1,750 ohm-m, respectively. Those of dacite and siliceous rocks are 318 and 336 ohm-m, respectively.
The tuff specimens have a low resistivity, 162 ohm-m on average.

(3) The relatively low resistivity of siliceous rock may indicate that the silicification is not effective on AR.

(4) The statistical distributions of resistivity are overlapped each other, that is, there are no significant differences in resistivities between any kinds of rocks. Accordingly, it may be difficult to identify rocks on the basis of the differences in resistivity.

Survey results

The field survey results are represented in the cross sections of FE, AR and MF. The areal distribution of FE, AR and MF is also indicated in the plan maps at various levels of 100 m (n = 1), 200 m (n = 3) and 300 m (n = 5). The panel diagram representation makes it easy to consider a three-dimensional distributions of FE and AR.

As a result of the survey, taking into consideration the geological data and the rock specimen tests, the FE anomalies are recognized in the following five locations.

A) Aşağı Mamlis hamlet and its neighborhood (FE - I Anomaly).

B) The northern part of Sivri Kaya (FE - II Anomaly)

C) The southeastern part of Haydar Tepe (FE - III Anomaly)

D) The southwestern part of Haydar Tepe (FE - IV Anomaly)

E) The southern part of Mamlis Maden (FE - V Anomaly)

A) Aşağı Mamlis Anomaly (FE-I Anomaly)

(1) The wide distribution of the FE-I anomaly may be caused by the development of mineralized and argillized zones.

(2) The anomalous area of FE 2.5% or higher coincides with a pyrite-disseminated, silicified and argillized zone in quartz diorite. The fact that the field AR measured on Line E_6 is lower than the result of laboratory test of a quartz diorite specimen may indicate the extension of an alteration zone east of this line.

(3) The fact that this anomaly trends NW-SE may also indicate the northern extension.

(4) The downward continuation of this anomalous body cannot be expected.

B) North Sivri kaya Anomaly (FE-II Anomaly)

(1) The area surrounded by a FE 3% contour corresponds to gossan outcrops of dacitic pyroclastics. In the eastern part of this anomaly, the downward continuation to a deeper conductor can be expected.

(2) The primary sulfide minerals cannot be expected to be found at the bottom of the gossan.

C) Southeast Haydar Tepe Anoma ly (FE-III Anomaly)

(1) This anomaly is related to the gossan. Among Line E_2 and E_6 it trends in the E-W direction.

(2) The depth of the anomaly source is thought to be shallow-seated beneath Lines E_2, E_3 and E_6, but relatively deep beneath Lines E_4 and E_5. Although the geological survey results prospect the source structure is gently-sloped southwards the simulation analysis do not find such a tendency.

(3) The most promising gossan has been found by the geological survey on Lines W_1 and W_2 west of this anomaly. However, there is no geophysical anomaly over the gossan, so that the deeper continuation of the gossan can not be prospected.

(4) The primary sulfide minerals can be expected to be found at the bottom of gossan at Lines E_4 and E_5 No. 16 - 17 stations.

D) Southwest Haydar Tepe Anomaly (FE-IV Anomaly)

(1) This anomaly may possibly be continued westwards and southwards beyond the survey area. Unfortunately, the entire picture of this anomaly has not been captured because it is located at the southwest corner of the survey area.

(2) This anomaly may be related to the shallow-seated source, whose continuation downward can not be presumed.

E) Southwest Sivri kaya High AR

(1) The high AR zone, as high as 500 ohm-m, coincides with quartz diorite in the southwest Sivri kaya. However, the corresponding FE anomaly is not found. This may imply that the fresh quartz diorite body without mineralization and alteration is continued downwards.

F) Remarks on the Mamlis Mine Prospectings

(1) The anomaly pattern related to the Mamlis Mine has been clarified by a 50 m-interval electrode configuration but not by a 100 m-interval one. An outstanding clear anomaly has been captured on Line W_3 (8-18), on the other hand, the corresponding anomaly becomes very weak on Line W_4 (8-18). Accordingly, it is not expected a westward extension of this anomaly.

Future Plan of Geophysical Exploration (Fig. 3-6)

(1) For the purpose of disclosing the anomaly sources, the following drillings are desired.

Rank	Anomaly	Location of Drilling	Direction	Depth
A	FE-III	Line E_5 No. 16-17	Vertically down	250-300 m
A	FE-I	Line E_5 No. 4-5	Vertically down	100-150 m
B	FE-IV	Line W_4 No. 19-20	Vertically down	200-250 m
B	FE-III	Line E_2 No. 15-16	Vertically down	250-300 m
B	FE-I	Line E_5 No. 7	Vertically down	100-150 m
B	FE-III	Line E_5 No. 18	Vertically down	250-300 m

(2) For the purpose of clarifying the entire picture of the FE-I anomaly found in the northeastern part, the further geophysical prospecting to the north and east of the present survey area is desired.

(3) The western and southern extensions of the FE-IV anomaly should be surveyed because it may be continued in these directions.

3-6-4 Survey Results of Sin Area

Results of rock samples tests

FE and AR laboratory tests are made with 27 rock specimens sampled in the Sin area. The sampling locations are illustrated in Fig. 3-8. The results of rock specimen tests are shown in Fig. 3-7.

The statistical distribution ranges of FE and resistivity except for both the maximum and minimum values together with its mean values are given below.

Rock	FE (%)	Mean	Resistivity (ohm-m)	Mean
Ore	2.9 - 18.2	(8.2)	1,580 - 3,280	(2,200)
Dacite	1.6 - 3.5	(2.6)	185 - 3,160	(903)
Tuff	1.1 - 1.9	(1.5)	196 - 217	(207)
Limestone	1.4 - 2.4	(1.9)	773 - 1,810	(1,290)
Mudstone	0.7 - 2.1	(1.3)	258 - 1,530	(746)

The followings can be pointed out from the results of rock sample tests.

FE:

(1) The FE values of ore specimens range from 2.9 to 18.2%, lower than ore specimens sampled in the Mamlis area. This may be caused by abundance of oxide minerals.

(2) The FE values of dacite, tuff, limestone and mudstone range from 0.7 to 3.5%. The specimens including pyrite- and hematite-bearing quartz vein indicate a slightly higher FE.

Resistivity:

(1) The resistivity values of rock specimens sampled in the Sin Area range from 64 to 8,550 ohm-m. Those of dacite and mudstone specimens are statistically distributed in wider ranges.

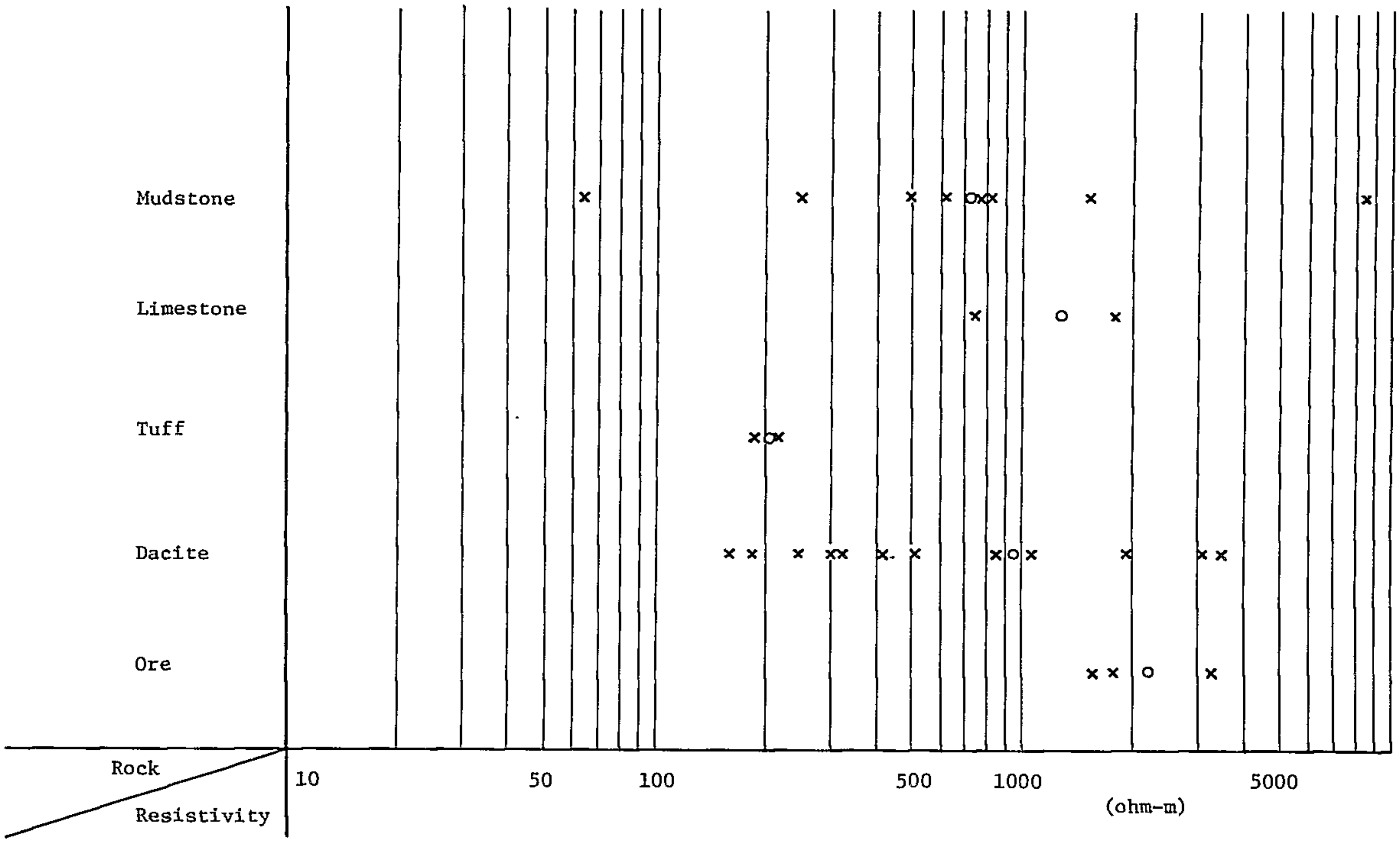
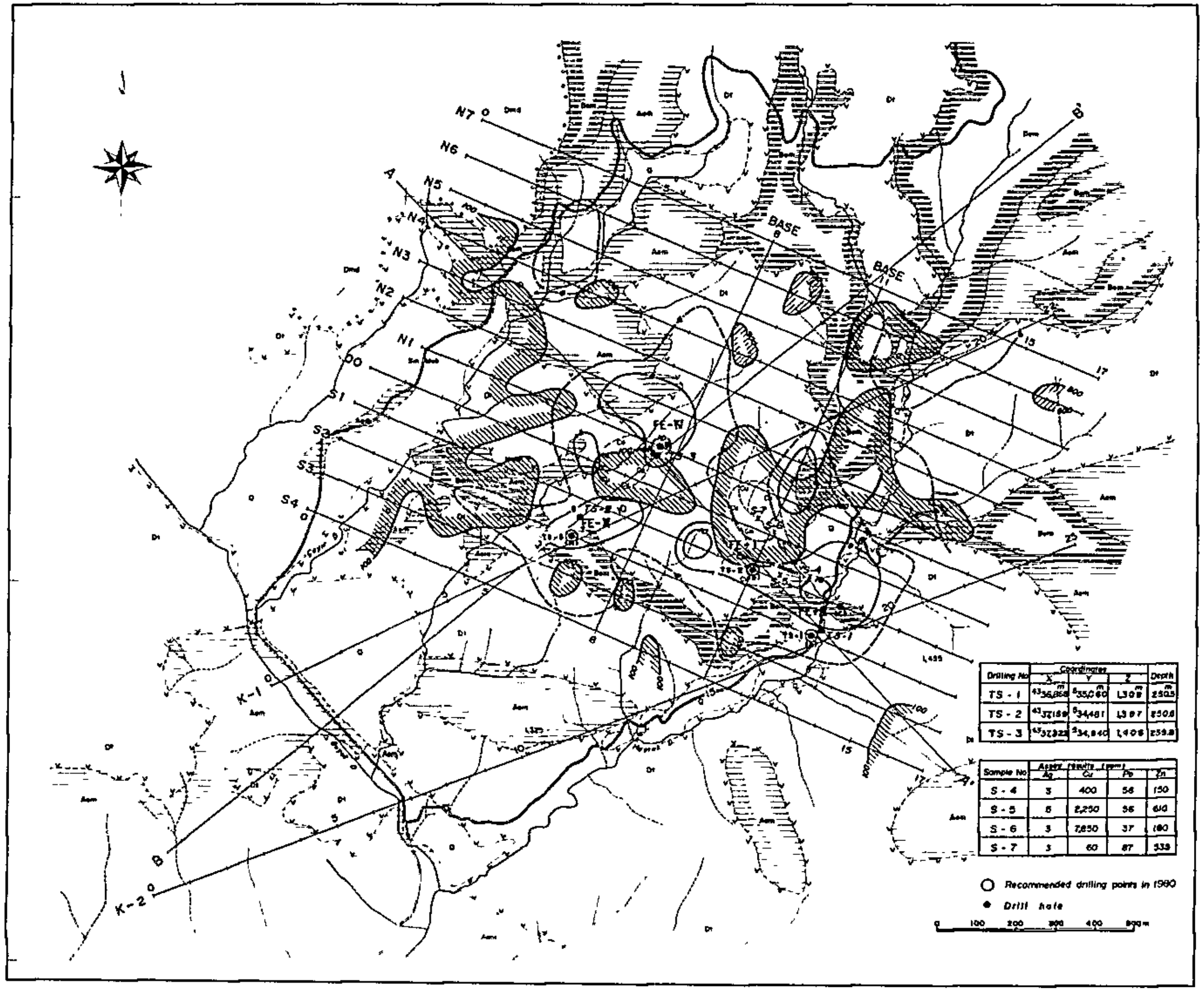


Fig. 3-7 Distribution Range of Resistivity in Laboratory Measurements (Sin Area)



Drilling No	Coordinates X	Coordinates Y	Coordinates Z	Depth
	m	m	m	m
TS - 1	^{43}36,868	^{8}35,060	1,308	250.5
TS - 2	^{43}37,169	^{8}34,481	1,387	250.6
TS - 3	^{43}37,323	^{8}34,840	1,406	259.8

Sample No	Assay results (ppm) Ag	Cu	Pb	Zn
S - 4	3	400	56	150
S - 5	6	2,250	56	610
S - 6	3	7,850	37	180
S - 7	3	60	87	339

A — A'

1500

TS-3

LEGEND

GEOLOGICAL AGE and FORMATION

Quaternary		Q	Gravel, Sand
Miocene	Dözpelit F	Dmd	Dacite lava, Dacitic pyroclastic rock
Eocene	Bertepe F	Bem	Mudstone, Calcarious sandstone
	Aladoğdu F	Aem	Mudstone, Sandstone

IGNEOUS ROCKS

Tertiary	Dt	Dacite
	Pt	Porphyrite
	Gi	Diorite

MINERALIZATION and ALTERATION

- Go Gossan
- Va Cu-pb-Zn vein
- Vg Quartz – Limonite vein
- Do Disseminated zone
- Cu Oxide copper zone
- As Argillization zone
- Si Silicification zone
- Si Strong silicification zone
- Lm Limonitization

- FE-I Name of anomaly
- ● Recommended drilling points by Geophysical survey
- (A) Priority of recommendation
- High FE zone (n = 3 plane)
- High AR zone (n = 1 plane)
- Low AR zone (n = 1 plane)
- UNIT FE : %, AR : Ohm-m

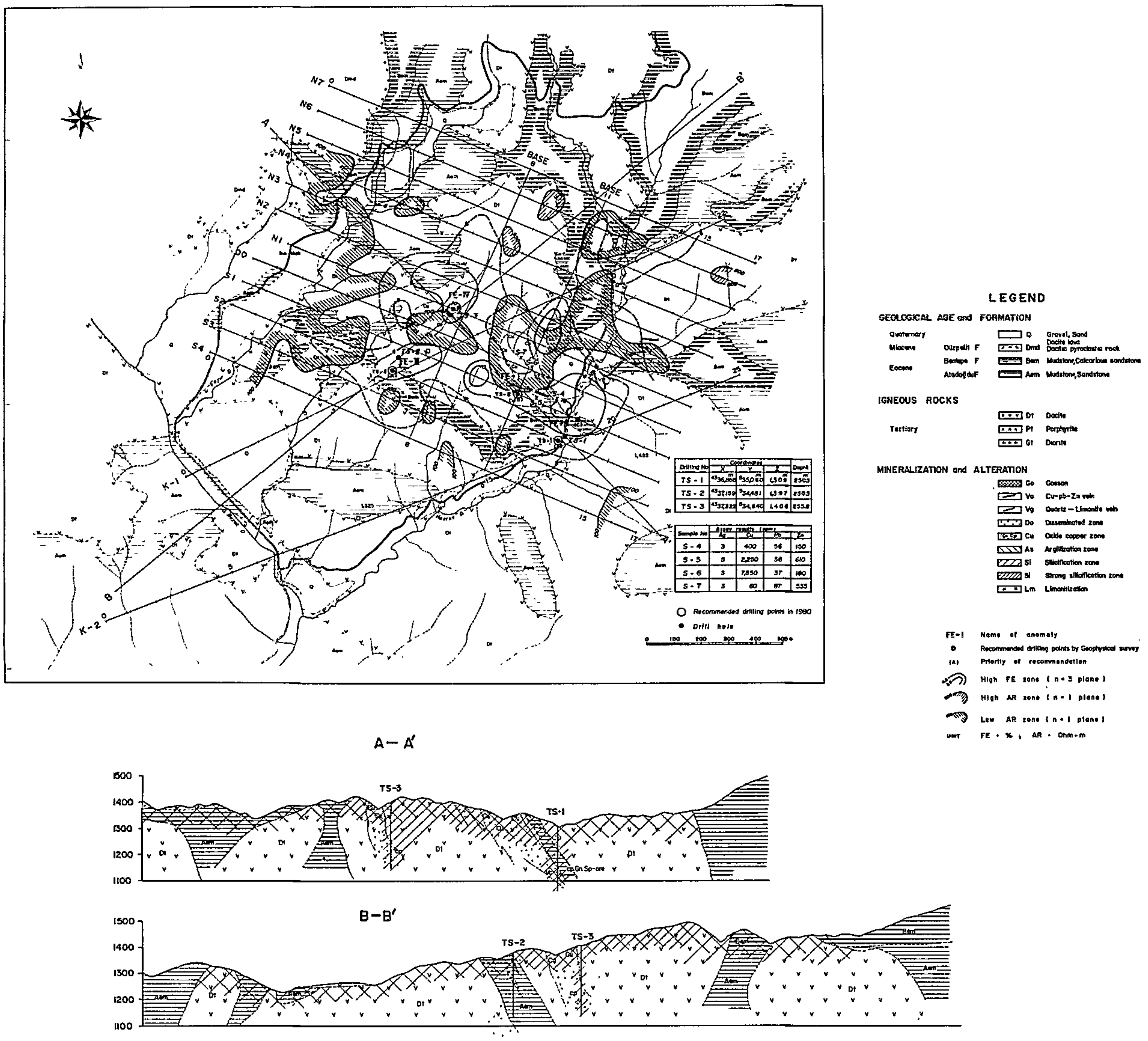


Fig. 3-8 Interpretation Map of Sin Area

(2) Ore specimens take resistivity values as high as 1,000 ohm-m. Possible causes of such high resistivities may be the silicification of dacite as host rock and abundance of oxide minerals.

(3) Although we have tested a few specimens of lime stone and tuff, we can conclude that limestone has a high resistivity amounting to 1,000 ohm-m in contrast to tuff having a low resistivity amounting to 200 ohm-m.

(4) Judging from the statistical distribution of resistivity values of rock specimens, it may be difficult to classify rocks on the basis of differences in resistivity.

Survey results

The cross section of FE, AR and MF are drawn by the use of the field survey data processed by the method as same as Mamlis area. The data are also used for drawing plan maps of FE, AR and MF at various levels of 100 m (n = 1), 200 m (n = 3) and 300 m (n = 5) below the ground surface. The panel diagrams represent three-dimensional distributions of FE and AR.

The synthetic considerations of both the geophysical and geological together with the results of rock specimen tests make us the qualitative and quantitative interpretation as follows. As a result of the survey, taking into consideration the geological data and the rock specimen tests, the FE anomalies are recognized in the following four locations.

A) Central Anomaly (FE-I Anomaly)

B) Southeast Anomaly (FE-II Anomaly)

C) Southwest Anomaly (FE-III Anomaly)

D) Central West Anomaly (FE-IV Anomaly)

What we obtained in the Sin-area survey is briefly summarized as follows, in addition, the future plan of geophysical prospecting will be mentioned later.

A) Central Anomaly (FE-I Anomaly)

(1) This is caused by the mineralized bodies around the open pit of the closed Sin Mine. According to the results of computer simulation analyses, the high FE zone (FE 20%, resistivity 1,500 ohm-m) sloping westwards is presumed.

(2) This anomaly continues downwards to the FE-II anomaly as the southern extension. Meanwhile, the western extension of this anomaly is thought to be continued downwards to the FE-III anomaly.

B) Southeast Anomaly (FE-II Anomaly)

(1) This is located right below the anomaly at Line S_2 No. 13 station. The simulation analyses conclude that this is a promising anomaly amounting to 20% FE and 1,500 ohm-m resistivity located at a depth of 200 m below the Nos. 12 and 13 stations.

C) Southwest Anomaly (FE-III Anomaly)

(1) This covers Line S_2 No. 5 - 7 and S_3 No. 6 - 8 stations.

(2) The simulation analyses point out as anomalous zone of 20% FE and of 1,500 ohm-m resistivity near Line S_2 Nos. 6 and 7 stations.

D) Central West Anomaly (FE-IV Anomaly)

(1) This anomaly is related to the mineralized zone confirmed by the geological survey at Line N_1 No. 5 - 9 and Line N_2 No. 6 - 9 stations.

(2) According to the results of computer simulation, the FE and resistivity reach up to 20% and 1,500 ohm-m, respectively, around Line N_1 No. 7 - 9 stations.

Future Plan of Geophysical Exploration (Fig. 3-8)

(1) The following drilling explorations are desired to disclose the anomaly sources.

Rank	Anomaly	Location of Drilling	Direction	Depth
A	FE-II	Line S_2 No. 12-13	Vertically down	250 m
A	FE-III	Line S_2 No. 6-7	Vertically down	250 m
B	FE-I	Line S_1 No. 10-12	Vertically down	200 m
B	FE-IV	Line N_1 No. 7-8	Vertically down	200 m
C	FE-I	Line S_1 No. 13-14	Vertically down	200 m

(2) The further geophysical prospecting to the south of the present survey area can be expected to capture the southern extension of the FE-II anomaly.

(3) A precise IP survey with a 50 m-interval electrode configuration may be effective for clarifying the sources related to small-scale network vein which has been confirmed by the geological survey.

3-7 Diamond Drilling in the Sin and Mamlis Areas

3-7-1 Outline of the Operation

Diamond drilling was performed for the purpose of exploring subterranean minerals and clarifying the geological structure of the mineralized areas of copper, lead and zinc which had been found as the result of a geological survey and geophysical prospecting (I.P. Method) executed in FY 1978 and 1979 in the Sin and Mamlis areas of the Tunceli district. Three drill holes with a total drill length of 750 m, and two with a total drill length of 500 m were planned in Sin and Mamlis areas respectively.

3-7-2 Purpose of the Diamond Drilling

The diamond drilling operation started on June 12, 1980 and ended on November 9. The number of holes drilled in this period was five, while the total drill length was 1,175.70 m. The operation was performed mainly on a single shift basis by organizing three Japanese engineers, one Turkish engineer and three chief drillers into three teams using three drilling machines (Atlas Corp., D-750).

Drilling was performed by coring the overburden with tricon bits, then with NQ-WL and BQ-WL. The drilling resulted in low ratios of both drilling efficiency and core pick-up recovery rate due to the occurrence of hole-wall caving, loss of circulation, etc. in some fractured zones and intensely altered zones.

The drilling sites and the total drill length by hole are as shown in Table 3-5.

Table 3-5 List of Drill Holes in Sin and Mamlis Areas

Drilling site	Drilling number	Direction, inclination	Total drill length	Core recovery rate
Sin	TS-1	-90°	250.50 m	100%
Sin	TS-2	-90°	250.50	82.5
Sin	TS-3	-90°	255.80	84.0
Mamlis	TM-1	-90°	250.30	99.8
Mamlis	TM-2	-90°	168.60	78.6
Total	5 holes		1,175.70	90.0

3-7-3 Diamond Drilling Operation

Base development and setting-up of equipment: Prior to carrying out the operation, the base development, and the arrangement of vehicles and laborers had already completed by M.T.A. Starting from June 12 the access roads were repaired and the lands for drilling emplacement were levelled. The diamond drilling machines and equipment/materials were then carried in by trucks from the Malatya and Diyarbakır Branches of M.T.A. to their respective drilling sites. The transfer to the Mamlis area was done by truck after the road had been constructed by bulldozers.

Drilling operation: The rocks to be drilled consist mainly of dacite, mudstone, sandstone, etc. in the Sin area, and dacitic pyroclastics, diorite, etc. in Mamlis area. The presence of fractured zones and clay zones was forecasted in both areas. The wireline method was used in the drilling using bentonite mud water.

As the result of diamond drilling, the depths of the overburden were found to range from 0.6 m to 7.50 m. The overburden was drilled using 4 5/8" tricon bits. Coring was then performed with NQ-WL and BQ-WL. In the course of drilling for fracturing clay zones, hole-wall caving and loss of circulations occurred in the TS-2 and TM-2 holes, and the hole-walls were protected by inserting casing pipes on performing cementation. Meanwhile, it was rather easy to drill the other three holes to attain the initial aim. The results were that the gross drill length per shift was 3.91 m and the net drill length per shift was 5.45 m from all the holes, while the average core recovery rate was 90.0%. The results by hole are as shown on Table 3-5.

3-7-4 Drilling Operation in Tunceli District

As the result of the diamond drilling performed in FY 1980, we would like to state for future reference the results of the study on problems of diamond drilling in the area, and countermeasures to be taken.

Selection of diamond drilling machine: In order to achieve an efficient drilling, the selection of a diamond drilling machine with a sufficient capacity for the planned depth is important. It is also necessary to take into account a possible additional drilling in accordance with the geological conditions. In a case where the final caliber is to be BX size, it is desirable to select a machine capable of drilling the final depth in the next-largest NX size. Further, it is necessary to take into account lowered engine efficiency when operating on high ground.

Drilling mud: Although bentonite mud water is effective for drilling such stabilized rocks as dacite and diorite, but in the course of drilling fractured and altered zones, its wall building properties are lowered due to increased solid composition, viscosity and fluidity, the occurrence of sticking, and increased dehydration. In such cases, it is necessary to switch the mud water with a dispersing/peptizing agent (for example, XP-20, Spersen) which functions as drilling mud water under low viscosity.

Countermeasures for loss of circulation: Since loss of circulation induces vibration of the rod string and is apt to result in a lowered recovery rate, excessive consumption of diamond, damage to machinery and so forth, it is important to prevent it as much as possible. If the loss is small, insertion of bentonite or injection of cement is effective, while if the loss is large, stuffing with straw chaff, perlite, etc. is effective. In the case of a loss of circulation which cannot be stemmed by these methods, insertion of casing pipes is a better measure in consideration of operational efficiency. In such a case, it is desirable to forecast how long the loss of circulation will continue. If the rock in the loss zone is good for cores, it is best to continue the drilling as it has been and insert casing pipes when such a zone is passed through.

Core recovery: Rock properties in the Sin and Mamlis areas are highly fracturable and clayey. For this reason, core clogging is so frequent and difficult to forecast that core recovery in clay zones is difficult.

Core recovery in BQ size was particularly difficult. To improve the core recovery rate, it is necessary to take the following measures:

(1) Drilling should be done in NQ size as much as possible.

(2) Hole walls should be protected by using high quality mud water and completely removing the sludge.

(3) Water circulation should be kept to a minimum, drilling be made rather speedily, and bit rotation be kept rather low. Coring equipment should be fully maintained and properly used.

Diamond bit: Diamond bits used in FY 1980 were of NQ and BQ sizes. The average life of NQ was 14.10 m, while that of BQ was 14.12 m. These bit-life values are too low for rocks in these areas. Such short lives are attributable to the following: Removal of sludge in the course of drilling was incomplete; Drilling was continued because core clogging in the course of drilling clayey zones had been impossible to forecast; Overload on bits accelerated damage to diamonds.

As to the sludge removal, it is important to always use high quality drilling mud water and to circulate the necessary water to remove the sludge. In this case, it should be noted that too much water brings about excessive pressure and induces loss of circulation, hole-wall caving, etc. The necessary amount of water varies according to the condition in the hole, grain size of the sludge, function of the circulating water, etc. Therefore, the appropriate amount of water to be pumped cannot generally be expressed in figures. Although the amount of water necessary to maintain the 1.00 m/sec. or more of annular velocity which is needed to remove sludge is 40ℓ/min. or more for a NQ-WL string, or 24 ℓ/min. or more for a BQ-WL string. It is hoped that the amount of water suitable to the drilling conditions will be provided using the above values as standards.

As to the core clogging, it is important to pay attention to the changes in the respective drilling situation as well as to ensure proper maintenance of core barrels, pumps, pressure gauges, etc.

As to the overload on bits, though the theoretical net load on the bit is 1,500 kg for NQ, or 1,000 kg for BQ, in practice it is difficult to obtain proper mechanical load on the bit at the hole bottom because of buckling of the string and other factors. Therefore, it is necessary to select a drilling speed appropriate to the kind of rock under drilling. Proper drilling speeds by rock distributed in this region are roughly as follows:

	Drilling speed	r.p.m
Granite, diorite	25 - 40 mm/min.	700 - 1,000 r.p.m
Dacite, siliceous rock sandstone	35 - 60 mm/min.	500 - 700 r.p.m
Tuff, mudstone	50 - 80 mm/min.	300 - 500 r.p.m

When it has become difficult to maintain the above speeds, it is necessary to withdraw the bit to determine whether it is reusable or not. When 25% or more of the diamonds are observed to be damaged in this case, it is best to change the bit.

How to carry out future operation: Since the operable period of work in this area is four months from June through October, operations must be carried out efficiently. In performing the work, it is considered that 24-hour operations on three shifts should be enforced to use equipment effectively, to improve the drilling ratio, and to decrease costs with keeping the equipments in line under the drilling plan.

3-7-5 Results of the Drilling

Sin area: The drilling of three holes in this area confirmed the existence of chalcopyrite associated with the well developed network quartz veins in dacite. In TS-1, Cu 1.21, Pb 2.63, Zn 4.86% ore was confirmed in 95 cm width between 204.15 and 205.10 cm depth, and in TS-3, copper and zinc dissemination was observed in 79.40 m width from 171.70 to 251.20 m, the average grade between 180 and 205 m where mineralization was strong was Cu 1262, Zn 363 ppm. Chalcopyrite was associated with quartz veins as disseminations or veinlets, and was found in quartz-sericite, propylite, and orthoclase zones. Therefore, this area is considered interesting and worth further investigation.

Mamlis area: Notable mineralization was not found by the two drillings. Weak pyritization associated with local silicification and sericitization was observed, but major mineralization could not be found in TM-1. It is interpreted that the mineralized zone has a steep dip from the exposure and is buried in deeper zones. In TM-2, silicified zone and pyrite dissemination was confirmed in the quartz diorite, but only minor amount of chalcopytite was observed associated with quartz veinlets. It will be necessary, in the future, to drill several holes and clarify the nature of mineralization of this area.

3-8 Conclusion

In the Tunceli district, the alteration at Sin and Mamlis areas was noted as the result of geological and geochemical surveys, and the IP anomalies ware drilled. It was shown by the drilling that in the Sin area, although of low grade, network type copper-zinc mineralization occurred widely in strongly altered dacite andesite bodies. In the Mamlis district, only the pyrite-bearing silicified zone was drilled.

The above results show that further prospecting is warranted in the Sin area. It should be conducted on the basis of the results of the studies where malachite stains are found on the surface, IP anomalies, and the drilling work. The prospecting should be extended into the Meterisler area as further drilling results become available. In the Mamlis area, only the localities near the mineralized zone have been

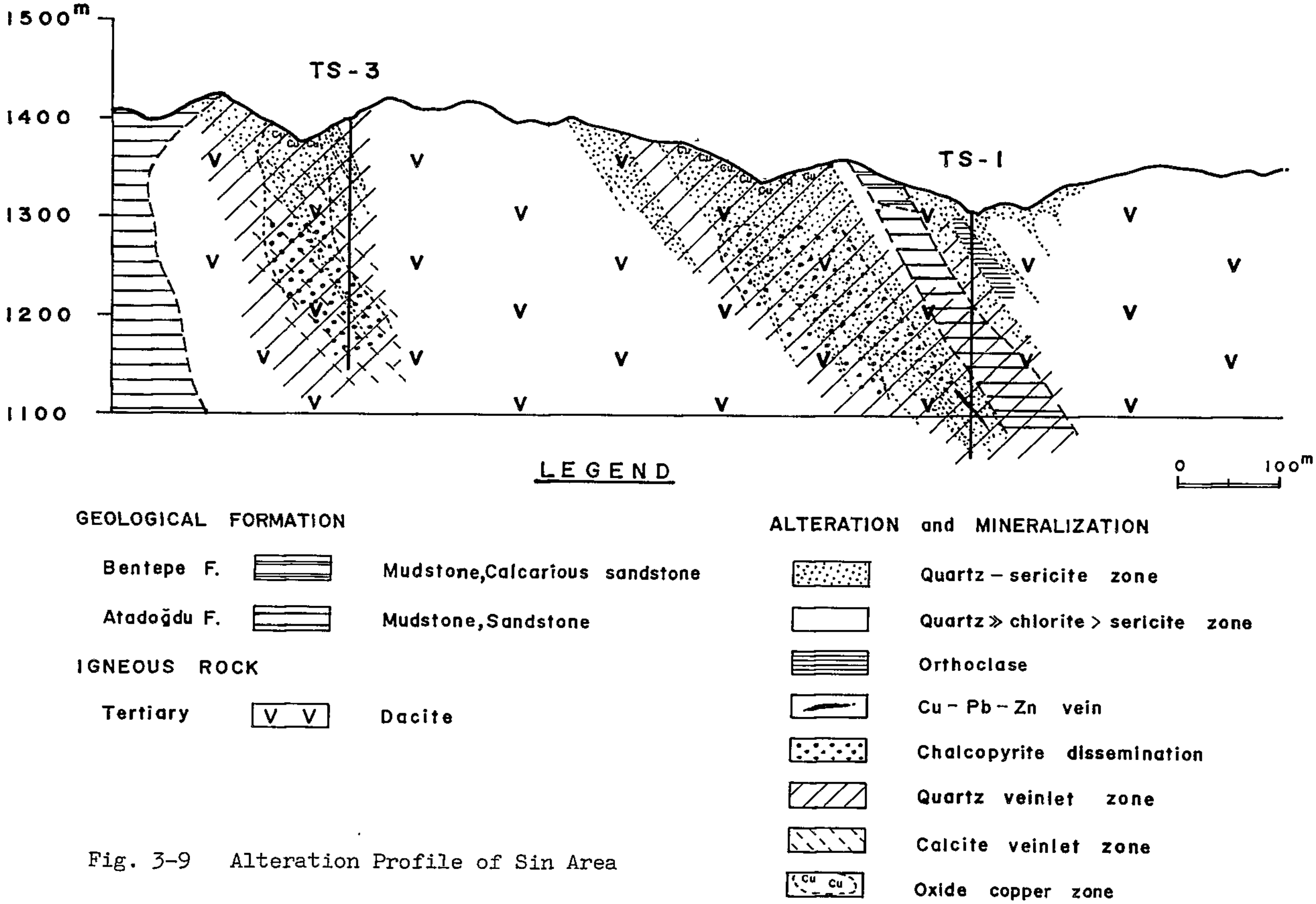
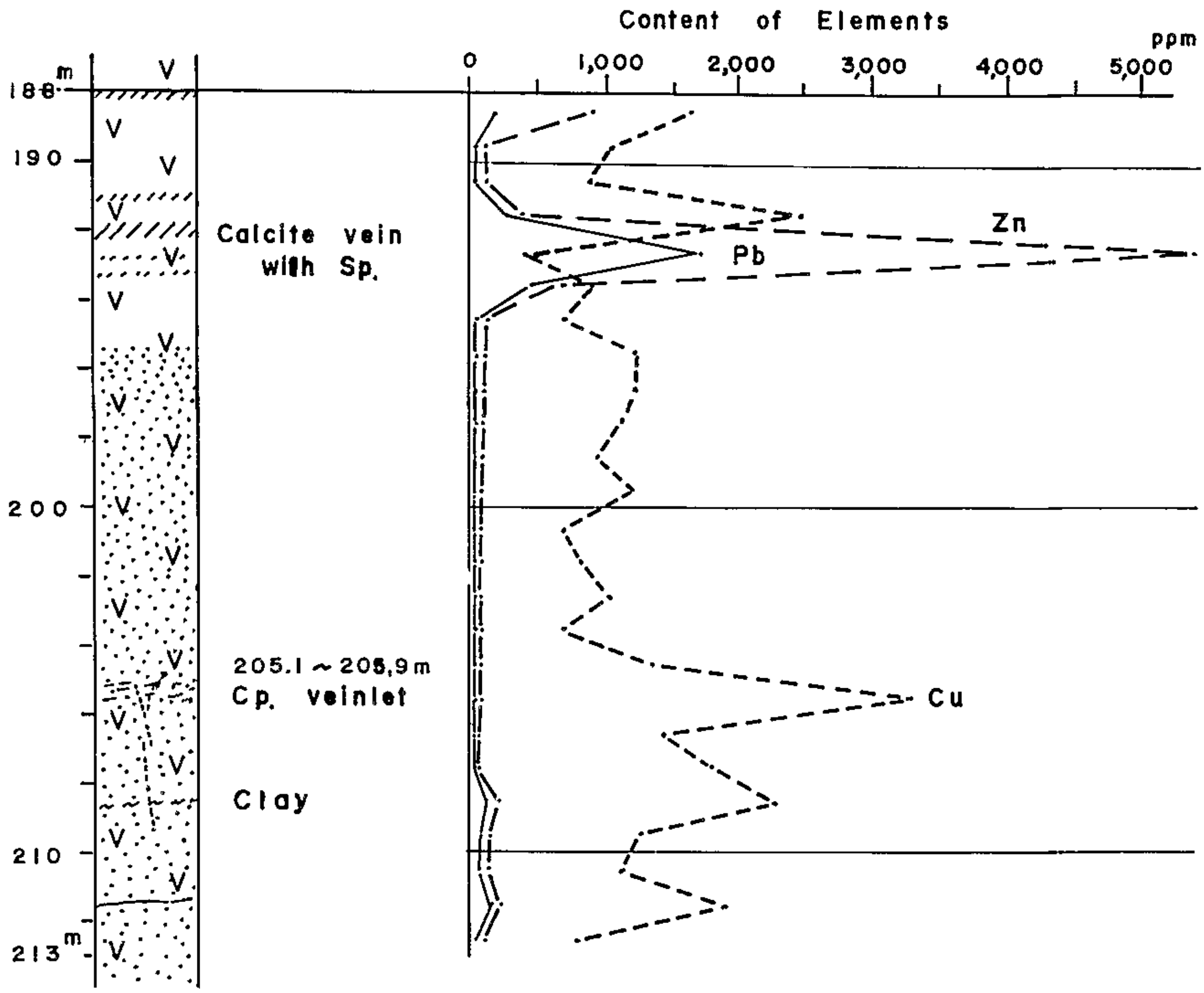


Fig. 3-9 Alteration Profile of Sin Area



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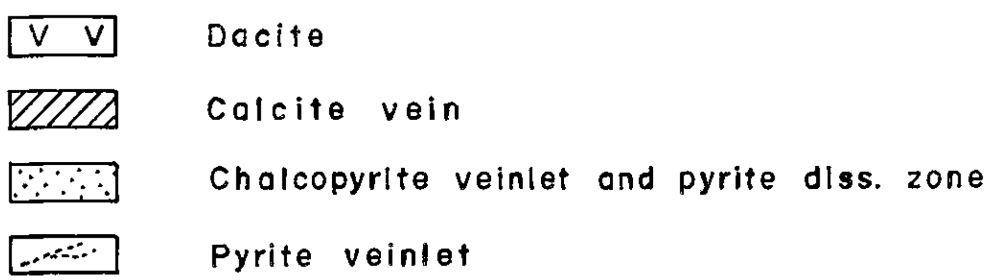

Sp : Sphalerite

Cp : Chalcopyrite

Fig. 3-10 Mineralized zone of TS-3 (188 ~ 213m)

prospected. It will be necessary to construct roads, and drill locations where IP anomalies are extracted and gossans observed on the surface.