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CONTENTS

Cover Picture:Pseudoumud Cracks (Photo taken by Fethi SABUNSOY)

Dear Colleagues,

In this issue of our bulletin, besides the other articles, you will find a master thesis prepared by Mehmet Necdet under the control of his supervisor Asist Prof.Dr.Mesut ANIL. This thesis supported by the Post-graduate School of Science Project by Scientific Research Foundation of Çukurova University is the outcome of throughout study, which was carried out as a metallogenical and geological investigation of manganese occurrences observed around the Balalan and Ziyamet villages placed in Karpas Peninsula of Turkish Republic of Northern Cyprus. At the same time, being the most current study in the field of geology took place in North Cyrus, it will be useful scientific reference resource for further studie on related subjects.

Evary day our publication is becoming more interesting and to have higher quality. We wish to take new supports from our collegues in Turkish Republic of Northern Cyprus.

We want to thank all people whose have assistances for our new issue and wait for their future supports.

Bektaş GÖZE
President
Union of the Chamber of the Cyprus
Turkish Engineers and Architects

To the Readers,

We are together again our new issue(16) that we know as a mission to train to you new developments in earthsciences in spite of some financial troubles of our chamber.

The importance of the energy, raw materials and technology which are the main movements for the developing countries to become more development, became more understanding today. The developments of the energy and technology manufacturing and together with them is are mission of the earth scientists to determine new metalic and raw materials presenting for the human usage.

In the first article "The Geological and Metallogenicel Study of Manganese Occurences in Karpas Peninsula(T.R.N.C.)"of Mehmet Necdet and Mesut Anıl points out the importance of this kind of mineralizations and the possibilities of enrichment of ancient deposits.

The next article "Paleozoic-Mesozoic Stratigraphy of Feke-Fekedağ (Adana) Area(Eastern Taurus)"prepared by Cengiz Yetiş explains a series of rock units largely from Paleozoic to Tertiary.

The third article "The Geomechanics Classification(RMR System) of the Zabuk Quartzites around Sır Damsite " prepared by Cavit Demirkol states that the structural discontinuites of the low grade Cambrian aged rocks and the rock mass classes of the Zabuk Quartzites.

The last article "Etude Géologique et Gitologique du District Polymetallique(Pb-Zn-Cu-Ag) de la Région de Kalkım-Handeresi-Karaaydın(Presqu'ile de Biga-Turquie)" prepared by Mesut Anıl describes the some mineralization properties of the study area.

Yours sincerely
Olgun ÜSTÜN
Editor

YERBİLİMCİNİN SESİ | MART 1988 | Sayı 16
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THE GEOLOGICAL AND METALLOGENICAL STUDY OF MANGANESE OCCURENCES IN KARPAS PENINSULA TURKISH REPUBLIC OF NORTHERN CYPRUS(x)

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SUMMARY

In this study manganese occurences having volcanic and sedimentary origin around the villages of Ziyamet and Balalan and the geology of Mehmetçik and Ziyamet Areas were investigated on the border of T.R.N.C.(Turkish Republic of Northern Cyprus).

Hilarion Limestone(Jurassic), Lapithos Formation(Upper Cretaceous),Pillow Lavas(Paleocene), Kythrea Formation(Middle Miocene), Pakhna Formation (Middle Miocene),Nicosia Formation(Lower Pliocene), Beach Deposits and Alluvium which derived from these different lithological units at the beginning of Pleistocene, were observed in the area under investigation.

The structural geology of the study region is related to the tectonics of Kyrenia Range and also the authoctonous units have NE-SW trend.

The pillow lavas placed north of Balalan have spilitic and spilitic basalt characters. Manganese deposits which are found along a discontinous zone in pillow lavas have Pyrolusite, Psilomelane and Polyanite.

The sedimantary manganese occurences are found as nine separate levels among marl,chalk and limestones of Pakhna formation outcropping in the south of Ziyamet. A lot of microfossils were identified and the spaces of microfossils filled with Psilomelane.

(x) This study was supported in the Postgraduate School of Science Project by the Scientific Research Found of Çukurova University

The gypsum depositions situated in the southern district of study area and copper mineralizations located in the westhern front of pillow lavas are of interest.

ÖZET

Bu çalışmada K.K.T.C.(Kuzey Kıbrıs Türk Cumhuriyeti) sınırları içindeki Karpas Yarımadısının Ziyamet ve Balalan köyleri çevresindeki volkanik ve sedimanter türdeki manganez zuhurları ile Mehmetçik-Ziyamet alanının jeolojisi incelenmiştir.

İnceleme alanı içinde gözlenen birimler; Hilarion Kireçtaşı(Jura),Lapta Formasyonu(Üst Kretase), Yastık Lavları(Paleosen),Değirmenlik Formasyonu (Orta Miyosen),Pahna Formasyonu(Orta Miyosen),Lefkoşa Formasyonu(Alt Pliyosen) ile Pleistosen'den itibaren bu birimlerin aşınmasından türeyen plaj çökelleri ve alüvyondur.

İnceleme alanının yapısal jeolojisi Girne sıradağlarının tektonizması ile ilgili olup,otokton birimler KD-GB uzanımlıdırlar.

Balalan'ın kuzeyindeki spilitik bazalt ve spilitik karakterli yastık lavları içinde yer alan volkanik kökenli zuhur süreksizlik zonu içinde yerleşmiş olup, pirolüzit,pisilomelan ve polianit içerir.

Ziyamet'in güneyinde Pahna formasyonuna ait marn,tebeşir ve kireçtaşları arasında 9 seviye halinde gözlenen sedimanter manganez zuhurlarına ait örneklerde mikrofoslller gözlenmiş olup,pisilomelan mikrofosil boşluklarını doldurmuş durumdadır.

İnceleme alanının güneyindeki jips yataklanması ile lavların batısındaki bakır cevherleşmeleri de ilginçtir.

1.INTRODUCTION

Cyprus has been interesting to many earth scientists regarding the evolution of geology. The previous investigations on the Cyprus geology have been started in the middle of 19 th century. Bergeat(1),Gaudry(2), realized some studies in English and French succesively. Paleontological observation were studied in English by Bate(3) and other investigations were done by Reed(4).

Cyprus geological map of 1/250 000 scale was published by Browne and Mc Ginty(5). After that time, many geologists(supported by the aid programme for developing countries of United Nations) came to island to study their own subjects about general geology and mineral oppurtinities. Up to the middle of 1970's,earth scientits from the U.S.A. and other European countries conducted excursions to the island.

Two geological associations can be observed on the island according to these studies. The first one, which is placed in Northern Cyprus, is Kyrenia Range and its surrounding geological units. Another one is Troodos Massif which contain volcanic and plutonic rocks placed at the southern Cyprus and its authoctonous and allochtonous units.

Some foreign geologists carried out many investigations dealing with the geology and mineral resources in Karpas Peninsula at the beginning of 1960's. Saucier(6) recorded small barite mineralization having the probable hydrothermal origin and forming small pockets which developed along the fracture zones. In addition to these, Horowitz and Supkow(7) studied eastern part of the area and found chalky manganese around Derince village, which is another part of the Ziyamet manganese occurences. They stated that manganese grade into these stratiform deposits reaches to 25 percent. Gypsum depositions comprising a large area at the southern district of the peninsula were

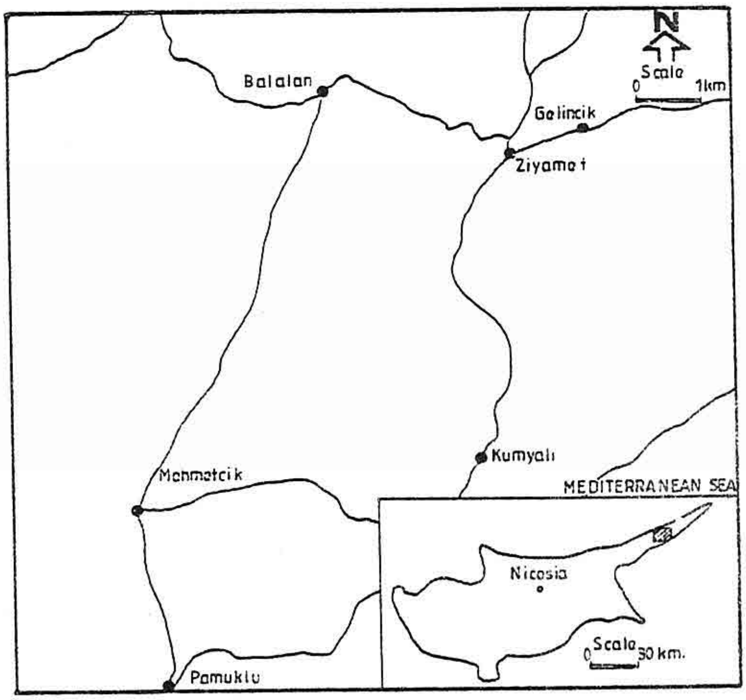

Figure 1. Location map of study area.

recorded by Saucier and Major(8) during their investigation period. During this investigation, a copper mineralization orginated and placed in pillow lavas was also determined in the western part of Balalan.

A small manganese mineralizations observed in pillow lavas exposed in the nortwest of Balalan and northern part of the study area(figure 1) were firstly determined in 1950. Manganese occurences having sedimantary origine which is the subject of this M.Sc. Thesis were firstly determined as nine separate levels Ziyamet by Cyprus Mines Company(C.M.C.) and Saucier and Major (8) carried out a detail study in this region and pointed out these occurences. Cyprus Mines Company carried out enrichment experiments on these low grade ores in 1963 but gave poor results. Then Dalkılıçlar(9) from M.T.A. realized some enrichment experiments on the samples picked up from these occurences. According to these test result, magnetic seperation method became succesful and it was possible to obtain manganese concentration having 40 percent grade.

Baroz(10) realized some investigations on pillow lavas occur in the study area and parallel to the volcanic rocks of Kyrenia Range. He indicated these alcaline type rocks beloging to the Paleocene volcanism different from the Maestrichtien volcanism having calcalcaline products in the western district,out of study area.

2.LITHOSTRATIGRAPHIC UNITS OF STUDY AREA

The Mesozoic,Tertiary and Quaternary formations outcrop in the study area(figure 2). These units are composed of limestone,chalk,sandstone, marl-chalk-limestone alternation and marl-calcarenites.

2.1.Hilarion Limestone

It outcrops about 2 km western part of Balalan being 200-250 m wide in the study area(figure 2). These limestones having the character of compact and breccia texture which is determined by sharp relief from light white to dark gray and include karstic caves.

It was placed over the Kythrea flysch as blocks when it was broken off from original unit of Kyrenia Range situated in the study area. These rocks outcropping widely along the summit of Kyrenia were aged as Jurassic by Henson et al.(11).

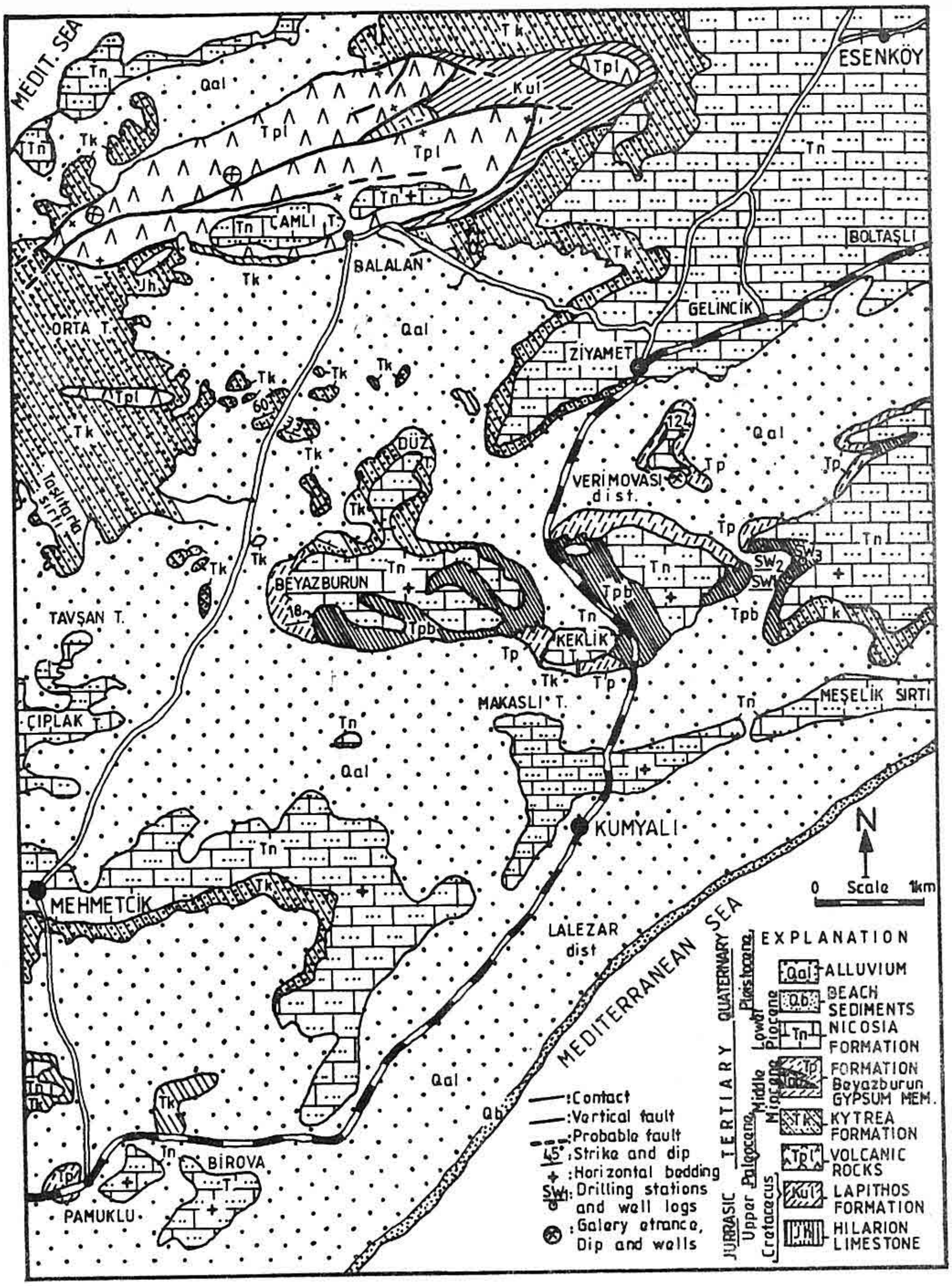

Figure 2— The geological map of study area (Revized from Cyprus Geological Map 1/100.000 scale of Bear (12)

2.2.Lapithos Formation

The Lapithos formation crops out in the eastern part of Balalan and northern coast in the study area. The Lapithos is made up predominantly of highly sheared and crushed white chalks with subordinate beds of compact limestones and chert. These chalks are often situated as relatively thin slices along the thrust planes, and normally have tectonic contact as thrust with Kythrea beds.

The general trend of formation is N 70^{0}E (figure 2) and it is not possible to estimate the thickness of formation because of formation because of being highly sheared and crushed. The estimated age of formation is given as Upper Cretaceous by Henson et al. (11).

2.3.Kythrea Formation

This formation is observed as commonly and crops out in the southern and northern flanks of Kyrenia Range. In the study area the formation is composed of marls around Mehmetçik, hard and thick beds of sandstones in the east of Balalan, marl and sandstones in the south and tuffs between the lava contact.

Any turbiditic marks have not been observed in the study area, and the general trend of formation is NE-SW and the dips are generally between 30^{0}-60^{0}, sometimes approximately 80^{0} to NW. The Kythrea contact between Nicosia and Pakhna is unconformable. The estimated thickness of the formation is more than 2000 m.

The paleontological examinations according to Mac Fadyen (13) and Weiler (14) are as below; Globigerina, Globigerinita, Hastigerina, Orbulina, Sphaerordinellopsis, Operculina sp., Borelis sp., Quinqueloculina and Globigerina sp. which all belong long to Middle Miocene.

Some thin section examinations on these rocks are given as follows;

. Sandstone consists of microcrystaline and rarely policrystaline quartz as 25-40 percent and feldspars, which are Ortose and Plagioclases composed of Albite and Oligoclase. Plagioclases are generally undestroyed and grain sizes smaller than 0,2 mm due to 15-20 percent of rock content. Carbonated rock fragments (5-10 %), Pyroxene (2-5 %), serpertinisized ophiolite and opaque minerals were also examined (Plate 1, figure 1).

. Limestone consists of great amounts of sparitic cement and a little amount of micritic cement. Most of the grains are intraclasts with quartz and a little amount of extraclasts are found. The Borelis sp. was also examined (Plate 1, figure 2).

. Marl named as Biolutite by Weiler (14) was examined as micritic matrix which contains Globigerinoides and Pteropoda in clayish bands and transits to greywacke.

. Tuff consists of small amounts of quartz and big and zoned Plagioclases in a vitreous matrix. Flowing marks and many different kinds of microlites, subparallel to these, and volcanic rock fragments having various texture were obviously observed too (Plate 1, figure 3).

For paleogeography, many authors (11,13,14,15,16) studied on Kythrea flysch and according to these authors opinion Kythrea flysch basin was a narrow sea trough and filled by turbidites. During the period of Oligocene-Miocene the sea was not too deep, the Ceyhan River delta, which is the source of turbidites, carried wildflaysch to both flanks of Kyrenia Range and created the basement of Kythrenia flysch basin. Emery et al. (17) explained the relations between Clicia trough and Kythrea basin which placed between Cyprus and Turkey. The evolution of Kythrea formation and the relations between Kythrea and Adana basins were given in figure 3.

According to the recent studies on the geological and tectonical evolution of Eastern Mediterranean, Eastern Mediterraean tectonism are very complex than the other Mediterranean Basins (18). The eastern mediterranean is marked by continental collision between Anatolia and Africa-Arabia. Allochtonous ophiolites in Cyprus in Cyprus and southeastern Turkey (Troodos-Kizil Dag-Kevan nappe, Biju-Duval et al.(19) are interpreted as obducted oceanic material from the Mesozoic oceanic area which was created between Africa-Arabia and Aegean-Anatolia (figure 4). Neogene infilling especially the salt layer is very thick. It has been affected by recent compressional tectonics until recent times (Misis-Kyrenia Ranges, South Cyprus-Florence Rise overthrust).

2.4.Pakhna Formation

This formation which contains sedimentary manganese occurences is made up of gypsum, marl, chalk having manganese, chalk and limestones.

Pakhna formation outcropping in the middle part of the study area has an unconformity contact with Kythrea formation. The gypsum series which are found as blocks in formation and are partly covered by the overlain younger sediments. Chalks including manganese layers having 10 to 15 cm

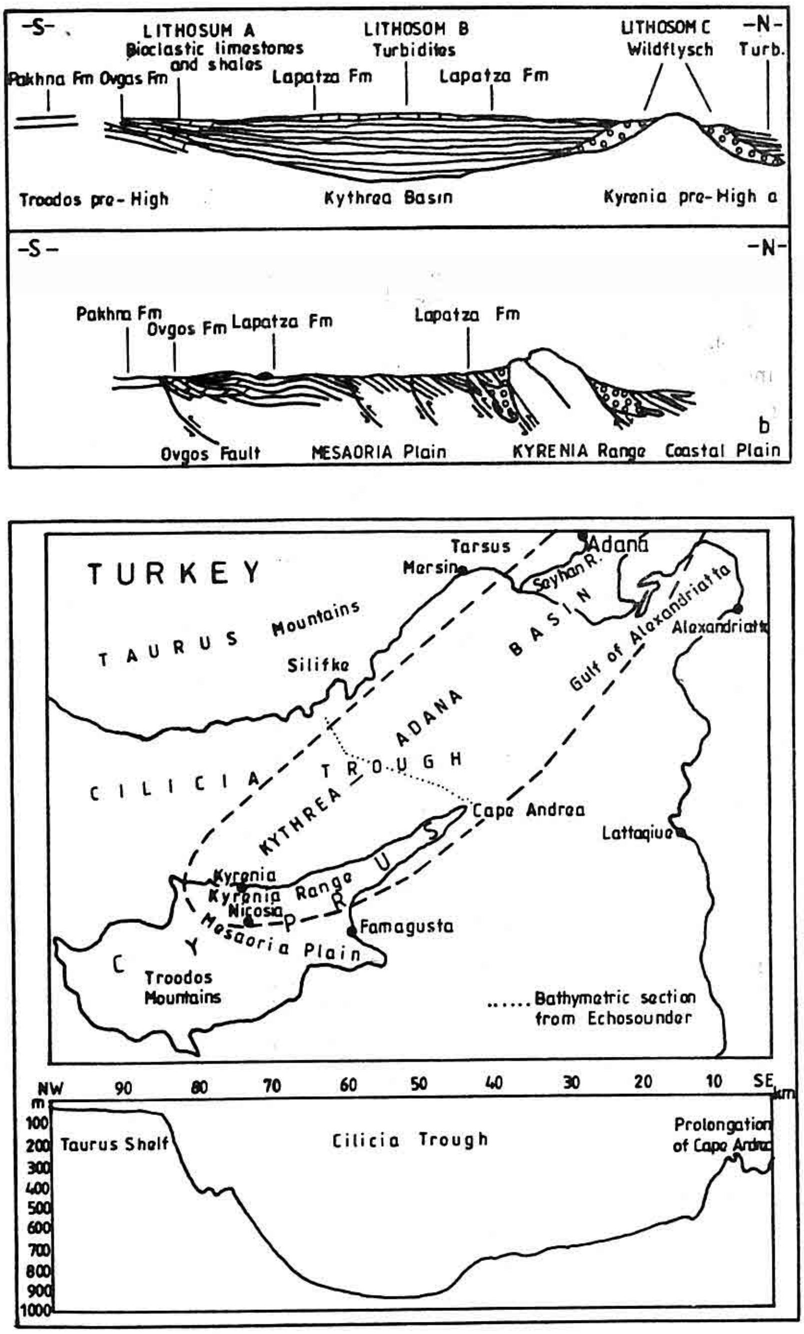

Figure 3.The evolution of Kythrea formation(on the top section) and the relations between Kythrea and Adana basins in schematic and hypothetic sections(14,20).

thickness are located in the upper parts of marls which are included by the formation and its contact with upper most Nicosia formation is unconformable.

In this formation observed as marl, chalk and limestones approximately 1 km southern at Ziyamet includes nine manganese levels which have 15-80 cm thickness.

The gypsum deposits crops out in the southern district, in some places deposits are covered by younger sediments.

The symmetry axial plane of Pakhna formation which displays an open asymmetrical syncline structure is parallel to the trend of Karpas Peninsula. According to the previous paleontological examinations on chalks and marls of formation and then they gave Middle Miocene from; Orbulina Universa d'Orbigny 1839, Orbulina bilobata (d'Orbigny) 1846, Globorotalia c.f. Scitula (Brady) 1882, Globigerinoides trilobus (Reuss) 1850 and also

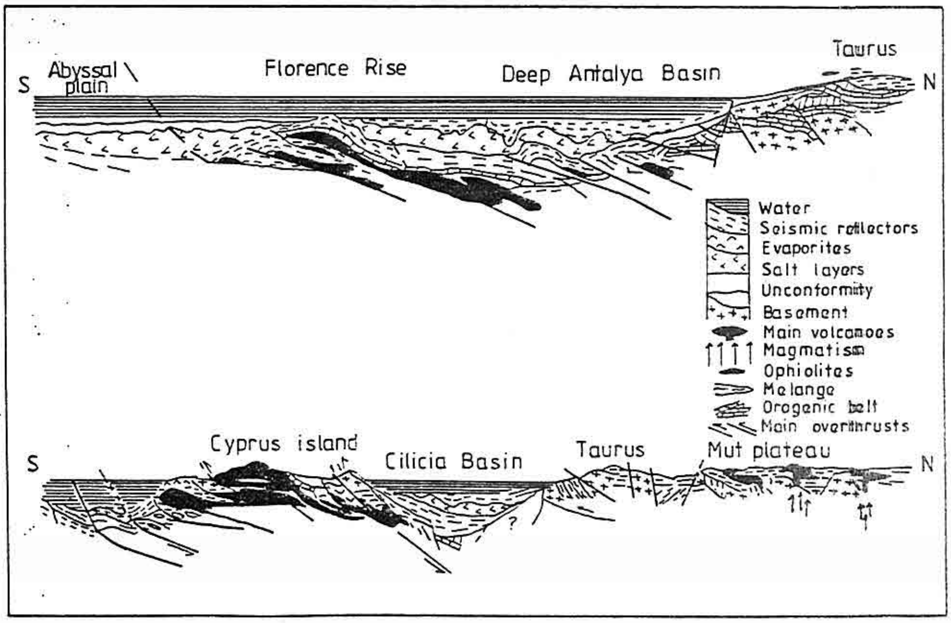

Figure 4. Interpretative geological cross-section through the Cyprus arc (from Biji-Duval and Montadert(21). Upper section: Florence Rise and Antalya Basin; Lower section: Cyprus and Cilicia Basin. Ophiolites and tectonic melanges of Cretaceous age in black.

examinations of chalk included by manganese levels, due to Globigerina venezuelena Hedberg, 1937; Globorotalia obesa Bolli, 1957; Globigerina sps,. Orbulina sp. and Globigerina sp.

The microscopic observations based on marl and chalk samples gave following results;

. Marl, 5-8 percent Globigerina, opaque (manganese) minerals and carbonate as cement material are observed. The chemical analysis done by Baroz (22) and Fluoresence method of X-rays indicate that these marls have strongly stable chemical composition.

. Chalk, 10 percent fossil remnants 3-5 percent opaque minerals and sparitization around microfossils are observed in this lithology having micritic cement (Plate 1, figure 4).

2.5.Necosia Formation

This formation which is observed widely in study area, covers the oldest units and crops out in the north of Balalan as overlying pillow lavas, thick cover Ziyamet, Gelincik, Boltaşlı and in the north of Kumyalı around Mehmetçik. Nicosia formation dip towards shore in the northern part of the study area are composed of calcarenite and marl layers.

Marl, which is light yellow, white and gray coloured, displays a contact towards bioclostical limestones created by Upper Pliocene regression and is observed as thick cover approximately 4 km south of Balalan around Ziyamet. Saucier (6) named as Athalasa formation for this various lithology.

Calcarenites are composed of sequence of beds having 10-20 cm thickness and towards the top silts and marls are placed.

Nicosia formation having 60 cm thickness was aged as Lower Pliocene by Lymbourides (23).

In the examination of samples belonging to that unit with high clay content, it is composed mostly of crystallized extraction limestone fragments, 50-60 percent sedimentary rock fragments and 20 percent microlitic basic lava fragments a little amount cement made up clayish micrite.

2.6. Caliches

These are generally observed as pockets, soft white coloured and partly chalky in Nicosia formation. Following a wet period, arid was effective in the region during Holocene, carbonaceous solutions increased towards the surface and they precipitated over the surface. They are signs for arid climate, and cause to hardnesses of contained rock.

These formations are observed near Ziyamet, the main road between Kumyalı-Ziyamet and around Mehmetçik in Nicosia.

2.7.Beach Sediments

In the southern district of study area, beach sediments were originated by the weathering of calcarenite and marl Nicosia formation. There are also pebbles which were carried from inner basins to the coast by small streams.

Volcanic pebbles originated from the weathering of pillow lavas as well as sands originated from the weathering of Nicosia are observed in the northern coast.

2.8.Alluvium

It is composed of clay and silt sized material accumulation over lower levels and derived from the formations placed in the study area as a result of weathering after Pleistocene.

3.STRUCTURAL GEOLOGY

The structural geology of the study area is related with tectonism of Kyrenia Range and Moore (24) pointed out that it developed towards the end of Miocene. Henson et al. (11) determined that younger tectonic movements destroyed the older tectonical marks.

The units observed mostly having general trend N 75^{O}E are due to confirm similarity of these ideas. Examples may be given for this case as; the fault which divides pillow lavas into two parts shows broken and crushed lithology which have conformable elongation with that trend, of Lapithos formation and serpentinite pebbles occured from a fault openning which observed at the bottom elevations of lavas.

The observation of tectonic marks are prevented by the Tertiary aged units because of their easily erroded lithology. The gypsum depositions placed over the Pakhna formation and being spread out towards the south verifies that this formation is a synclinal dipping to the south.

4.VOLCANIC ROCKS

The volcanic rocks are commonly pillow lavas having spilitic and spilitic basalt characters. The pillow lavas north of Balalan occur as 4x1,5 km area and characteristic pillow structure (Plate 1, figure 5). Volcanic breccias were observed in the SW of Balalan between the lavas and Kythrea contact.

Some examinations of thin sections on these rocks are concluded as follows;

. Spilitic Basalt, contains high percent Plagioclase displays microlitic texture Pyroxene, a few Olivines, sedondary calcite and spherolitic Zeolite were also observed (Plate 1, figure 6).

. Spilite, consists of high percent Plagioclase which has microlitic texture. The spaces among the Plagioclases are filled by calcite. Calcites are observed as synthetic twins and sometimes deltoitic. In addition to euhedral Olivine in the form of small grains distributed irregularly, subhedral Amphibole, Clorite and opaque minerals were also observed.

. Volcanic breccia, consists of ophiolitic gravels which were cemented by volcanic material. Serpentinisized ophiolitic fragments, spherolitic Zeolite, calcite filled the spaces, Plagioclases as phenocrystalls and small amounts of opaque minerals were observed too.

. Scarn, contains quartz and opaque minerals. Quartzes give as grift appearence and the spaces among the quartzes were filled by magnetite.

The stratigraphical section of study area is given in figure 5.

4.1.The Geochemistry of Volcanic Rocks

The chemical analysis results on basalts, spilites and spilitic basalts of study area were given in table 1. According to the analysis results, the geochemical characters of the volcanic rocks are given as follows;

. The criteria of Irvine and Baragar (26) in Na_2O K_2O - f(SiO_2) diagramme gives alcaline character (figure 6).

. In K_2O - SiO_2 diagramme (figure 7) (MgO content is very low and K_2O/Na_2O --- is generally lower than 0.58. This point gives us to compare the basalts between the shoshonitic series) the basalts have similar characters with shoshonitic series of island arc and the active continental margin.

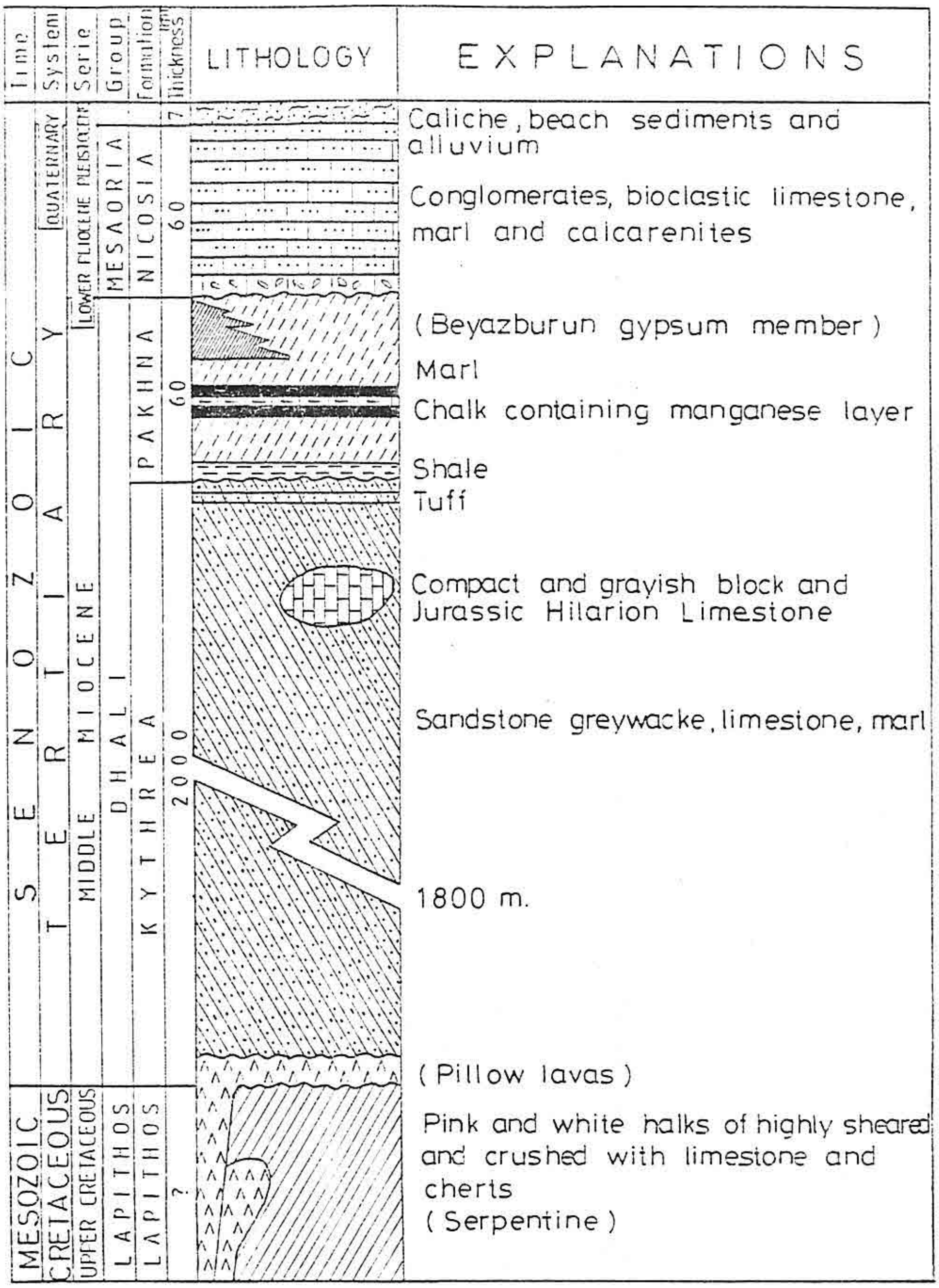

Figure 5. Stratigraphical section of study area (from Necdet) (25).

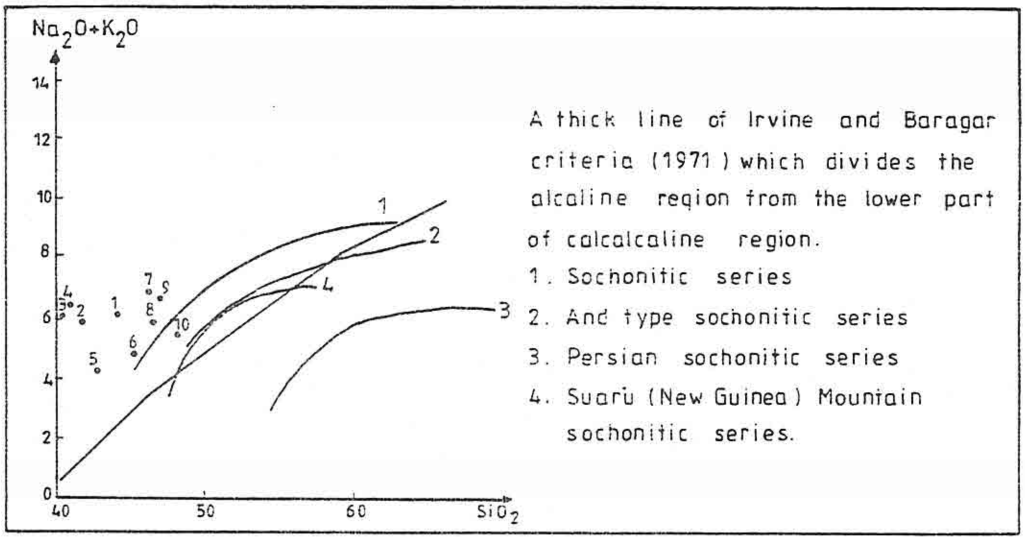

Figure 6.The distribution of Paleocene volcanics in alcaline diagramme(the points of 5-10 were taken from Baroz)(10).

- To the Green (27) diagramme (figure 8) the rocks present similar characters to the alcaline basalts and to the margin of the calcoalcaline series.
- In Church (28) diagramme (figure 9) results are placed in basalt part or its vicinities.
- According to the Gottini (29) diagramme (figure 10) these volcanic rocks have Simatic origin.

5.MINERALIZATIONS IN THE STUDY AREA

The main mineralizations in the study area are manganese occurences having volcanic and sedimentary origins,the gypsum depositions displaying lateral continuity and a small amount of copper mineralization.

5.1.The Balalan Manganese Occurence

This occurence belonging to the volcanic origin was determined in 1950's and then Saucier and Major (8) emphasized too. Some exploration rips were done on this occurence and then small tonages of ores were picked up.

Brute datas

Sample no. / Elements	1	2	3	4	5	6	7	8	9	10
SiO_2	37.00	35.80	33.46	36.71	31.60	36.90	35.00	38.50	36.80	37.70
Al_2O_3	12.50	13.80	12.70	14.60	13.80	15.80	16.00	14.85	16.40	15.60
Fe_2O_3	--	--	--	--	8.59	10.84	8.99	8.40	9.75	10.07
Fe_2O_3	8.00	8.15	7.98	8.16	--	--	--	--	--	--
FeO	0.85	0.91	0.87	0.93	--	--	--	--	--	--
MnO	0.19	0.26	0.22	0.17	0.19	0.14	0.13	0.28	0.13	0.12
MgO	3.00	3.17	3.91	3.63	5.64	3.55	3.33	4.65	2.82	2.71
CaO	17.40	18.61	19.01	17.59	19.37	15.10	13.50	16.54	11.98	15.76
Na_2O	1.25	1.33	1.87	2.01	2.02	2.93	2.83	1.61	3.04	2.93
K_2O	3.50	3.49	3.40	3.61	1.18	1.11	2.36	3.31	2.18	1.40
TiO_2	0.50	1.05	1.61	1.49	1.47	1.55	1.65	1.39	1.71	1.40
Volatiles	15.00	13.43	14.97	11.10	16.15	11.22	15.98	10.65	14.57	12.65
Total	99.11	99.37	99.93	99.90	100.01	99.14	99.77	100.18	99.38	100.34

Recalculed datas

Sample no / Elements	1	2	3	4	5	6	7	8	9	10
SiO_2	43.99	41.52	41.65	41.34	42.98	45.46	46.66	46.84	47.39	47.62
Al_2O_3	14.86	16.09	14.94	16.44	18.77	19.46	21.33	18.07	21.12	19.70
Fe_2O_3	9.51	9.50	9.39	9.18	4.04	3.74	4.19	3.52	4.12	3.67
FeO	1.01	1.06	1.02	1.04	6.87	8.65	7.01	6.03	7.59	8.14
MnO	0.22	0.34	0.25	0.19	0.25	0.17	0.17	0.34	0.16	0.15
MgO	3.56	3.69	4.60	4.08	7.67	4.37	4.44	5.65	3.63	3.42
CaO	20.60	21.70	22.37	19.80	13.05	11.25	7.07	11.85	7.05	10.13
Na_2O	1.48	1.55	2.20	2.26	2.74	3.61	3.77	1.96	3.91	3.70
K_2O	4.16	4.07	4.00	4.06	1.60	1.36	3.14	4.02	2.80	1.77
TiO_2	0.59	1.22	1.89	1.67	1.99	1.91	2.20	1.69	2.20	1.77

Analysis : The first 4 columns from M.T.A Laboratories, Ankara. 5 to 10 columns from C.P.P.G Nancy, France of Baroz (1977).

Table 1 : The chemical analysis results of Paleocene volcanic rocks of study area (from Necdet, 1988)

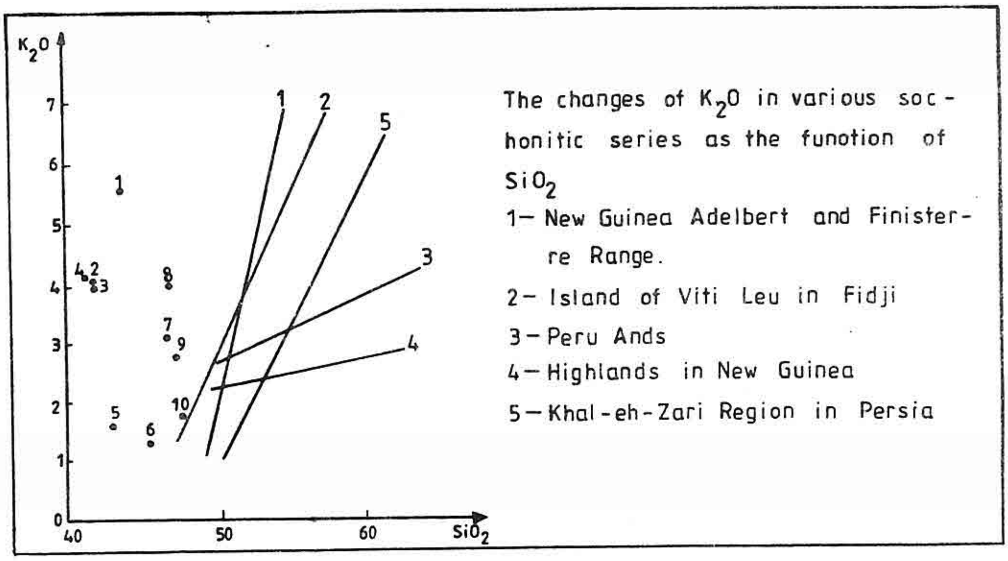

Figure 7. The state of Paleocene volcanic series in K_2O-SiO_2 diagramme(points from 5 to 10 taken from Baroz)(10).

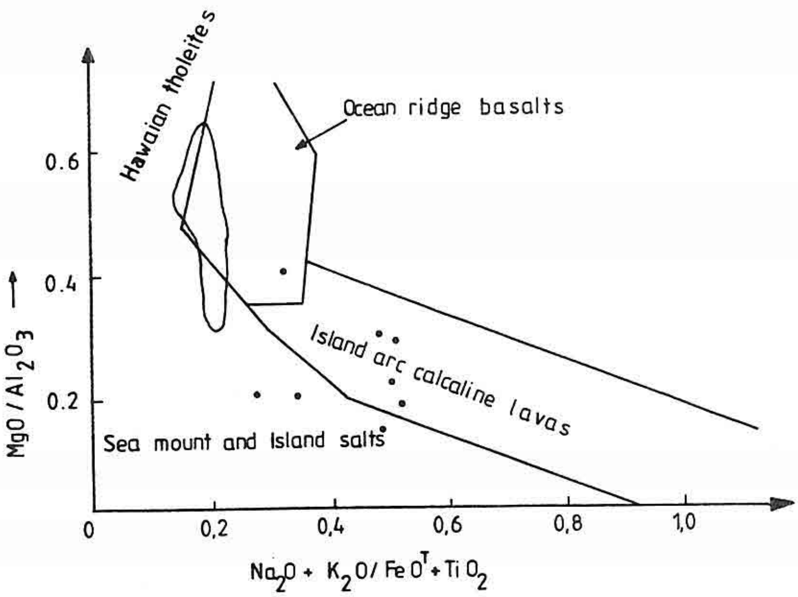

Figure 8. The state of volcanic belonging to the study area in the Green(27) diagramme.

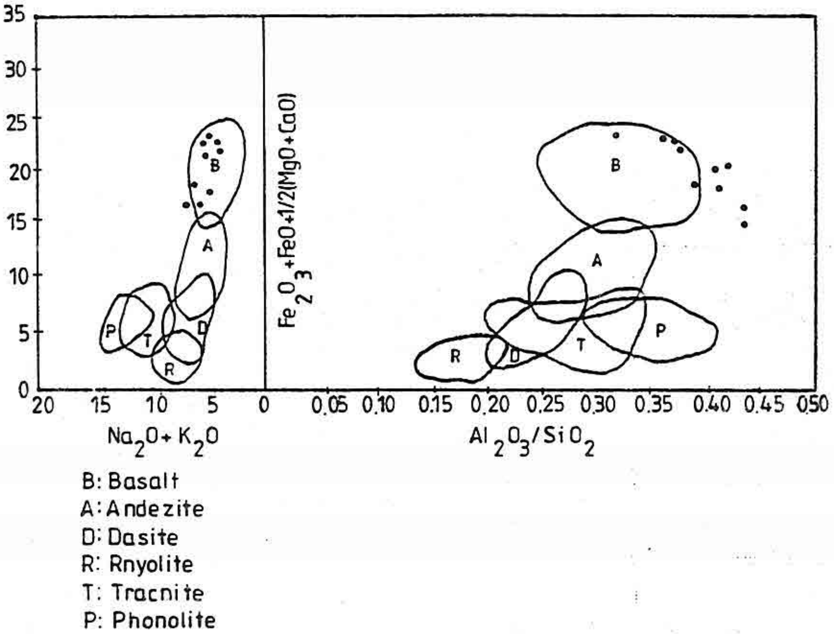

Figure 9.The Church classification of volcanic in study area.

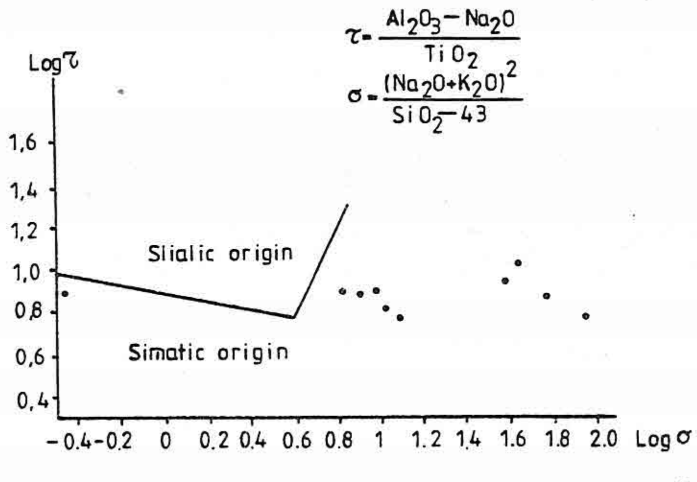

Figure 10.The state of basaltes belonging to the study area in the diagramme of Gottini(29).

- ... curence consists of compact manganese and on the surface zones have too much fractures which were filled by calcite veins.

After picking the ores from the surface mineralization which sinks down towards the base, they were left because of some political and economical reasons.

Some polished section examinations on the samples from this occurence were given below;

. Pyrolusite; it was observed as many and generally small crystalls. Microcrystaline calcite having subhedral and euhedral shapes filled the spaces among the Pyrolusite crystalls. The Pyrolusite crystalls some times display excellent cleavage (Plate 2, figure 1).

. Psilomelane; It displays relatively less and small grains accumulations. The rich part of Psilomelane made of grain accumulations have cataclastic structure locally and these cracks were filled by calcite and more enrichment Psilomelane crystalls (Plate 2, figure 2).

. Polyanite; It is observed among the Pyrolusite and have euhedral and subhedral crystalls (Plate 2, figure 3).

. Limonite; It is observed as stains of serisite of secondary minerals.

Calcite is the one of the gangue minerals present large grain crystalls and sonetimes thin grain form. Quartz is found between calcite veins. As the same time, a little amount clay and serisite were observed.

5.2.The Ziyamet Sedimentary Manganese Occurences

Brown and black manganese occurences are found in marl, chalk and limestones of Pakhna formation placed in the southern of Ziyamet. These occurences were determined by C.M.C. (Cyprus Mines Company) in 1950's and Saucier and Major (8) emphasized too (Plate 2, figure 4).

In the field observations, nine levels of manganese occurences having varies thicknesses from 15 cm to 1 m were determined among the marl, chalk and limestones of Pakhna formation (figure 11). The gypsum bands observed on the marly manganese beds (Plate 2, figure 5). The crystallization direction of the gypsum is the opposite of bedding surface (figure 12).

The marly bands don't have regular manganese bands and this is an evidence of the manganese bearing solutions didn't come regularly to the sedimentation environment (25). Some polished section examinations of these occurences are given as follows;

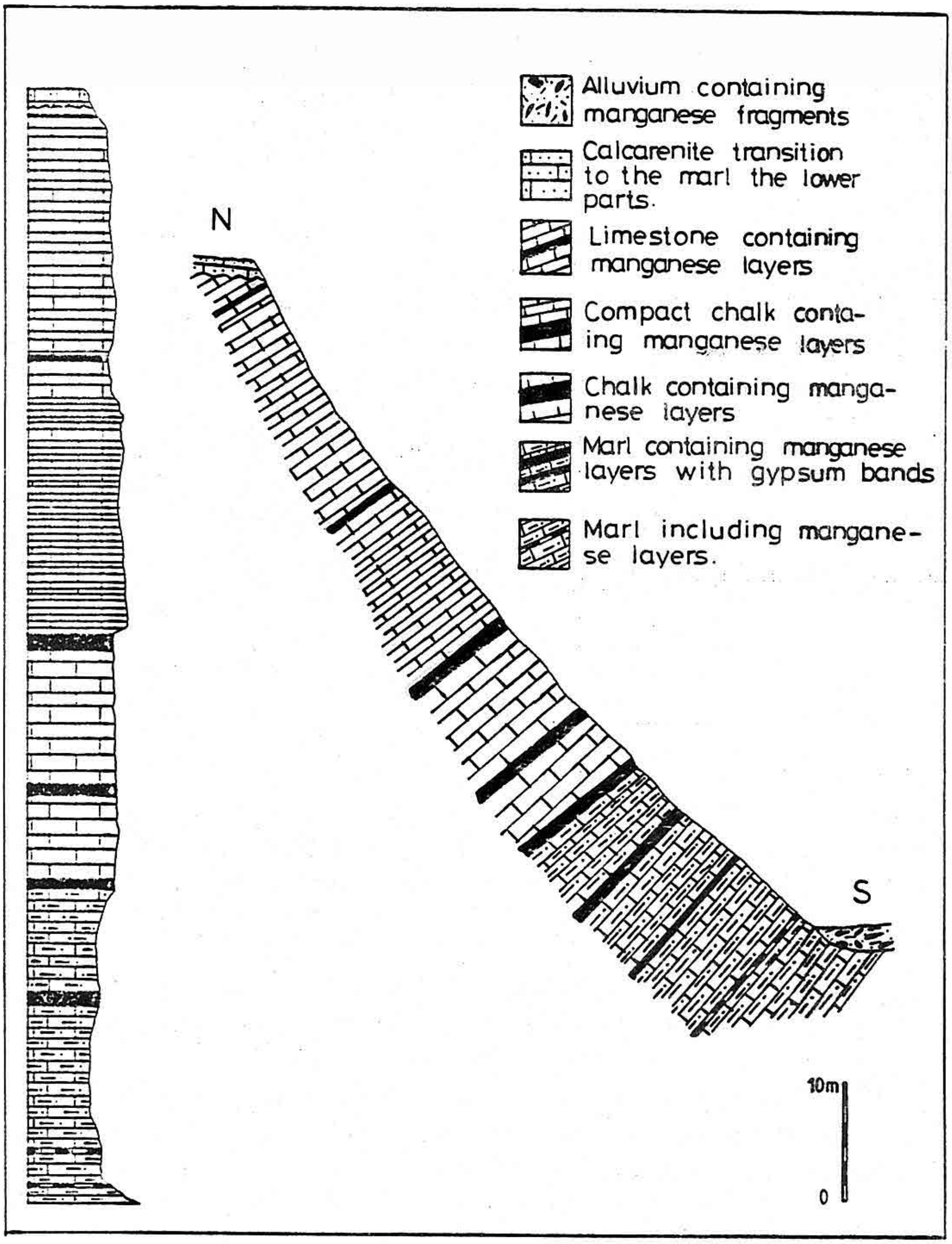

Figure 11.The vertical and horizontal sections of sedimentary manganese occu-rences as nine levels south of Ziyamet(from Necdet)(25).

Psilomelane is observed commonly and stains calcite and clay minerals. It sometimes displays concentric shell and botryoidal growings and has matted surface. Spaces and microfossil remmants were observed in some sections. These microfossils are sometimes found as together and sometimes one by one. The shells of microfossils were made of generally calcite, but insides were composed of Psilomelane (Plate 2, figure 6).

It wasn't possible to make good polished-sections from the ore samples so that it wasn't identified other manganese minerals, except Psilomelane.

5.3.The Results of Chemical Analysis of Manganese Occurences

The results of chemical analysis of volcanic and sedimentary manganese occurences were given in table 2. It is seen from the table 2, the manganese grade of sedimentary occurences is low. The Balalan occurence gave good results for grade but it has very limited extent.

The appearant reserve of sedimentary occurences is 500.000 m^3 and it is possible to enrichment of this low grabe ores because of its economic importance. The first enrichment experiments on these ores were done by C.M.C. in 1963, but gave poor results. In 1983 some manganese ore samples picked up from Ziyamet mineralization area were sent to the Central Laboratories of M.T.A. and they were realized floating-sinking and density experiments to determine their sensibilities to the gravimetric

the crack zones, after that changed into high grade manganese such as Pyrolusite, Psilomelane and Polyanite under the effect of surficial weathering conditions. This mineralization which has no any relationship with any sedimentary units as the same time in this region related to the tectonic of Kyrenia-Misis complex.

- Ziyamet sedimentary manganese occurences, which have very different existing mechanism from Balalan, are located as nine levels in marl, chalk and limestones which their thicknesses varies from 1 to 23 m. This is due to the solutions including manganese precipitation to environment irregularly. After the examinations of thin and polished section of samples picked from these occurences up, many microfossils were examined such as Orbulina sp., Globigerina sps. ect. This is an evidience to explain of the sedimentary origin. The source of these occurences is the basaltic volcanics including a volcanic origin occurence and the manganese, which is the product of superficial weathering of volcanic rocks, was transported into the basin and deposited as layers having different thicknesses in the shallow segments. The manganese occurence (North of Balalan) is an indication for enrichment of manganese content of these volcanics.

ACKNOWLEDGMENT

The authors are grateful to the directors of Çukurova University Research Foundation for financial contribution during the study, and Dr.Ahmet

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PLATE I

Figure 1 : Microphoto, P.L., Thin section from sandstone, Quartz (Q), Plagioclase (Pl), Calcite (C) were cemented by micrite.

Figure 2 : Microphoto, P.L., Borelis sp. is observed in the limestones of Kythrea formation, Sparitic cement (C_s) is high percent and a little micritic cement (C_m) is observed too.

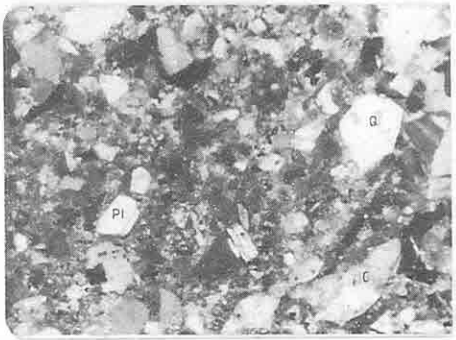
Figure 3 : Microphoto,p.L., Flowing marks in tuffs. Microliths in a vitreous matrix display subparallel to the flowing direction.

Figure 4 : Microphoto,P.L., Manganese minerals display a dendritic spreading in chalks.

Figure 5 : Typical pillow lavas (Tpl) at eastren entrance of Balalan. The light colour unit at the lower part is tuff of Kythrea formation (Tk).

Figure 6 : Microphoto,P.L., Spilitic basalt. Gaseous spaces were filled by big and synthetic texture of Calcite (C). Plagioclase (Pl) microliths and opaque minerals are observed in matrix too.

PLATE I



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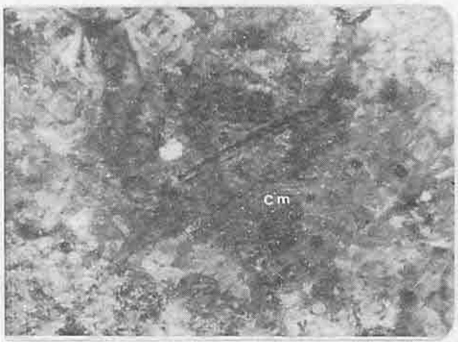

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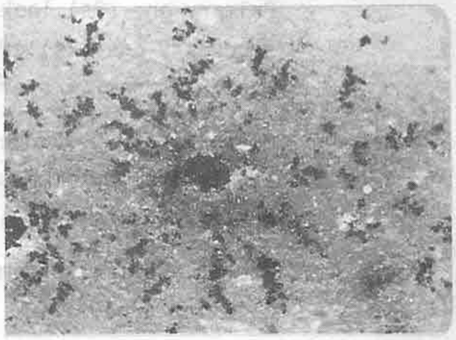

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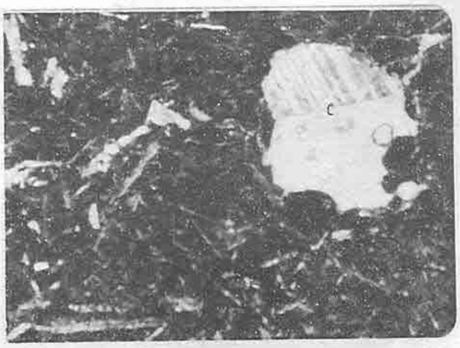

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PLATE II

Figure 1 : Microphoto,R.L., Small and destroyed Pyrolusites, big and subhedral Pyrolusites (Pi) were also observed from Balalan manganese occurence. The gangue is only calcite.

Figure 2 : Microphoto,R.L., Primary and secondary Psilomelane crystalls. Primary one (Ps) looks like a wolf eaten speciality and the secondary one (Ps) gives a more rich content of manganese. The fractures were filled by calcite.

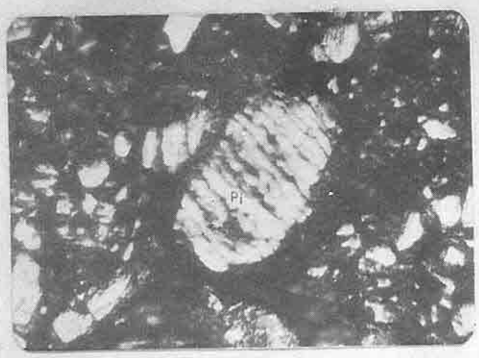
Figure 3 : Microphoto,R.L., Euhedral and subhedral Polyanite (Po) crystalls from Balalan manganese occurence. The little crystalls are Pyrolusite (Pı) and the gangue is calcite.

Figure 4 : The ore remmants from previous operations in Ziyamet mineralization area.

Figure 5 : The gypsum sequence (Gyp) of upper and lower part of marly manganese in Ziyamet sedimentary mineralization area. The thickness of gypsum bands changes between 2 and 4 cm.

Figure 6 : Microphoto, R.L., Psilomelane (Ps) which filled the fossil remains of sedimentary manganese ores.

PLATE II



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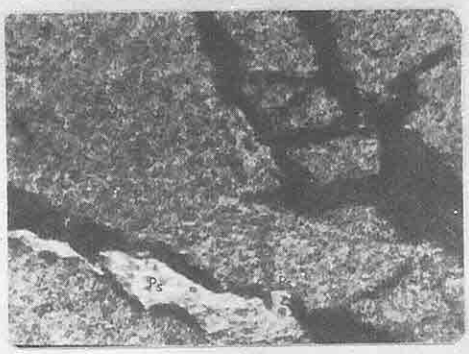

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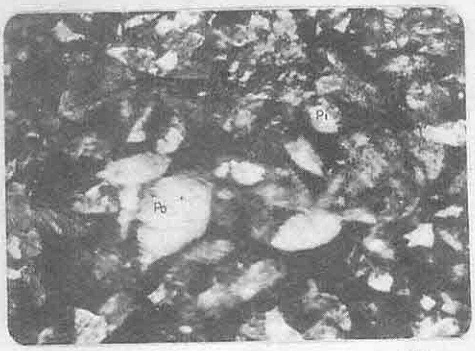

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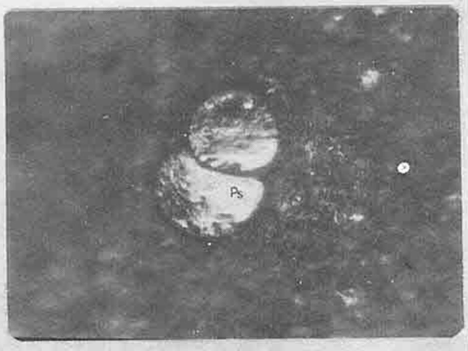

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PALEOZOIC-MESOZOIC STRATIGRAPHY OF THE FEKE-FEKEDAĞ (ADANA) AREA (EASTERN TAURUS)

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ABSTRACT: Paleozoic-Mesozoic stratigraphy was described from Cambrian to Jurassic in a lithostratigraphic sence in the Feke-Fekedağ area situated in the Eastern Taurus Belt of the Taurus range. Investigated area comprises a series of rock units largely from Paleozoic to Tertiary. Cambrian to Jurassic sequence belongs to autochthonous platform carbonates and clastics, and allocthonous ophiolithic suite does not outcrop at the Feke area. The Paleozoic succession comprises the following: Cambrian carbonates of Değirmentaşı; Ordovician shale of Armutludere; Lower Silurian conglomerate-sandstone of Halityaylası and shale of Puşçutepe; Lower Devonian sandstone-carbonate of Yukarıyayla, Middle Devonian dolomite of Şafaktepe, Upper Devonian quartzite-carbonate alternations of Gümüşali (Kızkapan and Çıkak members) and Upper Permian shale interbedded limestone of Yığıltepe formations. Mesozoic is represented by Jurassic limestone-dolomite alternations of Demirkazık formation. Similar to the Adana basin Tertiary succession of the Feke-Fekedağ area begins with Oligocene-Lower Miocene aged terrestrial Gildirli formation.

FEKE-FEKEDAĞ (ADANA) DOLAYININ PALEOZOYİK-MESOZOYİK STRATİGRAFİSİ (DOĞU TOROSLAR)

ÖZET: Bu incelemede Toros kuşağının, Doğu Toros kesiminde yer alan Feke-Fekedağ alanının Kambriyen'den Jurasik'e litostratigrafik ayırıma dayalı Paleozoyik-Mesozoyik stratigrafisi açıklanmıştır. İnceleme alanı Paleozoyik'ten Tersiyer'e kadar uzanan yaş aralığında kaya birimleri kapsar. Kambriyen-Jurassik istifi platform karbonatları ile kırıntılılardan oluşma otokton istife aittir. Allokton,ofiyolit dizisi kayaçlar Feke-Fekedağ alanında yüzeylemezler. Paleozoyik istifi karbonatlardan ibaret Kambriyen yaşlı Değirmentaşı; Ordovisiyen yaşlı şeylden oluşma

Armutludere; Alt Silüriyen yaşlı konglomera-kumtaşından ibaret Halityaylası ve şeylden oluşma Puşçutepe; Alt Devoniyen yaşlı kumtaşı-karbonat ardalanmasından ibaret Yukarıyayla, Orta Devoniyen yaşlı dolomitik Şafaktepe, Üst Devoniyen yaşlı kuvarsit-karbonat ardalanmasından oluşma Gümüşali (Kızkapan ve Çıkak üyeleri) ve Üst Permiyen yaşlı şeyl arakatmanlı kireçtaşından oluşan Yığılıtepe formasyonları oluşturur. Mesozoyik kireçtaşı-dolomit ardalanmasından oluşan Jurasik yaşlı Demirkazık formasyonu ile temsil edilir. Feke-Fekedağ alanının Tersiyer istifi Adana basenine benzer şekilde Oligosen-Alt Miyosen yaşlı Gildirli formasyonu ile başlar.

1. INTRODUCTION

The aim of this study is to summarize the Paleozoic-Mesozoic stratigraphy and to establish representative stratigraphic columns for the Eastern Taurus belt in the Feke-Fekedağ area. For this reason previous studies looked over and Feke-Fekedağ area was mapped to a scale of 1/25 000. The Feke area is situated 125 kilometres to the Northeast of the Adana province. The Eastern Taurus Belt forms an important link in the southern sector of the Alpine-Mediterranean mountain chain in Turkey which belongs to the Outher Taurus Belt (Fig.1).

The geologic investigation on the the Eastern Taurus Belt began with the works of Blumenthal (1). He reported Devonian aged units,overlain by Cretaceous units with a great stratigraphic gap in the Fekedağ area. Abdüsselamoğlu (2,3) defined lithologies of Silurian aged sandstone,conglomerate, schist; Devonian aged nodular limestone with Orthoceras and sandy schist; Permian aged limestone in the Fekedağ area. Demirtaşlı (4) described main lithostratigraphic units of the Eastern Taurus Belt of the Pınarbaşı, Sarız, Mağara area. Özgül et al.(5,6) described Emirgazi formation at the base of Değirmentaşı formation and applied Tremadosien Arenigien (Ordovician) age to the Demirtaşlı's Armutludere formation in the Tufanbeyli area. On the other hand, the Özgül 's (7) Geyikdağı unit of the Tufanbeyli region is mainly compatible with the lithostratigraphic units of the Feke-Fekedağ area. Demirtaşlı (8) studied Paleozoic stratigraphy and Variscan events of the Taurus Belt. Geologic mapping were accomplished by Ayhan (9), İplikçi and Ayhan (10) for the area of Kozan, Feke, Saimbeyli, and by Metin (11), Metin et al. (12) for the Tufanbeyli,Sarız, Göksun, Saimbeyli, Develi area (13) summarized Ordovician to Neogene stratigraphy of the Samibeyli area using Demirtaşlı's (4) and Özgül's (6) basic lithostratigraphic definitions. The Upper Permian foraminiferal biostratigraphy of the Taurus Belt was given by Altıner (14) from Antalya to Hakkari. Tekeli et al. (15) examined in Upper Devonian-Early Senonian aged Par-autochthonous platform carbonate deposition of the Aladağ mountain, and Özgül and Turşucu (16) divided Triassic-Cretaceous aged Munzur limestone into 6 limestone members of the Eastern Taurides. Demirtaşlı et al.(17) described Permian-Late Cretaceous aged slate intercalated with slightly metamorphosed limestone in the Inner Taurus Belt, and nonmethamorphic units of Permian-Cretaceous aged at the Bolkar Mountains of the outher Taurus Belt. Finally, Metin et al.(18) prepared geologic map of the Elbistan-I 22 quadrange with explanations based on the works of Demirtaşlı (4), Özgül et al.(6) Metin et al. (12).

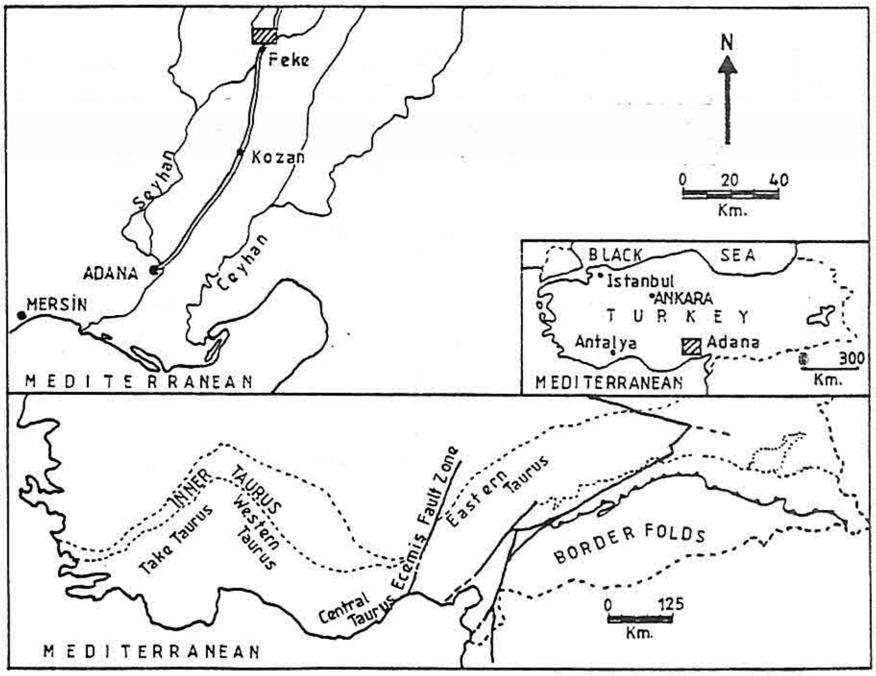


Figure 1. Principal Tectonic Belts of the Southern Turkey and location map of the study area.

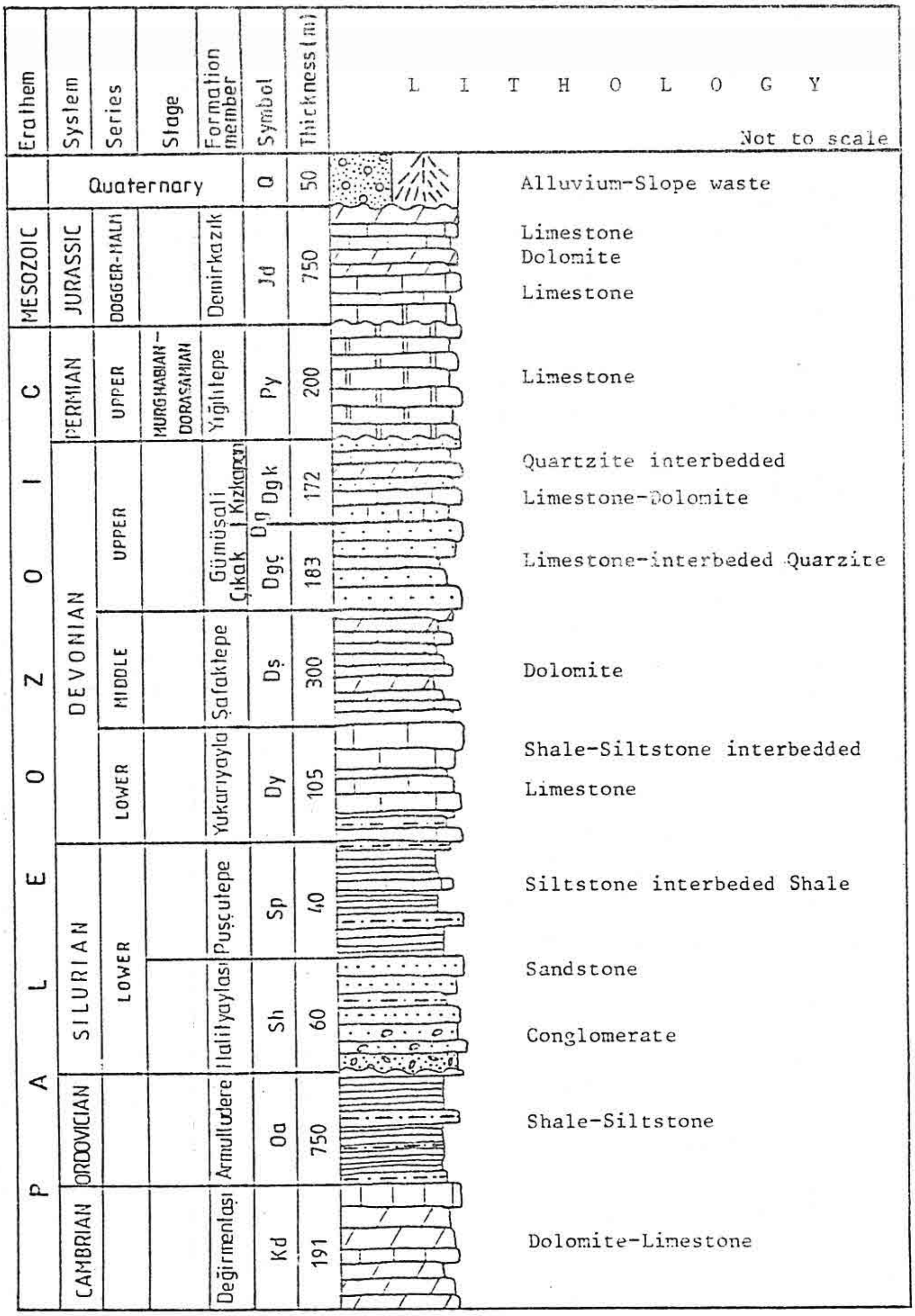


Figure 2. Generalized stratigraphic section of the Feke-Fekedağ (Adana) area.

2. STRATIGRAPHY

Cambrian to Jurassic sequence of the autochthonous platform carbonates and clastics of the Feke-Fekedağ area comprises 9 formations and 2 members in a regional scale (Fig.2). These are Cambrian aged Değirmentaşı,Ordovician aged Armutludere, Lower Silurian aged Halityaylası and Puşcutepe shale, Denonian aged Yukarıyayla, Şafaktepe, Gümüşali (Kızkapan and Çıkak members), Upper Permian aged Yığılıtepe and Jurassic aged Demirkazık formations. Main sedimentary breaks were determined between Ordovician-Silurian, Devonian-Upper Permian, and Permian-Jurassic.

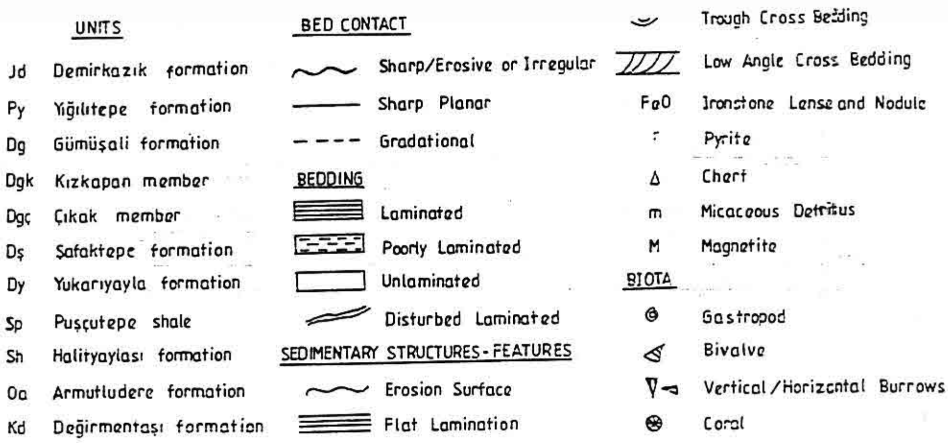


Figure 3. Key to symbols of the measured sections.

2.1. Değirmentaşı Formation (Kd)

This formation was named by Demirtaşlı (4) and mainly composed of recrystallized limestone and shale with nodular limestone interbeds towards the top. In the investigated area it crops out at the western side of the Feke-Çardak tepe trends and northeastern side of the Feke country.

Değirmentaşı formation is represented by dark grey to white recrystallized limestone-dolomite, thick bedded, sometimes laminated and unfossiliferous. It is composed of nodular limestone interbedded yellowish green-brown thinly bedded, micaceous siltstone and dark grey fissile shale alternation at the top.

The lower boundary of the Değirmentaşı formation is not observed in the investigated area. Around the Topakkaya Tepe contact zone of the Değirmentaşı and Armutludere formations, approximately N-E trending fault was noted. Similar tectonic basal contact relation was also seen at the northeastern side of the Feke county. Normally Değirmentaşı formation concordantly passes to Armutludere formation. Northwestern side of the Feke, a thickness of 191 metres was measured along the Göksu river and it may be much more thicker at the western outcrop. Demirtaşlı (4) described a thickness of 280 metres for this formation.

No fossil observed in Değirmentaşı formation around the Feke area. Demirtaşlı (8) reported some trilobites from the upper level of the formation, and Metin et al.(18) noticed some of coral detritus in the limestone levels, using the regional correlation Latest Cambrian age was proposed by Demirtaşlı (4, 8) and Middle Cambrian age by Metin et al.(18).

2.2. Armutludere Formation (Oa)

This formation was named by Demirtaşlı (4) at the Sarız area and it mainly consists of shale and siltstone alternation in the type locality. The main outcrop of the Armutludere formation is found along the Feke-Çardak trend, and a smaller one crops out at southern side of the Çaltepe.

At the Feke area, carbonates of Değirmentaşı formation transits to shale-siltstone alternation of Armutludere formation with a nodular transition zone. In the this zone grey recrystallized limestone, greenish grey fissile siltstone and reddish pink disturbed laminated mudstone are very characteristic. Towards to top 2-4 cm thick roughly nodular, light green limestone interbedded pale green-pink sandy siltstone is found. This level transits to very fine quartzose sandstone interbeded greenish grey shale, which contains abundant micaceous detritus. Finally, at the top dark grey-brown, fissile, in some place laminated, abundant micaceous silty shale and shale are dominant. In thin section fine sandy siltstone comprises subrounded quartz (60 %), Micas (10 %), and cubic opac minerals (15 %) in iron-rich serisitic matrix.

Armutludere formation has a tectonic contact relation with the Değirmentaşı formation around Asmaca Çayı and Devonian aged rock units at eastern side of the Çardak Tepe. This formation conformably overlays the Değirmentaşı formation with a nodular transition zone at southern side of the Çaltepe. The thickness of the Armutludere formation could not be measured in the field. A thickness of 1150 metres was determined by Demirtaşlı (8) and 1100 metres by Metin et al (18).

Few graptolites were observed at the lower section of the formation. Demirtaşlı (8) reported some graptolites (Didymograptus sp.,Tetragraptus sp.), Trilobites (Asaphids and Symphysurus), Delerorthis sp.,Orthis sp. in the siltstone of Sarız area. On the other hand, Macropyge taurina sp. nov was determined by Dean, W.T., and Didymograptus extensus (Hall), Didymograptus nicholsoni Lapwoth, Didymograptus cf. nitidus (Hall), Didymograptus aff. deflexus Elles and Wood by Rickards R.B.,at Eastern Taurus zone of Sarız-Tufanbeyli area (as cited Özgül et al. 5). The fossils, indicate deposition during Ordovician for the Armutludere formation.

2.3. Halityaylası Formation (Sh)

This formation was named by Demirtaşlı (4) and composed mainly of thick bedded conglomerate and feldpathic sandstone at the Sarız area.

Halityaylası formation has a very restricted outcrop at the eastern side of the Fekedağ. At this type locality, formation begins with a conglomerate, but the basal level of the formation could not be seen due to folding and faulting (Figure 4,5). Yellow to buff coloured conglomerate to pebbly sandstone is unsorted; thick beds have subrounded quartz, quartzite, shale and heavy mineral grains of 4-5 cm long. Conglomeratic basal level of the formation transits to sandstone with decreasing grain size. Pale green sandstone (lithic graywacke) poorly sorted, and laminated contains medium to thick sand grains being mainly composed of quartz (55 %), rock fragments (10 %), feldspars (5 %), micaceous detritus % 2 (Plate 1/A). Single and composed plutonic vein type quartz grains has straight to slightly ondulose extinction, and contain scarce vacuols and microlits. The grains indicate a granitic source rock for the unit.

The lower boundary of the Halityaylası formation was not observed in the Feke area, but in the region it unconformably overlays Ordovician aged Armutludere formation (10).On the other hand,Halityaylası formation transits to Puşçutepe shale at the top (Fig.4,5). For the Halityaylası formation a thickness of 110 metres Demirtaşlı (8) and 110-160 metres

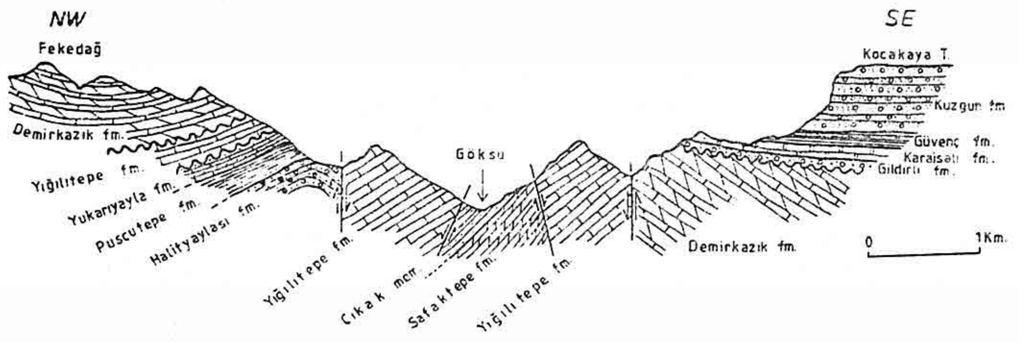


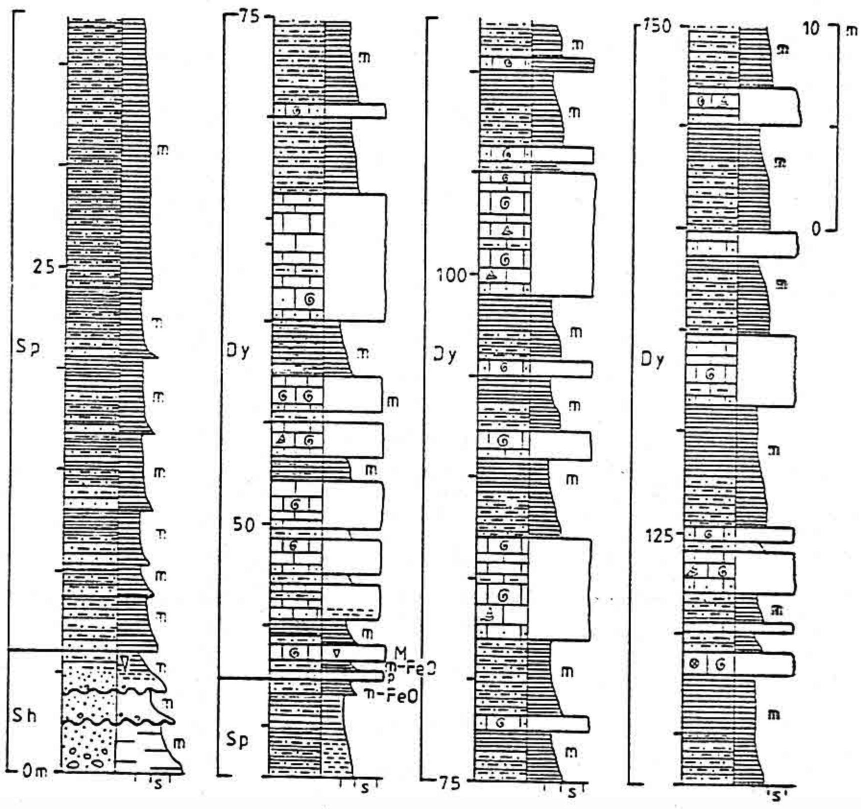
Figure 4: A sketch section showing contact relations of the differentiated lithostratigraphic units from Fekedağ to Hovdu

Metin et al. (18) were proposed in the Eastern Taurus Belt. In this study an observable thickness of 6 metres was measured for the Halityaylası formation. No fossils were observed in the Halityaylası formation. According to the close contact relation of the Ordovician aged Armutludere formation at the base, and Lower Silurian aged Puşçutepe shale at the top, Lower Silurian age was applied to the Halityaylası formation. Basal section of the Halityallası formation indicates a stratigraphic gap between Ordovician and Lower Silurian time Period.

2.4. Puşçutepe Formation (Sp)

This formation was named by Demirtaşlı (4) in the Eastern Taurus Belt and mainly composed of shale at the type locality. With the close contact relation of the Halityaylası formation it has a unique outcrop at eastern side of the Fekedağ. This area forms the type locality and type section for the formation to a regional scale.

The Puşçutepe shale mainly consists of alternations of shale ,siltstone and minor amounts of carbonate interbeds in the Feke area. Green-dark green shale is thick bedded, fissile and contain quartz grains with small amounts micaceous detritus, and at the basal level fine sandstone interbeds are common. Dark-gray-black carbonaceous shale, on the other hand, is thin-bedded, laminated, fissile and at the upper level limestone interbeds



Figuri 5: Gedik measured section. Sh:Halityaylası formation, Sp: Puşçutepe shale, Dy: Yukarıyayla formation.

are found. This formation transits to Yukarıyayla formation with increasing carbonate amounts to the top (Fig. 4,5).

Puşçutepe shale has a transitional contac relation with the Halityaylası formation at the base, and Yukarıyayla formation of Late Silurian-Early Devonian at the top (Fig.4). In this study a thickness of 36 metres was measured for the Puşçutepe shale. For the Eastern Taurus Belt a thickness of 120 metres by Demirtaşlı (8), and 60-120 metres by Metin et al. (18) were proposed.

Graptolites and a few trilobite fragment were observed in the Puşçutepe shale. For this formation Demirtaşlı (8) reported Monograptus spiralis, Monograptus convolutus, Monograptus denticulatus; on the other hand Monograptus spiralis (Geinitz), Monograptus lobiferus (M'Coy), Monograptus halli (Barrande), Monograptus convolutus (Hisinger), Monograptus denticulatus Törnquist, Monograptus decipiens, Törnquist were determinated by Kallioğlu, A. as cited in Özgül (6). These fossil determinations indicate a deposition of the Puşçutepe shale during the Early Silurian.

On the Fekedağ area first transgressive unit begins with conglomeratic Halityaylası formation and marine facies of this transgressive cycle is represented by Puşçutepe shale.

2.5. Yukarıyayla Formation (Dy)

This formation was named by Demirtaşlı (4) and consist of black shale and dark grey limestone alternations in the Pınarbaşı-Sarız area. On the other hand, Özgül et al. (8) differentiated Lower Devonian aged Ayıtepesi formation of clayey limestone interbedded sandstone-mudstone alternations at the Tufanbeyli area. In this study Özgül et al.'s Ayıtepesi formation is studied as Yukarıyayla formation.

The type locality of the formation is found eastern side of the Fekedağ. In the type section it begins with a transitional contact relation on the Puşçutepe shale; by contrast it is disconformably overlain by Upper Permian aged Yığılıtepe formation. Other outcrops are found western side of the Fekedağ and along the Göksu river.

In the Feke-Fekedağ area, the Yukarıyayla formation begins with nodular limestone-shale alternations on the Puşçutepe shale and it is followed by alternations of limestone-sandstone, shale at the top (Fig. 5). Shale and fine sandstone interbeded siltstone is dark grey, brownish grey, black parallel-cross laminated, fissile and silty levels comprises micaceous detritus and limonite. These fine detritus of the Yukarıyayla formation transit to siltstone interbedded dark grey, medium to thick bedded nodular limestone which contains abundant Orthoceras sp.. One of limestone sample is described in thin section as sandy biomicrite with magnetite (Plate I/2). Which contain Orthoceras and undetermined forams (30 %), fine sand and silt grains sized quartz (5 %), equigranular sparry calcite filled veins and pore spaces, well developed stylolite and euhedral magnetite (10 %). At the upper level of the formation dark grey-black carbonate were determined as boundstone, biomicrite and micritic limestone which are dark grey, medium to thick bedded, sometimes laminated, and contains a different kind of coral, brachiopoda, with magnetite, pyrite. Fine sandstone interbeds are greenish gray, parallel-cross laminated containing abundant brachiopoda.

Yukarıyayla formation has a transitional contact relation on the Silurian aged Puşçutepe shale and is conformably overlain by the Middle Devonian aged Şafaktepe formation at eastern side of the Fekedağ. It is disconformably overlain by the Upper Permian aged Yığılıtepe limestone. Basal section of this unit was not seen at eastern side of Feke and Western side of Fekedağ due to faulting. A thickness of 104 metres was measured in the Gedik section (Fig.5). Demirtaşlı (4) was proposed a thickness of 400 metres, Metin et al. (18) 800 metres with Ayıtepesi formation, İplikçi and Ayhan (10) more than 1000 metres.

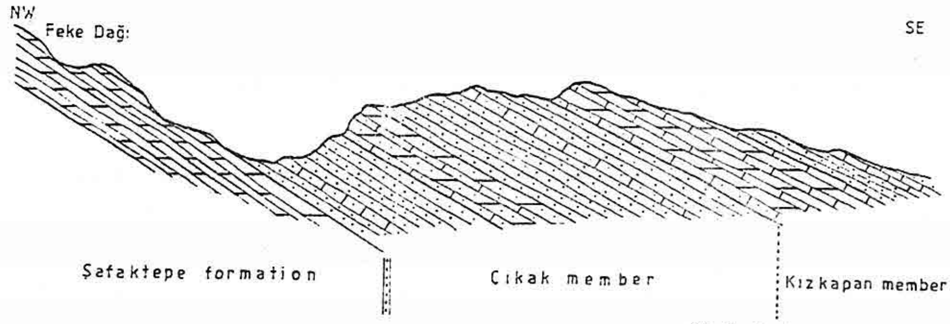
Yukarıyayla formation contains abundant Cephalopoda (Orthoceras sp.), Coral (Disphyllum sp.) brachiopoda, bryozoa etc. In a regional scale, Demirtaşlı (4) and Metin et al.(18) proposed Late Silurian-Early Devonian in an age for the formation according to the Orthoceras sp. determination. Özgül et al. (6) proposed Lower Devonian age for the Ayıtepesi formation according to the following fossils: Acrospirifer sp., spirifer cf.undiferus Roemer (Determination by Salancı, A.). These fossils indicate a deposition during Early Devonian.

2.6. Şafaktepe Formation (Dş)

This formation was named by Demirtaşlı (4) and mainly made up by argillaceous limestone, siltstone and calcareous mudstone at the Sarız area. In the Eastern Taurus Belt Metin et al. (18) used "Şafaktepe limestone" for the dolomite interbedded limestone. İplikçi and Ayhan (10) used dolomitic limestone for this formation.

Main outcrop of the Şafaktepe formation is found at the southern flank of the Fekedağ; another outcrop is located at the northeastern side of the Kazancı extending parallel to the Göksu river. In the Fekedağ area Şafaktepe formation consists of light grey to dark grey, medium-thick bedded dolomite, dolomitic micrite and mudstone which contains sparse brachiopoda. In thin section medium crystalline dolomite of sutured mosaic fabric (19) comprises stylolite, sparse calcite, fossils, iron oxide and clay envelope are developed around the weathered crystal boundaries (Table I/3).

Şafaktepe formation conformably overlays the Yukarıyayla formation at the base and transits to Gümüşali formation Çıkak and Kızkapan members at the top between Fekedağ and Feke area (Fig.6,7). Around Kazancı area it is overlain conformably by Çıkak member of Gümüşali formation and has a tectonic contact relation with the Upper Permian aged Yığılıtepe formation (Fig.4).



Figuri 6: A sketch section showing contact relation of Şafaktepe formation and Çıkak-Kızkapan members of Gümüşali formations.

Thickness of the formation could not be measured in the study area. A thickness of 600 metres by İplikçi and Ayhan (10), 1000 metres by Demirtaşlı (8) and 1000-2000 metres by Metin et al. (18) were proposed. In the study area Şafaktepe formation contains small amounts of undeterminable brachiopoda.

On the other hand, coral (Amphipora ramosa and Thamnophyllum sp.) were reported by Demirtaşlı (18); stramatoporoid, brachiopoda and coral by Metin et al. (18). In addition Coenites sp. and Thamnophyllum trigemme were determined by Kırağlı, C. as cited Özgül et al. (6).These fossils indicate a deposition during Middle Devonian.

2.7. Gümüşali Formation (Dg)

This formation was named by Demirtaşlı (4) and it consists mainly of quartzitic sandstone, siltstone, shale and limestone alternations. These differentiation are used by Özgül et al. (6) and Metin et al.(18) in the same sense for the Eastern Taurus Belt.

In this study Demirtaşlı's (4) Gümüşali formation was differentiated into two main members: quartzite rich basal section of the formation was investigated as Çıkak member, and carbonate rich upper level as Kızkapan member (Fig.2, 7).

2.7.1. Çıkak Member (Dgç)

Çıkak member of the Gümüşali formation crops out between Fekedağ-Çaltepe and Kazancı-Köleli trend. Type locality and type section of the member are found southern flank of the Fekedağ. In the Çıkak measured section Çıkak member of the Gümüşali formation begins with a light grey quartzite which is fissile, thick bedded and fine quartz grained. This level transits to greenish gray siltstone and dark grey limestone. Upper section of the member quartzite is dominant with small dolomitic-limestone,siltstone interbeds (Fig. 6, 7). Light yellow-white quartzite, medium to thick bedded, fine quartz grained, fissile fine siltstone-medium dolomitic limestone interbedded, sparse cross bedded and contain small amount of mafic minerals. Dark grey dolomitic limestone is medium bedded and laminated. In thin sections medium cryistalline dolomites and sparse sandy dolomites were determined. Crystal boundaries of dolomite indicates signs of weathering and iron rich clayey envelope, and stylolite were also found. Sandy dolomite comprises very fine single to composite subrounded sand grains of quartz (2 %) which have ondulose extinction, and are found along the stylolitic ways. Some pore spaces are filled with coarse spary calcite cement. For the SiO_2 distribution of the unit 3 samples rich in quartzite were collected from this member. XRD analysis showed 72 %, 100 %, 70 % SiO_2.

Çıkak member of the Gümüşali formation conformably overlays dolomitic Şafaktepe formation at the base both at the southern side of the Fekedağ and around Kazancı area (Fig. 6). On the other hand, it transits to Kızkapan member at the top around southern side of the Fekedağ. By contrast, it has tectonic contact relations with the Ordovician aged Armutludere formation and Upper Permian aged Yığılıtepe formation in the Feke area.

For the Çıkak member of the Gümüşali formation a thickness of 184 metres

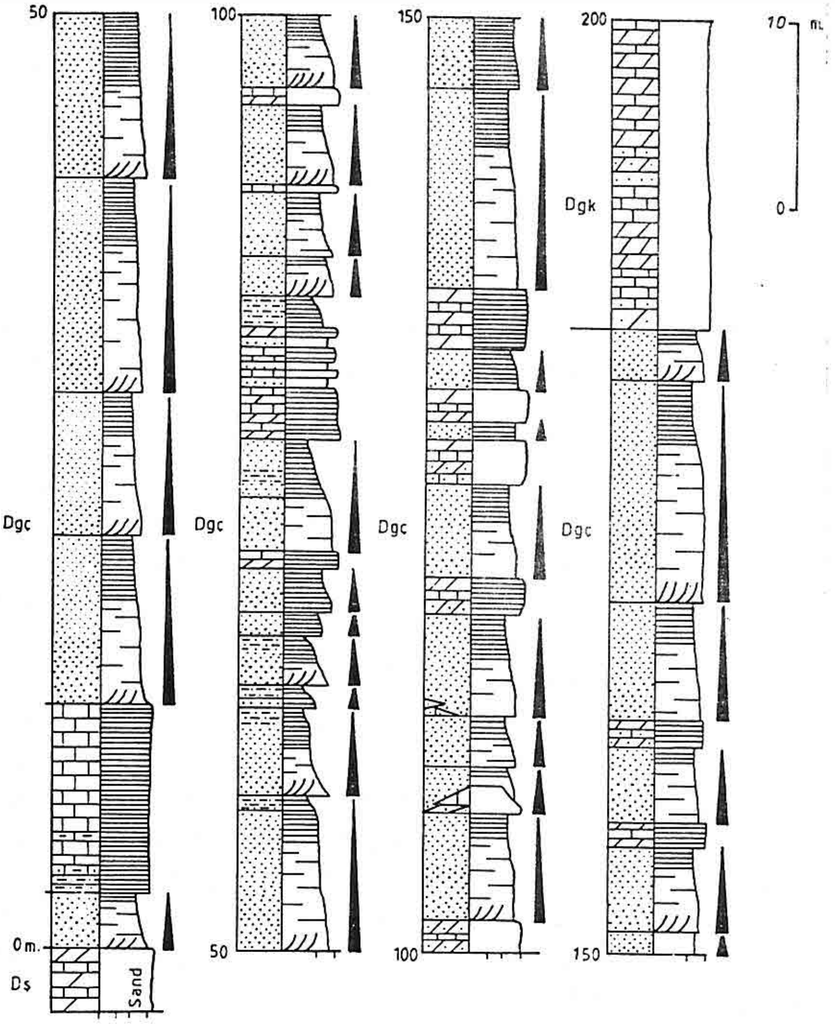


Figure 7: Çıkak measured section. Dş: Şafaktepe formation, Dgç: Çıkak member, Dgk: Kızkapan member.

was measured. A thickness of 450 metres was proposed by İplikçi and Ayhan (10) for the whole unit. No fossils were found in the quartzitic levels; by contrast, dolomitic limestone and sandy levels have some brachiopoda etc. With the close contact relation of the Kızkapan member this unit must be deposited during Upper Devonian.

2.7.2. Kızkapan Member (Dgk)

This member was named by the author, and crope out approximately at the midpoint of the Feke-Fekedağ trend. Kızkapan member is composed of dark grey, medium to thick bedded dolomites with sparse sandy dolomitic limestone horizons including thin sandstone interbeds. In thin sections dolomite sample has silt to very fine sand grains of angular, ondulose extinction of composite quartz (3 %), opaque minerals (1 %), and very fine dolomite crystals; veins are filled with equigranular sparry calcite.

Kızkapan member has a transitional contact relation with the Çıkak member at the base. It conformably overlays the Şafaktepe formation at the western side of the Göksu river (Fig.6). The apparent thickness of the Kızkapan member was measured to be 172 metres at the Feke area. Demirtaşlı (4) reported some Disphyllum caespitosum,Cyrtosipirifer sp., Hexagonaria sp., Cytoterrorhynchus gr. arpaensis in the Sarız area. Disphyllum minus (Roemer), Disphyllum goldfussi (Geinitz), Hexagonaria darwini (French), Alveolites suborbicularis Lamarck, Atrypa reticularis Linné, Fenestella sp., Thamnopora sp., Spinocyrtia sp., Spinatrypa sp., Productella subaculata (Murchison). Crytospirifer cf.vernuelli (Murchison) Cyrtospirifer cf. brodi (Wenjukoff), Rhynchonella cuboidas (Sowerby), Spirifer aff. boucardi (Murchison), Camaratocechia sp. were determined by Kırağlı, C., Baydar,M., and Sallancı, A. as cited in Özgül (6) and Metin et al. (18) in the Tufanbeyli and Saimbeyli area. These fossils indicate deposition during Upper Devonian.

2.8. Yığılıtepe Formation (Py)

This formation was named by Demirtaşlı (4) as a "Yığılıtepe limestone" but later "Yığılıtepe formation" applied to this unit by Özgül et al.(6), Tutkun (14), Metin et al.(18). In the reference section it consist of black shale interbedded dark grey limestone.

Yığılıtepe formation crops out around Fekedağ area, along the Göksu river and Kızılçukur Tepe in the Feke area. None of these outcrops form a type section for the unit. Tectonic contact relations and truncations by the Jurassic transgression of the unit prevent formation of a characteristic section. A reference section may be seen along the Göksu river.

Yığılıtepe formation mainly consists of dark gray-black. medium to thick bedded limestone which contains 20-30 centimetres thick carbonaceous fissile black shale interbeds at the basal section around the Göksu river. This shale interbeds were not seen in the other outcrops. Limestone layers contain abundant Mizzia which is a very useful criterium for determination of the Permian unit (Plate I/4). At the NW of Pınarbaşı, Upper Permian unit begins with clastics at the base (a) and succeeded by a limestone unit subdivided by Altıner (14) into two members a lower carbonate unit (b) and upper carbonate unit (c). Similarly Upper Permian limestone is extremely rich in dasycladacean (Mizzia) and gymnocodiacean algae. In thin sections biomicrite and fossiliferous micrite are determined. Biomicrite, contain Mizzia and other bioclast (20-50 %), intraclast (1-10 %), opaque minerals (1-2 %) in a micritic matrix (Table I/4). Fossils are coated with a micritic envelope and pore spaces sometimes filled with equigranular spary calcite. In some sample spary calcite filling veins and stylolite is observed. Fossiliferous micrite contains bioclast (10 %) mainly being Mizzia in a micritic matrix. Sparse silty detritus with stylolite, spary calcite filling veins and lamination are also found.

Permian aged Yığılıtepe formation disconformably overlays Devonian aged Yukarıyayla and Şafaktepe formations, and is disconformably overlain by the Jurassic aged Demirkazık formation at the Fekedağ area (Fig. 4). By contrast, at the other outcrops it has a tectonic contact relations with the other formations. Truncations and tectonic contact relations prevent measuring the real thickness of the formation in the Feke area. Demirtaşlı (8) proposed 800 metres, İplikçi and Ayhan (10) 200 metres, Tutkun (13) 300-350 metres, Metin et al. (18) 650 metres a thickness for the Yığılıtepe formation.

Yığılıtepe formation contains the following fossils in the limestone levels (determined by Altıner, D., M.E.T.U): Hemigordius aff. ovatus, Hemigordius irregulariformis, Hemigordius bronnimanni, Hemigordius sp., Agathammina pusilla, Agathammina sp., Pseudovermiporella nipponica, Permocalculus fragilis, Permocalculus sp., Gymnocodium sp., Mizzia velebitana, Pachyphloia ovata, Pachyphloia schwageri, Globivalvulina decrouezae, Globivalvulina sp., Globivalvulina vonderschmitti, Paraglobivalvulina sp., Stafella sp., Neoendothyra reicheli, Angelina alpinotaurica, Lunucammina postcarbonica, Lunucammina sp., Fusulinacea, Stafella sphaerica Dunbarula sp., Pseudolangelle fragilis, Pseudokahlerina sp., Dagmarita *chanakchiensis*, *Permocalculus fragilis*, *Climacammina* sp., *Fondina permica*, *Ungdarella*, *Gymnocodium bellerophontis*.

These fossil community indicates a deposition during Upper Permian (Murghabian-Dorashamian). Devonian aged lithostratigraphic units are overlain disconformably by shallow marine-subtidal deposits of Yığılıtepe formation in the Fekedağ area. On the other hand Carboniferous deposits have not been defined so for at the investigated area. Therefore,another important stratigraphic gap is found between Upper Devonian-Upper Permian time period.

2.9. Demirkazık Formation (Jd)

Upper Triassic-Cretaceous aged carbonates was named by author as Demirkazık formation in the eastern territories of the Ecemiş Fault Zone (20, 21). In this study, this definition is applied to limestone-dolomite alternation of Jurassic carbonates of Feke-Fekedağ area.

Demirkazık formation typically crops out in the Fekedağ and at the eastern side of the Göksu river. Southwestern flank of the Fekedağ forms type locality and Fekedağ measured section is the type section for the formation (Fig.8-9).

In the Fekedağ area Demirkazık formation disconformably overlays Devonian aged Yukarıyayla and paraconformably overlays Upper Permian aged Yığılıtepe formation (Fig.4). Contact relation between Yukarıyayla formation and Demirkazık formation is very clear in the southwestern flank of the Fekedağ.This relation could not be seen easily between carbonates of Upper Permian aged Yığılıtepe and Jurassic aged Demirkazık formations in the southeastern flank of the Fekedağ. There is a weathered surface between them which could be diffucultly seen in some places. On the southwestern flank of the Fekedağ. Demirkazık formation begins with a fossiliferous dolomitic micrite on the limestone, siltstone, sandstone alternations of Lower Devonian aged Yukarıyayla formation (Fig.8). First 324 metres of the Demirkazık formation consists mainly of limestone which includes algal biomicrite, biomicrite, and sparse dolomitic fossiliferous micrite. Following 172 metres mainly comprises dolomite and dolomitic micrite. Upper level is mainly composed of limestone which includes sparse fossiliferous micrite, biomicrite, algal biomicrite and small amount of dolomitic micrite. At the top of the succession dolomite is dominant.

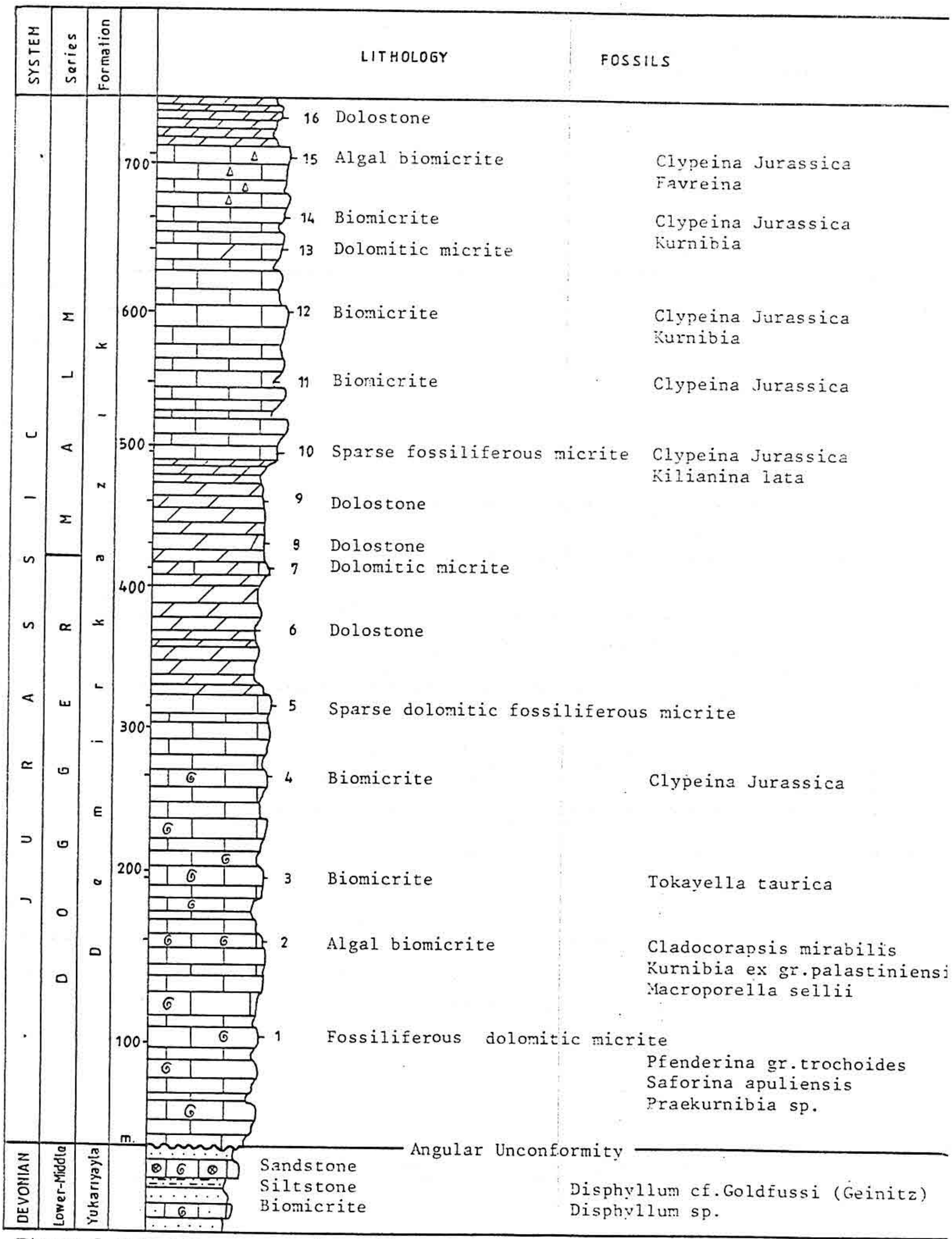


Figure 8. Fekedağ measured section.

In hand specimen micritic limestone is light gray-beige medium-thick bedded, sparse fossiliferous, and it comprises calcite veins and chert in some levels. On the other hand white to beige, roughly laminated dolomite is generally thick bedded, medium to thick crystalline, porous (mouldic and intercrystalline), in some places dolomite sand was formed by the weathering of dolomite. Fossiliferous dolomitic micrite contains medium to thick crystalline dolomite (15 %) and bioclast (10 %) in a micrite matrix, and veins filled with thin sparicalcite are common. Biomicrites of the lower section of the formation contain fossils (25-45 %) which have micrite envelope and most of them filled with equigranular spary calcite (Plate I/6). Sparse dolomitic fossiliferous micrite comprise exceptionally fine-medium dolomite crystals (5 %). Fine, medium to thick cristalline sometimes well zoned sieve mosaic fabric of dolomite and floating rhomb fabric of dolomitic micrite (19) has spary calcite filled veins and intercrystalline, intracrystalline, vuggy type of porosity (7, 15 %,Table II/1, 3, 4). Uppermost limestone unit of micrite-biomicrite always contains Clypeina Jurassica, pelloids, stylolites etc. (Plate I/5). Bioclasts have micrite envelope and veins and fossils in sight filled with spary calcite. Uppermost sieve mosaic Fabric of dolomite is medium to thick cryistalline, well zoned and porous-intercrystalline porosity (Plate II/2).

Devonian unit is disconformably and Permian unit of Fekedağ area paraconformably overlain by the Jurassic aged Demirkazık formation (Fig. 4). On the other hand, at the eastern side of the Göksu river, Demirkazık formation has a tectonic contact relation with the Permian-Devonian units at the west; by contrast it is disconformably overlain by the Tertiary succession of the Adana basin at the east.

In the Fekedağ section a thickness of 754 metres was measured for the Demirkazık formation. Fossil contents of the Demirkazık formation are presented in Fig. 8 (determinations by Altıner, D.,M.E.T.U.). These fossils indicate that lower limestone unit was deposited during Dogger and Upper level Malm. Therefore, Mesozoic succession of the Feke-Fekedağ area must have been deposited during Jurassic. Basal level of the Shallow marine-subtidal character of Demirkazık formation also indicate an important stratigraphic gap between Upper Devonian-Jurassic time period.

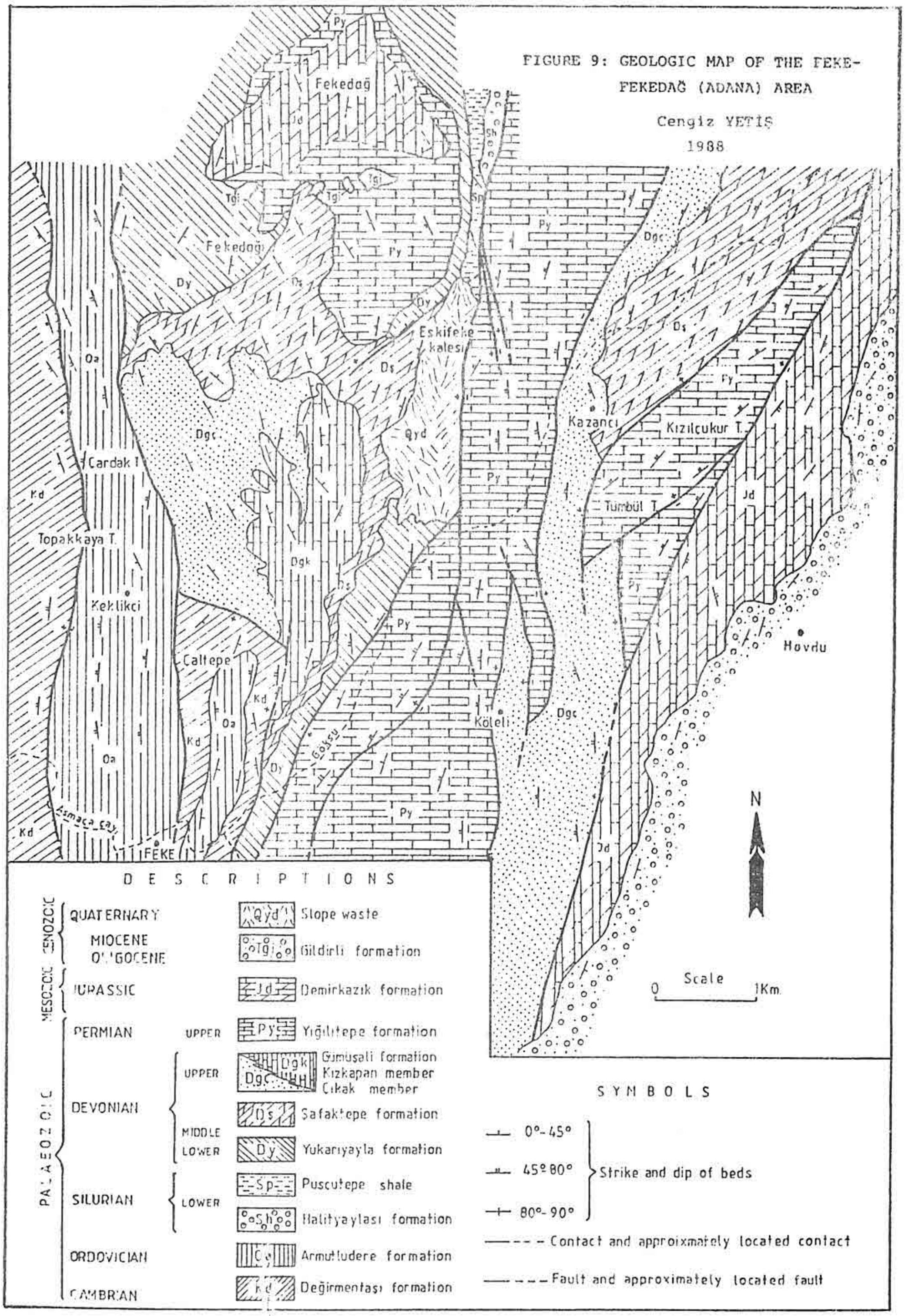


FIGURE 9: GEOLOGIC MAP OF THE FEKE-FEKEDAĞ (ADANA) AREA
Cengiz YETİŞ
1988
Fekedağ
Fekedağ
Eskifeke kalesi
Kazancı
Kızılçukur T.
Tumbül T.
Çardak T.
Topakkaya T.
Keklikci
Çaltepe
Köleli
Hovdu
FEKE
Göksu
Asmaca çay
N
Scale
0
1Km
DESCRIPTIONS
CENOZOIC
QUATERNARY
MIOCENE OLIGOCENE
MESOZOIC
JURASSIC
PALAEOZOIC
PERMIAN
UPPER
DEVONIAN
UPPER
MIDDLE
LOWER
SILURIAN
LOWER
ORDOVICIAN
CAMBRIAN
Slope waste
Gildirli formation
Demirkazık formation
Yiğıltepe formation
Gümüşali formation
Kızkapan member
Çıkak member
Şafaktepe formation
Yukarıyayla formation
Puscutepe shale
Halityaylası formation
Armutludere formation
Değirmentaşı formation
SYMBOLS
0°-45°
45°-80°
80°-90°
Strike and dip of beds
Contact and approixmately located contact
Fault and approximately located fault

3. RESULTS

Paleozoic to Mesozoic (Cambrian to Jurassic) succession of the Eastern Taurus Belt of the Feke-Fekedağ area was presented by 9 formations and 2 members. Carbonifereous deposits were not detected. Main sedimentary breaks were shown to be between Ordovician-Silurian, Devonian-Upper Permian and Permian-Jurassic. Upper Devonian aged Çıkak members of the Gümüşali formation was distinguished by high SiO_2 content. Related fossil determinations (by Altıner, D.) indicated Murghabian-Dorashamian (Upper Permian) age for Yığılıtepe formation and Dogger-Malm (Jurassic) for Demirkazık formation.

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PLATE I

1. Lithic graywacke (Halityaylası formation): quartz (55 %), rock Fragment (10 %), feldspar (5 %) and sparse micaceous detritus. X nicols, X 40.

2. Sandy biomicrite with magnetite (Yukarıyayla formation). X nicols, X 100.

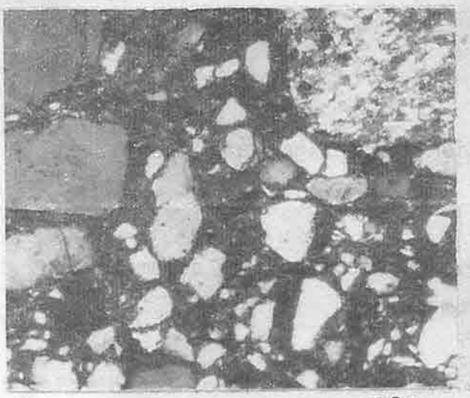
3. Dolomite (Şafaktepe formation):sutured mosaic fabric. X nicol ,X 40.

4. Biomicrite with Mizzia (Yığılıtepe formation): abundant dasycladacean and gymnocodian algae in a micritic matrix. Parallel light, x 40.

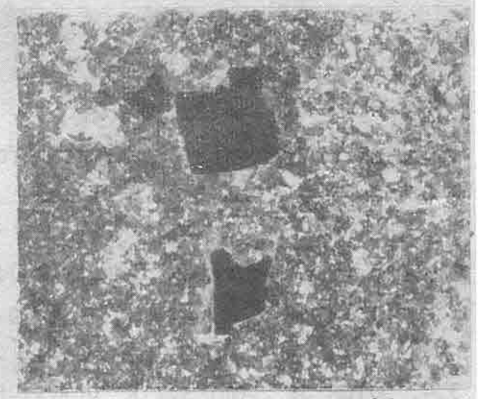
5. Biomicrite with Clypeina Jurassica (Demirkazık formation) parallel light, X 40. (Fig. 8, number 15).

6. Biomicrite with Clypeina Jurassica (Demirkazık formation): more than 45 % bioclasts in a micritic matrix. Parallel light, X 40. (Fig.8, number 4).

PLATE I

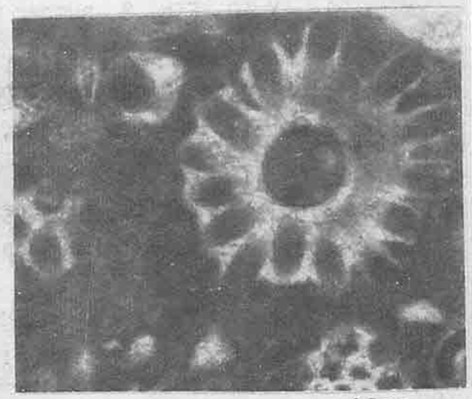


1 — 0,5 mm.

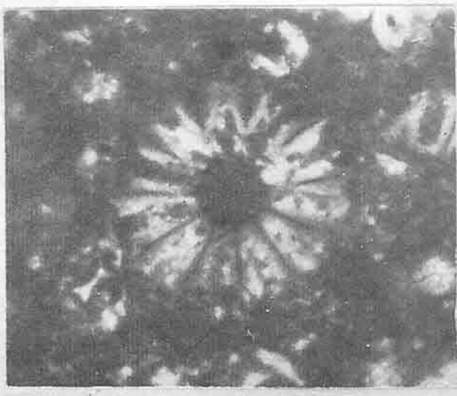


2 — 0,2 mm.

3 — 0,5 mm.



4 — 0,5 mm.



5 — 0,5 mm.

6 — 0,5 mm.

PLATE II

1. Dolomitic micrite (Demirkazık formation): Floating rhomb fabric. X nicols, X 40 (Fig. 8, number 7).

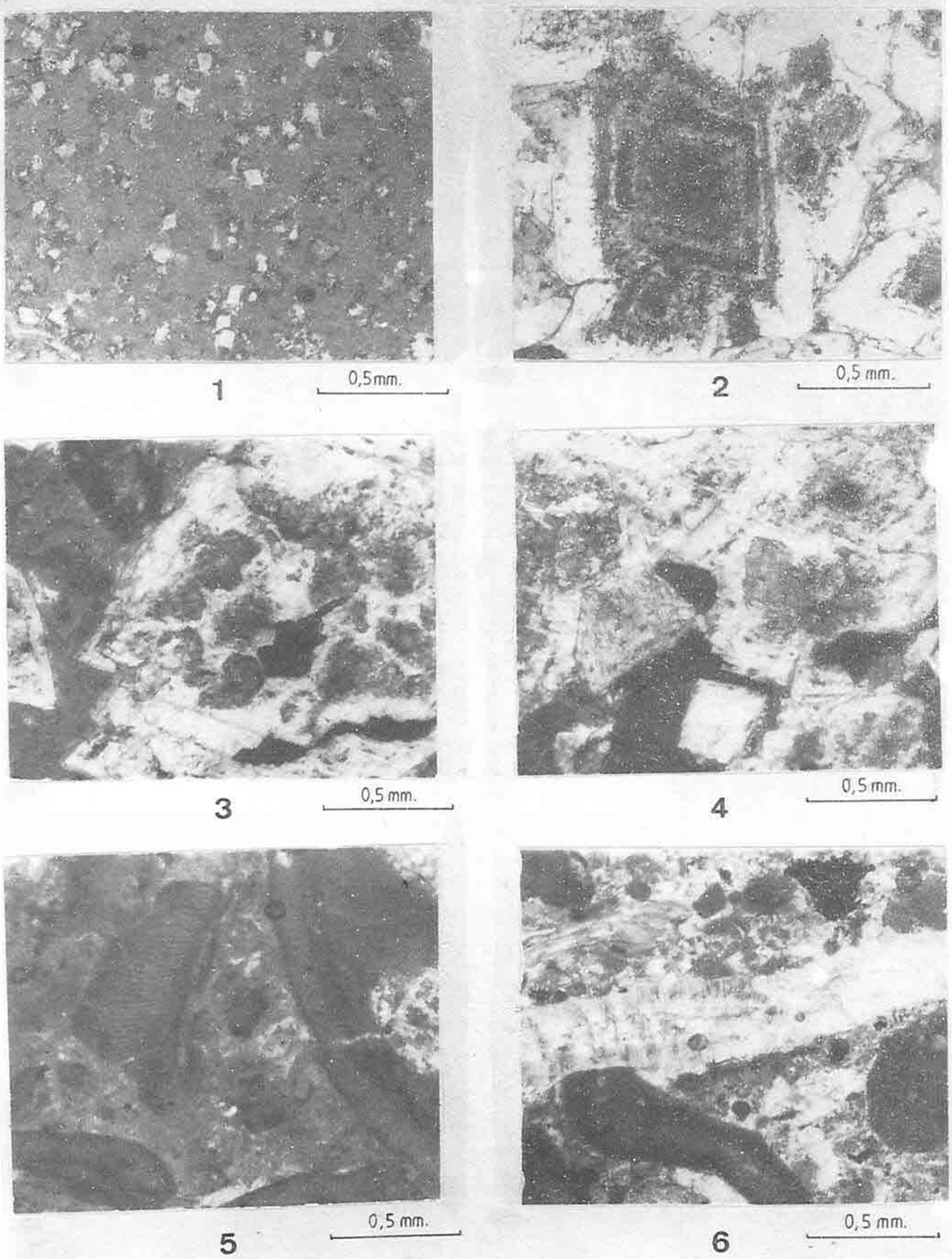
2. Dolomite (Demirkazık formation): Sieve mosaic fabric of dolomite are well zoned. X nicols, X 40 (Fig.8, number 16).

3.4. Dolomite (Demirkazık formation): Sieve mosaic fabric of zoned dolomite with intercrystalline, intracrystalline and vuggy type of porosity. X nicols, X 40 (Fig. 8, number 9).

5. Sandy biomicrite (Miocene): containing echinids and algae in a sandy micrite matrix. Parallel light, X 40.

6. Sandy algal biomicrite (Miocene): Abundant forams and algae (40 %) in a sandy micrite matrix. Parallel light, X 40.

PLATE II



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THE GEOMECHANICS CLASSIFICATION (RMR SYSTEM) OF THE ZABUK QUARTZITES AROUND THE SIR DAMSITE

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SUMMARY: The aim of this study is to establish the Geomechanics classification (RMR System) of the Zabuk Quartzite formation on which the Sır dam will be constructed. The structural discontinuities of the low grade metamorphic quartzose sandstone-quartzite of Cambrian age are well exposed on the abutments and in the explatory adits. Rock mass classes of the Zabuk Quartzites which were determined by the "basic rock mass ratings" vary from "class II-good rock" to "class III-fair rock".

SIR BARAJ YERİ DOLAYINDAKİ ZABUK KUVARSİTİNİN JEOMEKANİK SINIFLANDIRILMASI (RMR SİSTEMİ)

ÖZET: Bu çalışmanın gayesi, üzerinde Sır barajı'nın yapılacağı Zabuk kuvarsitinin jeomekanik sınıflandırılmasının (RMR sistemi) yapılmasıdır. Barajın temelinin oturacağı ve araştırma galerilerinin üzerinde yer aldığı kesimde yapısal düzensizliklerin bulunduğu Kambriyen yaşlı, düşük metamorfik kuvarslı kum taşı-kuvarsit yüzlekleri yaygın olarak bulunmaktadır. Temel kaya kütle sınıflamasına göre Zabuk kuvarsiti "Sınıf II-iyi kayadan "sınıf III-oldukça iyi kaya" ya doğru bir değişim göstermektedir.

INTRODUCTION

The Sır Dam is planed to be a 115 m high thin double curvature arch dam. In order to establish the geotechnical problems of the Sır Damsite, 27 coreborings (LS-101-RSI-127) for a total length of 3702 m and 9 exploratory adits for a total length of 718 m were performed by E.I.E during the Preliminary investigations, Feasibility and Final project phases. New additional drilling programme (RSI-128, 132) is in progress for the diversion tunnel (DT-1, 2) and for the right bank curtain geometry. The plans are also made to drill holes in the river for determining rocks stability (Figure 1,2).

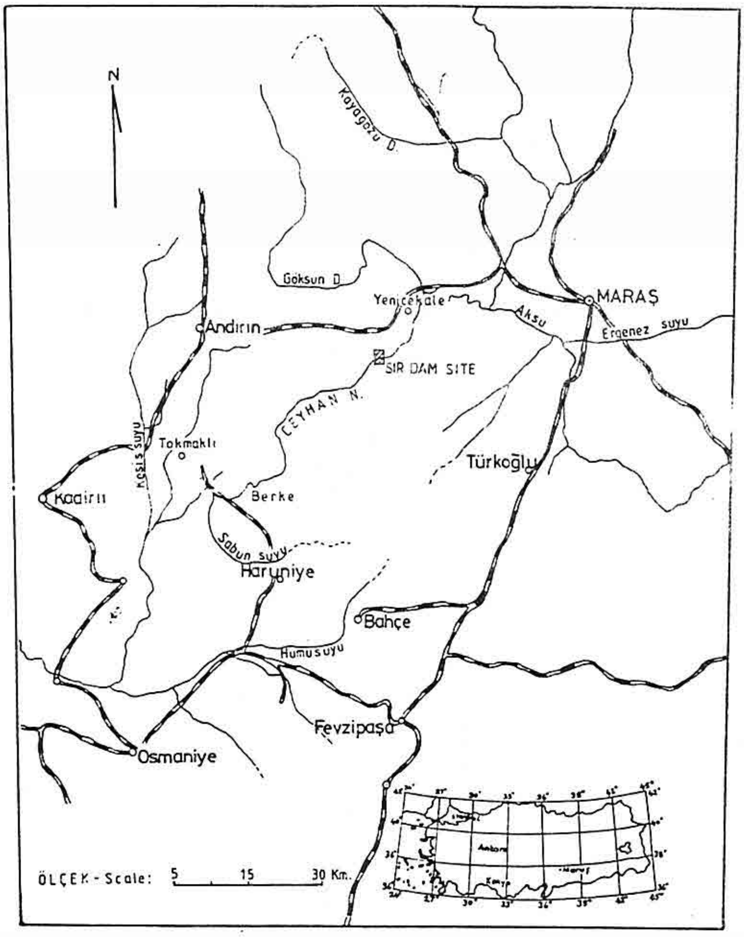

Figure 1: Location map of the study area

The new drillings are carried out by E.I.E. "Electrical Power Resources Survey and Development Administration".

The Geomechanical classification (Bieniawski, 1976, 1983) is based on the following parameters; strength of intact rock material, drill core quality "R.Q.D", spacing of discontinuities, condition of discontinuities, ground water conditions and orientation of discontinuites. The input data for these parameters were obtained from the exploratory

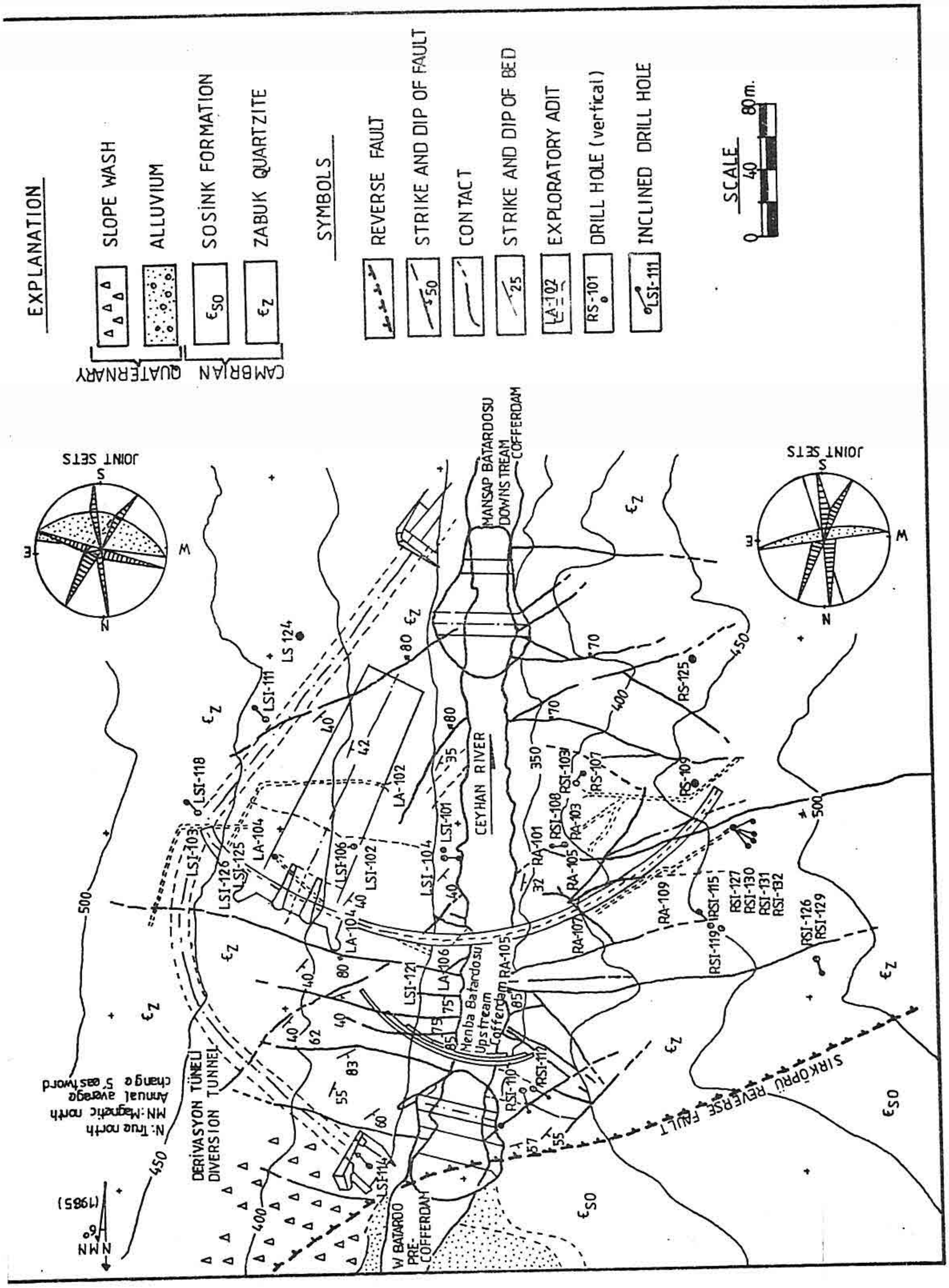

Figure 2.Geological map of the Sır Dame site.

adits, by using 598 survey stations for the discontinuity planes and 1436 survey stations for the determination of R.Q.D. This subsurface data was also supplemented by the field observations. The detailed geological sections of adits made by experienced engineer geologists (E.I.E) become very helpful for this investigations. The density percentages of the total 5590 points were calculated by the IBM center of E.I.E and the laboratory tests on the samples taken from the fault-zone were also carried out by E.I.E.

GENERAL GEOLOGY

The Ceyhan-Berke-Sır Dam project area is situated to the northwest part of the Amanos Mountains occupying the folded border region of the Arabian Platform. The Amanos range includes an autochtonous sequence ranging in age from Cambrian to Cretaceous. The ophiolite nappes must have been emplaced during the late Campanian and the early Maastrichtian, and their overburden range in age from the Upper Maastrichtian to Eocene and to Miocene.

The Amanos Mountains range forms an anticlinorium trending in the NE-SW direction. While the eastern part of the range is bordered with the regional scale fault system, the imbricated structures associated with ophiolite nappes are dominant in the western part.

DAMSITE GEOLOGY

There are two formations observed in the dam site:

1. Zabuk quartzite (Єz)

The dam is to be found on slightly metamorphosed, gray-pink, cross bedded quartzose sandstone-quartzite of Cambrian. The quartzite cropps out on both banks of Ceyhan river, and is limited by Sır Köprü reverse fault at 130 meters upstream from the dam axis. The rock mass is pink on fresh parts, light grey-white, greenish to pinkish, yellowish on weathered parts, mostly fine to medium, occasionally coarse grained (conglomeratic), medium to thick quartz veined, closely jointed, minor scale faulted, occasionally quartz-rich phyllite and mica-schist intercalation containing and intack rock is very strong.

In thin section quartzite has well interlocked, equi-dimentional quartz crystals bounded with a matrix composed of sericite probably originated from clayey matrix of the original rock. Few amount of feldspar (microcline albite) and opaque minerals present and quartz crystals show an orientation giving a weak schistosity to the rock (2,4).

2.Sosink formation (ꞓso)

Sosink formation is made of siltstone, sandstone and shales, and is more than 150 m thick in the dam site area. The formation comprises monotonous, grey or green grey shales with occassional siltstones, all of which weather to a distincly light yellow-brown colour. The shales often contain detrital mica but are practically devoid of sandstone intercalations, in sharp contrast to the quartzitic strata of the underlying unit (2,5). The rocks are often strongly cleaved. Although exposures are both numerous and large, fossils are very rare.

The general dip of the beds, though variable, is to the west southwest at about 40^{0}. The weathered shale beds of Sosink formation dip gently southwest. The boundary between the Sosink formation and Zabuk quartzite is not normal because of the presence of the Sırköprü reverse fault.

STRUCTURAL DISCONTINUITIES

The most important major fracture is the Sır Köprü high angle-reverse fault which diagonally crosses the river about 60 m upstream (U/S) of the cofferdam. This ENE-WSW striking fault is also noted from study of the old exploratory core-boring (RSI-110, RSI-112, RSI-119). A new exploratory drill hole (RSI-128) is being drilled to explore the fault plane developed between Zabuk quartzite (ꞓs) the transition zone and Sosink formation (ꞓso) has the dip varying from 70^{0} to 90^{0} (Figure 2,3; Table 1,2).

The other minor-scale discontinuities such as bedding planes, fault and normal faults are well exposed in the abutments and exploratory adits. The bedding faults which are formed when the beds slipped relative to one another during folding dip an average at 40^{0} towards upstream in the vicinity of dam axis and their strikes make the angles of 40^{0} to 60^{0} with the Ceyhan river (Figure 4,5). The normal faults can be classified as two sets according to their trends in the abutments (Figure 2). The first set trends in the E-W direction across the valley and dips towards upstream (65^{0}-85^{0}) and dowstream (55^{0}-85^{0}). The second set trends in the NE-SW direction dips towards upstream (50^{0}-75^{0}) and dowstream (65^{0}-85^{0}).

Location	ADIT No.	Entrance Elev. / Lenght	Total number of poles	Smax Strike: Dip direction	Smax Dip	Submax 1 Strike: Dip direction	Submax 1 Dip	Submax 2 Strike: Dip direction	Submax 2 Dip	Submax 3 Strike: Dip direction	Submax 3 Dip	Submax 4 Strike: Dip direction	Submax 4 Dip	Submax 5 Strike: Dip direction	Submax 5 Dip	Submax 6 Strike: Dip direction	Submax 6 Dip	Submax 7 Strike: Dip direction	Submax 7 Dip
U/S	LA-102	368.94	505	N50 E-050		E-W-090		N70 E-070		N40W-320		N20 W-340		N60 W-300		—		—	
		114 m.		S 40 E 140	75°	S 180	64°	S 20 E 160	40°	S 50 W 230	70°	N70 E 070	60°	S 30 W 210	80°	—	—	—	—
Dam axis	LA-106	346.38	766	N 14 W-346		N70 W-290		N84 E-084		E-W-090		—		—		—		—	
		50 m.		N76E 076	80°	Vertical	90°	S 6 E 174	46°	N 360	70°	—	—	—	—	—	—	—	—
	LA-108	389.34	774	E-W-090		N74W-286		N 20 E-020		N70 W-290		—		—		—		—	
		50 m.		S 180	30°	N 16 E 016	80°	S 70 E 110	80°	S 20 W 200	66°	—	—	—	—	—	—	—	—
	LA-104	433.87	651	N10 W-350		N60 E-060		N 20 E-020		E-W-090		N30 E-030		N40 E-040		N60 E-060		N 10 E-010	
		114 m.		N80 E 080	75°	Vertical	90°	N70 W 290	80°	N 360	70°	S60 E 120	50°	S 50 E 130	70°	S 30 E 150	70°	Vertical	90°
Down Stream	RA-101	347.00	361	N 20 E-020		N 74 E-074		N50 E-050		N 70 W-290		N-S-360		E-W-090		N46 W-314		N40 W-320	
		126 m		S70 E 110	75°	N 16 W 344	70°	S 40 E 140	60°	S 20 W 200	64°	E 090	80°	S 180	40°	S 44 W 224	42°	S 50 W 230	70°
	RA-103	395.51	766	N 14 W-346		N84 W-276		N-S-360		N 10 W-350		N30 E 030		—		—		—	
		99 m.		N 76 E 076	80°	S 6 W 186	50°	Vertical	90°	S80 W 260	76°	S 60 E 120	80°	—	—	—	—	—	—
Dam axis	RA-105	345.76	805	N36 E-036		N10 W-350		N40 E-040		E-W-090		N-S-360		—		—		—	
		60 m.		S54 E 126	77°	S 80 W 260	70°	N 50 W 310	70°	N 360	60°	E 090	75°	—	—	—	—	—	—
	RA-107	304.25	494	N80 W-280		N 10 W-350		N60 E-060		E-W-090		N40 E-040		N 40 E-040		N20 E-020		N10 W-350	
		55 m.		S 10 W 190	60°	Vertical	90°	S30 E 150	70°	S 180	[illegible]	0E 130	50°	N50W 310	40°	S 70E 110	60°	S 80 W 260	70°
	RA-109	431.50	593	N 16 E-016		N-S-360		N60 E-060		N40 W-320		—		—		—		—	
		50 m.		S74 E 106	80°	Vertical	90°	S30 E 150	50°	S50 W 230	80°	—	—	—	—	—	—	—	—

Table 1. The orientations of the joint sets in the exploratory adits of the Sir Dam(Refer for all directions to the magnetic north).

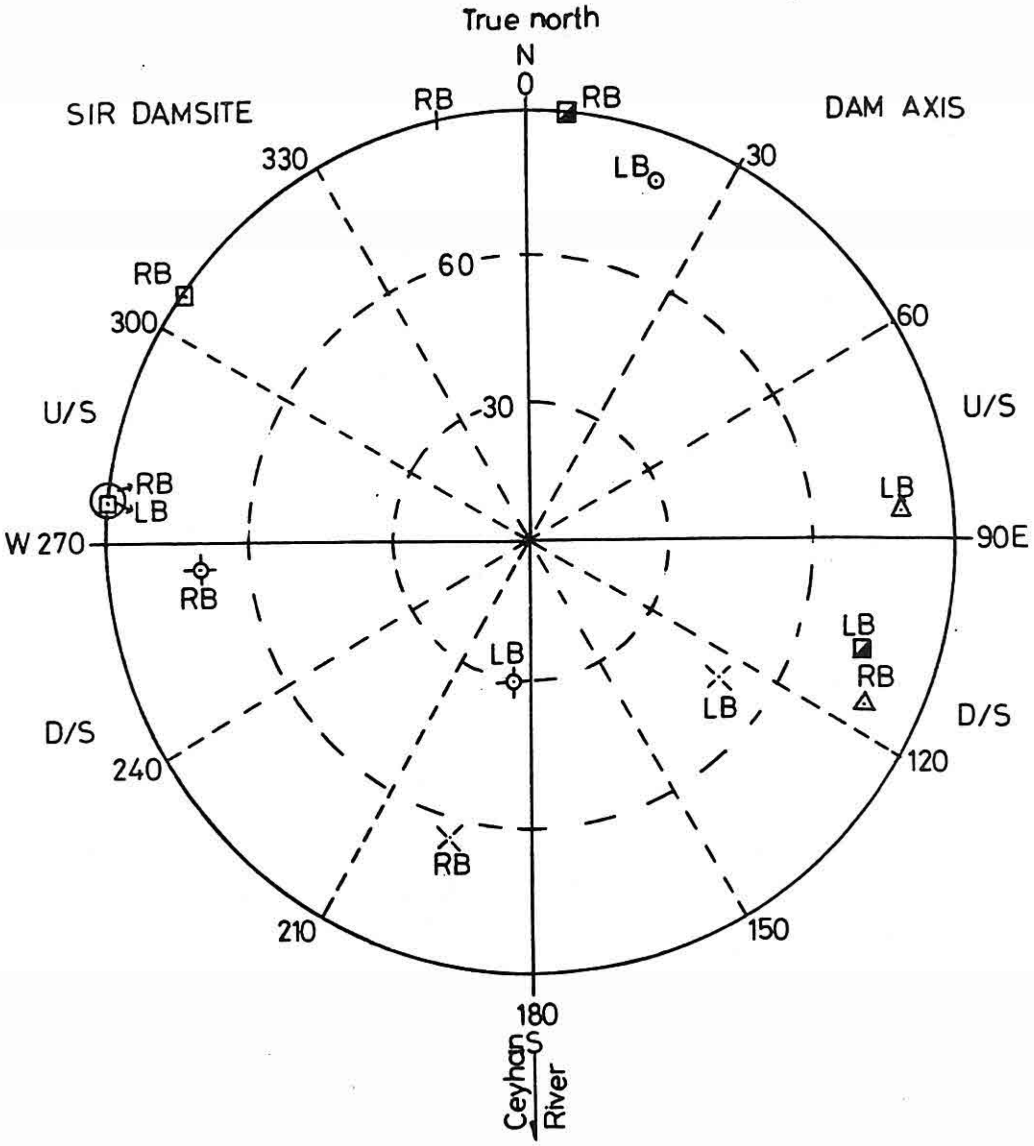

Figure 3. THE POLES OF THE JOINT SETS IN SIR QUARTZITE
(Equatorial net of equi-interval projection-upper hemisphere)

△ Smax
⊡ $Submax_1$
⊙ $Submax_2$
◪ $Submax_2$
-ф- $Submax_4$
✕ $Submax_3$
+ $Submax_6$
LB Left Bank
RB Right Bank

Location	ADIT No.	Entrance Elev.	Total lenght	Total number of potes	Smax Strike		Submax 1 Strike		Submax 2 Strike		Submax 3 Strike		Submax 4 Strike		Submax 5 Strike		Submax 6 Strike	
					Dip direction	Dip	Dip direction	Dip	Dip direction	Dip	Dip direction	Dip	Dip direction	Dip	Dip direction	Dip	Dip direction	Dip
D/S	LA 102	36894	114m	505	N 50E—050		E W—090		N 70E—070		N 40W—320		N 60W—300		—		—	
					S40E 140	75°	S 180	64°	S 20E 160	40°	S 50 W 230	70°	S30W 210	80°	—	—	—	—
Dam axis	LA 106 LA 108 LA 104	346.38 389.34 433.87	214m	2191	N10W—350		E-W — 270		N76W—284		N12E—012		E-W — 090		N 30E—030		—	
					N80E 080	80°	Vertical	90°	N 4 E C14	80°	S78E 102	75°	S 180	30°	S60E 120	50°	—	—
D/S	RA 101 RA 103	347.00 395.51	225m	1127	N10W—350		N40E—040		N–S—360		N86W—274		N10W—350		N70E — 070		—	
					N80E 080	80°	S50E 130	80°	Vertical	90°	S4W 184	50°	S80W 260	74°	N20W 340	66°		
Dam axis	RA 105 RA 107 RA 109	345.76 384.25 431.50	165m	1892	N20E—020		N60W—300		E-W — 270		N-S —360		N10W—350		N80W—280		N20W—340	
					S70E 110	80°	Vertical	90°	Vertical	90°	Vertical	90°	S80W 260	70°	S10W 190	64°	Vertical	90°
Left bank	LA 102 LA 104 LA 106 LA 108	368.94 433.87 346.38 389.34	328m	2696	N10W—350		E-W—270		N26E—026		N75W—025		N55E—055		E-W —090		—	
					N80E 080	80°	Vertical	90°	S64E 116	76°	N15E 015	78°	S35E 145	70°	S 180	36°	—	—
Right bank	RA 101 RA 103 RA 105 RA 107 RA 109	347.00 395.51 345.76 384.25 431.50	390m	3019	N20E—020		N—S—360		N10W—350		N20W—340		N10W—350		N80E—080		—	
					S70E 110	80°	Vertical	90°	N80E 080	80°	Vertical	90°	S80W 260	74°	S10E 170	72°	—	—

Table 2.Summary of the joint sets-orientations in the exploratory adits(Refer for all directions to magnatic north).

Stereograms of both fault planes measured in the adits have the same orientations to each other (Figure 4,5). Both types of faults consist of fault gauge and crushed-foliated rock material with occassional quartz veinlets.

The closely spaced joint sets are also well developed and well exposed in the abutments and exploratory adits. Figure 3 and Table 1 and 2 show the orientations of joint sets in detail. The above mentioned fault classification can also be roughly applied for the joint set orientations.

The strongly marked bedding plane is an important weakness plane in the rock mass at the Sır Dam site. The strikes of beds make an agle of 40^0 to 60^0 with the river direction and cross the damsite diagonally. Bedding planes dipping upstream and towards the right bank (NW) and their dip vary from 30^0 to 70^0. Near the Sır Köprü reverse fault becomes more steeper and even overturned.

GEOMECHANICS CLASSIFICATION (RMR SYSTEM) OF THE ZABUK QUARTZITE

The Geomechanics Classification (RMR System) is based on the following six parameters (Table III);

1. Strength of intact rock material (point load strength index or uniaxial compressive strength),
2. Drill core quality (RQD),
3. Spacing of discontinuities (ISRM recommendation),
4. Condition of discontinuities (roughness, persistence, seperation, weathering, infilling),
5. Ground water conditions,
6. Orientation of discontinuities.

These six major geotechnical parameters constitute the basic input parameters. For each parameter, five ratings were considered. Importance ratings are allocated to each parameter and the total rating for rock mass clases are specified. The basic in-situ Rock Mass Rating (RMR) values determine five rock mass classes: I (very good rock), II (good rock), III (fair rock), IV (poor rock) and V (very poor rock). The meanings of rock mass clases cover average stand up time for tunnels. Friction angle and cohesion of the rock mass, and modules of deformability (6,7).

ZABUK QUARTZITE

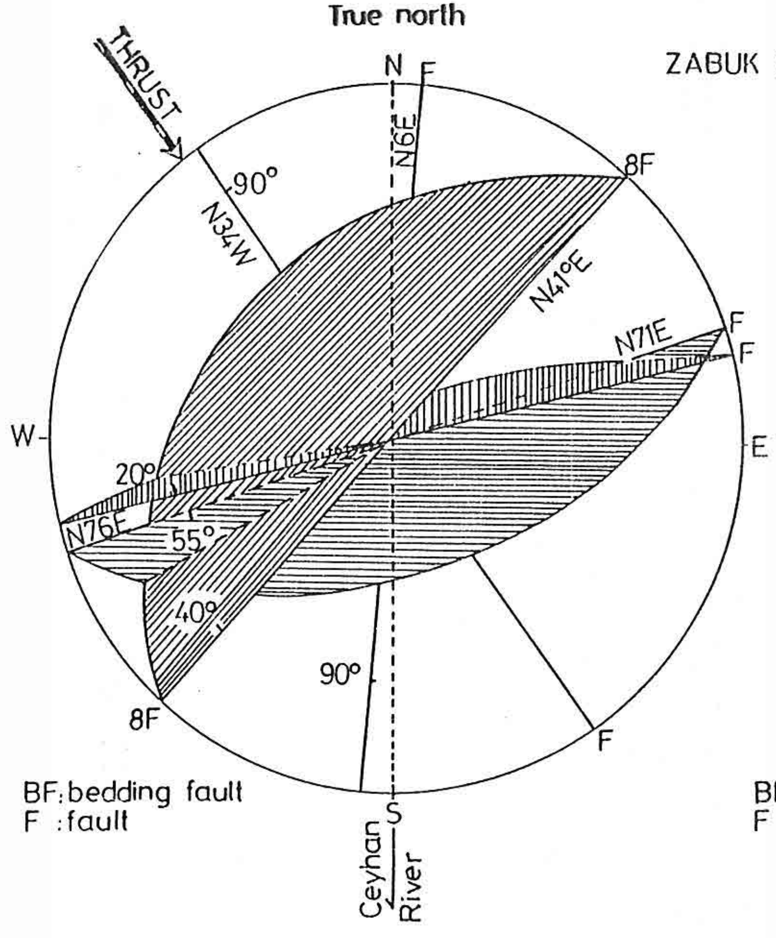

Figure 4. STEREOGRAMS OF FAULT PLANES AT RIGHT BANK (equatorial net of equi-interval projection)

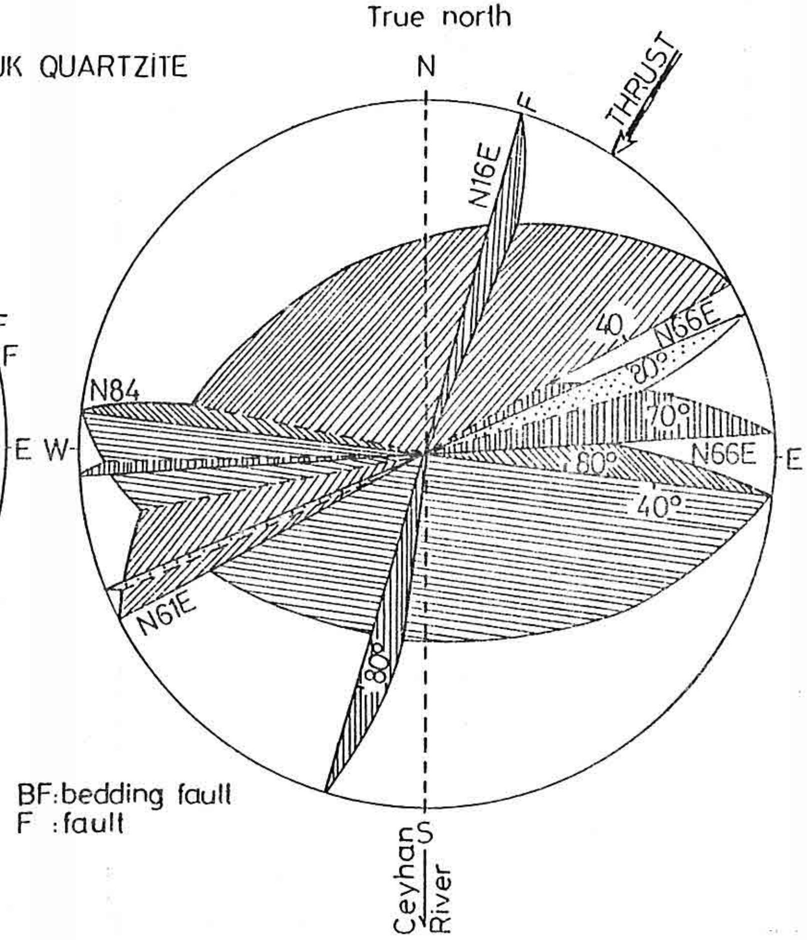

Figure 5. STEREOGRAMS OF FAULT PLANS AT LEFT BANK (equatorial net of equi-interval projection)

In order to apply the Geomechanics Classification, to the Sır Dam site identify the structural regions within the rock mass. Since the rock type and spacing and condition of major discontinuities are more or less uniform, a single structural region has been considered for the Sır Dam. The exploratory adits excaveted at different levels could also be accepted as a sub-structural region, in application of the geomechanical classification to the Sır Dam.

After identifying the structural region, the first step is to establish the sum of all the ratings obtained from each five parameters. This will give the "Basic rock mass rating". The second step is to make rating adjustment according to the orientations of the discontinuities. This step is seperated, because the influences of discontinuity orientations depend upon the selection of the engineering application, e.g. foundation slope stability, tunnel excavation. The adjustment for discontinuity orientation yields the final (adjusted) rating.

The reference tables (6,7) for the adjustment of distontinuity are as follows;

Reference table 1. The effect of discontinuity strike and dip orientation in tunnelling (Bieniawski, 1976, 1983).

Strike perpendicular to tunnel axis				Strike parallel to tunnel axis	
Drive with dip		Drive against dip			
Dip 45^0-90^0	Dip 20^0-90^0	Dip 45^0-90^0	Dip 20^0-45^0	Dip 45^0-90^0	Dip 20^0-45^0
Very Favourable	Favourable	Fair	Unfavourable	Very Unfavourable	Fair
Dip 0^0-20^0 : Unfavourable, irrespective of strike					

Reference table 2, Assessment of discontinuity orientation favourability upon stability of dam foundation (Bieniawski, 1976; 1983)

Dip 0^{o}-10^{o}	Dip 10^{o}-30^{o} Dip Direction		Dip 30^{o}-60^{o}	Dip 60^{o}-90^{o}
	Upstream	Downstream		
Very favourable	Unfavourable	Fair	Favourable	Very unfavourable

Note:

This table is based on experience and on consideration of stress distributions in foundation rock masses as well as on an assumption that in a dam structure both the arch and the gravity effects are present.

The initial in-situ state of stress is not considered here as in dam foundations in situ stresses are mainly important when considering grouting, drainage curtains and the excavation sequence of the foundations. For this last aspect recent evidence shows that high horizontal stresses may be expected in near surface rock masses.

This table is tentative only and represents simplifications of a problem which is justified for rock mass classification purposes only.

Reference table 3. Rating adjustment for discontinuity orientations (Bieniawski, 1976)

Strike and dip orientations of discontinuties		Very favourable	Favourable	Fair	Unfavourable	Very Unfavourable
Ratings	Tunnels	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	-60

The present study is mainly concerned with the determination of "Basic rock mass rating" for the Sır Dam site, The estimated parameters are summarized bellow;

1. Strength of Intact Rock Material

The matrix of quartzite is hard and strong. The quartz grains are well interlocked. Average result of compressive strength tests for 4 specimens is 1155 kg/cm^2 (tested at the METU "Middle East Technical University" Ankara). The artifical aggregate samples taken from left bank near by U/S cofferdam which were tested at the DSI "State Hydraulic Works" gave the following results: 1095, 1195, 1250, 1405 and 1410 kg/cm^2. These values were also supported by sclerometer readings (petite-sismique Survey-Dr.B.Schneider). These results correspond to the range of value "100-250 MPa" giving a rating of 12 (Table III) for the left and right bank. The percentage of mica-schist having the low value of compressive strength represents 3 % to 5 % within the quartzite mass.

2. Drill Core Quality (RQD)

Rock quality designation R Q D is a quantitative index based an modified core-recorvery (NX size) percentage in which all the sound core pieces over 100 mm long are counted as recovery and are expressed as a percentage of the length drilled (7).

Since the borecore was not available, the RQD has been determined from the joint measurements in the exploratory tunnels, and the number of joints per meter for each joint set is taken for RQD calculations.The following relation was used to convert the joint frequency to RQD for the case of clay-free rock masses (8).

R.Q.D = 115 - 3.3 Jv

Jv = Total number of joints per m^3

R.Q.D = 100 for Jv "4,5"

During the determination of RQD in the adits, total number of joints per m^3 (Jv) was calculated for each meter of the left and right wall separately. Then the average value of RQD was obtained from the mean of these two values.

A_CLASSFICATION PARAMETERS AND THEIR RATINGS

	PARAMETER		RANGES OF VALUES						
1	Strength of intact rock material	Point load strength index	>10 MPa	4–10 MPa	2–4 MPa	1–2 MPa	For this low range uniaxial compr. test preferred.		
		Uniaxial compressive strength	>250 MPa	100–250 MPa	50–100 MPa	25–50 MPa	5-25 MPa	1-5 MPa	1 MPa
	Rating		15	12	7	4	1	1	0
2	Drill core quality RQD		90%–100%	75%–90%	50%–75%	25%–50%	< 25%		
	Rating		20	17	13	8	3		
3	Spacing of discontinuites		> 2m (F1)	06–2m (F2)	200-600mm (F3)	60–200mm (F4)	< 60mm (F5)		
	Rating		20	15	10	6	1		
4	Condition of discontinuities		Very rough surfaces No continuous No sperations Unweathered wall rock	Slightly rough surfaces Seperation < 1mm Slightly weathered wall rock.	Slightly rough surfaces Seperation < 1mm Highly weathered wall rock	Slickensided surfaces or Gouge < 5mm thick or Seperation 1-5mm Continuous	Soft gouge > 5mm thick Seperation > 5mm Continuous		
	Rating		30	25	20	10	0		
5	Ground water	Inflow per 10m tunnel length	None	10 litres/min	10–25 litres/min	25–125 litres/min	>125 litres/min		
		Ratio Joint water pressure / major principal stress	OR 0	OR 00–01	OR 01–02	OR 02–03	OR >03		
		General conditions	OR Completely dry	OR Damp	OR Wet	OR Dripping	OR Flowing		
	Rating		15	10	7	4	0		

B_ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS

Rating	100 — 81	80 — 61	60 — 41	40 — 21	< 20
Class No.	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

C_MEANINGS OF ROCK MASS CLASSES

Class No.	I	II	III	IV	V
Average stand up time	10 Years for 15m span	6 months for 8 m span	1 week for 5 m span	10 hours for 2.5m span	10 minutes for 1m span
Cohesion of the rock mass	400 kPa	300–400 kPa	200–300 kPa	100–200 kPa	< 100 kPa
Friction angle of the rock mass	> 45°	35°–45°	25°–35°	15°–25°	< 15°
Modulus of deformability	>54000 Mpa	54000–16000 Mpa	18000–5600 Mpa	5600–1800 Mpa	<1800 Mpa

Table 4

SHEAR STRENGTH OF ROCK (J.L. SERAFIM and J.P. PEREIRA, 1983)

Strength of intact rock material								
	Point load strength	> 10 MPa	4–10 MPa	2–4 MPa	1–2 MPa	For this low range uniaxial comp test preferred.		
	Uniaxial compressive strength	> 250 MPa	100–250 MPa	50–100 MPa	25–50 MPa	5-25 MPa	1-5 MPa	<1 MPa
Rating		15	12	7	4	2	1	0
Cohesion of the rock material		> 25 MPa	25–15 MPa	15–85 MPa	85–45 MPa	[illegible]	<1 MPa	
Friction angle of rock material		> 65°	65°–55°	55°–48°	48°–41°	41–33	<33°	

Table 5

SHEAR STRENGTH OF DISCONTINUITES (J.L. SERAFIM and J.P. PEREIRA, 1983)

Condition of discontinuities / Ground water	Raiting	Very rough surfaces Not continuous No speration Unweathered wall rock.	Slightly rough surfaces Separation <1 mm Slightly weathered wall rock.	Slightly rough surfaces Separation < 1 mm Highly weathered wall rock.	Slickensided surfaces or Gouge < 5 mm thick or Separation 1–5mm Continuous	Soft gouge >5mm or thick Separation > 5mm Continuous
		30	25	20	10	6
Completely dry	15	45°	35°	25°	15°	10°
Damp	10	43°	33°	23°	13°	< 10°
Wet	7	41°	31°	21°	11°	< 10°
Dripping	4	39°	29°	19°	10°	< 10°
Flowing	0	37°	27°	17°	< 10°	< 10°

Table 3,4 and 5.Geomechanics classification(Bieniawski,1976; 1983),Shear strength of rock material(Table 4), Shear strength of discontinuites (Table 5).

The divisions of Rock Quality Designation (R,Q,D) and their rating (RMR-System) are as follows (Bieniawski, 1976; 1983)

Description	R Q D	Rating
Very good quality	90 % - 100 %	20
Good quality	75 % - 90 %	17
Fair quality	50 % - 75 %	13
Poor quality	25 % - 50 %	8
Very poor quality	$<$ 25 %	3

The dominant RQD values in the adits have been taken into consideration for the "basic rock mass classes" (Table VII). At the dam axis, high percentage of RQD distribution is within the range of 50 % - 75 % which gives the rating of 13 (Table VI). The higher RQD values (75 % - 90 % and 100 = 17 and 20 ratings) were only observed at the left bank adits LA-104 and LA-108. The lower values of RQD (25 % - 50 % = rating 8) are dominant in the right bank adits RA-109.

The RQD values of down stream (D/S) exploratory holes indicate that very poor to poor quality rock form a band of appropiate 15 m thick at left abutment and 20-25 m thick at right abutment, near surface. Beneath this zone, there is 30 m thick zone formed from fair to good quality rock. Towards the depth, poor quality rock bands are found again. But the number of the holes at the abutments are not quite sufficient in order to get more clear picture.

3. Spacing of Discontinuities

Four kinds of discontinuity planes were distinquished at the site. These are bedding planes, joints, bedding faults, and normal faults. The data on these discontinuities were obtained from the field surveys on the abutments and in the adits, not from borehole log. Spacing of discontinuities represent the average perpendicular distances between adjacent discontinuities. The following ISRM terminology are used (Bieniawski, 1976).

Description	Spacing
Very wide spacing	$>$ 2000 mm
Wide spacing	600 - 2000 mm

LOCATION	ADIT NO.	LENGTH	RATINGS (RMR-SYSTEM)			
			8	13	17	20
			%	%	%	%
Left Bank	LA—102	114 m.	5	81	14	—
	LA—104	114 m.	2	15	48	35
	LA—106	50 m.	4	90	6	—
	LA—108	50 m.	6	54	40	—
Right Bank	RA—101	126 m.	24	70	6	—
	RA—103	99 m.	34	66	—	—
	RA—105	60 m.	—	87	13	—
	RA—107	55 m.	62	38	—	—
	RA—109	50 m.	58	42	—	—
L. Bank Downstream	LA—102	114 m.	5	81	14	—
L. Bank Dam axis	LA—104 LA—106 LA—108	214 m.	3	42	36	19
R. Bank Downstream	RA—101 RA—103	225 m.	28	66	4	—
R. Bank Dam axis	RA—105 RA—107 RA—109	165 m.	38	57	5	—

Table 6. Drill core quality (RQD) results of the adits and percentages of their ratings (RMR-System).

Bank	LOCATION	ADIT NO. / Elavation	CLASSIFICATION PARAMETERS AND THEIR RATINGS					ROCK MASS CLASSES		
			Strength of intact rock	Drill core quality RQD	Spacing of discontinuities	Condition of discontinuities	Ground water	Basic total ratings	Class no.	Description
Left Bank	D/S	LA 102 368.94	12	13	20	10	10	65	II	Good rock
Left Bank	DAM AXIS	LA 106 346.38	12	13	15	10	10	60	III	Fair rock
Left Bank	DAM AXIS	LA 108 389.34	12	13	15	10	10	60	III	Fair rock
Left Bank	DAM AXIS	LA 104 433.87	12	17	20	10	10	67	II	Good rock
Right Bank	D/S	RA 101 347.00	12	13	20	10	7	62	II	Good rock
Right Bank	D/S	RA 103 395.51	12	13	20	10	10	65	II	Good rock
Right Bank	DAM AXIS	RA 105 345.76	12	13	20	10	10	65	II	Good rock
Right Bank	DAM AXIS	RA 107 384.25	12	8	20	10	10	60	III	Fair rock
Right Bank	DAM AXIS	RA 109 431.50	12	8	20	10	10	60	III	Fair rock

Table 7.Geomechanics classification(Bieniawski) of the Zabuk Quartzites.

Moderate spacing	200 ÷ 600 mm
Close spacing	60 - 200 mm
Very close spacing	< 60 mm

The spacing division, the frequency and the percentage in terms of the total number of the joints measured at each 1 meter of the survey-station in the adits, are as follows:

Adit	Survey-station	Spacing (mm)					
		200-600		60-200		60	
No	(Number)	(Number)	%	(Number)	%	(Number)	%
LA-102	65	3	0.5	484	96	18	3.5
LA-104	92	3	0.5	577	88.5	71	11
LA-106	92	-	-	749	98	17	2
LA-108	80	-	-	607	78	167	22
RA-101	35	-	-	276	76.5	85	23.5
RA-103	68	-	-	330	43	436	57
RA-105	66	-	-	246	30.5	559	69.5
RA-107	52	-	-	119	24	375	76
RA-109	48	-	-	127	21.5	466	78.5
Total	598	6	0.1	3515	61.7	2194	38.1

In the dam axis, while the closely spaced joints (60-200 mm) are more dominant (78 % - 98 %) at the left abutment, very closely spaced joints (60 mm) are more frequent at the right abutment.

The spacing of bedding faults and normal faults generally vary from 0.6 m to 3 m or more, but an average 0.6 m to 2 m in the adits. The thickness of bedding is also changing in general, between 15-30 cm and 50-150 cm. By taking into consideration the physical properties of the discontinuities, the combined spacing value of the bedding and normal faults are considered for the RMR system. Ratings varying between, 15 and 20, have been estimated for the basic rock mass class.

4. Condition of Discontinuities

This parameter includes roughness, persistence (continuity), separation and wall rock condition of the discontinuities. The terms roughness refer to large or small scale undulated surfaces and smooth to slickensided surfaces. Persistence (continuity) is the discontinuity trace length as observed in an outcrop. Separation (aperture) is the perpendicular distance between adjacent rock walls of an open discontinuity in which the intervening space is air, water or partly filled with occasionally washed away infilling material. Well rock condition is the weathering grade of rock material on the adjacent rock wall of an open or partly filled discontinuity.

The following ISRM suggested divisions are used.

Persistence (continuity)	
Very low	< 1 m
Low	1 - 3 m
Medium	3 -10 m
High	10 -20 m
Very high	> 20 m

The term of "continuous" for the exploratory adit in 2 m diameters to a discontinuity having in excess of 1.5 m or more measured along strike or dip of the plane.

Separation (aperture)	
Very tight	< 0.1 mm
Tight	0.1-0.5 mm
Moderately open	0.5-2.5 mm
Open	2.5-10 mm
Very wide	> 10 mm

The persistence of the joint sets in the adits are generally limited by the existence of the faults. The dominant sets which are also well expressed in the abutments show high to very high persistence. The space of more than ninety percent of the joints vary from 0.1 mm to 0.1-0.5 mm (very tigh to tight). They are mostly represented by slightly rough to rough and rarely smooth to slickensided surfaces. Joint wall rocks are generally unweathered to slightly weathered.

The normal faults and especially the bedding faults are well developed within the Zabuk quartzites. Their continuous outcrops are strongly expressed on the abutments and in the adits, Roughness of the fault planes varies between slightly rough-rough surfaces and slickensided surfaces.

The following table shows the separation divisions of the faults which were surveyed at the dam axis-adits:

Adit	Separation 1 - 5 mm		Separation 5 mm		
No	Bedding fault	Fault	Bedding fault	Fault	Total
LA-104	9	-	24	21	54
LA-106	2	1	18	7	28
LA-108	7	1	18	11	37
	18	2	60	39	119
RA-105	2	1	8	3	14
RA-107	1	1	4	9	15
RA-109	3	5	4	11	23
	6	7	16	23	52

As seen from the table, both types of faults with the separation division of over 5 mm are more accentuated at left and right abutments.

The fault wall rocks are mostly slightly and occasionally moderately weathered (LA-104 "A", LA-106). This description of weathering grade only concerns the fault walls starting from the boundary of fault zone material which is included in the foliated part of the rock.

4.1. Infilling (Fault zone material)

The infilling material of the bedding fault zone is mainly originated from the mica-schist intercalations. During the tectonic movements, the thin mica-schist intercalations within the resistant quartzite layers were subjected to high compression and shear stresses. The present clayey gouge material is formed as a result of weathering and decomposition of these crushed and re-foliated schistose rocks. Most of the bedding fault zones are bearing greyish green coloured thin mica-schists (occasionally chlorite-talc schist) and weakly schistone quartzite-schist layers (9).

According to the hydrometer and sieve analysis of the fault zone-samples, the amount of the particles in clay-size range varies from only 9 % to 18 %. The standart Atterberg limit tests could not be made. As the samples taken from different adits show "non-plastic" properties. One test which was carried out on the material passing NO.200 sieve gave the following Atterberg limit values; LL = 22.5 %,PL = 15.7 %,PI = 6.8 %. These values indicate a very low plastic property.

Mineralogic determination and X-Ray diffraction analysis reveals that the clay minerals are composed of illites and kaolinites. Their percantages vary from 35 % to 55 %. The other important component are quartz (35 % to 55 %), feldspar (5 % to 10 %), and calcite (5 % to 15 %, in only two samples). The accessory minerals are zircon, rutile, pyroxene apatite and leucoxene.

Kaolinites are very stable clays owing to their tight inexpandible structure resisting the introduction of water. The kaolinites are also low to moderately plastic and they have higher coefficient of internal friction than other clay minerals. The minerals of the "illites" have a more limited hydration capacity less expansive properties and high internal friction in comparison with the "montmorillonite" clays which are matter of engineering concern.

The general and common description of the fault zone-materials is as follows; the greyish green to occassionally brownish coloured filling materials are mostly damp without free water and occasionally wet with drops of water (at the lower level adits of the dam axis), and are composed of gravel-sand size to silt-clay size particles (gravel-sand size particles are predominant, 58 %-80 %); mostly 1 mm to 20 mm thick-fault gouge zone is irregularly, penatrated into the crushed and foliated rock materials and the width of the zones varies between 20 mm and 200 mm (max.1000 mm). Crushed and foliated schistose rocks in the fault zones are moderately to occasionally highly weathered, in general associated with thin to thick (max.15 cm) quartz veinlets which are parallel to the fault planes.

The normal faults and especially the bedding faults which contain continuous infilling material from the river level up to the dam-crest level, are of the most important weakness planes for the engineering structures. Therefore, a rating of 10 was chosen for the basic rock mass classification of discontinuities by taking into consideration their most convenient characteristics among the ranges of values (Table III).

5. Ground Water Condition

Ground water has important effect on the behaviour of fractured rock mass. In the quartzites, water seepage through partially open discontinuities is the result of secondary permeability of the rock mass.

At the Sır Damsite; the observations of ground water table were carried out in the borehelos numbered LS-101, LS-102, LS-103 (left bank) and RS-105, RS-109, RS-117 (right bank), by comparing the elevations with the gauge stations which were installed at the left bank D/S of the old collapsed bridge between the years 1972 and 1976 (Figure 2). The furthest distances between the observation holes and the river are 160 m at the left bank and 110 m at the right bank. The water table which has a low hydraulic gradient is higher than the river level in both abutments.

The limited exposures of the quartzites give a small quantity of ground water which is observed in the lower adits level of the right abutment (RA-101 and RA-105). During the field inspection of the adits in October 1985, the following flow measurements were made; 15 lt/min (RA-101) and 2 lt/min (RA-105). All of the other adits were damp. These values give the ratings as 10 and 7 for groundwater condition of the adit RA-101.

6. Orientation of Discontinuities

Discontinuity surveys were carried out in adits at 598 stations to collect the geotechnical and statistical data for the analysis of joints and faults planes. The declination angle between true north and magnetic north was 6^{0} for the Sır Dam area in 1985 and the annual rate of change is 3^{0} eastward. In Figure 3,4 and 5, the discontinuity planes were plotted with the reference of true north. The density percentages of the poles (5715 measurements for joints and 275 measurements for faults) were calculated at "E.İ.E, IBM center-IBM system 34-Program İÇTEN". These percentages were plotted on the polar equal area net and the contour diagrams were prepared by using "Dimitrejevic counter" (9). Since the poles are not counted more than once as for the Schmidt method, they do not violete probability theory and they show the real percentages. The equatorial equi-interval projection "Kawraiski" net was used for the stereograms (Figure 4,5),

The orientations of the joint sets surveyed in the dam axis-adits can be summarized as follows (refer all directions to true north):

Adit No	Density Order	Attitude	Angle With River	Dip towards Upstream (U/S)	Down-stream (D/S)
LA-106 LA-108 LA-104	Smax	N4W 80° NE	4°	80°	-
	Submax 1	N84W 90°	84°	-	-
	Submax 2	N70W 20° NE	70°	80°	-
	Submax 3	N18E 75° SE	18°	-	18°
	Submax 4	N84W 30° SW	84°	-	30°
	Submax 5	N36E 50° SE	36°	-	50°
RA-105 RA-107 RA-109	Smax	N26E 80° SE	26°	-	80°
	Submax 1	N54W 90°	54°	-	90°
	Submax 2	N84W 90°	84°	-	-
	Submax 3	N6E 90°	6°	-	-
	Submax 4	N4W 70° SW	4°	-	70°
	Submax 5	N74W 64° SW	74°	-	74°
	Submax 6	N14W 90°	14°	-	-

The strikes of bedding fault which are diagonally crossing the dam axis dip upstream-towards the right abutment at moderate angles. The orientations of bedding and normal faults are given below (refer all direction to true north, Figure 4,5);

The numbers of the fault measurements are not quite sufficient in order to prepare accurate contour diagrams, therefore the above mentioned orientations show the average strikes and dips.

CONCLUSIONS

The geomechanics classification (Bieniawski) of Zabuk quartzites was mainly carried out in the 9 exploratory adits. The subsurface data were also supplemented by the field observations. The "basic total ratings" of the adits at different levels indicate that the rock mass classes of

Bank	Attitude of the set	Angle with river	Dip towards Upstream(U/S)	Dip towards Downstream(D/S)
Left (faults)	N86E 70° NW	86°	70°	-
	N84W 80° NE	84°	80°	-
	N66E 80° SE	66°	-	66°
	N84W 40° SW	84°	-	40°
	N16E 80° SE	16°	-	80°
Bedding f.)	N61E 40° NW	61°	40°	-
Right (faults)	N6E 90°	6°	-	-
	N76E 80°	76°	80°	-
	N41E 70° NW	41°	70°	-
	N34E 90°	34°	-	-
	N71E 55° SE	71°	-	55°
Bedding f.)	N41E 40° NW	41°	40°	-

the quartzites vary from "class II-good rock" to "class III-fair rock" (Table VII).

The classificatino does not include the adjustment of discontinuity orientations for the specific engineering application, e.g. tunnel, basement or slope. The rating adjustments for this kind of specific engineering problems require more detailed geotechnical study on the considerable large number of vertical and horizontal geological sections.

However, it can be stated that the adjusted rock mass classes of the Zabuk quartzite would still stay in the "class III-fair rock" range suggesting a friction angle of 25°-35° and deformability modules of 18 000, 5 600 MPa for the rock mass. The direct shear tests on the Zabuk quartzite samples gave the friction angle on average 38° for the sample without filling and 28° for the samples with filling. On the other hand, a value of 100 000 kg/cm^2 is proposed for the average value of the rock mass elastic modulus.

The strongly marked stratification keeps its homogeneity in both abutments in spite of the faults which are diagonally cross the river.

The slips of the beds along the fault planes are generally, in minor scale and the orientations of the beds do not show any important deviation along the both walls of the faults. Therefore, the stratification which is one of the most important and continuous discontinuity planes can be accepted as an homogenous structural weakness medium.

On the other hand, the main weak point especially for the left bank is the bedding faults which are formed when the beds slipped relative to one another during folding. The continuous outcrops of the well developed bedding faults are strongly expressed on the abutments and in the adits. The roughness of the fault planes varies from slightly rough to rough and occassionally slickensided surfaces within the limited distances. It has been observed during the field observations that the bedding fault planes have mostly ondulated surfaces. The amounts of the relative movements determined by means of the shifted quartz veinlets or the faults are also of minor importance (in general 5-10 or 30 cm).

According to the statistical analysis results, the separation division of over 5 mm for the both types of faults are more accentuated at left and right abutments. The fault walls beyond the crushed and foliated part of the quartzite are mostly slightly and occassionally moderately weathered.

The continuous infilling materials (fault gouge) which are especially found in the bedding faults show mostly non-plastic and occossionally low to very low plastic properties. The presence of subangular to angular sand to gravel size (58 % to 80 % of infilling) quartzite and quartz particles, greatly improves the stregth of these crushed and foliated fault zones. "Kaolinite" and "Illite" are the stable clay minerals found in the fault planes, have relatively high internal friction and limited hydration capacity than other clay minerals.

The thin to thick bedded, jointed, hard and sound quartzite is an adequate foundation rock for the arch dam. The deep anchoring may be needed for the stabilization of main dam and upstream cofferdam foundation excavations, owing to the orientations and physical properties of the weakness planes.

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ETUDE GEOLOGIQUE ET GITOLOGIQUE DU DISTRICT POLYMETALLIQUE(Pb-Zn-Cu-Ag) DE LA REGION DE KALKIM-HANDERESI-KARAAYDIN (PRESQU'ILE DE BIGA-TURQUIE)

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RESUME

La lithologie du secteur de Kalkım-Handeresi-Karaaydın peut etre regroupée en quatre types: la série cristalisée de Kazdağ,la série de Kalabak(gneis) , les calcaires du Permien Inférieur avec les formations détritiques superposées et les roches magmatiques et volcaniques du Néogène. La granodiorite de Kalabak d'âge paleozoique et la granodiorite d'Eybek d'âge néogène ont donné naissance aux plusieurs minéralisations de type du métamorphisme de contact dans la région de Kalkım(Yenice).

Le gisement d'Handeresi et le gisement de Karaaydın(Simli Kurşun Madeni) peuvenet etre liés â la meme origine. Ils sont sités près du contact de la granodiorite de Kalabak montrant un aspect gneisique. La paragenèse de la minéralisation polymetallique du secteur étudié est la suivante: Galêne(très abondante et souvent en grandes plages, voir parfois des cubes de dimmension de 1.5 cm), Sphalérite(moins abondante et postérieure â la galêne), Chalcopyrite(soit sous forme des cristaux sub-automorphes,soit sous forme des inclusions dans les sphalérites),Pyrite(rare et souvent sous forme des cristaux automorphes),Magnetite(subordonnée),Hématite(plus abondante que la magnétite, mais souvent transformée de ce dernière),Covéllite et limonite(formées seconderment de l'altération de chalcopyrite et pyrite).

On a observé rarement des inclusions d'argentite(1-5 μ) surtout dans les échantillons provenant de la mine de Karaaydın. Cette observation est vérifiée par des résultats des analyeses chimiques. Les réserves éstimées du secteur étudié, sont de l'ordre de 200.000 t de Pb+Zn,32 t de Cu et une petite quantité d'Ag.

ÖZET

Kalkım-Handeresi-Karaaydın bölgesindeki litoloji dört gruba ayrılabilir: Kazdağ kristalize serisi,Kalabak serisi,detritik formasyonlarla örtülü Alt Permiyen yaşlı kireçtaşları ve Neojen yaşlı magmatik-volkanik kayaçlar. Paleozoyik ve Neojen yaşlı granodiyoritler Kalkım Bölgesinde kontak metamorfik tipde bir çok cevherleşmeye sebeb olmuşlardır.

Handeresi ve Karaaydın madenlerini aynı orijine bağlamak mümkündür. Her ikisi de gnaysik bir iç yapı gösteren Kalabak granodioritinin kontağına yakın yerlere yerleşmişlerdir. İnceleme alanında görülen cevherleşmenin parajenezi şöyledir: Galen(oldukça fazla ve genel olarak iri plajlar halinde olup bazen 1.5 cm boyutunda iri kübik kristaller gösterir),Sfalerit(galenden sonra oluşmuş olup daha azdır),Kalkopirit(gerek yarı özşekilli kristaller ve gerekse sfalerit kristalleri içinde kapanımlar halinde bulunur),Pirit(oldukça az ve daha çok öz şekilli kristaller içerir),Manyetit(seyrek),Hematit(manyetitten fazla ancak onun alterasyonundan oluşmuştur),Kovelin ve limonite ikincil olarak rastlanır.Bunlar kalkopirit ve piritin alterasyonu sonucu oluşmuşlardır.

Çok seyrek olarak Karaaydın Madeninden alınan örneklerin parlak kesitlerinde boyutları 1-5 µ arasında değişen arjantit kristallerine inklüzyonlar halinde rastlanılmıştır. Bu gözlem kimyasal analizler ile de doğrulanmıştır.İnceleme alanında 200.000 t Pb+Zn,32 t Cu ve biraz Ag 'lik bir rezerv tesbit edilmiştir.

INTRODUCTION

La région de Kalkım-Handeresi-Karaaydın est située au Nord-Est de Kazdağ dans la Presqu'ile de Biga(Figure 1).Cette région constitue un très beau spécimen de minéralisation polymétallique Pb-Zn-Cu-Ag essentiellemnt de type filonien. L'exploitation du Pb-Zn a été entamée à la fin 19 ème siècle. Actuellement les gisements d'Handeresi et Karaaydın sont exploités par deux sociétés privés. Les réserves estimées sont de l'ordre de 200.000 tonne de Pb+Zn,32 t de Cu et une petite quantité d'Ag.

La lithologie du secteur étudié peut etre regroupée en quatre types: la série cristalisée de Kazdağ,la série de Kalabak(la granodiorite schisteuse de Bağırkaç),les calcaires du Permien Inférieur avec les formations détritiques feldspatiques superposées et les roches magmatiques et volcacaniques du Néogêne,

Les plus importants travuax effectués dans cette région appartiennet à Gümüş(1),Aslaner(2).Bingöl(3),Dayıoğlu(4),Bingöl et al.(5),Yücelay(6), Bingöl (7) , — Anıl(8),Çağatay(9) ,Çetinkaya et al.(10). Les condions géologiques favorables et la proximité de villes industrialisées de la Prisqu'ile de Biga attirent les géologues turcs et étrangers. Depuis 1935(date de la création du M.T.A.),environ 300 études,dont 15 thèses, ont été réalisées dans toute la région.

La présente étude a pour but de préciser les relations entre les différentes formations encaissantes de minéralisations du Pb-Zn-Cu-Ag

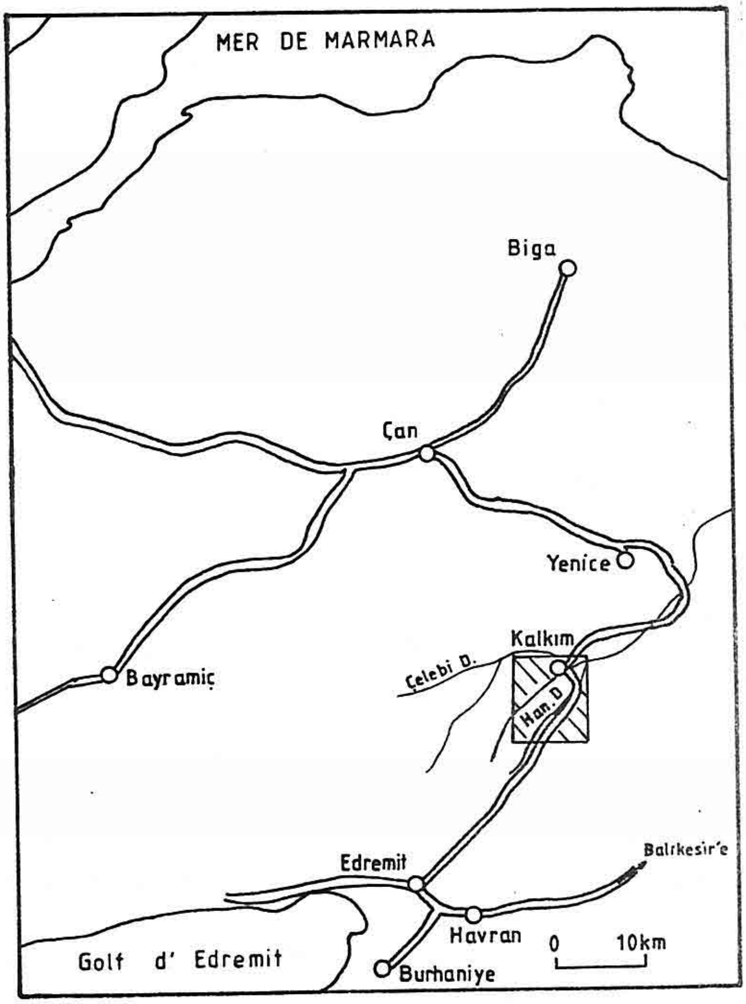

Figure 1.Situation géographique du secteur étudié.

et d'en étudier la paragenèse ainsi que la succession des minéraux constituants de ce corps minéralisé.

STRATIGRAPHIE

Eu égard à l'absence de fossiles dans les roches du secteur, on adoptera ici une subdivision lithostratigraphique. Un âge sera proposé pour les différentes formations par les études effectuées récemment.

Le Paléozoique est représenté essentiellement par des formations métamorphiques de Kalabak. Plus d'un quart du secteur(figure 2) est constitué par ces formations, qui donnent des reliefs assez doux, généralement couverts de terre végétale et de forets. Cette série a un contact tectonique avec des roches cristallines de Kazdağ et constitue un socle pour les autres roches. Elle est composée par des schistes chloriteux,séricciteux et micacés. Les lentilles de calcaire métamorfique sont intercalées dans cette série dans laquelle les silts de diabase sont intrusives. On voit rarement des arkoses dans la série de Kalabak.

L'étude microscopique des schistes permet d'en distinguer principalement deux types différents.Ce sont; les schistes chloriteux sériciteux et les schistes quartzeux et micacés. On rencontre rarement un autre type de schiste micacé dans lequel la proportion du quartz est augmentée.

Les schistes chlcriteux et sériciteux plus fréquents sont caracterisés par le feutrage orienté des lamelles de chlorite et de séricite,renfermant des grains du quartz de différents dimmensions,soit sub-angleux, soit sub-arrondis. Parfois,des fragements de feldspaths les accompagnent.

Les schistes quartzeux et micacés présentent des lits micacés dont l'épaisseur varie généralement entre 0.2 mm et 3 mm. La structure des lits quartzeux est granoblastique. Ces lits ont été plissotés et étirés au cours de plusieures phases. Les lits micacés sont faits de séricite et parfois de chlorite et sont rares dans certaines lames minces.Occasionallement, des feldspaths(très souvent de l'albite),du zircon,du sphène et parfois de l'épidote accompagnent le quartz et les micas.

Les calcaires métamorphiques sont entièrement recristalisés et ont une couleur gris clair oubleuatre. Ils ont un aspect massif, un grain fin et un aspect homogène. Cette roche est azoique dans le terrain étudié. Ces calcaires métamorphiques affleurent sous forme de lentilles dans les formations schisteuses qui ont un aspect doux morphologiquement.

En lame mince, ils ont souvent une texture mozaique ou bien rarement

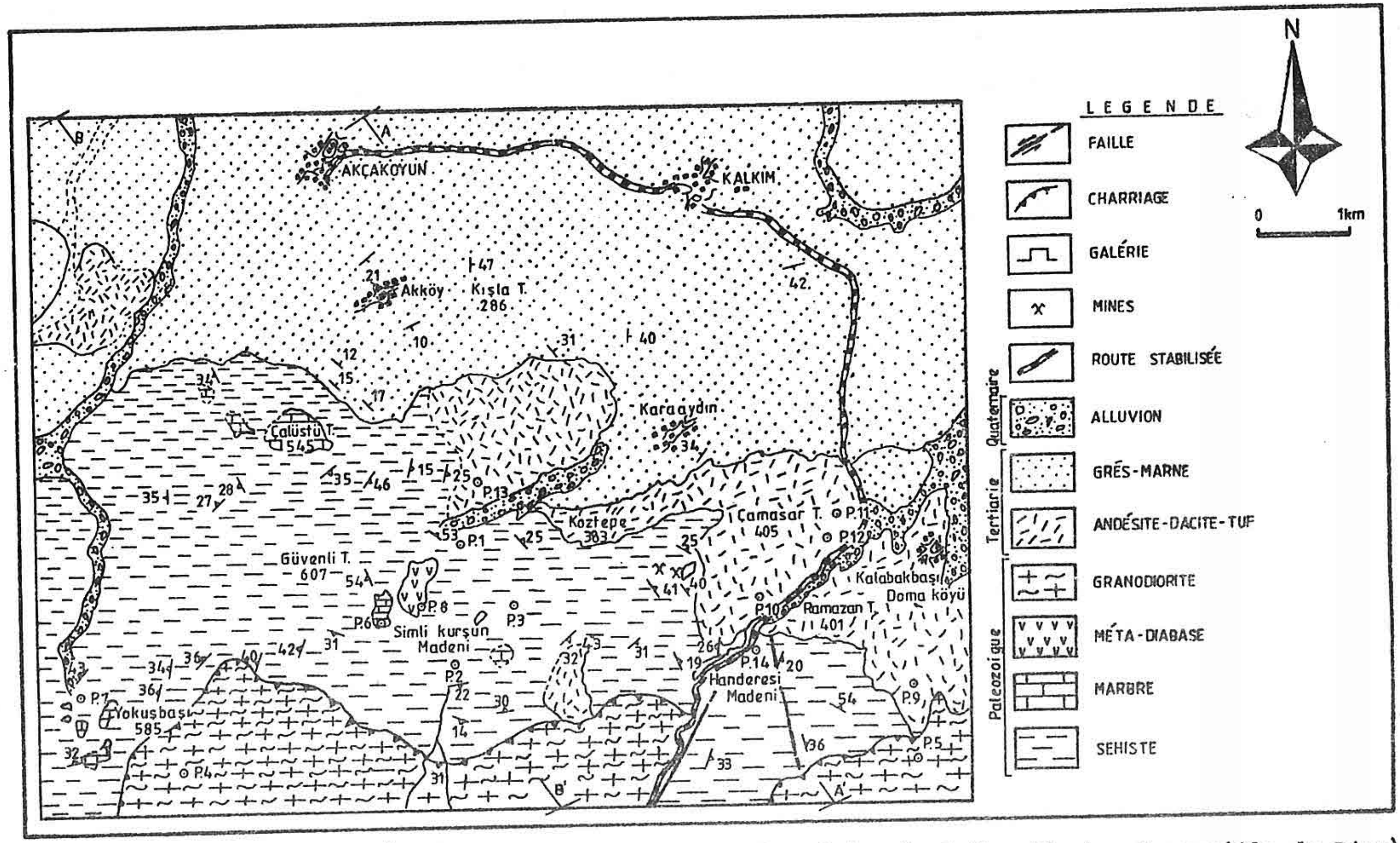

Figure 2.Carte géologique des mines(Pb-Zn-Cu-Ag) de la région de Kalkım(Yenice-Presqu'ile de Biga).

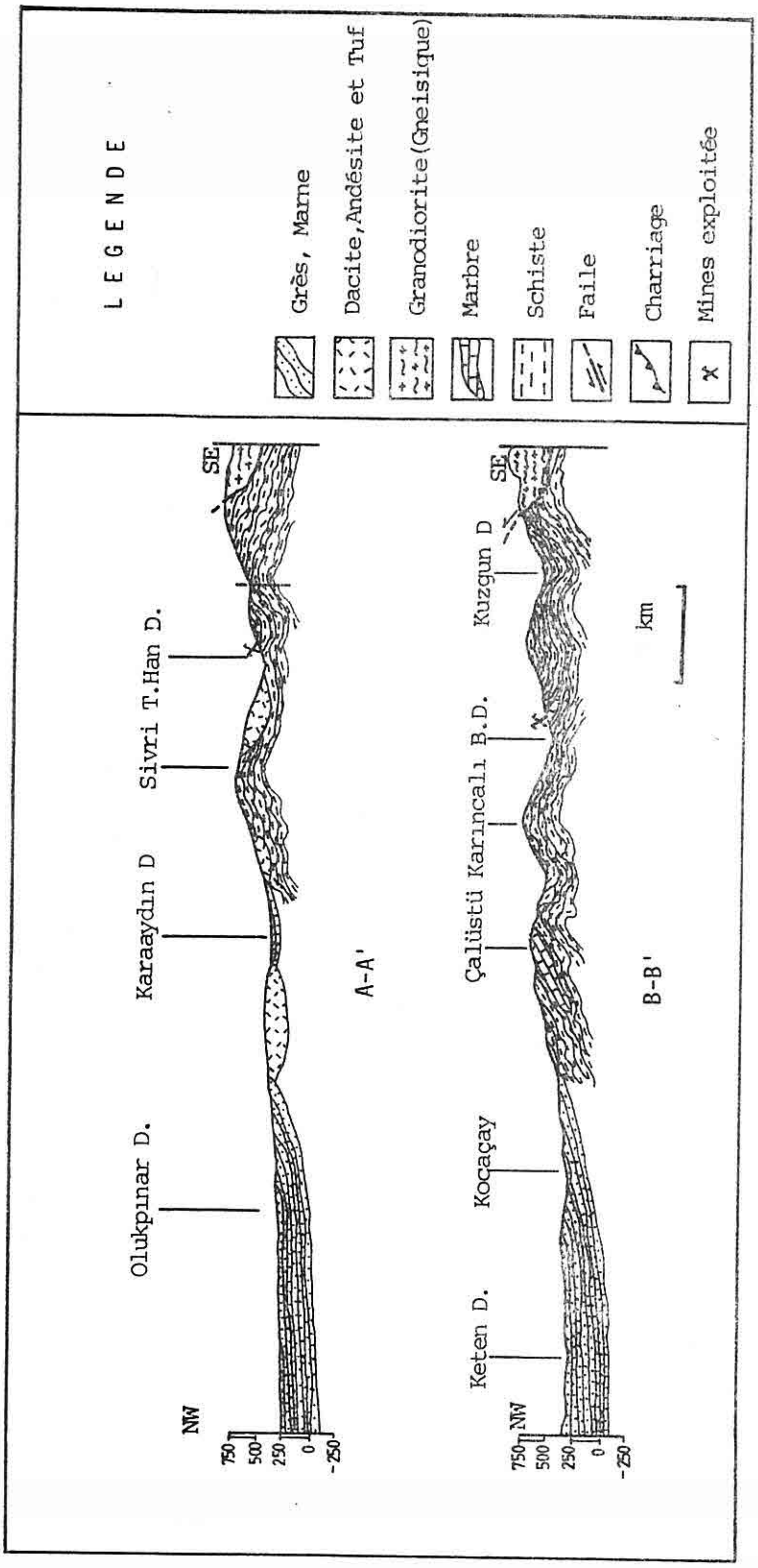

Figure 2a. Coupes A-A' et B-B' dans la figure 2.

microgreunue avec une schistosité légerement visible. La roche est essentiellement constituée(plus de 95 %) de calcite. On observe de rares lits avec des concentrations de grains de quartz souvent arrondis. On observe également très peu de plagioclase oriéntée comme le quartz. On voit souvent des filonnets de calcite qui traversenet la roche. Ces derniers sont surtout constitués par des gros cristaux à macles polysynthétiques déformés.

Le grès et la marne du Néogène, situés au nord,couvrent un tiers du secteur étudié. Cette série est composée par des conglomérats, des grès, des marnes et des silts.Elle est caractérisée par une couleur brun clair. Ces roches sont généralemement moins consolidées et comportent porfois des lignites exploitées à Kalkım, à Çan, à Gönen etc.

Le Quaternaire et les formations récentes se manifesten par des alluvions, des silts et des galets arrondis et par des produits torrentiels dans les lits récents et anciens des vallées.

MAGMATISME

L'activité magmatique de la région de Kalkım-Handeresi-Karaaydın est assez variée. On y distingue les roches vertes basiques(les métadiabases), les intrusions acides(la granodioirte de Kalabak d'âge paleozoique et la granodiorite d'Eybek d'âge néogène) et les roches volcaniques.

Les méta-diabases sont plus ou moins abondantes dans la Presqu'ile de Biga n'affleurent que quelques endroits dans le terrain étudié. Ces diabases ont un aspect massif, un grain très fin et une couleur vert foncé. Les minéraux constituants cette roche ne sont pas visibles à l'oeil nu mais on observe très souvent une imprégnation de pyrite. Les minéraux essentiels sont du plagioclase, en cristaux allongés à bords irregulièrement lobés. Les phénocristaux ne comportent que des macles simples, de chlorite, du quartz,du leucoxène et des carbonates subordonnés. Une altération est développée donnant une paragenèse spilitique à la roche.

La granodiorite de Bağırkaç couvre le sud du secteur étudié et est orienté de l'Ouest à l'Est. A cause d'une forte végétation(foret de spain) son contact avec les autres roches n'est pas très visible. Elle est caractérisée par une couleur gris brunatre et une couleur sombre, ou gris blanchatre lorsqu'elle est fortement altérée. Cette granodiorite a subi un métamorphisme régional comme les autres roches anciennes du secteur. On observe le quartz,feldspaths et plagioclase à l'oeil nu. Elle montre une schistosité bien visible. La granodiorite de Bağırkaç est charriée avec une orientation N 80 W et inclinée 30 SW à Ada Dere(6).

L'étude microscopique montre également très visiblement une schistositeé. Dans une texture grenue(rarement écrasée et mylonitisée) on distingue du quartz,des feldspaths potassiques,rarement du muscovite,d'apatite, du zircon et du sphène. Le quartz a une granulométrie variable de quelques microns à 3-4 mm. Il ne dépasse pas 10 % du volume de la roche. Les feldspaths sont moins abondants que les plagioclases qui constituent 60 % de la roche. Au contraire des feldspaths, ces derniers sont moins altérés. Leur granulométrie est variable(maximum 9 mm) et présente des macles d'albite et de Carlsbad.

Muller et Burgath(11) ont appelé cette roche comme granodiorite très altérée et granodiorite cataclastique ou gneis granitique.

La granodiorite d'Eybek(Çınarlıhan) n'affleure que sur une petite surface dans le secteur mais au SE de la région d'Handeresi elle coupe nettement les formations paléozoiques. Elle contient souvent des gros grains et a une couleur blanchatre et rougeatre. Cette roche est arenitisée dans les endroits ouverts. Elle montre parfois une texture porphyique.

Les plagioclases altérés, le quartz,l'hornblende et la biotite composent la matrixe dans laquelle on voit de l'ortoclase automorphe. On rencontre souvent des filons aplitiques qui traversent la roche. La granodiorite d'Eybek a été datée radiologiquement par la methode K/Ar au Néogène(12,13).

Les roches volcaniques du Tertiaire couvrent trois parties dans le secteur étudié et s'étendent en dehors du terrain étudié sur plusieurs centaines de km. L'étude de terrain de l'ensemble de ces roches volcaniques dans la Presqu'ile de Biga montre qu'il ya plusieurs phases d'activité volcanique séparées par des périodes calmes(2,8).

Les roches volcaniques du secteur sont composées par des andésites, des dacites et de tufs. A cause d'une forte végétation ces roches sont cartographiées ensembles sur les terrain étudié. Elles sont caractérisées par une couleur gris blanchatre et rougeatre de minéraux ferromagnesiens lorsque la décomposition est poussée.

La composition minéralogique de ces andésites est assez homogène et ne varie qu'en fonction de l'apparition ou de la disparition de pyroxène et de la biotite.

Toujours avec une texture porphyrique et rarement microlitique on figure des plagioclases(très abondants,andésine et souvent fraiches), d'augite(en phénocristaux, souvent sub.automorphes), l'amphibole(hornblende résultant de l'altération d'augite), de biotite(en grandes lamelles corrodées,souvent altérée en oxyde de fer) et minéraux accésoires(calcite, chlorite,épidote et minéraux opaques).

Les tufs andésitiques sont souvent caractérisés par une couleur blanchatre. Dans une texture pyroclastique on figure du plagioclase,du quartz (rare), des anciens pyroxènes, des biotites totalement disparues et les minéraux argileux de kaolinite et de séricite. On observe presque dans toutes les lames une petite quantité des minéraux opaques.

Les dacites el les brêches dacitiques affleurent dans quelques endroits dans le secteur étudié mais ils sont abondants dans la Presqu'ile de Biga. Il est vraissemblable que ces roches soient postérieures aux andésites qui sont souvent encaissées dans les dacites. Les dacites sont caractérisées par une couleur claire.

Les plagioclases, le quartz et les ferromagnesiens sont des minéraux constituants. On figure des microbaguettes de plagioclases ainsi que le quartz en petite dimmmension et les chlorites dans la matrice.

Les zones de silicification n'affleurent qu'en quelques endroits.Ces roches forment une sorte de carapace très dure et rarement poreuse. Elles peuvenet etre bleuatres et finement recristalisées, aucun minéral n'étant visible à l'oeil nu. L'étude microscopique montre la forme des anciens phénocristaux et des minéraux opaques. On voit quelques phénocristaux de quartz,de grain irrégulier d'oxyde de fer. La matrice est constituée par des petits grains du quartz. Ce type de roches était certainement une andésite ou une dacite au départ, mais elle a subi une silicification hydrothermale.

Un profil stratigraphique synthétique du secteur de Kalkım-Handeresi-Karaaydın est donné dans la figure 3.

TECTONIQUE

La plupart des roches du secteur d'Handeresi-Kalkım sont paléozoiques pour cela on observe différentes directions de fracturation et de schistosité, soit à l'échelle macroscopique, soit àéchelle microscopique.

Cette région a subi une forte tectonique autrefois lors de l'orogenèse Alpine. A cause d'abondantes formations argileuses on voit surtout des plissements ainsique quelques directions de fracturation.Les roches vol-

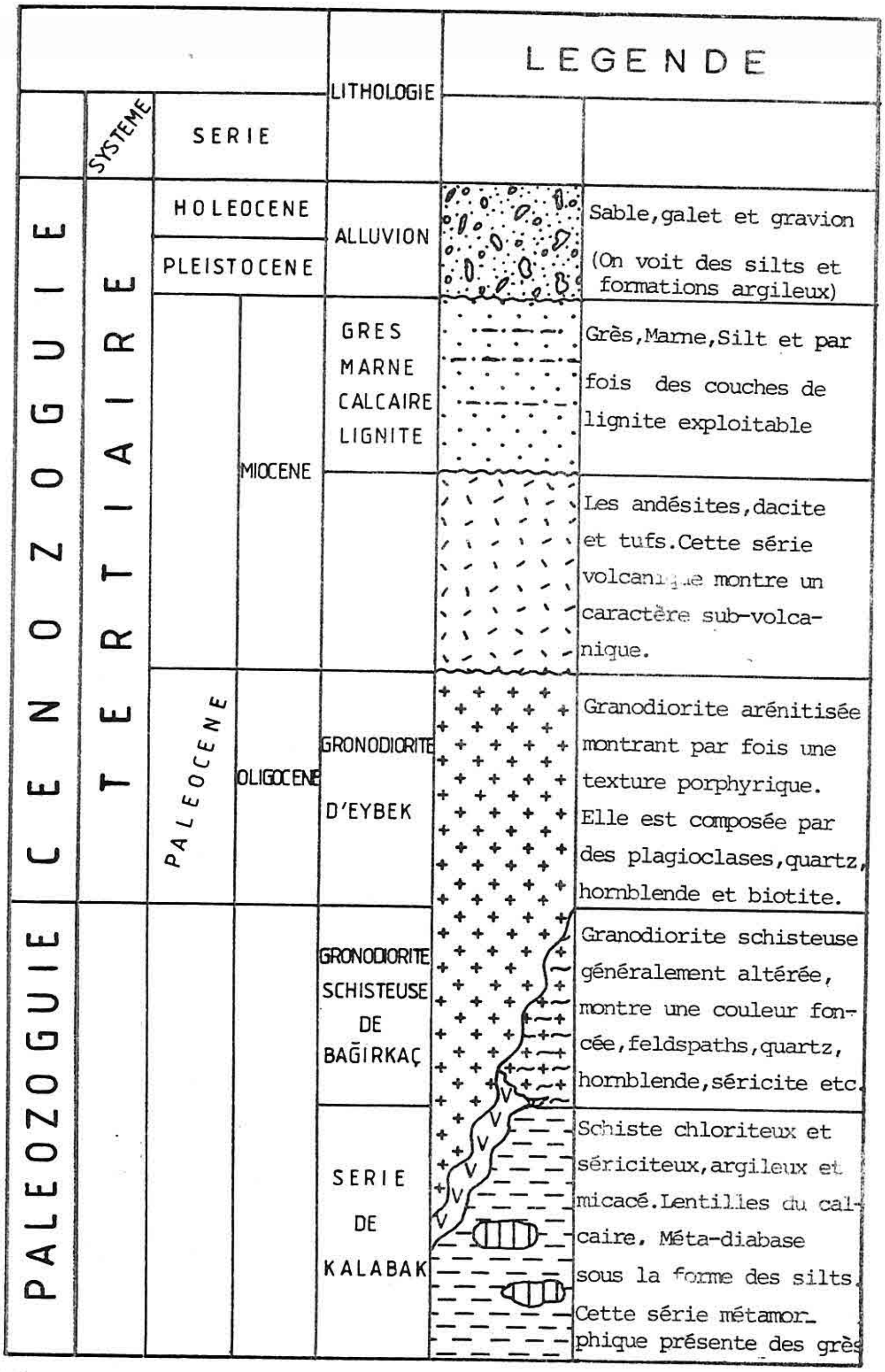

Figure 3.Le log stratigraphique synthétique du secteur de Kalkım.

caniques du tertiaire sont en discordance sur la série de Kalabak.

Les directions de schistosité dans les schistes de Kalabak sont plus ou moins paralèlles à la direction de couches. Les plissements se rencontrent souvent oriéntés NE-SW avec une ondulation visible. Les failles sont surtout orientées N-S. Les fracturations ont joué un role sur les minéralisations et donné une discontinuité dans le corps minéralisés.

En commençan SW du terrain étudié on observe une charriage orienté E-W.Cette charriage se poursuie sur une quinzaine de kilomètres entre les schistes et les granodiorites.

DESCRIPTION DE MINERALISATION DU SECTEUR ETUDIE

Les gisements d'Handeresi et Karaaydın(Simli Kurşun Madeni) sont actuellement exploitables. Le gisement de Karaaydın a été exploité autrefois par une société minière française et est exploité une centaine de milliers de tonne de minerai jusqu'a 1935. Les informations historiques sur cette mine et la mine de Balya, comme sur toute les mines de Turquie en générale, sont très dispersées, car devant l'établissement de la Republique les exploitations étaient dans des maines étrangères et les documents se sont trouvés dispersés et disparues. C'est pourquoi on ne sait jamais les chiffres réels pour ces mines.

La mine d'Handeresi a été découvert par une prospection détaillée par M.T.A. âpartir de 1970.

Mine d'Handeresi

Travaux Miners

Les activités minières sont en cours depuis 1980 dans ce secteur. Les travaux de recherche et d'éxploitation étaient accélérés et plusieurs dizaines de mètre de galéries ont été réalisée dans cette mine(Figure 4). Ces galeries sont effectuées en direction de N-S et NE-SW. Elles ont une extention horizontale maximume de 200 mètres et traversenet plusieurs poches minéralisées exploitées. L'ensemble de ces travaux a été réalisés sur plusieurs années. Au début de l'exploitation, il y'avait trois galéries principale(figure 5) dont la première a été ouverte au niveau 382. Elle a une orientation NW-SE et une longueur 150 m. Un deuxième étage (cote 383) présente la meme diréction ainsi que le troisième étage(cote 384) est plus décalé vers l'Ouest.

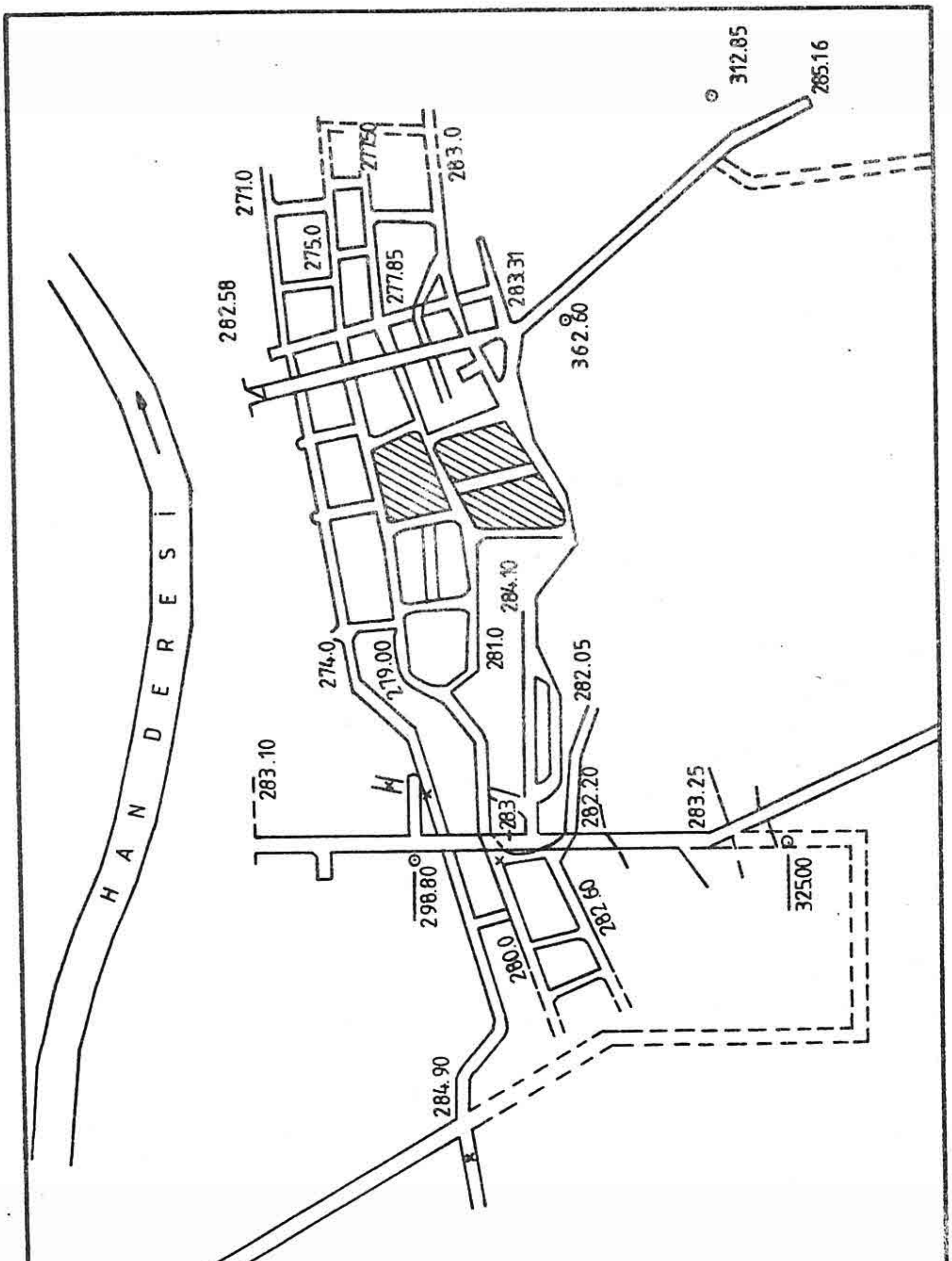

Figure 4.Plan des travaux de la mine d'Handeresi.

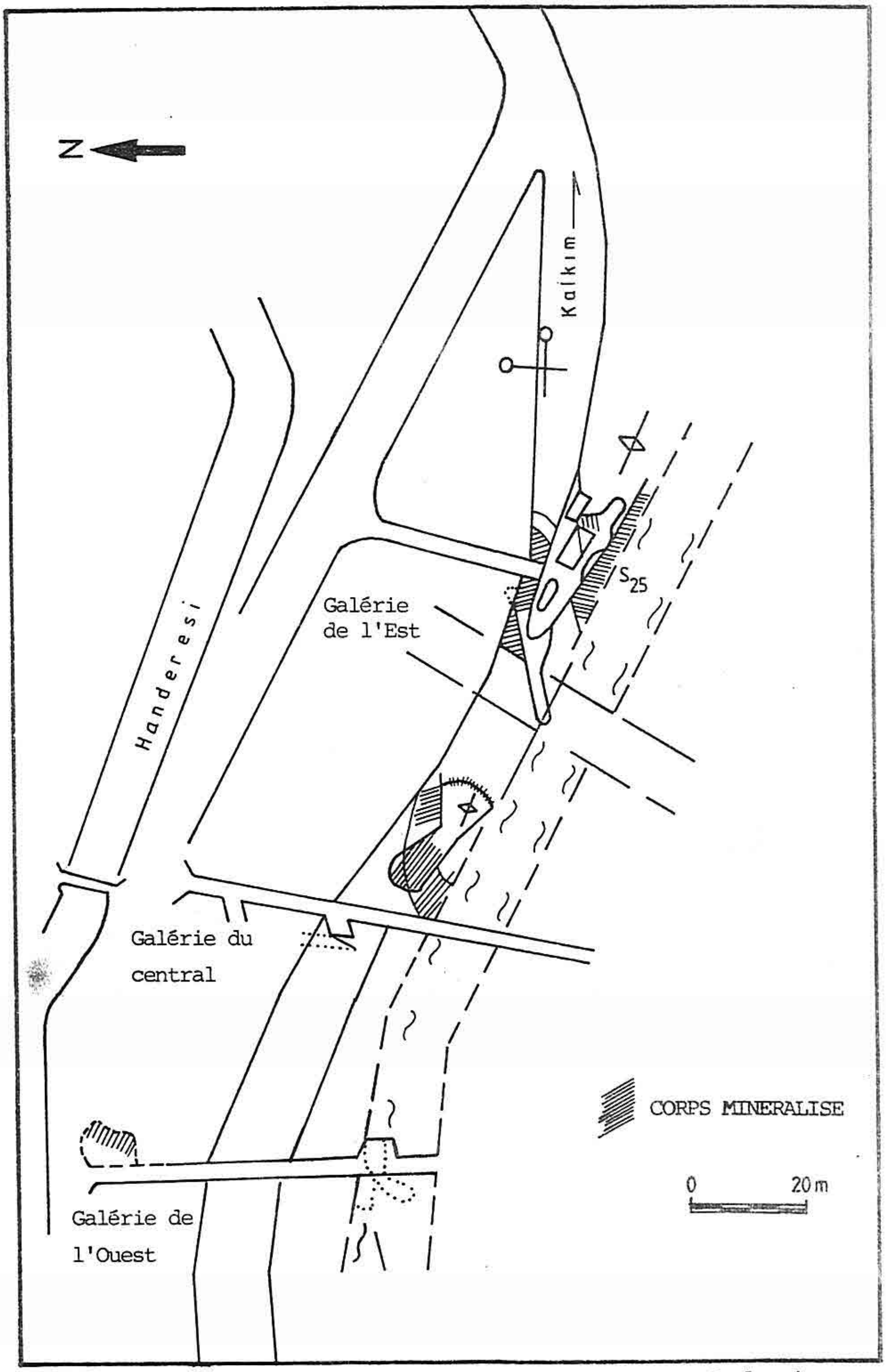

Figure 5.Les principaux travaux au début de la découvert de la mine d'Handeresi.

Corps Minéralisés

La mine d'Handeresi exploite un filon situé plus ou moins parallèle à la vallée d'Handeresi, connu depuis la découverte de cette zone. Grâce de plusieurs sondages réalisés sur ce corps on peut suivre facilement cette zone minéralisée. La puissance reduite de ce filon atteint au minimum 5 cm au maximum 75 cm. Le filon est encaissé dans le schiste et le marbre. Ce schiste montre très souvent une forte silicification surtout dans le corps minéralisé à cause d'une altération hydrothermale.

Observation et Etude Macroscopique du Minerai

La minéralisation plombifère-zincifère et cuprifère est visible à l'oeil nu. Elle se présente sous forme de filons,impregnations et veins liés aux zone de cantact.

Le minérai d'Handeresi est riche en galène présentant souvent en gros cristaux cubiques. La dimmension des cubes atteint parfois 1.5 cm. La proportion de la blende change beaucoup dépandant de la chalcopyrite et pyrite(Figure 6).

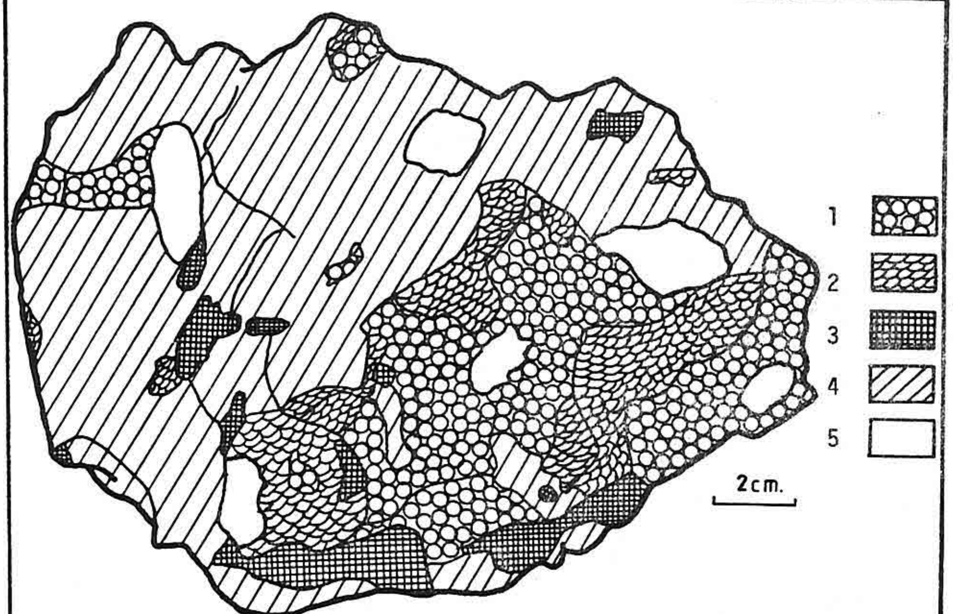

Figure 6. Minerai riche en galène de la mine d'Handeresi.

Un autre type de minerai caractéristique de cette mine est moins riche en galène qui se présente là en cristaux fins, la pyrite en imregnation est très abondante et la chalcopyrite se présente parfois en grandes plages.La sphalérite est subordonné.Le quartz forme la gangue(figure 7).

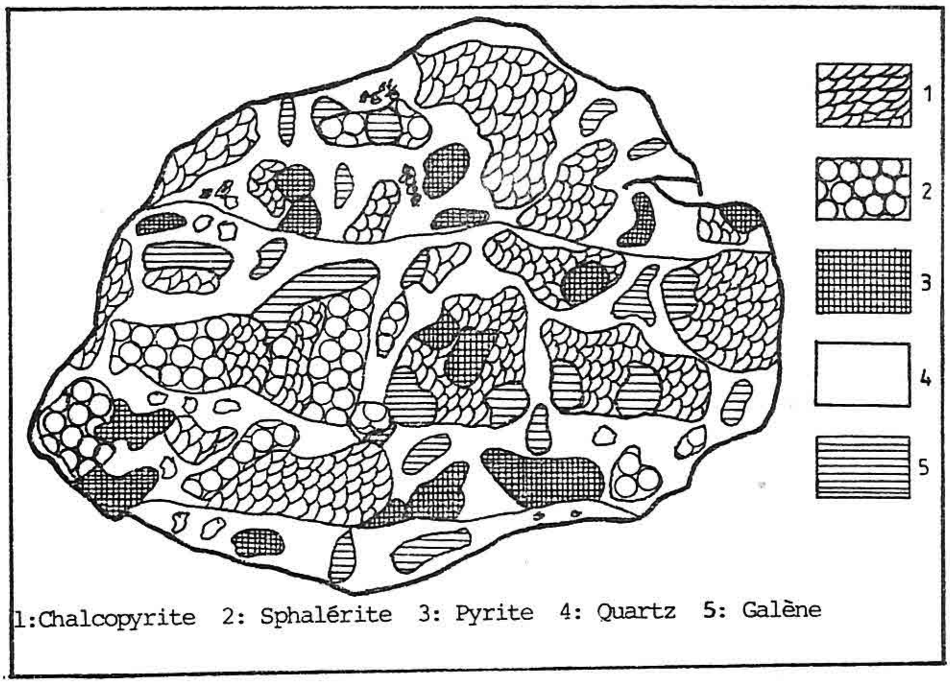

Figure 7.Minerai de Karaaydın.

Un troisième type a été observé également dans la mine de Karaaydın caractérisé par un aspect massif. Ce minerai est riche en magnetite et limonite par rapport aux précedents.

On peut remarquer quelquefois un type de minéralisation très riche en pyrite et chalcopyirite, soit sous forme d'impregnation,soit autour d'un noyeau formé d'un fragement de roche.

Etude Microscopique et Minéralogique de Minerai Provenant des Mines de Karaaydın et D'Handeresi

La minéralisation se manifeste par une association sulfure mixte et rarement par une association oxyde.

. Galène:

La galène est souvent abondante et toujours en grandes plages, souvent pure, mais parfois avec des inclusions de sphalérite. Les cristaux de galène sont des automorphes, sub-automorphes et xenomorfes. Elle est également parfois sous forme d'inclusion dans la sphalérite. Elle contient rarement des inclusions d'argentite .Ce dernier rencontre surtout dans les échantillons provenant de la mine de Karaaydın.La galène se présente parfois une forme de remplissage entre des grenats automorphes zonés. Elle ramplace des fois les grenats sous la forme de petits cristaux.

. Sphalérite:

La sphalérite est généralement se présente des cristaux sub-automorphes. La dimmension de grain est parfois de l'ordre de 3 mm. Elle se trouve très souvent eutour de galène mais on rencontre on rencontre parfois des cristaux isolés. La reflexion interne de ces cristaux montre une couleur clair cequi signale la pauvreté de FeS. Les cristaux de sphalérite contiennent très souvent des inclusions de chalcopyrite en lammelles, fréquement parallèle aux clivage. Elle entoure aussi, comme la galène, les grenats et remplisse parfois les fractures.

. Chalcopyrite:

La chalcopyrite est plus ou moins abondante surtout dans les échantillons provenant de la mine d'Handeresi. Elle présente souvent des cristaux sub-automorphes.Elle est aussi sous la forme des inclusions dans la sphalérite.La chalcopyrite montre parfois un aspect cataclastique.Elle est certainement postérieur à la pyrite dont la fracture on voit de la chalcopyrite.Au bord des cristaux de chalcopyrite est détérminé un peu de covellite et limonite.

. Pyrite:

La pyrite est généralement présentée de peu quantité et souvent sous la forme des petit cristaux automorphes.Elle est plus ancien minéral dans l'association sulfure mixte.

. Magnetite:

La magnetite est très rare. On la rencontre surtout sous la forme des veinules dans les échantillons de la mine de Karaaydın.

. Hématite:

L'hématite est plus abondant que la magnetite. Elle se présente souvent des lamelles radiales.

. Covellite et limonite:

A la fin de l'altération de la chalcopyrite et de la pyrite on se forme ces deux minéraux secondaires. Au contraire à la mine de Karaaydın on les rencontre très limité dans la mine d'Handeresi.

. Minéraux de quangue:

Le quartz est plus abondant que les autres minéraux de gangue. On voit égalment de calcite et les minéraux du métamorphisme de contact.L'étude microscopique des sections polies des échantillons provenanant surtout de la mine de Karaaydın, on détermine des grenats en très beaux cristaux zonnés automorphes. La diobsite,la chlorite, l'épidote,l'actinote,la trémolite et la séricite les accompagnent.

La paragenèse D'Handeresi et de Karaaydın se présente comme la suivant:

Galène + Sphalérite + Chalcopyrite + Pyrite ∓ Argentite + Quartz ∓ Calcite (Pour la paragenèse sulfure mixte)

Galène + Sphalérite + Chalcopyrite + Pyrite ∓ Argentite ∓ Magnetite∓ Hematite + Quartz ∓ Calcite ∓ Grenats ∓ Diopsite ∓ Actinote ∓ Trémolite ∓ Séricite etc. (Pour la paragenèse sulfure + oxyde)

On peut noter que la pyrite est le premier minéral dans l'association sulfure mixte. Les grenats se forment en premier sans doute au début de la mise en place de l'intrusion de granodiorite.

Origine de La Minéralisation de La Region Etudié

La minéralisation du secteur étudié se manifeste dans les formations métamorphiques près de contact de la granodiorite de Bağırkaç. Le corps minéralisé se trouve 10-250 m de ce contact. La paragenèse est typique de types du métamorphisme de contact(8,9,10,14). Le magma granitique peut accepter comme la source de cette minéralisation. Lors de la mise en place de la granodiorite de Bağırkaç dans les schistes intercalés avec des lentilles du calcaire, les fluides magmatiques riche en certain métaux donnent cette minéralisation. Les lentilles du calcaire et les niveaux riche en carbonate sont favorables de developper aux corps minéralisés. En effet la métasomatose est facilement developpée surtout aux niveaux carbonatés parallèlement à la schistosité. C'est pourquoi on rencontre les bandes minéralisées oeilées dans les mines de Karaaydın et d'Handeresi.

Etude Chimique et Aspect Economique

On a effectué une série d'analyse pour déterminer la qualité du minérai. On a recherché d'abord l'argent une vingtain d'échantillons de galène pratiquement pure cristalisée en grandes cubes. Les résultats de ces analyeses sont reproduits dans le tableau 1.

Ag ppm	1	2	3	4	5	6	7	8	9	10
	901	620	860	1011	613	785	930	890	1050	1110
	11	12	13	14	15	16	17	18	19	20
	689	790	1034	940	678	1120	1076	900	870	589

Tableau 1.L'argent en trace dans les galènes de la mine de Karaaydın et d'Handeresi.

Au cours de réalisation un projet commun entre M.T.A. et Une équipe d'Allemagne pour rechercher les minéralisations de Pb-Zn-Cu dans la Presqu'ile de Biga, on a réalisé de millieres d'analyses sur les différentes roches de la région. Les résultats concernant le secteur étudié sont raportées dans le tableau 2 et 3.

Lithologie	Province	Pb ppm	Zn ppm	Cu ppm
Schiste de Kalabak	Karaaydın	85-6000	120-2900	95-1000
Marbre	"	80-6000	180-7300	50-1400
Diabase	"	265-6600	380-5700	70-800
Granodiorite de Bağ.	"	135-3160	215-1450	35-425
Granodiorite de Çın.	"	35-630	75-500	35-1550
Hornfels et skarns	"	40-2600	95-2570	45-3900
Volcaniques	"	60-1050	55-830	15-370
Quartzite	"	10-50	50-295	1-20
Amphibolite	"	45-55000	95-16600	35-500

Tableau 2.Dosages de Pb-Zn-Cu en tarces dans les differents roches de la mine de Karaaydın.Résultats d'après de Markvich et Haude(15).

Lithologie	Provinece	Pb ppm	Zn ppm	Cu ppm
Schiste de Kalabak	Handeresi	85-6000	120-2900	45-1000
Marbre	"	80-6000	180-7300	50-1400
Diabase et spilite	"	265-6600	380-5700	70-800
Granodiorite de Bağırkaç	"	135-3160	215-1450	35-425
Granodiorite de Çınarlıhan	"	35-630	75-500	35-1550
Hornfels et skarns	"	40-2600	95-2570	45-3900
Volcaniques	"	60-1050	55-830	15-370
Quartzite	"	10-50	50-235	1-20
Amphibolite	"	45-55000	95-16600	35-500

Tableau 3.Dosages de Pb-Zn-Cu en traces dans les différentes roches de la mine d'Handeresi. Résultats d'après de Markvich et Haude(15).

L'étude de ces deux tableaux montre nettement que les dosages du Pb-Zn-Cu sont supérieur du Clarke. Les formations encaissantes des minéralisations polymetalliques du secteur étudié contiennent une certaine quantité de ces métaux.

Les tenneurs de minerai d'Handeresi et de Karaaydın sont l'ordre d'un aspect économique. Les résultats des analyses chimiques d'une quinzain échantillons provenant de la mine d'Handeresi et de Karaaydın sont portées dans le tableaux 4.

No de tranchée	Province	Pb %	Zn %	Cu %
1	Handeresi	18.60	5.61	1.66
2	"	6.56	3.26	0.93
3	"	5.17	3.96	1.02
4	"	30.61	4.27	2.21
5	"	9.27	6.10	1.90
6	"	7.60	2.97	0.70
7	"	21.11	5.28	1.70
8	"	3.47	2.96	0.76
9	"	43.63	7.77	1.90
10	Karaaydın	38.13	8.12	2.21
11	"	17.56	5.11	1.97
12	"	11.87	4.61	2.00
13	"	6.87	3.11	1.32
14	"	3.45	2.10	0.76

Tableau 4.Tenneurs de minerai de la mine d'Handeresi et de Karaaydın.

Les moyenes arithmétiques de ces résultats sont 16.22 Pb, 4.68 Zn et 1.42 Cu pour la mine d'Handeresi et 15.57 Pb, 4.61 Zn et 1.65 Cu pour la mine de Karaaydın. On peut noter que au début de l'exploitation de la mine d'Handeresi les échantillons systématiques collectés sur 150 tonne de minerai brut ont donné le résultat suivant: Pb 3.62 % ,Zn 3.11 % et 0.04 % (12).

Les Réserves

Une dizaine de sondages a été réalisée entre 1970 et 1974 par le M.T.A. dans ce secteur. L'étude des profils de sondages d'une part,et les travaux miniers effectués ultérieuremnet de ces sondages d'autre par, donnent beaucoup facilité pour estimer les réserves du secteur étudié.Les réserves éstimées sont de l'ordre de 200.000 t de Pb-Zn, 32 t de Cu et une petite quantité d'Ag.

CONCLUSION

L'istoire géologique des roches métamorphiques est assez complexe. La série schisteuse de Kalabak est représentée par différents types lithologiques: schistes chloriteux et séririciteux, schistes micacés et quartzeux. On y observe,également,en discondance, des lentilles de calcaire métamorphique(début du marbre).

L'intrusion granodioritique de Bağırkaç recoupe les schistes et les lentilles de calcaire métamorphique. Les minéralisations du Pb-Zn-Cu-Ag du secteur de Kalkım est type du métamorphisme de contact. La paragenêse du minérai est également vérifiée ce dernier. Lors mise en place de la granodiorite de Bağırkaç dans la série de Kalabak(y compris des lentilles de calcaire) les fluides magmatiques riches en certain métaux, donnent naissance aux minéralisations du secteur étudié. Les lentilles de calcaire et les niveaux riches en carbonate sont plus favorables de developper aux corps minéralisés.

Pendant l'orogenèse alpine, le secteur a subi intense fracturation ainsi que le corps minéralisé est fracturé dans cette époque.Malgré les discontinuités des corps minéralisés, la mine d'Handeresi et de Karaaydın ont un intéret économique et exploitable dans les conditons du pays.

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