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THE REPUBLIC OF TURKEY

REPORT ON THE COOPERATIVE MINERAL EXPLORATION OF GÜMÜŞHANE AREA

CONSOLIDATED REPORT

DECEMBER 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

The Government of Japan, in response to the request extended by the Government of the Republic of Turkey, agreed to conduct a metallic mineral exploration survey in the Gümüşhane Area, and commissioned its implementation to the Japan International Cooperation Agency.

The agency, taking into consideration the importance of the technical nature of the survey work, sought the cooperation of the Metal Mining Agency of Japan to accomplish the task.

The Government of the Republic of Turkey appointed the Mineral Research and Exploration Institute (M.T.A.) to execute the survey as a counterpart to the Japanese team. The survey has been carried out jointly by experts of both Governments.

The collaboration survey for metallic mineral, which lasted three years, consists of geological, geochemical, and geophysical surveys, supported by drilling and laboratory work. This consolidated report hereby submitted summarizes results of the said survey.

We wish to take this opportunity to express our gratitude to all sides concerned in the execution of the survey.

December, 1986

Keisuke Arita

Keisuke ARITA
President,
Japan International Cooperation Agency

Junichiro Sato

Junichiro SATO
President,
Metal Mining Agency of Japan

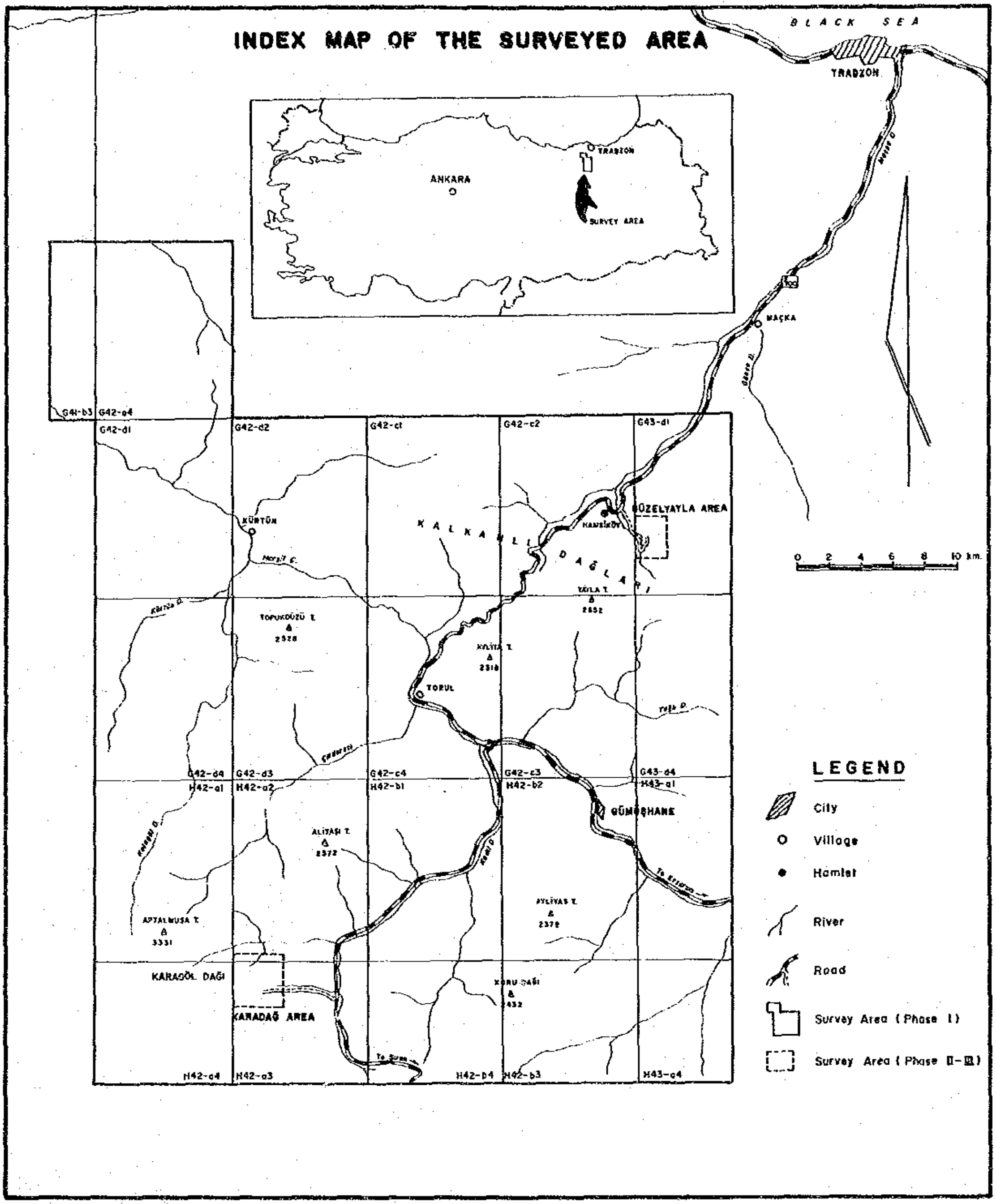


Fig. 1 Index Map of the Surveyed Area

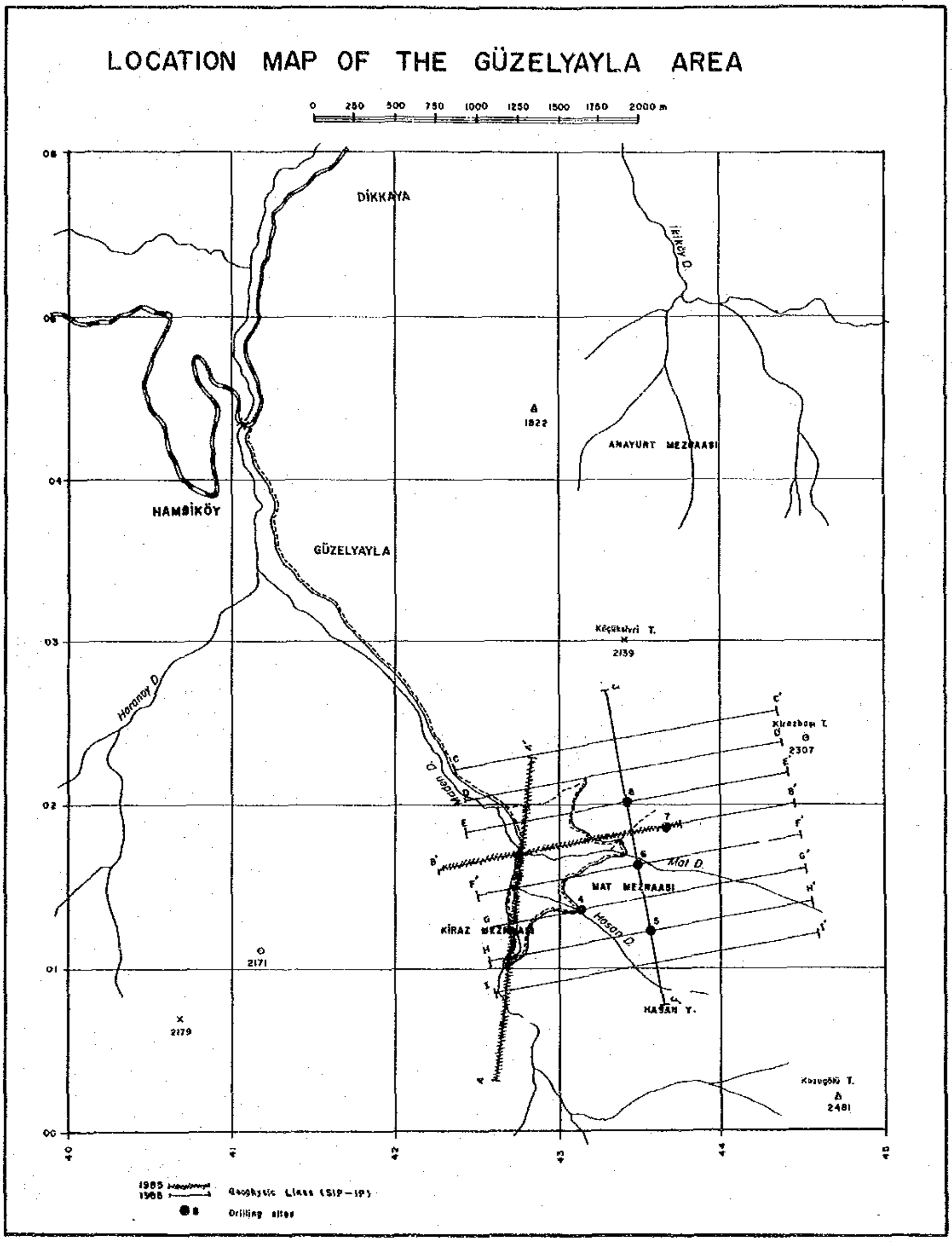


Fig. 2 Location Map of the Güzelyayla Surveyed Area

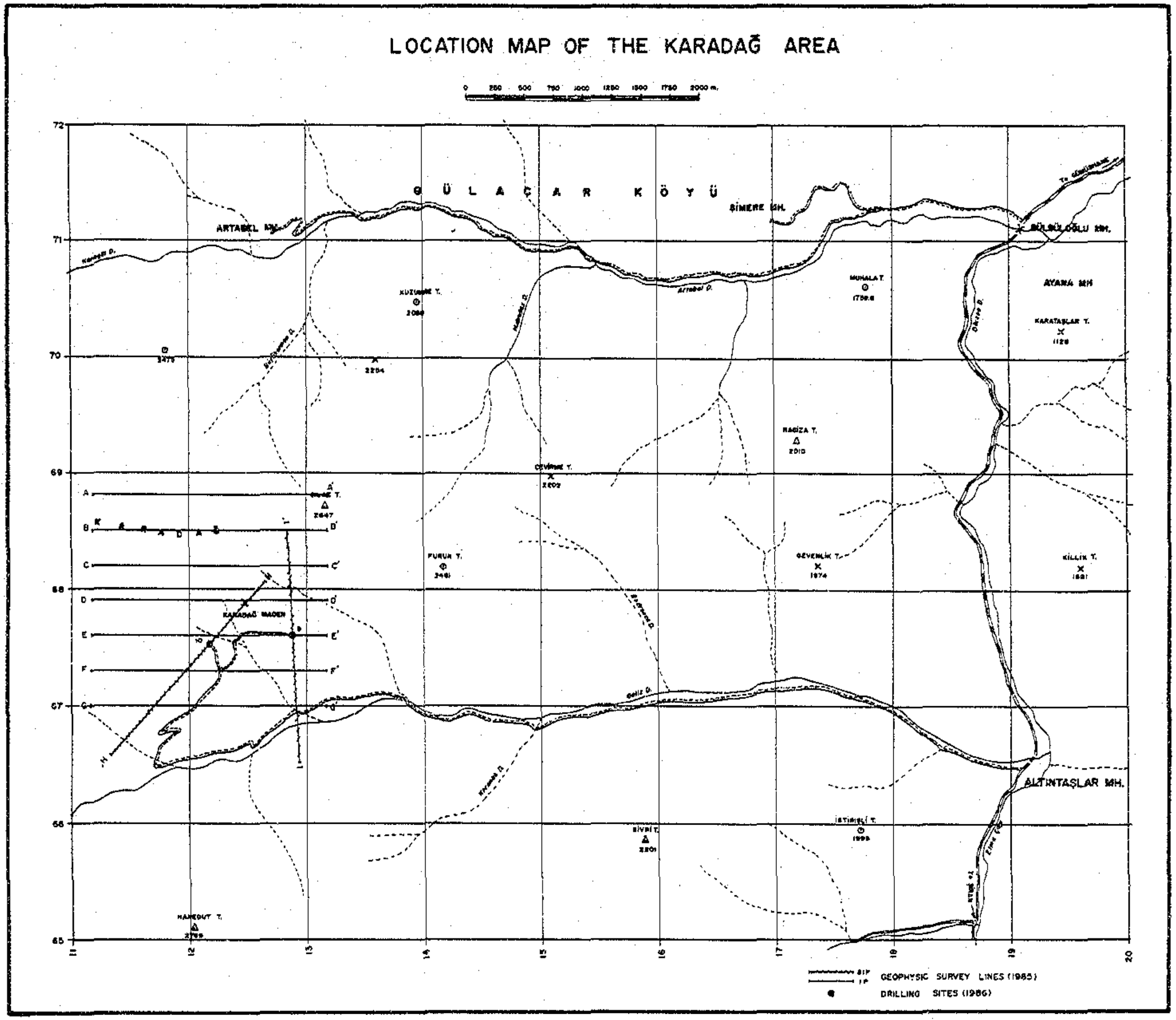


Fig. 3 Location Map of the Karadağ Surveyed Area

SUMMARY

The government of the Republic of Turkey requested the Japanese government to conduct the Cooperative Mineral Exploration Survey in the Gümüşhane Area. In response to this request, the Japanese government conducted the geological, geochemical, geophysical and drilling surveys from 1984 to 1986. The consolidated report is summarized as follows;

1. Geology

The geological basement of this area is composed of the Kurtoğlu Metamorphic Complex consisting of gneiss and biotite-muscovite schist considered to be of Carboniferous-Permian age and of the Gümüşhane Granite which intruded into this complex. These rocks are unconformabley overlain by Jurassic-Eocene basic-acidic volcanic and pyroclastic rocks. Limestone, mudstone, sandstone and others are intercalated, representing the dormant stage of volcanism. These sedimentary units are classified by fossils into, in the stratigraphically ascending order, the Lower Jurassic Kırıklı Formation, Upper Jurassic Kuşakkaya Limestone Formation, Upper Cretaceous Zigana Formation and Eocene Venk Yayla Formation. The Gavur Dağı Volcanics, which is considered to be upper-Eocene, overlies the above formations.

The intrusive rocks are old granite-the Gümüşhane Granite which intruded during the Paleozoic-and young granodiorite, quartz porphyry and dolerite which intruded during the Late Cretaceous to Eocene.

Structually, the area can be divided into northern and southern parts with the E-W trending Gümüşhane Thrust as the boundary. Gümüşhane Granite and Lower Jurassic basalt are developed in the south while Upper Cretaceous andesite is widely distributed in the northern part. Young intrusive bodies are more abundant in the northern part.

2. Mineralization

The mineralization of this area is largely grouped into skarn, vein (fissure-filling) and dissemination (porphyry copper) types. Skarn type mineralization occur at the contact of andesite and limestone of the Zigana Formation with iron minerals sometimes accompanied by chalcopyrite, sphalerite and galena. This type is more abundant in the northern part. Vein type deposits are of small scale

but have high grade, and they occur in the Kırıklı, Zigana and Venk Yayla Formations. Disseminated mineralization is associated with young intrusives, developed in and near granodiorite bodies and forms low grade molybdenum-copper, copper-zinc, pyrite-molybdenum mineralized zones.

3. Geological structure

It is considered that the relationships between geological structure and the mineralized zone in the surveyed area are as follows: the major intrusive bodies were intruded in an ENE-WSW to NE-SW direction while much of the vein type mineralization occurred along ENE-WSW to E-W trending fissures. E-W trending folds and faults are prevalent in the geological structure of Turkey and the area under consideration probably has a large number of E-W trending fissures.

4. Geochemical prospecting

The results of the geochemical work of the following samples were taken into consideration in dealing with the problem of geochemical anomalies and mineralization. Approximately 2,000 stream sediment samples of Zone B were collected by the UNDP project of 1970-1974, 910 stream sediment samples were collected by the cooperative project in 1984, and 1,331 soil samples were collected from Güzelyayla by MTA in 1984 and 1985. Analysing and interpreting the combined results of both the geochemical and geological works, we have delineated 50 geochemically anomalous zones. From these zones, we have selected two geochemically anomalous zones which warrant further invesigation. They are the Güzelyayla (Mo, Cu) and Karadağ (Ag, Cu, Pb, Zn) areas.

4. Güzelyayla area

(1) The initial survey indicated that geochemical anomalies of Ag, Cu, Mo, Pb, Zn, Sn and W were found, and an emplacement of a porphyry copper-type mineralized zone was expected through geological survey. In the second phase, the distribution of a porphyry copper type mineralization caused by intrusion of altered porphyritic granite (Pg1) was delineated by geological and geochemical surveys. A drilling survey was conducted in the area of the intrusive rock and andesite of the Zigana Formation which was accompanied by mineralization, and a promising mineralized area of copper and molybdenum was obtained.

(2) Results of the geophysical survey (IP and SIP methods) revealed that

there is strong mineralization accompanied by pyrite in the periphery of the altered porphyritic granite, and also that the mineralized area and unmineralized area are divided by a fault. Although rock properties of drill cores show specific types of phase spectrum, they do not correspond with specific metal contents of Cu and Mo, but may be related with pyrite mineralization.

(3) As a result of the drilling surveys, the promising mineralized zones were intersected by drill holes, and geological ore reserves were calculated as approximately 49 million tonnes using the assay data of MJT-3, 6 and 8 (ore grade of 0.356% copper equivalent), and as roughly 104 million tonnes including the predominantly molybdenum mineralized zones of MJT-7 and the lower part of MJT-8 (ore grade of 0.300% copper equivalent).

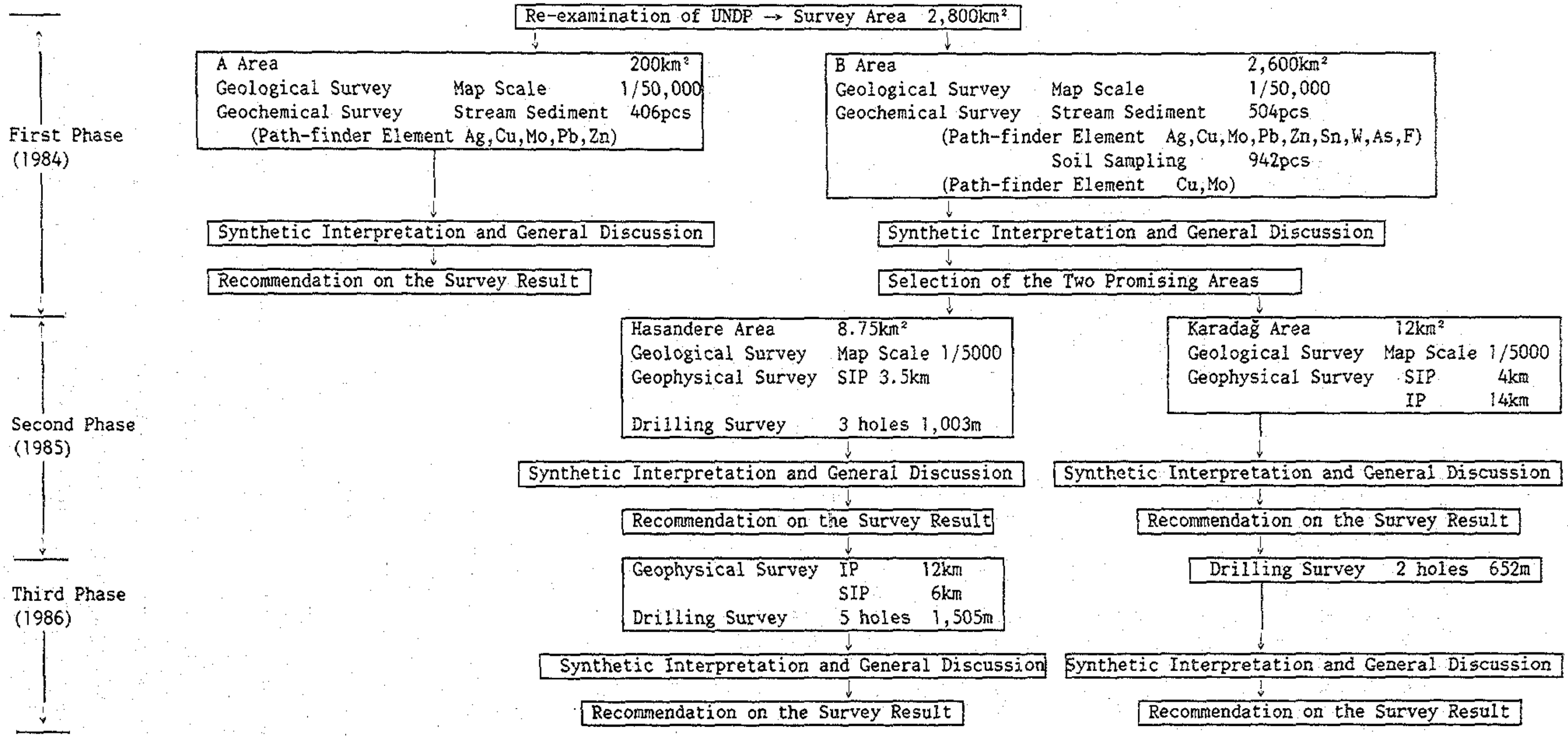
5. Karadağ Area

(1) The old Karadağ ore deposit located up the Maden Dere is embedded in the skarn zone of limestone, and is accompanied by copper,lead and zinc ores. The old mine had produced ore in the vicinity of the skarn type anomalous area. A geochemical anomaly of Ag, Cu, Mo, Pb, Zn, and W was found, and according to the initial survey, dissemination-type mineralization was also expected to be embedded in the survey area.

(2) In the second phase, geophysical surveys (IP and SIP methods) were conducted, and the geophysical survey obtained three promising anomalies. Two extensive anomalies out of these three are expected to be dissemination-type mineralization embedded in the granodiorite stock and the andesite of the Zigana Formation 200m to 300m below the surface. The third is inferred to be skarn type mineralization owing to the existence of limestone at depth. However, the geophysical survey could not directly clarify the emplacement of old Karadağ ore deposits because they may be embedded in the shallow part, oxidized completely, or small in scale.

(3) Two holes were drilled in the anomalous areas where dissemination-type mineralization and skarn type mineralization were expected. It is considered from the results of the drilling survey that the geophysical anomaly of MJT-9 indicated pyritization in the andesite and granodiorite and that the anomaly of MJT-10 indicated weak mineralization (malachite and pyrite) of the skarn zone. We could not directly intersect the promising mineralized zone.

Table 1 Flow Chart of Survey in Gümüşhane Area



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Chapter 1 Outline of the Survey

1-1 Introduction

Cooperative Mineral Exploration Projects in the Republic of Turkey were conducted in the Trabzon Area (1974~1976) and in the Tuncelli and Kopdağ Areas (1977~ 1980). These projects described the occurrence of fundamental materials upon the exploration of metallic mineral resources. Moreover, these surveys have contributed to the improvement of the survey technicians of the Mineral Research and Exploration Institute, participating in the projects.

The Ministry of Energy and Natural Resources of the Republic of Turkey delivered to the Japanese Government a proposal for a new cooperative survey on metallic mineral resoures and requested that the Japanese Government execute the survey. The Japanese Government responded to the request by dispatching a preliminary survey mission. The survey mission conducted preliminary investigations on the proposal of the survey areas and consulted with the Mineral Research and Exploration Institute, which is in charge of the project as the Turkish counterpart.

It was agreed by both Governments that the Gümüşhane area would be surveyed. The survey was conducted with the objective of understanding the nature of metal concentration in the Gümüşhane area of the Republic of Turkey by clarifying the detailed geolgy.

1-2 Duration and Organization of the Survey

Survey schedule, term and members are shown in Table 2.

1-3 Survey Methods and Amount of Work

Survey Methods and Amount of Work are shown in Table 1. The Gümüşhane project covers an area of 2,800km^2, which is bounded by the following longitude and latitude (Fig.4).

Table 2 Survey Schedule, Term and Members

SURVEY	SURVEY PERIOD	SURVEY MEMBERS JAPAN	SURVEY MEMBERS Turkey
Phase I (1984) Survey Programing & Negotiation	March 17～26,1985 June 8～17,1985	Kohei ARAKAWA Katsuhiro ASAI Tadaaki EZAWA Yoshiyuki KITA	Orhan ÖZKOÇAK Mehmet C.YILDIZ Ömer T. AKINCI Temel Y. NEBİOĞLU
Geological Survey & Geochemical Survey	March 22～June 12, 1985	Hisashi MIZUMOTO Susumu TAKEDA Hiroshi KANBARA Kazuyasu SUGAWARA	Dr.Yusuf Z.ÖZKAN İsmail H.GÜVEN Murat ER Kemal ÖZDOĞAN Hüseyin YILMAZ Ali I. ERÇİN
Phase II (1985) Survey Programing & Negotiation	Aug.31～Sep.8,1985 Nov.3～Nov.15,1985	Takeshi IZUMI Ichizo MORIKAWA Yoshiyuki KITA Hideki OKAMOTO	Orhan ÖZKOÇAK Ramiz ÖZOCAK Ömer T. AKINCI Temel Y. NEBİOĞLU
Geological Survey	Sep.4～Oct.7,1985	Hisashi MIZUMOTO Hiroshi KANBARA	Dr.Yusuf Z.ÖZKAN İsmail H.GÜVEN Murat ER Kemal ÖZDOĞAN Hüseyin YILMAZ Ali I. ERÇİN
Geophsical Survey(IP,SIP)	Sep.4～Nov.4,1985	Masao YOSHIZAWA Takashi YAMAISHI Shinichi SUGIYAMA	Mustafa DEMİRHAN Asim ÖZMEN Kadircan AKTAŞ Faik SARAÇ Ethem OFLU
Drilling Survey (Güzelyayla Area)	Sep.12～Oct.30,1985	Saichi ISHII Tadateru SUGIBUCHI Mitsuo NOMURA	Cemal ÖZSOY Levent MEHMET
Phase III (1986) Survey Programing & Negotiation	May 12～May 20,1986 Oct. 5～Oct. 6,1986	Makoto ISHIDA Kenichi ORITA Takashi KAMIKI Yoshiyuki KITA Hideki OKAMOTO	Orhan ÖZKOÇAK Ramiz ÖZOCAK Ömer T. AKINCI Temel Y. NEBİOĞLU
Geophysical Survey(IP,SIP)	May 14～July 7,1986	Masao YOSHIZAWA Shinichi SUGIYAMA Kazuyasu SUGAWARA	Mustafa DEMİRHAN Hasan UĞURLU Ethem OFLU Cemil ÖZTÜRK
Drilling Survey	June 17～Oct.6,1986	Hisashi MIZUMOTO	Dr.Yusuf Z.ÖZKAN Murat ER Kemal ÖZDOGAN
Güzelyayla Area	June 17～Oct.27,1986	Saichi ISHII Yoshio SASAKI Mitsuo NOMURA	Cemal ÖZSOY Ali KARTAL
Karadağ Area	June 30～Aug.22,1986	Takashi KAKISHITA Tadateru SUGIBUCHI Junichi KATO	Yemlihan YUREKLİ İlker ÖZKAN

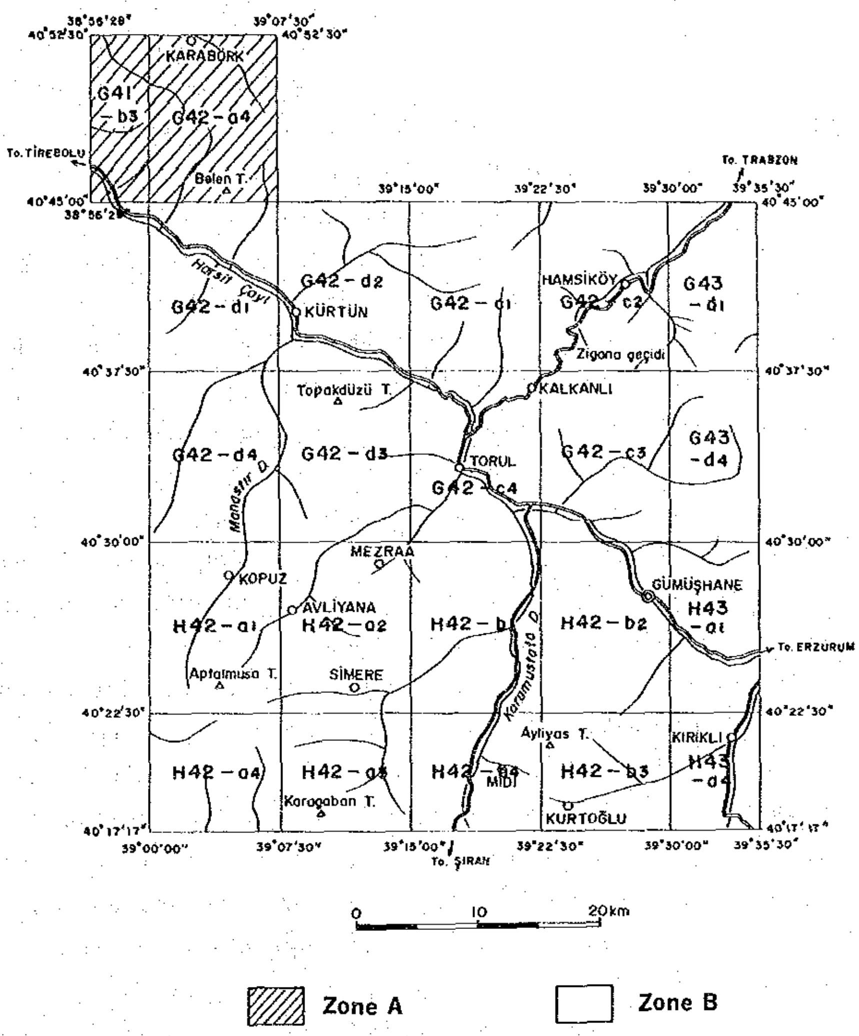


Fig 4 Location Map of the surveyed Area

Chapter 2 Outline of the Survey Area

2-1 Geography

Topography: The survey area is located approximately 550 km east of Ankara and 60km south of Trabzon on the Black Sea. The highest peak in the survey area is the Aptalmtusa Tepe (3,331m), and Karbörk Village (300m) in Zone A is the lowest. Small streams which cut the high plateaus caused the steep and broken grounds. Torul (940m), in the centre of the survey area, is not so steep. It is altititude ranges from 1,000 to 1500m.

Climate: Zigana Pass (2,000m), which is located along Route 65 between Trabzon and Gümüşhane, forms the dividing ridge extending in an E ~ W direction. The coastal climate of the northern dividing ridge is humid and there are many rainy days in all seasons. The average precipitation is 700~ 1,000m/year.

The intercontinental climate of the southern dividing ridge has low humidity. During the summer season (July-August) the temperature reaches 30℃, the temperature of the winter season (December-Feburuary) often goes down below zero degrees. There is almost no snow near Trabzon, but there is permanent snow during six months, from November to May, in the high plateaus.

Vegetation: Vegetation in the northern area of the dividing range is extremely developed, but the general area in the southern area consists of vegetation of small trees and grass. The high mountains are more than 2,000m, and they are above the upper limits of forests and are used as summer camping areas for villagers and also as meadows. These places are called "Yayla".

Access: The Turkish Airline has daily services between Ankara and Trabzon by a DC-9 jet airliner. The transportation to other cities can be done on highways. The main road in the survey area is Route 65 connecting Trabzon, Troul and Gümüşhane, and is 70% paved. There are several unpaved roads which branch from the main road, and they are mostly accessible except during snowy and rainy seasons. Then, four-wheel drive vehicles can be used. It takes about two and a half hours by car from Trabzon to Torul. Most of the roads in the survey area are in poor condition and vehicles can only be driven at less than 30km/h.

Population: Gümüşhane is the largest city in the survey area and facilities such as banks, police, hospitals, hotels are available. The population is about 12,000. Torul, at which the base camp for field work was set up, is the second largest city of the Gümüşhane Province, and its population is more than 3,000. In addition, small villages are scattered in the area.

Industry and Agriculture: People live mainly on agriculture. Nuts and tea are the main products of Zone A near the Black Sea Coast. Animal products, milk, butter, etc. provide the main income for the people living in the highland. The people also earn an income from forest products. Lumber is transported mainly to Trabzon, and a sawmill is worked during the summer season at Karadağ Village. A cement factory, juice factory and flour mill are operated on a small scale in Gümüshane. Midi mine, which is located 15km SW of Gümüşhane, is operated during the summer season. This mine producted 400 tonnes of lumpy zinc ore last year.

2-2 Previous Works

There are few studies on the geology and mineral deposits of the project area. In 1962, the geological map of the Trabzon area 1;500,000 in scale was compiled and published by M.T.A., based on the geological map of 1;100,000 and 25,000 compiled in 1959. Recently, M.T.A. conducted the geological survey in the southwestern portion of the project area.

Gümüşhane Granite widely distributed in the project area, was petrographycally studied by YILMAZ (1974). With respect to mineral occurrences in the project area, there is a report on two mines, Hazine Mağara and Kırkpavli in Eski Gümüşhane. Kovenvo(1937) reported that Hazine Mağara is a Ag replacement deposit in calcareous sediments overlaying Gümüshane Granite, and that Kırkpavli is of Ag-Au vein-type. M.T.A. has conducted a follow-up survey in the Eski Gümüşhane area in these years. Other reports or studies are not available.

The Mineral Exploration Project in the Merzifon-İspir and Menders Massif areas was excuted jointly by the United Nations and the Government of Turkey between 1970-1974. A regional geochemical reconnaissance survey was carried out. The Gümüşhane area is a central portion in the Merzion-İspir of about 24,000km². This work resulted in the recognition of 47 geochemical anomalies in the Merzifon-İspir area, of which 8 anomalies are concerned with the Gümüşhane area.

2-3 General Geology and Ore Deposits of the Survey Area

Turkey is geologically divided into four tectonic units, namely the Pontids, Anatolids, Taurids and Border Folds from north to south. These belts generally extend in an E-W direction. The surveyed area belongs in the Pontids, consisting of the Ordovician to the Oligocene. The Pontids is characterized by extensive volcanic deposits, including a calc-alkaline basalt-andesite-dacite series of the Upper Cretaceous-Tertiary period. This violent volcanism was acccompanied with emplacement of granitic rocks. Most of the ore deposits in the Pontids are genetically related to this magmatism.

The surveyed area predominates in andesite and its equivalent pyroclastics of the Upper Cretaceous, dipping gently northward, with some subsidiary folds. On the other hand, to the north of the surveyed area, dacite series are mainly distributed according to the result of a collaboration mineral exploration programme in 1974~1976 (Trabzon area). The great majority of the massive and stockwork sulfide deposits are located between the Black Sea Coast and the Gireson-Harsit-Çaykara-Artvin line in the Eastern Pontids. These deposits are associated with dacite series of the Upper Creataceous, and is similar to the Kuroko deposits in Japan with regard to geological environments and modes. Murgul is a representative operating mine in this region. The Çayeli copper deposit near Samson (indicated reserves: 30 million tons, 3.3% Cu, 10.2% Zn) is planned to be developed by Etibank and a joint venture of Phelps Dodge, Gama Industrie and Demir Export. In the Eastern Pontids, a few porphyry copper type deposits were explored by drilling at Bakirçay and Ultuş. The mineralization, mainly of copper and molybdenum, is related to Laramian quartz diorite and quartz monzonite. A geological map of northwestern Turkey is shown in Fig.5.

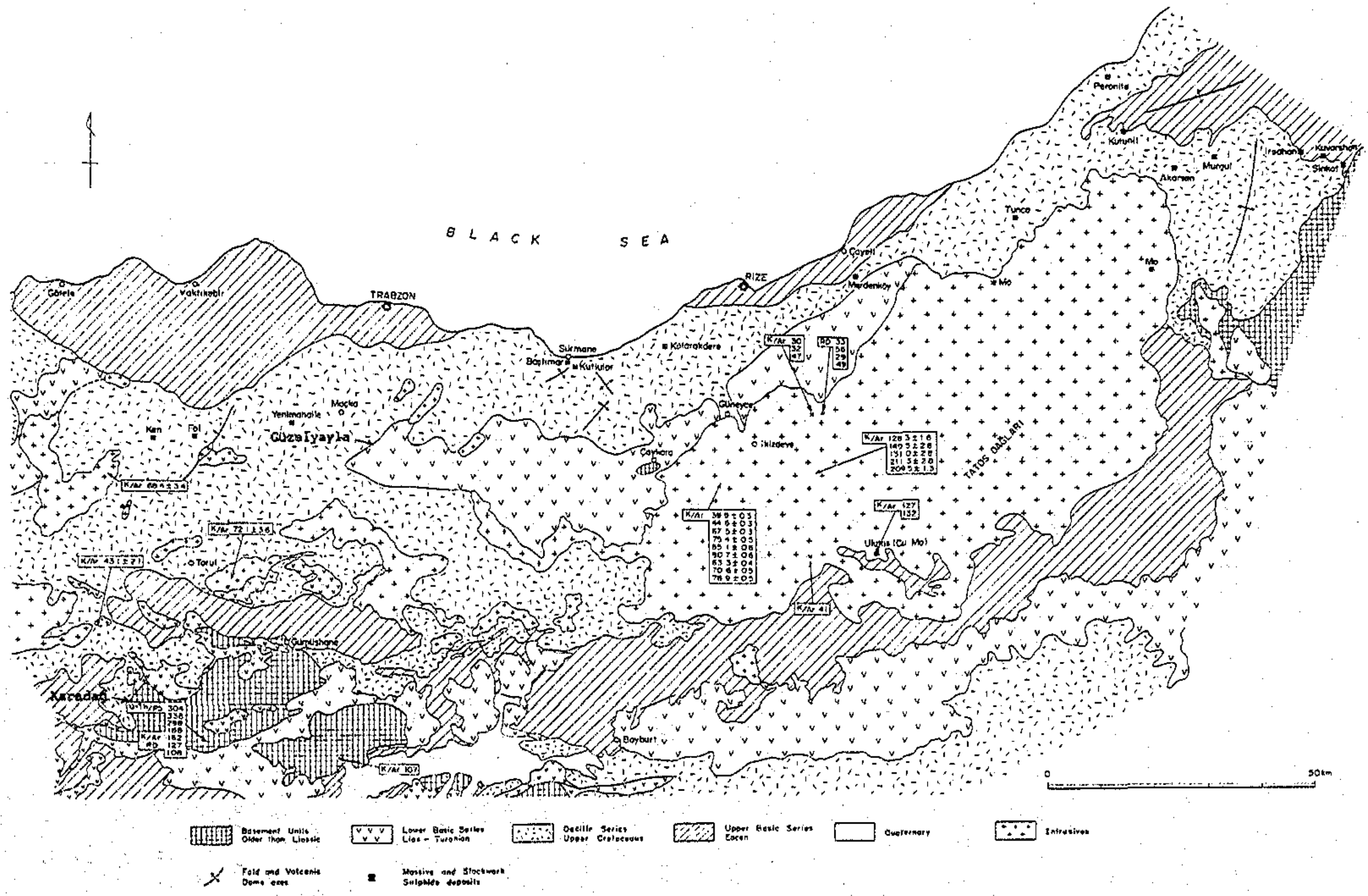


Fig. 5 Geological Map of the Surveyed Area(Geology compiled from AKINCI'85)

Part 2 RESULTS OF GEOLOGICAL SURVEY

Part 2 RESULTS OF GEOLOGICAL SURVEY

Chapter 1 Geology

1-1 General Geology

The basement rocks of the surveyed area consist of Paleozoic Kurtoğlu Metamorphics which are distributed in the southern part of the Gümüşhane area and the Gümüşhane Granite which intruded into these rocks during the late Paleozoic period. These basement rocks are overlain by the Kırıklı Formation consisting of lower Jurassic Lias basaltic rocks. The major unit of this formation is basalt lava with some spilite lava and sandstones. Red limestone is developed locally and this is correleted to the Lias Stage by fossils in the limestone which occurs to the east of the surveyed area.

The Kuşakkaya Limestone Formation overlies the Kırıklı Formation. Jurassic fossils were found in this massive limestone and thus this formation is correlated to the Dogger-Malm Stage.

The Zigana Formation is widely distributed unconformably overlying the basement, the Kırıklı Formation, and the Kuşakkaya Formation. The major unit of this formation is andesitic volcanic rocks. In the southern part of the surveyed area, basaltic unit is observed below this formation, and dacitic volcanic rocks are associated in the later deposits of the Zigana Formation. Flysch type sedimentary formations are developed in the southeastern part of the area and this indicates that the andesitic volcanic activity ceased during this period. This sedimentary formation consists of rhythmical alternation of mudstone and sandstone. Massive limestone, red limestone, mudstone and others are intercalated in this formation, but these intercalations are not continuous. Fossils of Upper Cretaceous Senonian Stage are found in the limestone of the lower part of this formation.

The Venk Yayla Formation unconformably overlies the Zigana Formation, and it is composed of andesitic volcanic rocks and flysch type sedimentary rocks. It is distributed in the central part of the area. A large amount of nummulites considered to be of Eocene age occur in limestone which is developed in the lower part of this formation.

The uppermost formation of this area is the Gavur Dağı volcanics which is considered to be of late Eocene age. It is distributed in the highland which has an elevation of more than 2,500m above sea level in the southwestern part.

The intrusive rocks of this area are mostly granodiorite and quartz porphyry. Also small veins of dacite and dolerite are observed. Large bodies of granodiorite are observed particularly in the Torul, Kürtün and Kopuz areas.

Small bodies have also intruded into the Gümüşhane granite.

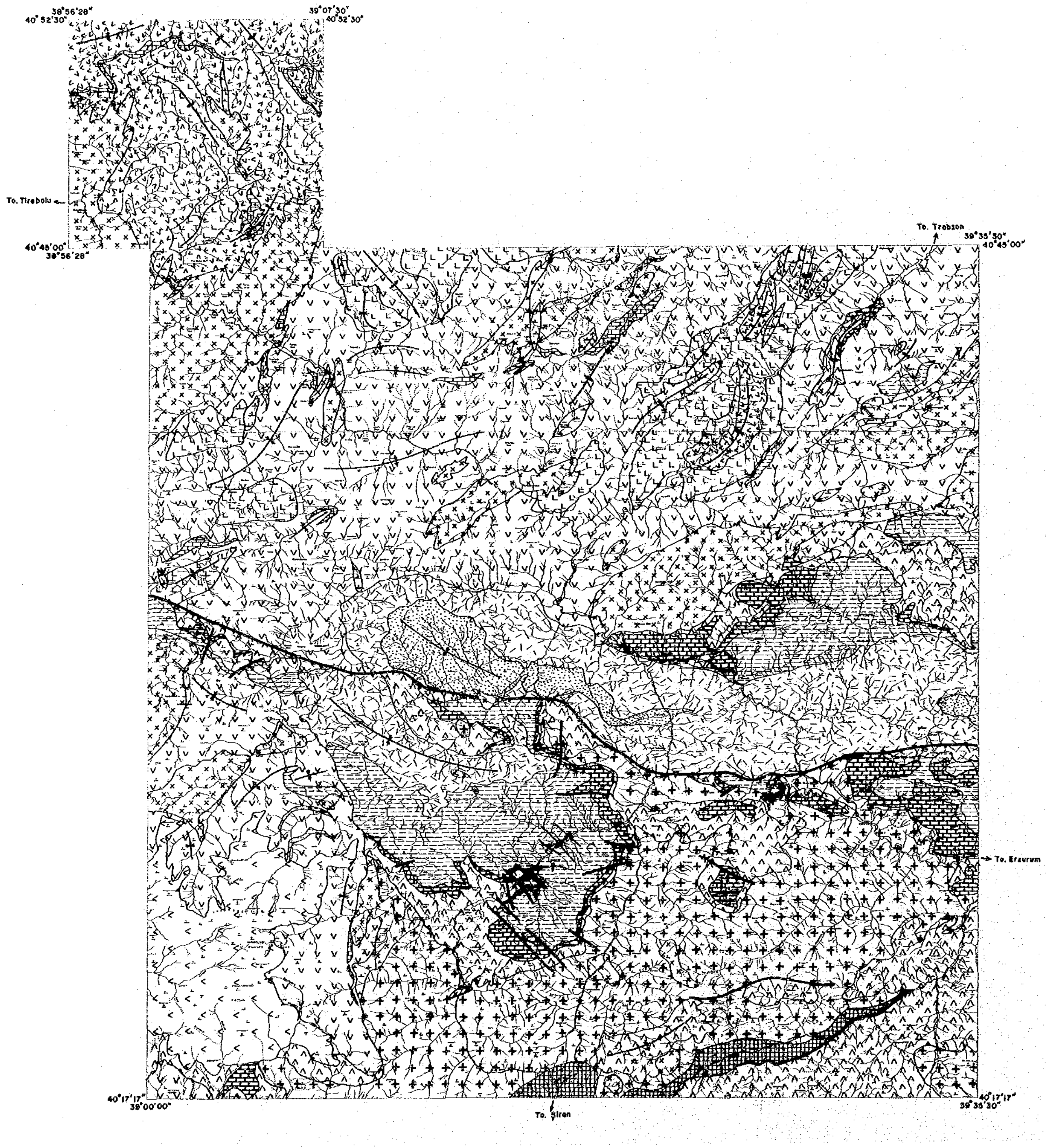
The WNW-SWS trending thrust (Gümüşhane Thrust) forms the geology of this area with the development of the basement rocks consisting of Kurtoğlu Metamorphics and Gümüşhane Granite, the Kırıklı Formation and Kuşakkaya Limestone to the south of this thrust. While to the north, the major unit is granodiorite which intruded into the Zigana Formation and Tertiary strata. The geology and schematic column are shown Figs. 6 and 7.

1-2 Stratigraphy

Kurtoğlu Metamorphic Complex : These metamorphic rocks are distributed in a ENE-WSW trending belt of several kilometers in width. The belt extends from Kurtoğlu Village to the Tezene River, along the Kurtoğlu River and also near the Tersun Range. The lithology of this unit consists of gneiss, biotite schist, muscovite schist and quartz-sericite schist. Gneiss is widely distributed from the vicinity of Yeniköy Village along the Kurtoğlu River to the west of Kurtoğlu Village. The rock is grayish white, coarse-grained with strong foliation. Megacrysts of muscovite up to 2cm are observed in some parts of this rock. Muscovite schist and quartz-sericite schist are white with frequent occurrence of megacrysts of muscovite. Biotite schist is dark brown, fine-grained and hard. Also, there are intercalations of metamorphosed conglomerate lenses of 0.5m. The biotite and muscovite schists show microscopically lepidoblastic texture. The major rock forming minerals are biotite, muscovite, quartz, plagioclase with small amounts of opaque minerals. However, these rocks are metamorphosed and folded, and thus the detailed structure is not clear. It is inferred that the general trend of the foliation and the fold axis is E-W with a northward plunge. The thickness of this formation is not clear, but is estimated to be more than 500m by its surface distribution.

This complex is bounded by a thrust to the Kırıklı Formation in the south and is intruded by Gümüşhane Granite in the north. The thrust is observed to the south of Asagitezene Village, the strike is approximately E-W with a northward dip, and it extends to the Kurtoğlu River in the west. Yilmaz (1979) determined the age of this formation to be Carboniferous to Permian.

Kırıklı Formation : This formation is distributed in many parts of the surveyed area unconformably overlying the Paleozoic formations. The major occurrences other than at Kırıklı Village are at Gümüşhane, half-way down the Nivena River and downstream of the Körum River in the south; also Hamsiköy River in the north, and north of Kopuz Village in the western part of the area. This



LEGEND

Tertiary	Gavurdağı Volcanics		Andesite lava, Pyroclastics
	Venk yayla F.		Flysh
			Andesite lava, Pyroclastics
Upper Cetaceous	Zigana F.		Limestone
			Dacite lava, Pyroclastics
			Andesite lava, Pyroclastics, Dacite
			Dacite lava, Pyroclastics
			Andesite lava, Pyroclastics
			Flysh
Jurassic	Kuşakkaya Limestone		Limestone
	Kırıklı F.		Sandstone, Mudstone Basalt lava, Basaltic and Dacitic Pyroclastics
Paleo-zoic	Gümüşhane Granite		Granite
	Kurtoğlu Metamorphics		Gneiss, Schist

Intrusive rocks

- Granodioritic rocks, Porphyritic granite
- Quartz porphyry, Dacite

- Anticlinal axis, Synclinal axis
- Fault
- Thrust fault

0 5 10km

Fig. 6 Geological Map of Gümüşhane Area

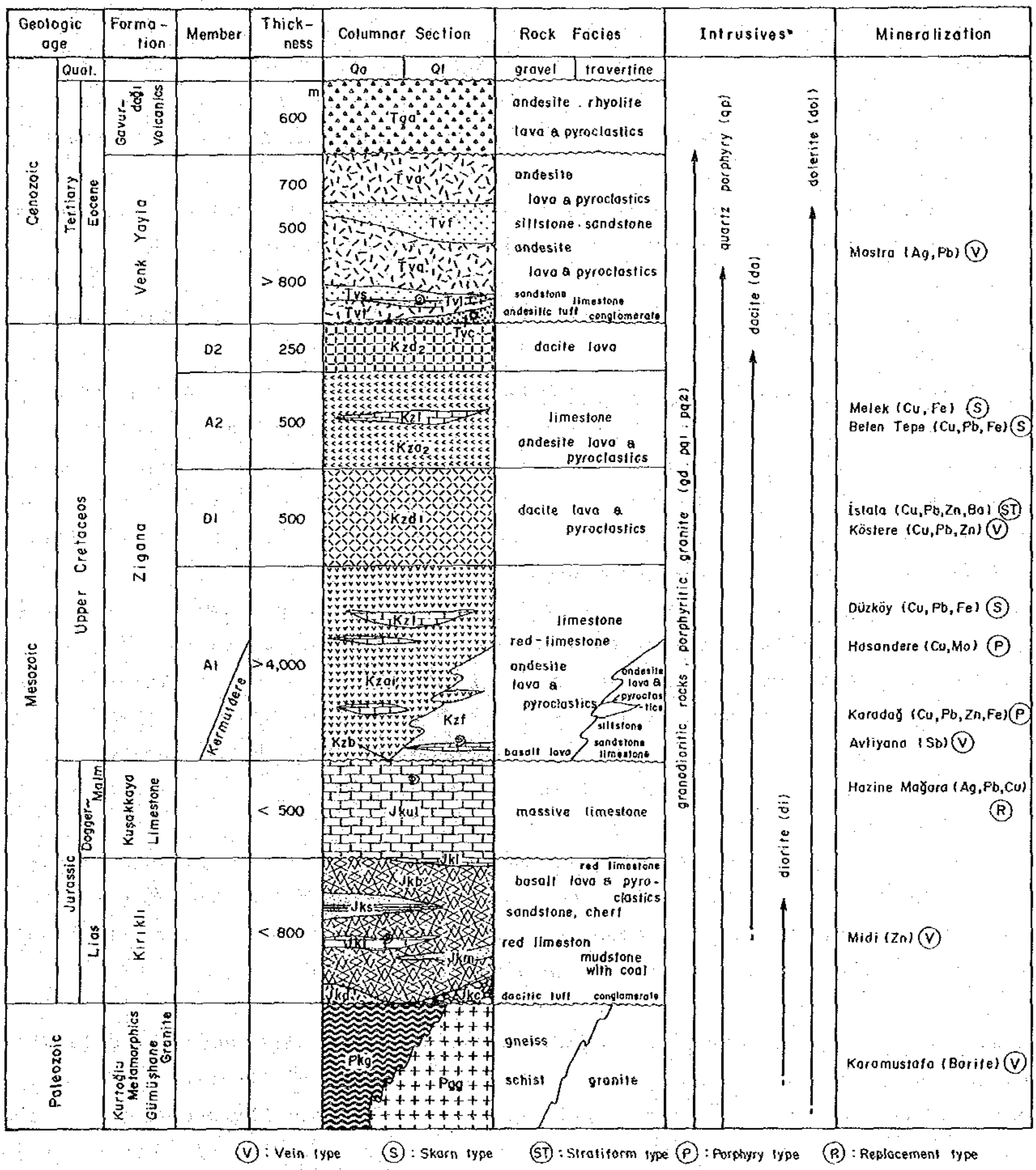


Fig. 7 Schematic Geological Column of Gümüşhane Area

formation consists of basal conglomerate, dacitic tuff, basalt lava, basaltic pyroclastics, spilite lava, red limestone, sandstone, mudstone, chert and thin coal seams.

Basal conglomerate: Development is local and the unit is not continuous. It unconformably overlies the Gümüşhane Granite in the southern part of the surveyed area as well as near Midi Village and in the vicinity of Gümüşhane City in the southeast. It similarly overlies the Kurtoğlu Metamorphics to the east of Kurtoğlu Village.

Dacitic tuff: This is found only to the north of Altıntaşlar Village in the southern part of the surveyed area and unconformably overlies the Gümüşhane Granite . It is pale yellow, strongly silicified and argillized, with dissemination of pyrite and oxidized copper minerals. Quartz veins are also developed.

Basalt lava, basalt pyroclastics, spilite lava: These rocks are distributed mainly to the north of Altıntaşlar Village, Mezraa Village and in the vicinity of Gümüşhane City in the south-southeastern part of the area and along the downstream part of the Körum stream. The basalt lava is generally dark green to reddish brown, the plagioclase is green and is chloritized and epidotized, and calcite veinlets are well developed.

Red limestone: Red limestone occurs as lenses and is not continuous. It is found at Simere Village in the south, along the upstream part of the Uzun Stream in the southeast and to the southwest of Gümüşhane City. This is marl limestone and is characteristically red. The occurrence of fossils are reported from this limestone at Kermut Village (outside of the surveyed area) 10km east of Gümüşhane City (MIA data). These fossils are correlated to the Lias of the Late Jurassic.

Sandstone, mudstone, chert coal seams: These rocks occur near Kırıklı Village in the southeast. They occur as alternation of sandstone and mudstone with sandstone as the major component. Bedding is developed clearly and basalt lava and basaltic pyroclacstics are locally intercalated.

Kuşakkaya Limistone Formation : This formation covers the underlying Kırıklı Formation. It conformably overlies the red limestone of the Kırıklı Formation and unconformably the pyroclastics of the same formation. The occurrence of the Kuşakkaya Formation is limited to localities where the Kırıklı Formation is distributed, mainly in the southern part of the surveyed area. The limestone of this formation is grayish white to white and mostly massive, but red limestone, dolomitic limestone, detrital limestone and others are also observed.

The fossils are reported from the vicinity of Mt. Ucbacali which is located approximately 3km northeast of Altıntaşlar Village (MTA data), and are correlated to the Upper Jurassc Dogger-Malm Stage.

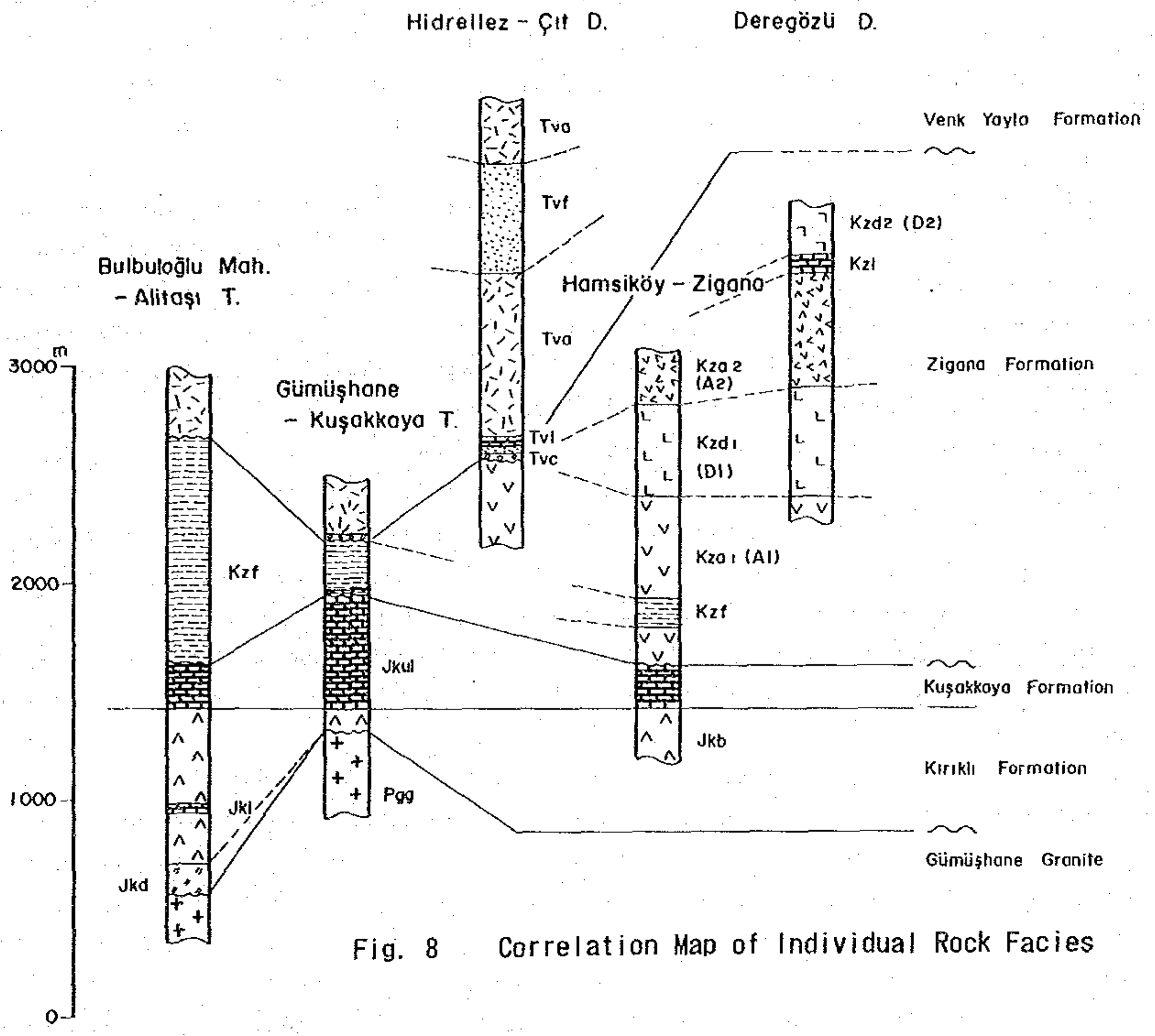


Fig. 8 Correlation Map of Individual Rock Facies

<u>Zigana Formation</u> : This formation is divided into five stratigraphic units, they are, in ascending order, the A1, D1, A2 and D2 Members.

<u>Kermut dere Member:</u> This member is distributed to the northwest and north of the Gümüshane Granite. The lithology becomes mostly an alternation of mudstone and sandstone near the northwestern body of the Gümüşhane Granite, while near Avliyana Village, which is at a distance from the Gümüşhane Granite, mudstone and sandstone rapidly decrease and andesite becomes predominant. Pale gray to pale grayish white and sometimes brownish gray to pale brown mudstone,calcareous siltstone and sandstone alternate rhythmically, gradually intercalating with

andesite and andesitic pyroclastics in the upper parts and finally changing to the andesite (A1 Member) of the overlying unit. It is flysch type sedimentary rock. The strike and dip vary considerably, and in some parts, the unit stands rather steeply, but generally, it has a low angle dip (approximately 30°). There are many faults but large ones are scarce. H.Gunduz (MTA) identified Globotruncana sp. and Gloveriginidae from the calcareous siltstone of this member and thus it belongs to the Upper Cretaceous Senonian Stage. In localities where this member is developed, it often unconformably overlies Kusakkaya Limestone.

A1 Member: The major part of the Zigana Formation consists of this member. Basalt lava is developed in the lower part and the lithology gradually changes upward to andesite lava, autobrecciated lava, agglomerate, lapili tuff and medium-to-fine-grained tuff. The colour is generally pale green to dark green. Basalt lava is developed along the anticlinal axes of Karadağ～Avliyana and 10km north of Torul in the southern part of the surveyed area. Andesites are developed in other parts. The vicinity of Zigana to Torul is considered to be the centre of the volcanic activity because lavas and pyroclastics are predominant. Mudstone, sandstone, limestone and siltstone are increasingly intercalated to the north and west. The intercalated sedimentary rocks are not continuous, but bedding plane and laminae are well developed.

D1 Member: The major rocks of this unit are dacite and dacitic pyroclastic rocks. There are two types of dacite. Dacite lava is grayish white to grayish green and massive with clear flow structure. Autobrecciated lava is grayish white to white. The pyroclastic rocks consist of tuff breccia, lapili tuff and fine-grained tuff. These pyroclastic rocks are altered, white to pale green and a small amount of pyrite is associated. D1 is distributed in the mountains to the north of Zigana Pass, in the northern part of Kürtün, in the moutains (over 1,500m above sealevel) to the southwest and in Zone A. D1 overlies A1 conformably.

A2 Member: The major rocks of this member are andesite and andesitic pyroclastics. They are similar to those of A1. This unit occurs to the north of Zigana Pass and Zone A overlying D1 conformably. It undulates and generally dips northward. Thus, it is distributed widely in Zone A in the north. Andesite lava is predominant near the Zigana Pass, but the major rocks become dark green andesite agglomerate to tuff breccia west of Dikkaya Village in the north. The distribution of this unit is narrow near the Zigana Formation with no intercalations of sedimentary rocks, while in Zone A, it occurs widely with massive limestone intercalations and is relatively continuous.

D2 Member: This unit consists of pale green to white dacite lava and conformably overlies A2 in a relatively narrow range of 1,400 ～1,800m altitude in relatively high mountains in western Zone A.

Venk Yayla Formation : This formation overlies the Paleozoic and Mesozoic formations unconformably and occurs at Çit, Kodil, along Hasara River and at other localities in the central part of the surveyed area. The major components of this formation are andesite lava and andesitic pyroclastics. It is characteristic of this formation that flysch type sedimentary rocks developed during the dormant period of the andesitic volcanic activity. This formation is composed of piles of basal conglomerate, limestone, sandstone and andesitic pyroclastics, and rhythmic alternation of sandstone-siltstone occupy the volcanically inactive period.

Gavur Daği Volcanic Rocks : These volcanic rocks form the Gavur Range located at the southwestern part of the surveyed area. Mt. Aptalmsa is the main peak in this range. These rocks unconformably overlie Paleozoic and Mesozoic formations (Gümüşhane Granite, Kırıklı Formation, Zigana Formation). They are distributed over approximately 15km north-south and 10km east-west and also outside of the surveyed area to the west. The major components are pale gray to grayish brown andesite lava rich in plagioclase phenocrysts and tuff breccia of the same lithology. The andesite generally contains minor amount of hornblende phenocrysts, but locally, these are sometimes abundant and show flow structure. Generally, the lava is massive with clear joints, but in some cases the rock is autobrecciated. Reddish brown tuff breccia without clear bedding plane is intercalated.

1-3 Intrusive Rocks

Gümüşhane Granite (Pre-Jurassic Intrusive Rocks) : The distribution of this granite is wide and is elongated in a southwesterly direction from the south of Gümüşhane City. It covers an area of 37km E-W and 15km N-S. The lithology of this intrusive body was described in detail by Yilmaz in 1974. The body is divided in this report into granodiorite, Camlica adamellite, Gümüşhane adamellite and fine-grained porphyritic granite. The major part of the igneous body, however, consists of fine-grained porphyritic granite. As it was difficult to distinguish the lithology in the field, we identified this body as the granite which intruded into Paleozoic formations. The rock is generally massive, grayish white, greenish gray, or yellowish gray to pink. The appearance varies greatly from fine to coarse-grained. The general tendency is finer-grained toward the periphery and coarser-grained toward the inner parts of the intrusive body. In the large area to the south of Gümüşhane City, the rock is coarse-grained, generally brittle and contains large crystals of potash feldspar, quartz grains of 2~3mm and is rich in biotites.

Microscopically, it is holocrystalline, has equigranular to porphyritic texture and consists of quartz, alkali feldspar, plagioclase, biotite, muscovite and amphibole. The alkali feldspar is anhedral to irregular in shape and often shows perthitic texture. Plagioclase is euhedral to subhedral, often shows albite twinning and sometimes has zonal structure. Some of the mafic minerals are replaced by chlorite and epidote. The unit is classified microscopically as quartz monzonite. Aplitic properties are observed in this body at west of Altıntaşlar Village, east of Artabel, in the vicinity of Edire Village and other areas. The aplitic part is compact, massive, and rich in quartz, plagioclase and feldspars.

Younger Intrusive Rocks :

Hypabyssal rocks: Many intrusive bodies of dacite, quartz porphyry and other rocks which are closely associated with Upper Jurrassic submarine volcanic activities are found in the Upper Jurassic Zigana Formation (A1, D1, A2). Most of these bodies are elongated in NE-SW to N-S directions but rarely NW-SE. These bodies are distributed to the north of the Gümüşhane Thrust. Both are weakly altered to the unaided eyes. Minor amounts of pyrite are associated. Also, the youngest quartz porphyry intrudes into the Venk Yayla Formation and granodiorite. Small scale dolerite intrusion is observed in Gümüşhane Granite.

Plutonic rocks: Most of the plutonic rocks of the surveyed area are granodiorite. They are named according to their geographic distribution as Kopuz Granodiorite, Kürtün Granodiorite, Torul Granodiorite and Hasandere porphyritic granite. These intrusive bodies are elongated in NE-SW, N-S directions. They form a batholith in the central to northern part of the surveyed area and occur as stocks near the periphery. There are granodiorite and diorite intrusions into the Gümüşhane Granite, but they are of small scale.

Kopuz Granodiorite: This granodiorite is distributed from Kopuz to Asağı Village and consists mainly of three bodies. The stock which occurs northeast of Kopuz Village is fine-grained biotite-amphibole granodiorite and extends 3km E-W and 2km N-S. Plagioclase, alkali feldspar, amphibole biotite and opaque minerals are found under the microscope. The plagioclase is euhedral granular and has carlsbad, albite twinning with strong zonal structure. The granodiorite body near Asağı Village is large and extends westward out of the surveyed area. It is pale grayish white and contains euhedral amphibole of 2-3mm. The rock is holocrystalline with equigranular texture and euhedral plagioclase. The constituent minerals are plagioclase, quartz, alkali feldspar, amphibole and opague minerals. Some stocks are found near this body, and altered zones with pyrite associations are developed in the stock and the host at Beskise.

Kürtün Granodiorite: This is a large batholith extending from Kürtün to Dogankent which lies west outside of A Zone of the surveyed area. The major rocks are amphibole granodiorite and biotite granodiorite associated partly with quartz porphyry, dacite and dolerite dykes. The granodiorite is holocrystalline with equigranular texture and some of the plagioclase forms porphyritic megacrystals. The constituent minerals are plagioclase, quartz, alkali feldspar, and amphibole. Biotite may or may not be present. Some of the mafic minerals are replaced by chlorite and epidote.

Torul Granodiorite: There are some medium to small scale granodiorite bodies in the vicinity of Torul. These are called Torul Granodiorite. These bodies are generally elongated in a NE-SW direction. The granodiorite body extending from Sarisaman 7km, northwest of Torul, to Şive Village is pale gray to pale brownish white to pink and the rock is amphibole ganodiorite, but the rock becomes finer-grained and dacitic to the east. The mass which extends from Torul to the south of Mt. Ayeser is 20km×5km and is elongated NE-SW∼ENE-WSW. This granodiorite is characterized by biotite and quartz, plagioclase, alkali feldspar, biotite, muscovite, epidote and opaque minerals are observed microscopically. In some places, alkali feldspar and plagioclase have been altered to fine grain size. This intrusive body cuts through the Kurtoğlu and Zigana Formations. Mt.Ayeser to the north of this intrusive body is composed of fine-grained amphibole-biotite granodiorite.

Hasandere Porphyritic Granite: This granite is distributed from Maden Dere (main Dere of Hasan Stream) to Turnagol River. Although there are parts which show equigranular texture, these are local and the general characteristic of this rock is porphyritic texture of quartz and plagioclase. The above name is thus given. This rock is grouped into two types by alteration, namely Pg1 and Pg2. Altered porphyritic granodiorite (Pg1) constitute a small body consisting mainly of sericite and biotite. It is argillized and silicified. Pg2, on the other hand, is unaltered porphyritic granodiorite elongated in an ENE-WSW direction.

1-4 Volcanic Activity

The surveyed area belongs to the Pontids Fold Belt which is characterized by intensive Upper Cretaceous and Tertiary volcanic activity. This volcanism was mostly submarine, and cycles of basic to acidic activity were repeated several times. The volcanism started with basaltic activity in a Lias shallow sea characterized by pillow lava. The area uplifted and limestone deposition occured after subsidence. In Upper Cretaceous time, basaltic activity started again, but the following andesitic volcanism lasted for a long time with intense activity over a large areaa emitting large amount of lava and pyroclastics. During the early phase of the andesitic volcanism, flysch type sediments of a deep sea turbidity current is associated. As the volcanism became intense, however, these sediments disappear and volcanic rocks began to occupy the area between Zigana and Torul in the central part of the surveyed area. Mudstone and limestone are intercalated at distances from the central part, but they are not continuous. As the sedimentation and volcanism shifted northward, dacitic submarine volcanism became predominant. In some localities, dacitic activity occured together with the andesitic type. The area was uplifted and then subsided from Late Cretaceous to Eocene and subsequent submarine volcanism resumed. The activity during this period was mainly acidic andesite associated with some dacite in a sedimentary basin intercalating flysch type sediments. This volcanism is of far smaller scale compared to that of Cretaceous. The only subsequent activity are the andesitic Gavur Dağı volcanics which probably is of late Eocene age.

1-5 Diagenesis and Alteration

Of the geological units in the surveyed area, the Kırıklı and Zigana Formations have suffered wide spread diagenesis and strong alteration. Epidotization, chloritization and carbonatization are conspicuous in the Kırıklı Formation. On the other hand, the some andesites of Zigana A1 and A2 contain fresh original minerals and some have totally new mineral compositions due to the formation of epidote, secondary quartz and chlorite by diagenesis. Haviyana and Altıntaşlar are the two localities where alteration occurrd in the Kırıklı Formation. Silicification and argillization are not accompanied by pyrite formation. In the Zigana Formation, the zone between Torul and Zigana has been strongly altered. In some places sericitization and silicification is so strong that original rock cannot be indentified. Also, some zones of contact with granodiorite are altered, D1 is particularly strongly argillized.

1-6 Geological Structure

The geological structure of the surveyed area is largely controlled by E-W thrusts and a NE-SW fold structure.

Faults: The Gümüşhane Thrust extends in a NWN-SES direction through the central part of the area. To the south of this thrust, Kurtoğlu Metamorphics and Gümüşhane Granite are exposed over a wide area. These are both basement rocks. The Gümüşhane Thrust forms the boundary of the two zones. On the other hand, to the north of the thrust, the geology is characterized by the Upper Cretaceous Zigana Formation. Small thrusts are also found; one extends ENE-WSW and occurs near the Asagitezene Village. This thrust dips northward at about 40° and is the boundary between the Kurtoğlu Metamorphics and the Kurtoğlu Formation. The Gümüşhane Thrust cuts through the Venk Yayla Formation, and as the younger granodiorite has intruded along this fault, it is inferred that it was formed sometime between Late Eocene to Miocene.

Fold structure: The geologic units generally dip northward at low angles with gentle undulations in the northern half of the area. The axes of the fold trend NE-SW, NNE-SSW and NW-SE. NE-SW is particularly conspicuous and the younger granodiorite has intruded in this direction. In the southern half of the area, the main trend of the folds are found in the southern part where the Kırıklı Formation and Kuşakkaya Limestone Formation are developed and these are mostly trending NW-SW, NE-SW with less than 100m displacement.

1-7 Age Determination

The granites of the surveyed area are largely divided into old granites which intruded before the Jurassic-namely the Gümüşhane Granite-and the young granodiorite which intruded from the Cretaceous to Tertiary, namely the Torul, Kürtün, Kopuz, Hasandere Granodiorites. The age of the old granites was inferred to be 300Ma and that of the young granodiorites to be 100Ma. The former was determined by Rb-Sr method and the latter by K-Ar method.

Rb-Sr method : Samples for age determination were collected at two localities. One at Gümüşhane City along National Highway 65 (Sample No. H-1, 5, 7. H series); this locality lies on the northern side of the Gümüşhane Granite Body. The other at Karamustafa (Sample No. A-2, 3, 5. A series); this locality lies on the southern side of the granite body. Efforts were made to obtain samples of fresh rocks and those of different lithology were collected from the same rock body. This granite is two-mica granite and although the appearance to the unaided eyes is fresh, detailed examination under the microscope showed it to be altered. For example, the margins of amphiboles and biotite are replaced by chlorite and epidote, and plagioclase is partly sericitized. Also, the ratio of the constituent minerals of each sample varied considerably. The result of the measurements are as follows.

	Rb	Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
H-1	183.5ppm	74.1ppm	7.20	0.74999± 0.00005
H-5	163.5ppm	95.2ppm	4.99	0.73721± 0.00009
H-7	143.2ppm	140.9ppm	2.95	0.71965± 0.00006
A-2	138.3ppm	97.8ppm	4.10	0.72695± 0.00009
A-3	141.6ppm	103.7ppm	3.96	0.72721± 0.00013
A-5	143.2ppm	0.5.0ppm	3.96	0.72630± 0.00010

Figure 9 is the computer graphic of this result. The $^{87}Rb/^{86}Sr$ values of the H series vary while those of the A series samples are relatively constant. The age of H series from isochron obtained by the least squares method is 533Ma, but in this case, the initial isotope ratio becomes 0.6975 and is too low for the age to be credible. The samples of A series have different lithology but the values are similar. These values should be significant, but the age calculated using the measurements of both A and H series becomes 535Ma. In this case the original values are again very low, 0.6968, and thus is not correct. The values of two points N-1 and H-5 are not necessarily conclusive. The calculation shows the original value to be 0.7084 and the age 406Ma, Early Devonian. In the past, age determination by U-Th/Pb method had been attempted for this granite body and the result was 298, 338Ma-a Carboniferous intrusion. The plutonic intrusive bodies of this period is considered to be those of the Hercynian Orogeny and the age should be Devonian, but the determination showed a younger age. The reason for this age discrepancy probably is the result of some kind of isotopic disequilibrium within the granite body which caused variations in the original values of the isochron.

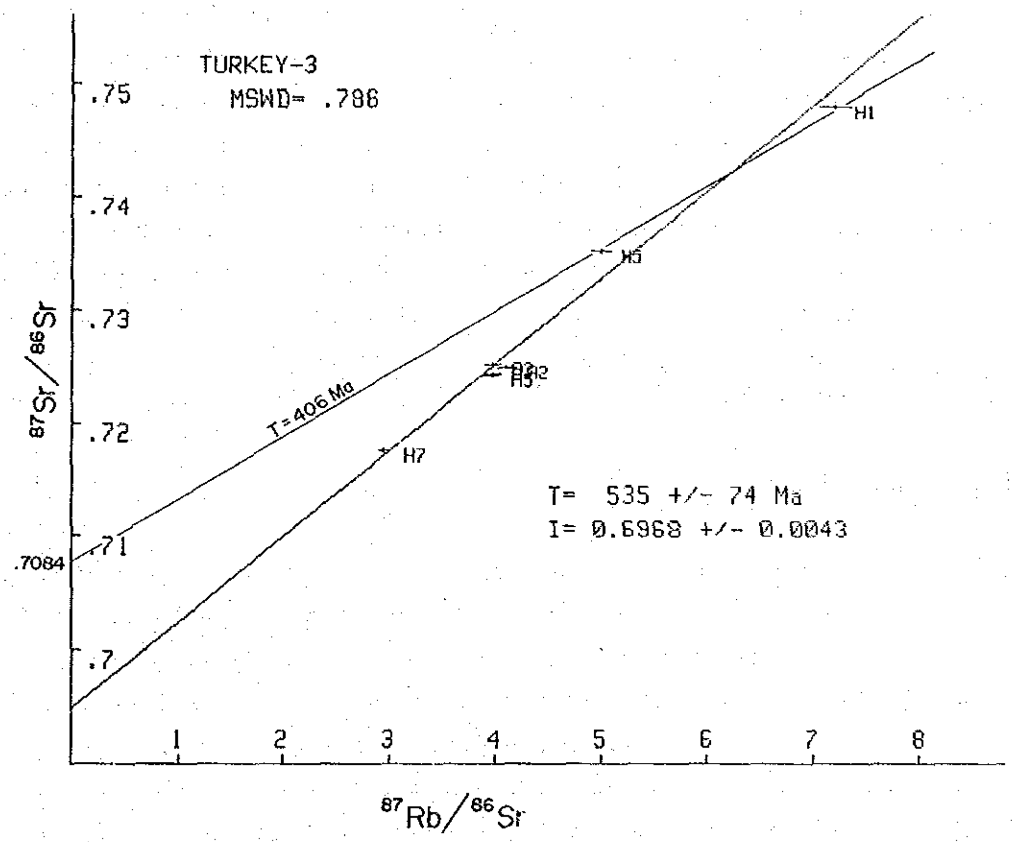


Fig. 9 Result of Rb-Sr Age Determination in Gümüşhane Granite

K-Ar method : The samples were collected from the granodiorite mass at Torul (Sample No. M-30), Kürtün (Sample No. S-69), and Kopuz (Sample No. T-1).

Simple No.	40Ar* (Sec/gm× 10^{-5})	%40Ar*	%K
M-30	0.450,0.474	93.0,94.7	2.72,2.73
S-69	0.561,0.590	74.1,74.5	2.12,2.13
T- 1	0.881,0.915	88.5,88.2	3.13,3.15

Ar*; Radiogenic Argon

The calculated ages are

Torul	Granodiorite	72.1± 3.6Ma	Upper Cretaceous
Kürtün	Granodiorite	68.4± 3.4Ma	Upper Cretaceous
Kopuz	Granodiorite	43.1± 2.2Ma	Middle Eocene

The decay constants used are $\lambda e = 0.581 \times 10^{-10}/y$, $\lambda = 4.962 \times 10^{-10}/y$. The Torul and Kürtün Granodiorites were emplaced during the Upper Cretaceous. This indicates that these bodies intruded at the latest stage of the Upper Cretaceous marine volcanism. On the other hand, Kopuz Granodiorite intruded in Eocene time. Thus this granodiorite intrusion occurred from Mesozoic to Tertiary in the Pontids Fold Belt, and these bodies are widely distributed. The age of the rocks distributed at Tatos northeast of Torul has also been determined by K-Ar method with the result of 30～80Ma, mid-Alpine orogeny. This is correlated to the Laramide phase of North America. The intrusion of the host rocks of the major porphyry copper deposits of North America is 54～72Ma (K/Ar), a similar period.

1-8 Whole Rock analysis

A total of 30 rock samples representing the surveyed area were chemically analysed- 9 old granites, 10 young granodiorites and 11 Jurassic to Eocene volcanic rocks. Analyses were made for 12 elements including a minor constituent Ba. Potassium permanganate titration was used for FeO determination and X-ray fluorescence and atomic absorption were applied for other elements. The results of the analyses together with normative minerals, differentiation index (DI) and solidification index (SI) are shown in Table 3. All analysed samples were microscopically studied. Some of the granite samples were used for radiometric age determination.

<u>Granites</u> : The chemical composition of the old granites and young granodiorites were studied as shown in the diagrams of Figures 10～16. The results are summarized as follows.

① The old granite occupies an area higher than the young granite in the normquartz-(plagioclase)-orthoclase diagram. In other words, it is quartz monzonite of the Bateman et. al. (1963) classification. The young granite occupies the granodiorite range.

② Both granites have distinctive compositional ranges as shown in the DI-oxide diagram.

③ A similar trend appears in the CaO-alkali ratio with the young granodiorite in the high CaO field (Fig.13)

	Old Grainte	Young Granodiorite
DI	82～91	60～78
SiO_2	71～75	61～69
MgO	0.3～1.2	1.1～2.6
CaO	0.5～1.8	2.0～5.4

Recently, genetic classification of granitic rocks has been proposed by Chappell and White (1974) and Ishihara (1977). Chappell and White (1974) uses Na_2O content, $Al_2O_3/(Na_2O+K_2O+CaO)$ mol ratio, normative diopside and corundum values as the basis for the classification. In this classification, both granites of this area belong to the I-type. Also, the low $^{87}Sr/^{86}Sr$ original value indicate I-type for the old granites. Ishihara (1977) classified granites on the basis of the mode content of opaque minerals and the Fe_2O_3/FeO ratio. The opaque minerals have not been studied under reflected light, but from the mode content and the Fe_2O_3-FeO diagram (Fig.14), the young granodiorite is inferred to be of the magnetite series. There are some old granites with low Fe_2O_3/FeO ratio, but they are inferred to belong to the magnetite series from the original strontium values and the amount of opaque mineral. Generally the magnetite series granite is characterized by Mo and those of the ilmenite series by Sn. The fact that these granites belong to the magnetite series support the fact that greisenization accompanied by Sn occurred in the area.

Volcanic rocks : The volcanic rocks of the Venk Yayla Formation belong to the andesite-dacite field of the SiO_2-Na_2O-K_2O diagram (Fig.11). The andesite-dacite of the Zigana Formation lie in the rhyolite field, but this probably is the result of the increase of SiO_2 by alteration. Also, the characteristics of the basalt of the Zigana Formation and the basaltic andesite of the Kırıklı Formation is relatively high in alkali (Na_2O+K_2O) content, but strong alteration is observed microscopically and thus, it will not be discussed in detail here. The MFA diagram (Fig.12) and SiO_2-FeO/MgO diagram (Fig.15) also indicate the volcanic rocks of the Venk Yayla Formation to be of the calc-alkaline series.

Barium : Barium, due to the similarity of the ionic radius, behaves in a similar manner as potassium and often is a constituent of biotite and potassium feldspar. Therefore, the relation of the element with SiO_2, K_2O and DI was studied and the result is shown in Figure 17. The result is summarized as follows;

① Granites contain larger amounts of Ba than volcanic rocks except for those of Venk Yayla.

② The Ba content of old granites vary widely from 200～1,000ppm while that of

Table 3 Chemical Analyses and CIPW Norms for Granitic rocks and Volcancis(No.1)

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sample No.	H-1	H-3	H-5	H-6	H-7	A-2	A-3	A-5	T-107	E-198	S-69	E-3	M-30	H-141	Y-2
SiO_2	71.47	74.88	70.65	71.28	71.30	71.30	72.35	70.45	73.05	61.42	74.79	68.02	61.69	61.05	68.47
TiO_2	0.29	0.24	0.37	0.34	0.31	0.33	0.31	0.29	0.29	0.61	0.24	0.38	0.62	0.54	0.38
Al_2O_3	15.08	13.36	14.59	14.47	13.94	15.17	14.42	14.88	14.65	15.97	13.17	15.30	16.76	16.83	14.93
Fe_2O_3	0.62	0.55	0.25	0.01	0.40	1.37	0.01	1.42	0.18	2.04	0.75	1.18	2.22	0.70	1.49
FeO	1.09	0.82	1.72	2.44	2.11	0.11	1.82	1.23	1.48	3.74	1.16	2.12	3.23	4.74	1.57
MnO	0.07	0.07	0.08	0.07	0.08	0.07	0.07	0.08	0.07	0.10	0.08	0.10	0.10	0.13	0.10
MgO	0.45	0.43	0.69	1.23	0.83	0.29	0.45	0.50	0.42	2.63	0.69	1.31	2.46	2.49	1.69
CaO	0.71	0.53	0.89	0.63	1.80	1.55	1.41	0.91	1.28	5.44	1.51	3.22	5.07	5.03	1.94
Na_2O	4.39	3.52	3.81	3.40	3.63	3.89	3.70	4.55	3.85	2.79	4.36	3.36	3.39	3.31	3.99
K_2O	5.12	4.08	5.41	4.11	3.82	3.81	4.00	4.87	4.10	3.71	2.47	4.46	3.72	4.26	2.96
P_2O_5	0.25	0.20	0.31	0.08	0.06	0.07	0.06	0.05	0.05	0.14	0.05	0.10	0.13	0.17	0.09
$H_2O(+)$	0.58	0.83	0.80	1.76	1.61	1.07	0.87	0.85	0.73	1.62	0.49	0.59	0.86	0.46	1.84
$H_2O(-)$	0.12	0.15	0.14	0.22	0.16	0.37	0.22	0.26	0.09	0.21	0.25	0.06	0.17	0.14	0.19
Total	100.24	99.66	99.91	100.04	100.05	99.40	99.69	100.34	100.24	100.42	100.01	100.20	100.42	99.85	99.64
Ba (ppm)	299	184	274	998	714	656	561	612	960	999	405	877	1001	897	1082
Q	24.33	37.22	24.79	30.97	29.19	30.54	30.65	22.45	30.72	15.11	35.28	22.10	13.12	9.23	26.96
C	1.62	2.67	1.59	3.47	0.70	2.00	1.58	0.59	1.67	-	0.70	-	-	-	1.85
or	30.26	24.11	31.97	24.29	22.58	22.52	23.64	28.78	24.23	21.93	14.60	26.36	21.98	25.18	17.49
ab	37.15	29.79	32.24	28.77	30.72	32.92	31.31	38.50	32.58	23.61	36.89	28.43	28.69	28.01	33.76
an	1.89	1.32	2.39	2.60	8.54	7.23	6.60	4.19	6.02	20.09	7.16	13.49	19.53	18.48	9.04
ne	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
di wo	-	-	-	-	-	-	-	-	-	2.50	-	0.76	1.99	2.24	-
di en	-	-	-	-	-	-	-	-	-	1.43	-	0.42	1.23	1.01	-
di fs	-	-	-	-	-	-	-	-	-	0.95	-	0.32	0.65	1.22	-
hy en	1.12	1.07	1.72	3.06	2.07	0.72	1.12	1.25	1.05	5.12	1.72	2.84	4.90	5.19	4.21
hy fs	1.14	0.78	2.49	4.04	3.18	-	2.95	0.76	2.22	3.41	1.26	2.16	2.61	6.26	1.21
ol fo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ol fa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
mt	0.90	0.80	0.36	0.01	0.58	-	0.01	2.06	0.26	2.96	1.09	1.71	3.22	1.01	2.16
hm	-	-	-	-	-	1.37	-	-	-	-	-	-	-	-	-
il	0.55	0.46	0.70	0.65	0.59	0.38	0.59	0.55	0.55	1.16	0.46	0.72	1.18	1.03	0.72
ru	-	-	-	-	-	0.22	-	-	-	-	-	-	-	-	-
ap	0.58	0.46	0.72	0.19	0.14	0.16	0.14	0.12	0.12	0.32	0.12	0.23	0.30	0.39	0.21
S.I.	3.86	4.57	5.81	10.99	7.69	3.06	4.51	3.98	4.19	17.64	7.32	10.54	16.38	16.06	14.44
D.I.	91.74	91.12	89.00	84.03	82.48	85.97	85.60	89.73	87.53	60.65	86.77	76.89	63.79	62.42	78.21

Rock Name	Geological Unit	Locality
1. Biotite-hornblende quartz monzonite	Gümüşhane Granite	Gümüşhane
2. Biotite-muscovite quertz monzonite	ditto	ditto
3. Biotite-muscovite quartz monzonite	ditto	ditto
4. Muscovite quartz monzonite	ditto	Southeast of Gümüşhane
5. Biotite quartz monzonite	ditto	ditto
6. Biotite quartz monzonite	ditto	Midi
7. Biotite quartz monzonite	ditto	ditto
8. Biotite quartz monzonite	ditto	ditto
9. Biotite quartz monzonite	ditto	West of Altıntaşlar
10. Hornblende granodiorite	Younger Granitic rocks	Çami (A area)
11. Biotite granodiorite	ditto	Ikibaca
12. Hornblende quartz monzonite	ditto	Sarısaman
13. Biotite-muscovite quartz monzonite	ditto	Demircıköy
14. Hornblende-biotite granodiorite	ditto	West of Ayasar Tepe
15. Porphyritic granodiorite	ditto	Maden dere(Hasandere area)

Table 3 Chemical Analyses and CIPW Norms for Granitic rocks and Volcancis (No.2)

No.		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Sample No.		H-38	T-1	E-202	E-201	H-31	H-108	E-204	E-205	E-158	Y-70	M-74	E-113	A-172	A-173	E-203
SiO_2		67.53	69.43	69.31	78.88	69.09	63.10	57.58	47.88	48.35	71.30	79.26	83.52	51.38	49.87	50.28
TiO_2		0.38	0.37	0.32	0.12	0.31	0.47	0.56	1.59	0.59	0.31	0.13	0.12	0.83	0.70	1.37
Al_2O_3		15.86	15.21	14.07	13.36	15.42	16.63	16.65	19.35	17.51	12.89	11.47	8.97	17.11	15.53	16.59
Fe_2O_3		1.32	1.06	1.52	0.01	1.08	2.31	3.59	5.23	1.81	1.19	1.34	0.19	4.39	4.26	6.74
FeO		2.05	1.68	1.64	0.79	0.54	2.32	2.83	4.45	6.81	2.53	0.62	0.69	3.53	4.09	2.54
MnO		0.10	0.12	0.11	0.05	0.08	0.11	0.13	0.09	0.13	0.16	0.06	0.06	0.10	0.14	0.20
MgO		1.32	1.14	1.38	0.52	0.70	2.40	3.73	7.04	5.95	1.75	0.60	0.46	3.84	4.37	6.55
CaO		3.51	2.96	4.42	0.01	0.69	5.54	8.34	6.73	5.11	0.97	0.01	0.14	8.93	10.51	3.45
Na_2O		3.84	3.52	2.90	0.41	5.24	3.60	3.17	4.12	4.87	4.69	0.43	2.23	2.80	4.52	6.30
K_2O		3.68	3.67	3.03	3.80	5.41	2.39	1.11	2.06	1.05	1.10	3.47	1.32	0.46	0.67	0.75
P_2O_5		0.11	0.09	0.07	0.01	0.07	0.15	0.18	0.31	0.08	0.07	0.02	0.01	0.11	0.09	0.30
$H_2O(+)$		0.54	0.45	1.54	1.94	0.96	0.95	2.06	1.23	6.96	2.31	2.63	1.91	5.73	4.40	4.99
$H_2O(-)$		0.09	0.17	0.24	0.07	0.32	0.09	0.58	0.21	0.46	0.16	0.03	0.45	1.16	0.98	0.29
Total		100.33	99.87	100.55	99.97	99.91	100.06	100.51	100.29	99.68	99.43	100.30	100.07	100.37	100.23	100.35
Ba (ppm)		1093	949	802	634	1492	881	804	204	221	139	108	102	192	168	135
	Q	21.24	26.29	29.95	62.04	15.67	18.11	13.91	-	-	33.75	64.32	64.07	10.36	-	-
	C	-	0.28	-	8.76	-	-	-	-	-	2.39	7.23	3.64	-	-	-
	or	21.74	21.69	17.91	22.81	31.97	14.12	6.56	12.17	6.21	6.50	20.59	7.80	2.72	3.96	4.43
	ab	32.49	29.79	24.54	3.14	44.34	30.46	26.82	28.88	38.42	39.69	3.67	18.87	23.69	33.95	51.95
	an	15.17	14.10	16.42	-	2.57	22.16	27.92	28.22	22.82	4.35	-	0.63	32.67	20.02	14.77
	ne	-	-	-	-	-	-	-	3.24	1.51	-	-	-	-	2.34	0.74
di	wo	0.64	-	2.11	-	0.16	1.81	5.13	1.31	0.84	-	-	-	4.52	13.34	0.16
di	en	0.36	-	1.38	-	0.14	1.28	3.93	1.07	0.48	-	-	-	3.45	9.48	0.14
di	fs	0.25	-	0.58	-	-	0.38	0.65	0.08	0.33	-	-	-	0.60	2.69	-
hy	en	2.93	2.84	2.05	1.30	1.60	4.70	5.36	-	-	4.36	1.50	1.15	6.12	-	-
hy	fs	1.99	1.82	0.86	1.45	-	1.40	0.89	-	-	3.45	0.13	1.02	1.07	-	-
ol	fo	-	-	-	-	-	-	-	11.54	10.05	-	-	-	-	0.99	11.34
ol	fa	-	-	-	-	-	-	-	1.01	7.68	-	-	-	-	0.31	-
	mt	1.91	1.54	2.20	-	1.10	3.35	5.20	7.58	2.62	1.72	1.85	0.28	6.36	6.18	4.87
	hm	-	-	-	-	0.32	-	-	-	-	-	-	-	-	-	3.38
	il	0.72	0.70	0.61	0.46	0.59	0.89	1.06	3.02	1.12	0.59	0.15	0.23	1.58	1.33	2.60
	ru	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ap	0.25	0.21	0.16	-	0.16	0.35	0.42	0.72	0.19	0.16	-	0.02	0.25	0.21	0.70
S.I.		10.81	10.30	13.18	9.40	5.40	18.43	25.85	30.74	29.04	15.54	9.29	9.41	25.57	24.40	28.63
D.I.		75.48	77.77	72.40	87.99	91.98	62.70	47.30	44.30	46.14	79.94	88.58	90.74	36.77	40.23	57.12

Rock Name	Geological Unit	Locality
16. Hornblende granodiorite	Younger Granitic rocks	Aşağı
17. Hornblende-biotite granodiorite	ditto	Kopuz
18. Hornblende granodiorite	ditto	Karadağ area
19. Muscovite quartz porphyry	Dyke	ditto
20. Augite-hornblende dacite	Venk Yayla Formation	Topcatı
21. Biotie-hyperthene-augite-hornblende dacite	ditto	Southeast of Hıdrellez
22. Qz bearing hyperthene-biotite-augite-hornblende andesite	ditto	Kodil
23. Basalt	Zigana Formation	Avliyana
24. Basalt	ditto	North of Evliya Tepe
25. Andesite (altered)	ditto	Çalman
26. Dacite (altered)	ditto	Soğuksu Dere (A area)
27. Dacite (altered)	ditto	Zıyaret Tepe
28. Basaltic andesite	Kırıklı Formation	Kırıklı
29. Hyperthene-augite basaltic andesite	ditto	Yeniköy
30. Basaltic andesite	ditto	Loncunos

Table 4 Coordinates of Whole Rock Chemical Assay

Sample No.	Coordinates			Map Name	No.
	X	Y	Z		
H- 1	44 79 200	5 40 150	1,140	Trabzon	H 42-b_2
H- 3	44 78 750	5 40 750	1,140	Trabzon	H 42-b_2
H- 5	44 78 700	5 40 950	1,150	Trabzon	H 42-b_2
H- 6	44 75 050	5 45 050	1,210	Trabzon	H 43-a_1
H- 7	44 75 050	5 45 050	1,210	Trabzon	H 43-a_1
A- 2	44 65 100	5 29 000	1,610	Trabzon	H 42-b_4
A- 3	44 65 100	5 28 875	1,610	Trabzon	H 42-b_4
A- 5	44 64 800	5 28 800	1,620	Trabzon	H 42-b_4
T-107	44 67 000	5 13 400	1,980	Trabzon	H 42-a_3
E-198	45 17 800	4 95 100	650	Samsun	G 41-b_3
S- 69	45 07 600	5 03 450	560	Trabzon	G 42-d_1
E- 3	44 96 500	5 21 900	900	Trabzon	G 42-c_4
M- 30	44 89 800	5 29 775	1,400	Trabzon	G 42-c_3
H-141	44 96 475	5 42 975	2,400	Trabzon	G 42-d_2
Y- 2	45 00 050	5 42 950	1,700	Trabzon	G 43-d_1
H- 38	44 84 700	5 00 100	1,850	Trabzon	G 42-d_4
T- 1	44 80 050	5 06 000	1,840	Trabzon	H 42-a_1
E-202	44 67 600	5 12 325	2,350	Trabzon	H 42-a_3
E-201	44 67 000	5 12 950	2,100	Trabzon	H 42-a_3
H- 31	44 85 825	5 28 900	1,250	Trabzon	G 42-c_4
H-108	44 88 750	5 14 000	1,850	Trabzon	G 42-d_3
E-204	44 81 450	5 31 600	1,100	Trabzon	H 42-b_1
E-205	44 77 800	5 11 350	1,750	Trabzon	H 42-a_2
E-158	45 08 500	5 16 200	1,420	Trabzon	G 42-d_2
Y- 70	44 96 700	5 05 250	1,150	Trabzon	G 42-d_4
M- 74	45 04 000	5 14 150	930	Trabzon	G 42-a_4
E-113	45 02 500	5 14 350	1,650	Trabzon	G 42-d_2
A-172	44 67 250	5 47 750	1,410	Trabzon	H 43-a_4
A-173	44 62 950	5 41 000	1,550	Trabzon	H 42-b_3
E-203	44 69 900	5 18 800	1,500	Trabzon	H 42-a_3

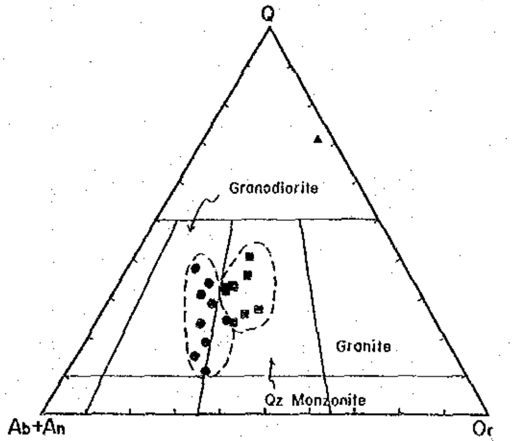


Fig.10 Classification of Granite Rocks

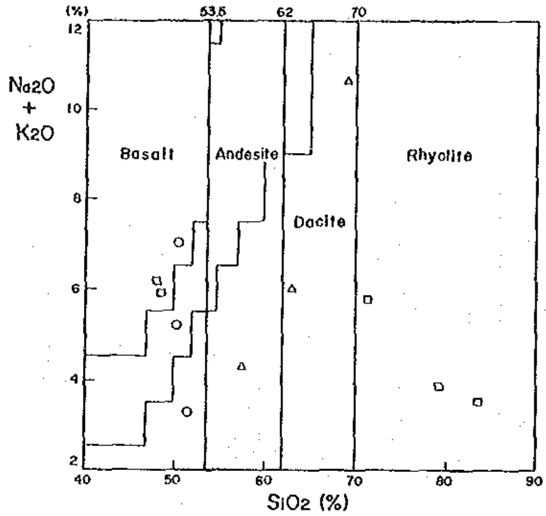


Fig.11 Classification of Volcanics

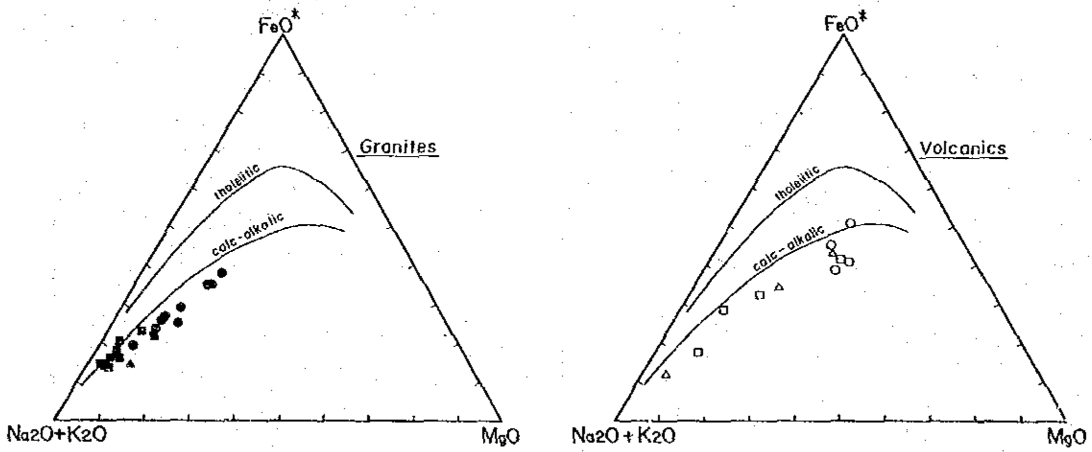


Fig.12 MFA Diagrams.

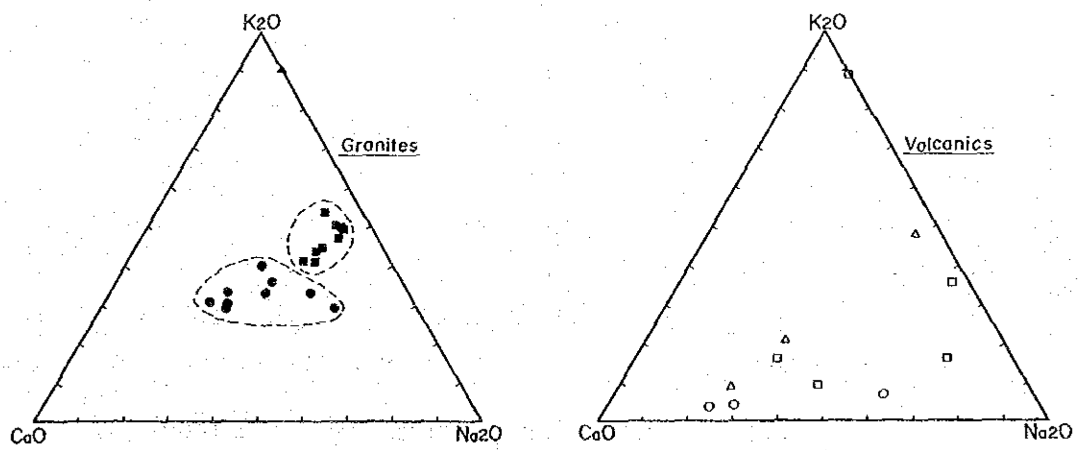
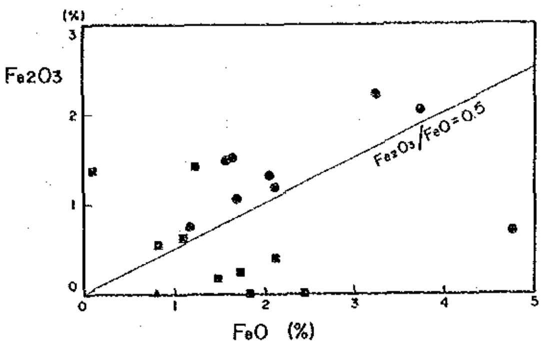


Fig.13 $CaO \cdot Na_2O \cdot K_2O$ Diagrams

Simbols in each figure are in same : See in Fig. 17.



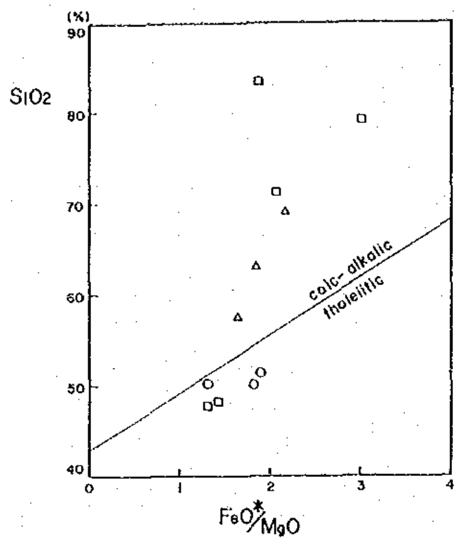


Fig.14 Fe_2O_3-FeO Diagram for Granitic Rocks

Fig.15 SiO_2-FeO$*$/MgO Diagram for Volcanics

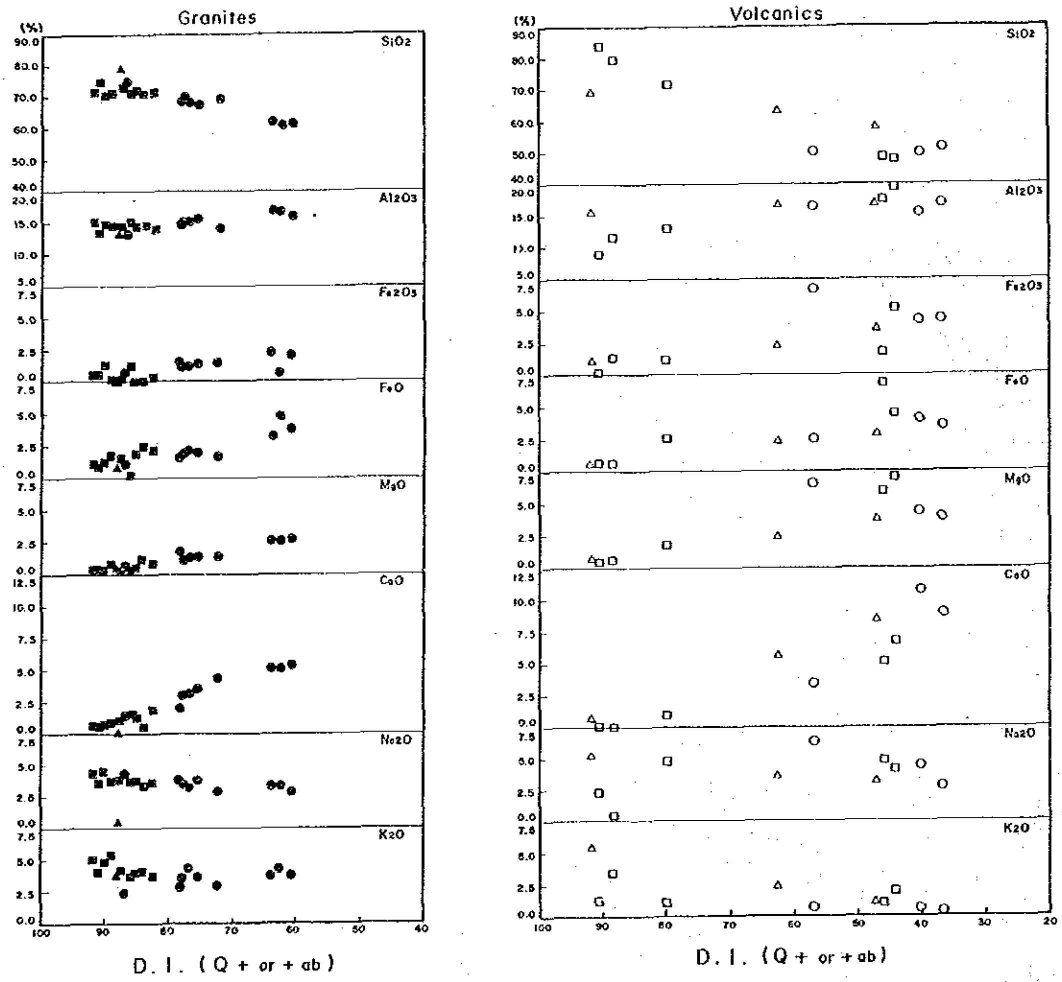


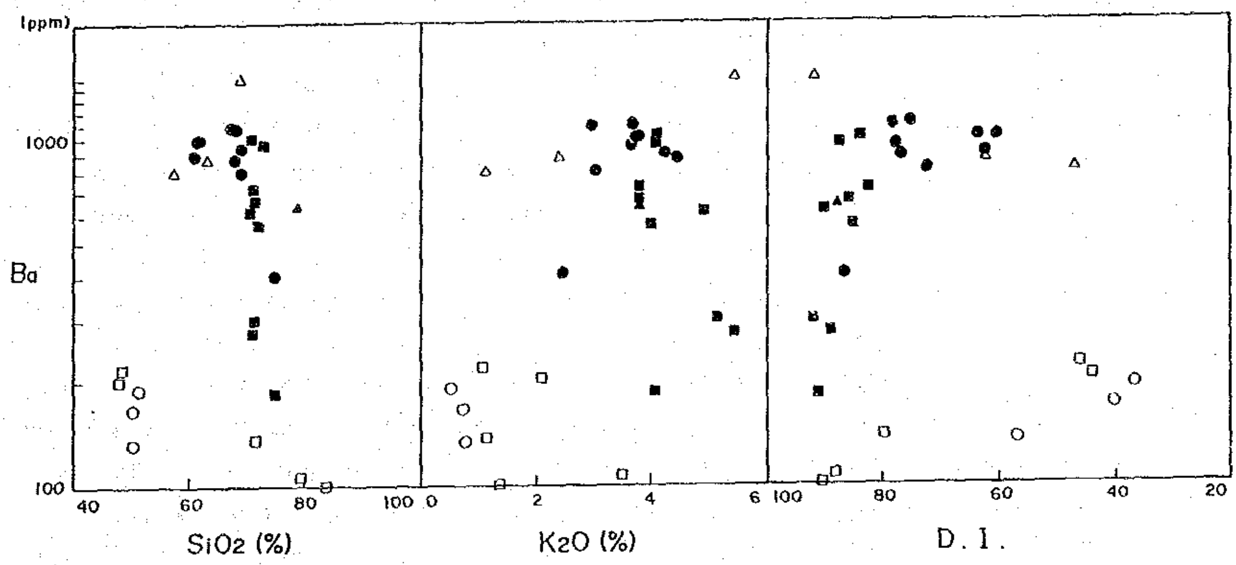
Fig.16 Variations Diagrams (D.I.- Oxides)

Simbols in each figure are in same : See in Fig. 17.

young granites lie in a relatively narrow range.

③ In granites, no correlation between Ba and SiO_2, K_2O was observed while Ba increases rapidly with high DI values.

④ Volcanic rocks can be divided into high and low Ba groups. Those of the Venk Yayla Formation have high Ba content, and positive correlation between Ba and SiO_2, K_2O, DI is observed while the volcanic rocks of the Zigana and Kirikli Formations have low Ba content with the relation between Ba and SiO_2, K_2O, DI being unclear.



Symbols (Same as in Fig.10～Fig16)

■ : Gümüşhane Granite

● : Younger Granitic rocks

▲ : Quartz porphyry dyke

△ : Venk Yayla Formation

□ : Zigana Formation

○ : Kirikli Formation

Fig. 17 Variation of Ba contents with SiO_2, K_2O and D. I.

Chapter 2 Mineralized Zones

2-1 General Outline

The major mineralization of the surveyed area is skarn, vein and dissmination. The major metal concentration is iron, copper, lead, zinc, molybenum, iron sulphides and barite. Most of the mineralization occurs in the Upper Cretaceous Zigana Formation or from the granodiorite intrusive bodies of the Zigana Formation. Skarn mineralization of this area is related to the limestone of the Zigana Formation. Iron minerals are predominant in most cases as in the case of the Demirdere mineralized zone, but copper, lead and zinc minerals are associated in some localities for example at Belen Tepe. Vein type (fissure-filling) mineralization occurs very widely from the Gümüşhane Granite and Kırikli Formation in the lower horizon to the Venk Yayla Formation in the higher part. The deposits are small but of high grade and the ores are copper, lead, zinc, silver, antimony and barite. The general trend of these veins are E-W. Typical vein deposits of this area are the Köstere (Cu, Pb, Zn) mine, the Mastra argentiferous galena mine and the Midi sphalerite mine. Only the Midi mine is presently worked. Stibnite veins were discovered recently at the Avliyana mine, but only trenching was conducted. Barite is found in Gümüşhane Granite and high grade veins consisting only of barite are of relatively small scale. Barite has been mined recently and detailed prospecting is being conducted by MTA in this area.

Metal dissemination in this area is related to Tertiary granodiorite and the mineralization occurs from the granodiorite stock to the Zigana Formation in the vicinity. Mineralized zones are at Güzelyayla (Mo,Cu), Karadağ mine (Cu, Zn), Beşkise, Sarıdere, and Degermen dere (all pyrite). Güzelyayla is noted as a porphyry copper type mineralization.

Many bedded deposits are known in the Pontids Fold Bell and mineralization in the Upper Cretaceous acidic rocks is reported to be Kuroko type, although the age is different from those of Japan. In the Trabzon area immediately north of the the surveyed area, mineralization similar to the Kuroko type is reported from the 1974～1976 survey, but in the present area, only the İstra mineralized zone is of similar nature. The outline of the mineralization of the surveyed area is laid out in Fig. 18 and Table 5.

2-2 Main Mineralized Zones

<u>Avliyana mineralized Zone</u> : This zone is located 1km southwest of Avliyana

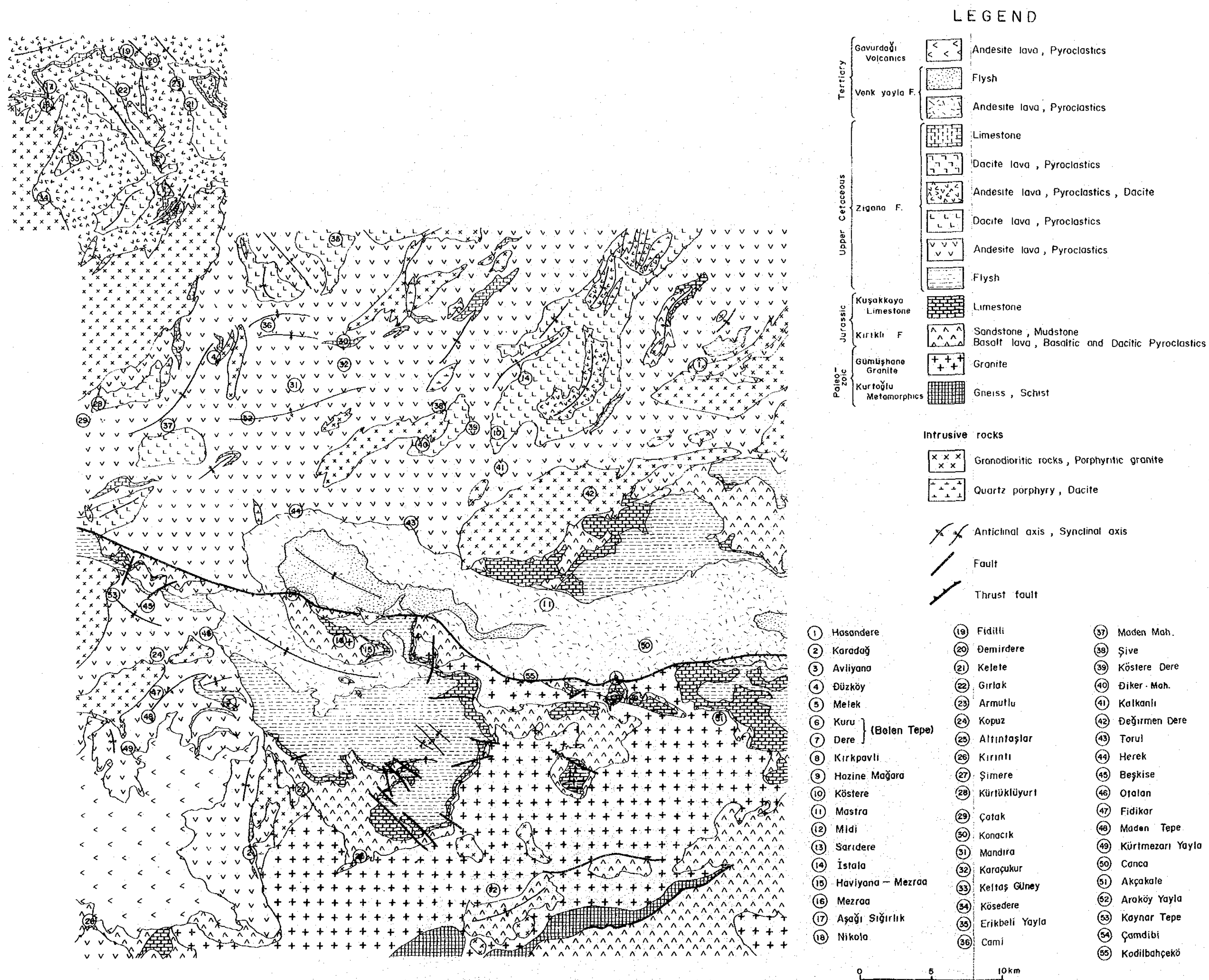


Fig.18 Distribution Map of Mineral Occurrences

Table 5 List of Mineral Occurrences

NO NAME	LOCATION	FORMATION	KIND OF MINERAL DEPOSITS	HOST ROCKS	TYPE OF MINERAL DEPOSITS	THICKNES OF WIDTH	ORE MINERAL	GANGUE MINERALS	GRADE OF ORE	DIRECTION OF VEIN STRIKE DIP	REMARKS
1 Hasandere	Hamsiköy Güzelyayla	Pgl Zigana	Mo,Cu	Porphyritic granite Andesite	Dissemi.	1.7km× 1.4km	Molybdenite Chalcopyrite Pyrite				Soil sampling by MTA
2 Karadağ	Galiz Dere	Zigana	Cu,Pb,Zn, Fe	Basaltic Andesite	Dissemi.		sphalerite Oxide copper Galena	Quartz Garnet Epidote			Float of slag
3 Avliyana	Avliyana	Intrusives Zigana	Sb	Qz porphyry Andesite	Vein	wd:+20cm	Stibnite Cinnabar	Quartz Clay	Sb_2S_3 60%	N70° W,80° N	
4 Düzköy	Düzköy	Zigana	Fe,Pb	Limestone Andesite	Skarn		Specularite Galena Chalcopyrite	Calcite Garnet Epidote			
5 Melek Maden	Deregözü (Kürtün)	Zigana	Fe,Cu	Limestone Andesite	Skarn	wd;2.0m	Specularite Magnetite Chalcopyrite	Actinolite Epidote Garnet	Cu:1~2%		
6 Kuru Maden (Belen Tepe)	Deregözü (Kürtün)	Zigana	Cu,Pb	Limestone Andesite Granodiorite	Skarn		Chalcopyrite Galena Specularite Pyrite	Actinolite			Gallery ; direction N60° E
7 Dere Maden (Belen Tepe)	Deregözü (Kürtün)	Zigana	Cu	Limestone Andesite	Skarn		Chalcopyrite Pyrite		Cu:1-2%	N40° W 30° NE	
8 Kirkpavli	Eski Gümüşhane	Kirikli	Au,Ag	Limestone	Vein	<1.0m	Pyrite	Quartz	Au:3-5g/t Ag:16-22g/t		
9 Hazine Mağara	Eski Gümüşhane	Kuşakkaya	Ag,Pb,Cu	Limestone	Replace- ment		Tetrahedrite Pyrite Galena	Barite		N70° W,40° S?	
10 Köstere	Kalkanlı Zigana Dere	Zigana	Pb,Cu,Zn	Dacite	Vein	wd;3.5m ℓ;50m	Galena Chalcopyrite Sphalerite Pyrite	Quartz Clay	Cu:2-3% Pb+Zn:10%	N85° W 60° N	3 old galleries and dumps
11 Mastra	Mastra Mah.	Venk Yayla	Ag,Pb	Andesite	Vein	wd;20cm ℓ;40-80m	Galena Sphalerite Chalcopyrite Pyrite	Quartz Clay		80° S E-W~ 80° N	Shut down last year
12 Midi	Midi Mah. Talanlar D.	Kırıklı	Zn,Pb	Basalt~ Basaltic tuff	Vein	wd;2-10m ℓ;100m+α	Spahlerite Galena Smithsonite	Epidote Clay Quartz Calcite	Zn:20%	N80° E 60~70° N	Working mine, another skarn zone with Pb+Zn
13 Sarıdere	Eski Gümüşhane	Grano- diorite	Py	Granodiorite	Dissemi.	2kmX1km	Pyrite	Quartz			Soil sampling by MTA Argillization
14 İstala	İstala Mah.	Zigana	Cu,Pb,Zn	Dacite	Massive	1.0m-2.5m	Galena Chalcopyrite Pyrite	Quartz Clay		S10° W 65° W N80° W 50° S	Vein along fault
15 Haviyana- Mezraa	Haviyana Mah. Acısu D.	Kırıklı	Ba,Pb,Cu	Basaltic andesite	Vein	Wd:3.0m ℓ:5m+α	Galena Chalcopyrite Tetrahedrite Pyrite	Barite Quartz		N50° W,60° SW	Quartz veinlets with limonitiza.
16 Mezraa	Mezraa Mah. Mezraa D.	Gümüşhane granite	Ba,Pb	Granite	Vein	Wd:1-1.5m ℓ:100+α	Sph.,Py. Gal.,Chal.	Quartz Barite		N50° E 50° NW N70° W 50° SW	3~5 old trenches
17 Asağı Sığırlık	Gülpınar Mah.	Zigana	Fe,Cu	Limestone Andesite	Skarn		Malachite Azurite Pyrite				N40° W of old gallery
18 Nikola	Çatak Köyü	Zigana	Fe,Cu	Limestone Andesite	Skarn	ℓ:3-4m	Specularite Magnetite Malachite	Epidote		E-W 35° N	
19 Fidilli	Karabörk Mah.	Zigana	Fe	Limestone Andesite	Skarn	+50cm	Specularite Magnetite Oxide copper	Actinolite Epidote	Fe:25%		
20 Demirdere	Deregözü (Görele)	Zigana	Fe	Limestone Andesite	Skarn		Specularite Magnetite	Actinolite Epidote	Fe:40%		
21 Kelete (Deregözü)	Deregözü (Görele)	Zigana	Fe,Cu	Limestone Andesite	Skarn		Specularite Chalcopyrite Pyrite				
22 Gırlak	Karabörk Mah.	Zigana	Fe	Limestone Andesite	Skarn	10cm-1.0m	Specularite Magnetite Oxide copper	Actinolite Epidote			
23 Armutlu	Deregözü Mah.	Zigana	Cu	Dacite Limestone	Vein		Chalcopyrite Specularite Pyrite	Quartz	Ag:2.0-170 g/t Cu:1% Zn:1%	N55° W 90°	wd:15m mineralized zone
24 Kopuz	Kopuz Mah.	Zigana	Fe	Limestone Andesite	Skarn	?	Magnetite	Epidote	Fe:67%		
25 Altıntaşlar	Kocadal Köyü	Kırıklı	Cu	Dacitic tuff	Vein	wd:0.5m ℓ:100~ 200m	Chalcopyrite Pyrite	Quartz	Cu:9.80% Pb:0.20% Zn:0.40%	N-S 70~ 80° E	
26 Kırıntı	Kırıntı Yayla	Kırıklı	Pb	Andesite	Vein		Pyrite Galena				Old dump
27 Şimere	Şimere Mah.	Kırıklı	Cu,Ba	Andesite	Vein		Chalcopyrite Pyrite	Barite			Old dump
28 Kürtüklüyurt	Kürtüklüyurt Yayla	Zigana	Fe	Limestone Andesite	Skarn	wd:1.5m ℓ:5-10m	Specularite Magnetite	Epidote Actinolite			
29 Çatak	Çatak Yayla	Zigana	Fe	Limestone Andesite	Skarn		Specularite Magnetite	Epidote Actinolite			Old gallery
30 Konacık	Büyük Yayla	Zigana	Fe,Cu	Andesite	Skarn	wd:0.5-1m	Pyrite Oxide copper Sphalerite	Epidote			Slag
31 Mandıra	Mandıra Mah.	Zigana	Zn	Andesite	Vein	Wd:0.5-1m ℓ:50-60m	Pyrite,Spha. Chalcopyrite	Quartz		N85° W, 65~86° N	
32 Karaçukur	Dolumlu Mah	Zigana	Fe	Andesite Limestone	Skarn		Magnetite Specularite Pyrite	Actinolite Tremolite		N60° E	Old dump Old gallery (100m)
33 Keltaş güney	East of Dereyatak Mah.	Zigana	Cu,Fe	Dacite	Vein		Malachite Py. Chalco.	Quartz			
34 Kösedere	Piredil Mah.	Zigana	Fe	Limestone Andesite	Skarn		Magnetite	Epidote			
35 Erikbeli Yayla	Virankilise Tepe	Zigana	Fe	Dacite Andesite	Dissemi.		Pyrite				Argillization
36 Cami	Cami Mah. (Kürtün)	Zigana	Fe	Andesite	Dissemi.		Pyrite Malachite				
37 Maden Mah.	Maden Mah.	Zigana	Fe,Cu	Andesite	Vein		Pyrite Malachite	Quartz		N45° E,60° NW	Old gallery
38 Şive	Şive Mah.	Zigana	Fe	Andesite Granodiorite	Dissemi.		Pyrite				Silicifi. Argillization
39 Köstere Dere	Ayur Dere	Zigana	Fe,Cu	Andesite	Dissemi.		Oxide Copperr				Silicifi. Argillization
40 Diker Mah.	Kızılcık Mah.	Granodiorite	Fe	Granodiorite	Dissemi.		Pyrite				Silicifi.
41 Kalkanlı	Kalkanlı Mah.	Zigana	Cu,Fe	Andesite,Lim. Granodiorite	Skarn Dissemi.		Py. Mag.Specul. Oxide copper				Argillization
42 Değirmen Dere	Küplü Mah.	Granodiorite	Fe	Granodiorite	Dissemi.		Pyrite				Silicifi. Limoniti.
43 Torul	Torul	Zigana	Cu,Fe	Andesite	Dissemi.		Oxide copper				Silicifi.
44 Herek	Herek Mah.	Zigana	Cu,Fe Zn	Andesite	Dissemi.		Oxide copper				Silicifi. Argillization
45 Beşkise	Beşkise Granodiorite	Zigana	Fe	Andesite Granodiorite	Dissemi.		Pyrite				Silicifi. Limoniti.
46 Otalan	Otalan Mah.	Zigana	Fe	Andesite	Dissemi.		Pyrite				Silicifi.
47 Fidikar	Fidikar Mah.	Zigana	Fe	Andesite	Dissemi.		Pyrite				Silicifi.
48 Maden Tepe	South of Fidikar	Zigana	Fe	Andesite	Dissemi.		Pyrite				Limoniti.
49 Kürtmezarı Yayla	South of Fidikar	Zigana	Fe	Andesite	Dissemi.		Pyrite				Argillization
50 Canca	Davunnu Mah.	Venk Yayla	Fe	Andesite	Dissemi.		Pyrite				Argillization Limoniti.
51 Akçakale	Aşağı Mah.	Gümüşhane granite	Cu,Zn Ba,Pb	Granite	vein		Chalcopyrite Galena Pyrite	Barite			
52 Araköy Yayla	Araköy Yayla	Zigana	Cu,Fe	Andesite	Dissemi.		Oxide copper pyrite				Silicifi.
53 Kaynar Tepe	Kaynar Tepe	Zigana	Fe	Limestone	Skarn		Specularite Hematite				
54 Çamdibi	Çamdibi Mah.	Zigana	Cu	Andesite	Vein	Wd:10cm	Chalcopyrite Oxide copper	Quartz		N20° W	
55 Kodilbahce köyü	Kodil Mah.	Gümüşhane granite	Fe	Granite	Skarn?		Specularite Magnetite				

Village and veins are developed on both sides of the Avliyana Dere. Granodiorite and quartz porphyry have intruded into the Zigana Formation. Antimony mineralization along the fissures of the intrusive body was found recently. Trenching was conducted at the limonite zone (50cm wide) on the western slope, and stibnite was found in Trench Nos 1 and 2 at the silicified part of the granodiorite. The stibnite is massive, 2～10cm, and minor amount of cinnabar are associated. Romeite 【$(Cu, Fe, Mn, Na)_2(Sb,Ti)_2O_6(O,OH,F.)$】 was identified by X-ray diffraction. This is a secondary oxidized mineral of antimony and occurs here associated with stibnite.

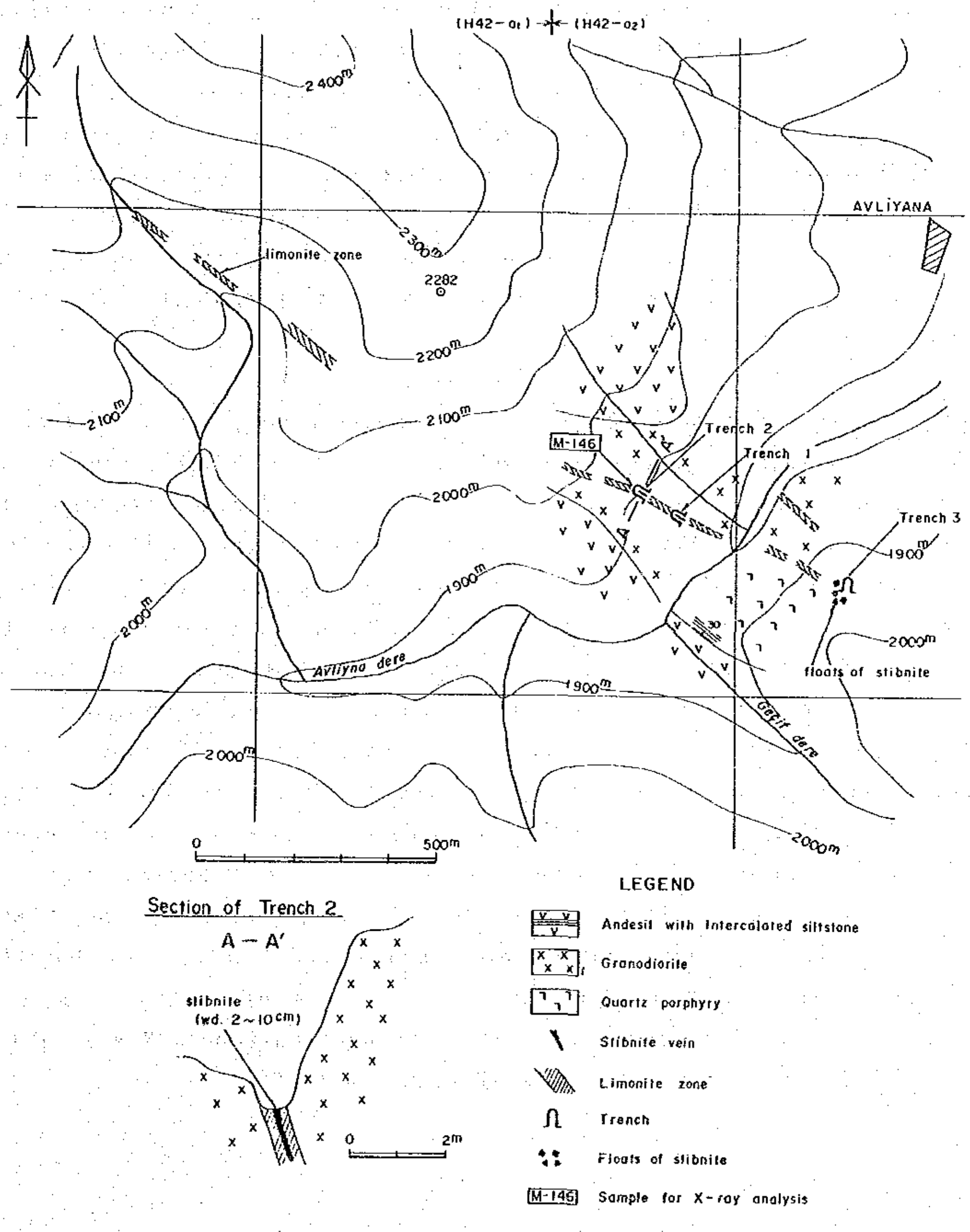


Fig.19 Geological Sketch of the Avliyana Mineralized Zone

The strike of the vein is N70 ° W and dip 80° N. Trench 3 was dug on the other side, the eastern slope, but ore minerals have not been found. Some of boulders on the eastern slope, however, are good ores and it is inferred from these that the veins here would be more than 20cm wide massive ores. The distance between the No.2 trench on the western slope and the boulders on the eastern side is about 500m and including the limonite zone of the west it will be even larger. The eastern extension is a forest and covered by soil. Thus the extension or outcrops are not known. The boulders indicate that the mineral showings on the eastern side should be significant .

The results of the geological survey show that although thin, the veins are firm and the grade is estimated to be higher than 60% Sb. The width of this zone of veins varies considerably, but it is continuous and has the characteristics of an area of minable deposits. Also in the vicinity, there is a parallel limonite zone and there is a possibility of antimony veins in the lower parts (Fig.19). The discovery of romeite provides a clue as to the behaviour of antimony during oxidation and it is expected that the element would be fixed in the soil as romeite. There is a possibility that this mineral will be useful for geochemical prospecting.

Belen Tepe mineralized zone : This zone is distributed at an elevation of 1,600～2,000m, 10km north～northwest of Kürtün. The mineralization is iron, copper, lead, zinc skarn. Many mineral showings and old mines are distributed in an area of 3km E-W, 2km N-S around the Belen-Tepeyurt mountains in the southeastern part of A Zone. The access to this locality is by timber road from Kürtün through Mindidi to Alanobası Yayla, then by foot for about an hour.

The geology of the area mainly consists of Upper Cretaceous andesitic pyroclastics, massive limestone (A2, Zigana Formation) and granodiorite which intruded into the former. Mineralization is developed at the contact between the limestone and the andesitic rocks. The limestone is diveded into two horizons. The thickness are both in the order of several tens of meters to over one hundred meters and the layers are more or less horizontal. The granodiorite body is in a NE-SW direction and is a part of the "Kürtün Batholith" which is developed on a large scale from Kürtün to Dogankent. This mineralized zone consists of mineral showings and old mines. They are, from the north : Dere mine, Kuru mine, old adit near Sulucaoba Yayla, old adit east of Körrükalanabası Yayla and others (Fig.20, Table 5).

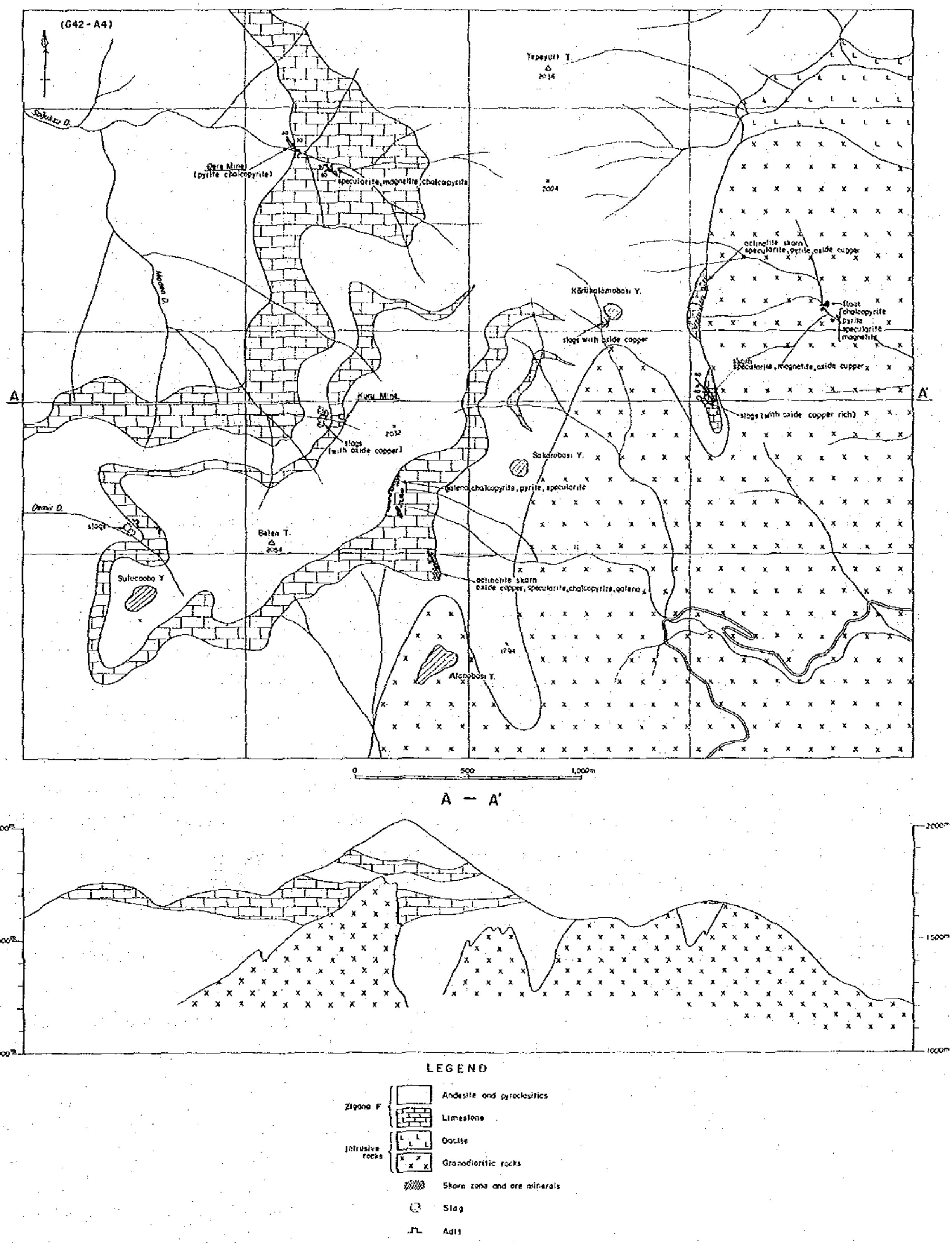


Fig. 20 Geological Map of the Belen Tepe Area

Kırkpavli mine : This mine is located at Eski Gümüşhane, elevation 1,350m, and 3km west of Gümüşhane City. The deposit is vein type and the Kırıklı Formation is the country rock. The subsurface geology consists of limestone, andesite, and conglomerate (not observed on surface, inferred to be pyroclastics from 1937 data). There is a silicified zone of approximately 20m and quartz veins containing large amounts of pyrite occur in this zone. According to old documents, this mine had a cross cut extending 250m and four drifts which were all short. This is due to the quartz-pyrite veins which are not continuous. The width of the veins are not known. The assay of samples collected from the left and right walls of the silicified zone show Au 3.2/t, Ag 16g/t, Pb 0.8%, Zn 0.2% and Au 4.9g/t, Ag 22.5g/t, Pb 0.0%. It is not clear from the documents of Kovenko (1937) how much gold and silver were mined (Fig.21).

Hazine Mağara mine : This mine is located 1km southwest of Gümüşhane City, at 1,500~1,620m above sea level. This is a replacement deposit formed by the brecciation of Kuşakkaya Limestone by parallel E-W trending faults and galena and pyrite mineralization in the matrix. Underground mining was done by joining the adits 80m below the outcrops. Most of the ore bodies consists of massive pyrite with local concentrations of galena and tetrahedrite. D'Andria of MTA surveryed the deposit in 1940 and reported that its major constituent is pyrite and that the dimensions are 100m long, 5m thick and 100m in dip direction. The reserve is 200,000t with the grade of Au 2.55g/t, Ag 89g/t, Cu 0.8%, Pb 3.04%, Zn 2.0%. The silver content is high where tetrahedrite is concentrated, up to Ag 1600g/t. Also, the orebody was confirmed by two drill holes and the extent of the orebody was determined to be 75m N55 ° W, 1.6m wide with an average grade Pb of 5.03%. It is thought to be the continuation of a signal orebody, but the relationship of the data is not completely clear. The basement consisting of Gümüşhane Granite occurs below the ore deposit, and the ores occur only where the Kuşakkaya Limestone has dropped by faults. Therefore, the downward extension of the orebodies cannot be expected (Fig.22).

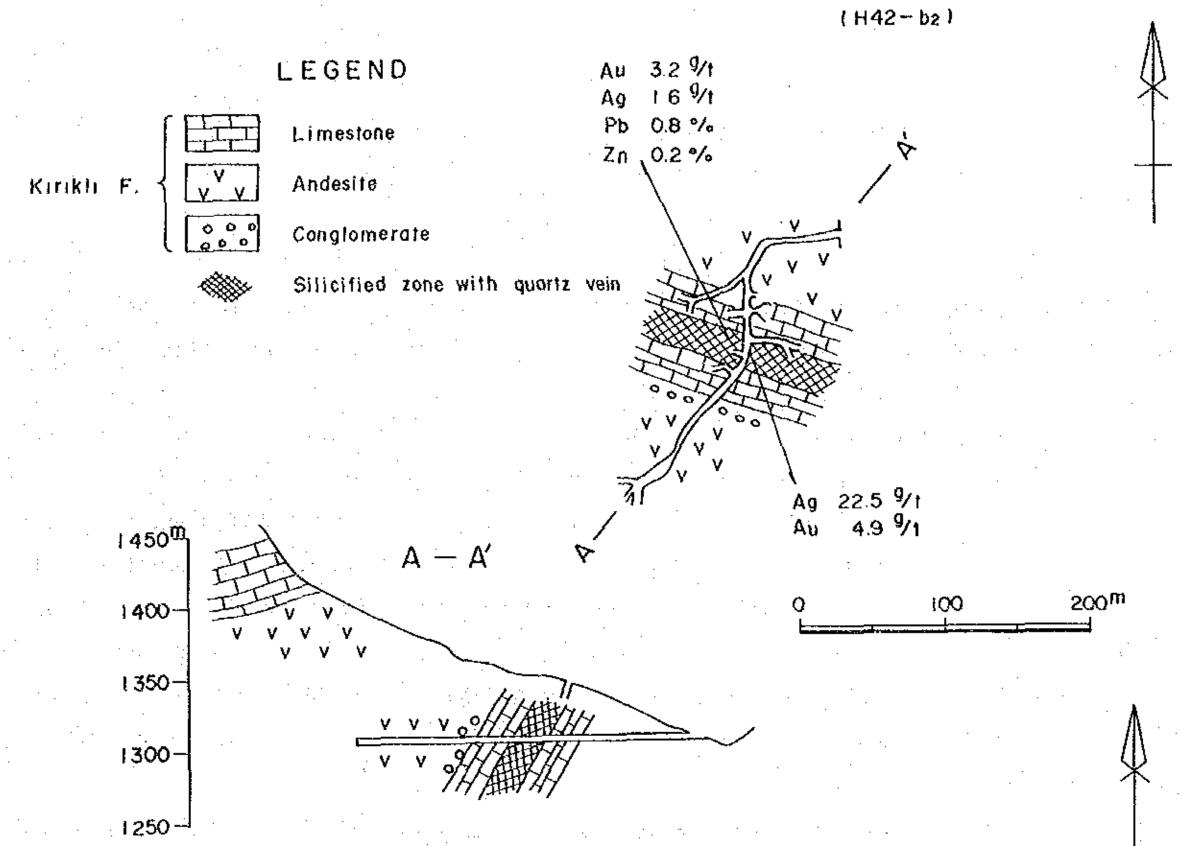


Fig.21 Compilation Map of the Kırkpavli Mine

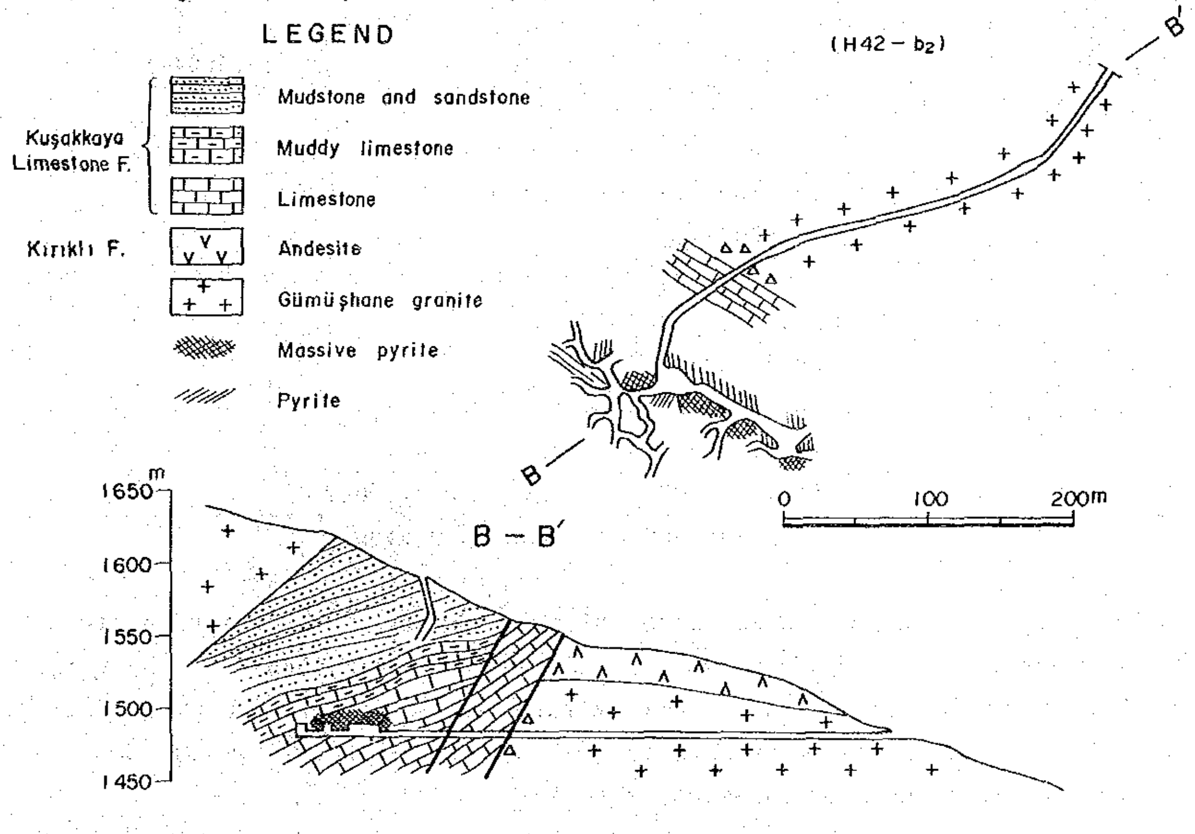


Fig.22 Compilation Map of the Hazine Mağara Mine