REPUBLIC OF TURKEY

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

PHASE III

JANUARY, 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 collaborative mineral exploration project in Tunceli and Kopdağ areas in eastern Turkey and entrusted its execution to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The project started in 1977 in close collaboration with Maden Tetkik ve Arama Enstitüsü (MTA) of the Republic of Turkey. The intention of the project is to study potentiality of copper and chrome deposits in the investigated areas.

From 18 May, 1979 to 2 October, 1979 and from 17 June, 1980 to 29 September, 1980, the Metal Mining Agency of Japan dispatched a survey team headed by Mr. Hisashi Mizumoto to conduct geological survey, geophysical prospecting, trench and drilling, Phase III of the project.

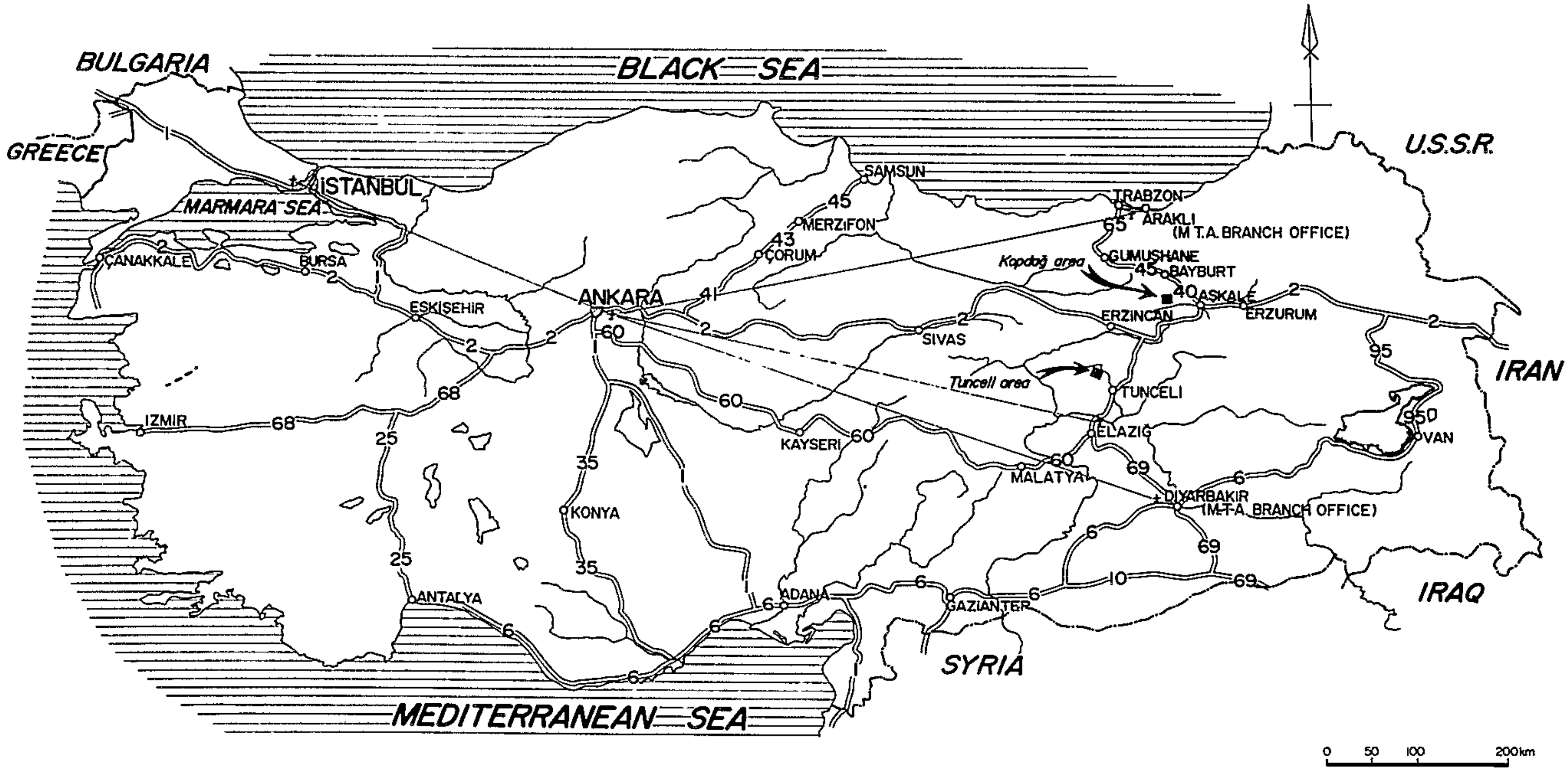
This report is a compilation of the basic survey findings of Phase III. At the completion of the project an overall report will be submitted to the Government of the Republic of Turkey.

We wish to express our appreciation to all the organizations and members who bore the responsibility for the project the Government of the Republic of Turkey, Maden Tetkik ve Arama Enstitüsü, and other authorities and the Embassy of Japan in Turkey.

January, 1981

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan



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SUMMARY

This report summarises the investigation of the Tunceli and Kopdağ areas, undertaken as a part of a cooperative program between Turkey and Japan, with the aim of conducting mineral exploration in the Tunceli and Kopdağ areas, eastern Turkey.

In the fiscal year 1977 and 1978, photogeological analysis, geological survey, and geochemical survey were carried out. The surveys clarified the geology and selected the mineralization-alteration zones.

Based on the above-mentioned information, geological investigation, geochemical prospecting, geophysical prospecting (I.P. method), trenching and hole drilling were undertaken in the fiscal year 1979 ; drilling of Ezan area was, however, carried out in 1980.

In the Tunceli area, geological investigation was carried out on a scale of 10,000 in an area of 50 km^2 and geochemical soil samples were obtained by the Ridge and Spur method, the samples were collected at an interval of 100 m and 300 m, and the sampling density was 12 samples per km^2.

In the Kört and Garipuşağı areas, where noteworthy mineral indications were found, detailed geological investigation on 1:2000 scale was carried out and mineralizations were clarified. Both areas are in the size range of 7 km^2.

As a result of the 1978 geological survey in the Sin and the Mamlis areas, where noteworthy mineral indications had been found, geophysical prospecting (I.P. method) was carried out, total lines of I.P. were 24.6 km in the Sin area and 28.6 km in the Mamlis area. In the Kopdağ area, detailed geological investigation was carried out on a scale of 1;1,000 in an area of 2 km^2, which contains the Ezan and Coşan mines. Trenches were dug to expose the extension of Ezan ore deposits, the volume of trenches was about 500 m^3. Drillings for the purpose of prospecting about 50 m below the outcrops of orebody were done, in the Ezan mine, total length of the 8 holes was 542.6 m. However, it was planned to drill 1000 m, and so the rest of drilling was carried out in 1980.

The result of investigation is as follows.

In the Tunceli area, the rocks consist of the Atadoğu, the Bentepe, and the Kamışlık Formations correlated to the Eocene, and the Düzpelit Formation correlated to the Miocene. Sediments of the Eocene are composed mainly of Filsch-type calcareous mudstone, and rocks of the Miocene consist of submarine pyroclastics, predominantly of dacitic composition. Intrusive rocks consist of quartz diorite, andesite and biotite dacite, they were most likely formed during the Miocene. Mineral occurrences are divided into Garipuşağı and Mamlis types, the former is characterized by disseminated pyrite and hematite, and is related to dacitic lava dome, the latter by network with sphalerite-galena (chalcopyrite), and is related to Bulanık quartz diorite.

Especially, Mamlis mineralized and altered zone is widespred, and a large of gossan and anomaly areas of copper and lead were found in it, however, the characteristic feature of this zone is that sulphide minerals can not be found under microscope, and it is assumed that they were completely leached out. Accordingly covered ore deposits are expected in this area and might be discovered by future prospecting.

In the Kopdağ area, geology of the area consists of the Meyramdağ limestone correlated to the Uppermost Jurassic-Lower Cretaceous and Kopdağ limstone correlated to Miocene-Pliocene, igneous rocks belong to the so-called ophiolite belt and consist of ultrabasic rocks, basic - intermediate igneous rocks, forming cumulate structure parallel to the above-mentioned sedimentary rocks. The ophiolite belt can be divided into three zones ; the Coşan and Ezan mining area chromite deposits are embedded in the northern dunite zone, which lies in the middle part of the ophiolite belt. The northern dunite zone is strongly altered, consists of foliated serpentinite, massive serpentinite of dunite origin, serpentinized dunite and pyroxenite. Ore horizon was found in the foliated serpentinite, and three ore horizones were recognized to be present at least in the Ezan mining area, on the other hand, although ore deposits were cut by faults in Coşan mining area, there was only one ore horizon. Continuity of the ore deposits in both mines could be clarified by a trench.

Chromite ores in the areas are mainly disseminated, a small amount of massive ore is associated with the disseminated ore, sametimes nodular and banded types of ore are observed. Massive ore is generally accompanied by kaemmererite and uvarovite which are considered to be secondary alteration products of chromite formed by hydrothermal solution. Disseminated and banded ores indicate frequently cumulate structure.

Geophysical survey (Induced Polarization Method) was carried out in Mamlis and Sin areas. IP anomalies were analized from FE, AR, MF plan maps and cross sections of each survey line, and with simulation analysis by computer and the result of rock sample tests.

From the results of said survey performed in Mamlis area, five good FE anomalies were found out, of which following two anomalies were especially estimated - "FE-III Anomaly" in southwest Haydar Tepe which is generated by gossan and "FE-I Anomaly" in Aşağı Mamlis hamlet which is related to the sulphide minerals in quartz - diorite.

As to result of survey in Sin area, four good FE anomalies were discovered. "FE-I Anomaly" in the central survey area was given the best estimation, which continues for both "FE-II Anomaly" in the southeast of the survey area and FE-III Anomaly in the Southwest of the survey area. The distribution of mineralization in and around Sin mine was defined.

CHAPTER 1 INTRODUCTION

1. Introduction

1-1 Survey History

This project is the second phase of the Turkish-Japanese collaboration with the Development of Mineral Resources in Turkey. The first one was completed during the interval from 1973 to 1975 around Trabzon area.

The project aims to find economic mineral deposits in Tunceli and Kopdağ areas. However, because basic data on general geology and mineral deposits in the areas were insufficient, the work had to start from reconnaissance investigation.

The investigation has been carried out since 1977. Phase 1 and 2 of this project have already been mentioned in the "Report on Geological Survey of Tunceli and Kopdağ Area, Eastern Turkey.

Phase 1: Photogeological Survey (June 1978)

Phase 2: Geological and Geochemical Survey (February 1979)

1-2 Purposes

The first and main purpose of the survey was to determine the mining potential of the areas with respect to Cu-Pb-Zn-Cr and to evaluate the existing mineral occurrences. Owing to the investigation in 1978, the mineralization of Tunceli area consists of Cu-Pb-Zn ore deposits, related to dacite-granodiorite of submarine igneous activity in the Tertiary.

The ore deposits are of the dissemination, stockwork, and vein types. On the other hand, chromite ore deposits embedded in the serpentinite in Kopdağ area, are of the podiform type, which is composed of disseminated, lenticular, and banded deposits. The extension of ore body and geological structure are mostly identical, and cumulate structure is frequently present in disseminated ore.

In Tunceli area, this project was based mainly on detailed geological mapping, geochemical sampling, and geophysical measurements (I.P. method) in 1979.

1-3 Procedure of the Works

The survey of this year has began on the middle of May, 1979. Turkish team prepared camping facilities, field vehicles, guide workers, drilling machine, I.P. equipments, and other necessary equipments for field works. However, due to the snowfall, collapse of roads, and lack of gasoline, especially it was late for completion of the camp-building in Kopdağ area.

Japanese members arrived in Ankara as follows:

19th May:	Two Japanese (leader, subleader)
2nd June:	Four Japanese (geologist and geophysicist in Tunceli)
13th June:	One Japanese (supervisor for drilling)
8th July:	Two Japanese (geologists in Kopdağ)

After completing necessary procedure in Ankara, one part of the Japanese team arrived in Tunceli on 7th June via Diyarbakır where branch office of MTA is situated, the other part arrived in Kopdağ on 27th June, but because the camp-building was not complete, the first drilling was started on 19th July. Field survey began in the middle of June and ended at the end of September in those areas. Although seven drillholes were finished, owing to bad weather conditions, the drilling program with 12 holes planed, had to end on 1st October. The rest of drilling was finished in 1980.

Laboratory work and preparation of the report were carried out at Eastern Black Sea branch of MTA (Araklı) and Tunceli until 9th November, after discussion of the field results and of future prospects at MTA, Ankara, Japanese survey team returned to Tokyo at the end of November. Meanwhile, Japanese mission headed by Kazunori KANOH, Metal Mining Agency of Japan, visited Tunceli and Kopdağ from 10th July to 21st July, second Japanese mission headed by Kyuzoh TADOKORO visited Tunceli and Kopdağ from 14th October to 29th October and discussed the project for 1980.

1-4 Amount of work

Amount of work done in 1979 and 1980 is as follows:

Tunceli area

Geological survey (map scale 1:10,000): 50 km^2

Detailed geological survey (map scale 1:2,000):	7 km^2
Soil sampling:	620 samples
Geophysical prospecting (I.P. method in Mamlis and Sin areas):	53.6 km

Kopdağ area

Detailed geological survey (map scale 1:1000):	2 km^2
Sketch of trenches (map scale 1:500):	525 m^3
Drilling (14 holes):	1,004.15 m

Pocket compass and plain table were used to make the topographic maps for detailed geological survey and sketches of trenches.

Tin sections:	37 samples
Polished sections:	17 samples
X-ray diffraction analysis:	17 samples
Chemical analysis of ore:	10 samples
(Cr_2O_3, Al_2O_3, $FeO+Fe_2O_3$, MgO and SiO_2)	
Chemical analysis of soil samples:	620 samples
Chemical analysis of gossan & ore:	31 samples

1-5 Personnel Participating in the Work

Personnel who participated in the work in 1979 and 1980 are shown hereunder.

Turkish Team (M.T.A.)

Mithat KAYAALP:	Coordinator of the project
Torun YILMAZ:	Geologist of Tunceli area (camp chief)

Erdem YAZICI:	Geologist of Tunceli area
İbrahim KOÇ:	Geologist of Kopdağ area (camp chief)
Necdet YURDUSEV:	Geologist of Kopdağ area
Doğan YILDIRIM:	Geophysicist of Tunceli area (camp chief)
Necdet PAKER:	Geophysicist of Tunceli area
Seyran ŞARDAĞ:	Geophysicist of Tunceli area
İbrahim KONAK:	Prospector of Tunceli area
Guner AYTAC:	Camp chief of drilling section in 1979
Nuri ŞAHİN:	Camp chief of drilling section in 1980
Ugur ŞENTÜRK:	Topographer of Tunceli area
Halil KÖSE:	Topographer of Tunceli area
Hüseyin DANACI:	Topographer of Tunceli area
Faik SARAÇ:	Topographer of Kopdağ area
Ekrem ÖZBAYRAK:	Topographer of Kopdağ area

Supervisor (M.M.A.J)

Kyuzoh TADOKORO	Planning division, Overseas department
Tetsuhiro NAKANOMORI	
Kazunori KANOH	
Hisamitsu MORIWAKI	

Japanese Team

Hisashi MIZUMOTO:	Leader, geologist
Masawo YOSHIZAWA:	Sub-leader, geophysicist

Kazuyoshi MASUBUCHI:	Geologist of Kopdağ area
Nobuyuki GOTOH:	Geologist of Kopdağ area
Hidewo SUZUKI:	Geologist of Tunceli area
Tadashi NYUI:	Geophysicist of Tunceli area
Norikiyo SUGIURA:	Geophysicist of Tunceli area
Nobuhiko YAMAMOTO:	Drilling supervisor in 1979
Michiyoshi KIMAZUKA:	Drilling supervisor in 1980

1-6 Location of the area (Fig. 1-2, 1-3)

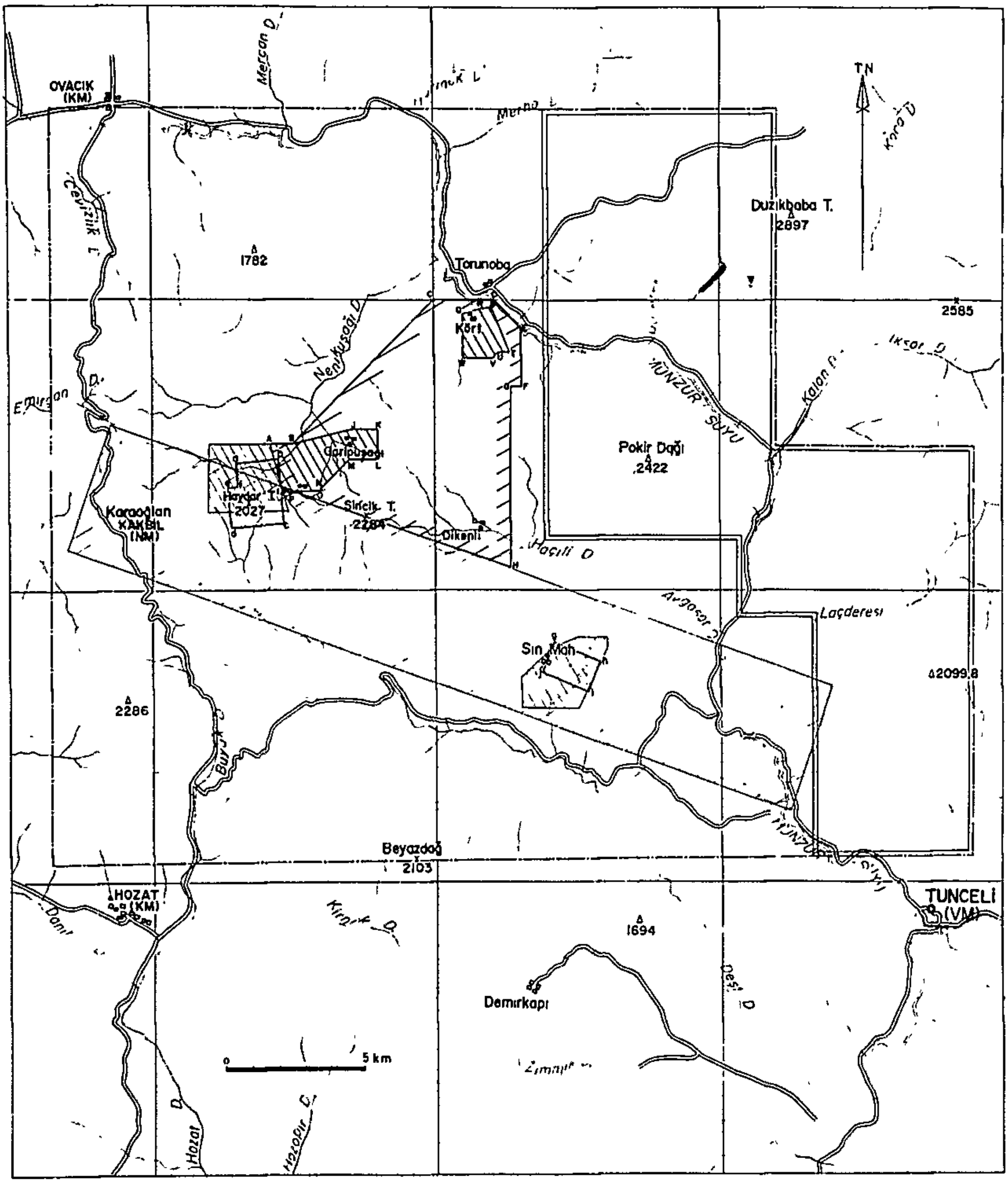
The location of the survey area in Tunceli is as follows:

(A) Geological survey area in Tunceli

	Latitude	Longitude
A	$43_{45}000$	$5_{24}150$
B	$43_{45}000$	$5_{25}000$
C	$43_{50}000$	$5_{30}000$
H	$43_{50}000$	$5_{32}000$
E	$43_{49}000$	$5_{33}000$
F	$43_{47}000$	$5_{33}000$
G	$43_{47}000$	$5_{32}600$
H	$43_{40}750$	$5_{32}600$
I	$43_{43}550$	$5_{24}630$

(Total area: 50 km^2)

Fig. 1-2 Index map in Tunceli area



LEGEND

Photogeological and geological reconnaissance survey area (1977 / 1979)

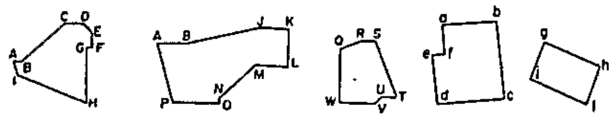
Geological survey area combined with geochemical survey area in 1978 / 1979

Detailed geological survey area in 1978 / 1979

Reconnaissance (geochemical survey) area

Geophysical survey area

survey area in 1979



1/10000 Geological and geochemical survey area

(Garipuşağı) (Kört) 1/2000 Detaild geological survey area

(Mamils) (Sın) Geophysical survey area

○ City • Town Stream and river Road

ABBREVIATIONS

T. Hill Da Mountain D Stream S River

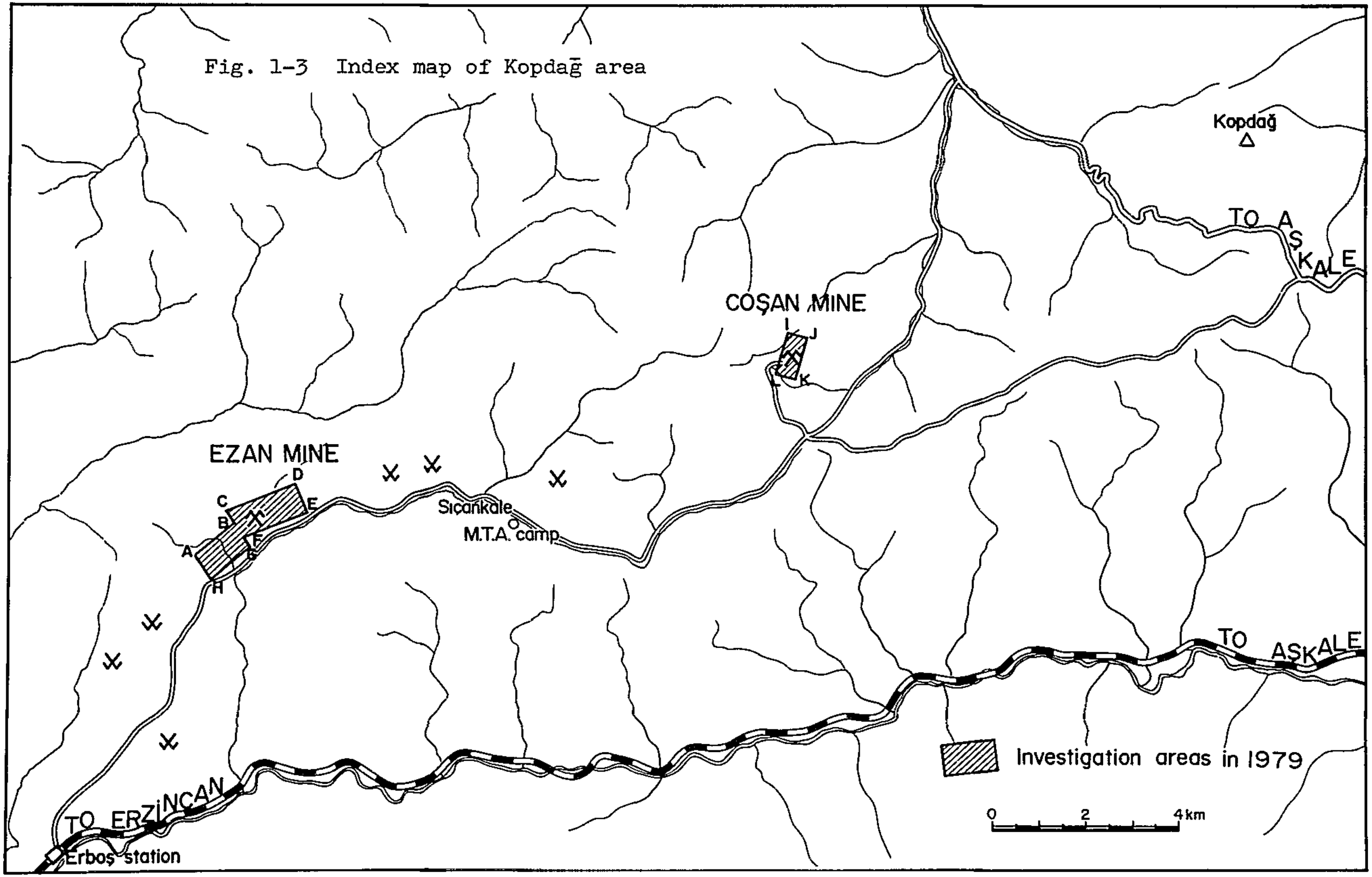
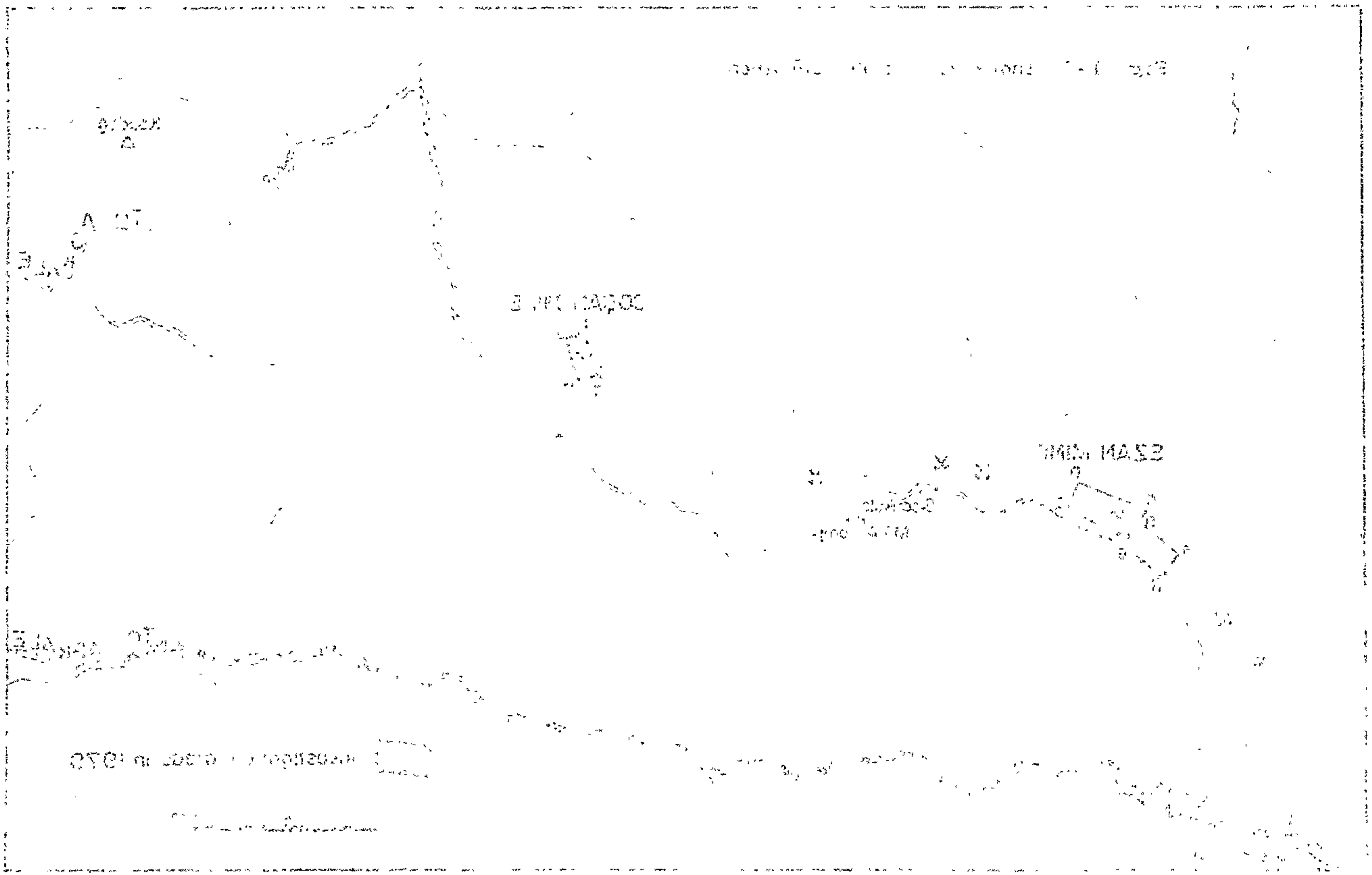


Fig. 1-3 Index map of Kopdağ area



(B) Detailed geological survey area in Kopdağ

	Latitude	Longitude	
A	25.922N	5.940	Ezan Area (1.6 km²)
B	26.618N	6.795	
C	26.893N	6.618	
D	27.440N	8.102	
E	26.850N	8.325	
F	26.330N	6.980	
G	26.115N	7.120	
H	25.41N	6.270	
I	30.900N	18.810	Coşan Area (0.4 km²)
J	30.790N	19.190	
K	29.830N	18.900	
L	29.940N	18.520	

1-7 Environment Around the Project Area

Tunceli area

The area occupies a part of the inner arc of the outer Eastern Taurus Mountains. The main range has an E-W trend, but the topography is complicated and the subordinate range has a N-S trend. The mountain peaks are rugged and their slopes are steep. The northern margin of the area passes into the Ovacık basin, toward the south, the mountains decrease in altitude down to the Elazığ plain. The Munzur river, which is a tributary of the Murat river, flows from the northwest to the southeast across the mountain ranges. The highest part of the area is located in the center where there are several mountain peaks, e.i. Mt. Pokir (2,422 m), Mt. Sincik (2,284 m), and Mt. Duzikbaba (2,897 m). Altitudes along Munzur river range from 950 to 1,300 m above sea level, and most of the area lies between the altitude of 1,300 m and 1,800 m.

The area belongs to the central Anatolia climate zone and is characterized by a continental climatic pattern. It is hot and dry in summer, cool and wet in winter. Half of the area is covered with scattered trees, mainly oaks and pines, and the rest is grassland. There are corn fields in the Ovacık basin and farms around villages. The population density is about one person per square kilometer, small hamlets are present along the Munzur river and on the hillsides. The main city is Tunceli, with population of approximately 10,000. It is the center of education, medical facilities and the supply of workers.

Access to Tunceli is convenient, Turkish Air Lines link Ankara and Diyarbakır with two flights a day by DC-9. The distance between Diyarbakır and Tunceli is 250 km via national route No. 69, it takes four hours by car. The road network inside the area is incomplete, motor-vehicle traffic is closed from December to March due to snowfall.

Kopdağ area

The area is situated in the inner arc of the Eastern Taurus Mountains. There are mountain ranges in the northern and southern parts of the area which extend east to west in parallel with the Eastern Black Sea Mountains. The mountain ridges, composed mainly of ultra-basic rocks are generally rugged. The Karasu river, which starts at Erzurum and runs through the central part of the area from east to west, is the upper stream of the Firat river, whose lower reaches flow into the Persian Gulf across Syria and Iraq. The highest point of the area is Mt. Kop (2,918 m) in the northeast. Most of the area lies between the altitude of 2,000 m and 2,500 m.

The climate is cooler and drier than that of the Tunceli area, the snowfall season extends from the middle of October to April. Shrubby trees can be seen along the streams, but otherwise the area is a grass-land lacking tree cover.

The population of the area is smaller than that of Tunceli area, it is particularly sparse in the surveyed area. The main cities in the region are Aşkale (population about 20,000) in the east and Bayburt (population about 20,000) in the north, they are centers of education, medical facilities, and the supply of workers.

This area belongs to the Eastern Black Sea branch office of MTA which is located Araklı; the distance between this area and Araklı is approximately 280 km via national route No. 60, 45 and 40. It takes 8 hours driving through Trabzon, Gümüşhane and Bayburt. Turkish Air Lines link Ankara and Trabzon with one flight a day by F-28, the traffic network is less developed than in the Tunceli area. The Kopdağ area can be reached from Tunceli by taking national route No. 69 and No. 2 from Tunceli to Aşkale, and then by taking national route No. 40 from Askale to Kopdağ area. Distance between Tunceli and Kopdağ is about 250 km. it takes 4 hours. Public transportation between the two areas is inconvenient.

1-8 Acknowledgements

We would like to dedicate this report to the Hüseyin CETİN, Director of Mineral Exploration Department of M.T.A. He was in charge of this project and until his death in November 1979, provided guidance and invaluable assistance in all stages of this work.

We wish to express our sincere gratitude to Prof. Dr. Nezihi CANITEZ, the former General Director of M.T.A and to Dr. Erol İMRE, the present General Director M.T.A for their help and permission to use M.T.A facilities.

We would like to thank Mete TEŞREKLİ, Deputy Director of Mineral Exploration Department, Dr. Ünal ARTAN, chief of Chromite Section, Ruhi ÇALGIN, chief of Copper Section of the above mentioned department, Bekir SEZGİN, Duputy Director of Drilling Department, Işık TURGAY, chief Section of Geophysical Department. Also we take pleasure in recognizing the help and support of the staff of the Eastern Black Sea Branch and Diyarbakır Branch of M.T.A. We would also like to thank the staff of Laboratory Department for chemical analysis.

CHAPTER 2 GEOLOGICAL SURVEY OF TUNCELİ AREA

2. Geological Survey in Tunceli Area

According to the results of the 1978 survey, phase III (1979) geological survey of Tunceli area was concerned with the mineralization zone around the Bulanık quartz diorite. Geological and geochemical investigations were carried out on a scale of 1:10,000 in an area of 50 km^2. Mineralization zones of interest were found in Garipuşağı and Kört areas which belong to geological survey area of 1979, detailed geological investigation on a scale of 1:2,000 was carried out in those areas and the extent and character of mineralizations were clarified. The Garipuşağı area covers about 5 km^2 and the Kört area about 2 km^2. The former area is situated east of a noteworthy mineralization zone and a geochemical anomaly found in Mamlis area as a result of the 1978 survey. The latter area is located southeast of Kört hamlet. There are two mining galleries, but the mine has not been worked for more than 10 years.

2-1 Outline of Geology

In the Tunceli area, the Munzur Paleozoic 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 Şavular and 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 and to the east of the Munzur river.

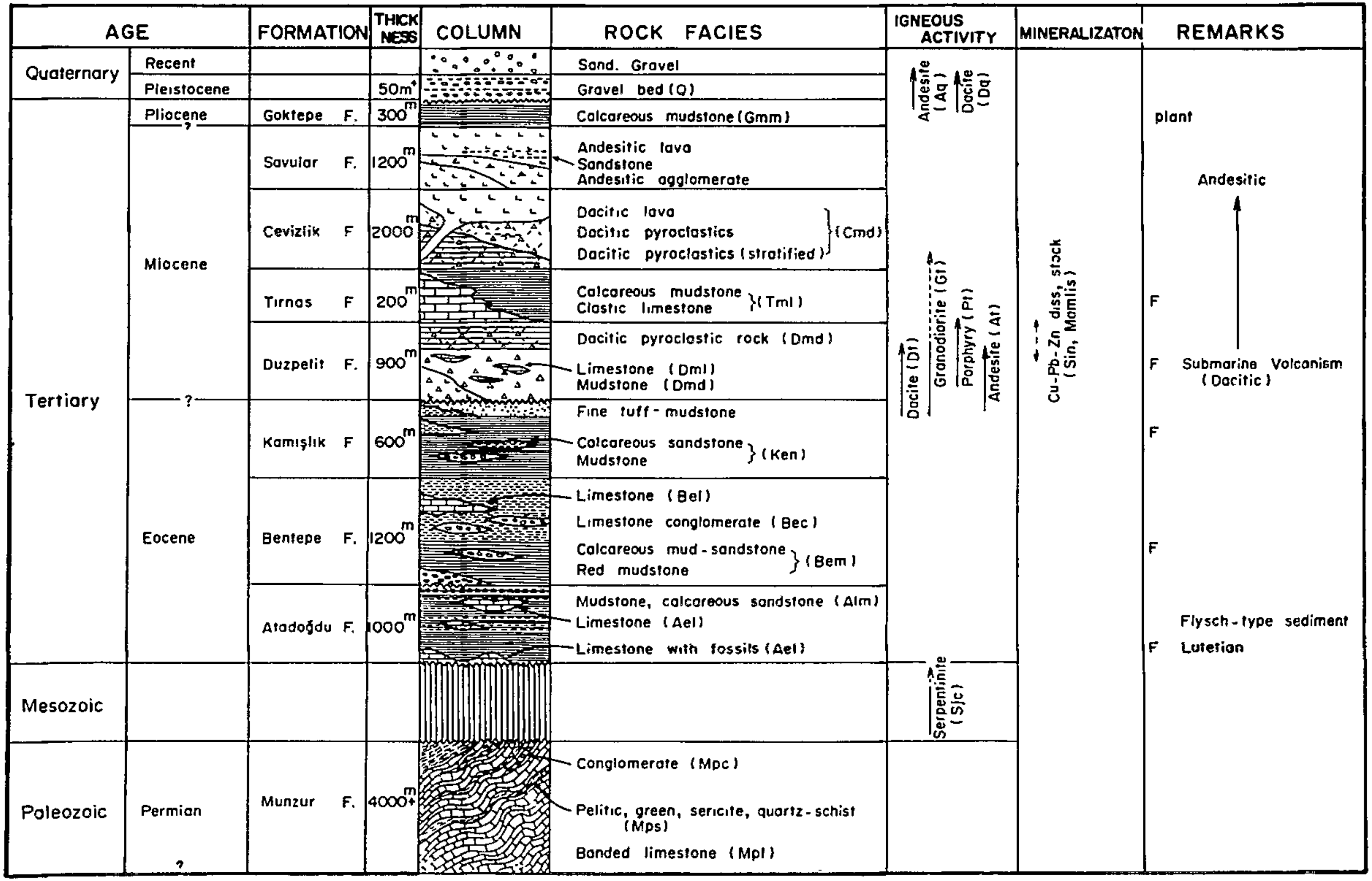
The Mesozoic Erathem is absent, and the Atadoğdu Formation comprised of the lowermost Eocene Series overlies the Munzur Paleozoic Formation unconformably. The sediments of the Atadoğdu, the Bentepe, and the Kamışlık Formations indicate stable sedimentation, and are distributed and influenced by structure of the Paleozoic Formation.

During the Miocene Series, early submarine volcanic activity resulted in the deposition of the Düzpelit Formation. This formation is widespread in the north and east portions of the area covered by geological survey. The Bulanık quartz diorite is predominant in the central portion of this area. Mineralizations in Garipuşağı and Kört areas were observed in the Düzpelit Formation around Bulanık quartz diorite.

2-1-1 Atadoğdu Formation

Upper part of the Atadoğdu Formation is confined to a small part in the northeast of the geological survey area. Upper part of the Atadoğdu Formation consists mainly of calcareous mudstone and sandstone. Grain size of the sandstone varies from coarse to medium, its color is brown.

Fig. 2-1 Geological succession of the Tunceli area



F = Fossil

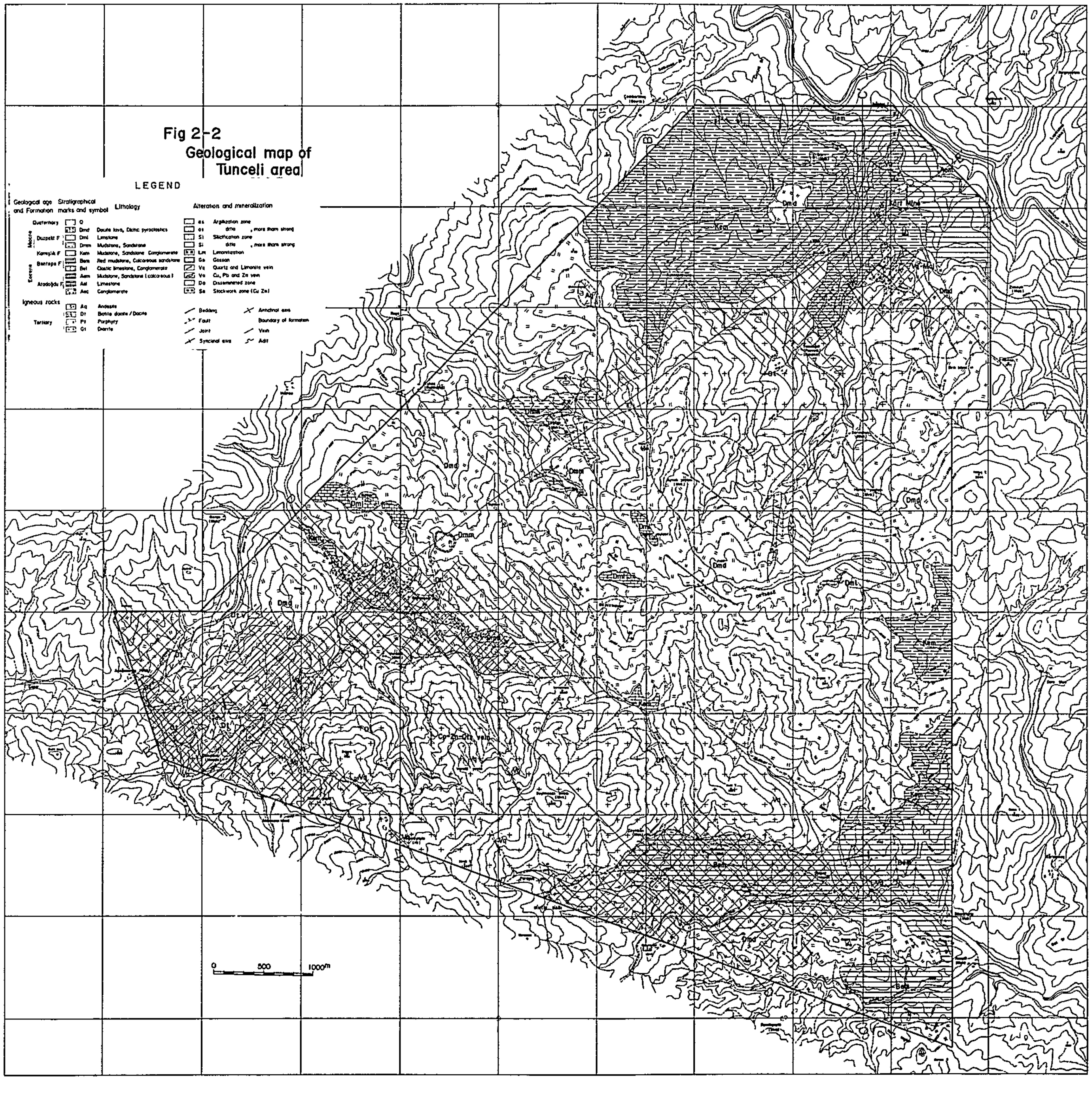
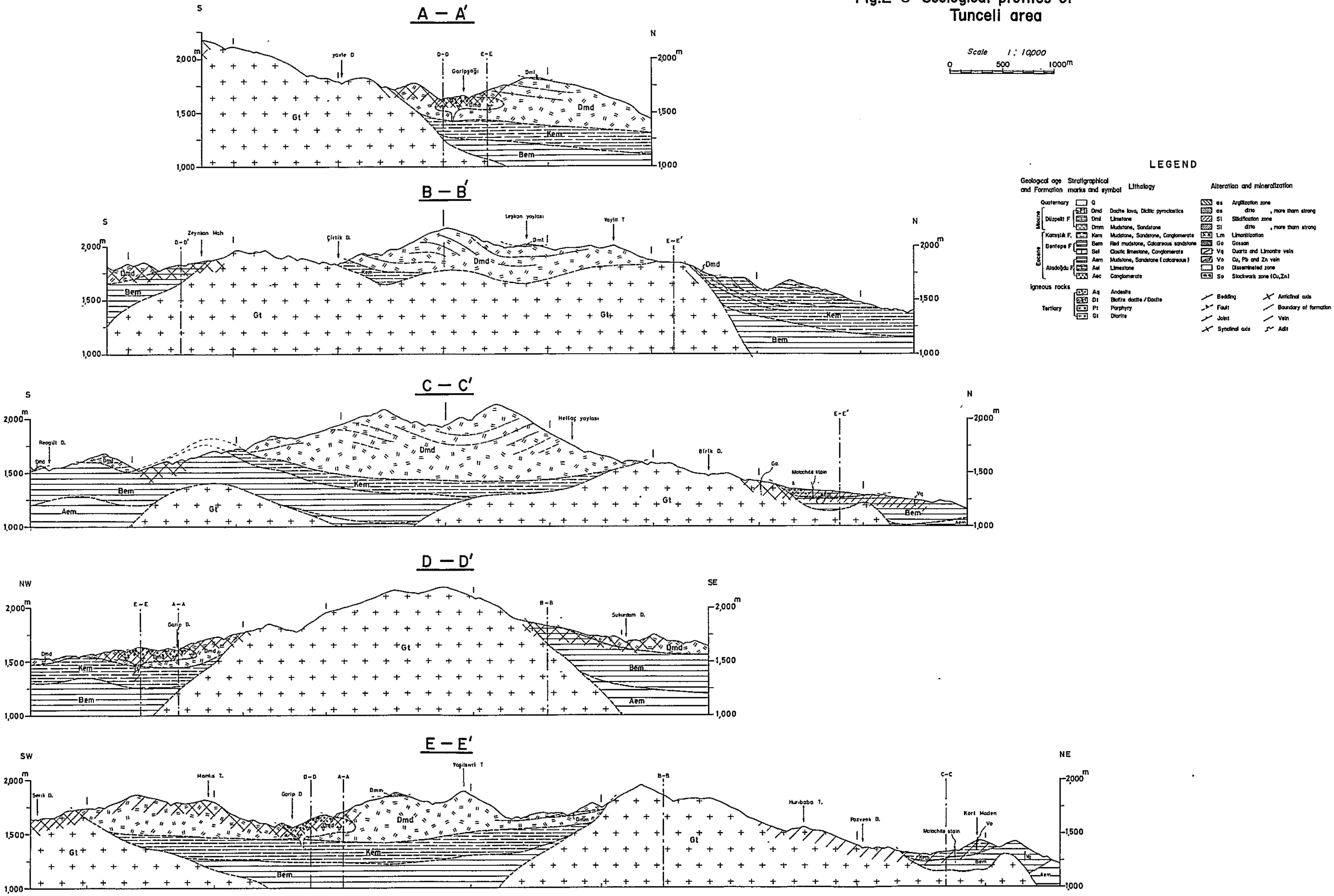


Fig 2-2 Geological map of Tunceli area

Fig.2-3 Geological profiles of Tunceli area



The Bentepe Formation, composed of conglomerate and sandstone, lies on the formation conformably.

2-1-2 Bentepe Formation

The Bentepe Formation extends from Kört mine to Dikenli hamlet, it is distributed in the northeast and southeast of the investigation area. This formation lies conformably on the Atadoğdu Formation and is conformably overlain by the Kamıslık Formation.

In the south and east of Dikenli hamlet, the Kamışlık Formation is pinched out, and the Bentepe Formation is unconformably overlain by the Düzpelit Formation. This formation is composed mainly of sandstone, and partly consists of alternation of conglomerate, sandstone and calcareous mudstone.

The fine-grained sandstone and conglomerate in the upper part of the formation, generally characterized by a red tinge, is called "Reddish sandstone or Reddish mudstone". The Bentepe Formation in the Kört mine area, generally strikes N60°E and dips west, and partly changes the strike to N20°E due to intrusion of quartz diorite.
This Formation continues to the west along the structure of the Munzur Paleozoic Formation anticline. In this formation, very strong silicified zones and scattered pyrite were observed. Quartz veins containing copper, lead, and zinc that were prospected more than ten years ago

by Kört mine, were recognized in the Bentepe Formation and upper part of the Kamışlık Formation.

2-1-3 Kamışlık Formation

This Formation is distributed in the north and west of the investigated area, and lies on the Bentepe Formation conformably, and is overlain unconformably by the Düzpelit Formation. This Formation is correlated with the upper Eocene and it is composed mainly of sandstone and mudstone, lower part is black mudstone and upper part is calcareous sandstone and tuffaceous sandstone. The upper part of this formation is unconformably overlain by the Düzpelit Formation, the formation is penetrated by the Bulanık quartz diorite in the south of Kört mine (Dervişhan to Ieşkan hamlet).

The Kamışlık Formation near the Bulanık quartz diorite has been subjected to argillization, silicification, pyritization, and some limonite-quartz veinlets were observed.

Remarkable alteration and mineralization zones were observed from Kört mine and Aynalipozvenk to Leşkan hamlet. Especially, strong silicification zone is mainly widespread in the Kört mine area.

Though magnetite floats were found in a stream near the Yenisöğüt hamlet, outcrops were not observed. The Kört mine is described in detail in the following part dealing with the mineralization.

2-1-4 Düzpelit Formation

The Düzpelit Formation is dominant in the central part of the investigation area, and unconformably overlies the Kamışlık Formation. It rests unconformably on the Bentepe Formation directly in Dikenli hamlet and west of Kört mine.

This formation is mainly composed of dacitic pyroclastic rocks, which are partly intercalated with muddy and sandy sedimentary rocks and limestones, and intruded by the Bulanık quartz diorite, over a wide area from Dervişhan hamlet in the south of Kört mine to Leşkan hamlet, Kula tepe to Bulanık tepe in the south of investigated area and Doludibek (Mamlis) hamlet.

This Formation was apparently subjected to intense argillization (sericite-quartz-pyrite), and partly to strong silicification and pyritization in the Uyuzçukuru tepe, Garipuşağı and Aşağimamlis hamlets around the Bulanık quartz diorite.

Specially remarkable silicification zone around the Garipuşağı was accompanied with impregnation by fine-grained hematite.
It has variable strike from about N50°W to N10°E in the dacite. The Düzpelit Formation is composed mainly of dacitic pyroclastic rock, which is pale grey to pale purple-grey in color. Under microscope, the matrix is greenish-grey to pale grey in color and includes large amount of plagioclase (ø 0,3 - 1 cm), and small amount of hornblende (ø 0,3 - 1 cm), aphanitic part is rare. The main constituents of the fragments are

greenish-grey dacite, containing large amount of plagioclase (ø 0,1 - 1 cm), grey hornblends-dacite, containing hornblend and plagioclase, dard-grey grassy dacite and reddish-purple andesite. The matrix is composed mainly of fragments of plagioclase, hornblende and quartz. Sorting is very bad.

2-2 Outline of Intrusive Rocks

The intrusive rocks in the investigated area called the Bulanık quartz diorite in the 1978 were intruded during the Miocene epoch. The mountains in the central part of the investigated area are formed mainly by holocrystalline quartz diorite and partially by instrusive dacite and andesite extending from the Seyhhasan kulesi to Bulanık mountains.

2-2-1 Bulanık Quartz Diorite

According to its distribution, the Bulanık quatz diorite is divided into two areas, one around the Yenisöğüt hamlet in the central part and the other near the Şeyhhasan kulesi in the southern part.

Quartz diorite in the Yenisöğüt area

Texture of the rock is almost holocrystalline, it is pale grey in color, partially shows porphyritic in the margin of quartz diorite, and seems to form a batholithlike mountain chain in the central area.

Alteration and mineralization are observed especially in the margin of the north and south of the quartz diorite. In the north marginal part, widespread alteration zone was observed from Aynalipozvenk through Kört to Leşkan hamlet.

The Kört mine area belongs to this alteration zone and belongs to an especially strong silicification area, but in the south, silicification, argilization and pyritization are predominant within Bulanık quartz diorite.

Quartz diorite of the Seyhhasan Kulesi area

Texture of the rock changes gradually from holocrystalline to porpyritic, and microphenocrysts in the margin of Bulanık quartz diorite, including biotite (ø 1 m/m), and feldspar are observed, but not common.

The northwest and south parts of the quartz diorite underwent weak silicification and argillization.

The Cu-Pb-Zn-quartz veins are located in the west and north of the central portion of the Bulanık quartz diorite. Those veins have N-S and N30°W direction. The direction of veins coincides with fissure filled with limonite-quartz veins observed around the quartz diorite body and the strike of quartz-sericite zone in the alteration zone.

2-2-2 Andesite

This intrusive rock is distributed around Mahmutkömü Tepe and confined within narrow limits. Düzpelit Formation was intruded by andesite which is considered to have been active at the end of the Tertiary period. The rock is hard, dark blue ~ dark green in color, and unaltered. Phenocrysts consist of plagioclase and hornblende, groundmass is fine-grained.

2-2-3 Biotite Dacite

This intrusive rock is distributed north of Doludibek hamlet, is 400 by 150 meters, and it is accompanied by a dyke 5 meters wide and 150 meters long.

The rock is hard, pale purple ~ pale green in color, and weakly altered. Phenocrysts consist of biotite (2 mm x 10 mm), feldspar and hornblend, groundmass is glassy. The rock is assumed to have been emplaced at the end of the Tertiary period.

2-3 Geological Structure

Flysh-type sediments are predominant in the area investigated in 1979. They are correlated with Eocene epoch, and composed of the Atadoğdu, Bentepe, and Kamışlık Formations, and are overlain uncomformably by dacitic rocks and dacitic pyroclastic rock of Miocene epoch.

The Atadoğdu Formation lies directly on the Munzur Paleozoic Formation correlated with the Permian period, which is distributed along the Munzur river, and it is distributed slightly in the northeast of investigated area.

The Atadoğdu Formation is composed mainly of calcareous mudstone and sandstone and indicates stable deep-sea sedimentary environment.

The Bentepe Formation formed by altenation of conglomerate, clastic limestone and calcareous mudstone may be considered to consist of shallow sea sediments, and it overlies comformably the Atadoğdu Formation.

The Kamışlık Formation indicates stable deep sea sedimentary environment as well as the Atadoğdu Formation. Those formations are influenced by the structure of basement and are characterized by rhythmical alternation between mudstone and sandstone. In general in the north of the investigated area, they strike about N20°E to N50°W and dip 20° to 35° south, along the basement of Munzur Formation.

From the east to the south of the investigated area, they strike N60°E and dip 20° west, and strike N45°W and dip 30° to 40° south in the south, where they border on anticline axis in the Dikenli hamlet area, but they lack the Kamışlık formation and were unconformably overlain by the Düzpelit Formation in Miocene epoch.

The Düzpelit Formation consists mainly dacite and dacitic pyroclastic rocks, which are partially intercalated with limestone and calcareous mudstone. It strikes N50° - 70° E, and dips northwest in the central of the investigated area. Around the Bulanık quartz diorite, it is strongly silicified and argillized. Its strike is constant, but dip is irregular. Structure could not be clarified.

2-4 Mineral Deposits and Alteration Zones

2-4-1 Outline of Mineralization and Alteration

The mineralization and alteration are mainly related to the intrusion of the Bulanık quartz diorite, and partially mineralization is connected with dacitic volcanism. According to distribution, the mineralization and alteration around Bulanık quartz diorite were divided into Yenisöğüt hamlet and Şeyhhasan Kulesi area. They both have widespread alteration zones.

The mineralization and alteration in the dacite are observed in the Garipuşağı hamlet and south of Kört mine. The dacites form a lava dome with strong pyritization and silicification, impregnated zone of hematite is observed in the Garipuşağı and malachite stain in the Kört area. They are assumed not to be related to quartz diorite, because mineralizated zones related to dacite are older than ores related to Bulanık quartz diorite.

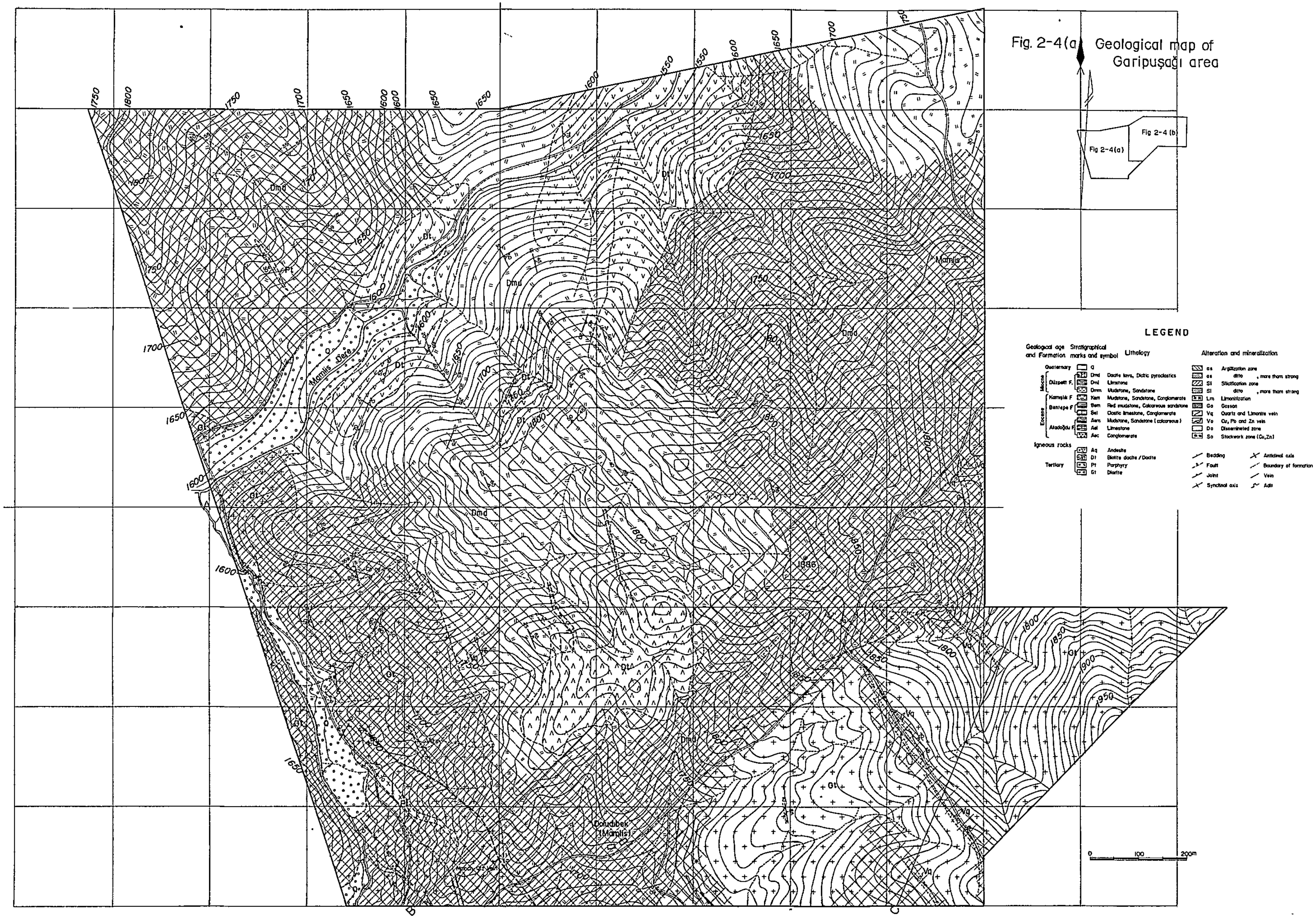


Fig. 2-4(a) Geological map of Garipuşağı area

Fig. 2-4(b) Geological map of Garıpuşağı area

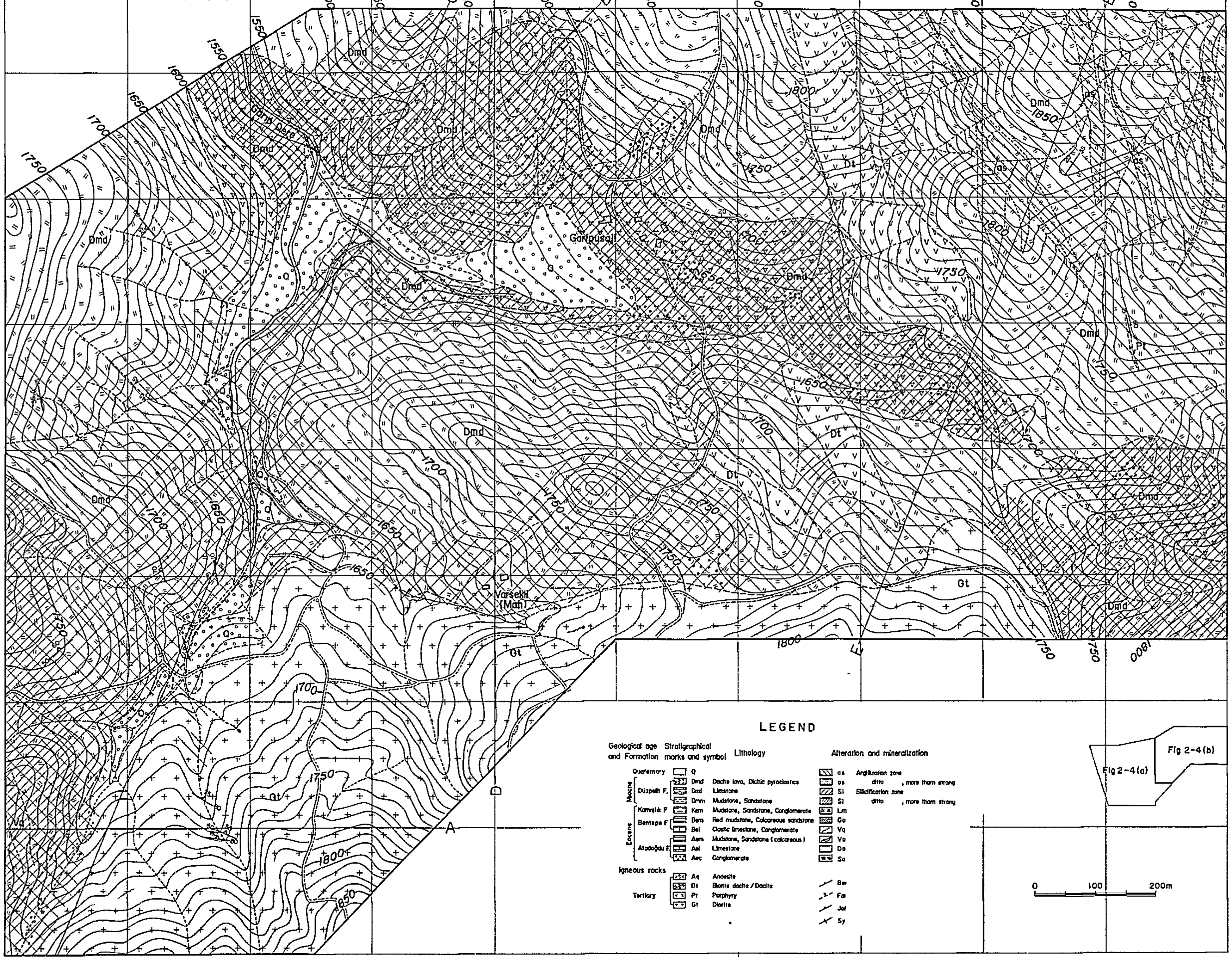
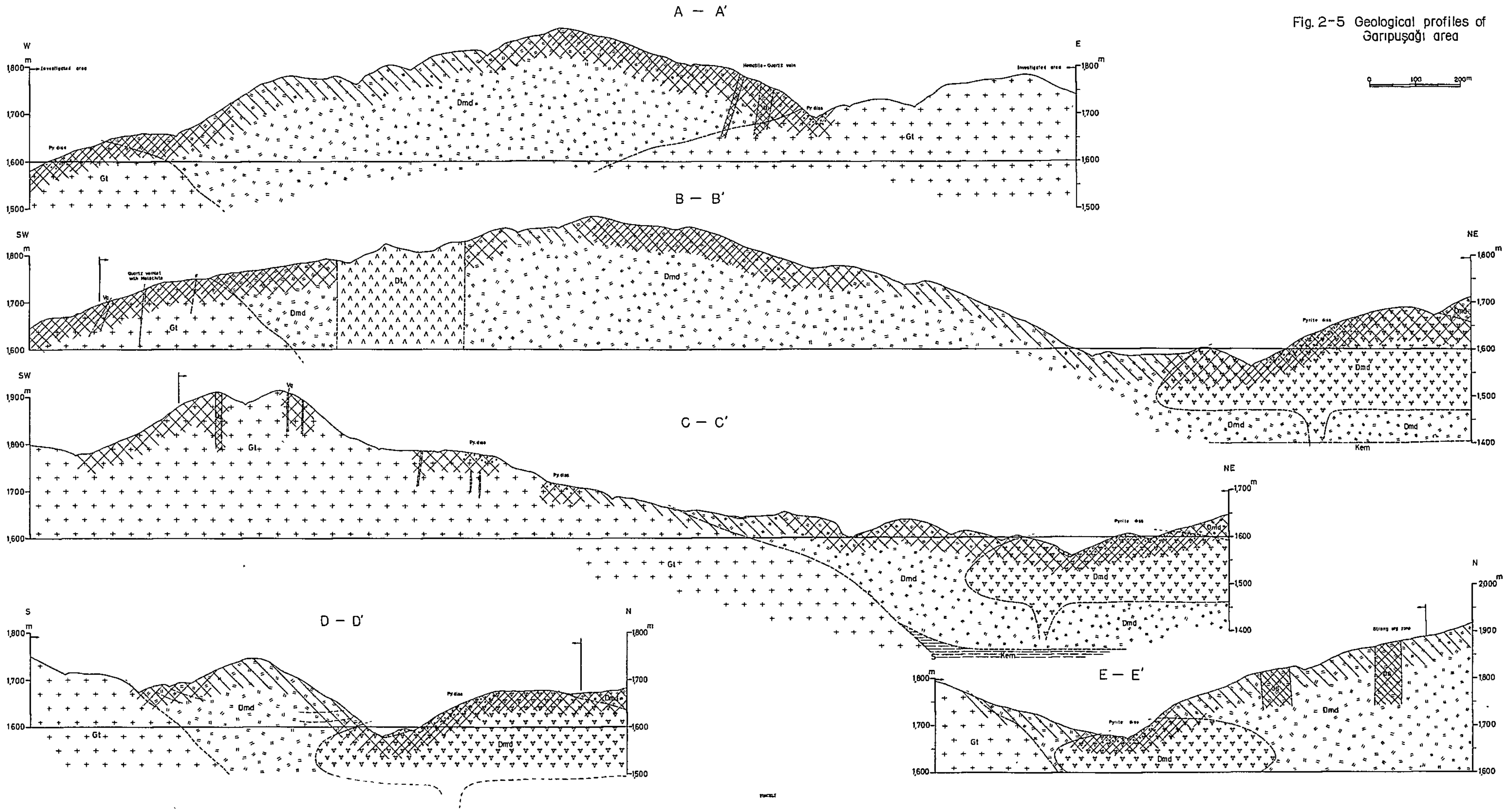
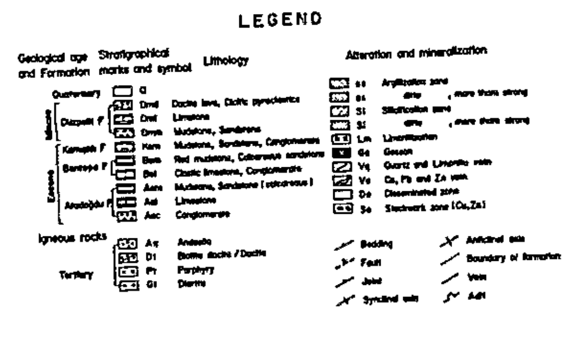


Fig. 2-5 Geological profiles of Garipuşağı area





2-6 Geological map of Kört area

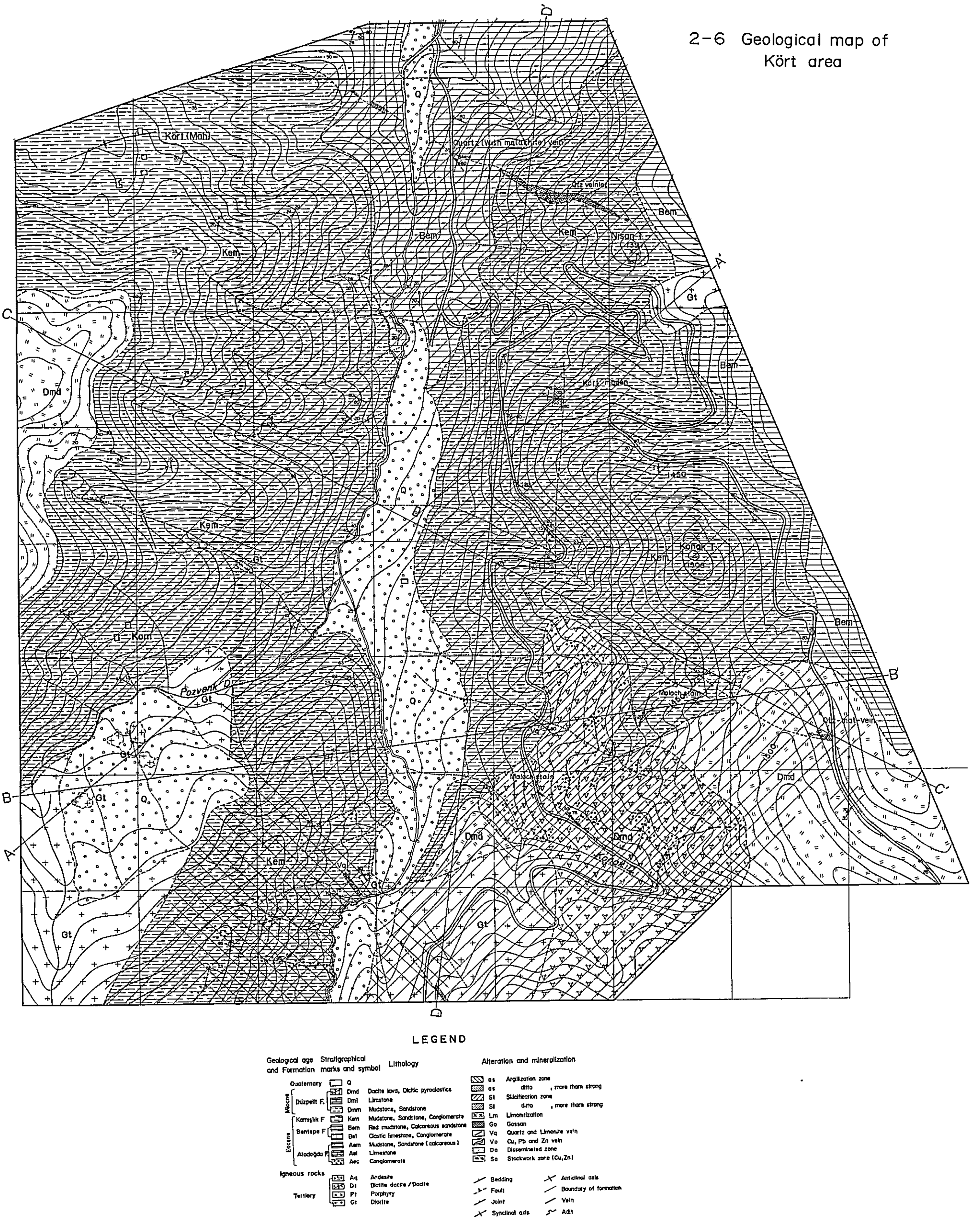
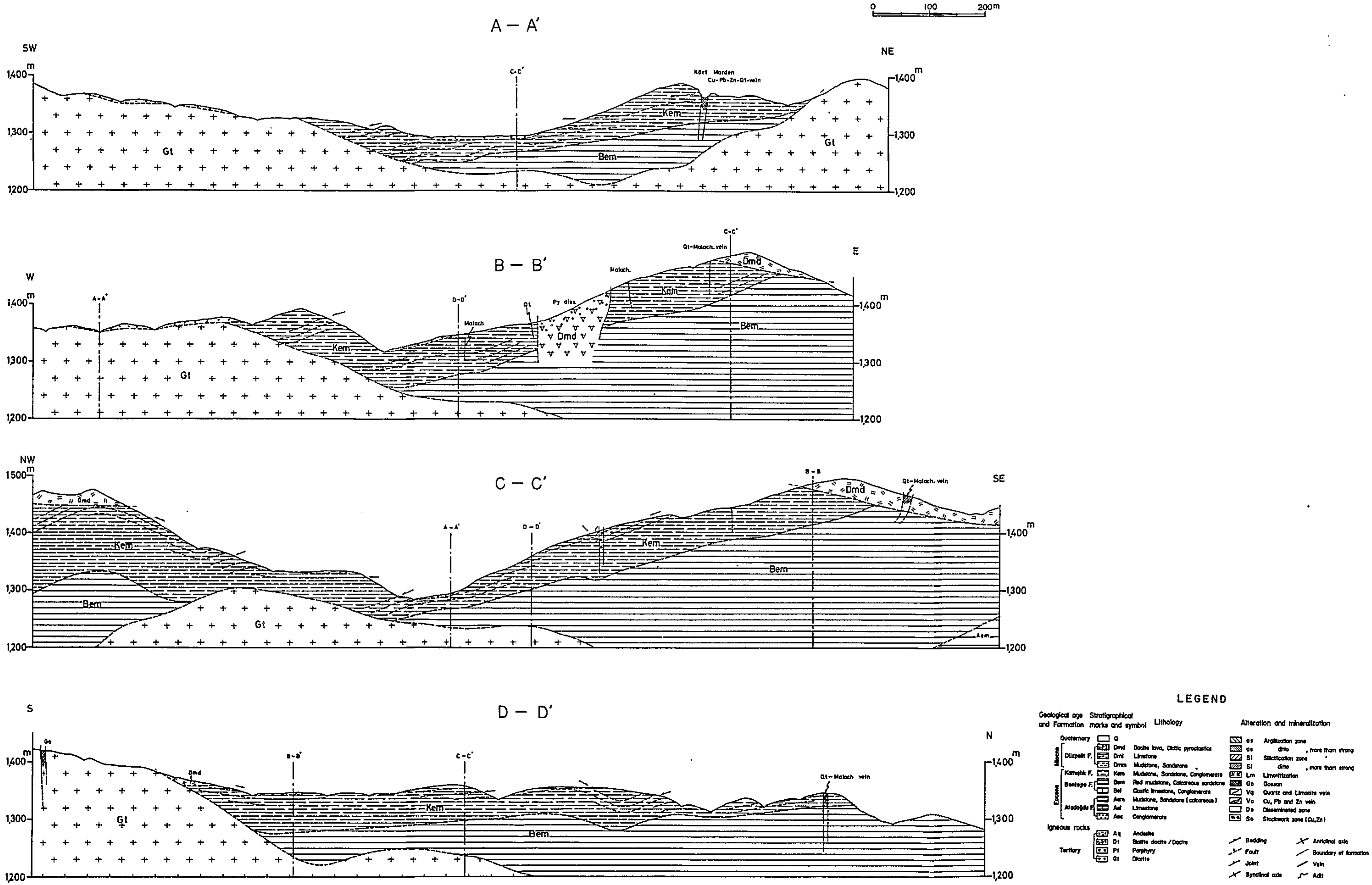


Fig.2-7 Geological profile of Kört area



2-4-2 Alteration and Mineralization Related to Bulanık Quartz Diorite

The alteration and mineralization zones related to Bulanık quartz diorite are divided into Yenisöğüt and Şeyhhasan Kulesi areas. The former is distributed from north to west around the northern quartz diorite block, for example Kört mine, Aynalipozvenk to Leşkan hamlet, the south of Dervişhan hamlet. The latter is distributed on the north side of Bulanık quartz diorite block from Mamlis to Garipuşağı area, and in the central part of the quartz diorite, where Cu-Zn quartz veins in N-S direction were found and a lot of limonite-quartz veins were observed.

Mineralization zone was assumed to extend eastward and detailed geological investigation was carried out from Malis to Garipuşağı area and Kört area in 1979.

(1) Kört mine (closed)

Kört mine is located about 700 m southeast of Kört hamlet, and about 1 km south of Torunoba hamlet. Torunoba hamlet lies halfway between Tunceli and Ovacık along the Munzur river and is situated on a road in good condition, 30 km away from Tunceli.

There are two galleries in Kört mine, as described in detail in the 1978 report. One (it was provisionally called No.1 gallery in 1978) is located next to an outcrop, but the shaft is buried below about 7 - 8 m and it is now impossible to enter inside. The other (No.2 gallery) is about 100 m to the west and about 50 m down from No.1 gallery. Both are located on the slope above the Pozvenk stream. No.2 gallery has been prospected for about 75 m and probably connected with No.1 gallery by a shaft, but it cannot be verified because No.2 gallery was blocked by material moved during the construction of a new road which was made last year (1978). The sheared zones belonging to the N20°E and N60°W system around the Kört mine, were subjected to detailed geological investigation on a scale of 1:2,000 this year. N60°W fissure system zone is superior in extent to N20°E system. Mineralization in the Kört mine was observed along a fissure of the N20°E system, which continued for more than 400 m on the surface. Also some weak fissures running parallel to the N60°W fissure pattern veins with malachite stain were observed in the area. The N60°W fissure pattern continues for about 200 - 600 m. It is interesting that quartz veins with malachite stain, malachite stain along the fissure zone and gossan of limonite-quartz-pyrite, were observed in this area. It seems that the fissure pattern resulted from the intrusion of Bulanık quartz diorite in the south of the investigated area.

(2) The alteration zone distributed from Analipozvenk to Leşkan hamlet

This alteration is widespread around Yenisöğüt hamlet, in an area which corresponds to the northwest part of the Bulanık quartz diorite.

The alteration zone was also observed in calcareous mudstone, sandstone of the Kamışlık Formation, dacitic pyroclastic rock of the Düzpelit Formation, and the Bulanık quartz diorite. The alteration zone is mainly composed of quartz-sericite, partially scattered pyrite. Limonite-quartz veins were observed and the alteration zone is similar to the one of marginal portion in Mamlis and Sin Mah areas.

The alteration zone extends to the southwest for a distance in the range of about 100 m along the direction of intrusion of the Bulanık quartz diorite. The alteration is weak in the Yeşilsivri Tepe, therefore it was not possible to clarify the relation of alteration between the above-mentioned area and Garipuşağı hamlet area, which is located about 2 km southwest of Leşkan hamlet.

(3) The area south of Dervişhan hamlet

The alteration zone in this area is small. It lies in the Bulanık quartz diorite, and consists of silicification, pyritization. Several fissures were observed. The silicification-pyritization is on the whole weak. The upper part of the quartz diorite is overlain by the Düzpelit Formation, which is mainly composed of dacitic pyroclastic rocks.

(4) The alteration zone east of Mamlis

This area, located eastward of Mamlis, has been made clear by detailed geological investigation in 1978.

Four veins were observed in the Bulanık quartz diorite. They were due to the Bulanık quartz diorite, and minerals are malachite and pyrite. Vein direction is N60°W, and many quartz-sericite fissures were observed parallel with several veins.

In this area, a quartz-sericite fissure with N20°W strike was found, but sulphide minerals were not observed.

The direction of the above-mentioned fissures is different from that of limonite ore (about E-W N70°E) in Mamlis area; it seems that the fissure pattern is related to the intrusion of the Bulanık quartz diorite.

(5) The Cu-Pb-Zn quartz vein in the Bulanık quartz diorite

The largest vein (champion vein) in the Bulanık quartz diorite is located on the slopes above Yavle stream around Varsilli Yayla. It is 1.5 m wide (maximum) and is composed of Cu, Pb, Zn and quartz. Ore minerals are chalcopyrite, galena and sphalerite, secondary chrysocolla was also observed. The vein extends north for about 150 m to a ridge trending north. Several quartz veins with malachite stain (quartz vein and alteration zone is 4 m wide), N-S strike, and west dip were observed. They are assumed to correspond to the northern extension of the Champion vein.

Several other quartz veins observed along the Garip stream on the east side of Varsilli yayla and the ridge of Mamlis yayla in the west of Bulanık T., strike at about N30°W. One quartz vein west of Bulanık T. continues for more than 1,000 m. Several parallel limonite-quartz veins cut across quartz diorite and dacitic pyroclastic rock of the Düzpelit Formation along the Garip stream between Doludibek hamlet and Garipuşağı hamlet.

They indicate the superior part of quartz-sericite alteration zone, which sometimes contains sphalerite, but sphlerite is weak and scattered. The above mentioned alteration zone is expected to cause geochemical anomaly of copper and zinc and is assumed to connect with the alteration zone in Mamlis area.

As a result of geological investigation in 1978, two parallel quartz-rich zones striking N30°E in the west of Bulanık T. were found. They are composed of a siliceous zone, a quartz vein and a network zone of limonite veinlets and are 2 - 3 m wide on the average (8 m wide maximum). One is about 1,000 m and the other 400 m long. They continue to the siliceous alteration zone in the south of Sincik Mountain, in where galena was observed in the argillization zone in 1978 investigation, they are also connected with Cu-Pb-Zn quartz vein that belongs to the N-S strike system in the ridge from above Yavle stream around Varsille Yayla.

Near the Doludibek (Mamlis) hamlet, several quartz veins with malachite and fissures with malachite are observed in quartz diorite. They strike N30°W and accord with the direction of the above-mentioned quartz sericite zone.

In this area silicification, argillization and pyritization are predominant in the Bulanık quartz-diorite.

(6) Mehmet ~ Sincik alteration zone

Alteration zone is observed in the Bentepe and Düzpelit Formations along the south side of the Bulanık quartz diorite. As a result of X-ray diffraction test, argillaceous sample, which was collected south of Mehmet hamlet, consists of hydrous sericite and orthoclase. A sample of a quartz vein in the Düzpelit Formation was 2 ppm Ag, 10 ppm Cu, 25 ppm Pb, 70 ppm Zn. Mineralization and alteration were weak in this area.

2-4-3 Alteration and Mineralization Related to Dacite Lava

Dacitic lava domes were found in the Düzpelit Formation, and are distributed in Garipuşağı hamlet and Konak dere areas. Minenalization related to lava domes consists of disseminated hematite, pyrite and sometimes malachite stain. Characteristic features of the lave dome are similar to Sin dacite, which is strongly altered.

As a result of geological investigation, dacitic lava dome was found to consist partly of intrusion and partly of lava.

(1) 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 Düzpelite Formation was subjected to intense silicification related to the intrusion of the Bulanık quartz diorite.

(2) Konak Dere mineralizated zone

A dacitic lava 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 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.

2-5 Relation Between Mineralization-Alteration and Geological Structure

In Tunceli area, 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 uncomformably. Marine regression took place during the interval from the late Eocene to Miocene. 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-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-SE trending of geological structure.

2-6 Comparison with Results Obtained in 1978

The alteration zones surrounding the Bulanık quartz diorite were clarified by the geological investigation in 1978. The zone lies in the area north of the Bulanık quartz diorite, from Mamlis to Garipuşağı hamlet, Aynalipozvenk to Leşkan hamlet and in the Kört mine area. Detailed geological survey was carried out in those areas in 1979 and geological evidence obtained in the investigation is as follows:

(1) Mineralizations related to dacite lava dome were found in Garipuşağı hamlet and south of the Kört mine.

(2) Disseminated hematite, malachite stain, pyrite, silicification, and argillization were also observed in those areas.

(3) Cu-Pb-Zn veins and fissures related to the intrusion of quartz diorite were observed in the Kört mine area.

(4) Fissure patterns from the N-S - N20°E and N30° - 60°W system in Mamlis - Garipuşağı and the Kört mine areas, Cu-Pb-Zn quartz veins strike N-S in the area from Varsilli yayla to Yavle stream, and the Kört mine.

(5) Another fissure pattern from the N30° - 60°W system east of Mamlis, and in the Kört hamlet area.

2-7 Conclusion

The geology of the area investigated in 1979 is composed of Flysch-type sedimentary rocks of Eocene epoch, and dacite ~ dacitic pyroclastic rocks accumulated in Miocene epoch. Intrusive rocks consisting of quartz diorite, andesite, and biotite dacite were most likely formed in Miocene.

Mineral occurrences are divided into Garipuşağı type and Mamlis type, the former is characterized by disseminated pyrite and hematite, and is related to dacitic lava dome, the latter by network with sphalerite-galena (chalcopyrite), and is related to the Bulanık quartz diorite.

As a result of X-ray diffraction test, minerals of alteration zone were found to be hydrous-sericite, sericite, kaoline, and montmorillonite. Quartz, orthoclase, and albite were also present. Generally speaking, the characteristic feature of Mamlis mineralized zone is that sulphide minerals can not be found under microscope, but soil samples contain Cu, Pb and Zn.

Fig. 2-8 Location map of rock samples in Tunceli area