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HYDROGEOLOGICAL STUDY OF THE ILDIRI (ÇEŞME) KARSTIC SPRINGS

A Thesis Submitted to the
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by
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İZMİR

M.Sc. THESIS EXAMINATION RESULT FORM

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and in quality, as a thesis for the degree of Master of Science

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ABSTRACT

Study area is approximately 20 km in the east of Çeşme. Nine rock units are identified according to lithological, stratigraphic and hydrogeological properties of the units in the study area.

Paleozoic, Mesozoic and Cenozoic age units are exposed in and around the study area. The basement of these units is formed the Paleozoic aged Alandere Formation.

This Formation is overlained by the Mesozoic (Triassic) aged karstic limestone formations. Which are Gerence, Camiboğazı, Güvercinlik in a range and Jura aged Nohutalan Formation, Cretaceous aged Aktepe Unit with carbonative structure, Cretaceous aged Balıklıova Formation, Neogene aged volcanics and Quaternary aged alluvium, slopewash from bottom the top.

Unconformities are seen between these formations contacts except one. This conformable contact is seen between Mesozoic (Triassic) aged karstic limestones and Jura aged Nohutalan Formation.

Graywackes which is formed basement in the field , they do not show the aquifer features due to having an impermeable structure. Volcanic rocks which are observed in the field do not have aquifer features but good quality water can be taken because of their cooling surfaces and flow structures.

Ildırı karstic springs which is the most important karstic spring of the Karaburun Peninsula, is located in the study area.Springs east of Ildırı village Camiboğazı stream, in Triassic limestone come out three different points.

According to observations which have been taken since 1984 by DSİ that the yearly mean discharge is 490 lt/sn

Water that is taken from the Springs by DSİ and me, made chemical analyses and Filiz (1982) isotope analyses results show that these springs water, there is a sea water intention cause salinity.

ÖZET

Çeşme'nin yaklaşık 20 km doğusunda yer alan inceleme alanında litolojik stratigrafik ve hidrojeolojik özelliklere göre 9 kaya birimi ayırtlanmıştır.

Çalışma alanı ve çevresinde Paleozoyik, Mesozoyik ve Senozoyik yaşlı birimler yüzeyler. Bu birimlerin tabanını Paleozoyik (Karbonifer) yaşlı Alandere Formasyonu oluşturur. Bu formasyon üzerine uyumsuz olarak Mesozoyik (Triyas) yaşlı karstik kireçtaşı formasyonları gelir. Bu formasyonlar sırasıyla Gerence, Camiboğazı ve Güvercinlik Formasyonlarıdır. Bu formasyonlar üzerine Jura yaşlı Nohutalan Formasyonu gelir. Nohutalan Formasyonu üzerine uyumsuz olarak Kretase yaşlı karbonat Aktepe Birimi gelir. Aktepe Birimi üzerine uyumsuz olarak Kretase yaşlı Balıklıova Formasyonu gelir. Balıklıova Formasyonu üzerine uyumsuz olarak Neojen yaşlı Volkanitler gelir. Volkanitler üzerine uyumsuz olarak Quvaterner yaşlı alüvyon gelir.

Inceleme alanında temeli oluşturan grovaklar geçirimsiz bir yapıya sahip olduklarından akifer oluşumuna elverişli değildir. Paleozoyik ve Mezozoyik yaşlı kireçtaşları geniş yayılımları ve litolojik özellikleri bakımından iyi bir akifer özelliğine sahiptir. Volkanik kayaçlar akifer olma özelliğine sahip değildir. Fakat soğuma çatlakları ve akma yapılarının bulunduğu kesimlerden iyi kalitede sular alınabilir.

Çalışma alanında Karaburun yarımadasının en önemli karstik kaynağı olan Ildırı kaynakları yer alır. Kaynaklar Ildırı köyünün doğusunda Camiboğazı deresinde Triyas kirçtaşlarından 3 değişik noktadan çıkmaktadır.

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DSİ tarafindan 1984 yılında alınmaya başlanan rasatlara göre yıllık ortalama debi 490 lt/sn dir.

Kaynaklardan DSİ ve tarafımızdan alınan su örneklerinin kimyasal analizleri ve Filiz (1982) tarafindan yapılan izotopik analiz sonuçlar bize kaynak sularında deniz suyu etkisi ile tuzlanmanın mevcut olduğunu gösterir.

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CHAPTER ONE

INTRODUCTION

1.1. Location of the Study Area

The study area is south of the Karaburun peninsula zone Urla L_{17} a_1-a_{14} and $L_{16}b_2$-b_3 section of a map is between (49-64) meridion and (43-54) latitude, nearly 150 km^2 area is covered (figure1.1) Ildırı, Balıklıova, Kadıovacık village is included in the study area. Study area arrived with asphaltic road from İzmir 60 km.

1.2. Purpose and Scope

This working Nine September Üniversity, technology science institute, parent science Branch Master Depree thes is prepared comprehemsive to present.

The study is covered, Ildırı, Kadıovacık, Balıklıova and around these area, study area 1/25000 scale geological mapping, rock units is differentiated withant using any system, determine statigraphic and structural relationship and it is made regional hidrogeological characteristic exploration.

Aim is to determine drink and irrigation characteristic of evaluate chemical analysis results of water which is taken from opened bore hole by DSI, Iller Bankası and individual.

In addition Ildırı and Halkapınar karstic sinkholes aquifer reservoir, rock and drainage area is evaluated. Aim is sinkhole reservoir with surface and subsurface water behaviour explosotion is intended.

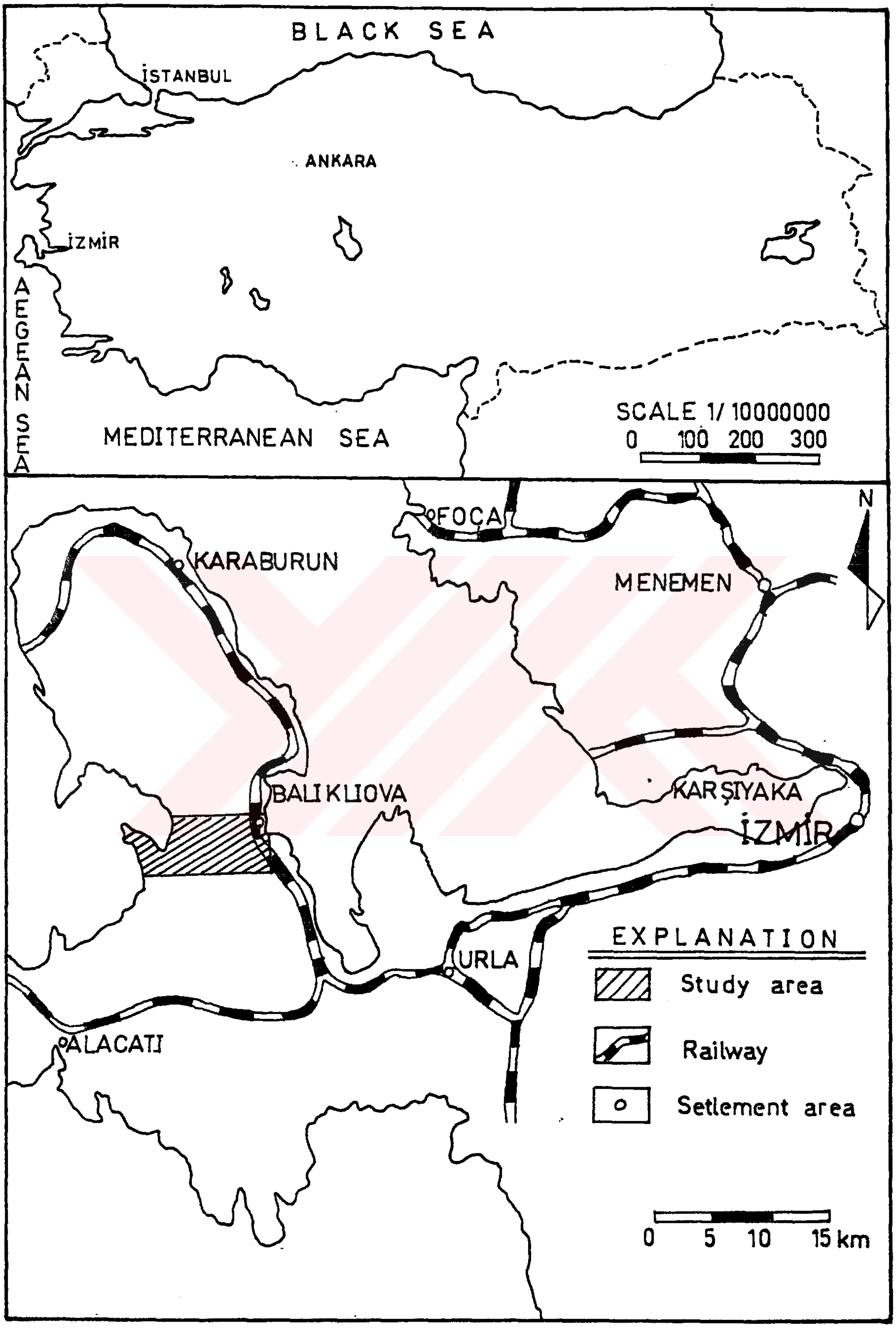


Figure 1.1. Location map of the study area

1.3. Previous Study

In this part study area and around environment, geological and hydrogeological previous study is given. In addition to previous study stratigraphic units are given comparisiontly.

PHILIPSON (1911) : All peninsula is surveyed according to geological of Sakız Island and Greece formation comparisiontly. First 1/30.000 scale geological map was made.Explorer study is to find one of big anticlane . East part is composed of Mesozoic aged limestone. This limestone is divided into two facies, massive limestone facies and plate limestone facies.

KALAFATÇIOĞLU (1961) : All Karaburun Peninsula 1/100.000 scale geological map was made. He determined that peninsula is affected from Hercenian and Alp orogeny. Upper part of Maastrichtian folding is affected to form of anticline and syncline is accepted.Explorer determine that Devonian age limestone lenses. Contain fossils, on clastic unit, gives.Lower Carboniferous age limestone. According to him between erce Jurassic Late Cretaceous age carbonate rock this paleozoic age sedimentary rock is unconformable over lain. During Neogene volcanism is active that Ryholite, Andesite and Basalts lav which was come out from fracture, is that old formation.

GÜMÜŞ (1971) :Study in Middle Karaburun the lowest Devonian age. Alandere unit was put in formation. This unit is unconformable overyling. Triassic unit, triassic lower to upper ;contains Domuzçukuru, Koyutepe, Laleköy, Camiboğazı, Hanaylı, and Güvercinlik units. Explorer in study area. Jura and Cretaceous units can't be determined. Andesite which is formed in Tertiary is unconformable overlain old units Explorer determined that in Paleozoic unit is formed perpendicular weak folding. Triassic unit Fault direction is conformable to Paleozoic Fault.

BRINKMAN and et all (1972): Pelagic Triassic is present and basement conglomerate is unconformable overlain this unit and Paleozoic graywacke. The basement can't be seen lidic and conglomerate lens without fossil graywacke. According to Philippson and Kitenas fossils. Findings start Devonian. This paleozoic basement is overlain basement conglomerate with

Domuzçukuru beddings starts the triassic. This unit is overlying carbonate facials. Koyutepe, Laleköy, camiboğazı, hanaylı, güvercinlik and Nohutalan beddings.
Triassic-Jura transition in Nohutalan beddings is normal, North of middle Karaburun Jurrassic -Malm age Cladoropsis bedding is passing.Transition between Cladoropsis bedding to Cretaceous is sharp but conformably in place bauxite lens is observed. Aktepe beddings generally represent carbonate deposit.

KONUK (1979) : According his observation and findings he divided into two series. Paleozoic age and Triassic age.

1. He defined Boynuzcuk, Karareis, Denizgiren, Güldağ, İldecik, Kayadibi and Tuzluk formation with flysch facies. Karareis Member.

2. Karareis member is overlain tectonically Domuzçukuru, Koyutepe, Camiboğazı formation.is formed Carbonate facies. Karaburun Group. Writer each two groups is setting foundation not known. Moreover, partly metamorphic, partly possible paleozoic age rock.

ŞAHINCI (1981) : Study in the region the karstic sinkhole occurrence is explained fault and fracture becoming wide, form of karstic structure. Along the karstic fracture is strained rain water in limestone follow fracture and crack solution canal. Limestone with impermeable graywacke contact outcrop and along the fault zone the groundwater reach the surface this water forms the karstic cold water spring.

FILIZ (1982) : In the region Karstic spring from the point of view is researched. This research results, Ildırı and Halkapınar spring natural isotope O^{18} value is big, determined from him that each spring has a sea intrusion In addition, he determined this spring water origin is from rain.

ERDOĞAN and et all (1990) : All Karaburun Peninsula near part he made formation nomenclature stage and in Peninsula lower to Upper that formation is differentiated lower middle Carboniferous age that is Alandere formation. This formation,in previous study is equivalent to distinction Tınaztepe and Alandere units.That is overlain Scitian - Anisian age

Denizgiren group which is made from explorer that this group is ordered into two formations which are Karareis and Gerence.

Gerence formation, in previous study, (Gümüş 1971, Brinkmann and at all. (1972)) is given come across Domuzçukuru, Koyutepe and Laleköy units.Later writer differentiated later Ladinian - Carnian age Camiboğazı formation, Norinian Resinian age Güvercinlik formation, Lias - Valennian age Nohutalan formation with Companian - Maastrihtian age Balıklıova formation. In addition northeast of Peninsula, Kalecik detailed research is made by explorer that conglomerate mudstone and limestone block units. Maastrihtian and Devonian age is given the name Bornova melange.

In the region the youngest forming unit is Neogene age Andesite and Lake sediment with Quaternary age Allivium.

1.4. Geography

1.4.1. Morphology :

In the study area morphologic view dependent to the geology of the area.Paleozoic and Cenozoic units are little roughness soft relief topographic present; Mesozoic age units poses quite steep relief undulating and high topography. Main the highest points are Yumrudağı (301), Yalama Mountain (374), Akdağ (305), Camiboğazı Hill (373), Saplaz Mountain (268), Salıyeri Mountain (357), Veli Mountain (303), Oynatan Hill (303). Except Camiboğazı stream, in study area, all stream seasonally flow. Different direction stream combine to form big stream.Volcanic rock is surface drainage, carbonate rock is tectonic inspection karstic having viveyards steep drainage. In study area the main streams are Camiboğazı Stream, Halkapınar Stream, Oynatan Stream, Yuvarlak Stream, Hanaylı Stream, Üçkuyular Stream.

During this period on carbonate rock karstic between two mountain (poljes and doline) is placed. The mains are Kadıovacık poljes, Çukuralan doline, small Oynatan poljes, Oynatan poljes, Aralıkdağı poljes, Domuzçukuru poljes and Zeytincik poljes.

1.4.2. CLIMATE :

In study area is typically appected Mediterranean climate that summer is hot and dry, winter is cool and rainy. Ilıca (Çeşme) meteorological station data between 1971 and 1995 year according to annual data mean rainy is 492.34 mm. The maximum mean annual main in 1984 year is 658.2 mm. The minimum annual mean rain is in 1989 year is 210.9 mm. The most part of rain is December - January months. In July - August months rain cannot be seen. (Table1.1)

Ilıca (Çeşme) meteorological station between 1971- 1995 years heat measurement is given (Table 1.2) . According to these data year mean hotness is 17.1 C that july is the hottest month. December is the coolest month.

24 years mean value benefit according to Turc technique evaporation - precipitation calculation was made. According to Turc technique in the study are annual rain (Figure 1.2)

(a). Raining Season

The end of the February rain amount is greater than potential evaporation- precipitation that point during that from this time rain amount is 175,3 ETP is 64,84 so that P-ETP= 110.46 mm that more rain surface and groundwater change end of dry season other rain season starts. From the beginning of November rain is move than ETP This excess rain complete the consumption fromthe soil. The left water is storage in soil and flow as a stream (Table 1.3)

(b). Dry Season Report

March - April month rain is less than ETP and soil water is used . (72.06 mm). Left of water in soil is consume at the end of May. So that at the end of October agricultural water need exposed that dry season ETP =1048.02 mm rain=155.29 mm water is completely evaporated then 100 mm soil water consume that Agricultural water need is 792.73 mm.

1048.02-(155.29+100)=792.73 mm

Table 1.1. Çeşme anual rain values of Ilıca rain between (1971-1995)

YEAR MONTH	January	February	March	April	May	June	July	Augost	September	October	November	December	TOTAL (m m)
1971	156.3	193.9	77.1	18.3	0.2	26.2	17.0	-	-	131.1	48.0	57.6	607.7
1972	29.6	62.8	24.3	23.7	43.9	1.9	8.3	0.5	0.2	90.9	12.4	6.4	304.9
1973	103.9	100.1	30.6	57.5	0.2	-	-	1.3	9.0	49.7	14.6	66.9	433.8
1974	21.4	45.3	111.7	15.9	19.6	-	-	1.6	8.0	40.3	80.8	90.7	435.3
1975	175.5	35.5	46.0	49.7	8.9	90.3	-	-	-	19.3	70.8	109.6	605.6
1976	63.2	60.9	78.0	111.4	8.7	3.6	-	-	-	152.3	53.3	80.5	611.9
1977	75.0	37.0	22.6	35.5	-	-	-	-	7.7	41.1	43.5	57.5	319.9
1978	205.5	172.8	20.9	38.7	10.9	-	-	-	75.3	35.4	37.9	18.8	616.2
1979	155.1	74.9	22.2	17.3	14.5	-	-	-	-	27.1	209.7	75.8	596.6
1980	142.5	68.0	57.5	16.7	5.2	1.3	-	-	-	7.6	37.0	144.8	480.6
1981	232.0	49.5	12.2	12.3	3.2	-	-	-	-	-	55.0	211.2	575.4
1982	65.5	48.3	60.7	54.6	77.9	-	13.1	-	-	61.8	64.5	142.0	588.4
1983	18.6	140.6	13.9	5.1	0.3	-	3.2	-	-	-	78.1	170.8	430.6
1984	153.5	121.8	129.6	76.6	-	-	14.5	-	-	-	99.3	62.9	658.2
1985	99.0	28.7	95.6	0.5	57.8	-	-	-	-	25.2	45.2	26.2	378.2
1986	126.3	141.0	31.9	47.8	5.4	20.2	-	-	-	16.0	12.2	39.3	440.1
1987	107.8	107.5	61.6	72.7	2.9	-	-	-	-	0.3	88.9	101.1	542.8
1988	63.6	69.7	184.6	43.6	7.2	-	-	-	1.3	-	110.9	126.8	607.7
1989	0.6	0.1	53.6	0.5	8.5	8.4	-	-	9.4	40.8	41.6	47.4	210.9
1990	0.3	26.1	11.5	16	0.2	7.5	-	1.5	5.6	15.5	2.8	231.9	318.9
1991	79.9	51.4	36.4	50.1	36.6	0.9	2.4	-	0.9	17.3	33.7	89.7	399.3
1992	1.0	11.7	82.2	25.8	5.6	-	-	2.0	-	0.7	52.7	133.5	315.2
1993	55.9	192.7	71.1	27.7	17.9	0.2	-	-	-	47.0	149.4	54.2	616.1
1994	80.5	154.4	47.8	22.4	65.6	1.0	-	-	-	55.7	96.0	123.0	646.4
1995	110.6	173.8	65.6	30.8	28.6	1.1	-	-	-	50.0	80.7	126.6	667.8

Table 1.2. Records of Average Heat which are Seperated in Months of Çeşme -Ilıca Meteorlog Station Between (1971-1995).

	MONTHS												
Meteorolojik Elemanlar	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	TOTAL
Medium Temperature	9.2	10.3	11.5	15.0	19.4	23.6	25.2	24.7	22.0	17.9	14.4	11.7	17.1
Minimum Temperature	-3.4	-2.0	0.6	1.8	6.0	12.0	14.1	14.0	10.0	4.2	0.5	-2.1	-3.4
Maximum Temperature	18.3	20.0	21.5	28.8	34.2	37.1	37.5	37.0	33.2	32.5	26.5	21.8	37.1

	January	February	March	April	May	June	July	Augost	September	October	November	December	Total
t°C	8.95	10.10	12.00	15.03	18.90	23.50	25.7	24.8	23.2	17.92	14.17	10.02	
H	315	311	404	415	442	455	425	337	345	308	301	298	
h	98.5	133.8	210	224.3	245.8	341.4	383.4	340.2	305.6	197.1	165.8	130.5	
h/H	0.313	0.43	0.520	0.540	0.556	0.750	0.902	0.902	0.886	0.640	0.551	0.438	
IgA	378	392	667	837	960	1025	989	892	684	559	419	348	
Ig	141.4	175.07	335.10	430.89	503.73	661.13	731.11	659.40	498.86	322.43	218.56	157.14	
ETP	28.61	36.23	68.46	96.27	121.09	173.63	197.29	176.82	133.36	81.10	52.18	33.18	
P=Rain (mm)	92.19	83.11	57.65	35.02	16.72	6.73	2.44	0.29	4.89	31.55	64.10	94.53	489.22
Soil halter	100	100	89.19	27.94	0	0	0	0	0	0	11.92	61.35	
Soil halter change	0	0	-10.81	-61.25	-104.37	-	-	-	-	-	-	-	
Etr	28.61	36.23	68.46	96.27	16.72	6.73	2.44	0.29	4.89	31.55	52.18	33.18	

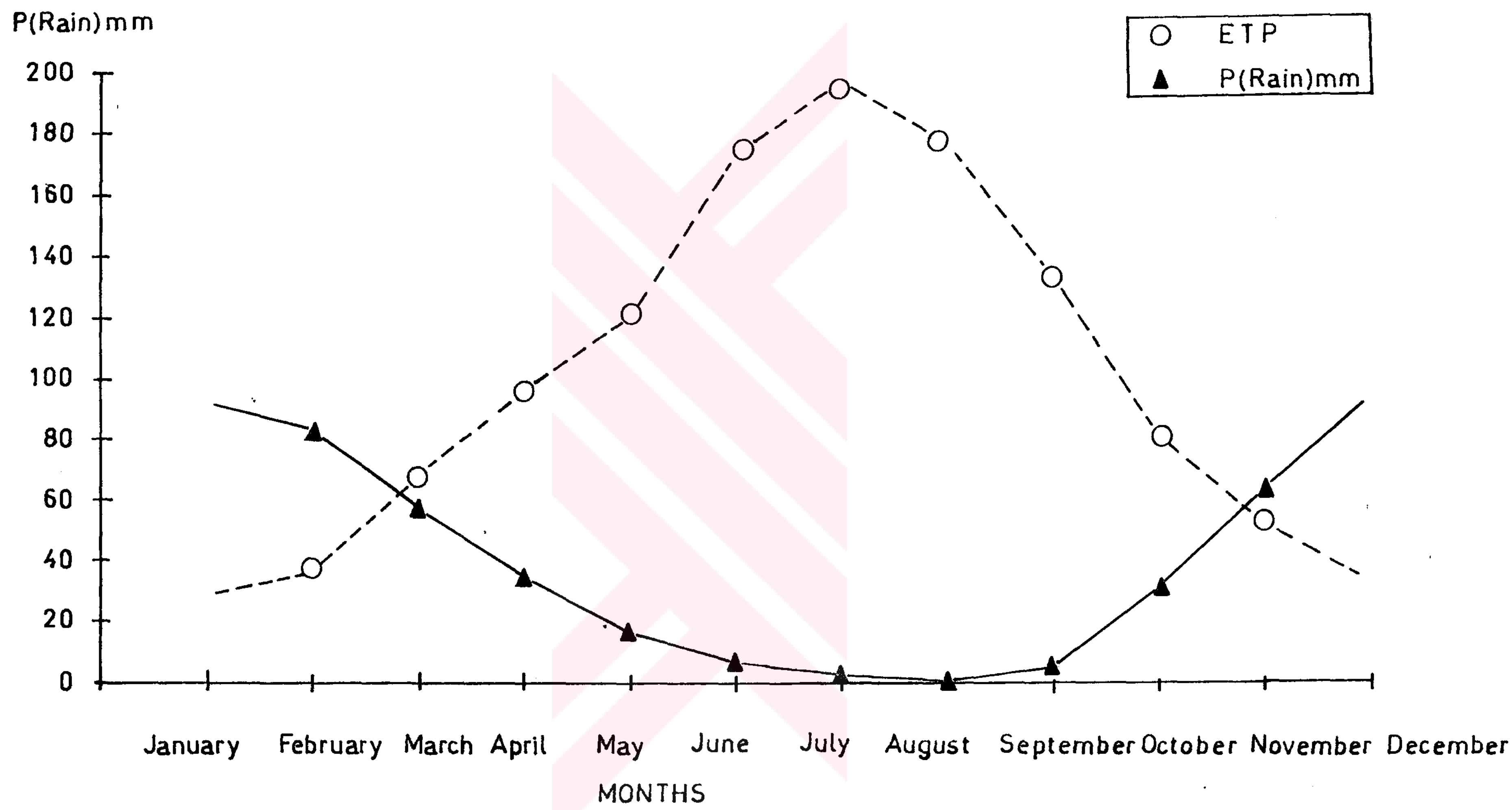


Figure 1.2. Diagram of Evaporation - Perspire

1.4.3. Vegetation

Mesozoic age unit dominant vegetation is magus smooth and gentle slope area, olive, vegetable, fruit and globe artichoke agricultural is made. Volcanic rock, small height rare and vegetal plant is dominant.

YK

CHAPTER TWO
GENERAL GEOLOGY

2.1. STRATIGRAPHY

In the field of study , nine rock units may be identified from Carboniferous and Quaternary ages (Figure 2.1).

2.1.1.Alandere Formation

The oldest rock unit of Karaburun sequence is Alandere Formation from below medium Carboniferous epoch. This unit covers region between Ildırı and Reisdere Villages. the formation consissts of graywacke and limestones with many fossils having dark brown and black colored crinoid stalks. According to Gümüş (1971),this formation complies with two units; Alandere and Tınaztepe Brinkmann et al. (1972) identified the unit as below Carboniferous limestones.

The base of this unit consists of graywackes with dark green color and brown seperation color; fine stratum (5-10 cm) coarse and medium grains (Figure 2.2).

From examinations of thin cross-sections of graywacke samples lithic crums, mica and quartz compounds can be observed (Figure 2.3(a), 2.3(b)).

With study area, there are conglomerate, lidite and shales as intermediary fine additives inside a graywacke unit. Conglomerate consists of generally badly sized lidite, shale and quartz particles with 3cm of maximum diameter. Lidites are block, uniformly stratified and have fine particles. Shale has greenish dark-grey color and it is a good laminae. Limestone is

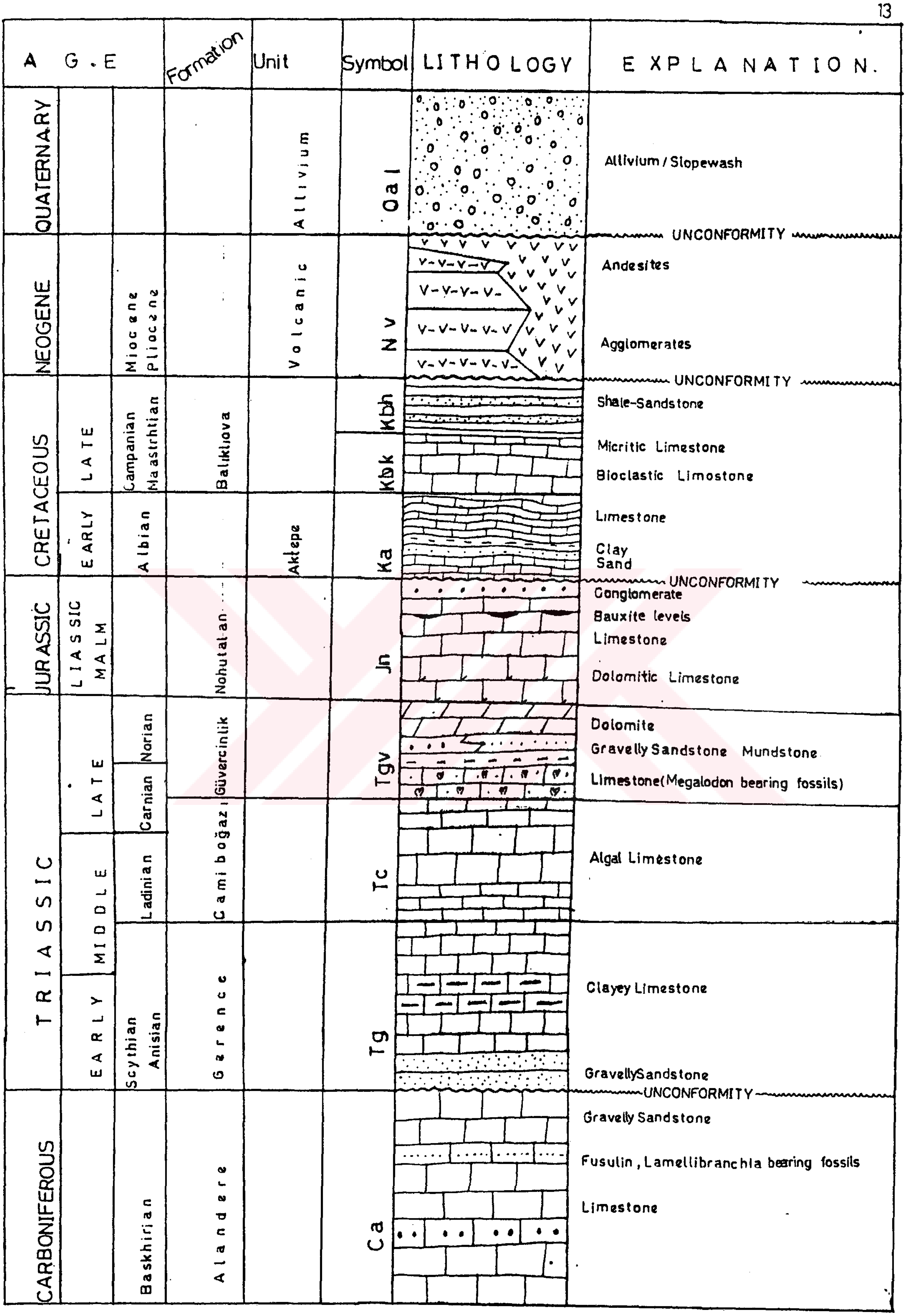


Figure 2.1. Generalized Stratigraphic Colomnuar Section of the Study Area

Figure 2.2. Graywacke appear on the Alandere Formation (54625/48800)

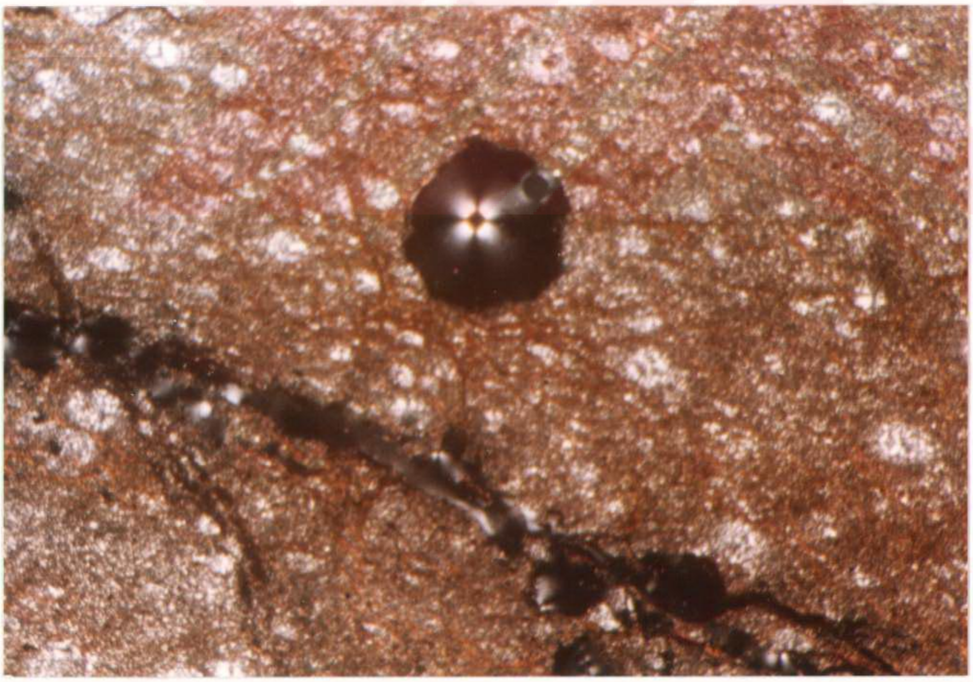


Figure 2.3 (a). Thin section analyses under the microscope of Graywacke with the Alandere Formation.

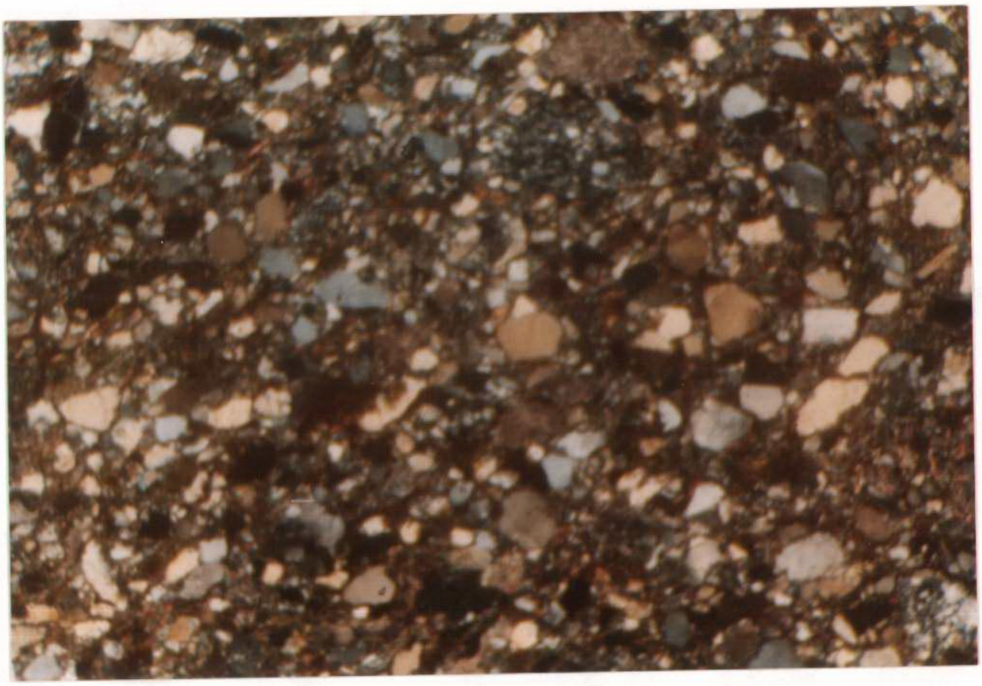


Figure 2.3 (b). Thin section analyses under the microscope of Graywacke with the Alandere Formation.

an inner structured massive unit with grey-light brown color. The most distinctive feature of this limestone is to have a huge amount of crinoid stalks and coral fossils.

The upper contact of Alandere Formation is observed along the road from Ildırı to Gerence Bay, and the unit consists of dark black limestones Where they superpose with below Trias rocks made of micrite structured limestones that includes light-greyish colored sponge spiculae. Along the whole contact, a zone can be observed with an oxidation surface and karstic hole.

Brinkmann et al. (1972), describes the unit known as Alandere Formation as Paleozoic massive limestone and determines the age as Pre-carboniferous. Gümüş (1971), determines the age as Late Carboniferous - Viscean period for the rocks equivalent to this unit. Below

Carboniferous limestones of these two sequence, there are rocks composed of graywacke and black cherts from possible Devonian epoch.

Erdoğan et. al. (1990), considers the age as Early-Medium Carboniferous (Baskhirian) based upon fossils present in the samples taken from various sections of Alandere Formation.

2.1.2.Gerence Formation

Gerence Formation has heterogenous lithological characteristics and shows lateral facies variations. Brinkmann et. al.(1972) consider these variations as separate as units and designated them as "Domuzçukuru, Koyutepe and Laleköy units from bottom to top respectively. Erdoğan et.al. (1990), consider these units as Gerence Formation . Gerence Formation is between the area of Gerence Bay and Ildırı Which is at western part of Peninsula
(Figure 2.4).

Figure 2.4. General view of Gerence Formation (57050/51100)

The formation consists of dolomite, sandstone red-green chert and limestone.

Dolomite has small crystalline particles with light color.

Sandstone with marl is light yellowish colored and good-stratified with additive of radiolaria .

Limestone is red colored, well stratified and has particles with good affininty. There are many ammonite and conodont fossils inside. The bottom sections of Gerence Formation have sandstone and red-green cherts. Middle and upper sections have red limestone with ammonite fossils. The intermediary additive at upper section of the formation is widespread pebblestone consisting of chert crumbs and limestone.

Gerence Formation sits over the Middle Carboniferous -aged Alandere Formation . Although there is no distinctive angular nonconformity throughout the contact ; Permian and Late Carboniferous epochs are lacking and there is a zone with karstic hole at the boundary.

To the top of Gerence Formation ; Camiboğazı Formation is superposed with on intermediary contact. There are limestone layers with medium -fine thicknesses in yellow color at the boundaries of both units, and they gradually disappear from bottom to upwards to the limestones massive and in grey color with pink veins of Camiboğazı Formation . Previous studies (Gümüş 1971,Brinkmann et. al. 1972) suggested Skitien-Anisien age to the Gerence Formation designated as Domuzçukuru, Koyutepe and Laleköy based upon ammonite, conodont and foraminiferida fossils. Radiolarian cherts present at bottom parts of Gerence Formations indicates the deep pelagic environment. Bioclastic limestones with mudstone additive which has thin layer shows presence of slope facies.

At the upper sections of Gerence Formation pebblesstones, red-colored sandstones as well as intermediary additive as thick layered limestone with algae indicates shallow sea environment. According to this, Gerence Formation a chain passing from bottom, the deep sea environment indicating shallow sea (Güngör 1989).

2.1.3.Camiboğazı Formation

Camiboğazı Formation consists of white and light grey limestone, it is distinctive by its steep morphology with compareson to other units. Camiboğazı Formation is defined with the same name by Gümüş (1971), Brinkmann et.al. (1972) and Erdoğan et. al.(1990).The most typical ones can be seen at Camiboğazı place at east of Ildırı, east of Zetincik.

Camiboğazı Formation has thick layer and present massive inner structure and it is formed by white limestone with algae. Red sandstone lenses and pink-verined limestone in the formation are typical. In Antic Ages, it has been exploited as marble because of this characteristic and now it is exploited as "Çeşme Pembesi"(Figure 2.5).

Figure 2.5. Limestone unit known **Çeşme Pembesi** belongs to the Camiboğazı Formation.(55450/42500)

Camiboğazı Formation covers Gerence Formation with conformity. The intermediary layer has pebblestones or red limestones with ammonites.

This unit is known by massive, grey limestone with algae. The upper contact of Camiboğazı Formation conforms with Güvercinlik Formation. Between the contacts inner structure and color differs, on regions near the upper surface.red-pink colored massive inner sutructure whit think and irregular stratum may be obsorved.

Brinkmann et. al.(1972) estimmated age of Camiboğazı Formation as Ladinian-Carnian based upon fossils of **Cladogiruaneila sp.** and **Tubyphytes sp.** available in Alp middle Trias.

Düzbastılar (1978), estimates the ammonites at the bottom of Camiboğazı Formation are Upper Anısien, **Involutina eomesozoica, Teutroporella nodosa, Parachaetetes karaburunensis, Caveuxia moldovica** at middle sections are ladinien, and **Involutina sinuosa, A. sinuosa pragsoides, Glomospirella friedli** at upper sections are Carnian aged. Erdoğan (1990), estimates age of Camiboğazı Formation as Ladinian-Carnian based upon determined and observed algae colonies, bioclastic rocks, foraminiferida fossils. Camiboğazı Formation is Ladinian-Carnian (Middle and Upper Triassic) aged according to the fossil content found by former researchers.

2.1.4. Güvercinlik Formation

In the study area of, formation is made of stramatolithic dolomites, limestones with megalodonts , mudstone and sandstone. The unit known as Güvercinlik Formation matches with two units of Brinkmann et al (1972) namely Hanaylı and Güvercinlik. These researchers suggested dolomites under Hanaylı and red sandstones and dolomites under Güvercinlik. Erdoğan (1990), also defined the unit the unıt with the same name.The most clear area of Güvercinlik formation can be observed throughout the road connecting Ildırı to Barboros Village.

Limestones have yellow-beige color, they have thin and meddium, regular, and resistant layers. The layers include megaladont shells that can attain 10 -20 cm lengths.

Mudstones can be obsorved in yellowish white, red and green colors. Mudstones have thın layer and presents an inner structure with laminae. They are not resistant so they have many cracks. They are liable corossion and they have broken and crumby structure (Figure 2.6).

Dolomites are cut from calcite fillers and they are formed in hexagonal inner structure. Dolomites near limestones have stramatolithic laminates. İnside the laminated Dolomites; there are birdseye structure filled with calcite about 1-2 mm diameter and intraformational pebble surfaces formed at dolomite laminates (Figure 2.7).

Figure 2.6. A point of view of Mudstone levels with the Güvercinlik Formation. (60550/45700)

Sandstones are made from quartz in red color, resistant and well compressed quartziferous sandstones have thin bedding and rare in nature in comparison with others.

The lower contact of Güvercinlik Formation has a transitivity relation with Camiboğazı Formation and upper contact with Nohutalan Formation.

Brinkmann (1972) gave Güvercinlik Formation the age of Carnian- Norian (Upper Trias) based upon fossils of **Involutina cf. progsoides, Colospongia catinulata, Trigonodus sp., Macroporella humilis, Microbutus communis** found during the researches at Karaburun Peninsula. Erdoğan et. al. (1990) gave Güvercinlik Formation the age of Norian- Resien based upon fossils of **Triassina hantkeni, Auloconus permediscaidea, Aulotortus sp., Aulotortus sinuosus pragosoides , Aulotortus tumidus, Ihaumatoporella parvare siculifera** at detailed studies made at Karaburun Peninsula.

Figure 2.7. A point of view of dolomitic levels with the Güvercinlik Formation (60525/46100)

2.1.5. Nohutalan Formation

In the area of study, the unit consists of thick-layered yellow-white dolomite, white dolomitic limestone, thick layered dark grey limestone and lense positioned bauxite . Formation is situated between Kadıovacık Village and Akdağ. Brinkmann et. al. (1972)

designates the formation as Nohutalan and Cladocoropsis , Erdoğan et. al. (1990) designates the unit as Nohutalan Formation.

Dolomites found at lower sections of Nohutalan Formation are in yellow-white color however, at lowest parts they are in brownish grey color.Layers generally are good with medium-thick and have stromatolithic laminae. Dolomitic limestone can be seen on dolomites. Dolomitic limestones have stromatolithic laminae and fragmented structure. Dark grey colored limestones on dolomitic limestones have thick layer with algae and they have medium resistance .

Bauxite intermediary additives are found on lense position situated at nonconforming cracks on dark grey colored limestones. Length of the lens is 250 m and width is 10 -30 m. The presence of bauxite shows a seperation on water after the unit has been formed. Bauxite which has a patched formation has oolithic inner structure.

A study made on bauxite by Esen (1993),shows that bauxite includes boehmite, diaspore, hematite rutile, quartz, calcite, kaolinite and gotite minerals. The bottom layer of Nohutalan next to Güvercinlik Formation is a passegeway,layer passes through dolomites of Güvercinlik Formation and dolomites of Nohutalan Formation. There is nonconformity with Aktepe unit.

Brinkmann et. al. (1972) give Nohutalan layers the age as Lias and Cladocoropsis layers the age as Lias- Malm

Erdoğan et. al.(1990) give the age to the formation as Lias- Malm based upon the fossils of; **Ataxophragmiidae, Paleodasycladus mediterraneus, Thaumatoporella porvovesiculifera , Cladocoropsis mirabilis, Ophthalmidium sp., Miliolidae.**

The botom sections of Nohutalan Formation reflects tide plainness and coastal sea carbonate precipitation surrounding like Güvercinlik Formation . The middle and upper sections of the formation have dolomite, limestone showing stramatolithic lamination, dark-

Figure 2.9 (a). Fossil which is found in Aktepe Unit thin section view

Figure 2.9(b). Fossil which is found in Aktepe Unit thin section view.

On the yellowish brown limestone, pebbles with sanstone is present, pebbles are connected with carbonate cement , pebbles reflect middle -coarse fineness in their inner structure and includes green santstone, chert pebbles and different color limestones. At the neighborhood of pebbles black grey colored massive crystallized limestone that have no relation with unit layer. Upper contact of Aktepe unit does not conform with Nohutalan Formation. The contact passes across the dark grey limestones of Nohutalan formation between Akdağ and Aktepe and yellowish brown limestones of Aktepe unit. Upper contact of Aktepe unit is vertically faulted and composed of andesite. Brinkmann et. al. (1972)give the unit the age of Early Cretaceous.

Erdoğan et. al. (1990) give the age to the formation as Albian- Cenomanian based upon the fossils of **Miliolidae, Orbitolinidae, Cuneolina sp., Textularia sp., Discorbidae, Cylindroporella sp., Glomospira sp.**

In the unit, Esen (1993) also give the age to the unit as Albian -Cenomanian based upon fossils of **Cuneolina sp., Miliolidae, Dicyclina sp., Apricardia sp.,** and rudist particles.

2.1.7. Balıklıova Formation

At the west of Balıklıova, a sequence at the age of late cretaceous and of which it composes of white yellow colored at the bottom and shale, sandstone and pebblestone at the top. This was first determined by Brinkmann et. al. (1977), Erdoğan et. al. (1985) bring out in detail the position, stratigraphy Upper Cretaceous units in Karaburun Peninsula, and introduced it with designation as Balıklıova unit, in this study the Late Cretaceous sequence named as Balıklıova Formation is divided to Karahasan limestone member and Hanaybaşı limestone member according to Erdoğan et. al. (1985).

2.1.7.(a). Karahasan Limestone Member:

Bottom surfaces of Karahasan limestone member is composed of crumby limestone massive in white color. On the crumby limestone, there are limestones with bioclastic rocks. Over this bioclastic level, red colored, sandy limestones with chert bans are included. The uppest level of the block that is composed of limestones contains thin-laered, red colored pelagic limestones. These limestones have spreaded pelagic foraminiferida.

Karahasan limestone member overlies the top part of Gerence Formation which is Early Trias aged, consisting of dolomitic limestone and red colored limestone without any angular conformity. Güngör (1989) gives Karahasan limestone member the age as Campanian - Maastrihtian.

2.1.7.(b). Haneybaşı Member:

Haneybaşı member is composed of thin layered, sandstone additive green shale.Bottom sections of member have red colored micritic limestone lens composed of pelagic forominiferida.

Haneybaşı member formed with sandstone and shale superposes over Karahasan limestone member with conformity. Transition from Haneybaşı member to Karahasan member is done by red colored micritic limestones. Micritic sandy limestones existing at the toppest level of Karahasan limestone member are Maastrihtian aged. The age of Haneybaşı member superimposing over Karahasan limestone member is also Maastrihtian.

2.1.8. Volcanites

Volcanites formed by agglomerates and andesite are widely spread at Ildırı Tepe and Punta Peninsula Germiyan area and east of area of study.

Agglomerate is formed by andesitic, dark brown colored compounds with thinner volcanic materials.

Andesites have often a massive structure. Andesites have reddish brown color but sometimes have dark grey color. Studying thin sections of andesite shows a poriferous structure and a thin matrice formed by plagioclastic microlithes. Flow veins are evident at some places. Big crystals have idiomorph-hipidiomorph appearance Andesites from thin cross- sections includes plagioclase, piroxene, amphibole and opaque minerals (Figure 2.10).

With respect to seperation level, andesites have different colors and presents some flow veins and cooling joints (Figure 2.11) At some places volcanites formed lithologies are transitionary with each other in vertical direction. From bottom to top; agglomerate and andesite covers the units in superimposed way without conformity.

Andesite contact at the north of Kadıovacık village and northeast of Akdağ, having many carbonates is vertically faulted.

Brinkmann et. al. (1972), Erdoğan et.al. (1990) state that volcanites widespread at Karaburun Peninsula are Miocene - Pliocene aged.

Borsi et. al. (1972) give the volcanites named Kocadağ sequence the age as 16,6 and 17,3 million years by radiometric method in their studies of the area. This conforms with the epoch of Middle Miocene.

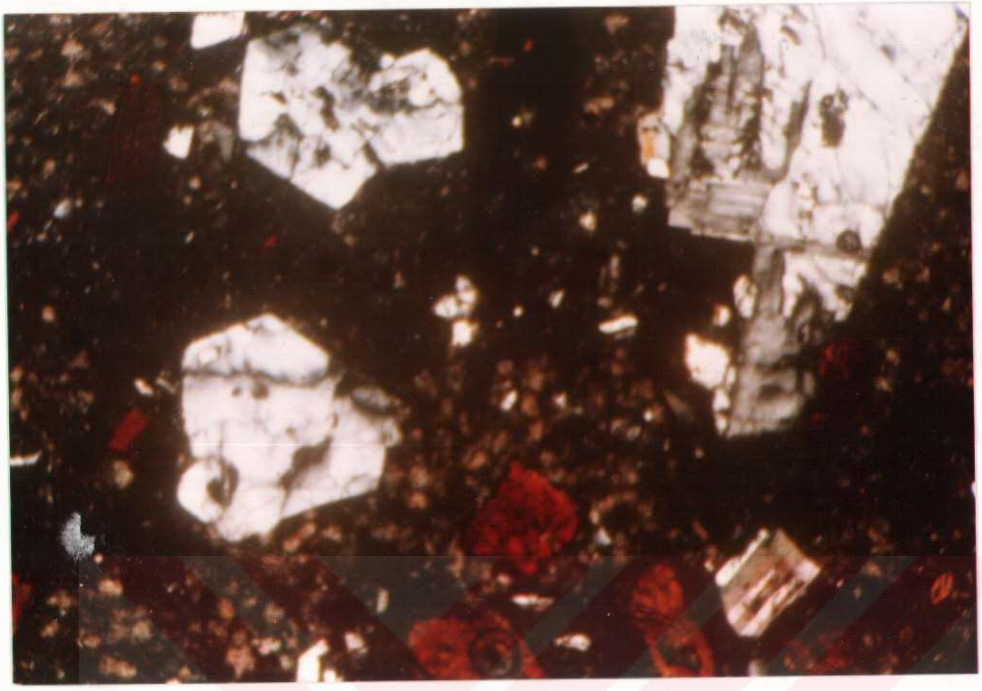


Figure 2.10. Thin section analyses of the Neogene aged andesite

Figure 2.11. Point of view of the andesite unit from the Ildırı Hill. (54575/48400)

2.1.9. Alluvium

Alluvium is widely spread at many places of the area of study. The alluvium consists of particles ranging in size between clay and gravel without being cemented and is angularly unconformable with the underlying rocks. Particles making up the alluvium i.e. clay,silt,gravel also show vertical gradation.

The thickness of the alluvium and slopewash is about 5-20m.

2.2. STRUCTURAL GEOLOGY

Karaburun carbonate accumulation starts with Carboniferous aged shallow limestones of the sea and there is territorialism before the Early Triassic. The next layer consists of pelagic limestones and shallow sea carbonates aged between Early Triassic and Early Cretaceous . Upper Cretaceous accumilation formed without conformation on Karaburun carbonate accumilation shows transition from platform to deep sea surrounding.

Karaburun carbonate accumulation is formed with current geological structure by accumilation of over thrust faults after Cretaceous ages. The area with overthrust structure is covered with andesitic volcanites at Miocene - Pliocene ages, unconformity.

In the area of study; structural elements are studied as unconformities, fractures, joints, folds and faults.

2.2.1. Unconformity

a. The contact between Baskhirian aged Alandere formation and Scythian - Anisian aged Gerence Formation is in unconformity. Gerence Formation superimposes Alandere Formation without any sutructural difference. Unconformity between formations are known by age differences.

b. Lias-Malm aged Nohutalan Formation and Albian aged Aktepe unit have transitionary contact in unconformity. Uncon formity between formations are known by age differences.

c. Lower contact of Balıklıova formation is in unconformity. Unconformity at the foundation of formation is evident from age and structural differences.

d. Foundation Miocene - Pliocene aged andesitic volcanites are in unconformity. There is distinctive rock difference between volcanites and carbonates.

e. Alliviums with Quaternary aged cover the other units in unconformity.

2.2.2.Joint and Cracks

Carboniferous and Triassic aged limestones in the area of study contains many fractures, joints, and melting pores. Carboniferous units generally run in NE-SW direction .A rose diagram is set according to the measurements of fractures and joints of Carboniferous limestones.The diagram shows that carboniferous limestones are under the effect of compressional forces acting on NE-SW direction and tensional forces acting on NW-SE direction (Figure 2.12).

Fracture and crack measurements from Triassic limestones showed that Triassic limestones are under the effect of NW-SE mean forces (Figure 2.13).

With comment of Filiz Ş.,Yalçın L., (1982) on air photography with 1/35000 scale, Paleozoic, Triassic, Jurassic,Cretaceous, Neogene and Quaternary units are seperated clearly. Also draining net structural linearities (faults, joints), karst structures (dolins, poljes) are plotted in the same map (Figure 2.14).

Jurassic rocks run in SW-NE and Crateceous rocks run in NW-SE direction.

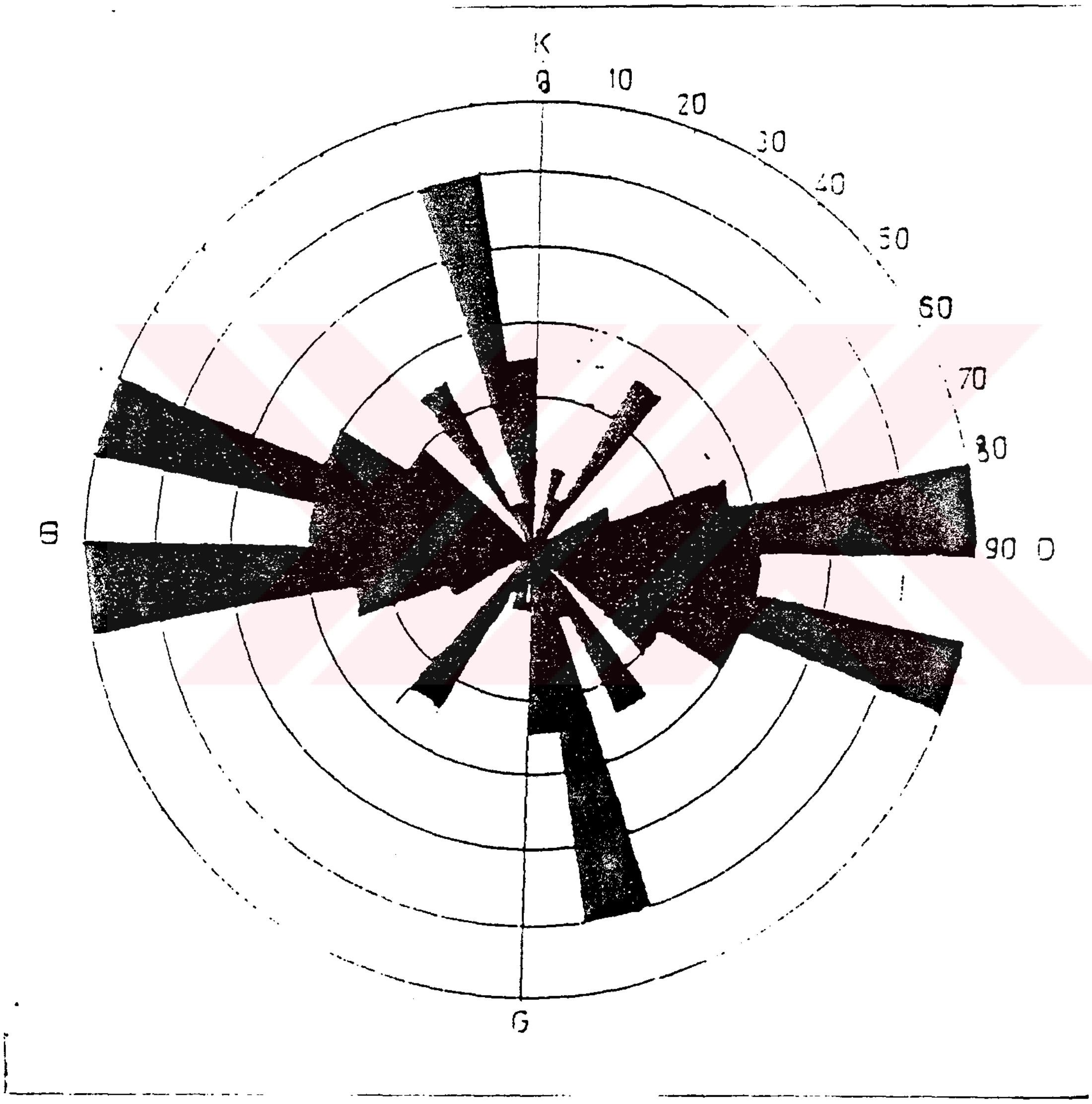
2.2.3. Folds

The axis of folds between Ildırı, Germeyan and Kadıovacık runs in NNE-SSW direction, at the same time southwest of Balıklıova in NNW-SSE direction. Between Germeyan and Kadıovacık, a synclinal and an anticlinal structure parallel to each other can be observed known as Camiboğazı, Güvercinlik and Nohutalan Formations.

Although it is not considered in the area of study, the nucleus of synclinal structure is Nohutalan Formation. Northwest wing of this synclinal is tilted, southeast wing of anticlinal lying between Nohutalan and Kadıovacık is tilted to southeast at Kadıovacık direction.

Folds observed in this area is followed on Güvercinlik Formation. These folds are covered with volcanites stratigraphically by Balıklıova tectonical superposition.

Apart from these big sized folds as well in the area of study (Figure 2.15).



Total 90 measurement

Figure 2.12. Rose diagram prepared using the joint measurements taken from Triassic aged limestone unit.

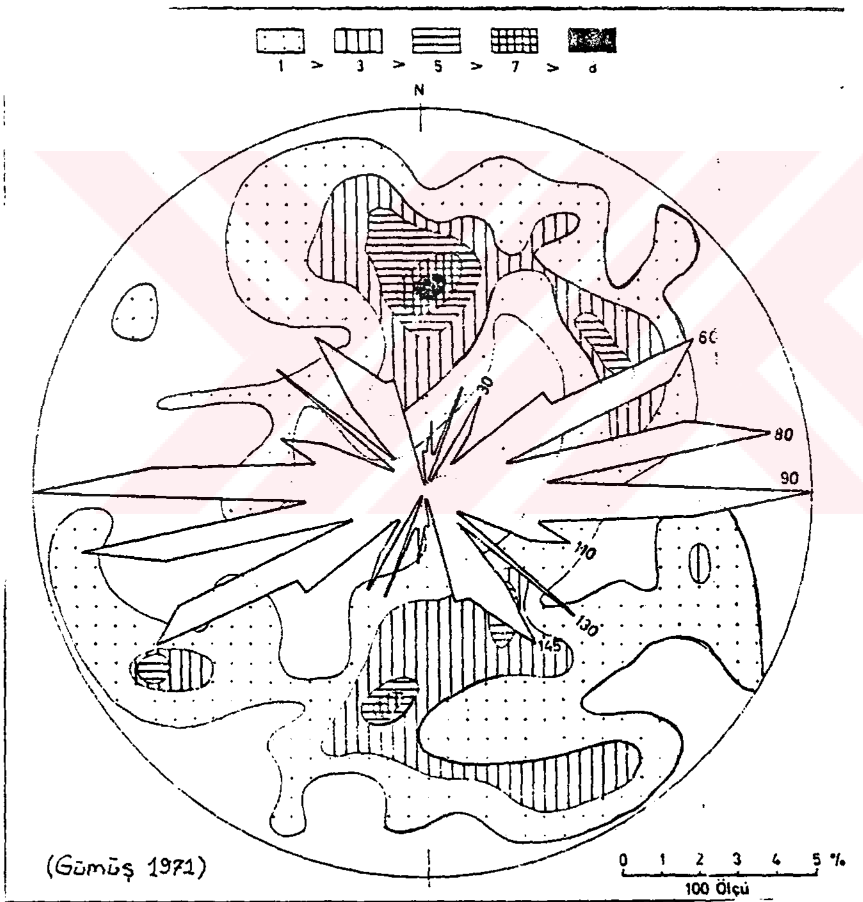


Figure 2.13. Rose diagram prepared using the bedding measurements taken from the Carboniferous limestones.

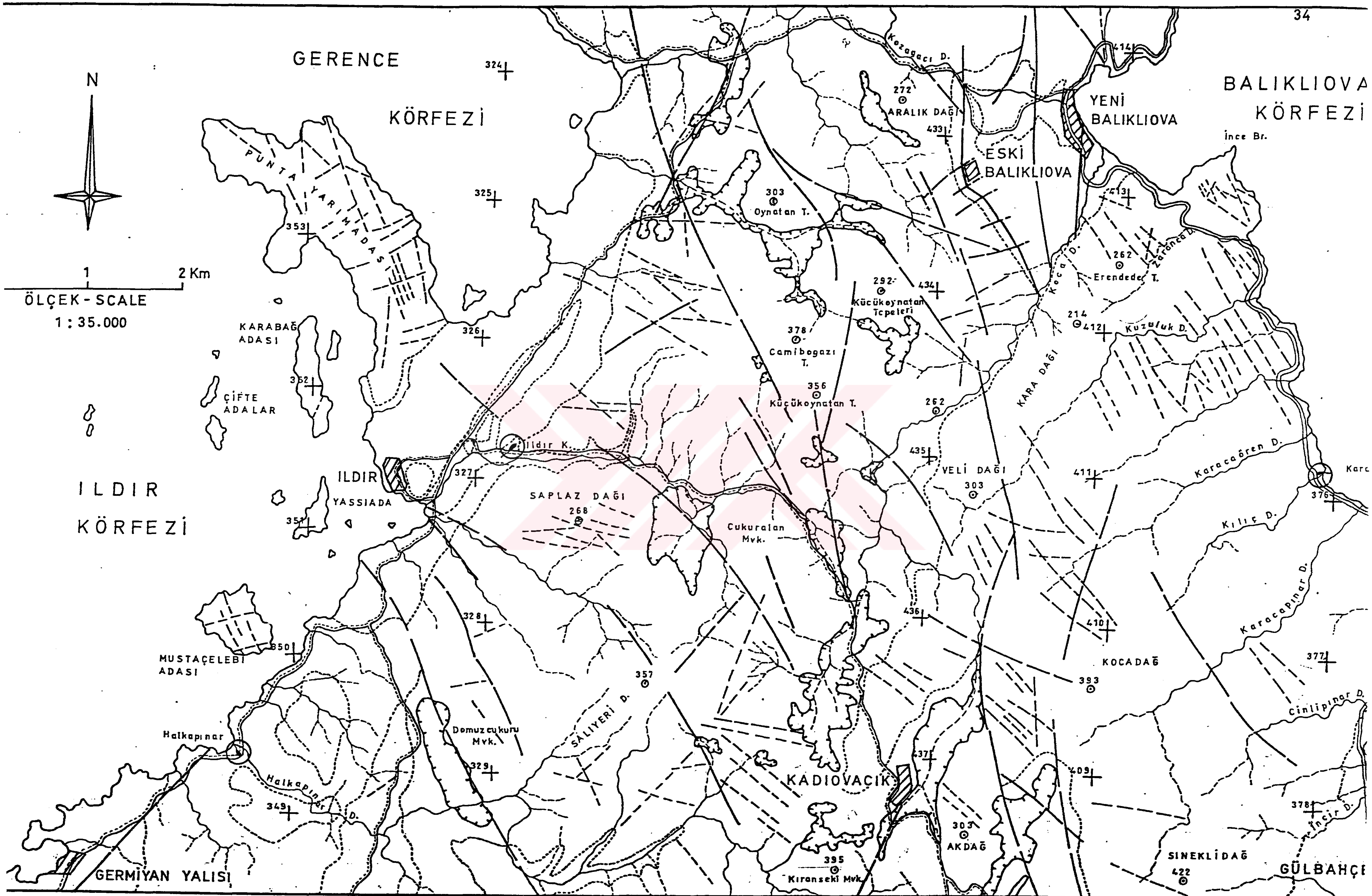


Figure 2.14. Tectonic map of the study area

Figure 2.15. On the Ildırı- Gerence road, small folding in graywacke (54625/48775)

2.2.4. Faults

In the study area overthroust faults with large angle (30-65) tilted to eastwards are determined. There are three overthroust faults intersecting each other on west Balıklıova. There is also a clip at Oynatan.

Overthroust faults determined do not have big ranges challanging the different tectonic belts. These faults are formed by slicing and accumulating of same carbonates by overthroust. Each layer repeats similar facies and stratigraphy.

Another overthroust fault observed seperates Gerence Formation from Güvercinlik Formation. This fault has small slope and it is an Kırdağ Hill and Kaplancık Hill.

In the study area vertical fault between Güvercinlik Formation and volcanoes is met. This fault is known by linear course in the area, seperating of sedimentary volcanics units and having a crushed zone.

Another vertical fault observed in the area of study runs in NW-SE direction. This fault is among Nohutalan Formation, Aktepe Unit and volcanites. This fault is manifested with linear course and seperating two units with different characteristics. Other important faults are Domuzçukuru fault, Çukuralan-Camiboğazı fault. Also there are many secondary faults superimposing on main faults or intersecting with different angles, too.

CHAPTER THREE

HYDROGEOLOGY

3.1. HYDROGEOLOGICAL CHARACTERISTICS OF ROCK UNITS

Graywackes, basis in the study area are not suitable for aquifer formation because of their permeable structure. On the top of graywackes, Paleozoic and Mesozoic area aged limestones do have a good aquiferic characterstics owing their lithological qualities and their large exponsions. It is found from the previous studies that these limestones have a karstic structure.

Limestones having minimal permeability and porosity in their first formation gradually gain a cracked and splitted structure under the effect of determations. Rainwater penetrated through these cracks and splits become richer in CO_2 depending on the paleogeographic and paleoclimatological effects and shows a midly acidic character. pH value of water is related with its CO_2 content. As seen from the equation(1);

$H_2O+CO_2= HCO_3+H$...(1)

CO_2 entering to the water forms bicarbonate and H is released. Since H=10 -pH, pH value of the medium will decrease and it gains an acidic character. If the reaction is carried further, carbonic acid would be formed (Tarcan ,1989).

Mildly acidic underground water will cause to form karstic structures in different sizes and different diameters such as lapioz, calyx structures, caves, dolines and poljes by dissolving the limestones (Figure 3.1).

Dissolving of limestones by underground to the karstic cavities are realized according to the equation (2):

$$CaCO_3 + H_2O + 2CO_2 = Ca + 2HCO_3 \quad \text{.......} (2)$$

Limestones in the study area contain karstic structures as melting cavity, poljes, dolines and caves (Figure 3.2, 3.3).

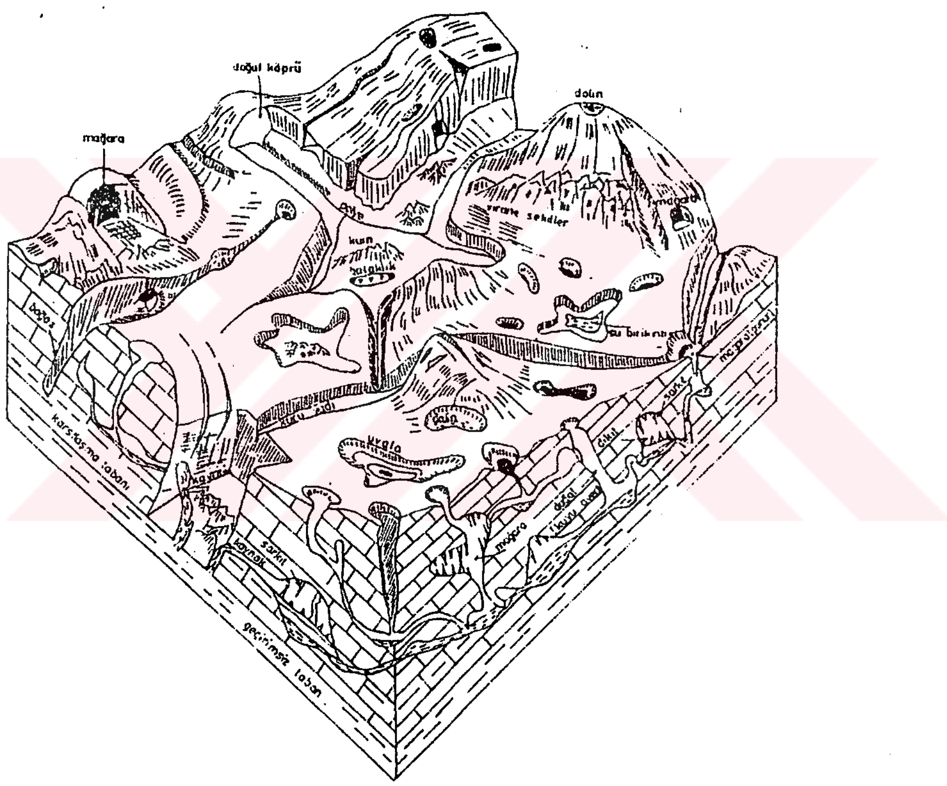


Figure 3.1. Karstic structure forming shape(Şahinci, 1986)

Volcanic rocks of the area of study do not have characteristic of being aquiferous. However they can take water with low flow rate and in good quality from cooling joints, flow structures and cracked or splitted sections. These volcanic rocks are ideal base for lagoons, cisterns and dams. There are many lagoons and cisterns built on volcanic rocks in and out of the scope of the area of study. These lagoons and cisternsare used for animal drinking water and agricultural purposes (Figure 3.4).

Outside the area of study, a dam is built on a base with tuff and andesite for supplying drinking water at Buca location.

Alluviums do not have aguiferous characteristics since they do not have sufficient thickness and age levels are present in deep locations. Shallow wells are situated on top of them.

Figure 3.2. Karstic holes in the Triassic aged limestone unit (57500/47125)

Figure 3.3. A point of view of the karstic caves in Triassic aged limestone unit.(59650/40625)

Figure 3.4. Irrigation aim podle and cistern in Kadıovacık.(61075/44475)

3.2. CHEMICAL PROPERTIES OF WATER

3.2.1. Electrical Conductivities of Water in the Study Area

Electrical conductance is the property of permeation of electricity. Electrical conductance is just opposite of electrical resistance with mho units. if electrical conductivity of water is high then water has property of causing high decaying When ion content in water increases, conductance proportionally increases. Classification according to electrical conductances for the water is shown below (Şahinci 1986).

Water source positions in the field of study according to this classification are given in Table 3.1 .

Table 3.1. Water classification which are ordered by there EC

EC (mmho/cm)	WATER CLASS
250	Very well
250 750	Well
750 2000	Permissible
2000 3000	Doubtful
3000	Impermisseble

3.2.2. pH Properties of Water in the Study Area

The pH of a solution is the negative common logarithm of the hydrogen ion activity, aH (Şahinci 1986).

pH= -log (aH)

In a dilute solution, the hydrogen ion activity is approximately equalto concentration of hydrogen ion. The pH of most raw water sources lies (electrometrically) within the range 6.5-8.5. Hydrogen ion concentration may be significantly altered during water treatment. Chlorination tends to lower the pH, where as water softening using the excesslime , soda ash process raises the pH level Tarcan G.(1995) pH levels in water samples of the study area vary from 6.45 to 8.07 standart unit, (Appendix 1).

3.2.3. Hardness of Water in the Study Area

Hardness of water is a measure of calcium and magnesium salts (Carbonates, Sulfates, Chlorides etc.) expressed as parts calcium carbonate permillion (mg/l) parts of waters.There are two kinds of hardness in the water one temporary hardness created by calcium and magnessium carbonate and bicarbonates Which can be get of boiling then this hardness goes a way. The permanent hardness is created by calcium and magnessium salts (Carbonates, Sulfates, Chloridese).

There are few hardness scales in the world. Some of them are France, English, Rusia, USA., etc. The most using hardness scale in Turkey is the "France total hardness".Hardness of water (Ht) (in France scale) is expressed as the amount of calcium carbonate in 100 ml water this

$Ht = 0,2497\ Ca + 0,4115\ Mg$ Where,

Ht, Ca and Mg are measured in milligrams per liter. The other equation is expressed as the following .**$Ht = 5\ (rCa + rMg)$** Where r is equal to milliequivalent per liter.

According to the France scale, hardness of water is classified as the following Table 3.2 (Şahinci 1986)

Table 3.2 Hardness classification (Şahinci 1986)

Hardness (As H_t in France)	Water Class
0-7.2	Very Soft
7.2-14.5	Soft
14.5-21.5	Slightly Hard
21.5-32.5	Moderately Hard
32.5-54	Hard
54 <	Very Hard

According to table 3.2 , hardness of water in the study area is classified as the following Table 3.3.

Table 3.3. Waters Of Studied Area Which Are Classified Through Out These Hardnesses

SAMPLE NAME	HARDNESS	CLASS
E_1	34.02	Hard
E_2	236.01	Very hard
E_3	47.66	Hard
E_4	370.79	Very hard
E_5	64.69	Very hard
E_6	40.79	Hard
E_7	5.81	Very soft
E_8	30.70	Moderately hard
E_9	38.61	Hard
E_{10}	38.46	Hard
E_{11}	30.54	Moderately hard
E_{12}	5.97	Very soft
E_{13}	19.83	Slightly hard
E_{14}	124.15	Very hard
E_{15}	44.59	Hard
E_{16}	59.23	Very hard
E_{17}	64.43	Very hard
E_{18}	38.69	Hard
E_{19}	67.27	Very hard
E_{20}	58.01	Very hard
E_{21}	38.69	Hard
E_{22}	64.66	Very hard
E_{23}	29.31	Moderately hard
E_{24}	32.38	Moderately hard
E_{25}	112.92	Very hard
E_{26}	43.69	Hard

3.2.4. Calcite,Dolomite, Sulfate Saturations and CO2 Gas Pressure in the Study Area

It is very important to have information on water with their saturation with salts such as calcite, dolomite and sulphate. Chemical precipitates cause problems on water distribution pipes and drilling wells. For this reason it is necessary to know in advance chemical precipitation characteristics of spring water to be capped and well water to be opened up.

Before determining calcite sulfate and dolomite saturations of water it is necessary to know relations used in calculations such as ionization potential, ion activation and ion activation index (F).

a(AC)=F*C Where

a (AC) is the chemical activity, **C (mol/l)** is the molal concentration, **F** is the activity coefficient In order to compute the activity coefficient of an individual ion, the ionic strength of the solution must be determined. For a mixture of electrolytes in solution, the ionic strength is given by

$$I = 0.5 * Ci \, . \, Zi$$ Where

Ci = is the molality of it ion

Zi = is the charge or valance of it ion

For groundwater, in Which the six common major ions are the only ionic constituents major ions are the only ionic constituents that exist in significant concentration are

$$I = 0.5 \, .[\, (Na) + 4\,(Ca) + 4\,(Mg) + (HCO_3) + (Cl) + 4\,(SO_4)\,]$$ (Şahinci 1986).

Where the quantities in parantheses are molalities. Once the ionic strength of solution of electrolytes is known, the activity coefficient of the individual ion can be determined from the following equations (Şahinci 1986).

Debye- Hückel equation = $-\log Fi = Azi. \sqrt{I}$ (if $I < 0{,}01$).

Extended Debye - Hückel equation = $-\log Fi = Azi^2 [\sqrt{I} / I + Ba . \sqrt{I}]$ (if $I < 0$)

Güntelberg equation = $-\log Fi = Azi^2 [\sqrt{I} / 1 + \sqrt{I}]$ (if $I < 0.1$)

Davis equation = $-\log Fi = Azi^2 [\sqrt{I} / 1 + \sqrt{I}]$ (if $I < 0.5$)

Where **Fi** is the activity coefficient of ionic species **I**

Zi is the charge of ionic species I

I is the ionic strength of the solution

A is a constant that is temperature - dependent

B is a constant that is temperature - dependent

a is the effective diameter of ion.

The values for **A,B** and **a** values may be found in the related tables (Şahinci 1986).

In this study, Debye - Hückel and Davis equations were used in the calculating of the activity coefficient of ions (F). Constant B and a were neglected in these calculation and the A were accepted as 0,5065. Activity coefficients were calculated for samples containing less than 1000 mg/l dissolved total ions using the Debye - Hückel equation; Other wise the Davis equation was used. The percentage value of the cations and anions of the ions dissolved in water are taken respectively. For example, if Na is considered, it is hypothesized that, it is percentage value as milli equivalents perliter (meq/l) in the other cations are taken. The same calculations were conducted for all cations and anions respectively.

3.2.4.(a). Saturation Index for Calcite (SIc)

Dissolving of CO_2 in water is directly proportional with CO_2 gas present in water as free state. $CaCO_3$ dissolved by the action of CO_2 gas is shown in the following equation:

$$\mathbf{CaCO_3 + CO_2 + H_2O = Ca(HCO_3)_2}$$

According to water temperature **Sc = log [(aCa^{++}). (aCO$_3$) / Kc]**

Kc = CaCO$_3$ equilibrium constant

At 25 C and 1 atm conditions a CO_3 value is calculated from equation and is substituted to equation **$[(aCa^{++}).(aCO_3)/(aCaCO_3)] = Kc = 10^{-8.3}$**

. K_c is equilibrium constant for HCO_3 and **a** is ion activation in mols/liter.

$aCO_3 = [K_2.(aHCO_3)/(aH^+)]\ (aH^+ = 10^{-pH})$

$Sc = \log[(aCa^{++}).(aHCO_3).0.01 / Kc.10^{-pH}]$

$K_2 / K_C = 0.01$

$Sc = \log[(aCa^{++}).(aHCO_3).0.01 / 10^{-pH}]$

$I_{APc} = [(aCa^{++}).(aHCO_3).K_2 / 10^{-pH}]$

If

$Sc > +0.1$ $CaCO_3$ Precipitation exits

$-0.1 < Sc < 0.1$ $CaCO_3$ Saturated

$Sc < -0.1$ $CaCO_3$ Disolved

Accordingly SIc values and interpretations are given in Table 3.4 with respect to analyses results of water at the study area.

3.2.4.(b). Saturation Index for Dolomite (SId)

As in the case of $CaCO_3$ dolomite saturation is proportional with CO_2 gas dissolved in water

$CaMg(CO_3)_2 = Ca^{++} + Mg^{++} + 2CO_3$

Saturation index for dolomite (Sd)

$Sd = \log[(aCa^{++}).(aMg^{++}).(aCO_3)^2 / Kd]^{1/2}$ or

$Sd = \log[Iapd / Kd]^{1/2}$

$Iapd = [(aCa^{++}).(aMg^{++}).(aHCO_3)^2 (K_2)^2 / 10^{-2pH}]$

Kd= $10^{-10.3}$ at 25 C and 1 atm where Kd is equilibrium constant of dolomite

SId can be explained as calcite saturation index. (aCa^{++}), (aMg^{++}) and ($aHCO_3$) are ion activations in mols /liter.

If **Sd > + 0.1** , Dolomite precipitation

+ 0.1 > Sd > -0.1, Dolomite Saturated

Sd < - 0.1 Dolomite disolved

Accordingly Sid values and interpretations are given in Table 3.5 with respect to analyses results of water at the study area.

3.2.4.(c). Saturation Index for Sulfate (SIs)

Sulfate ions are often in equilibrium with calcium ions . Solubility of CaSO4 in water is. saturation index for sulfate can be written as following from the relation above.

$CaSO_4 = Ca^{+} + SO_4$

Saturation index for sulfate

$Ss = \log [(a\ Ca^{++}). (aSO_4) / KCaSO_4]$

$KCaSO_4$ is equilibrium constant for calcium sulfate and is equal to $10^{-2.31}$ at 25 C and 1 atm. Interpretation of SIs same as saturation index for calcite. Saturation index for sulfate in water in the study area are given in Table 3.6.

3.2.4.(d). Partial Pressure of CO_2 in Water (PCO_2)

Rate constant for equilibrium of water and CO_2 gas dissolved in water is given as

$KCO_2 =[a\ H_2CO_3 / PCO_2]$

Where KCO_2 is equilibrium constant of CO_2 at 25 C and 1 atm and is equal to $10^{-1.46}$. In the above equation, instead of a H_2CO_3 , its equivalence in equation is substituted. Partial pressure of CO_2 gas in water is determined as follows.

$PCO_2(atm) = [(aH^{+}). (aHCO_3) / K_1. KCO_2]$

Partial pressure of CO_2 in water in the study area are given in Table 3.7. Partial pressure of CO_2 gas in atmosphere, carbonate, calcite and dolomite precipitation can be observed.

Table 3.4. Classification The Saturation Index for Calcide.

SAMPLE NAME	SIC	EXPLANATION
E_1	0.28	$CaCO_3$ Precipitation Exist
E_2	1.09	$CaCO_3$ Precipitation Exist
E_3	0.09	$CaCO_3$ Saturated
E_4	0.64	$CaCO_3$ Precipitation Exist
E_5	0.09	$CaCO_3$ Saturated
E_6	0.55	$CaCO_3$ Saturated
E_7	-0.82	$CaCO_3$ Disolved
E_8	0.05	$CaCO_3$ Saturated
E_9	0.34	$CaCO_3$ Precipitation Exist
E_{10}	0.40	$CaCO_3$ Precipitation Exist
E_{11}	0.13	$CaCO_3$ Precipitation Exist
E_{12}	-0.41	$CaCO_3$ Disolved
E_{13}	0.65	$CaCO_3$ Precipitation Exist
E_{14}	0.77	$CaCO_3$ Precipitation Exist
E_{15}	0.67	$CaCO_3$ Precipitation Exist
E_{16}	0.17	$CaCO_3$ Precipitation Exist
E_{17}	-0.19	$CaCO_3$ Disolved
E_{18}	0.07	$CaCO_3$ Saturated
E_{19}	0.06	$CaCO_3$ Saturated
E_{20}	-0.95	$CaCO_3$ Disolved
E_{21}	0.60	$CaCO_3$ Precipitation Exist
E_{22}	0.22	$CaCO_3$ Precipitation Exist
E_{23}	0.19	$CaCO_3$ Precipitation Exist
E_{24}	0.19	$CaCO_3$ Precipitation Exist
E_{25}	0.47	$CaCO_3$ Precipitation Exist
E_{26}	0.62	$CaCO_3$ Precipitation Exist

Table 3.5. The Saturation İndex for Dolomite in the Study Area (SID) and Explanation.

SAMPLE NAME	SID	EXPLANATION
E_1	-3.36	Dolomite Disolved
E_2	1.10	Dolomite Precipitation
E_3	-0.09	Dolomite Saturated
E_4	-7.73	Dolomite Disolved
E_5	0.17	Dolomite Precipitation
E_6	0.22	Dolomite Precipitation
E_7	-1.93	Dolomite Disolved
E_8	0.21	Dolomite Precipitation
E_9	0.56	Dolomite Precipitation
E_{10}	0.59	Dolomite Precipitation
E_{11}	0.40	Dolomite Precipitation
E_{12}	-0.44	Dolomite Disolved
E_{13}	0.56	Dolomite Precipitation
E_{14}	0.86	Dolomite Precipitation
E_{15}	0.44	Dolomite Precipitation
E_{16}	0.10	Dolomite Saturated
E_{17}	-0.22	Dolomite Disolved
E_{18}	-0.07	Dolomite Saturated
E_{19}	4.3×10^{-3}	Dolomite Disolved
E_{20}	0.51	Dolomite Precipitation
E_{21}	0.40	Dolomite Precipitation
E_{22}	0.08	Dolomite Saturated
E_{23}	-0.04	Dolomite Saturated
E_{24}	0.02	Dolomite Saturated
E_{25}	-0.20	Dolomite Precipitation
E_{26}	-0.26	Dolomite Disolved

Table 3.6. The Saturation Index for Sulfate in the Study Area (SIS) and Explanation.

SAMPLE NAME	SIS	EXPLANATION
E_1	-2.58	$CaSO_4$ Disolved
E_2	-2.69	$CaSO_4$ Disolved
E_3	-3.37	$CaSO_4$ Disolved
E_4	-2.51	$CaSO_4$ Disolved
E_5	-3.41	$CaSO_4$ Disolved
E_6	3.14	$CaSO_4$ Precipitation
E_7	-4.00	$CaSO_4$ Disolved
E_8	-3.87	$CaSO_4$ Disolved
E_9	-3.87	$CaSO_4$ Disolved
E_{10}	-3.83	$CaSO_4$ Disolved
E_{11}	-4.04	$CaSO_4$ Disolved
E_{12}	-4.17	$CaSO_4$ Disolved
E_{13}	-3.94	$CaSO_4$ Disolved
E_{14}	-3.09	$CaSO_4$ Disolved
E_{15}	-3.20	$CaSO_4$ Disolved
E_{16}	-3.69	$CaSO_4$ Disolved
E_{17}	-3.42	$CaSO_4$ Disolved
E_{18}	-4.38	$CaSO_4$ Disolved
E_{19}	-3.67	$CaSO_4$ Disolved
E_{20}	-3.91	$CaSO_4$ Disolved
E_{21}	-3.93	$CaSO_4$ Disolved
E_{22}	-3.75	$CaSO_4$ Disolved
E_{23}	-4.03	$CaSO_4$ Disolved
E_{24}	-4.15	$CaSO_4$ Disolved
E_{25}	-3.30	$CaSO_4$ Disolved
E_{26}	-3.85	$CaSO_4$ Disolved

Table 3.7. The Saturation İndex for pCO_2 and Explanation .

SAMPLE NAME	pCO_2	EXPLANATION
E_1	0.02	$CaCO_3$ Precipitation
E_2	$3.5x10^{-3}$	$CaCO_3$ Precipitation
E_3	0.03	$CaCO_3$ Precipitation
E_4	$9.36x10^{-3}$	$CaCO_3$ Precipitation
E_5	0.02	$CaCO_3$ Precipitation
E_6	0.01	$CaCO_3$ Precipitation
E_7	0.03	$CaCO_3$ Precipitation
E_8	0.03	$CaCO_3$ Precipitation
E_9	0.02	$CaCO_3$ Precipitation
E_{10}	0.01	$CaCO_3$ Precipitation
E_{11}	0.02	$CaCO_3$ Precipitation
E_{12}	$6.04x10^{-4}$	$CaCO_3$ Precipitation
E_{13}	$5.94x10^{-3}$	$CaCO_3$ Precipitation
E_{14}	$4.81x10^{-3}$	$CaCO_3$ Precipitation
E_{15}	0.03	$CaCO_3$ Precipitation
E_{16}	0.06	$CaCO_3$ Precipitation
E_{17}	0.06	$CaCO_3$ Precipitation
E_{18}	0.04	$CaCO_3$ Precipitation
E_{19}	0.04	$CaCO_3$ Precipitation
E_{20}	0.03	$CaCO_3$ Precipitation
E_{21}	0.01	$CaCO_3$ Precipitation
E_{22}	0.02	$CaCO_3$ Precipitation
E_{23}	0.03	$CaCO_3$ Precipitation
E_{24}	$9.04x10^{-3}$	$CaCO_3$ Precipitation
E_{25}	0.02	$CaCO_3$ Precipitation
E_{26}	$7.46x10^{-3}$	$CaCO_3$ Precipitation

3.3. CHEMICAL CLASSIFICATION OF WATER

There are many different classifications. In this study, water is classified according to total dissolved solids, according to Piper and according to Schoeller are considered.

3.3.1. Classification According to Total Dissolved Solids

Underground water according to the total quantity of dissolved ions in the water can be simply classified as follows (Table 3.8).

Table 3.8. Total Dissolved Solids

Water Quality	Total dissolved ions in the water
Fresh Water	**0-1000**
salt water	**1000 - 100000**
Salt Water	**10000 - 100000**
Very Salt Water	**> 100000**

3.3.2. Classification According to Schoeller

Schoeller classifies water with relation to the quantities of chloride, sulphate and carbonate, to the exchange between ion base and concentration of anions and cations. Water in the study area is classified with relation to chloride, sulphate and carbonate - bicarbonate concentrations.

3.3.2.1. Chlorides Concentration

a. Water With Hypochlorides : Water with chloride concentration ranging from 700 meq/l to saturation

b. Chloro Talasic Water : Water with chloride concentration ranging from 420 to 700 meq/l

c. Chloride - rich Water : Water with chloride concentration ranging from 140 to 420 meq/l

d. Medium Chloride Water : Water with chloride concentration ranging from 40 to 140 meq/l Water that is suitable for drinking contains 40 meq/l.

e. Water With Olgo Chloride Water : With chloride concentration ranging from 15 to 40 meq/l

f. Water With Chloride At Ordinary Levels : Water with chloride concentration less than 15 meq/l. Underground water contains chloride less than 10 meq/l. Changes in the chloride concentration level at water points in the study area are given in Table3.9.

3.3.2.II. Sulfate Concentration

a. Hiposulfate Water : Sulfate amount are more than 58 meq/l. The average sulfate amount is found 58 meq/l in the sea water.

b. Sulfate Water : Sulfate amount is between 24 to 58 meq/l in the drinking water for upper level is 24 meq/l

c. Oligosulfate Water : The mount of sulfate changes between 6 - 24 meq/l .

d. Natural Sulfate Water : The mount of sulfate are less then 6 meq/l sulfate concentration in the study area given in Table 3.10

3.3.2.III. Carbonate and Bicarbonate Concentration

a. Hiper Carbonate Water : $HCO3 + CO3 > 5$ meq/l

b. Natural Carbonate Water: $HCO3 + CO3$ around 2 - 7 meq/l

Table 3.9. Chlorides Concentration.

SAMPLE NAME	Cl meg/l	EXPLANATION
E_1	4.93	Natural Chloride Water
E_2	83.17	Medium Chloride Water
E_3	8.60	Natural Chloride Water
E_4	212.86	Chloride-rich Water
E_5	24.95	Olgo Chloride Water
E_6	4.76	Natural Chloride Water
E_7	0.73	Natural Chloride Water
E_8	0.82	Natural Chloride Water
E_9	0.62	Natural Chloride Water
E_{10}	0.82	Natural Chloride Water
E_{11}	1.13	Natural Chloride Water
E_{12}	0.68	Natural Chloride Water
E_{13}	0.99	Natural Chloride Water
E_{14}	62.02	Medium Chloride Water
E_{15}	6.48	Natural Chloride Water
E_{16}	9.16	Natural Chloride Water
E_{17}	19.73	Olgo Chloride Water
E_{18}	3.58	Natural Chloride Water
E_{19}	15.37	Olgo Chloride Water
E_{20}	17.96	Olgo Chloride Water
E_{21}	6.91	Natural Chloride Water
E_{22}	8.37	Natural Chloride Water
E_{23}	2.76	Natural Chloride Water
E_{24}	4.71	Natural Chloride Water
E_{25}	25.46	Olgo Chloride Water
E_{26}	6.06	Natural Chloride Water

Table 3.10. Sulfate Concentration.

SAMPLE NAME	SO_4 meg/l	EXPLANATION
E_1	2.83	Natural Sulfate Water
E_2	10.76	Oligo Sulfate Water
E_3	3.16	Natural Sulfate Water
E_4	21.32	Oligo Sulfate Water
E_5	4.27	Natural Sulfate Water
E_6	2.31	Natural Sulfate Water
E_7	3.44	Natural Sulfate Water
E_8	1.83	Natural Sulfate Water
E_9	1.98	Natural Sulfate Water
E_{10}	1.83	Natural Sulfate Water
E_{11}	1.17	Natural Sulfate Water
E_{12}	3.10	Natural Sulfate Water
E_{13}	1.48	Natural Sulfate Water
E_{14}	7.47	Oligo Sulfate Water
E_{15}	4.85	Natural Sulfate Water
E_{16}	1.60	Natural Sulfate Water
E_{17}	3.14	Natural Sulfate Water
E_{18}	0.27	Natural Sulfate Water
E_{19}	1.60	Natural Sulfate Water
E_{20}	1.35	Natural Sulfate Water
E_{21}	1.00	Natural Sulfate Water
E_{22}	1.06	Natural Sulfate Water
E_{23}	0.87	Natural Sulfate Water
E_{24}	0.62	Natural Sulfate Water
E_{25}	2.56	Natural Sulfate Water
E_{26}	0.92	Natural Sulfate Water

c. Hipo Carbonate Water : $HCO3 + CO3 < 2$ meq/l

Carbonate and bicarbonate concentration in the study area given in Table 3.11.

Schoeller suggests a semilogarithmic diagram which vertical axis showing rCa is logarithmic and horizontal axis showing rMg is arithmetic scaled. Each ion values in (meq/l) are plotted on logarithmic vertical axis and they are connected.This chemical properties of water are defined with broken lines. Different water can be recognized at first sight in semilog diagram (Figure 3.5).

Another diagram by schoeller is related with potable water.From this diagram one learns about quality and drinkability of water by considering electrical conductivity, Na, Cl, SO_4 values and hardnes. Water in the study area are classified according to Schoeller drinkability diagram in Table 3.12 and (Figure 3.6).

Table 3.11. Carbonate and Bicarbonate Concentration .

SAMPLE NAME	HCO_3+CO_3	EXPLANATION
E_1	6.20	Natural Carbonate Water
E_2	4.61	Natural Carbonate Water
E_3	5.39	Natural Carbonate Water
E_4	4.80	Natural Carbonate Water
E_5	5.39	Natural Carbonate Water
E_6	6.41	Natural Carbonate Water
E_7	1.39	Hipo Carbonate Water
E_8	7.00	Natural Carbonate Water
E_9	8.00	Hiper Carbonate Water
E_{10}	7.80	Hiper Carbonate Water
E_{11}	6.80	Natural Carbonate Water
E_{12}	1.20	Hipo Carbonate Water
E_{13}	4.20	Natural Carbonate Water
E_{14}	5.61	Natural Carbonate Water
E_{15}	4.61	Natural Carbonate Water
E_{16}	6.20	Natural Carbonate Water
E_{17}	6.00	Natural Carbonate Water
E_{18}	6.80	Natural Carbonate Water
E_{19}	6.20	Natural Carbonate Water
E_{20}	5.61	Natural Carbonate Water
E_{21}	6.61	Natural Carbonate Water
E_{22}	5.39	Natural Carbonate Water
E_{23}	8.41	Hiper Carbonate Water
E_{24}	4.00	Natural Carbonate Water
E_{25}	6.20	Natural Carbonate Water
E_{26}	5.20	Natural Carbonate Water

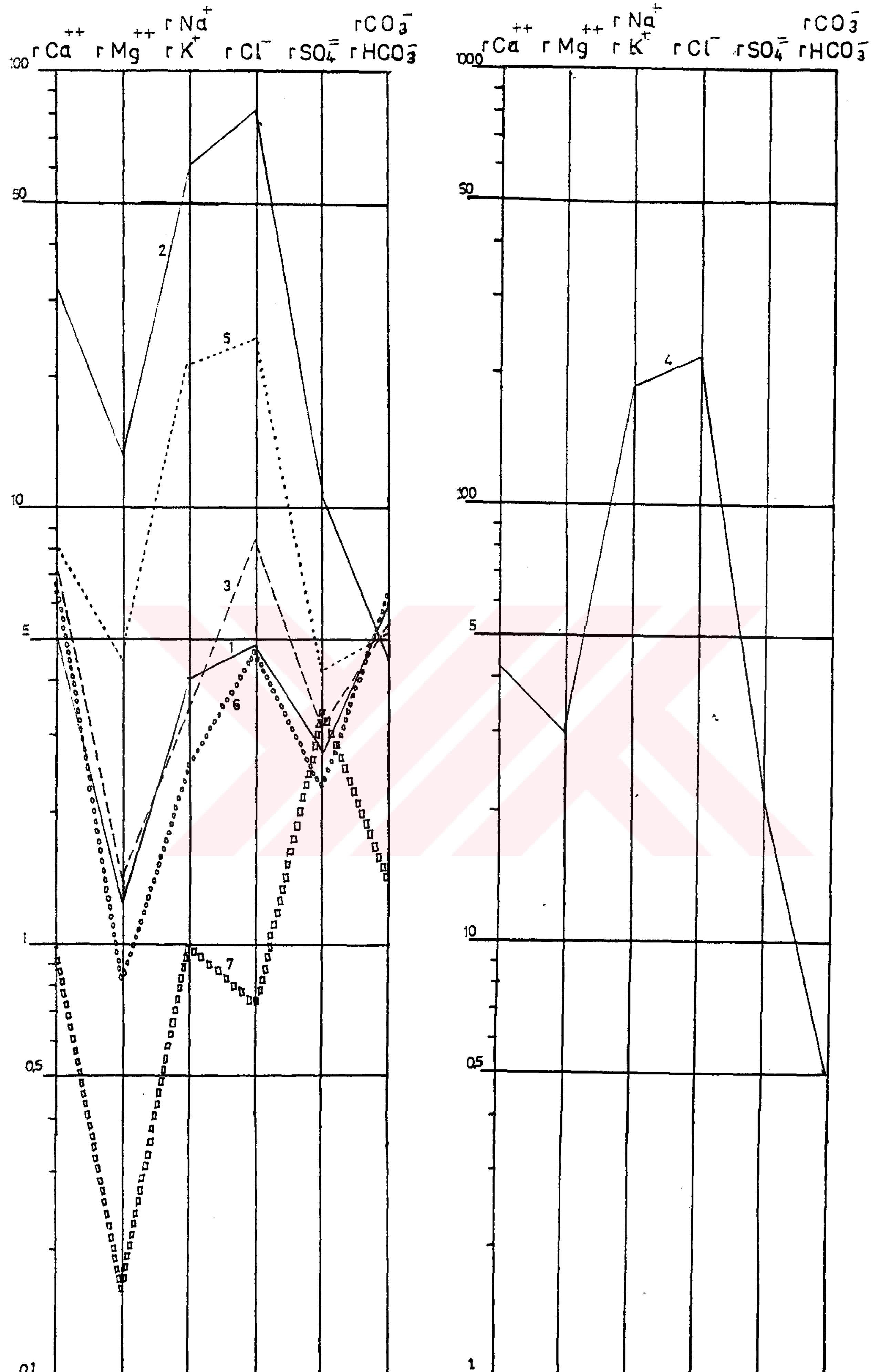


Figure 3.5.(a) Chemical Analyses of Water Shown on a Schoeller Semilogarithmic Diagram.

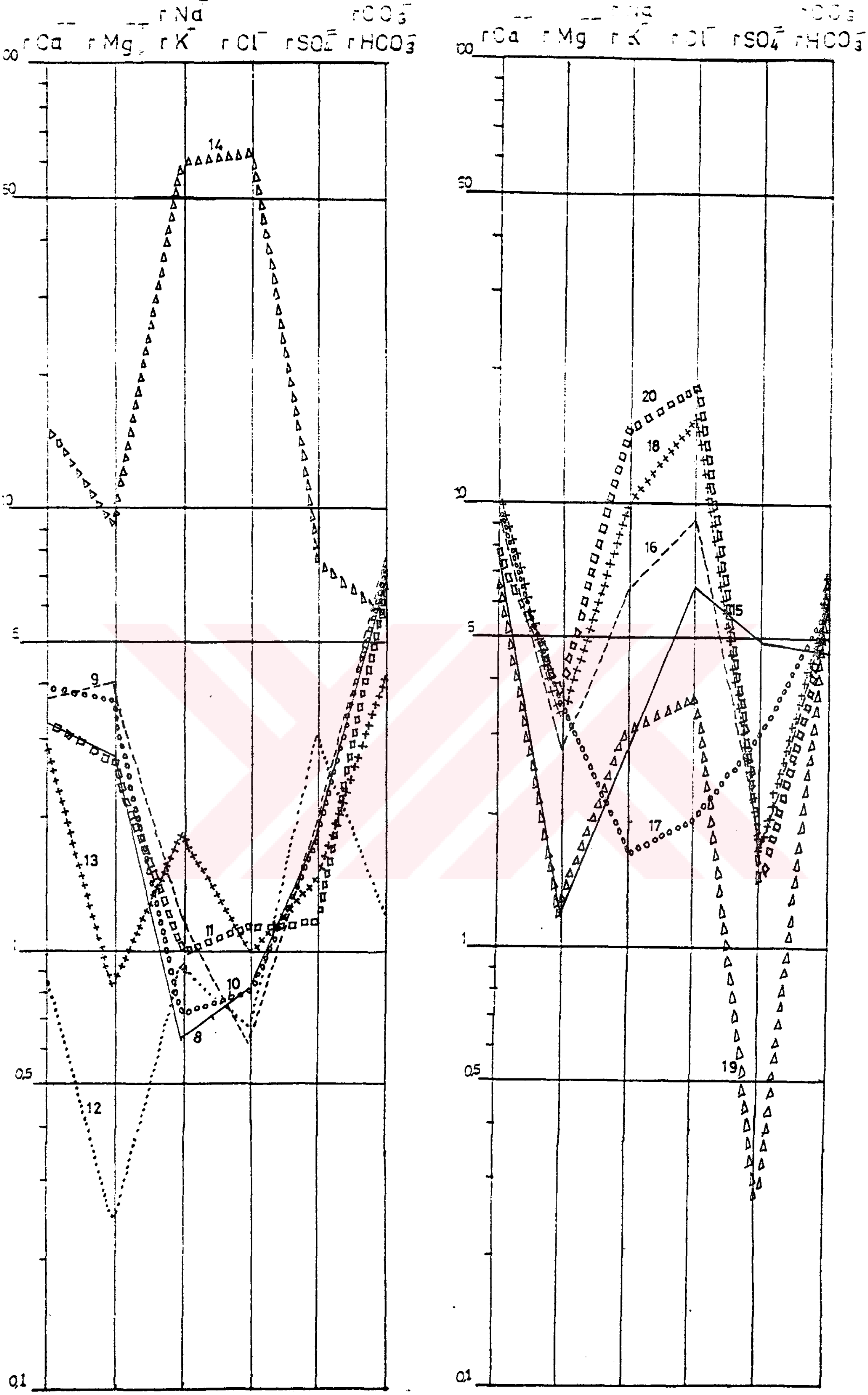


Figure 3.5.(b) Chemical Analyses of Water Shown on a Schoeller Semilogarithmic Diagram

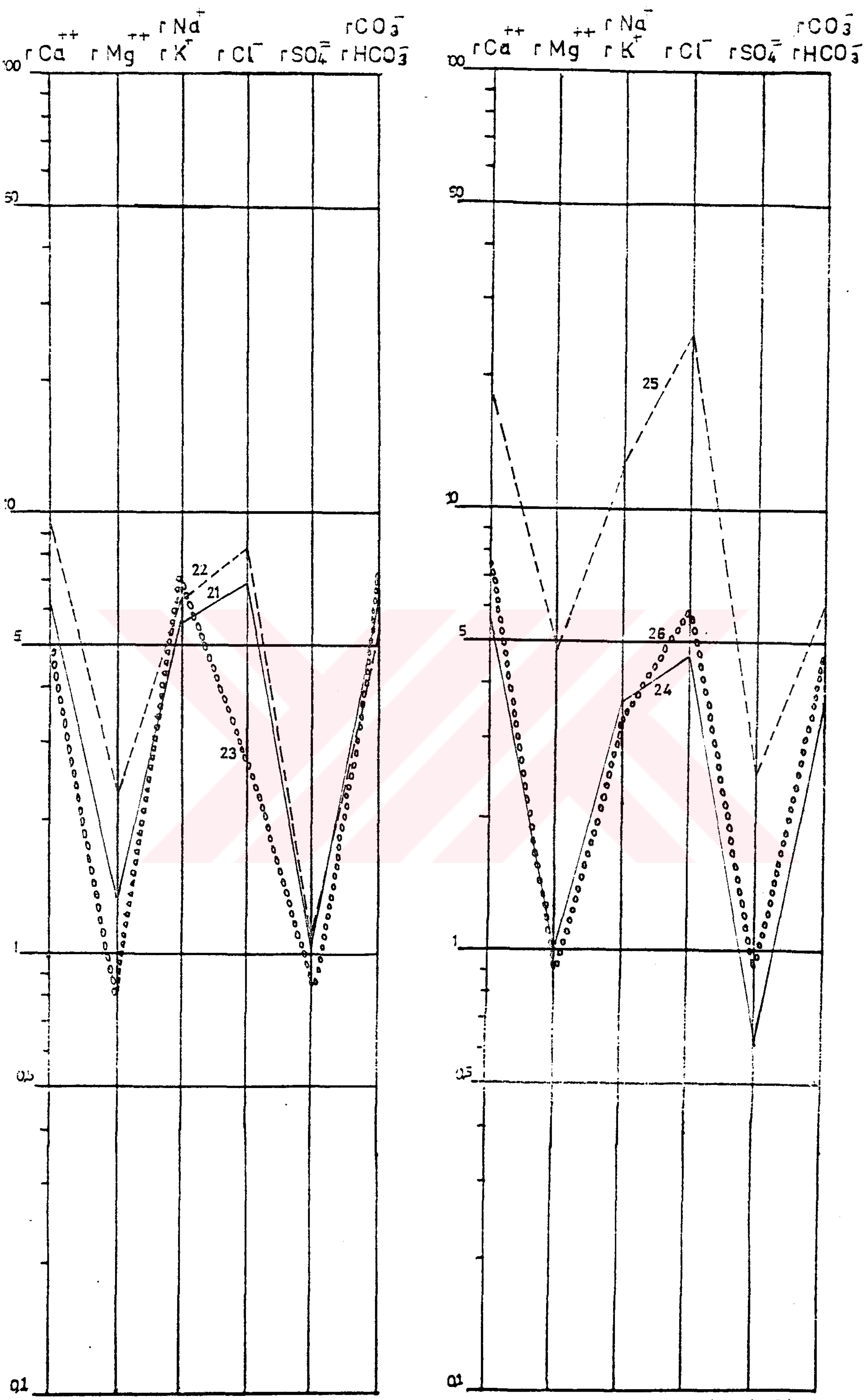


Figure 3.5.(c) Chemical Analyses of Water Shown on a Schoeller Semilogarithmic Diagram

Table 3.12. In Study Area According to Water Analyses Result Drinkable .

WATER NAME	EC mmho/cm	Fr	Na mg/l	Cl mg/l	SO_4 mg/l	EXP.
E_1	2490	34.02	91	175	136	Bad Quality
E_2	15150	236.01	1407	2950	517	Non Drinkable
E_3	3080	47.66	72	305	152	Bad Quality
E_4	34900	370.79	4134	7550	1024	Non Drinkable
E_5	5490	64.69	475	885	205	Non Drinkable Unless It's Necessity
E_6	1936	40.79	59	169	111	Middle Quality
E_7	443	5.81	17	26	165	Very Good Quality
E_8	1243	30.70	14	29	38	Middle Quality
E_9	1539	38.61	26	22	95	Middle Quality
E_{10}	1437	38.46	16	29	38	Middle Quality
E_{11}	1259	30.54	22	40	56	Middle Quality
E_{12}	411	5.97	19	24	149	Very Good Quality
E_{13}	1157	19.83	41	35	71	Middle Quality
E_{14}	11280	124.15	1338	2200	359	Non Drinkable
E_{15}	2140	44.59	62	230	233	Bad Quality
E_{16}	3130	59.23	122	325	77	Bad Quality
E_{17}	4670	64.43	361	700	151	Non Drinkable Unless It's Necessity
E_{18}	1940	38.69	69	127	13	Middle Quality
E_{19}	3730	67.27	226	545	77	Bad Quality
E_{20}	4160	58.01	323	637	65	Non Drinkable Unless It's Necessity
E_{21}	2260	38.69	126	245	48	Bad Quality
E_{22}	2540	64.66	141	297	51	Bad Quality
E_{23}	2030	29.31	136	98	42	Bad Quality
E_{24}	1700	32.38	82	167	30	Middle Quality
E_{25}	5530	112.92	297	903	123	Non Drinkable Unless It's Necessity
E_{26}	2160	43.69	75	215	44	Bad Quality

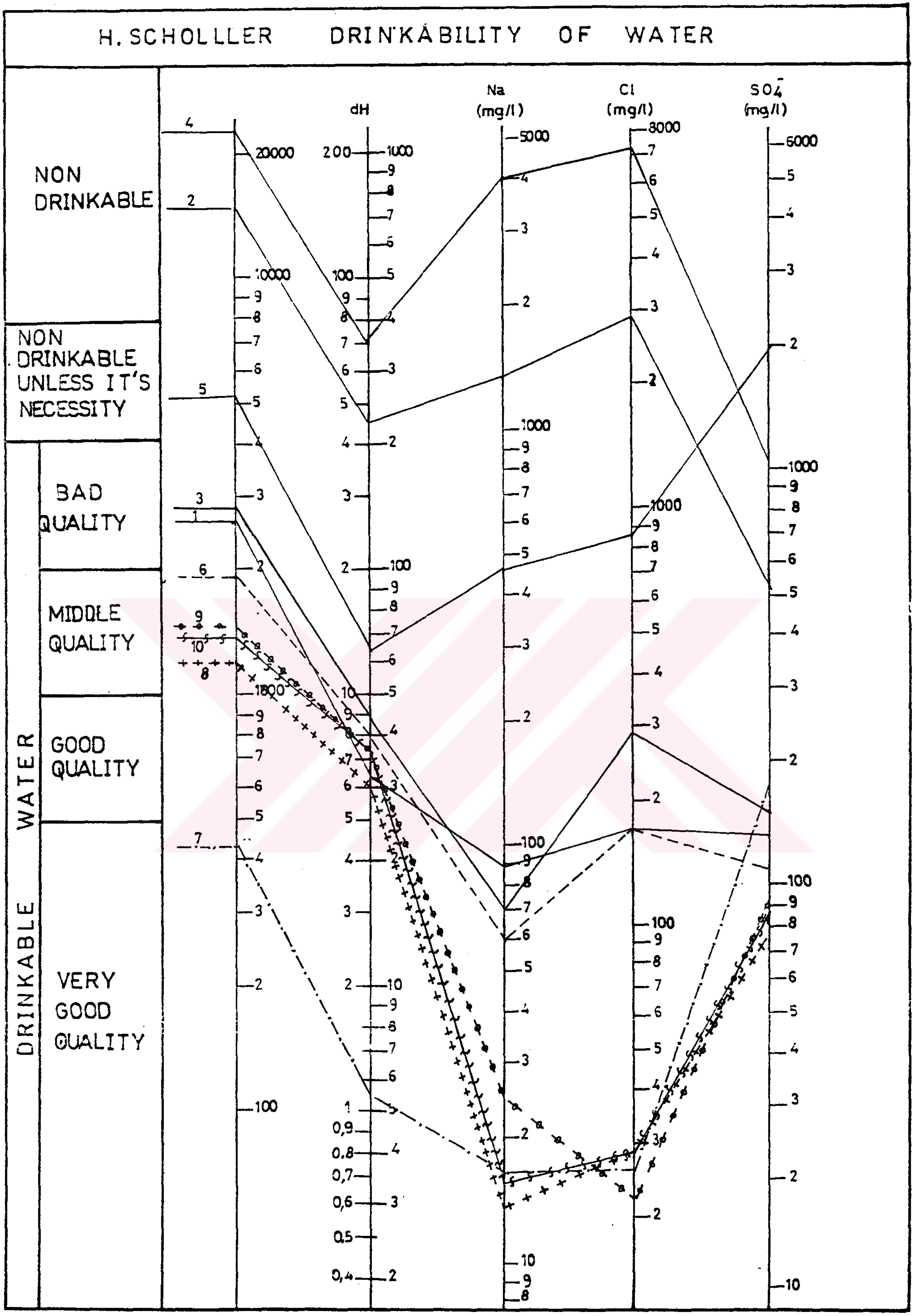


Figure 3.6.(a) Chemical Analyses of drinking water Shown on Schoeller diagram

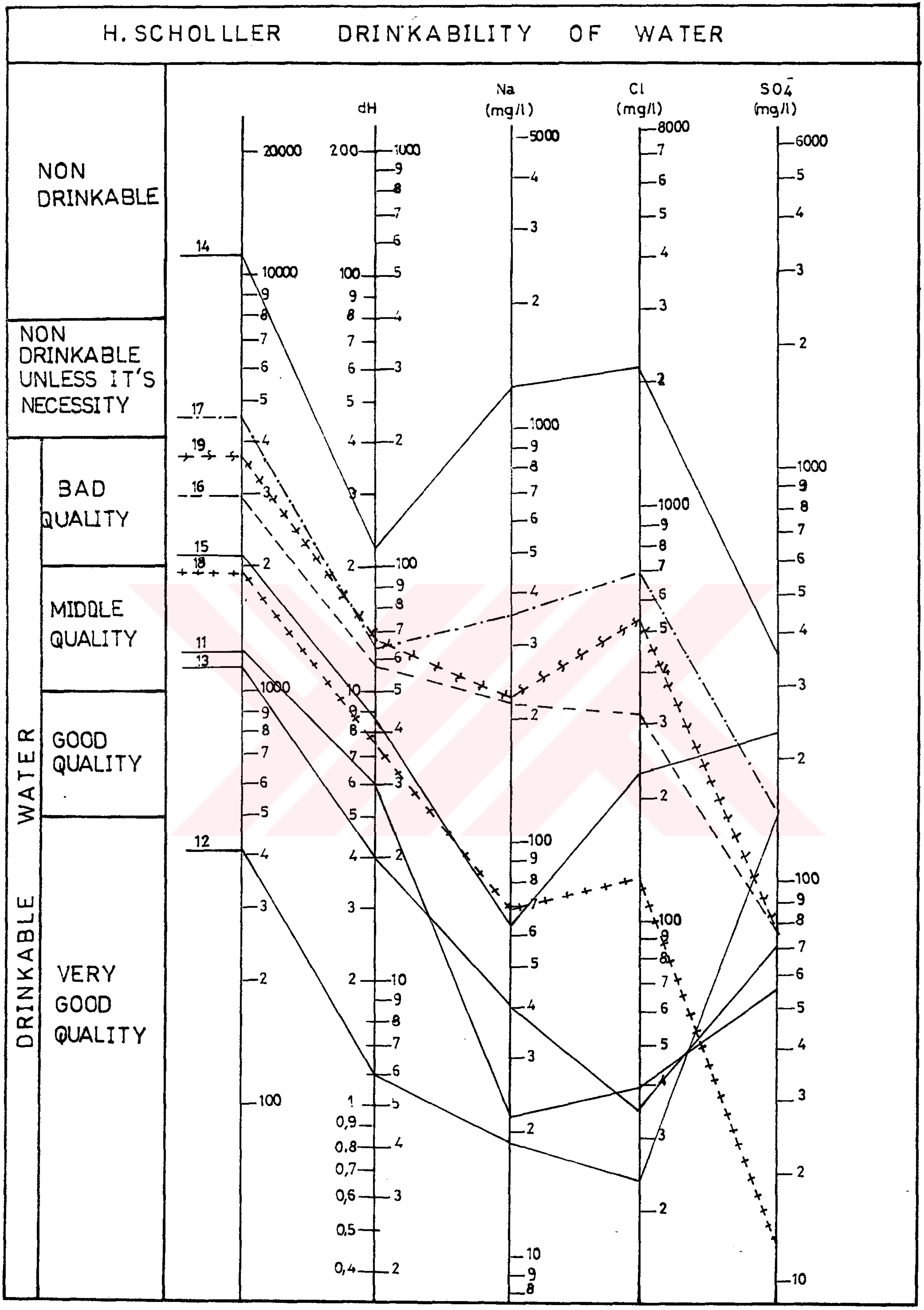


Figure 3.6.(b) Chemical Analyses of drinking water Shown on Schoeller diagram

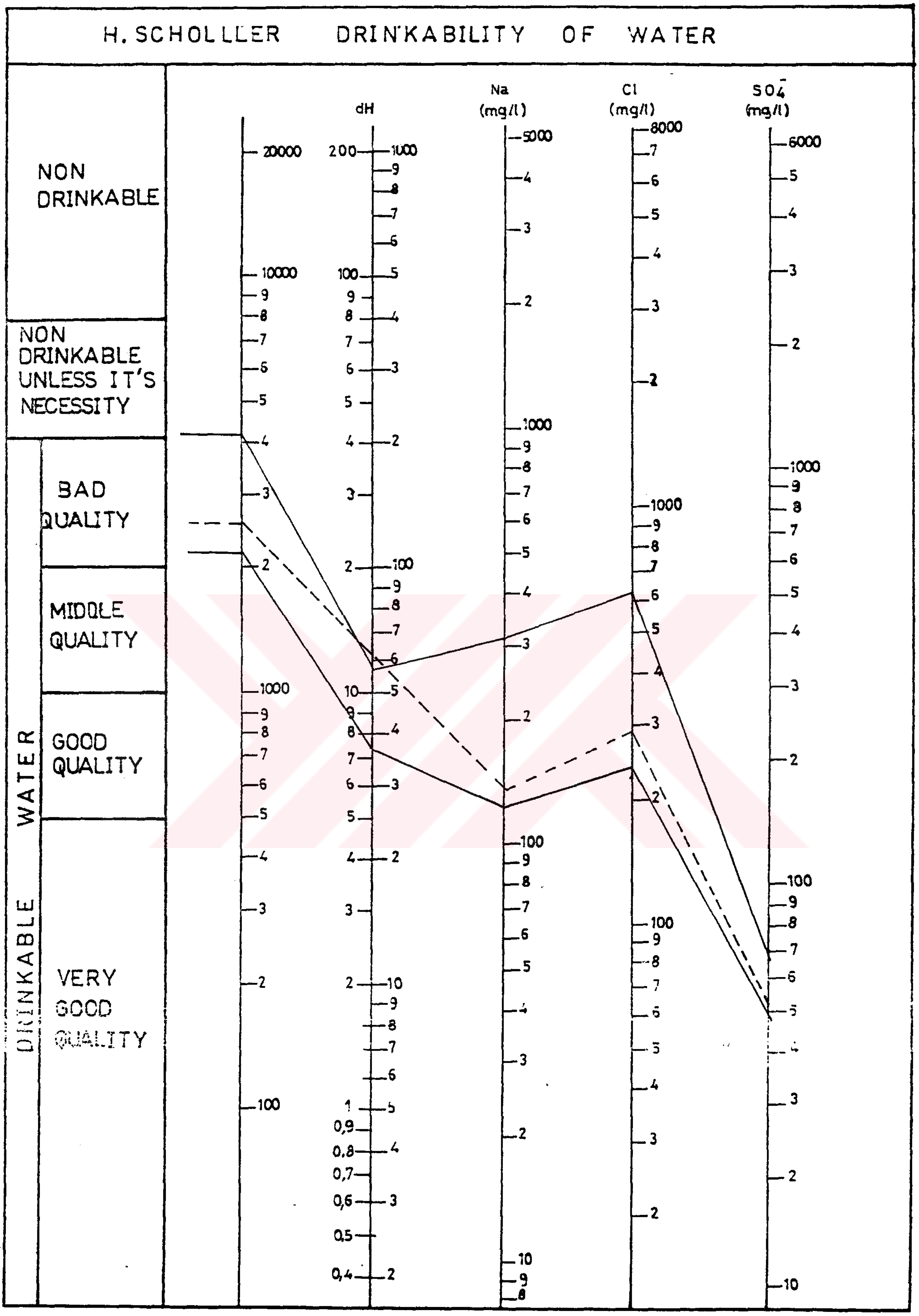


Figure 3.6.(c) Chemical Analyses of drinking water Shown on Schoeller diagram

3.3.3. Classification According to Piper

According to Piper. classification of water is done on triple diagram. According to this classification it is possible to determine chemical properties of anions and cations at each triangle (Figure 3.7), (Şahinci 1986).

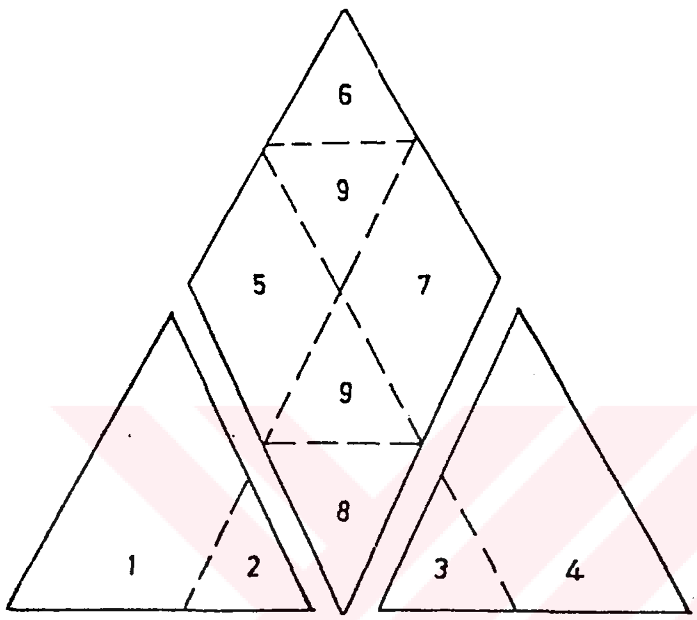


Figure 3.7. According to piper triangle position

No 1 Area : (Ca + Mg) > (Na + K)

No 2 Area : (Ca + Mg) < (Na + K)

No 3 Area : (CO_3 + KO_3) > (Cl + SO_4)

No 4 Area : (CO_3 + KO_3) < (Cl + SO_4)

No 5 Area : Water with carbonate hardnes more than 50%

No 6 Area: Water with hardness more than 50% but without carbonates.

No7 Area: Water with alkalinity more than 50% and without carbonates, NaCL, KCl, Na_2SO_4, alkalis and strong acids are dominant .Bitter water and sea water are in this area.

No 8 Area: Water with carbonate alkalis more than 50%. Soft water which is rare in nature is included in this area.

No 9 Area: Mixed water with any of ions less than 50%

Some water points in the study area are given in Figure 3.8, Table 3.13

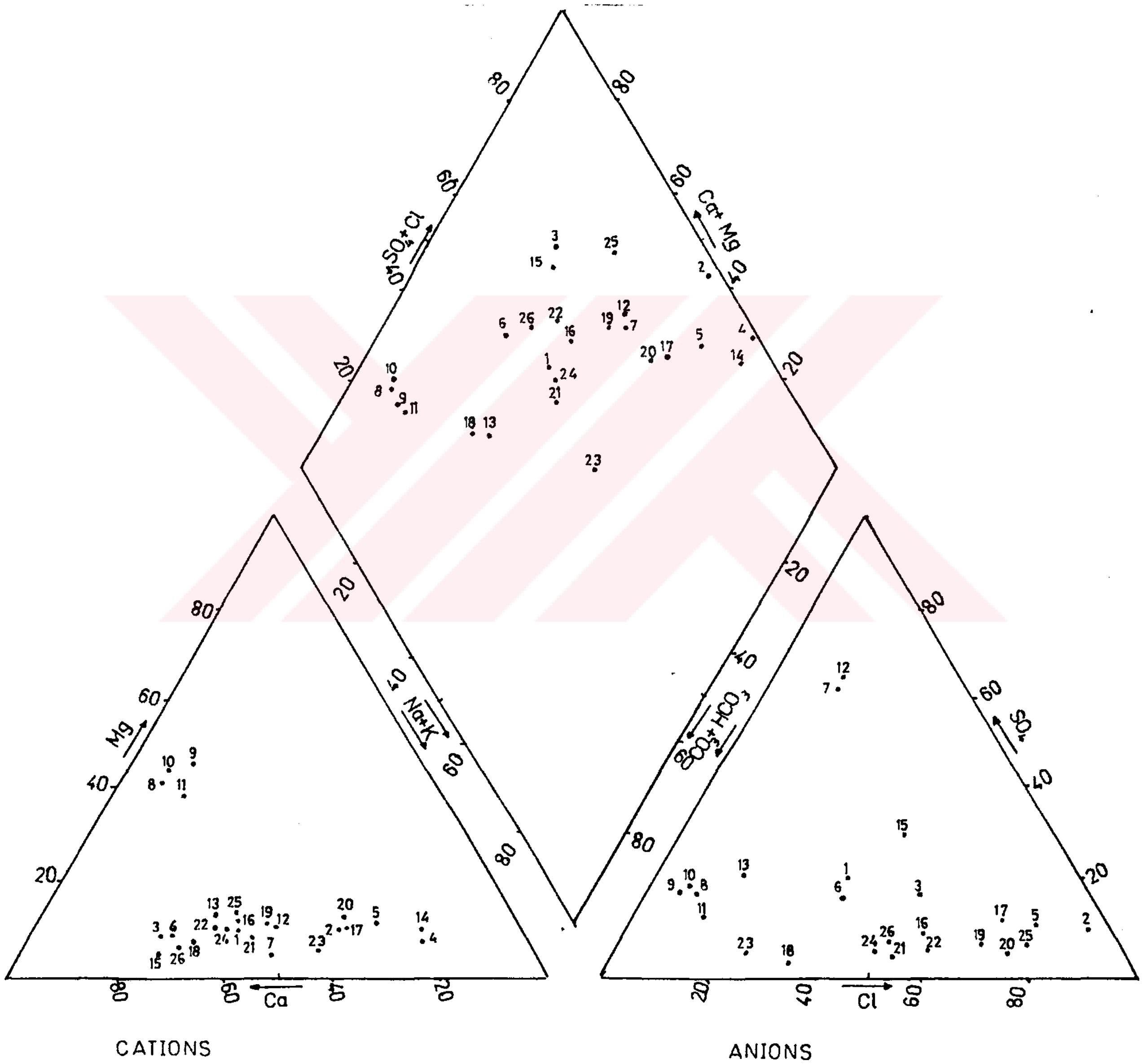


Figure 3.8. Trilinear diagram for representing chemical analyses and water types of water reference points in the study area

Table 3.13. Study area water triangle diagram position

SAMPLE NAME	AREA	AREA	AREA
E_1	9	1	4
E_2	7	2	4
E_3	9	1	4
E_4	7	2	4
E_5	7	2	4
E_6	9	1	4
E_7	9	1	4
E_8	5	1	3
E_9	5	1	3
E_{10}	5	1	3
E_{11}	5	1	3
E_{12}	9	1	4
E_{13}	5	1	3
E_{14}	7	2	4
E_{15}	9	1	4
E_{16}	9	1	4
E_{17}	7	2	4
E_{18}	5	1	3
E_{19}	9	1	4
E_{20}	7	2	4
E_{21}	9	1	4
E_{22}	9	1	4
E_{23}	7	2	3
E_{24}	9	1	4
E_{25}	9	1	4
E_{26}	9	1	4

3.3.4. Determination of Mixing Ratio of Waters

Mixing ratio of waters can be determined by mathematically and graphically. Ratios can be found from simple relations below.

$V_1 = V_3(C_2 - C_3) / (C_2 - C_1)$	V_1= Volume of first water in mixture
$V_2 = V_3(C_3 - C_1) / (C_2 - C_1)$	V_2=Volume of second water in mixture
$V_3 = V_1.C_1 + V_2.C_2 / C_3$	V_3=Volume of mixed water
	C_1=Totalion concentration of first water
	C_2=Total ion concentration of second water
	C_3=Total ion concentration of mixed water

It is possible to take any ion concentration (chloride) instead of total ion concentration of water (c) if mixed water volume is assumed one liter, V3= 1.With a simple graph, mixing ratio of waters can be found easily without any need for calculations (Figure 3.9).Vertical axis shows concentration of waters which are added to the mixture and horizontal axis defines mixing ratio of two waters in percent ion concentration of mixture is found on vertical axis and a parallel to horizontal axis is drawn. From the intersection point of line connecting concentrations of two waters, a perpendicular is drawn to the horizontal axis and mixing ratio of two water in percent can be found.

Water Point	**Total Ion Amount**
E_2 Altmış evler sitesi sondaj :	207.63
E_4 Çayaltı Dere	495.95
E_5 Ildırı Sondaj	68.57
E_{13} Camiboğazı Dere	159.06
E_{20} Ildırı Kaynak Çıkış	50.96

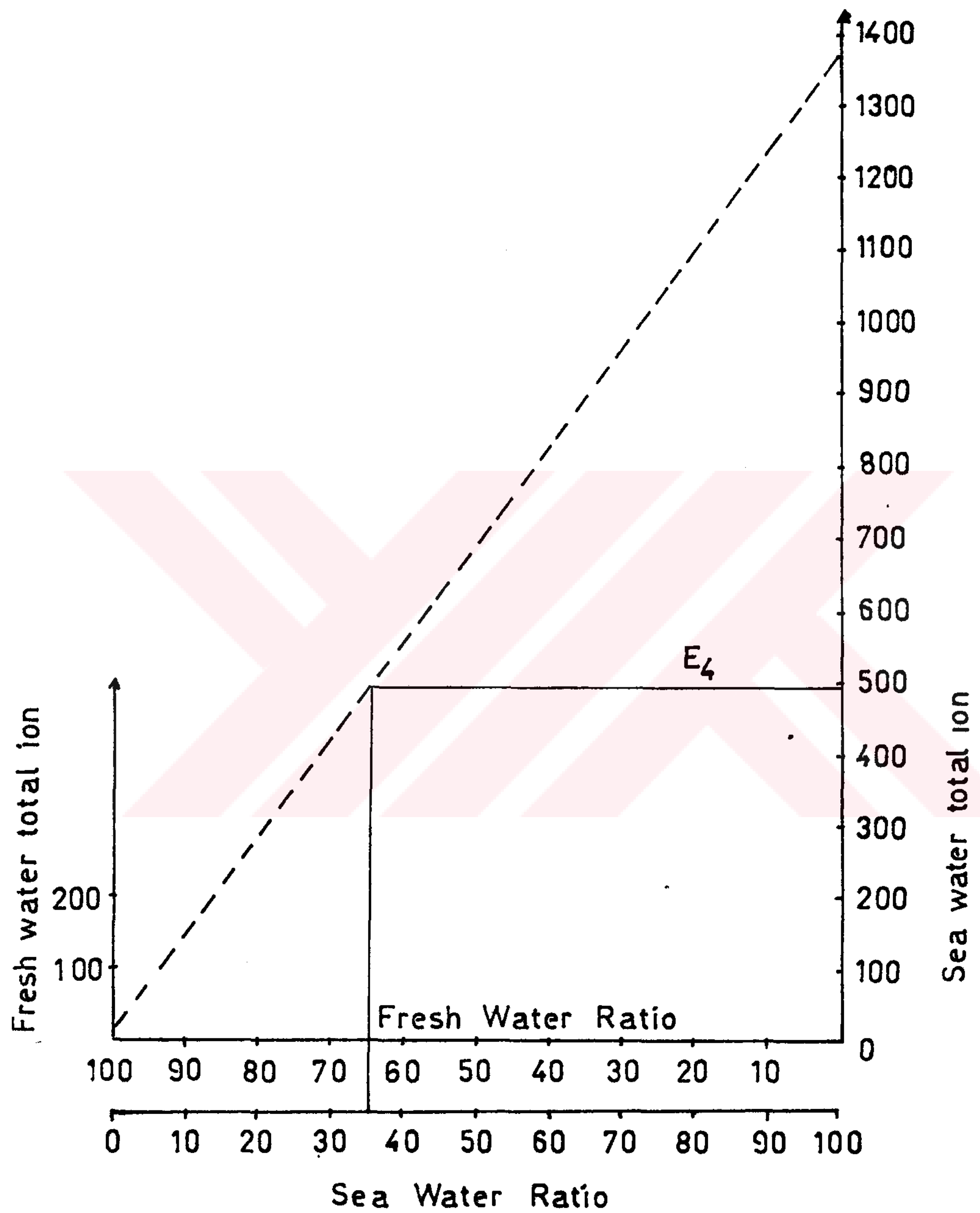


Figure 3.9. Ildırı springs fresh water - sea water mixing ratio graphically method soiling

Water point	Sea water ratio	Fresh water ratio
E_2	86	14
E_4	64	36
E_5	4	96
E_{13}	11	89
E_{19}	98	2
E_{20}	3	97

3.4. USE PROPERTIES OF WATER

There are many uses of water in different fields .These fields depend on physical and chemical properties of water.In this study, irrigation and potability of water, utilizability of water in some industrial fields are investigated.

3.4.1. Drinking Properties of Water

Determination of drinking properties of water depends on climate conditions and geological formations.Generally temperature of drinking water should be between 7 and 10 C. 5 C is minimaly and 18 C maximally can be accepted. Potable water should be colorless and odorless. It should not include any bacteria causing any illnes . Electrical conductivity should not pass 2200 micromho/cm, total hardness (Fr). should not exceed 45, evaporation residue should be maximum 1500 mg/l and chloride content shoul be 750 mg/l as the upper limit. In a good drinking water, total ion concentration is not allowed to exceed 7.5 meq/l, water with total ions more then 15 meq/l can be drank only under indispensable conditions.Irrigation and drinking water has pH between 7.5 and 8. It should not contain any abrasive, decaying or crusty material. A diagram suggested by schoeller is widespread showing dirinkability of water according to electrical conductivity, hardnees (Fr) and Na, Cl, SO_4 contents.

3.4. 2. Irrigation Properties of Water

If the ion content of water is great, this affects to the plants and agricultural soil by physical and chemical means and decreases the yield. Physical effect of these ions is to prevent accessibility of water in to leaves and branches by decreasing osmotic pressure in the cells of plant structure. By chemical effect, the metabolism of plant is damaged. Sodium in salted water substitutes with calcium ions which causes decreasing of earation and permeability of soil. Consequently plant development slows down. As resistances of plants to the salts in the water changes from one plant to another it is hard to give absolite upper limit of salt concentration for the irrigation water. Besides the relation of water quality with plant development, soil draining is an important factor. If permeability is high and draining is good, plant development can not prevented even if the water is salty. Conversely, with the soil that have poor draining and permeability. Plant development becomes harder by forming salt deposits on plant roots even if the water is less salty. So plant development is effected by type of soil, permeability of soil, draining of soil, climate conditions, quantity of water used, plant type, irrigation methods as well as water quality, too.

In order to determine chemical properties of irrigation water, several classifications are suggested. In this study, these classifications are applied.

3.4.2.1. Sodium Hazard (Sodium Adsorption Ratio = SAR)

Sodium amount are important in the irregation water. It spoil the soil structure and reduce it is permeability. If the irrigation water has high amount of sodiumwhich causes an impermeable zone in the upper level of soil. So the plants can not be ventilated and caused a posion condition.

The sodium ratio are calculated as below (Şahinci 1986).

$$\%Na = [\,100\,(Na + K) / (Na + K + Mg + Ca)]$$

Sadium Adsorption Ratio (SAR) = **[Na / Ca + Mg]**

According to SAR classification of water in Table 3.14

Table 3.14. SAR Classification (Şahinci, 1986)

% SAR	PROPERTIES WATER
<10	Very good quality properties water
10 - 18	Good quality water
18 - 26	Medium quality water
>26	Not good quality water

Water in the study area can be listed as follows according toSAR(Table 3.15).

Table 3.15. SAR Value in the Study Area.

SAMPLE NAME	SAR	WATER QUALİTY
E_1	2.15	Very good quality properties water
E_2	12.60	Good quality water
E_3	1.43	Very good quality properties water
E_4	29.53	Not good quality water
E_5	8.12	Very good quality properties water
E_6	1.27	Very good quality properties water
E_7	0.97	Very good quality properties water
E_8	0.35	Very good quality properties water
E_9	0.58	Very good quality properties water
E_{10}	0.35	Very good quality properties water
E_{11}	0.55	Very good quality properties water
E_{12}	1.07	Very good quality properties water
E_{13}	1.27	Very good quality properties water
E_{14}	16.52	Good quality water
E_{15}	1.28	Very good quality properties water
E_{16}	2.18	Very good quality properties water
E_{17}	6.19	Very good quality properties water
E_{18}	1.53	Very good quality properties water
E_{19}	3.79	Very good quality properties water
E_{20}	-5.83	Very good quality properties water
E_{21}	2.79	Very good quality properties water
E_{22}	2.41	Very good quality properties water
E_{23}	3.46	Very good quality properties water
E_{24}	1.98	Very good quality properties water
E_{25}	3.84	Very good quality properties water
E_{26}	1.56	Very good quality properties water

3.4.2.2. Classification of Irrigation Water According to Wilcox

Wilcox classifies irrigation water according to their sensitivities to sodium, chloride, sulfate, electrical condictivity and bor percentages. In this study bor is not determined at chemical analysis, bor risk is not mentioned. With exception of bor in water, wilcox classification is as follows Table 3.16

Wilcox developed a diagram for using water in irrigation purpose by considering Na % on vertical axis and electrical conductivity on horizontal axis (Figure 3.10). For a given electrical conductivity a perpendicular is drawn from the point found on horizontal axis parallel to vertical axis, where it intersects line parallel to horizontal axis from Na % value gives characteristics of water. We can interpret water in the study area according to Wilcox diagram as follows (Table 3.17).

Table 3.16. Willcox classification of water

Water Type	% Na	rCl	rSO_4	EC (mmho/cm)
Very well	<20	<4	<4	<250
well	20-40	4-7	4-7	250-750
Permissible	40-60	7-12	7-12	750-2000
Douptfull	60-80	12-20	12-20	2000-3000
Impermissible	>80	>20	>20	>3000

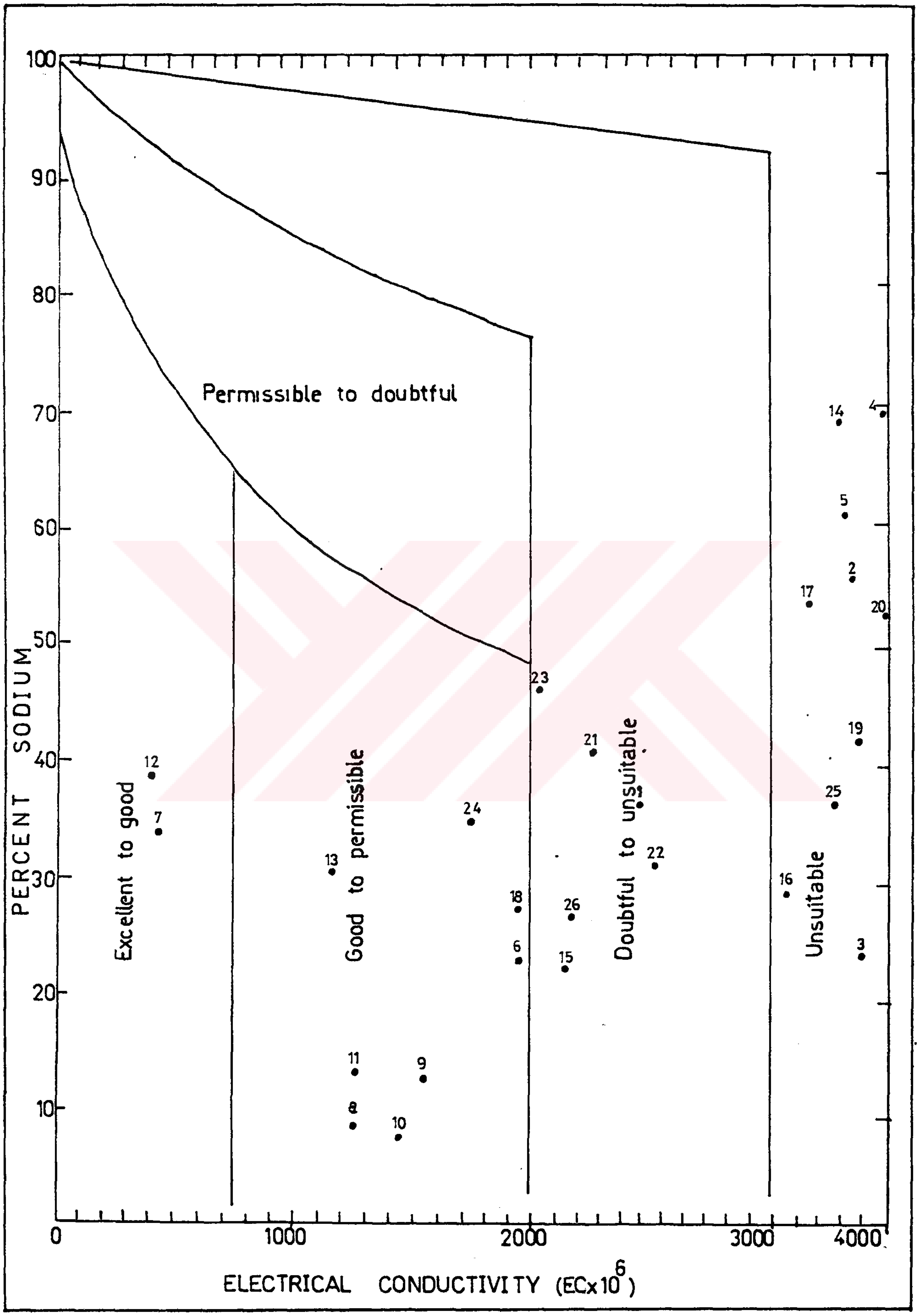


Figure 3.10. Chemical analyses of water shown in willcox diagram

Table 3.17. Wilcox classification in the study area

SAMPLE NAME	%Na	rCl^-	rSO_4	EC	EXPLANATION
E_1	36.17	4.93	2.83	2490	Doubtful unsuitable
E_2	56.10	83.17	10.76	15150	unsuitable
E_3	24.53	8.60	3.16	3080	unsuitable
E_4	69.97	212.8	21.32	34900	unsuitable
E_5	60.84	24.95	4.27	5490	unsuitable
E_6	23.82	4.76	2.31	1936	Good to permissible
E_7	34.26	0.73	3.44	443	Excellent to good
E_8	8.99	0.82	1.83	1243	Good to permissible
E_9	12.70	0.62	13.98	1539	Good to permissible
E_{10}	8.27	0.82	1.83	1437	Good to permissible
E_{11}	13.45	1.13	1.17	1259	Good to permissible
E_{12}	38.91	0.68	3.10	411	Excellent to good
E_{13}	30.61	0.99	1.48	1157	Good to permissible
E_{14}	69.32	62.02	7.47	11280	unsuitable
E_{15}	23.07	6.48	4.85	2140	Doubtful unsuitable
E_{16}	29.11	9.16	1.60	3130	unsuitable
E_{17}	54.10	19.73	3.14	4670	unsuitable
E_{18}	27.68	3.58	0.27	1940	Good to permissible
E_{19}	41.94	15.37	1.60	3730	unsuitable
E_{20}	53.96	17.96	1.35	4160	unsuitable
E_{21}	41.06	6.91	1	2260	Doubtful unsuitable
E_{22}	31.91	8.37	1.06	2540	Doubtful unsuitable
E_{23}	46.67	2.76	0.87	2030	Doubtful unsuitable
E_{24}	35.07	4.71	0.62	1700	Good to permissible
E_{25}	36.20	25.46	2.56	5530	unsuitable
E_{26}	26.61	6.06	0.92	2160	Doubtful unsuitable

3.4.2.3. Classification According to USA Salinity Laboratory Diagram.

This diagram is prepared by changes made on Wilcox diagram and irrigation water is divided into 16 groups. SAR values are located on vertical axis and EC values on horizontal axis. Determination of water classification is as Wilcox diagram (Figure 3.11).

Interpretation of the diagram is as follows :

General Salinity Properties :

C_1 (smaller than EC = 250 mmho / cm) little saline water is suitable for all type of soil plant.

C_2 (EC = 250-750 mmho / cm) medium saline water

C_3 (EC = 750-2250 mmho / cm) saline water

C_4 (EC = 2250 mmho / cm) very saline water

General Sodium Hazard Properties :

S_1 = Little Na Water : It can be used in almost all soilswithout sodium hazard

S_2 =Medium Na water: This type is used especially in soils where salinity is decreased by irrigation

S_3 =High Na water: there may be sodium hazard in many soil types

S_4 = Very High Na waters:Generally it is not suitable for irrigation.If total salt content of water is relatively low,it can be used in irrigation.

Thus C_1S_1,C_2S_1,C_3S_1 can be used in all irrigation;C_4S_1,C_3S_2 can be used in special conditions,C_4S_2 and C_4S_3 should never be used at all.

Water in the study area can be listed as follows according to USA Salinitiy Diagram (Table 3.18).

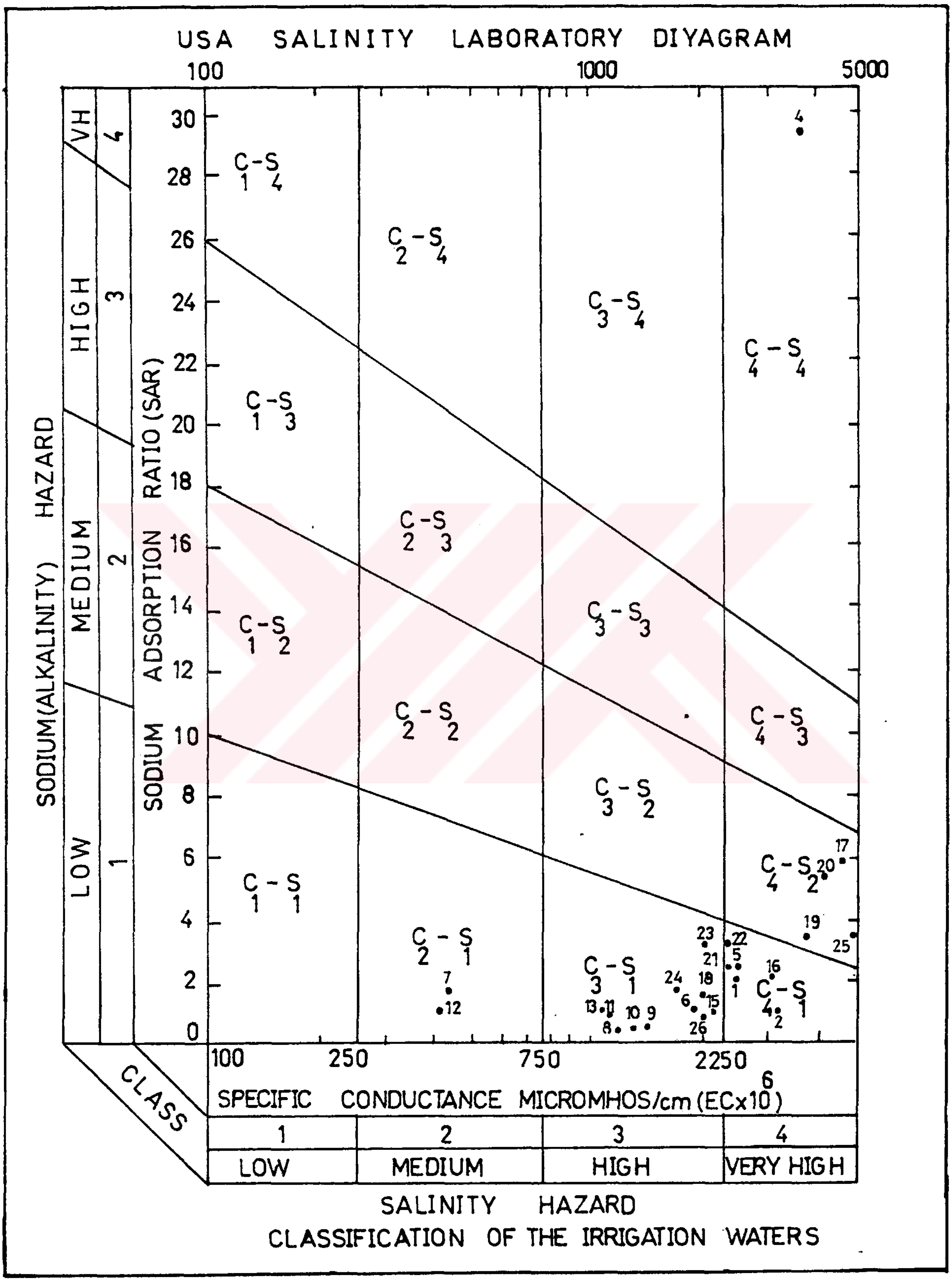


Figure 3.11. USA Salinity Hazard Diagram

3.4.3. The Properties of Industrial Water

The properties of industrial water changes according to the utilization purpose. Water utilized in steam boiler is important by its foaming property. The reason for foaming is collecting of some foams on water surface during boiling. This is cause of formation of sodium and potassium salts rich film layer when the water is boiling. Foaming of water during boiling (F) is classified according to the relation as follows

$$\mathbf{F = 62r\,Na + 78r\,K}$$

Foaming of water from this relation can be classified as follows

$F < 60$: While boiling was not froth water

$60 < F < 200$: While boiling are froth water

$F > 200$: While boiling are very froth water

Foaming properties of water in the study area are given in Table 3.19.

3.5. WATER SPOTS

3.5.1. Streams

In the study area, there is no regularly flowing stream. Merely there are many brooks showing flow only on rainy seasons (Appendix II).

Ildırı spring run down to the sea by Camiboğazı brook from the spot it is originated. For this reason, Camiboğazı brook has a regular flow.

3.5.1.1. Halkapınar Spring

From the poljes and dolines at west and southwest of Kadıovacık and at northwest of Nohutalan, it flows at first vertically:then with stages under control of litologic and structural properties it passes through Domuzçukuru and Zẹtincik poljes, finally arriving to the sea both from bottom and from the surface. It falls into the sea directly from limestones and it is docked 20 meters away from the the sea with aged cut stones. Average flow rate is 12 liters per second.

Table 3.19. Industrial water classification in the study area

SAMPLE NAME	F	EXPLANATION
E_1	259.56	While boiling are very froth water
E_2	3848.22	While boiling are very froth water
E_3	201.86	While boiling are very froth water
E_4	11382.8	While boiling are very froth water
E_5	1309	While boiling are very froth water
E_6	163.24	While boiling are froth water
E_7	66.16	While boiling are froth water
E_8	40.16	While boiling are not very froth water
E_9	73.96	While boiling are froth water
E_{10}	45.74	While boiling are not froth water
E_{11}	63.42	While boiling are froth water
E_{12}	59.26	While boiling are not froth water
E_{13}	116.6	While boiling are froth water
E_{14}	3680.1	While boiling are very froth water
E_{15}	173.64	While boiling are froth water
E_{16}	413.46	While boiling are very froth water
E_{17}	1007.7	While boiling are very froth water
E_{18}	193.8	While boiling are froth water
E_{19}	621.16	While boiling are very froth water
E_{20}	900.7	While boiling are very froth water
E_{21}	349.9	While boiling are very froth water
E_{22}	391.76	While boiling are very froth water
E_{23}	437.24	While boiling are very froth water
E_{24}	231.48	While boiling are very froth water
E_{25}	815.08	While boiling are very froth water
E_{26}	222.4	While boiling are very froth water

Houses neighboorhood of spring draw water by pump in order to meet their water requirements. Formerly spring water had 37 Fr hardness now it has 56 Fr hardness. Furthermore electrical conductivity was 1632 and now it has become 2000. Reason for these changes is increasing sea water mixture because of excessive drawing of water.

According to chemical and izotropic analysis by Filiz (1982), Halkapınar spring is drained from carbonates with respect to SiO_2 value it contains. Furthermore, presence of three ions Ca^{-2}, Mg^{-2}, HCO^{-}_3 in excessive levels shows the water of these springs have karstic origin. From natural isotopes, 0^{18} has high value in Halkapınar source which indicates that there is contribution of sea water to the spring (Table 3.20).

It is also seen Halkapınar spring water has rain origin depending on 0^{18}- H^2 double (Figure 3.12). Low value for Tritium (H^{-3}) is indication of Halkapınar spring water are young water (Several years) (Table 3.20).

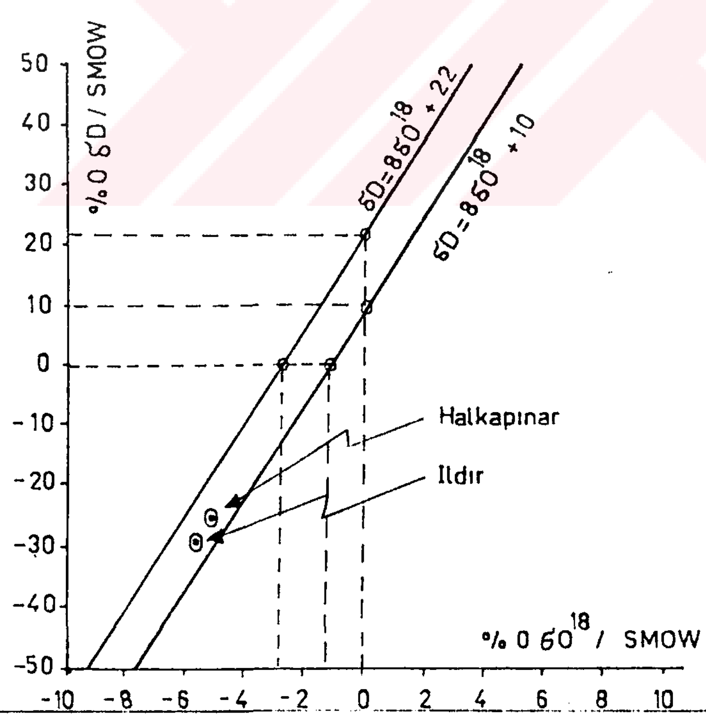


Figure 3.12. The relationship of O^{18}- H^2 in the waters of Halkapınar and Ildırı spring

Table 3.20. Natural isotope analyses results of the wells in the study area springs

SPRING NAME	NATURAL ISOTOPES			
	%o δO^{18} / SMOW	%o δH^{2} / SMOW	H^{3} (UT) Zenginleştirmeden	H^{3} (UT) Zenginleştirerek
Halkapınar	- 5.38*	- 26.6	27 ± 9	—
	- 5.39**	—	—	15 ± 4
Ildır	- 5.87*	- 29.4	13 - 26	—
	- 5.42**	—	—	8 ± 1

3.5.1.2. Ildırı Springs

From poljes and dolines at North of Kadıovacık and from Küçük oynatan poljes and dolines, it is orginated: then it passes through Çukuralan poljes at first vertically, then with stages under controlled lithology and structure: and appears at three different spots at Camiboğazı brook at east of Ildırı Village (Figure 3.13). Springs are run down from trias limestones (Figure 3.14).

Ildırı springs are numbered according to their distances from sea. No 1 spring is 1250 m for from sea , it runs down from 5.45 m altitude, No 2 spring is 900m away from the sea running down from 6.55m altitude. No 3 spring is 450m for from sea it runs down from 0.30m altitude. Yearly everage flow rate is 490 l/s from observations by DSI which started in 1984 and now going on. Chemical analysis of springs taken for this study and by DSI shows salinty is caused by seawater in springs (Table 3.21 (a),(b),(c))

Results of chemical and isotopic analysis by Filiz (1982) indicates low value of SiO_2 is related with springs originating from limestone and with effect of seawater .

High values for Ca, Mg, HCO_3 suggests spring water originating from karstic structure (Table 3.22). High O^{18} in Ildırı springs are an indication of salt water (Figure 3.12).

Figure 3.13. Viev of Ildırı Springs.(55500/48500)

Table 3.21.(a) Chemical Analyses Reports of Ildırı Wells (D.S.İ- 1985)

PARAMETRE	BIRIM	ÖLÇÜLEN DEĞER
DEBI	m^3/sn	-
SU SICAKLIĞI	°C	-
PH	-	7.65
ELEKTRİKSEL İLETKENLİK	µm hos/cm	3140
TOPLAM ÇÖZÜLMÜŞ KATILAR	mg/lt	2355
ASKIDAKI KATILAR	mg/lt	-
TOPLAM KATILAR	mg/lt	-
BULANLIK	NTU	0.24
RENK	PT-CO	0.00
METIL ORANJ ALKANITE	mg/lt $CaCO_3$	334.2
FENOLFTALEIN ALKANİTE	mg/lt $CaCO_3$	0.00
KLORÜR	mg/lt	833.9
AMONYAK AZOTU	mg/lt	0.2
NİTRİT AZOTU	mg/lt	0.002
NİTRAT AZOTU	mg/lt	4.00
ÇÖZÜNMÜŞ OKSİJEN	mg/lt	-
PERMANGANAT DEĞERİ	mg/lt	4.5
BİYOKIMYASAL OKSİJEN DEĞERİ	mg/lt	-
TOPLAM SERTLİK	mg/lt Ca CO_3	532
ORTA FOSFAT	mg/lt	0.00
SÜLFAT	mg/lt	68.64
SERBEST KARBONDİOKSİT	mg/lt	-
DEMİR	mg/lt	0.0
MANGAN	mg/lt	0.01
SODYUM	mg/lt	485.7
POTASYUM	mg/lt	4.68
KALSİYUM	mg/lt	116.8
MAGNEZYUM	mg/lt	51.6
TOPLAM KOLİFORM	SAYI/100 ml	-
TOPLAM GERM	SAYI/100 ml	-
KIMYASAL OKSİJEN DEĞERİ	mg/lt	-
TOPLAM KJELDAHL AZOTU	mg/lt	-
SIYANÜR	mg/lt	Yok
SiO_2	mg/lt	-
KLORÜR	mg/lt	0.12
BOR	mg/lt	0.00
ÇINKO	mg/lt	-

Table 3.21. (b) Chemical Analyses Reports of Ildırı Wells (D.S.İ- 1985)

PARAMETRE	BİRİM	ÖLÇÜLEN DEĞER
DEBI	m^3/sn	-
SU SICAKLIĞI	°C	-
PH	-	7.83
ELEKTRİKSEL ILETKENLİK	µm hos/cm	2960
TOPLAM ÇÖZÜLMÜŞ KATILAR	mg/lt	2220
ASKIDAKİ KATILAR	mg/lt	-
TOPLAM KATILAR	mg/lt	-
BULANLIK	NTU	0.22
RENK	PT-CO	0.00
METİL ORANJ ALKANİTE	mg/lt $CaCo_3$	347.09
FENOLFTALEIN ALKANITE	mg/lt $CaCo_3$	0.00
KLORÜR	mg/lt	828.00
AMONYAK AZOTU	mg/lt	0.15
NİTRİT AZOTU	mg/lt	0.003
NITRAT AZOTU	mg/lt	4.00
ÇÖZÜNMÜŞ OKSİJEN	mg/lt	-
PERMANGANAT DEĞERİ	mg/lt	3.50
BİYOKİMYASAL OKSİJEN DEĞERİ	mg/lt	-
TOPLAM SERTLİK	mg/lt Ca Co_3	463
ORTA FOSFAT	mg/lt	0.00
SÜLFAT	mg/lt	39.8
SERBEST KARBONDİOKSİT	mg/lt	-
DEMİR	mg/lt	0.0
MANGAN	mg/lt	0.0
SODYUM	mg/lt	472.6
POTASYUM	mg/lt	3.9
KALSİYUM	mg/lt	202.8
MAGNEZYUM	mg/lt	50.28
TOPLAM KOLİFORM	SAYI/100 ml	-
TOPLAM GERM	SAYI/100 ml	-
KİMYASAL OKSİJEN DEĞERİ	mg/lt	-
TOPLAM KJELDAHL AZOTU	mg/lt	-
SİYANÜR	mg/lt	Yok
SIO_2	mg/lt	-
KLORÜR	mg/lt	0.17
BOR	mg/lt	0.00
ÇİNKO	mg/lt	-

Table 3.21.(c) Chemical Analyses Reports of Ildırı Wells (D.S.İ- 1985)

PARAMETRE	BİRİM	ÖLÇÜLEN DEĞER
DEBİ	m^3/sn	
SU SICAKLIĞI	°C	
PH	-	7.92
ELEKTRİKSEL ELETKENLİK	µm hos/cm	10.040
TOPLAM ÇÖZÜLMÜŞ KATILAR	mg/lt	7530
ASKIDAKİ KATILAR	mg/lt	-
TOPLAM KATILAR	mg/lt	-
BULANLIK	NTU	0.34
RENK	PT-CO	0.00
METİL ORANJ ALKANİTE	mg/lt $CaCO_3$	368.44
FENOLFTALEİN ALKANİTE	mg/lt $CaCO_3$	0.00
KLORÜR	mg/lt	3423.5
AMONYAK AZOTU	mg/lt	0.1
NİTRİT AZOTU	mg/lt	0.002
NİTRAT AZOTU	mg/lt	4.00
ÇÖZÜNMÜŞ OKSİJEN	mg/lt	-
PERMANGANAT DEĞERİ	mg/lt	5.1
BİYOKİMYASAL OKSİYEN DEĞERİ	mg/lt	-
TOPLAM SERTLİK	mg/lt $CaCo_3$	1332
ORTA FOSFAT	mg/lt	0.01
SÜLFAT	mg/lt	81.12
SERBEST KARBONDİOKSİT	mg/lt	-
DEMİR	mg/lt	0.0
MANGAN	mg/lt	0.0
SODYUM	mg/lt	1782.5
POTASYUM	mg/lt	12.09
KALSİYUM	mg/lt	271.4
MAĞNEZYUM	mg/lt	156.7
TOPLAM KOLİFORM	SAYI/100 ml	-
TOPLAM GERM	SAYI/100 ml	-
KİMYASAL OKSİJEN DEĞERİ	mg/lt	-
TOPLAM KJELDARL AZOTU	mg/lt	-
SİYANÜR	mg/lt	Yok
SIO_2	mg/lt	-
KLORUR	mg/lt	0.2
BOR	mg/lt	0.0
ÇİNKO	mg/lt	-

Table 3.22. Physico- chemical analyses results of the spring water from the study area

Spring Name	Elektriksel İletkenlik μmho.cm (25°C)	SiO_2 (mg/lt)	CATIONS (mg/l)					ANIONS (mg/l)	
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Sr^{2+}	Cl^{-}	HCO_3^{-}
Halkapınar	1 632	33.3	1112	954	10 840	536	8.0	703	214.7
Ildır	6 637	13.5	146	108	1 054	47.2	1.2	2 677	134.7

Figure 3.14. Ildırı Spring Discharge.(54950/47950)

Furthermore, the age of Ildırı springs underground are less than 12 years old according to H^3 Tritium value .

Isotopes which have important function in hydrogeological studies may be briefly defined as follows.

Isotopes are defined as atoms whose nuclei contain the same number of protons but a different number of neutrons. The term isotopes was introduced by Soddy (1913) for nuclides which occupy the same position in the periodic table but which differ in nuclear properties.

It is convenient to denote isotopes in the from E, Where the superscript A represent the mass number and subscript Z represent the atomic number of an element E. For example, C is the isotope of carbon which has six neutrons (N = A- Z) in its nucleus.

Isotopes can be divided into stable and unstable (radioactivite) species. The term stable is relative, depending on the detection limits of radioactive decay times. In the range of atomic numbers from 1 (H) to 83 (Bi) , stable nuclides of all masses except 5 and 8 are known. Only 21 elements have only one stable isotope. All other elements are mixtures at least two isotopes. In most cases one isotope is predominant, the others being present only in trace amounts.

Tritium : Utilization of tritium values in hydrogeology is generally for determining relative age of water . Also it is possible to determine flow rate of underground water. Radioactive decaying equation may be used to find travel time for rain water after it is filtrated to the soil relative age of underground water .

$\mathbf{N = No \cdot e^{-\ t}}$

N : Tritium concentration of sample taken ,

No : Initial tritium concentration of water.

λ **:** Radioactive decaying constant for tritium.

0^{18} -Deuterium : O^{18} and deuterium isotopes do not play active part in decaying with time since they are not radioactive. They are used as tracer in water for their properties. These isotopes are used in underground water for determining origin. From water samples taken from rain falling on entrance and from discharge area, their values are plotted as δ D % 0 is taken ordinate and as δ O^{18} % O is taken as abscissa, where these values represent a straight line.Generally isotopes for rain water and underground water are gathered in the same group and on the same line.

We may suggest theories on formation of Ildırı springs as follows.

First Theory . Rain water comes to imperbeable graywackes after passing through fractures, splits and karstic structures. Carbonates at Camiboğazı valley have thickness of 60 meters. At the opening of Camiboğazı valley, thickness decreases and graywacke surface can be seen. Since carbonates have karstic structure. Salted sea water and rain water meet on the graywackes and come out from springs as mixed water. Early mixed water ratio was low but later sea water ratio is increased because excess water is pulled out from drilling wells opened by DSI (Figure 3.15)

Second Theory : There is a carbonate bridge between Ildırı and Balıklıova. Under control of faults and fractures these bridges are formed by karstic structure. This suggest water from

Balıklıova goes out from Ildırı . The bridge has salty water at the bottom and fresh water at the top. Formerly salt content was low however excess water is taken away from drilling wells and salty water ratio is increased.

In order to understand formation of springs clearly, tracer tests and isotopic analysis are requried. However these studies are not carried out because of long-term tests and lack of means.

Figure 3.15. Drilled wells which are opened by DSİ and İller bankası.(58300/48850)

3.5.2. Drilling Wells

In the area of study, DSI and İller Bankası opened 11 drilling wells in order to supply drinking water. Also there are many personal drilling wells for irrigation and drinking.

Nine drilling wells (25378,25379,34204-A,34204-B,34205,34206,34207,34208,34494) opened by DSI have depths between 30-80 m. Stutic level rangers 4.31-46.40 m. Flow rate varies between 10 and 40 l/s (Table 3.23).

Iller Bankası opened two research drilling wells (IB-I and IB-II) at Ildırı.

IB-I well has depth of 49.50 m. and as it is found dry, it is not used any more.

IB-II well has depth of 38 m,static level of 46 m, dynamic level of 89 m and flow rate of 50 l /s.

Drilling wells numbered 34204-B,34205,34206,34207,25378 by DSI and No.IB-II by Iller Bankası have chemical analysis results as below.

According to these results water is not suitable for drinking and irrigation.

If time vs electrical conductivity graph by DSI is examined, according to test result on research drilling well B35-344494,electrical conductivity increases to 1670 mho/cm with uniform flow rate of 20 l/s during 48 hours. If uniform flow rate is 40 l/s during 24 hours electrical conductivity increases from 1710 mho/cm to 1815 mho/cm.(Appendix 2.2). These figures shows electrical conductivity increases with water drawal rate and time. Salty wateraccessibility is increased because of excess water drawn away from DSI and Iller Bankası wells. Now they can not be used any more. DSI decreased the quantity of water drawn ofter the salty water entry has increased.

Currently water is drawn only from two wells. 16 base drilling wells are opened to form permeable injection suırtain at the location where Ildırı Springs are discharged and Camiboğazı Valley meets with the sea. However studies show such a curtain is hard to realize and the project is cancelled by DSI.

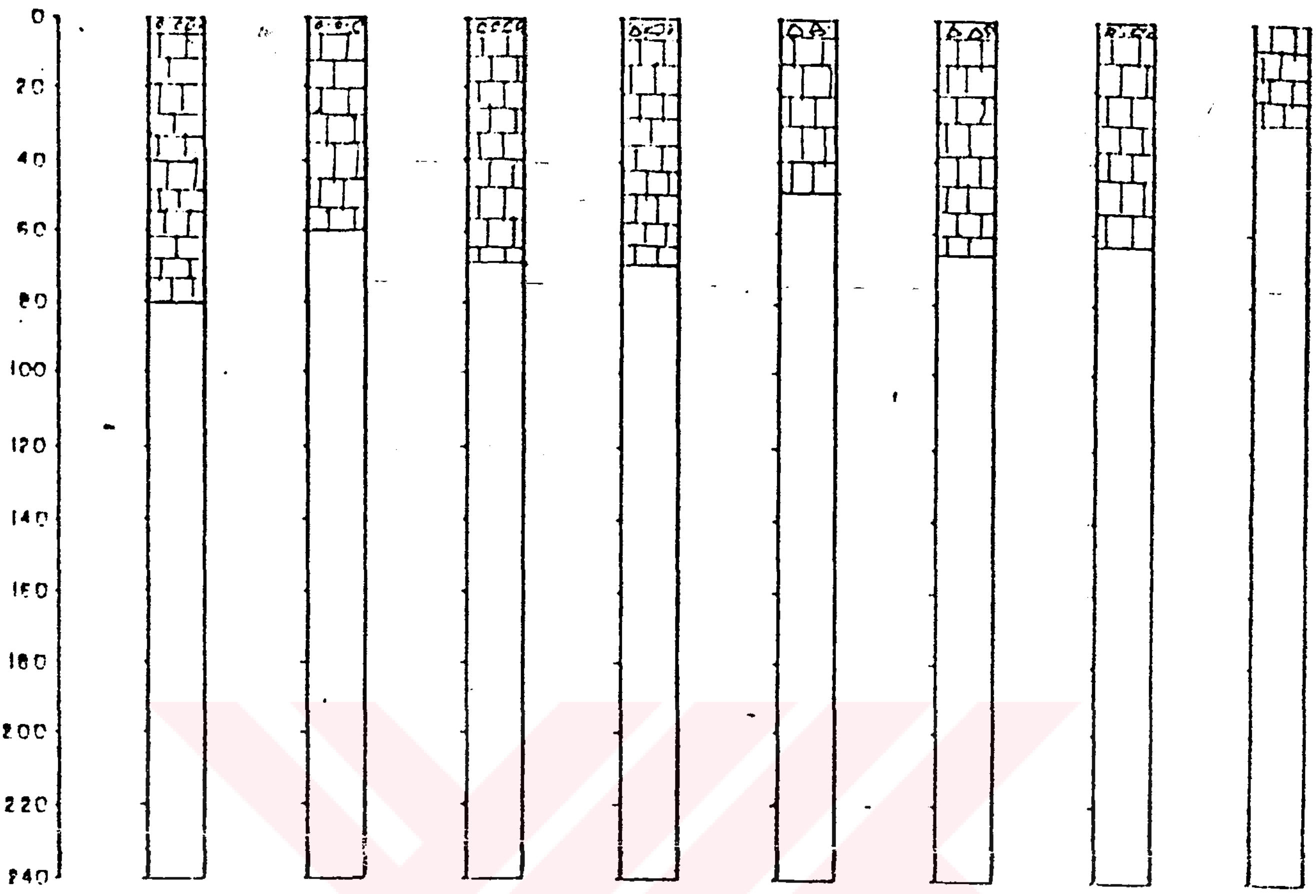
From results of chemical analysis of samples token from base drilling wells, a graph is prepared by DSI showing the relation between electrical conductivity and well depth (Appendix 2.3). To analyse the variation pof electrical conductance with depth of underground water is examined by this graph. Morever, a conductivity contour map is prepared by DSI to indicate the extension of sea water to inner sections depending on conductivity and depth (Appendix 2.4).

According to the results of this map and graph, mixing of sea water to the underground water decreases with the distance from the sea increased.

Also especially at opening of Camiboğazı Valley , sea water effect is important until the altitude of som. If depth increases and distance from Valley increases, salinity ratio desreases.

In the area of study drilling wells opened by people have depths varying from 10 m. to 40 m. Wells near scaside have more salt ratio.

Table 3.23. Chemical analyses results of wells and wells loge which are opened by DSİ



	34208	34204	34494	34204-B	34205	34207	34206	25378
ll	Çeşme-Ildır	Çeşme-Ildır	Çeşme-Ildır	Çeşme-Ildır	Çeşme-Ildır	Çeşme-Ildır	Çeşme-Ildır	Çeşme-Ildır
AMACI / Drilling	İçme suyu	İçme suyu	İçme suyu	İçme suyu	İçme suyu	İçme suyu	İçme suyu	İçme suyu
YIL / n Year	20.1.88	22.12.86	6.8.86	26.1.86	26.1.86	10.4.86	8.4.87	1978
TU / itude (m)					35.89	46.72		
	80	60	70	70	50	68	65	30
/ easurement				?.5.?7	26.1.86	10.4.87	8.4.87	-.11.78
VİYE / l (m)	34.42		39.58	45.81	28.97	39.10	33.10	4.31
ARTEZYEN Artesian								
POMPA Pump	40		20	20	20	20	10	40.62
(m)	1.56		0.4	0.59	0.73	1.69	7.2	1.43
lt/sn/m / ity l/sec/m	25.64		50	33.89	27.39	11.83	1.4	28.4
m³/gün/m / y m³/day/m	15.800		Yok	15.80	15.80	7900	7900	9168
	3180	2320	1730	2540	2400	1274	2370	3002
/ Water	C_4S_3	C_4S_1	C_3S_2	C_4S_1	C_4S_2	C_3S_1	C_4S_2	C_4S_2

Kireç taşı   Aglomera   Alüvyon

3.5.3. Cisterns and Caisson Boreholes

There are many cisterns and caisson boreholes opened for irrigation and drinking at many spots in the area of study .Many of these cisterns and caisson boreholes are old and historic. Depth of them varies from 4 m. to 15 m. Water levels of boreholes change with season When the boreholes are fall in winter, levels decrease a lot in the summer.

Currently these boreholes are used for drinking and irrigation purposes.

CONCLUSION AND RECOMMENDATION

1- In the study area crops out Paleozoic, Mesozoic, Cenozoic age unıts.

2- Recharge area Discharge points.

a) Ildırı springs,

b) Halkapınar springs,

c) Small discharge other springs,

d) Discharge through the sea

3 - Liquid and solid maste musn't throm away and these maste must be stared accordingto hidrogeological and geological suitabie place.

4 - Ildırı region archaeological excovation must continuous and this region tourism potential must increase.

5 - Ildırı springs flow out three different points. These springs mean dischange is 490 lt/sn.

6 - Water which is taken from borehole and sprngs, chemical analysis results . Show that . This water contains important degree salt.

7 - Big areal Karst is in mesozoic agea Carbonate rock in region, especrelly in trisassic carbonate improve.

8 - O^{18} natural isotope value; show there is a sea water intrusion through the Halkapınar Ildırı springs.

9 - To frustrate the sea water intrusion through the Ildırı springs that valley mouth impermeable injecction cut off wall idea was thougth by DSİ but . Suitable for sea water intrussion karstic formation threkness and wide spreat that three study gives a good results.

10 - In the study area the basewment is formed Carboniferous age Alandere Formation. This formation is overlain uncomformable triasssic age Gerence, Camiboğazı and Güvercinlik Formation. Triassic age these formation is conformable overlain Cretaceous age Aktepe unit and this unit is unconformable overlain Cretaceous age Balıklıova Formation.

11 - The water which is beloging to Ildırı spring can be mised. This water and after purification , can be used as a drink water.

12 - In the region Carbonate formation thick place, deep. borehole must be opened for taken drinkable water. These boreholes . Oynatan place, Zetincik place, Kadıovacık, nohutalan, Barbaros, Birgi place can .

13 - For supply Çeşme and Alaçatı drink water used a asbastos pipes. These pipes is dangereous for health.

14 - In there region there isn't any dravnage system. Setting region solid and liguid waste is given to sea or septic tank. All septic tank is permeable. The region is a karstic area that groundwater pollution is not surpmised.

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SAMPLE NAME : CAYALTI MVK. SONDAJ-1							LAB NO :K1	
DATE OF SAMPLING : 15.05.1996							TEMPERATURE(°C) : -	
IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	91	3.96	0.00396	0.00396	0.0020	0.0035	0.88	36.17
K+	7	0.18	0.00018	0.00018	0.0001	0.0002	0.88	1.64
Ca++	110	5.49	0.00274	0.01098	0.0055	0.0016	0.59	50.16
Mg++	16	1.32	0.00066	0.00263	0.0013	0.0004	0.59	12.02
Cl-	175	4.93	0.00493	0.00493	0.0025	0.0043	0.88	35.34
HCO3	378	6.20	0.00620	0.00620	0.0031	0.0054	0.88	44.38
SO4=	136	2.83	0.00142	0.00566	0.0028	0.0008	0.59	20.28

TOTAL CATION AMOUNT (meq/l)	: 10.94	PH (-Log H)	: 7.34
TOTAL ANION AMOUNT (meq/l)	: 13.96	EC(mmho/cm)	: 2490
TOTAL ION AMOUNT (meq/l)	: 24.90	Si(mg/l)	: ----
IONIC STRENGTH	: 0.017	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 2.15	HARDNESS(FR)	: 34.02
Cl/(SO4+HCO3)	: 0.55	Ca/Mg	: 4.17

SAMPLE NAME : ALTMIŞ EVLER SİTESİ SONDAJI							LAB NO :E2	
DATE OF SAMPLING : 15.05.1996							TEMPERATURE(°C) : -	
IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	1407	61.20	0.06120	0.06120	0.0306	0.0462	0.76	56.10
K+	27	0.69	0.00069	0.00069	0.0003	0.0005	0.76	0.63
Ca++	674	33.63	0.01682	0.06727	0.0336	0.0055	0.33	30.83
Mg++	165	13.57	0.00678	0.02714	0.0136	0.0022	0.33	12.44
Cl-	2950	83.17	0.08317	0.08317	0.0416	0.0628	0.76	84.40
HCO3	281	4.61	0.00461	0.00461	0.0023	0.0035	0.76	4.67
SO4=	517	10.76	0.00538	0.02153	0.0108	0.0018	0.33	10.92

TOTAL CATION AMOUNT (meq/l)	: 109.09	PH (-Log H)	: 7.81
TOTAL ANION AMOUNT (meq/l)	: 98.54	EC(mmho/cm)	: 15150
TOTAL ION AMOUNT (meq/l)	: 207.63	Si(mg/l)	: ----
IONIC STRENGTH	: 0.133	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 12.60	HARDNESS(FR)	:236.01
Cl/(SO4+HCO3)	: 5.41	Ca/Mg	: 2.48

SAMPLE NAME	: 62´LİLER SİTESİ SONDAJI	LAB NO :E3
DATE OF SAMPLING	: 15.05.1996	TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	72	3.13	0.00313	0.00313	0.0016	0.0027	0.87	24.53
K+	4	0.10	0.00010	0.00010	0.0001	0.0001	0.87	0.80
Ca++	163	8.13	0.00407	0.01627	0.0081	0.0023	0.56	63.71
Mg++	17	1.40	0.00070	0.00280	0.0014	0.0004	0.56	10.95
Cl-	305	8.60	0.00860	0.00860	0.0043	0.0074	0.87	50.12
HCO3	329	5.39	0.00539	0.00539	0.0027	0.0047	0.87	31.44
SO4=	152	3.16	0.00158	0.00633	0.0032	0.0009	0.56	18.44

TOTAL CATION AMOUNT (meq/l)	: 12.77	PH (-Log H)	: 7.06
TOTAL ANION AMOUNT (meq/l)	: 17.16	EC(mmho/cm)	: 3080
TOTAL ION AMOUNT (meq/l)	: 29.92	Si(mg/l)	: ----
IONIC STRENGTH	: 0.021	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 1.43	HARDNESS(FR)	: 47.66
Cl/(SO4+HCO3)	: 1.00	Ca/Mg	: 5.82

SAMPLE NAME	: ÇAYALTI DERE	LAB NO :E4
DATE OF SAMPLING	: 15.05.1996	TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	4134	179.82	0.17982	0.17982	0.0899	0.1278	0.71	69.97
K+	117	3.00	0.00300	0.00300	0.0015	0.0021	0.71	1.17
Ca++	878	43.81	0.02191	0.08762	0.0438	0.0056	0.25	17.05
Mg++	369	30.35	0.01517	0.06069	0.0303	0.0039	0.25	11.81
Cl-	7550	212.86	0.21286	0.21286	0.1064	0.1512	0.71	89.07
HCO3	293	4.80	0.00480	0.00480	0.0024	0.0034	0.71	2.01
SO4=	1024	21.32	0.01066	0.04264	0.0213	0.0027	0.25	8.92

TOTAL CATION AMOUNT (meq/l)	: 256.98	PH (-Log H)	: 7.37
TOTAL ANION AMOUNT (meq/l)	: 238.98	EC(mmho/cm)	: 34900
TOTAL ION AMOUNT (meq/l)	: 495.95	Si(mg/l)	: ----
IONIC STRENGTH	: 0.296	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 29.53	HARDNESS(FR)	:370.79
Cl/(SO4+HCO3)	: 8.15	Ca/Mg	: 1.44

SAMPLE NAME	: ILDIRI SONDAJ	LAB NO :E5
DATE OF SAMPLING	: 15.05.1996	TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	475	20.66	0.02066	0.02066	0.0103	0.0171	0.83	60.84
K+	14	0.36	0.00036	0.00036	0.0002	0.0003	0.83	1.06
Ca++	167	8.33	0.00417	0.01667	0.0083	0.0019	0.47	24.54
Mg++	56	4.61	0.00230	0.00921	0.0046	0.0011	0.47	13.56
Cl-	885	24.95	0.02495	0.02495	0.0125	0.0206	0.83	72.09
HCO3	329	5.39	0.00539	0.00539	0.0027	0.0045	0.83	15.58
SO4=	205	4.27	0.00213	0.00854	0.0043	0.0010	0.47	12.33

TOTAL CATION AMOUNT (meq/l)	: 33.96	PH (-Log H)	: 7.16
TOTAL ANION AMOUNT (meq/l)	: 34.61	EC(mmho/cm)	: 5490
TOTAL ION AMOUNT (meq/l)	: 68.57	Si(mg/l)	: ----
IONIC STRENGTH	: 0.043	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 8.12	HARDNESS(FR)	: 64.69
Cl/(SO4+HCO3)	: 2.58	Ca/Mg	: 1.81

SAMPLE NAME	: ÇAYALTI MVK. SONDAJ-II	LAB NO :E6
DATE OF SAMPLING	: 15.05.1996	TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	59	2.57	0.00257	0.00257	0.0013	0.0022	0.88	23.82
K+	2	0.05	0.00005	0.00005	0.0000	0.0000	0.88	0.48
Ca++	147	7.34	0.00367	0.01467	0.0073	0.0022	0.59	68.08
Mg++	10	0.82	0.00041	0.00164	0.0008	0.0002	0.59	7.63
Cl-	169	4.76	0.00476	0.00476	0.0024	0.0042	0.88	35.33
HCO3	391	6.41	0.00641	0.00641	0.0032	0.0056	0.88	47.53
SO4=	111	2.31	0.00116	0.00462	0.0023	0.0007	0.59	17.14

TOTAL CATION AMOUNT (meq/l)	: 10.78	PH (-Log H)	: 7.46
TOTAL ANION AMOUNT (meq/l)	: 13.49	EC(mmho/cm)	: 1936
TOTAL ION AMOUNT (meq/l)	: 24.26	Si(mg/l)	: ----
IONIC STRENGTH	: 0.017	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 1.27	HARDNESS(FR)	: 40.79
Cl/(SO4+HCO3)	: 0.55	Ca/Mg	: 8.92

SAMPLE NAME : KADIOVACIK GOLET LAB NO : E7
DATE OF SAMPLING : 15.05.1996 TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	17	0.74	0.00074	0.00074	0.0004	0.0007	0.92	34.26
K+	10	0.26	0.00026	0.00026	0.0001	0.0002	0.92	11.88
Ca++	20	1.00	0.00050	0.00200	0.0010	0.0004	0.72	46.24
Mg++	2	0.16	0.00008	0.00033	0.0002	0.0001	0.72	7.62
Cl-	26	0.73	0.00073	0.00073	0.0004	0.0007	0.92	13.18
HCO3	85	1.39	0.00139	0.00139	0.0007	0.0013	0.92	25.05
SO4=	165	3.44	0.00172	0.00687	0.0034	0.0012	0.72	61.77

TOTAL CATION AMOUNT (meq/l)	2.16	PH (-Log H)	6.45
TOTAL ANION AMOUNT (meq/l)	5.56	EC(mmho/cm)	443
TOTAL ION AMOUNT (meq/l)	7.72	Si(mg/l)	----
IONIC STRENGTH	0.006	B+++(mg/l)	----
SAR (SODIUM AD.RATIO)	0.97	HARDNESS(FR)	5.31
Cl/(SO4+HCO3)	0.15	Ca/Mg	6.07

SAMPLE NAME : CAMiBOGAZI ÇEŞME LAB NO : E8
DATE OF SAMPLING : 15.05.1996 TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	14	0.61	0.00061	0.00061	0.0003	0.0005	0.89	8.99
K+	1	0.03	0.00003	0.00003	0.0000	0.0000	0.89	0.38
Ca++	67	3.34	0.00167	0.00669	0.0033	0.0011	0.64	49.36
Mg++	34	2.80	0.00140	0.00559	0.0028	0.0009	0.64	41.28
Cl-	29	0.82	0.00082	0.00082	0.0004	0.0007	0.89	8.47
HCO3	427	7.00	0.00700	0.00700	0.0035	0.0063	0.89	72.54
SO4=	88	1.83	0.00092	0.00366	0.0018	0.0006	0.64	18.99

TOTAL CATION AMOUNT (meq/l)	6.77	PH (-Log H)	7.21
TOTAL ANION AMOUNT (meq/l)	9.65	EC(mmho/cm)	1243
TOTAL ION AMOUNT (meq/l)	16.42	Si(mg/l)	----
IONIC STRENGTH	0.012	B+++(mg/l)	----
SAR (SODIUM AD.RATIO)	0.35	HARDNESS(FR)	30.70
Cl/(SO4+HCO3)	0.09	Ca/Mg	1.20

SAMPLE NAME : AHMETAGA ÇEŞME LAB NO :E9
DATE OF SAMPLING : 15.05.1996 TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	26	1.13	0.00113	0.00113	0.0006	0.0010	0.88	12.70
K+	2	0.05	0.00005	0.00005	0.0000	0.0000	0.88	0.58
Ca++	74	3.69	0.00185	0.00739	0.0037	0.0011	0.61	41.47
Mg++	49	4.03	0.00201	0.00806	0.0040	0.0012	0.61	45.25
Cl-	22	0.62	0.00062	0.00062	0.0003	0.0005	0.88	5.85
HCO3	488	8.00	0.00800	0.00800	0.0040	0.0071	0.88	75.49
SO4=	95	1.98	0.00099	0.00396	0.0020	0.0006	0.61	18.66

TOTAL CATION AMOUNT (meq/l) : 8.90
TOTAL ANION AMOUNT (meq/l) : 10.60
TOTAL ION AMOUNT (meq/l) : 19.50
IONIC STRENGTH : 0.015
SAR (SODIUM AD.RATIO) : 0.58
Cl/(SO4+HCO3) : 0.06

PH (-Log H) : 7.45
EC(mmho/cm) : 1539
Si(mg/l) : ----
B+++(mg/l) : ----
HARDNESS(FR) : 38.61
Ca/Mg : 0.92

SAMPLE NAME : ANDEZiT KESON KUYU LAB NO :E10
DATE OF SAMPLING : 15.05.1996 TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	16	0.70	0.00070	0.00070	0.0003	0.0006	0.89	8.27
K+	1	0.03	0.00003	0.00003	0.0000	0.0000	0.89	0.30
Ca++	80	3.99	0.00200	0.00798	0.0040	0.0012	0.62	47.44
Mg++	45	3.70	0.00185	0.00740	0.0037	0.0011	0.62	43.98
Cl-	29	0.82	0.00082	0.00082	0.0004	0.0007	0.89	7.82
HCO3	476	7.80	0.00780	0.00780	0.0039	0.0069	0.89	74.65
SO4=	88	1.83	0.00092	0.00366	0.0018	0.0006	0.62	17.53

TOTAL CATION AMOUNT (meq/l) : 8.41
TOTAL ANION AMOUNT (meq/l) : 10.45
TOTAL ION AMOUNT (meq/l) : 18.87
IONIC STRENGTH : 0.014
SAR (SODIUM AD.RATIO) : 0.35
Cl/(SO4+HCO3) : 0.08

PH (-Log H) : 7.49
EC(mmho/cm) : 1437
Si(mg/l) : ----
B+++(mg/l) : ----
HARDNESS(FR) : 38.46
Ca/Mg : 1.08

SAMPLE NAME : CAMIBOGAZI SONDAJ LAB NO :E11
DATE OF SAMPLING : 15.05.1996 TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	22	0.96	0.00096	0.00096	0.0005	0.0009	0.89	13.45
K+	2	0.05	0.00005	0.00005	0.0000	0.0000	0.89	0.72
Ca++	68	3.39	0.00170	0.00679	0.0034	0.0011	0.64	47.69
Mg++	33	2.71	0.00136	0.00543	0.0027	0.0009	0.64	38.14
Cl-	40	1.13	0.00113	0.00113	0.0006	0.0010	0.89	12.40
HCO3	415	6.80	0.00680	0.00680	0.0034	0.0061	0.89	74.79
SO4=	56	1.17	0.00058	0.00233	0.0012	0.0004	0.64	12.82

TOTAL CATION AMOUNT (meq/l)	: 7.12		PH (-Log H)	: 7.31
TOTAL ANION AMOUNT (meq/l)	: 9.10		EC(mmho/cm)	: 1259
TOTAL ION AMOUNT (meq/l)	: 16.21		Si(mg/l)	: ----
IONIC STRENGTH	: 0.012		B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 0.55		HARDNESS(FR)	: 30.54
Cl/(SO4+HCO3)	: 0.14		Ca/Mg	: 1.25

SAMPLE NAME : KADIOVACIK SARNIC LAB NO :E12
DATE OF SAMPLING : 15.05.1996 TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	19	0.83	0.00083	0.00083	0.0004	0.0008	0.92	38.91
K+	4	0.10	0.00010	0.00010	0.0001	0.0001	0.92	4.83
Ca++	19	0.95	0.00047	0.00190	0.0009	0.0003	0.72	44.64
Mg++	3	0.25	0.00012	0.00049	0.0002	0.0001	0.72	11.62
Cl-	24	0.68	0.00068	0.00068	0.0003	0.0006	0.92	13.60
HCO3	73	1.20	0.00120	0.00120	0.0006	0.0011	0.92	24.05
SO4=	149	3.10	0.00155	0.00620	0.0031	0.0011	0.72	62.35

TOTAL CATION AMOUNT (meq/l)	: 2.12		PH (-Log H)	: 8.07
TOTAL ANION AMOUNT (meq/l)	: 4.98		EC(mmho/cm)	: 411
TOTAL ION AMOUNT (meq/l)	: 7.10		Si(mg/l)	: ----
IONIC STRENGTH	: 0.006		B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 1.07		HARDNESS(FR)	: 5.97
Cl/(SO4+HCO3)	: 0.16		Ca/Mg	: 3.84

SAMPLE NAME : BİRGİ SONDAJ						LAB NO :E13		
DATE OF SAMPLING : 15.05.1996						TEMPERATURE(°C) : -		
IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	41	1.78	0.00178	0.00178	0.0009	0.0016	0.91	30.61
K+	3	0.08	0.00008	0.00008	0.0000	0.0001	0.91	1.32
Ca++	63	3.14	0.00157	0.00629	0.0031	0.0011	0.67	53.96
Mg++	10	0.82	0.00041	0.00164	0.0008	0.0003	0.67	14.11
Cl-	35	0.99	0.00099	0.00099	0.0005	0.0009	0.91	14.81
HCO3	256	4.20	0.00420	0.00420	0.0021	0.0038	0.91	63.00
SO4=	71	1.48	0.00074	0.00296	0.0015	0.0005	0.67	22.19

TOTAL CATION AMOUNT (meq/l)	: 5.83	PH (-Log H)	: 8.03
TOTAL ANION AMOUNT (meq/l)	: 6.66	EC(mmho/cm)	: 1157
TOTAL ION AMOUNT (meq/l)	: 12.49	Si(mg/l)	: ----
IONIC STRENGTH	: 0.009	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 1.27	HARDNESS(FR)	: 19.83
Cl/(SO4+HCO3)	: 0.17	Ca/Mg	: 3.82

SAMPLE NAME : CAMİBOGAZI DERE						LAB NO :E14		
DATE OF SAMPLING : 15.05.1996						TEMPERATURE(°C) : -		
IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	1338	58.20	0.05820	0.05820	0.0291	0.0452	0.78	69.32
K+	36	0.92	0.00092	0.00092	0.0005	0.0007	0.78	1.10
Ca++	313	15.62	0.00781	0.03124	0.0156	0.0028	0.36	18.60
Mg++	112	9.21	0.00461	0.01842	0.0092	0.0017	0.36	10.97
Cl-	2200	62.02	0.06202	0.06202	0.0310	0.0481	0.78	82.58
HCO3	342	5.61	0.00561	0.00561	0.0028	0.0044	0.78	7.46
SO4=	359	7.47	0.00374	0.01495	0.0075	0.0014	0.36	9.95

TOTAL CATION AMOUNT (meq/l)	: 83.95	PH (-Log H)	: 7.68
TOTAL ANION AMOUNT (meq/l)	: 75.10	EC(mmho/cm)	: 11280
TOTAL ION AMOUNT (meq/l)	: 159.06	Si(mg/l)	: ----
IONIC STRENGTH	: 0.096	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 16.52	HARDNESS(FR)	:124.15
Cl/(SO4+HCO3)	: 4.74	Ca/Mg	: 1.70

SAMPLE NAME	: ALİ BAYIK SONDAJ		LAB NO :E15
DATE OF SAMPLING	: 15.05.1996	TEMPERATURE(°C) : -	

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	62	2.70	0.00270	0.00270	0.0013	0.0023	0.87	23.07
K+	3	0.08	0.00008	0.00008	0.0000	0.0001	0.87	0.66
Ca++	154	7.68	0.00384	0.01537	0.0077	0.0022	0.57	65.73
Mg++	15	1.23	0.00062	0.00247	0.0012	0.0003	0.57	10.55
Cl-	230	6.48	0.00648	0.00648	0.0032	0.0056	0.87	40.68
HCO3	281	4.61	0.00461	0.00461	0.0023	0.0040	0.87	28.90
SO4=	233	4.85	0.00243	0.00970	0.0049	0.0014	0.57	30.43

TOTAL CATION AMOUNT (meq/l)	: 11.69	PH (-Log H)	: 7.73
TOTAL ANION AMOUNT (meq/l)	: 15.94	EC(mmho/cm)	: 2140
TOTAL ION AMOUNT (meq/l)	: 27.63	Si(mg/l)	: ----
IONIC STRENGTH	: 0.021	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 1.28	HARDNESS(FR)	: 44.59
Cl/(SO4+HCO3)	: 0.69	Ca/Mg	: 6.23

SAMPLE NAME	: ILDIRI ÇEŞME		LAB NO :E16
DATE OF SAMPLING	: 15.05.1996	TEMPERATURE(°C) : -	

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	122	5.31	0.00531	0.00531	0.0027	0.0046	0.86	29.11
K+	42	1.08	0.00108	0.00108	0.0005	0.0009	0.86	5.91
Ca++	183	9.13	0.00457	0.01826	0.0091	0.0025	0.55	50.09
Mg++	33	2.71	0.00136	0.00543	0.0027	0.0007	0.55	14.89
Cl-	325	9.16	0.00916	0.00916	0.0046	0.0079	0.86	54.02
HCO3	378	6.20	0.00620	0.00620	0.0031	0.0053	0.86	36.53
SO4=	77	1.60	0.00080	0.00321	0.0016	0.0004	0.55	9.45

TOTAL CATION AMOUNT (meq/l)	: 18.23	PH (-Log H)	: 7.05
TOTAL ANION AMOUNT (meq/l)	: 16.96	EC(mmho/cm)	: 3130
TOTAL ION AMOUNT (meq/l)	: 35.19	Si(mg/l)	: ----
IONIC STRENGTH	: 0.024	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 2.18	HARDNESS(FR)	: 59.23
Cl/(SO4+HCO3)	: 1.17	Ca/Mg	: 3.36

SAMPLE NAME	: MARTI SİTESİ SONDAJ	LAB NO :E17
DATE OF SAMPLING	: 15.05.1996	TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	361	15.70	0.01570	0.01570	0.0079	0.0131	0.84	54.10
K+	17	0.44	0.00044	0.00044	0.0002	0.0004	0.84	1.50
Ca++	189	9.43	0.00472	0.01886	0.0094	0.0023	0.49	32.49
Mg++	42	3.45	0.00173	0.00691	0.0035	0.0008	0.49	11.90
Cl-	700	19.73	0.01973	0.01973	0.0099	0.0165	0.84	68.34
HCO3	366	6.00	0.00600	0.00600	0.0030	0.0050	0.84	20.78
SO4=	151	3.14	0.00157	0.00629	0.0031	0.0008	0.49	10.89

TOTAL CATION AMOUNT (meq/l)	: 29.02	PH (-Log H)	: 6.74
TOTAL ANION AMOUNT (meq/l)	: 28.88	EC(mmho/cm)	: 4670
TOTAL ION AMOUNT (meq/l)	: 57.90	Si(mg/l)	: ----
IONIC STRENGTH	: 0.037	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 6.19	HARDNESS(FR)	: 64.43
Cl/(SO4+HCO3)	: 2.16	Ca/Mg	: 2.73

SAMPLE NAME	: İMBAT SİTESİ KESON	LAB NO :E18
DATE OF SAMPLING	: 15.05.1996	TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	69	3.00	0.00300	0.00300	0.0015	0.0027	0.88	27.68
K+	4	0.10	0.00010	0.00010	0.0001	0.0001	0.88	0.95
Ca++	132	6.59	0.00329	0.01317	0.0066	0.0020	0.61	60.75
Mg++	14	1.15	0.00058	0.00230	0.0012	0.0004	0.61	10.62
Cl-	127	3.58	0.00358	0.00358	0.0018	0.0032	0.88	33.61
HCO3	415	6.80	0.00680	0.00680	0.0034	0.0060	0.88	63.85
SO4=	13	0.27	0.00014	0.00054	0.0003	0.0001	0.61	2.54

TOTAL CATION AMOUNT (meq/l)	: 10.84	PH (-Log H)	: 7.00
TOTAL ANION AMOUNT (meq/l)	: 10.65	EC(mmho/cm)	: 1940
TOTAL ION AMOUNT (meq/l)	: 21.50	Si(mg/l)	: ----
IONIC STRENGTH	: 0.015	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 1.53	HARDNESS(FR)	: 38.69
Cl/(SO4+HCO3)	: 0.51	Ca/Mg	: 5.72

SAMPLE NAME	: HALKAPINAR KAYNAGI	LAB NO :E19
DATE OF SAMPLING	: 15.05.1996	TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	226	9.83	0.00983	0.00983	0.0049	0.0083	0.85	41.94
K+	6	0.15	0.00015	0.00015	0.0001	0.0001	0.85	0.66
Ca++	207	10.33	0.00516	0.02066	0.0103	0.0026	0.51	44.07
Mg++	38	3.13	0.00156	0.00625	0.0031	0.0008	0.51	13.33
Cl-	545	15.37	0.01537	0.01537	0.0077	0.0130	0.85	66.33
HCO3	378	6.20	0.00620	0.00620	0.0031	0.0052	0.85	26.75
SO4=	77	1.60	0.00080	0.00321	0.0016	0.0004	0.51	6.92

TOTAL CATION AMOUNT (meq/l)	: 23.44	PH (-Log H)	: 6.93
TOTAL ANION AMOUNT (meq/l)	: 23.16	EC(mmho/cm)	: 3730
TOTAL ION AMOUNT (meq/l)	: 46.60	Si(mg/l)	: ----
IONIC STRENGTH	: 0.031	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 3.79	HARDNESS(FR)	: 67.27
Cl/(SO4+HCO3)	: 1.97	Ca/Mg	: 3.31

SAMPLE NAME	: ILDIR KAYNAK ÇIKIŞ	LAB NO :E20
DATE OF SAMPLING	: 15.05.1996	TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	323	14.05	0.01405	0.01405	0.0070	0.0119	0.84	53.96
K+	15	0.38	0.00038	0.00038	0.0002	0.0003	0.84	1.48
Ca++	160	7.98	0.00399	0.01597	0.0080	0.0020	0.51	30.66
Mg++	44	3.62	0.00181	0.00724	0.0036	0.0009	0.51	13.90
Cl-	637	17.96	0.01796	0.01796	0.0090	0.0152	0.84	72.07
HCO3	342	5.61	0.00561	0.00561	0.0028	0.0047	0.84	22.50
SO4=	65	1.35	0.00068	0.00271	0.0014	0.0003	0.51	5.43

TOTAL CATION AMOUNT (meq/l)	: 26.04	PH (-Log H)	: 7.07
TOTAL ANION AMOUNT (meq/l)	: 24.92	EC(mmho/cm)	: 4160
TOTAL ION AMOUNT (meq/l)	: 50.96	Si(mg/l)	: ----
IONIC STRENGTH	: 0.032	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 5.83	HARDNESS(FR)	: 58.01
Cl/(SO4+HCO3)	: 2.58	Ca/Mg	: 2.21

SAMPLE NAME : BAHÇELİEVLER SİTESİ SONDAJ LAB NO :E21
DATE OF SAMPLING : 15.05.1996 TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	126	5.48	0.00548	0.00548	0.0027	0.0048	0.87	41.06
K+	5	0.13	0.00013	0.00013	0.0001	0.0001	0.87	0.96
Ca++	132	6.59	0.00329	0.01317	0.0066	0.0019	0.58	49.35
Mg++	14	1.15	0.00058	0.00230	0.0012	0.0003	0.58	8.63
Cl-	245	6.91	0.00691	0.00691	0.0035	0.0060	0.87	47.59
HCO3	403	6.61	0.00661	0.00661	0.0033	0.0058	0.87	45.52
SO4=	48	1.00	0.00050	0.00200	0.0010	0.0003	0.58	6.89

TOTAL CATION AMOUNT (meq/l) : 13.35
TOTAL ANION AMOUNT (meq/l) : 14.51
TOTAL ION AMOUNT (meq/l) : 27.86
IONIC STRENGTH : 0.018
SAR (SODIUM AD.RATIO) : 2.79
Cl/(SO4+HCO3) : 0.91

PH (-Log H) : 7.56
EC(mmho/cm) : 2260
Si(mg/l) : ----
B+++(mg/l) : ----
HARDNESS(FR) : 38.69
Ca/Mg : 5.72

SAMPLE NAME : ERMAN MARKET SONDAJ LAB NO :E22
DATE OF SAMPLING : 15.05.1996 TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	141	6.13	0.00613	0.00613	0.0031	0.0053	0.86	31.91
K+	6	0.15	0.00015	0.00015	0.0001	0.0001	0.86	0.80
Ca++	213	10.63	0.00531	0.02126	0.0106	0.0029	0.55	55.31
Mg++	28	2.30	0.00115	0.00461	0.0023	0.0006	0.55	11.98
Cl-	297	8.37	0.00837	0.00837	0.0042	0.0072	0.86	56.47
HCO3	329	5.39	0.00539	0.00539	0.0027	0.0046	0.86	36.37
SO4=	51	1.06	0.00053	0.00212	0.0011	0.0003	0.55	7.16

TOTAL CATION AMOUNT (meq/l) : 19.22
TOTAL ANION AMOUNT (meq/l) : 14.83
TOTAL ION AMOUNT (meq/l) : 34.05
IONIC STRENGTH : 0.024
SAR (SODIUM AD.RATIO) : 2.41
Cl/(SO4+HCO3) : 1.30

PH (-Log H) : 7.10
EC(mmho/cm) : 2540
Si(mg/l) : ----
B+++(mg/l) : ----
HARDNESS(FR) : 64.66
Ca/Mg : 4.62

SAMPLE NAME : BAHÇELİEVLER GİRİŞİ SONDAJ LAB NO :E23
DATE OF SAMPLING : 15.05.1996 TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	136	5.92	0.00592	0.00592	0.0030	0.0052	0.88	46.67
K+	35	0.90	0.00090	0.00090	0.0004	0.0008	0.88	7.08
Ca++	101	5.04	0.00252	0.01008	0.0050	0.0015	0.60	39.76
Mg++	10	0.82	0.00041	0.00164	0.0008	0.0002	0.60	6.49
Cl-	98	2.76	0.00276	0.00276	0.0014	0.0024	0.88	22.93
HCO3	513	8.41	0.00841	0.00841	0.0042	0.0074	0.88	69.81
SO4=	42	0.87	0.00044	0.00175	0.0009	0.0003	0.60	7.26

TOTAL CATION AMOUNT (meq/l)	: 12.68		PH (-Log H)	: 7.15
TOTAL ANION AMOUNT (meq/l)	: 12.05		EC(mmho/cm)	: 2030
TOTAL ION AMOUNT (meq/l)	: 24.72		Si(mg/l)	: ----
IONIC STRENGTH	: 0.016		B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 3.46		HARDNESS(FR)	: 29.31
Cl/(SO4+HCO3)	: 0.30		Ca/Mg	: 6.13

SAMPLE NAME : ÜNLÜ PİDE SONDAJ LAB NO :E24
DATE OF SAMPLING : 15.05.1996 TEMPERATURE(°C) : -

IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	82	3.57	0.00357	0.00357	0.0018	0.0032	0.89	35.07
K+	5	0.13	0.00013	0.00013	0.0001	0.0001	0.89	1.26
Ca++	110	5.49	0.00274	0.01098	0.0055	0.0017	0.63	53.97
Mg++	12	0.99	0.00049	0.00197	0.0010	0.0003	0.63	9.70
Cl-	167	4.71	0.00471	0.00471	0.0024	0.0042	0.89	50.45
HCO3	244	4.00	0.00400	0.00400	0.0020	0.0036	0.89	42.86
SO4=	30	0.62	0.00031	0.00125	0.0006	0.0002	0.63	6.69

TOTAL CATION AMOUNT (meq/l)	: 10.17		PH (-Log H)	: 7.41
TOTAL ANION AMOUNT (meq/l)	: 9.33		EC(mmho/cm)	: 1700
TOTAL ION AMOUNT (meq/l)	: 19.50		Si(mg/l)	: ----
IONIC STRENGTH	: 0.013		B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 1.98		HARDNESS(FR)	: 32.38
Cl/(SO4+HCO3)	: 1.02		Ca/Mg	: 5.56

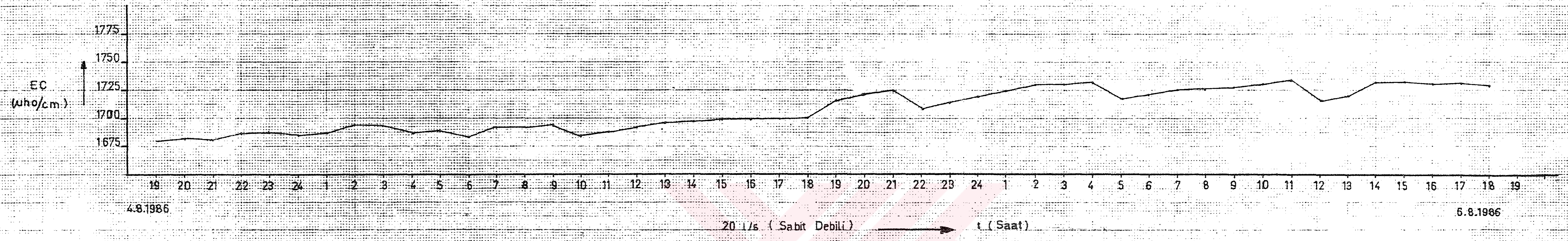
SAMPLE NAME : YENİ DOSTLAR KESON							LAB NO :E25	
DATE OF SAMPLING : 15.05.1996							TEMPERATURE(°C) : -	
IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	297	12.92	0.01292	0.01292	0.0065	0.0106	0.82	36.20
K+	7	0.18	0.00018	0.00018	0.0001	0.0001	0.82	0.50
Ca++	357	17.81	0.00891	0.03563	0.0178	0.0040	0.45	49.93
Mg++	58	4.77	0.00238	0.00954	0.0048	0.0011	0.45	13.37
Cl-	903	25.46	0.02546	0.02546	0.0127	0.0209	0.82	74.41
HCO3	378	6.20	0.00620	0.00620	0.0031	0.0051	0.82	18.11
SO4=	123	2.56	0.00128	0.00512	0.0026	0.0006	0.45	7.48

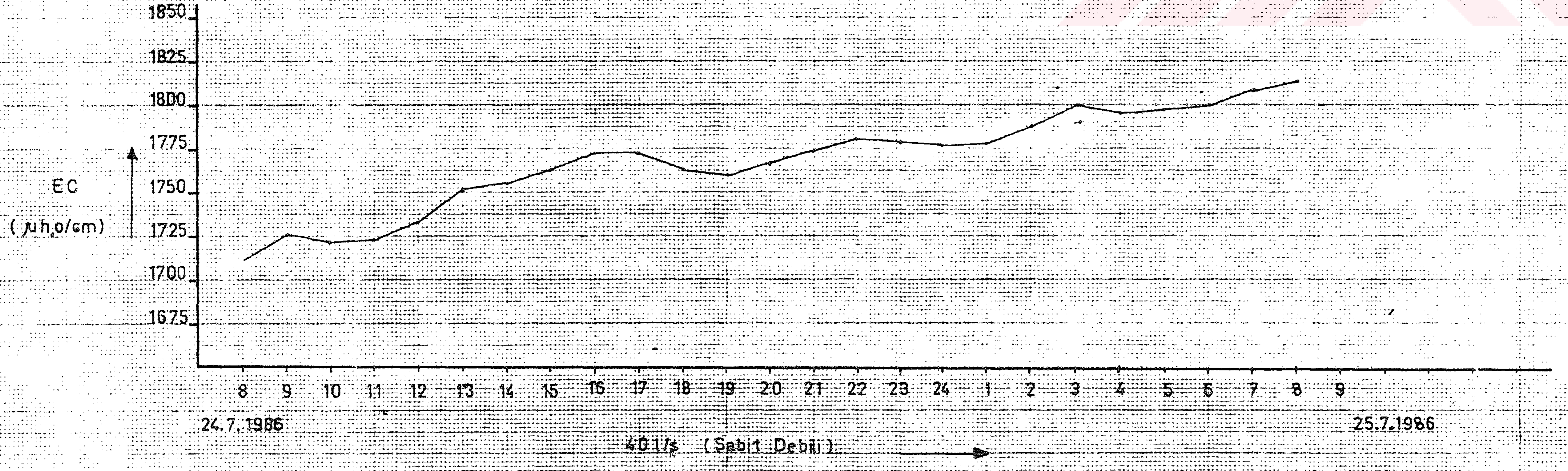
TOTAL CATION AMOUNT (meq/l)	: 35.68	PH (-Log H)	: 7.17
TOTAL ANION AMOUNT (meq/l)	: 34.22	EC(mmho/cm)	: 5530
TOTAL ION AMOUNT (meq/l)	: 69.90	Si(mg/l)	: ----
IONIC STRENGTH	: 0.048	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 3.84	HARDNESS(FR)	:112.92
Cl/(SO4+HCO3)	: 2.91	Ca/Mg	: 3.73

SAMPLE NAME : GERMİYAN CAMİ SONDAJ							LAB NO :E26	
DATE OF SAMPLING : 15.05.1996							TEMPERATURE(°C) : -	
IONS	mg/l	meq/l	mol/l	CZ2	.5CZ2	AC	F	%
Na+	75	3.26	0.00326	0.00326	0.0016	0.0029	0.88	26.61
K+	10	0.26	0.00026	0.00026	0.0001	0.0002	0.88	2.09
Ca++	157	7.83	0.00392	0.01567	0.0078	0.0023	0.59	63.91
Mg++	11	0.90	0.00045	0.00181	0.0009	0.0003	0.59	7.38
Cl-	215	6.06	0.00606	0.00606	0.0030	0.0053	0.88	49.79
HCO3	317	5.20	0.00520	0.00520	0.0026	0.0046	0.88	42.69
SO4=	44	0.92	0.00046	0.00183	0.0009	0.0003	0.59	7.52

TOTAL CATION AMOUNT (meq/l)	: 12.26	PH (-Log H)	: 7.60
TOTAL ANION AMOUNT (meq/l)	: 12.17	EC(mmho/cm)	: 2160
TOTAL ION AMOUNT (meq/l)	: 24.43	Si(mg/l)	: ----
IONIC STRENGTH	: 0.017	B+++(mg/l)	: ----
SAR (SODIUM AD.RATIO)	: 1.56	HARDNESS(FR)	: 43.69
Cl/(SO4+HCO3)	: 0.99	Ca/Mg	: 8.66

GRAFİK :4





ILDIRI RESOURCE WELLS
(B/35 34494) TIME ELECTRIC
CONDUCTIVITY GRAPF

APPENDIX 2.2
(DSİ)