THE REPUBLIC OF TURKEY

MINERAL RESEARCH AND EXPLORATION INSTITUTE

REPORT ON GEOLOGICAL SURVEY

OF

TUNCELİ AND KOPDAĞ AREA, EASTERN TURKEY

PHASE I

PHOTOGEOLOGICAL SURVEY

JUNE 1978

METAL MINING AGENCY OF JAPAN

JAPAN INTERNATIONAL COOPERATION AGENCY

GOVERNMENT 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 cooperative 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 under 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 areas.

Between 20 October 1977 and 31 March 1978, the Metal Mining Agency of Japan dispatched a survey team headed by Mr. Hajime Takahashi to conduct geological survey and photogeological analysis of the Phase I of the project.

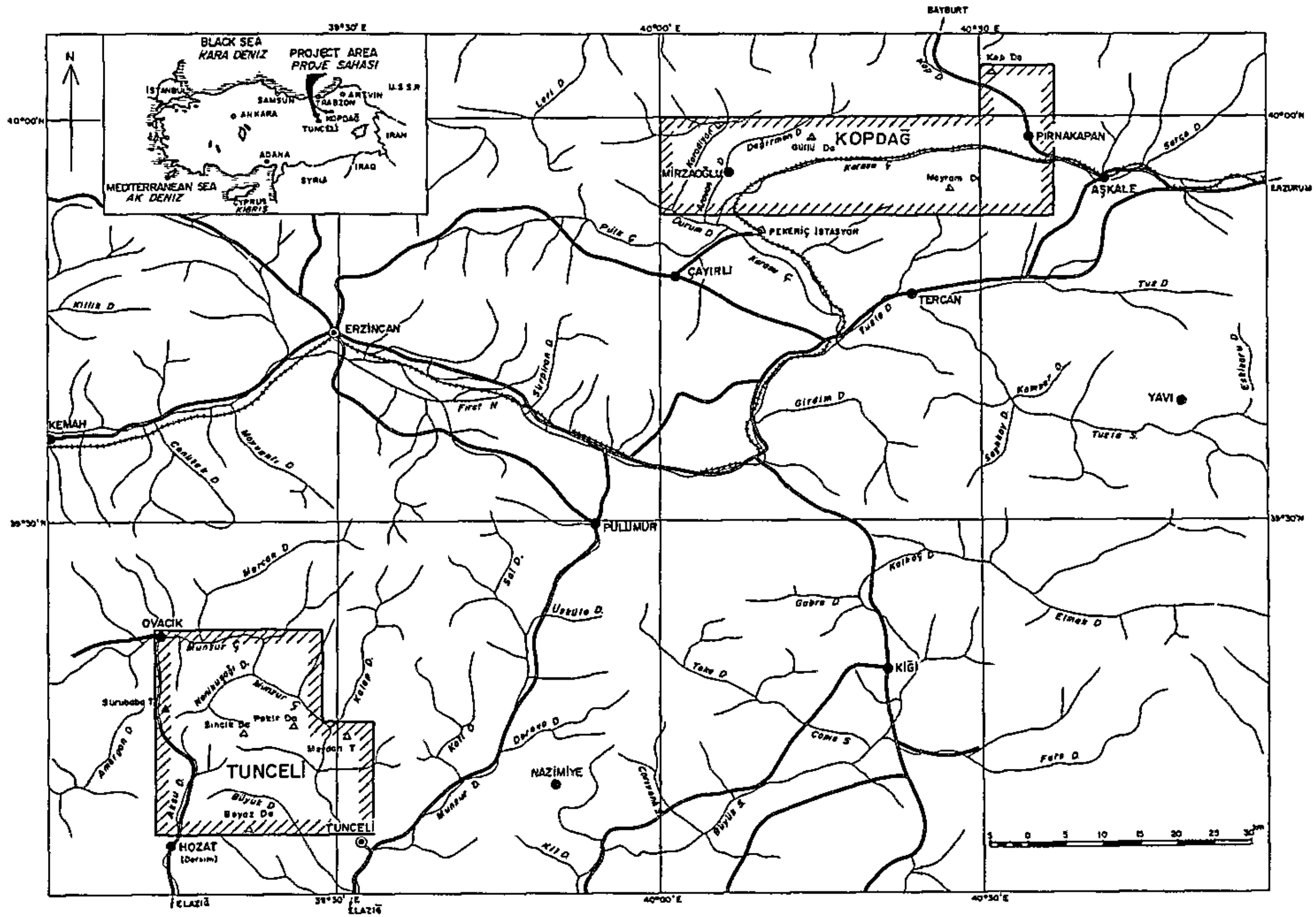
This report is a compilation of the basic survey findings of the Phase I. At the completion of the project consolidated report will be submitted to the Government of the Republic of Turkey.

We wish to express our appreciation to all of 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.

June 1978

Shinsaku Hogen
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan



LEGEND
Lejand

Preliminary photogeological survy area
Fotojeolojik ön çalışmalarıistenen saha

City *Şehir*	Town *Kaza*	Stream and river *Dere, suyu, cayi, nehir*	Road *Karayolu*	Rail road *Demiryolu*

ABBREVIATION
Kısaltma

T Hill *Type*	Da Mountain *Dağ*	D Stream *Dere*	S River *Suyu*	Ç River *Çayi*	N River *Nehir*

KEY MAP AND LOCATION MAP

LOKASYON HARİTASI

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SUMMARY

The contents of this report are summarized as follows.

1) The survey was started in fiscal year 1976 as part of a cooperative program between Turkey and Japan, with the aim of detecting copper, chromium, and other mineral deposits in the Tunceli and the Kopdağ areas. In the first year, photogeological analysis was carried out at the offices of the Mineral Research and Exploration Institute of Turkey.

2) The total area surveyed comprised 760 Km^2 in the Tunceli area and 820 Km^2 in Kopdağ area.

3) The Tunceli area occupies a part of the Taurus Mountains and is situated in the Munzur River valley. Its elevation is 950 m - 2,400 m above the sea level. Access from Ankara to Tunceli, the closest city to the area, is by air from Ankara to Elâzığ and then by road from Elâzığ to Tunceli. The former takes one hour and the latter takes two hours.

The Kopdağ area is located in the northernmost part of the Taurus Mountains and is 1,400 m - 2,900 m above the sea level. The Karasu River, which is the upper stream of the Fırat River, flows from east to west in the central part. It is a one-hour flight from Ankara to Erzurum and then a one-hour drive from Erzurum to Aşkale, the easternmost city of the area.

4) Conventional monochrome aerial photographs on a scale of 1 : 35,000 and 1 : 25,000 were used for analysis : 100 sheets for the Tunceli area and 149 sheets for the Kopdağ area. The results were compiled into a photogeological map with a scale of 1 : 25,000.

5) The Tunceli area was subdivided into 10 photogeological units. Of these, geological units from A to F indicate sedimentary rocks in ascending order. Units Ia to Id are intrusive rocks. According to previous data, Unit A correlates with metamorphic rocks and limestone of the Permian Period. Units B and C were included in the Permian System, but our analysis suggests they are the formation of a younger geological age. Unit B is pyroclastic rocks and Unit C is clastic rocks. Unit D is limestone and calcareous clastic rocks correlated with flysch sediments of the Eocene Epoch. Unit E correlates with the Tertiary System and is composed of volcanic rocks pyroclastic rocks and calcareous clastic rocks. Unit F is Quaternary sediments.

Unit Ia is intermediate intrusive rock ; Ib is serpentinite ; Ic is acidic intrusive rock ; and Id is intermediate intrusive rock. The former two units intrude into the units stratigraphically lower than Unit C. The latter two units penetrate the units up to E.

6) The Kopdağ area was divided into eight photogeological units. Units A to F are sedimentary rocks in ascending order and Units Ia_1 and Ia_2 are intrusive rocks.

Unit A is limestones of the Jurassic and the Cretaceous Systems, Unit B also consists of limestones that correlate with the Lower Cretaceous System. Unit C is clastic rocks of flysch sediments of the Eocene Epoch ; Unit D is Miocene limestone ; E is Neogene Tertiary limestones ; and F correlates with Quaternary sediments.

Unit Ia_1 is ultrabasic rocks and according to existing data correlates with serpentinite and ophiolite. Unit Ia_2 is distributed within Unit Ia_1 and is assumed to be serpentinite.

7) In the central part of the Tunceli area, alteration zones with NW - SE direction can be distinguished in Unit E, especially in the subunits E_{1-1} and E_3. They are

named Unit H. The largest of them has a dimension of 10 Km by 1.8 Km. The zones probably consist mainly of white clay minerals and are possibly silicified.

The alteration zone roughly corresponds with the anomaly area determined by the regional geochemical survey ; and since there is a strongly altered area near the Sin mineral deposit, the zone would seem to be related to mineralization.

8) A total of 46 old trenches were found in Units Ia_1 and Ia_2 in the Kopdağ area. Their concentration is seen in three areas. They generally show NE - SW direction. According to existing data the trench zone corresponds with the chromium mineralized zone.

9) From a photogeological view point, the alteration zones mentioned in 7) and the concentration zone of trenches mentioned in 8) are likely to be promising mineralized areas.

10) Based on consideration of available data and on the results of photogeological analysis a further survey should be carried out in fiscal year 1978 as follows :

In the Tunceli area, a geological survey on a scale of 1 : 25,000 to follow up the photogeological interpretation and a reconnaissance geochemical survey (excluding the areas already surveyed by MTA) should be carried out. Further, to clarify the features of the alteration zone and the already indentified geochemical anomaly area, a geological survey on a scale of 1 : 10,000 and a detailed geochemical survey will be necessary. When promising areas are found by these surveys, a highly detailed geological survey on a scale of 1 : 2,000 should be carried out.

In the eastern half of the Kopdağ area, a medium-scale geological survey on a scale of 1 : 25,000 is necessary to determine geological sequence and mineral occurrence. In the western half of the area where there are known chrome deposits, a semi-detailed geological survey on a scale of 1 : 10,000 should be carried out, and mineral deposits should be clarified by geological mapping in tunnel and trench surveys. Detailed geological surveys on a scale of 1 : 2,000 should be carried out in promising areas.

CHAPTER 1. INTRODUCTION

1.1 SURVEY HISTORY

The survey formed the second mineral exploration project carried out in cooperation between the Republic of Turkey and Japan.

Following the completion of the first project (a geological survey of the Trabzon area) new proposals were presented to the Japanese Government by the Mineral Research and Exploration Institute of Turkey (Maden Tetkik ve Arama Enstitüsü - hereafter referred to as MTA). Subsequently, a Japanese negotiating team visited Turkey in July 1977. The outline of the survey was agreed upon after Japanese team members had visited the proposed areas and after discussions had been held of the details of procedure. Members who took part in the discussions were as follows :

Turkish Team	Japanese Team
Recai KUTLU (MTA)	Yoshihiro SEKINE (Metal Mining Agency of Japan, MMAJ)
Tandoğan ENGİN (MTA)	Hiroyasu KAWAGUCHI (Ministry of International Trade and Industry, Agency of Natural Resources and Energy)
Ömer ÇELENK (MTA)	Eiichi ASANO (Japan International Cooperation Agency, JICA)
Ömer T. AKINCI (MTA)	Hisamitsu MORIWAKI (MMAJ)
Ünal ARATAN (MTA)	

After the exchange of official messages between the two Governments, the survey was started in October 1977.

Two Japanese specialists, Hajime TAKAHASHI (Mining Geologist) and Ken OBARA (Photogeologist), were selected as members of the preliminary survey group.

They visited Ankara on Oct. 22, 1977.

During the first half of November, they made field trips to the two areas with Mete TEŞREKLİ (Deputy Chief of Copper Section, MTA) and Sükrü ELEREN (Topographical survey Engineer, Geochemical Section, MTA).

They first visited the Eastern Black Sea Branch Office of MTA at Araklı in the Trabzon Region to gather geological data, procure a vehicle for field trips, and complete other preparations.

The party visited the Kopdağ area by way of National Route No. 40, which connects Araklı and Erzurum.

However, the road had been closed due to snowfalls and the team could not visit the main part of the area except to observe one of the outcrops of chrome deposit.

Fortunately, when the team members visited the Tunceli area, they were able to survey some of the mineralized areas and get *in situ* information on the geology and mineral deposits in the area. The party then reached the Elâzığ Camp of MTA and surveyed the Keban mining area.

Photogeological analysis was carried out at the central office of MTA between December 1977 and the end of March 1978. It was limited to a geological analysis of aerial photographs without field checks due to climatic conditions in the areas concerned. The following team members took part :

Turkish Team	Japanese Team
Suna HACALOĞLU	Ken OBARA
İnci SOYSAL	
Serpin İNAL	

In March 1978, a Japanese mission consisting of members from JICA and MMAJ visited Turkey. The aim of the mission was to evaluate the photogeological analysis which was carried out from December 1977 to March 1978 and to discuss with members of MTA the coming field survey due to begin in the spring of 1978. Members attending the discussions were as follows :

Turkish Team	Japanese Team
Recai KUTLU (MTA)	Kunio ASAKURA (MMAJ)
Tandoğan ENGİN (MTA)	Hideo YASUKI (JICA)
Ömer T. AKINCI (MTA)	Tetsuhiro NAKANOMORI (MMAJ)
Sunay AKDERE (MTA)	Satoru ISHIKAWA (MMAJ)
Engin ÇUBUKÇU (MTA)	Hisamitsu MORIWAKI (MMAJ)

The report described the results of laboratory photogeological analysis on the Tunceli and the Kopdağ areas.

1.2 OBJECTIVE OF THE SURVEY

The objective of the survey was to clarify the geology, geological structure, and mineralization of the Tunceli and the Kopdağ areas, and to reveal their potential through the discovery of new mineral deposits and evaluation of existing ones.

We expected to find chrome in the Kopdağ area and copper, lead and zinc in the Tunceli area.

If necessary, to attain the above objectives, photogeological analysis, geochemical surveys, geological surveys, geophysical surveys, drilling exploration, and adit driving should be carried out.

Photogeological analysis carried out in fiscal year 1977 as Phase I of the survey aimed at the clarification of the outline of geology and geological structure, the depiction of mineral alteration zones, and the acquisition of data in mineralized areas.

1.3 LOCATION OF THE AREAS

The location of the survey area is as follows :

Tunceli Area

North latitude	39° 21'30"	East longitude	39° 13'05"
ditto	39° 21'30"	ditto	39° 29'17"
ditto	39° 15'08"	ditto	39° 21'17"
ditto	39° 15'08"	ditto	39° 34'09"
ditto	39° 07'30"	ditto	39° 34'09"
ditto	39° 07'30"	ditto	39° 10'18"
		Total area :	760 km^2

Kopdağ Area

North latitude	40° 00'00"	East longitude	40° 00'00"
ditto	40° 00'00"	ditto	40° 30'00"
ditto	40° 03'44"	ditto	40° 30'00"
ditto	40° 03'44"	ditto	40° 37'30"
ditto	39° 52'30"	ditto	40° 37'30"
ditto	39° 52'30"	ditto	40° 00'00"
		Total area :	820 km^2

The Tunceli area lies within Tunceli Province which is divided into the Tunceli, Ovacık, and Hozat Districts. The northern part of the Kopdağ area lies in Bayburt District in Gümüşane Province ; the eastern part is in Aşkale District in Erzurum Province ; and the southwestern part lies within Çayırlı and Tercan Districts in Erzurum Province.

1.4 TOPOGRAPHICAL MAP

Topographical maps used in the survey are as follows :

Tunceli Area

1 : 100,000	Erzincan	J42, 43
1 : 25,000	Erzincan	J42 - a3, J42 - d2
		J42 - b4, J42 - c1
		J42 - b3, J42 - c2
		J43 - a3, J43 - d1

Kopdağ Area

1 : 100,000	Trabzon	H44
	Tortum	H45
	Erzincan	İ44
	Erzurum	İ45
1 : 25,000	Trabzon	H44 - d4, H44 - d3, H44 - c4, H44 - c3
	Tortum	H45 - d4
	Erzincan	İ44 - a1, İ44 - a2, İ44 - b1, İ44 - b2
	Erzurum	İ45 - a1

Kopdağ Area (Cont'd)

1 : 10,000	Erzincan	İ44 - a1 - 1,2,3,4
		İ44 - a2 - 1,2,3,4
		İ44 - b1 - 1,2,3,4

1.5 PREVIOUS WORK

Geological and mineralogical surveys of the Tunceli and the Kopdağ areas have previously been carried out by geologists of MTA and by other researchers ; several reports have been published so far. Of these, the geological map of the Erzurum area on a scale of 1 : 500,000 and explanatory text compiled by ALTINLI, İ.E. (1963) and that of the Trabzon area on the same scale compiled by GATTINGER, T.E. (1962) are the most important. Data from almost all previous work have been included in them. AFSHAR, F.A. (1965) has reported on the stratigraphy and geological structure of the Tunceli area.

In the Kopdağ area, an important survey of mineral deposits was carried out by KAADEN, G. (1962) and BARUTOĞLU, Ö.H. (1965). The reports evaluate chrome deposits in the area as well as describe the geology and mineral deposits.

There are only a few reports on mineral deposits in the Tunceli area and the survey areas are limited. KARAEFF, A. (1964) carried out a mineralogical survey of certain places in the area and reported them to be economically unpromising.

In 1960, an airborne magnetic and radiometric survey in the Erzincan J - 42 sheet map area (1 : 100,000), which covers almost all of the Tunceli area, was carried out by MTA. Several structural lines and highly magnetized rock were detected as a result.

In parallel with this project a further airborne survey will be carried out in the Tunceli area from fiscal year 1978 by MTA applying an integrated electromagnetic and magnetic survey system.

A regional geochemical survey has been completed by the Bilfer Co. over most of the Tunceli area. However, we were only able to obtain their geochemical anomaly map and unable to find out further details. We assume from the map that the samples were obtained from stream sediments and that Cu, Zn, Mo, and Ag were selected as indicator elements.

The map shows areal distribution of anomalously high Cu and Zn concentration ; however, it seems there are no remarkably high anomaly areas of Mo and Ag.

The anomaly area roughly corresponds with the mineralized area known from existing data.

MTA started a geochemical exploration program in the Tunceli area in 1977. The program aims at making a detailed geochemical survey in mineralized areas as well as carrying out a regional survey.

Exploration work has just been started and the results will be reported after 1978.

1.6 ACKNOWLEDGEMENTS

We wish to express deep gratitude to Doç. Dr. Sadrettin ALPAN, the General Director of MTA for his continuing support and backing from the beginning of this project.

Dr. Orhan ÖZKOÇAK, the Assistant Director of MTA, Mr. Recai KUTLU, the Director of the Mineral Exploration Department, and other members of the Department provided us with much help throughout the survey. Mrs. Sunay AKDERE, the Chief of the Photogeological Section, gave useful suggestions and guidance during the photogeological analysis.

On our geological inspection tour, members of the Eastern Black Sea Branch and the First Branch of Central Anatolia of MTA provided much assistance.

CHAPTER 2. GEOGRAPHY AND TRAFFIC

2.1. TUNCELİ AREA

The area occupies a part of the inner arc of the outer Eastern Taurus Mountains. The mian range has an E - W trend but the topography is complex and the subordinate ranges have a N - S trend. The mountain peaks are rugged and their slopes are steep. The northern margin of the area develops into the Ovacık Basin. Toward the south, the mountains decrease in altitude down to the Elâzığ Plain. The Munzur River, which is a tributary of the Murat River, flows from northwest to southeast across the mountain ranges. In the far north the Munzur River forms a broad valley which develops into the wide alluvial plain of the Ovacık Basin. However, the rest of the river course shows V-shaped valleys. The highest part of the area is located in the center where there are several mountain peaks : Mt. Pokir, with an elevation of 2,422 m, and Mt. Maydan to the east and Mt. Sincik to the west, both with an elevation of 2,284 m. Altitudes along the Munzur River range from 950 to 1,300 m above the sea level, and most of the area lies between 1,300 and 1,800 m in altitude.

The climate is that of the Central Anatolia Climate Zone, characterized by a continental climatic pattern with cool temperatures and moderate precipitation in winter and dry weather in summer. The snowfall season is from November to March with precipitation reaching the maximum in spring. The area seems to be favored with precipitation compared with the surrounding areas and thus vegetation is comparatively thick.

Half of the area is covered with scattered trees consisting of oaks and pines, and the rest is grassland. There are corn fields in the Ovacık Basin and farms around the villages.

Natural conditions are severe preventing human activity, so that the population rate is about one person per square kilometer. Small villages are seen along the Munzur River and on the hillsides. Main cities in or around the area are Tunceli, in the southeast ; Ovacık, in the northwest ; and Hozat, in the southwest. The population is 5,000 to 10,000 and these cities are the centers for education, medical facilities, and the supply of labor.

The main industries in the area are stock farming in the mountains and agriculture on the flatland.

Traffic access to Tunceli is convenient. Turkish Air Lines links Ankara and Elâzığ with three regular flights a week by F-28, and Ankara and Diyarbakır (where the First Branch of Central Anatolia of MTA is located) with one or two scheduled flights a day by DC-9. The distance between Diyarbakır and Elâzığ is 159 km via National Route No. 69 and that between Elâzığ and Tunceli is 90 km. It takes 2 1/2 hours and 2 hours by car respectively. The road is surfaced. Long-distance bus service is available from Ankara to Tunceli via Elâzığ every day and takes 14 hours.

The road network inside the area is incomplete. These are three main roads in the area : between Tunceli and Ovacık, running along the Munzur River and kept in good condition : between Tunceli and Hozat via Sin Köy ; and between Hozat and Ovacık. Apart from these, there are only short lanes connecting main roads and villages. Motor-vehicle traffic is closed from November to March due to the snowfall.

Telephone or telegram service to Ankara is available from cities such as Tunceli and communication to and from the villages is by mail.

The Kopdağ area can be reached from the Tunceli area by taking National Route No. 5 from Tunceli to Aşkale (located on the eastern margin of the Kopdağ area), and then by taking National Route No. 40 from Aşkale to Bayburt, located in the northern part of the area. The distance between Tunceli and Aşkale is 185 km, and between Aşkale and Bayburt, 75 km. The roads are almost all surfaced and it takes 4 hours to get to Aşkale from Tunceli and a further 2 hours to reach Bayburt. Public transportation between the two areas is inconvenient.

2.2 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 are generally rugged ; however, where they are composed of ultrabasic rocks, the summits slope away gently into plateau formation. The northern mountain ridge is the divide of the Çoruh valley drainage system, which flows into the Black Sea, and the Fırat valley drainge system, which flows into the Arabian Sea.

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 Fırat River (Euphrates R.), whose lower reaches flow into the Persian Gulf across Syria and Iraq. The river has a wide valley bottom, particularly at Aşkale. In contrast, the tributaries of the Karasu River are complex, showing roughly north to south stream courses with short and narrow valleys.

The highest point of the area is Mt. Kop (2,918 m) in the northeastern corner, and the next highest peak is Mt. Meyram (2,669 m) in the southeast. The northern range is 2,000 - 2,500 m in altitude, and the southern range is 1,800 - 2,400 m in altitude. The Karasu River valley area ranges from 1,400 to 1,500 m in altitude.

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

The population of the area is smaller than that of the Tunceli area, and it is particularly sparse in the north. Villages are scattered along the Karasu River and on the valley slopes. The main cities in the region are Aşkale (population about 20,000) in the east, Bayburt (population about 10,000) in the north, and Çayırlı (population about 5,000) in the west. They are centers for education, medical facilities, and the supply of labor.

The main industries are stockfarming, agriculture, and chromium mining. The mining area is in the west and the major mines are located on the southern slopes of the northern ranges.

The most convenient traffic route from Ankara is the Erzurum route. There is a regular flight service every day by DC-9 connecting Ankara and Erzurum. The distance between Erzurum and Aşkale is 51 km via National Route No. 2 ; it takes one hour by car. The distance from Araklı, where the Eastern Black Sea Branch Office of MTA is located, to Bayburt is 226 km via Trabzon and Gümüşane by way of National Routes No. 40 and No. 65. It takes 6 to 7 hours since the road crosses the Eastern Black Sea Mountains. There are convenient public bus transportation system in the big cities such as Erzurum, Erzincan, and Trabzon and in smaller cities like Bayburts ; however, the service is not very prompt. Along the Karasu River there is a railroad which connects Erzurum and Kars to the east and which reaches Ankara via Erzincan and Sivas to the west. The train passes through about once a day.

The traffic network is less developed than in the Tunceli area. Although National Route No. 40 crosses the western extrenity, there are no other roads except for one crossing the northern range, one crossing the southern range, and one or two from the west of the area or from railway stations to the chrome mines.

There is no road along the Karasu River. Telephone or telegram service is available only in the cities.

Both areas are earthquake-prone, and in particular the Kopdağ area is situated on an active earthquake zone extending from Erzurum to Erzincan.

CHAPTER 3 PHOTOGEOLOGY

3.1 PROCEDURE OF WORK

The aerial photographs used for analysis were all conventional monochrome photoprints on a scales of approx. 1 : 35,000 and approx. 1 : 25,000. 1 : 35,000-scale aerial photographs were used for the Tunceli area, and 1 : 25,000-scale aerial photographs were used for the Kopdağ area. Additionally, 1 : 35,000-scale photographs were used to cover the western part of the Kopdağ area. The format was 18 cm by 18 cm for the 1 : 35,000-scale photographs and 23 cm by 23 cm for the 1 : 25,000-scale photographs. The flight course was an E-W direction in the Tunceli area; while in the Kopdağ area, it was in N-S direction for the photographs on a scale of 1 : 35,000 and an E-W direction for the photographs on a scale of 1 : 25,000. A total of 100 sheets for the Tunceli area and 149 sheets for the Kopdağ area were used.

The procedure of aerial photointerpretation was as follows:

Firstly, photo mosaics of both areas were constructed by following the topographic sequences of the photographs.

Secondly, for every other sheet, fiducial points, drainage patterns, and main roads were delineated on a film overlay.

Thirdly, photogeologic interpretation was carried out by using a stereoscope and delineating the results on the overlay. Photogeologically analytical elements such as photo tonal characteristics (tone, texture), topographical characteristics (drainage pattern and density, resistivity of rock and cross section of valleys and ridges), lineament and bedding (direction, intensity and kinds), and vegetation pattern were examined to distinguish lithological units. These results are tabulated in Tables 1 and 2. The description of each geological unit was based on characteristics of surfaces with the least vegetation cover.

The results were plotted on a drainage map which was compiled from topographical maps on a scale of 1 : 25,000, and the interrelationships among the lithologic units were examined. If the results were found to be vague or contradictory, analysis was repeated for that particular section.

Finally, this information was correlated with existing geological data, mainly those of the geological map of Trabzon and Erzurum (1 : 500,000 scale). The results were compiled into the preliminary photogeological map with a scale of 1 : 25,000.

3.2 OUTLINE OF GEOLOGY AND MINERAL DEPOSITS

The outline of geology and mineral deposits in the areas, on the basis of the geological map of Erzurum (1 : 500,000) by ALTINLI, İ.E. (1963), the geological map of Trabzon (1 : 500,000) by GATTINGER, T.E. (1962), the geological report of the Tunceli - Bingöl area by AFSHAR, F.A. (1965), and the report on the chrome deposits in the Kopdağ area by KAADEN, G. (1962) is summarized as follows.

3.2.1 Tunceli Area

The basement rock in the area is weakly metamorphosed rock and limestone of the Permian Period; it crops out along the Munzur River in the eastern part of the area. The metamorphic rocks are sericite schist and quartzite and are gray in color. The rocks gradually change into limestone facies which are brecciated, subcrystalline, and dark in color. The limestone bears *Neoschwagerina Carticulifera* in the upper part of the formation and is thus thought to be Late Permian Age. The total thickness of the Permian formation is about 800 m.

Overlying the Permian formation unconformably, flysch sediments and limestone of the Eocene Epoch and distributed in the southern part of the area. According to ALTINLI, the Eocene series near the Tunceli area are composed of flysch sediments, red to green in color and overlain by gray flysch sediments intercalated with limestone which yields the fossil Pelecypoda of the Upper Lutetian Stage. The Lutetian formation is composed of *Nummulites* -bearing fine-grained marl, fine-grained sandstone, and granule conglomerate in the lower part which gradually changes to thin laminated limestone. AFSHAR subdivides the flysch sediments into thin bedded limestone with fragments of Pelecypoda, andesitic lava and tuff, and bedded agglomeratic pyroclastic rocks. The thickness of the Eocene series, according to ALTINLI, changes from several hundred to several thousand meters.

In the southwestern part of the area centering around Hozat, it develops into a marine Miocene series. The lower part is composed of basic lava and pyroclastic rocks which change to marl and limestone dominant facies in the upper part (ALTINLI). AFSHAR also subdivides the series into a lower part and an upper part. The rock facies of the lower part are thick, sandy to conglomeratic limestone, gray in color, which change from gray to creamy colored limestone and marl, intercalating thin lignite beds in the upper part. The upper part consists of, from the lower level to the upper level, thick sandstone with red beds of terrestrial origin, thin calcareous sandstone, sandy limestone, massive and dull yellow thick fossiliferous limestone, red shale, and basalt lava.

Alluvial deposits are distributed near Ovacık.

In the northern part of Ovacık, wide distribution of ophiolite is observed. ALTINLI considers the younger ophiolite to be the intrusive bodies of the Late Cretaceous Period to the Paleocene Epoch and the older ophiolites (called "green rocks") which encountered metamorphism to be the product of an older and unknown geosynclinal stage.

Wide distribution of andesites can be observed in the central part. They are hornblende-bearing trachyandesites that mostly erupted in Miocene time.

The andesites encountered strong hydrothermal alteration and are white, brown, yellow, and red in color. They are reported to have developed along thrust planes by ALTINLI.

AFSHAR observed granitic rocks intruded into the above-mentioned andesites at several places in the area.

The area belongs tectonically to the Taurus Orogenic Belt. The ophiolite zone in the northern part of the area is the core part of the orogenic belt and thus the area corresponds to the southern flank of the belt. The bedding plane generally shows E-W strike and north dip. The Pre-Mesozoic formations show complicated folding, while the Tertiary formations are gently folded along E-W axes. According to AFSHAR, the geologic history of the area can be explained as follows:

Metamorphic rocks of the Lower Permian Period correlate with Grödner Sandstein. The limestone above correlates with Zeckstein and Bellerophone Limestone. During the Triassic and Jurassic Periods, the area caused uplift due to the orogenic movement and it thus lacks sediments. At the beginning of the Cretaceous Period, the area turned into a geosynclinal stage, and under an eugeosynclinal environment, a deposition of thick sediments formed in the rapidly submerged through. The deposits of flysch-type sediments continued through Cretaceous to Tertiary time with intrusive activity of ophiolites and volcanism. The area encountered a Pre-Gosanen (Folding) Movement at the end of Early Cretaceous time and Laramide Movement in Late Cretaceous time. After an uplifting movement in the Eocene Epoch it became a shallow marine environment with deposits of *Nummulites* -bearing Lutetian limestone during the Oligocene Epoch. Limestone facies continued through to Miocene time. After Late Miocene time, the area became a terrestrial environment and terrestrial sediments were deposited. In the Pliocene Epoch the area encountered remarkable volcanic activity. Uplifting movements have been continuing from Late Miocene to Recent time.

There are many mineralized areas with Cu, Pb, Zn, Fe, and others in the area. Among these areas, the Sin mineral deposit in the southern part, the Mamlis copper deposit in the central part, the copper deposits along the right bank of the lower reaches of the Munzur River near Sorsivenk village, the copper-zinc deposit in the eastern part of the Kört village, and the iron deposit in the northern part of the Karşilar village are remarkable.

3.2.2 Kopdağ Area

According to KAADEN the basement rocks in the area are schists and actinolite-epidote schist of the Pre-Mesozoic Era in Aravans; and, according to GATTINGER and ALTINLI, there is wide distribution of limestone and marl of the Lias to Malm Stage in the northern and western parts of the area.

Overlying them, marly limestone and argillaceous to arenaceous shale of the Lower Cretaceous series are distributed east to west in the northern part of the area. (According to KAADEN, Jurassic formation and Lower Cretaceous System are distributed also in the southern part of the area). These are 1,500 m in thickness and are severely folded. Overlying them unconformably, wide distribution of the ophiolite series of the Cretaceous Period can be observed. The series consists of serpentinite, diabase, spilite, and tuffs intercalating radiolarite, sub-crystalline schist, limestone, marble, and siliceous marly schist.

The Tertiary System in the area begins with conglomerate, sandstone, granule conglomerate, and alternation of marl and sandy shale of the Early Paleocene Epoch and is succeeded by flysch sediments of the Middle to Late Paleocene Epoch. They are distributed in the northern part of the area conformably or unconformably with the Cretaceous System or other older rocks. The Miocene series are distributed widely around Aşkale and are composed of thick fossiliferous limestone with basal conglomerate at the bottom. The Miocene series are overlain unconformably with Late Miocene to Pliocene sediments of lacustrine or terrestrial environment; these sediments are distributed in the southern part of the area. The rock facies are brown-colored silt; sandstone of green, gray, and khaki colors; marl; white and creamy colored limestone; and alternation of marl and limestone.

Alluvial deposits are distributed along the Karasu River. Outside the area toward the north, or near Gümüşane, it is reported there are granitic rocks of the Variscan period. The rocks have coarse texture with phenochryst of red feldspar.

The ophiolites which are distributed in the central part of the area have been described previously in this report.

The time of intrusion is reported to be the Cenomanian Stage by GATTINGER and Cretaceous to Tertiary time by ALTINLI (The description of ALTINLI is that for the Tunceli area). Ultrabasic rocks of the ophiolite series area, according to KAADEN, reported to be strongly serpentinized and sheared.

In view of geological structure, the area is categorized into the Anatolides, which are sandwiched by the Pontoides and the Taurides. The folding structure is complex with NE-SW to E-W folding axes. The Maden - Ovacık Anticline and Syncline, the Kopdağ - Akbadağ Anticline, and the Aşkale - Başköy Syncline are the main folding structures among them. Faults are abundant and have NW-SE to WSW-ENE trend. Active faults related to present earthquakes are included among them.

According to GATTINGER, the geological history of the Anatolides can be summarized as follows: After the deposition of the Permian to Carboniferous series associated with the intrusion of granitic rocks, the area came under the influence of the Variscan Movement. Tectonic differentiation of the Anatolides and the Pontoides took place at the end of the Permian Period (Lower Kimmeridgian). The development of geosyncline in the Lias Stage brought thick limestone succeeded by a terrestrial environment in the Dogger Stage. The transgression took place again in the Malm Stage and the Late Cretaceous Period, and the intrusion of basic and ultrabasic rock was active in the Cenomanian Stage. The area was overlain by limestone of the Turonian Stage and flysch sediments in the Senomanian Stage. In the Tertiary Period, the area was in a regressive environment in the Eocene Epoch, then again became transgressive in the Oligocene Epoch. Flysch sediments were deposited and volcanism became active. During the Miocene Epoch, it formed a Morasse basin and the deposition of marine sediments at the beginning was gradually replaced by lacustrine sediments. From the end of the Miocene to Pliocene Epochs, faulting and volcanic activity took place associated with andesitic to basaltic products, and the area turned into a terrestrial environment at the end of the Pliocene.

There are many chrome deposits in the ophiolites of the area. According to KAADEN, there are two mineral-deposit belts that extend in a ENE-WSW direction. The northern mineral-deposit belt is economically important, having the Baltader mez. Pembegül, Ezan, and other mineral deposits. The extension attains about 17.5 km.

The southern mineral-deposit belt includes the Karalintepe, Erdaş, Cancık Köy, and other deposits and extends for 7 km. These are massive, banded, mineralized deposits, yielded in dunite. The Ore minerals are uvarovite and kammererite.

3.3 GEOLOGICAL UNITS (refer to PL.1-1, PL.1-2, and PL.2)

3.3.1 Tunceli Area

The area is divided into 10 geological units in terms of photogeological interpretation, with some units further divided into minor units as listed in Table 1. Among these, Units A to F are assumed to be sedimentary rocks, pyroclastic rocks and sediments, and Units Ia to Id are assumed to be intrusive rocks. The idealized cross section showing the relationships among the units is given in Fig.1.

1) Unit A

It can be observed distributed along the Munzur River and its tributaries.

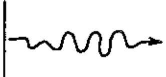
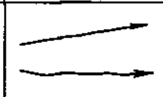
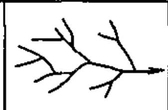
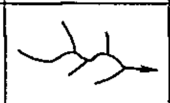
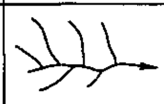
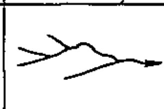
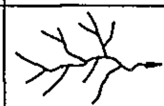
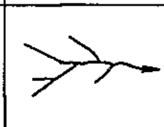
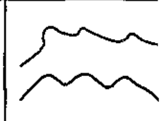
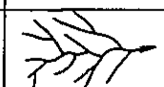
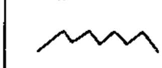
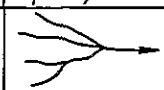
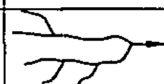
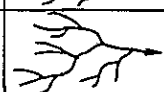
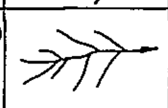
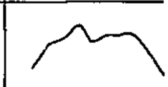
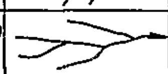
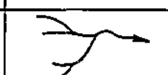
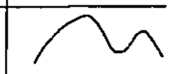
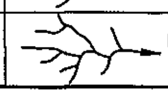
In the photo prints the tone is generally very light, but some very dark spots are observed in the middle reaches of the Munzur River. Texture is coarse and partly linear.

Topographically, the drainage pattern shows a sub-rectangular pattern with medium drainage density. The resistivity of the rock to erosion is very high; however, in the middle reaches of the Munzur River it is low, suggesting the existence of intercalation of a low-resistivity rock. As a while, the unit is massive and the cross sections of valleys are acute. In the middle reaches of the Munzur River, linear structure suggesting low-angle bedding planes with an E-W strike is observed but it is not evident in other areas.

The unit is assumed to be composed of marble intercalated with pelitic schist beds. Its boundaries with the other units are not clear except for that with Unit D which is comparatively well delineated. The unit is in the lowermost part of the area. Its thickness is assumed to attain over 4,000 m.

The unit is correlated withschist and limestone in the explanatory text of the geological map (1 : 500,000) of the Erzurum Quadrangle (this map will be

Table 1. Characteristic Chart o[f]
Tablo *Tunceli Sahasına ait I*

PHOTO UNITS		PHOTOGRAPHICAL CHARACTERISTICS		TOPOGRAPHICAL CHARACTE[RISTICS]				
		TONE	TEXTURE	DRAINAGE			RESISTIVITY	
				PATTERN		DENSITY	ROCK	CROSS SECTI[ON]
F	F_2	light ~ ((very dark))	hazy, ((patched)) fine ~ ((coarse))		meander	very dense	very low	
	F_1	very light ~grey	linear, ((patched)) fine ~ medium		parallel	medium	very low	
E	E_3	very dark ~light	rugged coarse		subdendritic	dense	high	
	$E_{2\text{-}2}$	very light ~light	checked medium		subdendritic	medium ~ rare	very high	
	$E_{2\text{-}1}$	very light ~ very dark	linear, smooth ((granule)) fine ~ coarse		subdendritic ~ subparallel	medium	very high ~low	
	$E_{1\text{-}2}$	very dark ~dark	smooth, ((spoted)) fine ~ coarse		subdendritic	medium	moderate ~high	
	$E_{1\text{-}1}$	very dark ~light	rugged coarse		subdendritic	dense	high	
D	D_2	((very dark)) ~ very light	hazy, ((rugged)) fine ~ coarse		subdendritic	medium	very high ~low	
	D_1	((very dark)) ~ very light	((rugged)) coarse		dendritic	very dense	high ~low	
C	C_2	very light ~ very dark	((rugged)), hazy linear fine~((coarse))		subdendritic dichotomic	medium	high & low	
	C_1	grey ~ very dark	smooth, ((granule)) fine ~ coarse		trellis	medium	low ~ moderate	
B		((very dark)) ~light	((granule)), linear coarse		subdendritic	dense	high	
A		very light ~ very dark	((granule)), linear coarse		subrectangular	medium	very high ~high	
Id		((very dark)) ~light	smooth, ((granule)) ((rugged)) medium ~ coarse		subdendritic subparallel	medium ~ dense	very high	
Ic		very light ~ ((very dark))	((rugged)) medium ~ coarse		subparallel	medium	very high	
Ib		light ~grey	smooth, ((granule)) fine ~ coarse		subparallel	medium	low	
Ia		light ~ very dark	rugged, specked medium		subdendritic	medium ~ rare	very high	
H		very light ~ ((very dark))	((granule)), linear medium		dendritic	very dense	very low	

Note; (( )) represent degree of tone and condition of texture caused by vegetation.

* Explanatory text of the geological map of Turkey (Erzurum, scale 1 : 500,000)

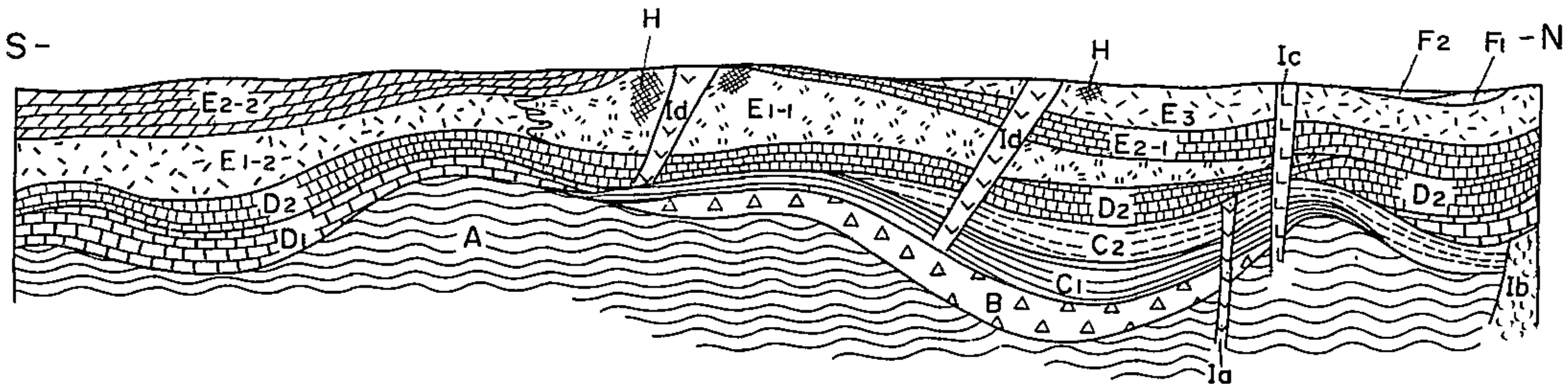
Table 1. Characteristic Chart of Photogeological Units of Tunceli Area

Tablo Tunceli Sahasına ait Fotojeolojik Ünitelerin Karekteristiklerini Gösteren Tablo

PHOTO UNITS		PHOTOGRAPHICAL CHARACTERISTICS: TONE	PHOTOGRAPHICAL CHARACTERISTICS: TEXTURE	TOPOGRAPHICAL CHARACTERISTICS: DRAINAGE: PATTERN	DRAINAGE: DENSITY	RESISTIVITY: ROCK	RESISTIVITY: CROSS SECTION	LINEAMENT-BEDDING: DIRECTION	LINEAMENT-BEDDING: INTENSITY	LINEAMENT-BEDDING: KINDS	VEGETATION	PROBABLE LITHOLOGY	PUBLISHED GEOLOGICAL MAP *
F	F_2	light ~ ((very dark))	hazy, ((patched)) fine ~ ((coarse))	meander	very dense	very low		-	-	-	few ~ medium (cultivated)	clastics	Qy : Holocene Recent
F	F_1	very light ~ grey	linear, ((patched)) fine ~ medium	parallel	medium	very low		-	-	-	no ~ medium (cultivated)	clastics	Qe : Pleistocene Qy : Holocene Recent
E	E_3	very dark ~ light	rugged coarse	subdendritic	dense	high		1 E-W N-S NNE-SSW 2 E-W	1 medium 2 weak	1 fault 2 bedding	many	intermediate ~ basic pyroclastic rocks with lava	α: andesite spilite porphyrite
E	$E_{2\text{-}2}$	very light ~ light	checked medium	subdendritic	medium ~ rare	very high		1 E-W 2 N-S NW-SE NE-SW	1 weak 2 strong	1 bedding 2 fault joint	no	limestone with marl	md . Miocene marine undifferentiated
E	$E_{2\text{-}1}$	very light ~ very dark	linear, smooth ((granule)) fine ~ coarse	subdendritic ~ subparallel	medium	very high ~ low		1 WNW-ESE N-S 2 NE-SW	1 strong 2 weak	1 bedding 2 fault	few ~ medium	calcareous rocks with shale and sandstone	α: andesite spilite porphyrite
E	$E_{1\text{-}2}$	very dark ~ dark	smooth, ((spoted)) fine ~ coarse	subdendritic	medium	moderate ~ high		1 E-W 2 NNE-SSW N-S NW-SE	1 weak 2 weak	1 bedding 2 fault	few	intermediate ~ basic lava and pyroclastic rocks	md . Miocene marine undifferentiated
E	$E_{1\text{-}1}$	very dark ~ light	rugged coarse	subdendritic	dense	high		1 NW-SE 2 NE-SW NW-SE NNW-SSE	1 very weak 2 weak	1 bedding 2 fault	many	intermediate ~ basic pyroclastic rocks	α: andesite spilite porphyrite
D	D_2	((very dark)) ~ very light	hazy, ((rugged)) fine ~ coarse	subdendritic	medium	very high ~ low		1 E-W 2 NW-SE NE-SW	1 very strong 2 medium	1 bedding 2 fault joint	few ~ medium	mainly limestone with clastic rocks	md : Miocene marine undifferentiated ef : Eocene, flysch
D	D_1	((very dark)) ~ very light	((rugged)) coarse	dendritic	very dense	high ~ low		NNW-SSE	weak	fault	medium	calcareous clastic rocks	ef . Eocene flysch
C	C_2	very light ~ very dark	((rugged)), hazy linear fine ~ ((coarse))	subdendritic dichotomic	medium	high & low		1 NE-SW 2 N-S ENE-WSW	1 very strong 2 weak	1 bedding 2 fault	medium	clastic rocks	pm : Permian
C	C_1	grey ~ very dark	smooth, ((granule)) fine ~ coarse	trellis	medium	low ~ moderate		NE-SW	medium	bedding	no ~ medium	clastic rocks (mainly shale)	pm : Permian
B		((very dark)) ~ light	((granule)), linear coarse	subdendritic	dense	high		1 NE-SW 2 NW-SE N-S	1 medium 2 weak	1 bedding 2 fault	many	intermediate ~ acidic pyroclastic rocks	pm : Permian
A		very light ~ very dark	((granule)), linear coarse	subrectangular	medium	very high ~ high		1 E-W 2 E-W N-S	1 medium ~ weak 2 weak	1 bedding (schistosity?) 2 fault	medium ~ few	low-grade metamorphic rocks (mainly marble with pelitic schists)	pm : Permian
Id		((very dark)) ~ light	smooth, ((granule)) ((rugged)) medium ~ coarse	subdendritic subparallel	medium ~ dense	very high		NE-SW	very weak	fault	few ~ medium	intermediate rocks (intrusive)	α: andesite spilite porphyrite
Ic		very light ~ ((very dark))	((rugged)) medium ~ coarse	subparallel	medium	very high		NNW-SSE NNE-SSW	medium	fault joint	medium	acidic rock (intrusive)	α: andesite spilite porphyrite
Ib		light ~ grey	smooth, ((granule)) fine ~ coarse	subparallel	medium	low		ENE-WSW	very weak	fault	few	serpentinite	σ : serpentinite
Ia		light ~ very dark	rugged, specked medium	subdendritic	medium ~ rare	very high		N-S NE-SW	very weak	fault	few	intermediate rock (intrusive)	pm : Permian
H		very light ~ ((very dark))	((granule)), linear medium	dendritic	very dense	very low		WNW-ESE	very weak	fault	medium	alteration zone	

Note; ( ) represent degree of tone and condition of texture caused by vegetation.

* Explanatory text of the geological map of Turkey (Erzurum, scale 1 : 500,000)



LEGEND

- D2 — Mainly limestone with clastic rocks
- D1 — Calcareous clastic rocks
- C2 — Clastic rocks
- C1 — Clastic rocks (mainly shale)
- B — Intermediate ~ acidic pyroclastic rocks
- A — Low-grade metamorphic rocks
- F2 — Clastics
- F1 — Clastics
- E3 — Intermediate ~ basic pyroclastic rocks with lava
- E2-1 / E2-2 — Calcareous rocks with shale and sandstone / limestone with marl
- E1-1 / E1-2 — Intermediate ~ basic pyroclastic rocks / intermediate ~ basic lava and pyroclastic rocks
- Id — Intermediate rocks (intrusive)
- Ic — Acidic rock (intrusive)
- Ib — Serpentinite
- Ia — Intermediate rock (intrusive)
- H — Alteration zone

Fig.1 Idealized Cross Section of Tunceli Area

Tunceli Arazisinin İdeallestirilmiş Kesiti subsequently referred to as "existing data").

2) Unit B

This unit overlies Unit A in the northeastern part of the area but its distribution is narrow.

It shows light gray tone, coarse texture, and parallel linear pattern can be partly observed.

The drainage pattern is subdendritic. The resistivity of the rock is high giving a massive appearance; it forms mountain ranges with gentle valley slopes. The general trend of strike of the bedding planes is a NE direction and it has a gentle dip gently to the northwest.

Density of vegetation is high.

The unit is assumed to be comparatively homogeneous intermediate to acidic volcanic pyroclastic rocks. Its relationship with Unit A is thought to be unconformity due to the difference of the strikes of both bedding planes; though the boundary of both units is not clearly delineated.

The maximum thickness of this unit is assumed to be about 1,200 m.

The unit is located in the Permian System according to existing data, but the result of photogeological analysis in terms of difference of rock types or distribution patterns makes this interpretation unlikely, and it may possibly be the product of a younger geological time.

3) Unit C

The unit is subdivided into two minor subunits, C_1 and C_2.

(1) Subunit C_1

The subunit is distributed in the northeastern part of the area occupying the northern part up to Unit B.

It shows gray to dark tone and smooth texture.

Drainage is trellis pattern. Rock resistivity is low and the valleys are V-shaped showing small undulations. Cuesta topography is partly evident and the bedding planes show a gentle slope in a NE or NNW direction.

The subunit is assumed to be composed of shale with some clastic materials. The boundary with Unit B is comparatively apparent and the sedimentary structure of both units is oblique; thus their relationship may be one of unconformity.

The thickness is assumed to be about 1,300 m.

According to existing data, the age of this subunit is the Permian Period; however, the rock facies and stratigraphical interrelationship suggest the subunit to be the product of a younger geological time.

(2) Subunit C_2

The subunit is distributed in the northeastern part of the area occupying the northern part to the Subunit C_1 concordantly.

It generally shows very light tone but includes very dark portions. Its texture is hazy in appearance and a parallel linear pattern is discerned suggesting boundaries of bedding planes.

The drainage pattern is dichotomic. The resistivity of the rock is both high and low and hence forms Cuesta topography with a strike of NE to ENE and a dip of NW to NNW or in part SSE.

Vegetation density is greater than that of Subunit C_1, but less than that of Unit B.

Subunit C_2 is assumed to be clastic rocks composed of an alternation of limestone, sandstone, and mudstone. It resembles the rock facies and geological structure of Subunit C_1 with which it is combined into the Unit C.

The thickness of the subunit is inferred to be about 1,000 m.

Although according to existing data Subunit C_2 is located in the Permian System, it is probably a younger formation, such as Subunit C_1.

4) Unit D

The unit is divided into Subunits D_1 and D_2.

(1) Subunit D_1

The subunit is developed along the Büyük River valleys in the southern part of the area, and has small distribution in the north of the central part.

The subunit shows very light tone and coarse texture. Rock resistivity is comparatively high, but in the Büyük River valleys where an anticlinal axis is located, it appears low due to erosion. The bedding plane of the subunit is not clear except for the anticlinal portion in the lower reaches of the Munzur River. Moreover, an anticline structure in the Büyük River valleys can be assumed from the curved drainage pattern.

Vegetation density is of the same degree as Subunit C_2.

The subunit is assumed to be composed of comparatively homogeneous calcareous clastic rocks. The subunit contacts Unit A with unconformity. Its relation with Units B and C is unknown but it has a more gentle geological structure and may be younger in age.

The thickness may reach to about 800 m.

It correlates with flysch sediments (ef) of the Eocene Epoch; however, the distribution is not necessarily the same.

(2) Subunit D_2

The subunit is observed in same area as D_1 and overlies it. In the middle reaches of the Munzur River, the subunit is observed on both sides into E_{1-1} and E_{1-2}, and E_2 further subdivided into E_{2-1} and E_{2-2}.

(1) Subunit E_{1-1}

It is developed from the central to the western part of the area.

It shows wide tonal variation from very dark to very light. The texture is coarse and gives a rugged appearance.

The drainage pattern is subdendritic and density is high. Rock resistivity is comparatively high and generally massive. However, bedding structures can be observed partly in such places as the northern part of the Sin Mah. village or the western part of the Karaoğlan village. The strike of the bedding plane is a WNW direction with a 10 to 25 degrees dip angle to NNE or SSW.

Vegetation density is high.

The subunit is assumed to be composed of intermediate to basic volcanic pyroclastics. The boundary with lower Subunit D_2 is partly evident and is thought to be located in a fault or unconformity.

The maximum thickness may be about 1,000 m.

The subunit is correlated with andesite, spilite, and porphyrite (α) of the Neogene Tertiary Period.

(2) Subunit E_{1-2}

The subunit is distributed in the southwestern part of the area.

It has very dark to dark gray tone and comparatively smooth texture.

It has the same subdendritic drainage pattern as Subunit E_{1-1} but the density is lower.

Rock resistivity is medium to high. The subunit is massive at the eastern part of the Uzundal village; however, vague lineament suggesting bedding planes is observed in the western part. This supposed bedding has a WNW strike with 10 degrees dip angle to SSW or NNE.

Vegetation density is very low.

The subunit is assumed to be composed of intermediate to basaltic lava and pyroclastics. It shows the same rock facies as Subunit E_{1-1}. Although judging from their lithologic relationship with the other units, the subunits seem to be in the same horizon, they are in fact both bounded by a fault. The boundary with Subunit D_2 is not evident; however, it may be one of unconformity since the strike of both bedding planes is not parallel.

The thickness of the subunit is assumed to be a maximum 850 m.

According to existing data it is assumed to be marine sediments (md) of the Miocene Epoch, but the result of photogeological interpretation strongly suggested it to be lava and pyroclastics as described above.

(3) Subunit E_{2-1}

The subunit is distributed forming a belt from an EW direction to a NS direction in the northwestern part of the area. The subunit shows wide tonal variation from very light to very dark, and the texture is partly characterized with dominant linear structure, which except for one area of smooth texture suggests bedding planes.

The drainage pattern is subdendritic to subparallel. Rock resistivity shows an alternation of extremely high and low beds; thus it forms Cuesta topography. The trend of the ridge varies from WNW to NW, then to NE. The dip angle of the bedding plane is maximally 30 degrees toward NNE, SW, and WNW.

Vegetation density is low.

The subunit is composed mostly of limestone with intercalated of the river overlying Units A and B.

The subunit is very light in tone and its texture is fine-to coarse-grained and often hazy.

The drainage pattern is subdendritic. Rock resistivity is very high but low-resistivity beddings interpose.

The bedding planes are the most apparent in the area and are as follows: in the northern part of the area - a NW strike with a 15 to 30 degrees dip angle to the NE; at the middle reaches of the Munzur River - an E to NE strike with a 5 to 20 degrees dip angle to N to NW; at the southern part of the Büyük River - a WNW strike with a 5 to 15 degrees dip angle to SSW; and at the lower reaches of the Munzur River - a WNW to E strike with a 5 to 20 degrees dip angle to SSW, NNE, or the S.

In low resistivity areas, vegetation density is high; in high resistivity areas, vegetation density is low.

The subunit is assumed to be composed mostly of limestone with clastic rocks of marl, shale, siltstone or sandstone. The rock facies resemble those of Subunit D_1 and since the geological structure is concordant both subunits are combined into the same unit - Unit D.

The maximum thickness may be about 800 m.

According to existing data, it is located in the Eocene-flysch-sediments and Miocene-marine-sediments distribution area. Judging from its relationship with Subunit D, it seems very likely that the unit correlates with the flysch sediments.

5) Unit E

The unit is subdivided into E_1, E_2, and E_3, and E_1 is further subdivided shale and sandstone beds. The stratigraphical relationship with Subunit E_{1-2} is partly conformable and partly unconformable.

The maximum thickness of the subunit is assumed to be about 800 m.

According to existing data this subunit is categorized into andesite, spilite, and porphyrite (α) of the Neogene Tertiary Period; but as interpreted above, it may be calcareous rock or clastic rock.

(4) Subunit E_{2-2}

The subunit is distributed in the southwestern part of the area and it is stratigraphically above Subunit E_{1-2}.

The tone is generally very light. The texture is medium-grained. It has a trellis pattern resulting from jointing or faulting and the parallel linear pattern suggests bedding planes.

Drainage shows a low dendritic pattern. Rock resistivity.istivity is very high. The strike of the subunit is assumed to be NW to WNW and the dip angle is maximally 10 degrees toward SW to SSW.

Vegetation is very scarce.

The subunit is mostly composed of limestone with occasional intercalations of thin marl beds. It is stratigraphically the same as Subunit E_{2-1}. The boundary with Subunit E_{1-2} is comparatively clear. The sequence of both subunits is conformable and their boundary is partly faulted.

The thickness of the subunit may reach 500 m at the most.

The subunit correlates with marine sediments (md) of the Miocene Epoch according to existing data.

(5) Subunit E_3

The subunit is distributed in the northwestern part of the area and stratigraphically it occupies the upper portion of Subunit E_{2-1}.

It shows wide tonal variation from very dark to very light. Texture is coarse-grained and rugged in appearance.

Drainage pattern is subdendritic and density is high. Rock resistivity is high and generally massive; however, linear structure showing bedding planes of strike in E-W direction and a north dip with an angle of about 30 degree can be observed locally.

Vegetation density is high.

The subunit is assumed to be composed of intermediate to basic pyroclastic rocks with lava. It is conformable with Subunit E_{2-1}.

Its thickness may reach a maximum of 900 m.

The subunit correlates with andesite, spilite, and porphyrite (α) of the Neogene Tertiary Period according to existing data.

6) Unit F

The unit is subdivided into Subunits F_1 and F_2.

(1) Subunit F_1

The subunit is distributed in topographically low areas such as the Ovacık Basin. It can also be locally observed along creeks or mountain slopes.

Its tone is gray to very light and its texture is hazy.

The drainage pattern is parallel. It forms river terraces in topographically low areas such as the outskirts of Ovacık and often shows landslide topography in mountainous area. Rock resistivity is very low.

Vegetation is scarce due to human activity and the area is cultivated.

The composition of the subunit may be clay, sand, gravel, and boulders. It overlies the lower units with distinct unconformity.

Its thickness is about 50 m at the most.

The subunit corresponds to Pleistocene sediments (Qe) and Holocene sediments (Qy) according to existing data.

(2) Subunit F_2

The subunit is distributed along the Munzur River valley and the Büyük River valley.

It has almost the same characteristic as Subunit F_1. However, it is observed along the banks of major rivers and creeks. It is recent fluvial deposits.

7) Unit Ia

The unit is observed inside Subunit C_2 in the northeastern part of the area.

The tone shows wide variation from very light to very dark and the texture is medium-grained and rugged in appearance.

Drainage pattern is subdendritic with comparatively low density. Rock resistivity is very high and forms massive knoll.

Vegetation is scanty.

The unit is thought to be intermediate intrusive rock. There are ten rock bodies; the largest of them has diameter of 2 km by 800 m.

The unit is intrudes into Subunit C_2 but its interrelationship with other units is unknown.

The unit is located in the area of the Permian formation (pm) but it is evidently younger intrusive rocks.

8) Unit Ib

The unit occupies a small area and is distributed at the northern end of the central part of the area.

It shows light gray to gray tone and texture is smooth. The drainage pattern is subdendritic and rock resistivity is low.

Vegetation is scarce.

The unit is presumed to be composed of serpentinite.

The boundary with Unit A is bounded by a fault and it is overlain by Subunit D_1.

According to existing data, the unit correlates with serpentinite (σ) of the Mesozoic to Paleogene ages.

9) Unit Ic

The unit is distributed between Unit A and Subunit E_3 in the north of the central part of the area.

It shows very light tone and its texture is medium-grained in appearance.

The drainage pattern is subparallel. Rock resistivity is very high and the unit forms a massive body. However, linear structure thought to be jointing or minor faulting can be observed in the unit.

Vegetation density is medium.

The unit is assumed to be acidic intrusive rock and intrudes into Unit A and Subunit E_3.

According to existing data the unit correlates with andesite, spilite, and porphyrite (α) of Neogene Tertiary time.

10) Unit Id

The distribution of the unit is seen in the areas where the Subunit E_{1-1}

and E_3 are located in the northwestern part of the area.

It shows light gray tone and texture is a mixture of smooth parts and rugged parts.

The drainage pattern is subdendritic to subparallel with high density. Rock resistivity is very high and thus the unit forms a massive mountain ridge.

Vegetation density is low.

The unit is assumed to be intermediate intrusive rock and penetrates Subunit E_{1-1} and E_3.

According to existing data the unit correlates with andesite, spilite, and porphyrite (α) of Neogene Tertiary time.

3.3.2 Kopdağ Area

The area is divided into eight photogeologic units with some of the units being further subdivided as listed in Table 2. Among the units, Units A to F may be sedimentary rocks and unconsolidated sediments, and Ia_1 and Ia_2 may be intrusive rocks.

The stratigraphical interrelationship of these units is schematically shown in Fig.2.

The vegetation of the area is very scanty.

1) Unit A

The unit occupies the small hilly land developed in the western part of the area.

It shows very light-to dark-gray tone and its texture is medium-to coarse-grained.

The drainage pattern shows low density and is parallel. Rock resistivity is very high at the center and low at the margins. The central part which shows

Table 2. Characteristic Chart of Photogeologic Units of Kopdağ Area

Tablo Kopdağ Sahasına ait Fotojeolojik Ünitelerin Karekteristiklerini Gösteren Tablo

PHOTO UNITS		PHOTOGRAPHICAL CHARACTERISTICS		TOPOGRAPHICAL CHARACTERISTICS							VEGETATION	PROBABLE LITHOLOGY	PUBLISHED GEOLOGICAL MAP *
		TONE	TEXTURE	DRAINAGE PATTERN	DRAINAGE DENSITY	RESISTIVITY ROCK	RESISTIVITY CROSS SECTION	LINEAMENT-BEDDING DIRECTION	LINEAMENT-BEDDING INTENSITY	LINEAMENT-BEDDING KINDS			
F		light ~grey	hazy, patched fine	meander	very dense	very low		–	–	–	few (cultivated)	clastics	Qy : Holocene Recent
F	F1	grey ~light	hazy, patched fine	parallel	medium	very low		–	–	–	very few (cultivated)	clastics	Qy : Holocene Recent n : Neogene continental
E		light ~grey	hazy, patched medium	subparallel subdendritic	medium ~rare	high ~low		NE-SW	weak ~strong	bedding	no (cultivated)	limestone with clastic rocks	n : Neogene continental jkr : Jurassic-Cretaceous
D	D2	grey ~ very light	hazy, patched medium	subdendritic	medium	very high & very low		E-W	strong ~weak	bedding (fault)	few (cultivated)	gypsfereous limestone with clastic rocks	ma : Lower Miocene
D	D1	(dark) ~light	smooth, (rugged) medium fine~coarse	subdendritic	medium	high & low		E-W	weak	bedding	medium ~few	limestone with clastic rocks	Mof : Mesozoic (Ophiolitic series) mainly Cretaceous
C		very dark ~ very light	smooth fine ~medium	subparallel subdendritic	medium ~dense	very high ~ very low		E-W	very strong ~weak	bedding	few ~ very few	clastic rocks with limestone	ef : Eocene, flysch n : Neogene continental
B	B2	grey ~light	smooth ~rugged fine~coarse	parallel subdendritic	medium	very high ~moderate		1 E-W NE-SW 2 NE-SW NW-SE	1 very strong ~medium 2 weak	1 bedding 2 fault	few	limestone with marl and shale	Mof : Mesozoic (Ophiolitic series) mainly Cretaceous
B	B1	very light ~light	(spotted) fine ~medium	subparallel subdendritic	medium ~rare	very high		E-W N-S	weak ~ very weak	bedding	few ~medium	limestone	kra : Lower Cretaceous
A		light ~grey	specked medium ~coarse	parallel	medium ~rare	very high & low		1 NE-SW 2 E-W N-S NW-SE	1 very weak 2 weak	1 bedding 2 fault (joint)	very few	limestone with marl and shale	jkr . Jurassic-Cretaceous
Ia2		very light ~grey	hazy very fine	subdendritic	dense	moderate ~low		ENE-WSW E-W	weak	fault	few	serpentinite	σ : Serpentinite Mof : Mesozoic (Ophiolitic series) mainly Cretaceous
Ia1		very dark ~dark	smooth, rugged very fine~coarse	subdendritic	medium	high & very high		1 E-W ENE-WSW N-S NW-SE 2 NW-SE N-S	1 weak 2 strong ~ very weak	1 fault 2 joint	rare ~few	ultrabasic rocks	σ : Serpentinite Mof : Mesozoic (Ophiolitic series) mainly Cretaceous

Note; ( ) represent degree of tone and condition of texture caused by vegetation.

* Explanatory text of the geological map of Turkey (Erzurum and Trabzon, scale 1 : 500,000)

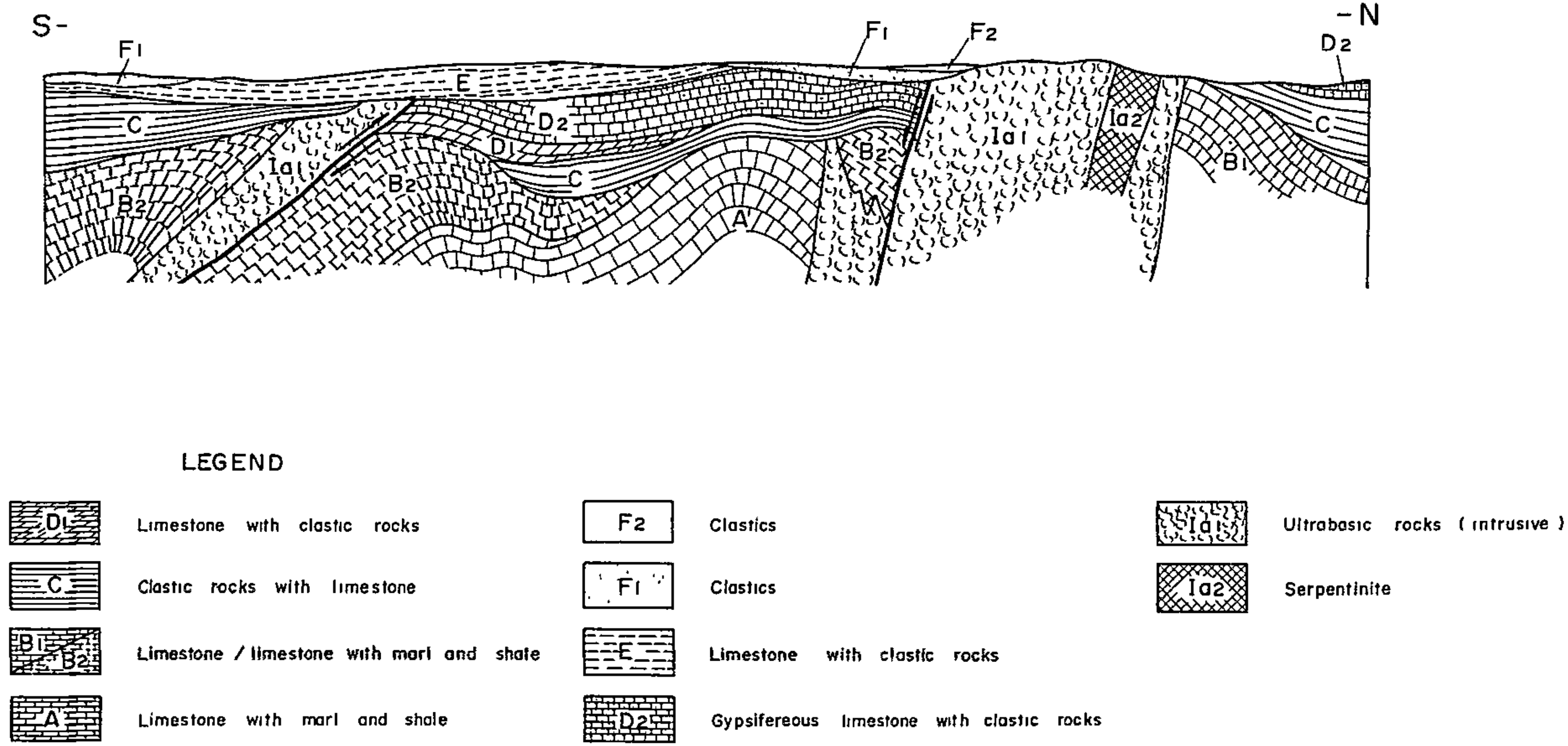


Fig. 2 Idealized Cross Section of Kopdağ Area
Kopdağ Arazisinin İdeallestirilmiş Kesiti

very high resistivity is massive and forms gently sloping hills. The development of sedimentary structure is poor, but it can be observed that the general trend of the distribution is in a NE direction; it forms an anticline structure with a SE and NW dip slope.

The central core part of the unit may be limestone and the margin may be marl and shale. The unit is the lowermost formation in the area.

As the lowest boundary cannot be determined, the total thickness is unknown; however, it is assumed to be over 400 m.

The unit correlates with limestone and marl of the Jurassic to Cretaceous Periods according to existing data.

2) Unit B

The unit is subdivided into Subunits B_1 and B_2.

(1) Subunit B_1

The subunit is distributed in the northwestern and northeastern parts of the area. In the northwestern part, it develops at the northeastern extention of Unit A, and in the northeastern part, it is distributed in an area stretching from the foot of Mt. Kop to the Dencik River valley and the Taşliağil River valley.

It shows very light tone and its texture is fine-to medium-grained.

The drainage pattern is subparallel to subdendritic with comparatively low density. Rock resistivity is very high and the unit generally shows a massive appearance. However, some linear structures suggesting bedding planes can be observed. It has a NE strike with a gentle SE dip angle in the northwestern part and an EW strike with a dip angle of about 60°N in the northeastern part. There are two small dolines in the northwest.

The unit is interpreted to be limestone. It is probably conformable with the lower part of Unit A.

The thickness is thought to be over 1,500 m.

The subunit correlates with marly limestone of the Lower Cretaceous Period (Kra).

(2) Subunit B_2

The subunit is distributed widely occupying the southern part of the Karasu River.

It shows gray to light-gray tone and the texture varies from comparatively smooth to rugged.

The drainage pattern is parallel to subdendritic. Rock resistivity is partly very high and partly low. Generally, the unit is massive and forms a mountain ridge but parallel linear structure suggesting bedding planes can be observed. It shows an E to NE strike and the dip angle is 15 to 60 degrees to NW or SE forming a folding.

The subunit may be composed mainly of limestone intercalated with marl and shale. It shows a close resemblance to the rock facies in Subunit B. Also since its geological structure and distribution are concordant with Subunit B, it is thought to have the same horizon.

The thickness of the subunit is probably over 1,500 m.

It is distributed in the ophiolite series (Mof) of the Mesozoic Era according to existing data.

3) Unit C

The unit is distributed in three separated areas: in the northwestern part, the southwestern part, and the southern edge of the central part.

It shows mostly dark tone but in the northwestern part it has a very light tone. Its texture is fine-to medium-grained and shows a smooth appearance.

The drainage pattern is parallel to subdendritic with comparatively high density. Rock resistivity ranges from high to low. In general, it is low and forms topographically low areas. However, it is very high in the northwestern part and thus forms gentle hilly land. Distinct linear structures showing bedding planes occur and form folding with an EW strike and a wide range of dip angles.

The unit is assumed to be composed mainly of clastics of shale and sandstones, and partly of limestone. It seems highly probable that it relates clino-unconformably to Subunit B_1 and conformably to Subunit B_2.

Its thickness is probably about 2,500 m at the most.

In the northwestern and southwestern parts of the area it correlates with flysch sediments (ef) of the Eocene Epoch. On the other hand, in the southern margin of the central part of the area it correlates with terrestrial deposits (n) of Neogene Tertiary. Under photogeological observation, both show the same characteristics and thus are thought to be flysch sediments (ef).

4) Unit D

The unit is subdivided into Subunits D_1 and D_2.

(1) Subunit D_1

The subunit is distributed with an E – W trend in the southeastern part of the area.

It shows very light tone and its texture is comparatively smooth.

The drainage pattern is subdendritic. Rock resistivity is mostly high. The subunit forms the axial part of a gently folded anticline structure with the axis extending east to west.

It is assumed to be composed mostly of limestone, with clastics of shale and sandstone intercalated. The interrelation with the lower part of Subunit B_1 is clino-unconformity.

The thickness is about 250 m.

The subunit is included in the ophiolite series (Mof) according to existing data.

(2) Subunit D_2

In the eastern part of the area, the subunit is distributed at both wings of the anticline structure which has Subunit D_1 as its axis.

It shows gray to very light tone and its texture is medium-grained and often hazy. Rock resistivity is generally low. Linear structures suggesting bedding planes are evident and the subunit partly forms Cuesta topography. Strike and dip are the same as for Subunit D_1.

The subunit is assumed to be gypsum-bearing limestone with clastic rocks and it is conformable with Subunit D_1.

Its maximum thickness is about 2,000 m.

The subunit correlates with limestone of the Lower Miocene series (ma) according to existing data.

5) Unit E

It has wide distribution in the western part of the area and limited distrubution in the southern margin of the central part of the area.

It shows light gray to gray tone and its texture is medium-grained and hazy. Spotted rectangular patterns which can be seen locally are cultivated farm land.

The drainage pattern is subparallel to subdendritic with low density. Rock resistivity varies widely from high to low but the topography has low relief.

Linear structure, which shows a NE trend, is observed in the western part of the lower reaches of the Karasu River. The existence of a syncline structure of very gentle folding can be expected.

The unit may be limestone with clastics of a younger geological age. It probably has a relationship of unconformity with Subunit D_2.

The unit correlates with a terrestrial Neogene Tertiary formation according to existing data and in part correlates with Jurassic to Cretaceous sediments (jkr). However, according to photogeological interpretation it seems to correspond with Neogene Tertiary System.

6) Unit F

The unit is subdivided into F_1 and F_2.

(1) Subunit F_1

The subunit is distributed mainly in the western part in areas such as the Karadiyan River valley, the Aravans River valley, and the Karasu River valley, or along small streams and mountain slopes.

It shows gray to light-gray tone and its texture is hazy.

The drainage pattern is parallel. River terraces are developed along the above-mentioned valleys, and in mountainous areas if often shows landslide topography. Rock resistivity is very low. The subunit is the main area for agriculture and is composed of clay, sand, and gravels.

The maximum thickness is about 30 m.

The subunit correlates with Pleistocene sediments (Qe) and Holocene sediments (Qy).

(2) Subunit F_2

The subunit is distributed along the Karasu River valley, the

Aravans River valley, and the Karadiyan River valley. It has the same characteristics as Subunit F_1. Its distribution is limited to the major river valleys.

It is fluvial deposits.

7) Unit Ia_1

The unit forms mountain ridges on both sides of the Karasu River. The unit is widely distributed on Mt. Güllü (2,603 m), Mt. Delavlar (2,516 m) and other mountains in the range north of the Karasu River. To the south of the Karasu River, it is distributed along the lower course of the Karasu River and in the southeastern part of the area.

It shows very dark to dark gray tone. Its texture is generally smooth but partly rugged.

The drainage pattern is subdendritic. Rock resistivity is high. The unit is massive and shows gently sloping mountain ridges. There are lineaments in a NE direction, some of which are thought to be faults, and others joints ; and there are some lineaments suggesting the difference of rocks.

The unit is thought to be ultrabasic rocks. It can be observed intruding into Unit B in the lower reaches of the Karasu River but cannot be observed intruding into Unit C. The unit is often replaced by Unit Ia_2 (described below) which has similar photogeological characteristics. This may indicate that the area encountered serpentinitization.

The unit correlates with serpentinite (σ) and ophiolite (Mof).

8) Unit Ia_2

The unit is distributed in the region occupied by Unit Ia_1 in the central part of the area. Wide distribution can be observed in the western part of the Sıçankale village, but it otherwise shows scattered distribution.

It shows very light tone and its texture is fine-grained and smooth. The drainage pattern is subdendritic with high density. Rock resistivity is low. It has low undulating topography.

The unit is assumed to be serpentinite.

The unit correlates with serpentinite (σ) according to existing data.

3.4 MINERAL DEPOSITS AND MINERALIZED ZONES

3.4.1 Tunceli Area

After photogeological analysis, 15 alteration zones were discerned from aerial photographs as listed in Table 3 ; they were categorized as Unit H.

This unit can be observed in Unit E, especially in Subunits E_{1-1} and E_3 in the central to northwestern parts of the area.

It shows very light tone and its texture is medium-grained with local linear features.

The drainage pattern is dendritic with high density. Rock resistivity is low to very low and can be distinguished from the surrounding rocks easily. The unit shows a distinct distribution pattern of elliptical shapes with the longer axes in a WNW - ESE direction. The largest of these can be observed near the Sin Mah. village ; it has a longer axis of 10 km and a shorter one of about 1.8 km. The smallest has a scale of about 0.8 km by 0.2 km.

Vegetation density is medium. The unit is assumed to be an alteration zone bearing white clay minerals, and it is possibly silicified. The alteration can be categorized into three grades : strong, medium, and weak. Strong alteration is observed around the Sin Mah. village and in the southeastern part of the Mamlis ore deposit. The distribution of the unit is limited to inside Unit E and an especially wide and strong alteration zone can be observed in the pyroclastic rocks or lava.

Table 3. List of Alteration Zones in Tunceli Area

No.	LOCATION	SCALE OF THE ZONE	GRADE OF ALTERATION	PHOTOGEOLOGICAL UNITS	REMARKS
T 1	4.6 km (S21°E) from Ovacık	1.2 km (N80°E) x 0.5 km	w	subunit E_3 (intermediate ~ basic pyroclastic rocks with lava)	
T 2	5.7 km (S10°E) from Ovacık	1.5 km (N32°W) x 1.1 km	m	ditto	
T 3	8.6 km (S 6°E) from Ovacık	0.9 km (N68°E) x 0.8 km	w ~ m	ditto	
T 4	8.1 km (S22°E) from Ovacık	0.7 km (N60°E) x 0.4 km	w	ditto	
T 5	8.8 km (S25°E) from Ovacık	1.9 km (N64°E) x 0.8 km	w ~ m	ditto	
T 6	9.6 km (S36°E) from Ovacık	2.6 km (N58°E) x 2.2 km	m ~ w	ditto	
T 7	10.1 km (S48°E) from Ovacık	1.2 km (N60°W) x 0.6 km	m	subunit E_{2-1} (calcareous rocks with shale and sandstone)	
T 8	1.9 km (N65°W) from Mamlis mine	3.3 km (N46°W) x 1.1 km	w	subunit E_{1-1} (intermediate ~ basic pyroclastic rocks)	
T 9	3.2 km (S39°E) from Mamlis mine	1.3 km (N58°E) x 1.0 km	s	ditto	
T 10	4.1 km (S74°E) from Mamlis mine	2.4 km (N80°W) x 1.2 km	w	ditto	
T 11	5.1 km (N62°W) from Sin Mah.	1.0 km (N82°W) x 0.5 km	m	ditto	
T 12	4.2 km (N47°W) from Sin Mah.	0.8 km (N84°W) x 0.2 km	w	ditto	
T 13	2.9 km (N42°W) from Sin Mah.	1.3 km (N57°W) x 0.6 km	w	ditto	
T 14	2.8 km (N70°W) from Sin Mah.	10.1 km (N78°W) x 1.9 km	s ~ w	ditto	corresponding with geochemical anomalous area. Sin mineral deposit is located in this zone.
T 15	0.6 km (S63°E) from Siliç	2.1 km (N63°W) x 1.0 km	m	ditto	corresponding with geochemical anomalous area.

Note ; grade of alteration s : strong
m : medium
w : weak

The southern end of the alteration zone is cut by faults with an EW direction or NW to SE direction ; therefore alteration is not observed south of the faults.

The alteration zone is not formed by weathering or diagenesis because the concentration is limited to specific rock types and a particular distribution pattern.

Among the alteration zones, T14 and T15 (as shown in PL. 3) correspond with the anomalously high concentration areas of Cu, Zn, and Mo clarified by the geochemical survey.

The already known Sin mineral deposit is located in the alteration zone T14. The Mamlis ore deposit does not directly correspond with the zone but is located in the margin of an altered area. Other ore deposits do not show good parallelism.

3.4.2 Kopdağ Area

After photogeological analysis, a total of 46 old trenches were found in 21 sites as listed in Table 4 and shown in PL. 4. The concentration zones are as follows.

(1) This zone connects Hacıbektaşkomu village and Sıçankale village.

Trench numbers : K1, K2, K5, K6 ; trend : NE - SW ; extention : 15 km ; mother rock : mainly Unit Ia_2 (serpentinite).

(2) This zone connects Erbaş station and Cancıkkomu village. Trench numbers : K3, K4 ; trend : NE - SW ; extention : 7.5 km ; mother rock : Unit Ia_1 (ultrabasic rocks).

(3) This zone occurs in the southern and eastern parts of Gülabikomu village. Trench numbers : K10 to K21 ; extention : 3.7 km ; trend : NE - SW ; mother rock : Unit Ia_1 (ultrabasic rocks).

As is mentioned above, the trench clusters show a NE - SW trend and most of the trenches themselves also show a NE - SW trend. The concentration of trenches can be observed around the outer margins of units Ia_1 and Ia_2, and it corresponds with the chromium mineralized zone according to existing data.

Table 4. List of Trenches in Kopdağ Area

No.	LOCATION	NUMBER OF TRENCHES	DIRECTION OF TRENCHES	PHOTOGEOLOGICAL UNITS	REMARKS
K 1	0.5 km (N50°W) from Hacıbektaşkomu	3	N15°E N25°W	unit Ia_1 (serpentinized ultrabasic rocks)	The symbol of the mine is described on the topographical map (1 : 25,000)
K 2	1.1 km (N45°E) from Hacıbektaşkomu	1	N 5°W	ditto	
K 3	0.7 km (S45°E) from Erbaş istasyon	3	N65°E	unit Ia_1 (ultrabasic rocks)	
K 4	0.5 km (S10°E) from Cancikkomu	1	spotted	ditto	The symbol of the mine is described on the topographical map (1 : 25,000)
K 5	4.8 km (S82°W) from Sıçankale	1	ditto	unit Ia_2 (serpentinite)	The symbol of the mine is described on the geological map (1 : 25,000)
K 6	4.9 km (S83°W) from Sıçankale	2	N54°E	ditto	
K 7	4.7 km (S86°W) from Sıçankale	4	ditto	ditto	
K 8	4.3 km (S89°W) from Sıçankale	1	N79°E	ditto	
K 9	3.4 km (S86°W) from Gülabikomu	2	E	unit Ia_1 (ultrabasic rocks)	
K 10	1.3 km (S46°W) from Gülabikomu	8	N80°E (?)	ditto	
K 11	1.3 km (S22°W) from Gülabikomu	4	N74°E (?)	ditto	
K 12	0.7 km (S36°W) from Gülabikomu	1	ditto	ditto	
K 13	0.4 km (S10°W) from Gülabikomu	1	ditto	ditto	
K 14	0.6 km (S10°E) from Gülabikomu	3	E	ditto	
K 15	1.0 km (S89°E) from Gülabikomu	3	E (?)	ditto	
K 16	1.5 km (N85°E) from Gülabikomu	1	N65°E (?)	ditto	
K 17	2.0 km (N75°E) from Gülabikomu	2	ditto	ditto	
K 18	2.3 km (N48°W) from Gülabikomu	1	spotted (?)	ditto	
K 19	3.5 km (N19°W) from Gülabikomu	1	ditto	ditto	
K 20	3.9 km (N32°E) from Gülabikomu	1	N62°E (?)	ditto	
K 21	4.5 km (N29°E) from Gülabikomu	2	N25°E (?)	ditto	
	Total	46			

3.5 SELECTION OF PROMISING AREAS

3.5.1 Tunceli Area

The alteration zone depicted by photogeological analysis showed good parallelism with the anomalous area of the geochemical survey. The Sin mineral deposit is included in one of the zones. The alteration zones extend in a NW - SE direction, and these alteration zones are judged to be promising for mineral occurrences.

3.5.2 Kopdağ Area

In this area, trenches were found in Unit Ia_1 (ultrabasic rocks) and in Unit Ia_2 (serpentinite). These were found to correlate with known chrome deposits ; therefore it is important to check them in more detail in the future. In particular, the zone connecting Hacıbektaşkomu village and Sıçankale village is a concentration zone of trenches and a distribution area of known mineral deposits. The zone can be said to be an important area for the chrome deposits exploration.

CHAPTER 4. FUTURE PROSPECTS

After the completion of photogeological analysis, a meeting of members of MTA, JICA, MMAJ, and the survey group of Phase I was held in March 1978 to discuss future prospects.

In the meeting not only the photogeological data, but also the existing geological and mineralogical data, and the results of the geochemical survey were examined.

This chapter outlines the results of the discussions.

1) Tunceli Area

(1) Because only small-scale geological maps are available for this area, geological mapping on a scale of 1 : 25,000 should be carried out as follow-up to the photogeological analysis.

(2) In order to clarify the potentiality of mineral deposits in the area, the regional geochemical survey commenced in 1977 by MTA should be continued.

(3) The geochemically anomalous areas already known roughly correspond to the alteration zones determined by photogeological analysis, and there are also some known mineral showings within this anomalous area. A geological survey on a scale of 1 : 10,000 and a detailed geochemical survey should be carried out.

(4) When promising areas are found after these surveys, a detailed geological survey on a scale of 1 : 2,000 should be carried out and this should form the basis for determining the next step in exploration. To begin with, it is suggested that an area of 10 km^2 should be surveyed.

(5) Areas to be covered by the geological survey are as follows.

Scale of 1 : 25,000 — Medium-scale survey - 640 km^2

Scale of 1 : 10,000 — Semi-detailed survey - 105 km^2

Scale of 1 : 2,000 Detailed survey - 10 km^2

(6) A reconnaissance geochemical survey should be carried out over an area of 220 km^2. Silt samples from stream sediments should be taken with a density of 1 sample/km^2 or 2 samples/km^2.

A semi-detailed geochemical survey should be carried out in the areas covered by the semi-detailed and detailed geological surveys (115 km^2). When geochemical anomalies are found outside the above-mentioned areas they should be included in further detailed surveys. The first-stage survey should be the Ridge-and-Spur Method, and soil samples should be obtained basically from Formation B. If samples cannot be obtained from Formation B, they should be taken from Formation C. Sampling density should be 10 to 15 samples/km^2. If promising areas are revealed by the semi-detailed geochemical survey, a more detailed survey using the Grid Method should be proceeded to. The indicator elements should be Cu, Pb, Zn, and Mo in both the reconnaissance and semi-detailed surveys.

2) Kopdağ Area

(1) A geological map on a scale of 1 : 25,000 has been completed for the western half of the area. The area is promising for chrome deposits, and thus a geological survey on a scale of 1 : 10,000 should be carried to clarify the state of ore occurrences. However, the eastern half of the area has not yet been covered by a large-scale geological map, so that a geological survey on a scale of 1 : 25,000 should be completed, beginning with the occurrence zones of chrome deposits.

(2) When some promising areas for chrome deposits are found after the above-mentioned geological survey, a detailed survey on a scale of 1 : 2,000 should be made and the possibility for drilling exploration, etc., should be examined. The suggested area should extend over 10 km^2.

(3) Geological mapping of mineral deposits in the tunnels of existing mines is necessary to clarify geological control in the occurrence of mineral deposits.

(4) At the extentions of outcrop of mineral deposits, trench surveys are necessary to clarify the scale and state of the ore bodies.

(5) The areas to be surveyed are as follows.

Scale of 1 : 25,000	Medium-scale geological survey - 300 km^2
Scale of 1 : 10,000	Semi-detailed geological survey - 100 km^2
Scale of 1 : 2,000	Detailed geological survey - 10 km^2
Scale of 1 : 500	Geological mapping in tunnels - 1,000 m
	Trench survey - 100 m^3.

3) Based on the results of their field trips in 1977, the Phase I survey group consider the deposits to be disseminated- or vein-type ore deposits rather than porphyry copper-type ore deposit. The scale and grade of alteration seems inferior, and mineral concentration at outcrops also seems poor. We realize it is too early to evaluate these ore deposits based upon the results of a short field trip; however, if the results of the survey in fiscal year 1978 reveal that there are no promising mineral deposits in the area, we suggest that the survey area be widened to include other regions.

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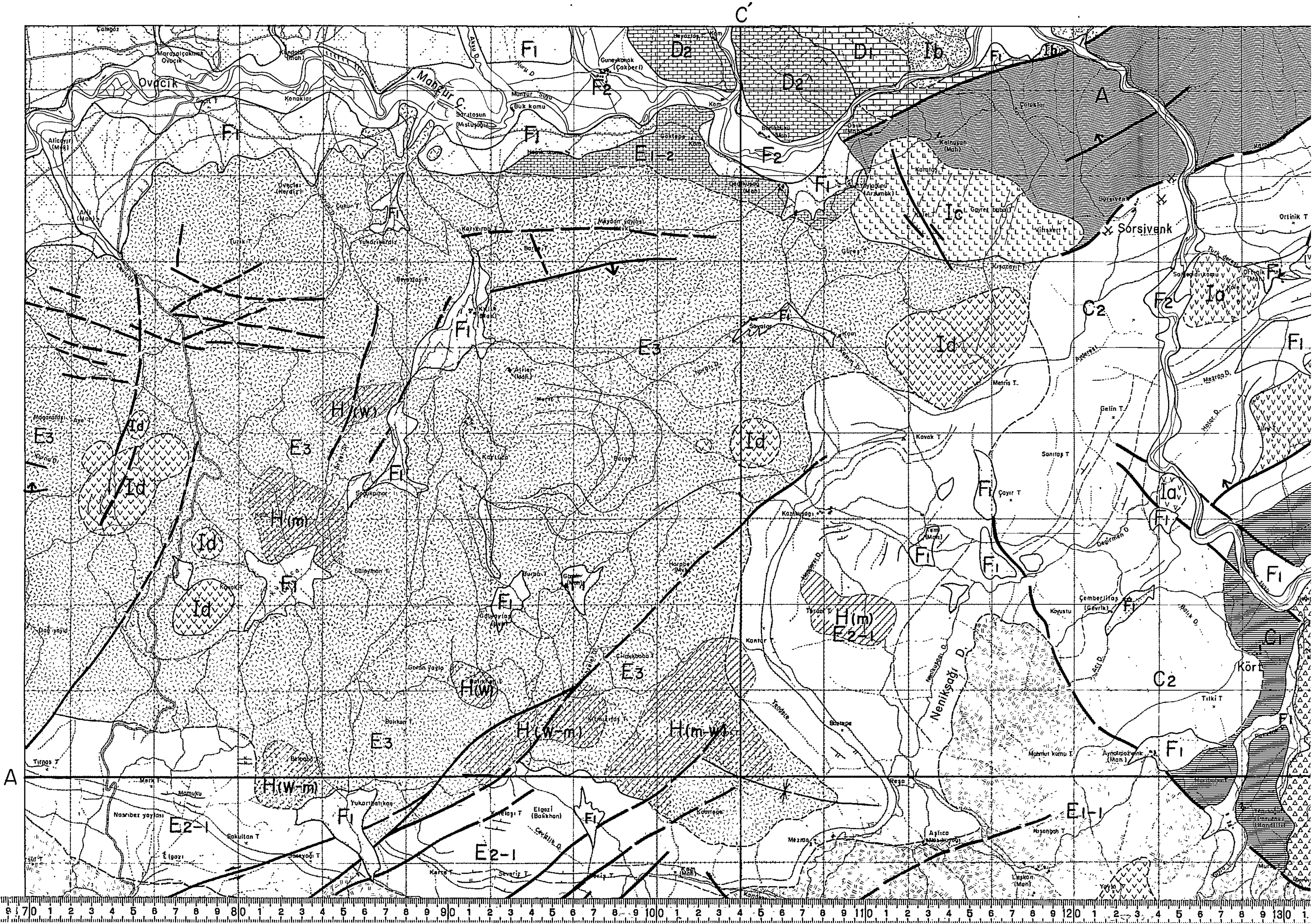
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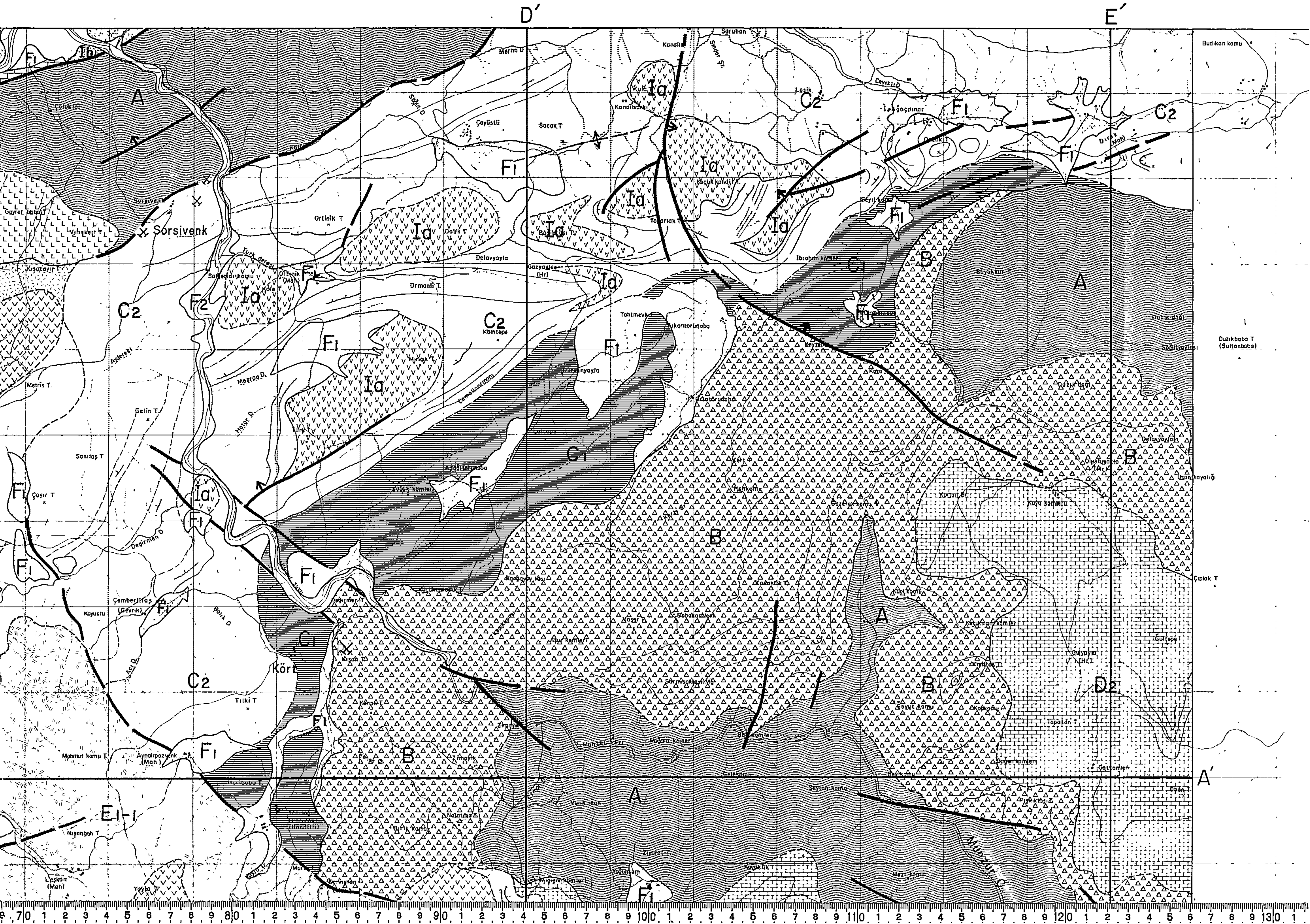

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