ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

SEDIMENTOLOGY OF MIO-PLIOCENE AGE SEDIMENTS IN THE VICINITY OF ÇERKEZKÖY, THRACE BASIN: FINDINGS RELATED TO MESSINIAN SALINITY CRISIS.

M.Sc. THESIS

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Geological Engineering Programme

DECEMBER 2016

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

TRAKYA HAVZASI, ÇERKEZKÖY VE CİVARINDA MİOYOSEN-PLİYOSEN YAŞLI ÇÖKELLERİN SEDİMANTOLOJİSİ. MESSİNİYEN KRİZİNE AİT BULGULAR.

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To my family,

FOREWORD

This study has been accomplished in Geological Engineering Department of Istanbul Technical University in Graduate School of Science and Engineering , under the title of `Sedimentology of Mio-Pliocene sediments in the vicinity of Çerkezköy,Thrace Basin. Findings Related to Messinian Salinity Crisis` in 2015-2016.

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ABBREVIATIONS

DSDP	**:** Deep Sea Drilling Project
EMCOL	**:** Eastern Mediterranean Centre for Oceanography and Limnology
MES	**:** Messinian Erosional Surface
MSC	**:** Messinian Salinity Crisis
MTA	**:** Maden Tetkik Arama ve Genel Müdürlüğü

SYMBOLS

m	**:** Meter
ϕ	**:** Grain-size based on Wentworth (1922) scale
km	**:** Kilometer

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SEDIMENTOLOGY OF MIO-PLIOCENE SEDIMENTS IN THE VICINITY OF ÇERKEZKÖY, THRACE BASIN: FINDINGS RELATED TO MESSINIAN SALINITY CRISIS

SUMMARY

Sedimentology and petrography of Mio-Pliocene sediments around Çerkezköy is studied within the context of this project. For this purpose, several field trips to Karacaköy, Karamandere and Akpınar village were arranged to reveal the evolution of fluvial environment and locate findings related to Messinian Salinity Crisis.

Stratigraphic field investigations on the eastern side of Strandja Sill in Karacaköy together with other climatic evidences, reveals that fluviodeltaic sediments of Ergene formation were deposited during the Late Miocene-Pliocene age. Strandja Sill is considered a marine gateway between Eastern Paratethys and Mediterranean during the Messinian Salinity Crisis, however fluvial erosion in Karacaköy combined with Messinian erosional surface in the southwestern part of the Black Sea denied this theory regarding possible marine gateway through the Strandja Sill. Significant fluvial erosion in Karamandere paleogorge and prograding deltaic system in offshore Black Sea show the occurrence of fluvial network in Karacaköy during the Late Miocene. On the other hand, Messinian dessication event may have caused the sea-level lowering of Black Sea, as suggested by the presence of paleovalley in downslope offshore Bosphorous. Present-day Karamandere River is too small to account for accumulated great amount of sediments, because of its restricted catchment area. Therefore, Ergene Fluvial Network is suggested to provide sediments deposited in the Messinian valley during the Messinian Salinity Crisis.

The study area is situated within Karacaköy, Karamandere and Akpınar villages on the northern part of Istanbul. In the study area, five exposed outcrops of the Ergene Formation were studied and sampled during the fieldtrip. During the field studies, each outcrop was sketched for sedimentary facies analysis in terms of geometrical properties and stratigraphical relationship of the sedimentary units of the Ergene Formation. Apart from stratigraphy of depositional units, for the description of lithological properties of the examined outcrops, we collected twenty-two samples for sieve and petrographic analyses in this study. Using sieve analysis, we examined lithological changes in detail through the vertical outcrop sections and related those changes to fluvial regime of the sedimentary unit and sediment sources. Together with lithology, studying macroform architectures of the sedimentary units reveals that the studied outcrops were presumably deposited by the gravelly low sinuosity channels in a fluvial depositional setting based on Yuanquang`s classification. For the provinence studies, we performed petrographic analysis on 12 samples taken from the outcrops and one sample from the present-day sediment of Maritsa River. The similarities on mineral compositions and sedimentary textures of fluvial sediments of Ergene Formation in Karacaköy region suggest that the fluvial sediments were transported by

a paleo-Maritsa River, prevailing since upper Miocene-Pliocene in the Trace Basin. They suggest that mineralogical compositions of the analysed samples from Karacaköy region, the source rocks of the paleo-river are mainly from basement rocks of the Strandja Sill, Tekerdere Formation. Sediments from Karamandere was sourced from Kırklareli plutonic rocks of basement of Strandja Sill. On the other hand, the same petrographic analysis on the outcrop samples from Akpınar region suggests that the Pliocene sediments were sourced mainly from the Tekedere Formation of the Strandja Sill, consisting of schists, gneisses, quartzite.

Miall`s architectural element classification along with Friend`s channel classification were referred to interprete the sedimentary facies. For grain size classification of samples, Folk`s (1974) grain-size nomenclature was used.

TRAKYA HAVZASI, ÇERKEZKÖY VE CİVARINDA MİOYOSEN-PLİYOSEN YAŞLI ÇÖKELLERİN SEDİMANTOLOJİSİ: MESSİNİYEN KRİZİNE AİT BULGULAR

ÖZET

Bu yüksek lisans tezi kapsamında Trakya'da Karacaköy, Karamandere ve Akpınar köyleri civarında, Üst Miyosen-Pliyosen yaşlı çökellerin sedimantolojisi ve petrografik doku özelliklerinin yanı sıra, Messiniyien Krizine ait bulgular belirlenmiştir. Çalışma alanı Türkiye'nin kuzey-batısında bulunan Trakya'nın kuzey-doğusunda, Istranca Masifi dolaylarında ve Karadeniz kıyısında yer almaktadır. Trakya havzası, Türkiye'nin Orta Eosen`de oluşmuş en büyük Tersiyer havzalarından biridir ve petrol, doğal gaz ve kömür içerdiği için yer bilimcileri tarafından kapsamlı bir şekilde incelenmiştir. Trakya havzası, çökelme ortamlarının mevkilerine göre, dört coğrafik bölgeye ayrılabilmektedir. Bunlar: Güney şelf, Orta Bölge, Kuzey şelf ve Kuleli yükselimidir. Araştırma alanı Trakya Havzası'nın Kuzey şelfinde yer almaktadır. Bu çalışma kapsamında Karacaköy, Karamandere, Akpınar köylerinde arazi çalışmaları gerçekleştirilmiştir. Yapılan arazi çalışmalarında Miall klasifikasyonuna dayanılarak litofasiyesler tanımlanmış, makroform ve mesoform yapıları ayırtlanarak akarsu ortamının evrimi ve çökelme ortamındaki değişiklikler tespit edilmiştir. Bu çalışma sonucunda arazide akarsu sisteminde gözlemlenen değişiklikler, Üst Miyosen-Pliyosen zamanı bölgede hakim olduğu söylenilen Ergene-Maritsa paleonehri ve Karadeniz'i etkisi altına alan Messiniyen Kriziyle karşılaştırılmıştır.

Ergene Formasyonu araştırma alanının büyük bir kısmında yüzeylenmekte olup, acı sulu göl ve akarsu ortamında çökelmiş çakıl, kumtaşı, silttaşı, miltaşından ibarettir. Ergene Formasyonu yapılan önceki jeolojik çalışmalarda Trakya havzasında Çekmece grubu hariç olmak üzere Ganosdağ-Hisarlıdağ-Korudağ yükseliminin kuzeyinde kalan Miyosen sedimanter birimleri kapsamaktatır. Çalışma alanında gözlenen bu formasyon Üst Miyosen-Pliyosen yaşındadır. Istranca Masifine ait temel ve örtü kayalar, araştırma alanının batısında yüzeylenmektedir. Proje kapsamında çalışma alanından Ergene Formasyonu'na ait 5 mostra incelenmiş ve dikey stratigrafik kesitlerde makroform ve mesoform yapılar belirlenmiştir. Belli mostralardan alınan örnekler ile İstanbul Teknik Üniversitesi Genel Jeoloji Laboratuvarında kuru elek analizi gerçekleştirilmiş, yoğun silt ve kil içeren örneklerde ise calgon ile solüsyon haline getirilerek İstanbul Teknik Üniversitesi EMCOL laboratuvarında tane-boyu analizi yapılmıştır. Bu çalışmada, Ergene Formasyonu'nu oluşturan flüvyal çökellerden alınan düşey ölçülü stratigrafik kesitlerde Miall (1985)`ın kırıntılı kayaçlarda belirlediği fasiyes sınıflaması uygulanmıştır ve mostradan alınan örnekler üzerinde Folk (1974)`un tane boyu sınıflaması yapılmıştır. Flüvyal çökellerde belirlenen makroform ve mesoform yapıların oluşturduğu yapısal ve jeometrik özellikler ayrıntılı olarak araştırılmıştır.

Trakya'nın Karadeniz kıyı şeridi boyunca uzanan metamorfik kaya topluluğunun Istranca Masifi olduğu bilinmektedir ve araştırma alanı Istranca Masifi'nin kuzey doğusunu kapsamaktatır. Istranca Masifi, Triyas öncesi bir temel kayadan ve bu temelin üzerine çökelen Triyas-Jura yaşlı karasal ve sığ denizel karakterli metasedimenter kayalardan oluşmaktadır. Triyas-Jura yaşlı sedimenter kayalar, Geç Jura ve Erken Kretase'de yeşilşist fasiyesinde metamorfizma ve sıkışmalı bir deformasyon geçirmiştir. Temel kayalar, amfibolit fasiyesinde başkalaşıma uğrayarak granatlı şist, biyotitli şist, amfibolit ve amfibolit şistten oluşmaktadır. Triyas-Jura metasedimenter örtü kayaları kaba taneli kırıntılılardan, ince taneli metaklastik kayalardan ve karbonatlardan oluşmuştur.

Istranca Masifi'nin Messiniyen Krizi zamanında Karadeniz'i Akdeniz'e bağlayan denizel koridor olduğu düşünülmüştür. Fakat Karamandere'de yüzeyleyen erozyonel yüzey ve Karadeniz açıklarında sismik kesitlerinde gözlenen Messiniyen paleovadisi, Istranca Masifi'nin denizel koridor olması fikrini reddetmiştir. Daha önceki çalışmalarda Karadeniz'de Miyosen-Pliyosen sınırında bulunan sığ denizel kayaçlar Messiniyen Krizi zamanı deniz seviyesinin düşük olduğunu göstermektedir. Bunu yanı sıra, Karamandere paleoderesi, Karadeniz'de deniz seviyesinin ani düşüşü ile oluşmuştur. Messiniyen Krizi zamanında, Karadeniz'in deniz seviyesinin yükselmesinden sonra (G.Ö. 5.45 Ma) Karamandere nehri bir nehir ağzına dönüşmüştür. Karamandere nehri o zamanki Karadeniz havzasına çok miktarda klastik malzeme sağlamıştır ve bunlar güncel sismik kesitlerde delta çökelleri olarak görülmektedir. Deniz seviyesinin düşük olduğu zamanlarda bu nehir ve Karadeniz'in güneybatısındaki diğer nehirler, havzanın derin kısımlarına yoğun miktarda kaba taneli klastik malzeme taşımışlardır.

Istranca Masifi'nin doğusunda yer alan Karacaköy'de yapılan stratigrafik arazi çalışmaları sonucunda Ergene Formasyonu'na ait olan akarsu ve deltayik çökellerin Üst Miyosen-Pliyosen zamanında çökeldiği tespit edilmiştir. Karamandere'de gözlemlenen flüvyal erozyon ve Karadeniz açıklarında bulunan deltayik çökeller Geç Miyosen zamanında Karacaköy civarında bir akarsu kanalının bulunduğunu göstermektedir. Diğer yandan Messiniyen Krizi İstanbul Boğazı açıklarında Karadeniz'de bulunan sismik kesitlerde belirlenmiş olan paleovadiden göründüğü gibi Karadeniz'in deniz seviyesinin düşmesine sebep olmuştur. Paleovadiyi dolduran Pliyosen zamanına ait klastik kayaçlar kriz zamanı havzaya daha güçlü nehrin aktığını göstermektedir.

Bugünkü Karamandere nehri Karadeniz açıklarında görülen sismik kesitlerdeki paleovadiyi doldurabilecek güce sahip değildir. Karamandere nehrinin kaynağı, Meriç nehri ile birleşerek Ege Denizi'ne akan Ergene nehrinin koluna daha yakındır. Meriç nehri 480 km uzunlukta olup Yunanistan ile Türkiye'nin sınırının bir kısmını oluşturan, Bulgaristan`da doğarak Türkiye'ye giren ve Edirne üzerinden Ege Denizi'ne dökülen bir nehirdir. Önceki çalışmalarda belirtilen Ege Denizi kıyısında yer alan Enez'de bulunan zayıf flüvyal erozyon Messiniyen krizi zamanında burada daha küçük bir nehrin varlığını göstermektedir. Bu nedenle Messiniyen Krizi döneminde Ergene Flüvyal Ağı, Meriç nehrinin kaynak havzasıyla birleşerek, Karadeniz'e döküldüğü düşünülmektedir. Bu nehir hem Karamandere vadisinin kazılmasında hem de Messiniyen paleovadisinin oluşmasına katkı sağlamıştır. Karamandere'de yapılan arazi çalışmasında Meriç nehrinden ve Karacaköy mevkisinden alınmış kötü boylanmalı, masif çakıltaşı fasiyesi örnekleri mineral içeriklerine ve dokusuna göre büyük bir benzerlik göstermektedir. Bu verinin ışığında

Ergene flüvyal ağının Messiniyen zamanında (G.Ö. 5.5 Ma) Karadeniz'e döküldüğü söylenebilir.

Arazi çalışmaları kapsamında her mostranın ister jeometrik açıdan ve isterse de sedimanter birimlerin stratigrafik ilişkilerini göstermek açısından resimleri çizilmiştir. Çökelme birimlerinin stratigrafisiyle beraber incelenmiş mostraların litolojik özelliklerinin tasviri için elek analizi ve petrografik analiz için 22 örnek alınmıştır. Elek analizi Retsch markalı eleklerde yapılmıştır. Elek analizinin sonucunda litolojik değişiklikler stratigrafik dikey kesitte detaylı incelenmiştir ve bu değişiklikler flüvyal rejimi oluşturan litofasiyeslerle ve kaynak kayaçlarla ilişkilendirilmiştir. Silt ve kil içeren örneklere lazer kırınımı yöntemiyle çalışan Analysette-22 Nanotec Fritsch markalı cihazda tane-boyu analizi yapılmıştır. Elek analizinde çoğunlukla 7 elekten oluşan bir elek dizisi kullanılmıştır.

Karacaköy Bölge:1A/B,C-İstanbul ilinde Çatalca ilçesinin Karacaköy şehir merkezinin 1.5 kilometre doğusunda yer almaktadır. Karacaköy`de kırıntılı kayaçlardan oluşan Ergene Formasyonu mostra vermektedir. Karacaköy Mostra-1A-da 8m-ye ulaşan sedimenter istif ölçülmüş ve elek analizi ve petrografik analiz için 9 örnek alınmıştır. Arazide gözlemlenen kanalların geometrik özelliklerine göre duraylı (fixed) multistorey ribbon kanallar olduğu tespit edilmiştir. Uzununa ve yanal barlar sedimenter istifte reaktivasyon yüzeylerinde gözlenebilmektedir. Ayrıca bölgede rastlanan silisleşmiş ağaçlar Üst Miyosen-Pliyosen zamanında Karadeniz ve çevresindeki ılıman bir iklimin varoluşunu göstermektedir.

Karamandere, Bölge:2-İstanbul ilinde Çatalca ilçesinin Karacaköy şehir merkezinin 2.55 kilometre batısında yer almaktadır. Karamandere mevkiinde fasiyes analizi için yalnız bir mostradan ölçülü stratigrafik kesit alınmıştır. Mostrada 6.5 metreye kadar sedimanter kesit ölçülmüş ve her fasiyesi temsil edecek şekilde 5 örnek alınmıştır. Sedimanter istif üste doğru kabalaşan bir tane boyu stratigrafisi göstermektedir. Mostranın en üst yüzeyinde yer alan masif, kötü boylanmalı, fakir imbrikasyon gösteren çakılların ephemeral yaygı-düzlüğü rejiminde çökeldikleri belirlenmiştir. Karamandere'de gözlemlenen litofasiyesler Üst-Miyosen-Pliyosen zamanında bölgede gelişmekte olan akarsu sisteminin kazıma süreci (Entrenchment-Phase) ile eş zamanlı meydana gelmektedir.

Akpınar Bölge :3 İstanbul ilinin Eyüp ilçesinde Karadeniz kıyısından birkaç kilometre uzaklıkta yer almaktadır. Akpınar mevkisinde Ergene formasyonu Danışmen Formasyonu üzerinde yüzeylenmektedir. Mostranın en üst yüzeyinde yanal olarak 50 metreye kadar gelişmiş bir kanal birimi gözlenmiştir. Akpınar'da sedimanter istiften 8 örnek alınmıştır. Ardalanmalı kumtaşı ve kil seviyeleri mostrada görülebilmektedir. Kum seviyeleri kanalları, kil seviyeleri ise taşkın ovasını temsil etmektedir.

Bu inceleme sonucunda Karacaköy`de rastlanan kanallar az sinüslü akarsu kanallarına atfetilmektedir. Karamandere`de ise gözlemlenen kum-yaygılı çökeller de kanallanma gelişmemiş ve çökeller akarsu yatağında geniş alanlara dağılarak kumtaşı yaygılarını oluşturmuşlardır. Akpınar'da örgülü nehir çökellerine rastlanmaktadır.

Kaynak kaya çalışması için Karacaköy, Karamandere, Akpınar'dan alınan örnekler ve Meriç nehrinden alınan örnekler üzerinde petrografik analiz yapılmıştır. Örneklerin mineral içeriği ve dokusu, petrografik özellikleri tespit edilmiştir. Karacaköy'de rastlanan Ergene Formasyonu'ndaki flüvyal çökellerin sedimanter dokusundan ve mineral içeriğindeki benzerliklerden yola çıkarak flüvyal çökellerin Üst Miyosen - Pliyosen zamanında Ergene flüvyal ağı ve Paleo-Meriç nehri tarafından taşındığı belirlenmiştir. Karacaköy ve Karamandere`den alınan örnekler sub-litikarenit olarak sınıflandırılmıştır. Akpınar'dan alınan örnekler ise sublitikarenit ve litikarenittir. Karacaköy`den alınarak incelenmiş örneklerin mineral içeriği kaynak kayanın Istranca Masifini teşkil eden temel kayaçlarından oluşturan Tekedere Formasyonu olduğu ileri sürülmüştür. Karamandere`den alınan örnekler ise Kırklareli Grubuna ait plutonik kayaçlardan kaynaklanmaktadır. Diğer yandan Akpınar köyünden alınmış örneklerin petrografik analizi Pliyosen yaşlı kayaçların Istranca masifinin temel kayaçlarını teşkil eden biotit şist, granatlı şist, amfibolit şistten kaynaklandığını göstermektedir.

1. INTRODUCTION

The existence of Ergene fluvial network in the Thrace basin is studied within the context of Messinian Salinity Crisis (MSC), which affected both the Black Sea and Mediterranean Sea basins during the Late Miocene age (Suc et al.,2015). As a consequence of Messinian Salinity Crisis, significant sea-level fall in the Mediterranean Sea gave rise to formation of evaporates in marginal and deep basins, associated with erosional surfaces throughout the shelves (Hsü et al., 1973). The impact of the Crisis continued with refilling of the flooded Messinian canyon heads and Gilbert deltas during the Pliocene (Clauzon et al.,1995; Hsü et al.,1973). Recent findings from cores drilled in Black Sea by Deep Sea Drilling Project (DSDP) reveal that the basin experienced significant sea-level fall at the end of Messinian (Gillet et al., 2007). In the context of Mediterranean Messinian Salinity Crisis model, sea-level fall of Black Sea is estimated to be 1600 m, due to evaporation (Hsü et al.,1973). In the wake of the crisis, marine transgressions termed as Zanclean reflooding, occurred in both Black Sea and Mediterranean Sea basins.

Recognition of large deltaic infill over deep Messinian valley on seismic sections associated with fluvial incision found in Karamandere village led to the theory of existence of strong river coinciding with Messinian Salinity Crisis (MSC) in the Thrace basin. At present, Karamandere River which flows toward Black Sea could not been responsible for Messinian valley evident in multichannel seismic profiles. On the other hand, 480 km long Maritsa River with its tributary Ergene River flows on the opposite course into the Aegean Sea. Smaller scale Messinian fluvial cutting and thin marine reflooding sedimentary sequences on the coast of Aegean Sea illustrates that just small river would have appeared there during the Messinian Salinity Crisis. Therefore, Maritsa River with its tributary Ergene River is proposed to direct towards the Black Sea during the peak of MSC (5.5Ma). To test this hypothesis, field investigations of Messinian erosional surface have been documented in the vertical sequences of Karacaköy, Karamandere, Akpınar villages. For the purpose of provenance determination, mineral composition and texture of rock samples recovered from outcrops, are studied under plane polarized microscope.

1.1 Purpose of Thesis

The goal of this thesis is to discuss the evolution of the Ergene fluvial network following the Messinian Salinity Crisis and determine the source of the Late Miocene-Pliocene fluviodeltaic sediments in the Karacaköy area. For this study, three-day fieldtrip was organized to localities such as Karacaköy, Karamandere and Akpınar. To construct sedimentology and stratigraphy, and sedimentary facies analysis of the sections, the samples were colected from each outcrop for further sieve, grain-size and petrographic analyses.

1.2 Previous Studies about the Thrace Basin

Thrace basin is studied extensively for its hydrocarbon potential by General Directorate of Mineral Research and Exploration (MTA) and Türkiye Petrolleri A.O.(TPAO). Firstly, Lebküchner (1974) in a paper `The Geology of Oligocene sediments of central Thrace basin`referred to his studies within the region at different times between 1957 and 1969. Fossil coverage and age of the unit named as a lignitic sandstone formation by Lebküchner, as well as regional geology are presented at length in this paper published by Mineral Research and Exploration (MTA). Doust and Arıkan (1974) covered at length the geology and hydrocarbon potential of Thrace Basin in the article `The Geology of the Thrace Basin`. They divided the basin into four sedimentary provinces. Küçükkaptan (1982) in his review paper, included drilling results by Mineral Research and Exploration (MTA) and Türkiye Petrolleri Anonim Ortaklığı (TPAO), General Directorate of State Hydraulic Works (DSİ) and İlbank A.Ş. Turgut and others. (1991) explained the petroleum potential of Thrace basin by linking it to the sedimentary and tectonic evolution of the basin. Görür (1996) proposed a fore-arc origin for Thrace basin by linking it to the Intra-Pontide subduction zone. Kara and others. (1996) discussed the general geology of Thrace Basin by listing significant coal deposits of Thrace basin in a separate chapter. Siyako (2005) in a report, `Tertiary Stratigraphy of Thrace basin and its surroundings` reviewed all Tertiary age units in detail. As a result, `Tertiary Stratigraphy of Thrace Basin` has been presented by benefitting from great part of studies accomplished by General Directorate of Mineral Research and Exploration (MTA) and General Directorate of State Hydaulic Works (DSİ). This report formed a basis for the journal `Turkey Stratigraphy Commitee Lithostratigraphy Series-2` published by General Directorate of Mineral Research and Exploration (MTA) on the basis of conference `Lithostratigraphy Nomenclature of Thrace Region` on May 2002. The report played a significant role to end a confusion in lithostratigraphic names. Siyako (2006) studied Oligocene age Osmancık Formation by renaming it `Lignitic Sandstone` in his paper `Lignitic Sandstones of Thrace Basin`. Islamoğlu and others. (2007) presented different palaeogeographic stages for Thrace basin with regards to its position in Tethys domain by studying pollen spectra of region. Strandja Sill which borders the Thrace Basin in the north-east, was studied within the context of Messinian events and its role to be marine gateway during the peak of Messinian Salinity Crisis (MSC) (Suc et al., 2015). However, this hypothesis has been denied on the basis of findings, such as fluvial erosion in the south of Karacaköy and delayed arrival of Mediterranean microorganisms (Suc and others, 2015). On the other hand, Balkans corridor has been suggested as a marine gateway, which enabled exchange of water mass between Mediterranean Sea and Eastern Paratethys (Suc and others., 2015). Evidences of the Messinian fluvial erosion in the Karamandere palaeogorge implies that there must have been a river incision during the Messinian Salinity Crisis (MSC). This allows us to conclude that the Ergene fluvial network with a catchment of the Maritsa River may have flown to the Black Sea at the peak of MSC (Suc and others., 2015).

1.3 Messinian Salinity Crisis (MSC)

Messinian Salinity Crisis (MSC) was a geological event in which Mediterranean Sea was largely dessicated during the Messinian age, lasting from 5.96 to 5.36 Ma. It is finished by the Zanclean flood, when the marine waters of Atlantic ocean entered the Mediterranean Sea. Black sea together with Mediterranean Sea experienced a dessication at the end of the Messinian age, as a result of Messinian Event. Hsü et al. (1979) firstly proposed the Messinian draw-down phase of Black Sea, which is recognized from shallow water siliciclastics found in cores of Deep Sea Drilling Project (DSDP) wells 380 and 381. In addition, Messinian sea-level drop of Black Sea is estimated to be 1600 m below the sea level, because of occurrence of shallow water clastics at the Miocene-Pliocene boundary in the Black Sea (Hsü and Giovanali, 1979). However, Tari et al. (2007) suggested that the magnitude of the sea-level drop in the Black Sea was less severe than that of Mediterranean Sea, according to long-offset seismic reflection data. As a result of MSC, base-level fall in the Black Sea caused substantial re-sedimentation and deposition of lowstand systems tract sediments (Suc et al.,2015). Hydrocarbons can be trapped in these sedimentary sequences. Modern oil discoveries in the Eastern Mediterranean and the Black Sea have proved this hypothesis (Suc et al.,2015).

Mediterranean Sea dessication hypothesis is commonly adopted, whereas lacking Messinian erosional surface in the Black Sea limited the hypothesis of Messinian dessication of the Black Sea basin at present. High resolution multichannel seismic data of BlaSON survey revealed the erosional surface corresponding to the top of Late Miocene shallow water environment observed in DSDP well 381 (Figure 1.3.1). Lower Zanclean unit overlies the erosional surface and dates it as the Messinian event. Apart from recently discovered inland erosional feature, the wide regional erosional surface on the western Black Sea proves the Black Sea Messinian dessication hypothesis (Gillet et al., 2007). In addition, BlaSON 1 and BlaSON 2 surveys have discovered erosional surfaces in numerous seismic proviles (Gillet et al., 2007). Major erosional surface was assigned to significant sea-level fall in the Black Sea, as a result of Messinian Salinity Crisis in the Mediterranean Sea. This explanation is confirmed by stratigraphic subdivision of the well such as Karadeniz 1 well in the Black Sea.

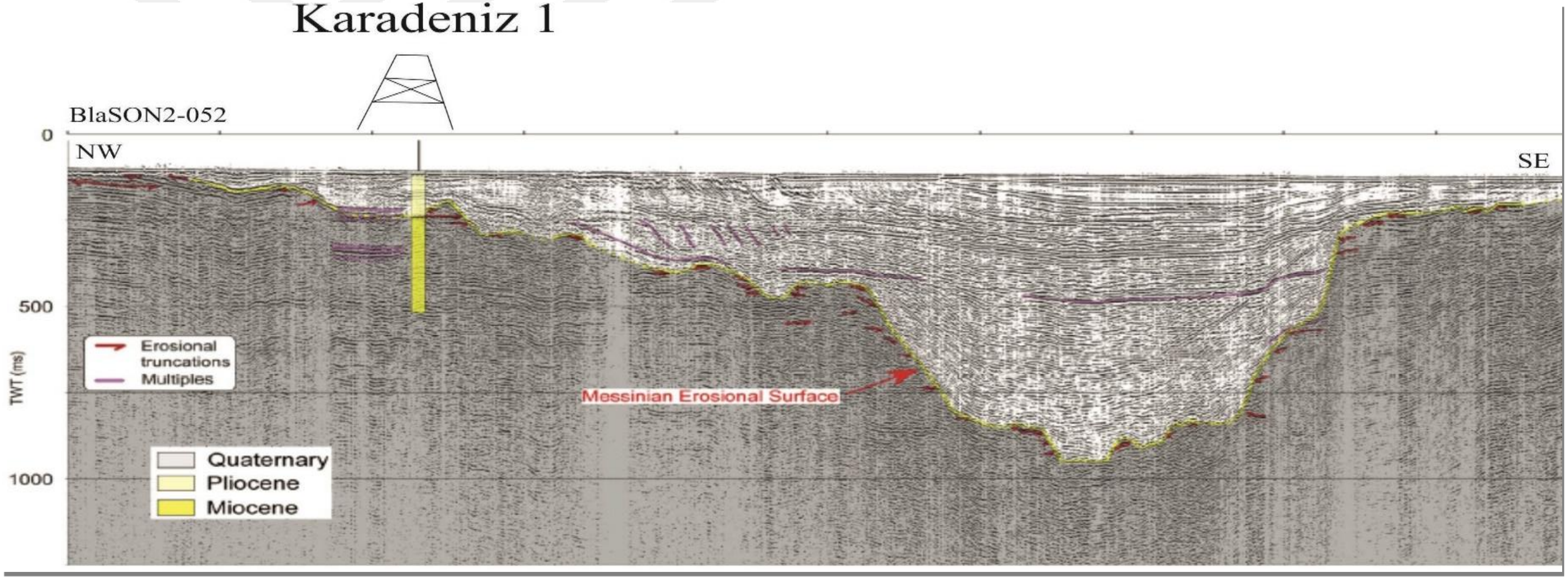


Figure 1.3.1 : Messinian erosional surface from seismic profile BlaSON2-052.

1.4 Study Area

Our study area is located in the northeastern part of the Thrace region. Study area is bordered to the north and north-east by the Black Sea, to the west by Çerkezköy, Saray, Silivri districts of Istanbul Province, Turkey (Figure1.4.1). As a part of the research, a fieldtrip to the area was organized in order to examine the stratigraphy and sedimentology of the Mio-Pliocene outcrops. In the study area, three main localities were chosen. These are Karacaköy, Karamandere and Akpınar villages. The Area-1 Karacaköy is 1,5 km away from center of the Karacaköy town. It can be reached using D020 state road of Istanbul to the northwest direction. The distance from Ayazağa Campus of Istanbul Technical University (ITU) to the Area-1 is about 86 km, and it is 2.5 kilometres far away from the the Black Sea shore of Istanbul.

The Area-2 lies in the west of Karacaköy town and is 2.55 km away from the city centre. Both Area -1 and -2 are close to the each other, therefore, the same route was followed to get these localities. Unconsolidated rocks of the Ergene Formation were exposed on both sides of road to the Karacaköy village. Vegetation cover is moderate to rich.

The Area-3 is located in the Akpınar village, Eyub District of Istanbul Province. It is 34,2 km away from ITU Maslak Campus. The area is currently exploited for coal deposits.

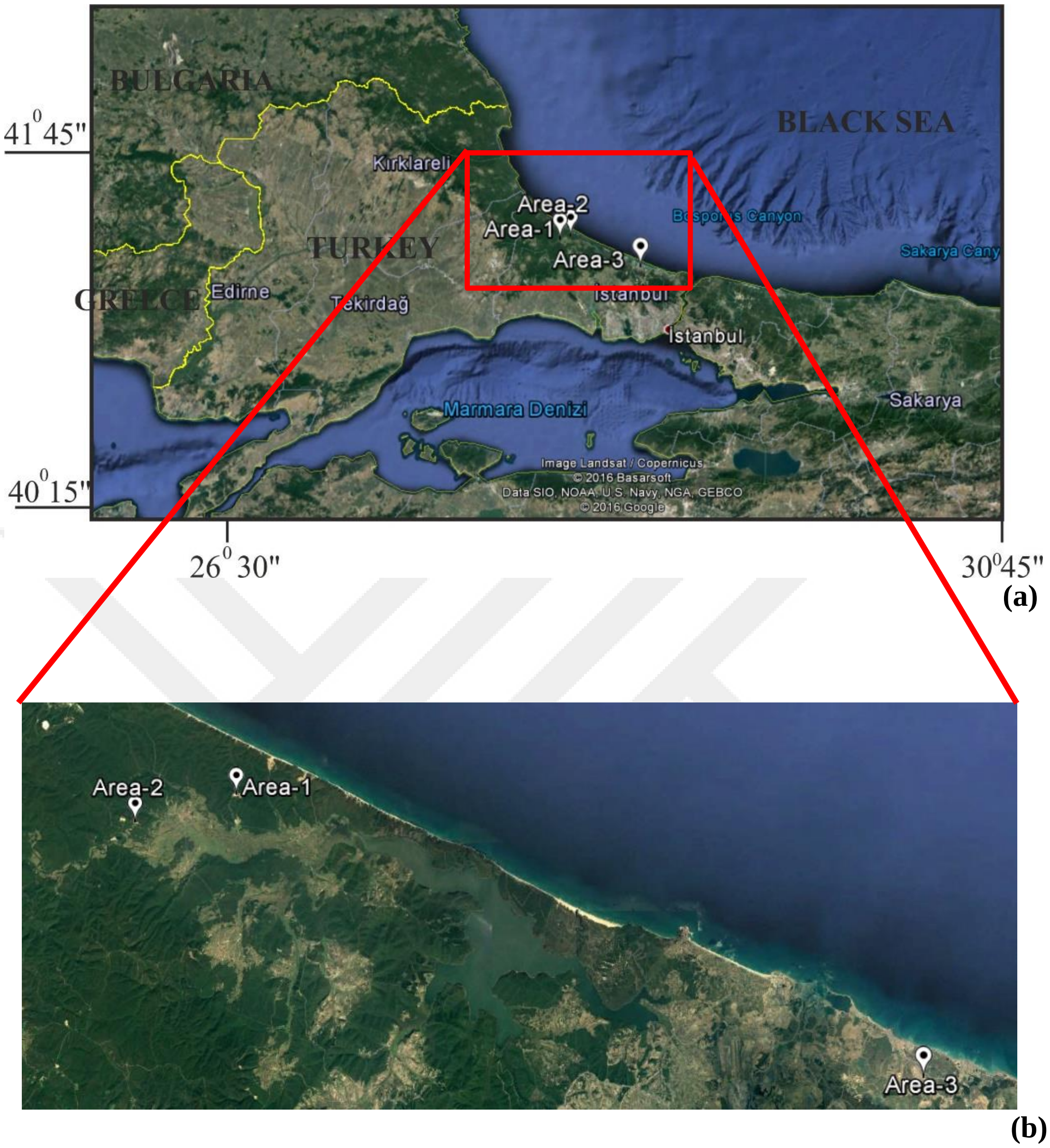


Figure 1.4.1 : (b) Location of study area in the Image LandSat view of Thrace region, Turkey (a).

1.5 Climate of the Study Area

Study area is located on the southwestern shores of Black Sea, therefore Black Sea climate is dominant in the study area. Landlocked Black Sea basin is located between Eastern Europe and Western Asia bordered by Bulgaria, Georgia, Romania, Russia, Ukraine, Turkey. It spans 1,175 km in east-west direction. Black Sea is the residual basin of Tethys Ocean, dating from 200 to 50 million years ago. It is formed during the Palaeocene epoch, when structural upheavals in Anatolia separated Caspian Basin from the Mediterranean Basin. Black Sea region has an oceanic climate (Köppen climate classification :Cfb); with high evenly distributed rainfall round. At the coast, summers are warm and humid, and winters are cool and damp. Apart from that, Black Sea coast receives the greatest amount of rainfall in Turkey.

Messinian Salinity Crisis largely affected the climate of the Black Sea causing negative hydraulic budget in the Black Sea during the Upper Miocene-Pliocene age. Pollen studies helped to determine the climate changes of the Black Sea and its surroundings throughout the geological history (Hsü and Giovanali, 1979). Furthermore, Black Sea had a warm climate as shown by pollen studies during the Messinian event and the climate was subtropical up to the Upper Miocene-Pliocene age (Suc et al., 2015). Laminated carbonates, aragonites, chalks, siderite units were deposited during that time. These interbedded shallow water sediments in the deep water succession suggests the significant sea-level fall of the Black Sea during the MSC (Hsü and Giovanali, 1979). Messinian draw-down phase of Black Sea continued for 100 000 years during the Lago Mare stage of the salinity crisis (Hsü and Giovanali, 1979). The climate became cooler following Messinian epoch (5.5 Ma), as Europe experienced continental glaciation and first lacutrine chalks were deposited. The main lithologic unit deposited during the last period of oscillating climatic changes was terrigenous mud (Hsü and Giovanali, 1979).

2. GEOLOGY OF STUDY AREA

Study area is bordered by Strandja Masif to the west, Thrace Basin to the south, Black Sea to the north and east. Middle Triassic-Jurassic cover rocks of Strandja Massif consisting of phyllites, greenish grey chlorite schists, calcschists, marble and metabasic rocks have large exposures in the study area, particularly around Area-1 and Area-2. Metagranite rocks of Kırklareli Group also crops out next to the Triassic-Jurassic cover rocks of the Strandja Massif. Thrace Basin is one of the largest Tertiary basins in Turkey.

Middle to Upper Eocene Soğucak Formation occurs at the foot of Strandja Massif in the southeastern part of our study area. Ceylan Formation, which is Upper Eocene-Lower Oligocene age occupies wider area between Terkos Lake in the north and Çekmece Lake in the south. Sedimentary successions related to Ergene Formation is sketched for depiction of lithofacies. In Area-1 and Area-2, Upper Miocene-Pliocene age Ergene Formation constitutes unconsolidated sandstone, gravel, siltstone and claystone (Işıker et al., 2002). In Area-3, Pliocene age rocks were assigned to Ergene Formation (Çağlayan and Yurtsever, 2002). In addition, Ergene Formation rests conformably on Danişmen Formation in this locality.

Ergene Formation is the main lithology in all localities which are studied in this project. This formation is deposited in fluviolacustrine environment and has a widespread distribution in the center of the Thrace Basin.

1:500 000 scale geological map of Turkey produced by General Directorate of Mineral Research and Exploration (MTA) was used in this study (Figure 2.1)

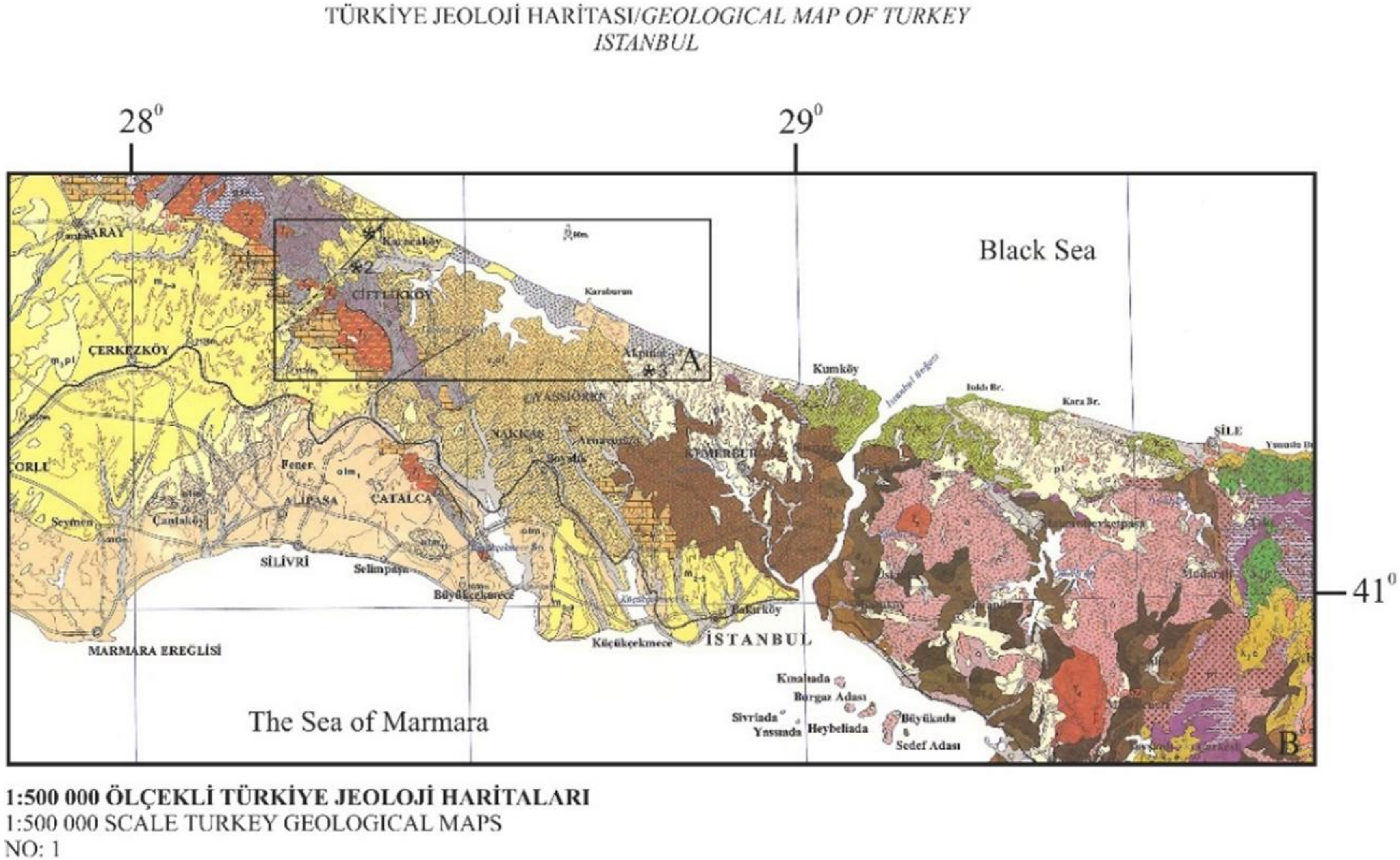


Figure 2.1 : (B) Geological map of study area, (A) *1, *2 ,*3 refers to localities Area-1, Karacaköy; Area-2, Karamandere; Area-3, Akpınar.

LEGENDS

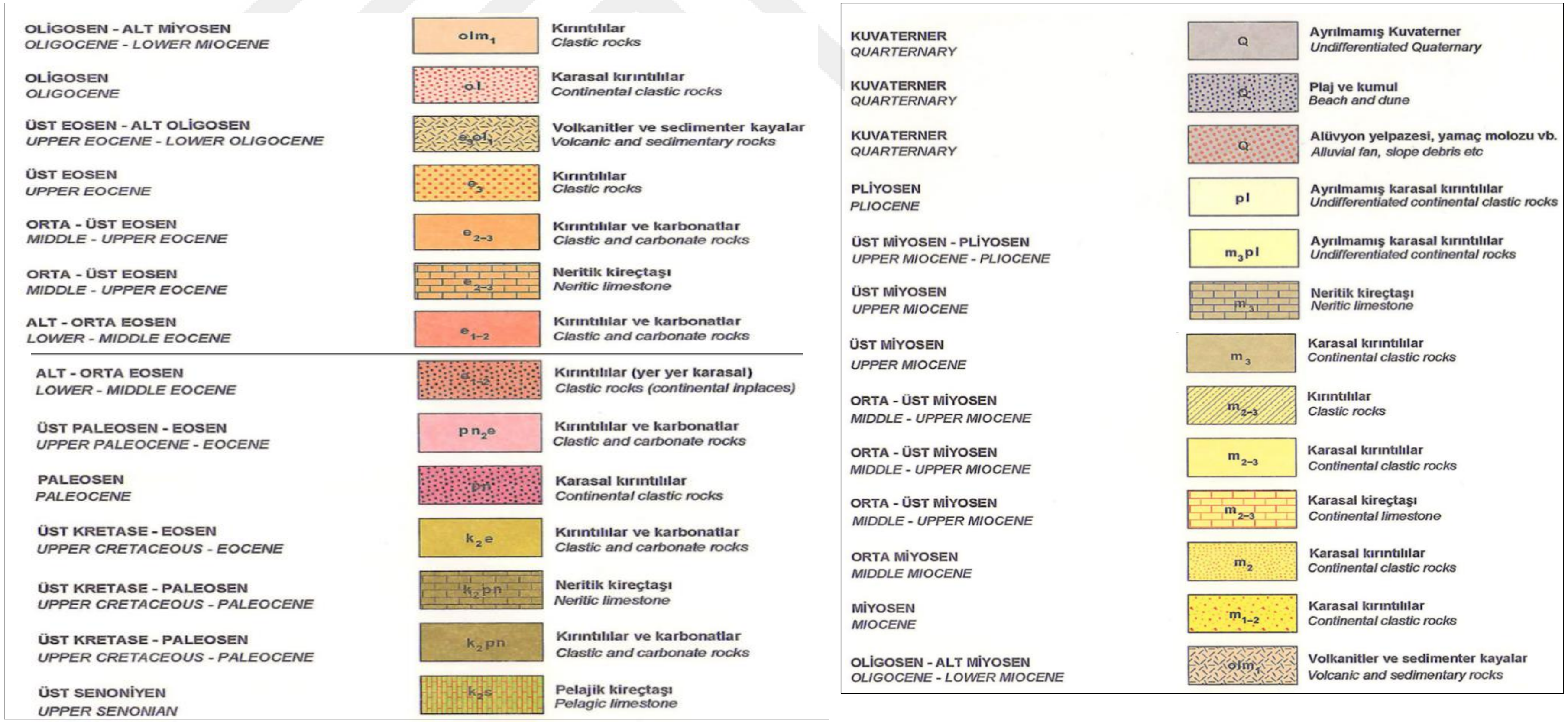
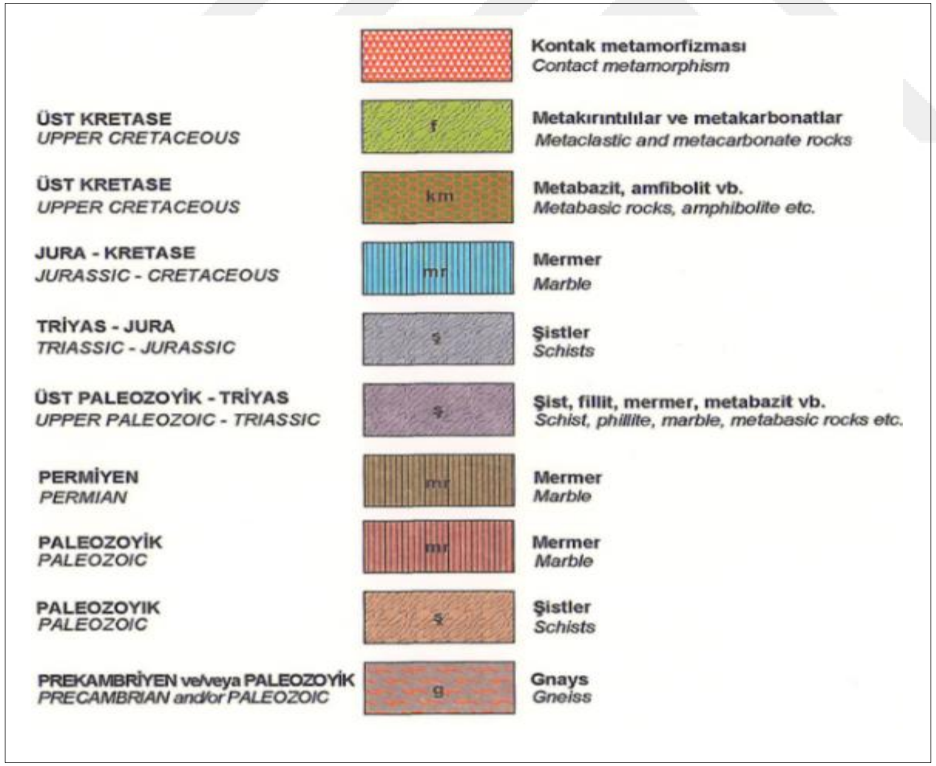


Figure 2.1 (continued): (B) Geological map of study area. (A) 1*, 2*, 3* refer to localities Area-1, Karacaköy; Area-2, Karamandere; Area-3, Akpınar.

Metamorphic Rocks	Plutonic Rocks



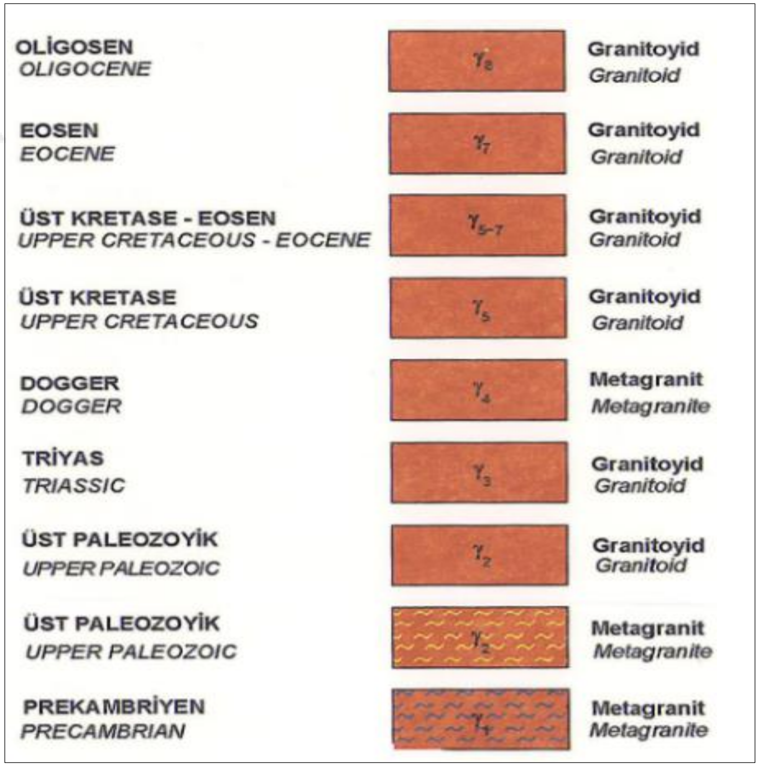


Figure 2.1 (continued): (B) Geological map of study area. (A) 1*, 2*,3* refer to localities Area-1, Karacaköy; Area-2, Karamandere; Area-3, Akpınar.

2.1 Strandja Sill

The northwestern part of our study area is dominated by the Palaeozoic age rocks of the Strandja Sill (Figure 2.1.1). Metamorphic rocks of Strandja Sill extends from Çatalca district of Istanbul to Bulgarian border with a width of 25-30 kilometers and length of 200 kilometers (Siyako et al, 2006). In addition, it has also a wide distribution in Bulgaria. As a result of studies on both bulgarian and turkish sides, it has been found that the Strandja Sill comprises a Paleozoic basement and unconformably overlying Triassic-Jurassic metasedimentary cover (Siyako et al, 2006). The basement rocks of Ordovician-Carboniferous constitutes a metamorphic rocks metamorphosed in amphibolite, upper greenschist facies conditions and intrusions of Late Palaeozoic granitoids (Siyako et al, 2006). Continental and shallow marine Triassic-Jurassic sedimentary rocks, which overlies this basement were metamorphosed in greenschist facies during the Late Jurassic to Early Cretaceous with compressional tectonics. Metamorphism at the Late Jurassic to Early Jurassic as well as compressional deformation affected inherently the basement rocks of Strandja Sill. Metamorphic rocks of Strandja Sill is overlain with unconformity by volcanic sedimentary succession starting to deposit at Cenomanian age (100.5-93.9 Ma) and have emplacements of Late Cretaceous intrusive rocks. Crystalline rocks of Strandja Massif is divided into three rocks: medium to high grade metamorphic rocks of basement of Strandja Sill; plutonic rocks of basement; Triassic-Jurassic metasedimentary cover (Siyako et al, 2006). The main source with regard to nomenclature of Strandja Sill units is 1: 100 000 scale geological maps published by Directorate of Mineral Research and Exploration (MTA) in 1998 (Çağlayan and Yurtsever, 1998; Siyako et al, 2006). The Strandja Sill is linked to the the Balkan Zone in Bulgaria and Pontides, which crops out along the Black Sea coast of Turkey and. The Pontides are thought to be a product of the Cimmerian orogeny with oceanic subduction lasting up to the Upper Triassic to Lower Jurassic (Şengör, 1984; Natalin et al, 2011). Strandja Massif was evolved as a part of the Rhodope-Pontide continental fragments derived from Gondwanaland (Şengör and Yılmaz, 1981; Natalin et al., 2011). Following Permian rifting, Rhodope-Pontide continental fragments moved to Eurasia, formed on the north by the southward-dipping subduction zone (Natalin et al, 2011). These fragments striked with Eurasia in the Triassic-Early Jurassic (Cimmerian orogeny) and generated a Palaeo-Tethyan suture. That suture was marked as a crosscutting the Balkan/Strandja units roughly aligning with border between Turkey and Bulgaria (Natalin et al., 2011). Paleozoic rocks of basement of Strandja Sill divided into two groups. These are metamorphic rocks of Tekedere Formation, which are metamorphosed in greenschist and amphibolite facies, Yassıgeçit Formation and Upper Paleozoic (Carboniferous-Permian) granitoids of Kırklareli Formation which is intruded into metamorphic rocks of the basement (Siyako, 2006) (Figure 2.1.1). Basement rocks of Strandja Sill is defined and termed as Tekedere Group which is metamorphosed in amphibolite facies within the Strandja Sill and occupies the lowermost section consisting of granitic schist, biotite schist, gneiss, amphibolite and amphibolite schist. Stratigraphically, the unit which underlies the Tekedere Group is not observed in the region (Figure 2.1.1). Tekedere Group is overlain with unconformity by Triassic-Jurassic age metasedimentary rocks and intruded by granitoids of Kırklareli Group. In addition, Tekedere Group crops out on top of Kırklareli Group (Siyako et al, 2006) (Figure 2.1.1).

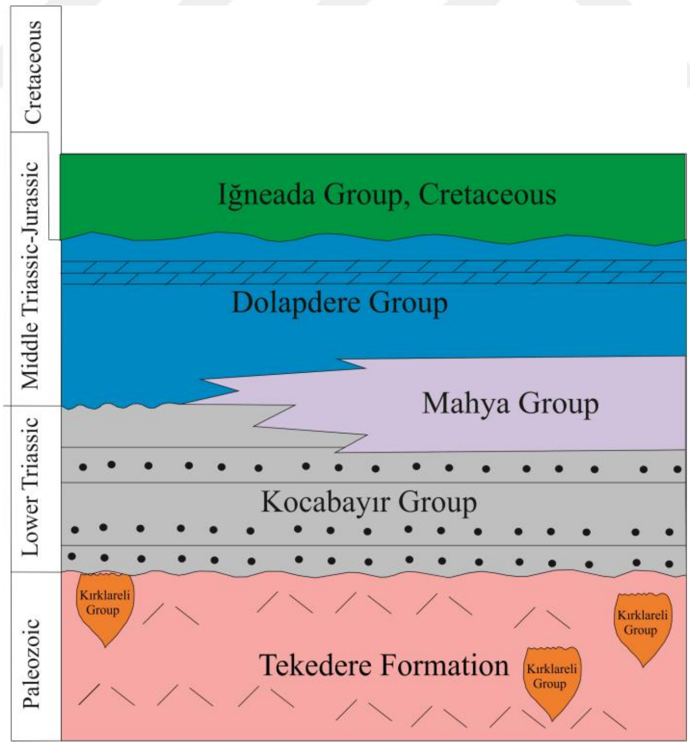


Figure 2.1.1 : Generalized stratigraphic cross-section of Strandja Sill.

Tekedere Formation constitutes biotite and augen gneiss, biotite migmatitic gneiss, biotite mica schist, garnet mica schist (Yassıgeçit Formation) and transitional calc-schist lenses (Hacıdanişment Kalkşist Member), amphibolite and amphibolite schist (Karaçoban Amphibolite Member). These rocks have been severely metamorphosed and deformed and lost their original sedimentary and magmatitic rock properties. Metamorphism of Tekedere Formation occurs in biotite and garnet section of green schist facies. It is found that the metamorphism rarely reached to amphibole facies conditions (Siyako et al., 2006).

Yassıgeçit Formation is firstly coined by Çağlayan and Yurtsever (1998) and composes dark grey amphibol, garnet schists together with biotite schists. It is located within Tekedere Formation in the form of discrete lenses. Yassıgeçit Formation is conformable with Tekedere Formation both above and below. It constitutes dark grey, biotite, amphibole mica schists interbedded with calc-schist (Hacıdanışment Calc-Schist Member) (Siyako et al., 2006) (Figure 2.1.2).

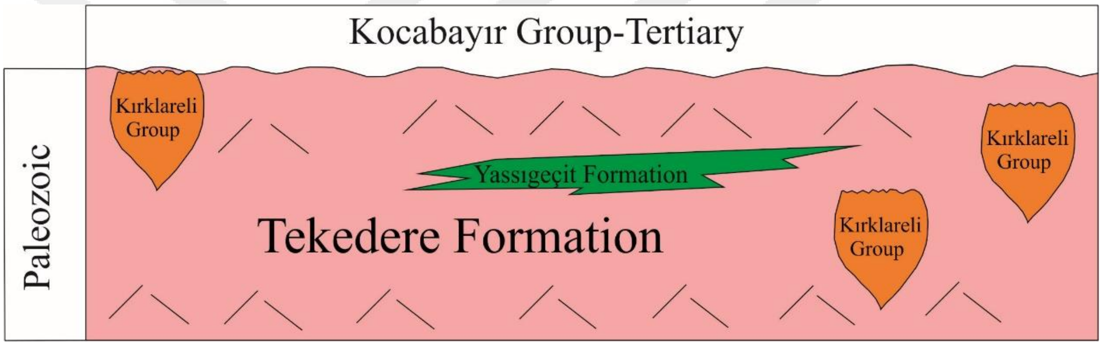


Figure 2.1.2 : Relationship between Tekedere Formation and Kırklareli Group within the Strandja Sill.

Kırklareli Group constitutes Upper Paleozoic intrusive rocks of the Strandja Sill. Plutonic rocks of the Kırklareli Group is overlain with unconformity by Triassic-Jurassic metasedimentary cover. As a result of subsequent tectonic events, Kırklareli Group overlies locally Tekedere Formation and Kocabayır Group (Figure 2.1.2). Kırklareli Group is represented by typical monzonitic granites. These granites show large phenocrysts of pink K-feldspar and almost ubiquitous porphyritic texture, which are related to the Kırklareli pluton. Locally, rocks are turned into augen gneisses (Natalin et al., 2011).

Triassic metasedimentary cover overlies unconformably the crystalline basement of Strandja Sill (Siyako et al, 2006). Lower-grade metamorphism relative to basement rocks took place in the metasedimentary cover in which sedimentary origin of rocks can be identified with local sedimentary structures such as cross-stratification.

Metamorphic rocks of the metasedimentary cover are divided into three groups (Figure 2.1.1). These are Kocabayır Group which composed coarse-grained clastic rocks, fine-grained metaclastic rocks of Mahya Group and Dolapdere Group which consists of carbonates. Kocabayır and Mahya Groups are of Early Triassic age, however Dolapdere Group is probably Early Jurassic age. Triassic metasedimentary cover is overlain unconformably by Late Cretaceous volcanic sedimentary rocks in İğneada near the bulgarian-turkish border. Isotopic age analysis showed that regional metamorphism which affected the Triassic metasedimentary cover of Strandja Sill has Late Jurassic age (155-149 Ma) (Siyako et al., 2006). Metamorphic rocks of metasedimentary cover composes clasts of various granite gneisses, metagranites, schists, quartzites, and paragneisses which frequently show a pre-S_2 foliation (Natalin et al, 2011).

2.2 Thrace Basin

Stratigraphy of the Thrace Basin consists of clastics of the Middle Eocene (Lutetian) to Quaternary, and the thickness of sediments has been estimated to be more than 9 km (Turgut et al., 1991). In addition, sedimentary infill of Thrace basin composes mainly middle Eocene to upper Oligocene age rocks (Figure 2.2.1). Pliocene and Quaternary cover rocks of Thrace Basin constrains the exposure of the. basement and sedimentary infill. However, several boreholes revealed subsurface structure of Thrace basin (Görür and Okay, 1996). Because of its location in the Strandja Zone and formation during the final elimination of most of the Neo-Tethyan oceanic domains in Turkey, some workers assumed that the basin is `intermontane` or collision-related in nature (Keskin, 1974; Turgut and Atalık, 1988; Yılmaz, 1988; Perinçek, 1991; Turgut et al, 1991). On the contrary, Görür and Okay (1996) proposed a Palaeogene evolution of the fore-arc basin by linking it to the subduction of the Intra-Pontide Ocean (Figure 2.2.2).

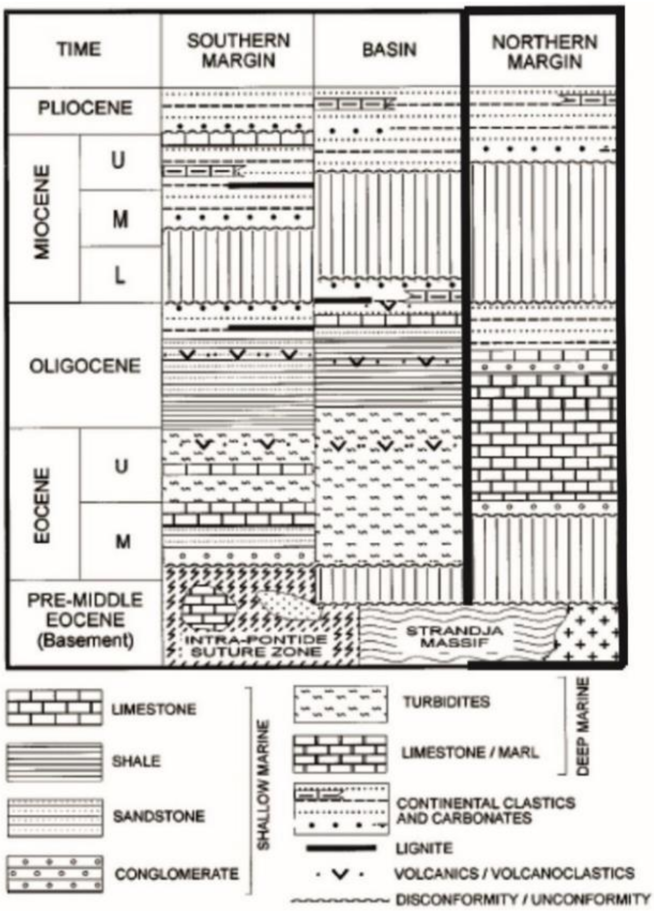


Figure 2.2.1 : Generalized stratigraphic cross-section of Thrace basin.

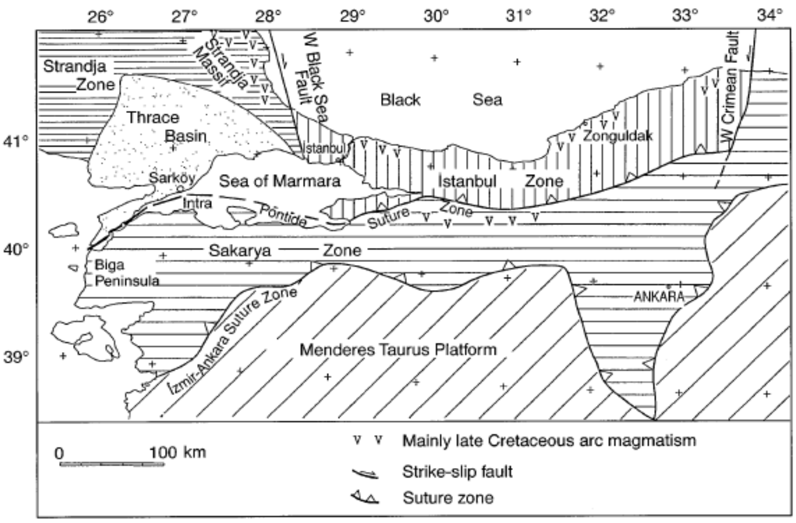


Figure 2.2.2 : Tectonic setting of the Thrace basin.

The Thrace Basin is suggested to be a fore-arc position between middle Eocene to Oligocene time (Görür and Okay, 1996). It was bound by magmatic arc to the north and its subduction accretion complex to the south (Figure2.2.2). Fragments of the subduction-accretion complex can be found in the Intra-Pontide suture zone (Görür and Okay, 1996). Granidiorites, andesites, tuffs, agglomerates of the Late Cretaceous age constitutes the magmatic arc in the Strandja Massif (Pamir and Baykal, 1947; Görür and Okay, 1996). Magmatic rocks relating to the Eocene age comprises mostly andesitic and dasitic tuffs and occurs inside the basin referring to the southern movement of locus of magmatism (Doust and Arıkan, 1974). Subduction complex on the southern frame is shown by ophiolitic melanges with blueschist blocks (Şentürk and Okay, 1984). It is observed in northern and eastern of Şarköy in the cores of small post-Miocene anticlines, and also found at the bottom of the Middle Miocene limestones in the petroleum wells from the Sea of Marmara (Şentürk and Okay, 1984; Siyako, 1989; Okay and Tansel, 1992; Görür and Okay, 1996). Şengör and Yılmaz (1984) concluded that the ophiolitic melange represents the suture of the Intra-Pontide Ocean situated between the Strandja Zone to the north, the Sakarya Zone to the south (Fig 2.2). It has been proved by the fact that suture zone divides the Istanbul and Sakarya zones with completely distinct basement and overlies the sedimentary fill next to the zone of sheared ophiolites, indicating inital southern vergence (Şengör and Yılmaz, 1981; Yılmaz, 1990; Görür and Okay, 1996). The Istanbul Zone owns the upper Cretaceous through the early Cenozoic island-arc association showing the duration of ocean elimination along the suture zone. Few data are available about the opening and closing of the ocean. Şengör and Yılmaz (1984) and Görür et al. (1984) proposed that it was opened in Lias and closed during the late Cretaceous to the Palaeocene time based on the Jurassic facies changes. On the other hand, findings of the Middle Palaeocene pelagic limestone blocks along with rocks of serpintinite and radiolarian chert in the stratigraphy of the Thrace Basin, show that the ocean existed untill the Palaeocene age (Okay and Tansel, 2002; Görür and Okay, 1996).

2.2.1 Soğucak Formation

Soğucak Formation was firstly used by Holmes (1961) as a member of Kırklareli Formation. Ünal (1967) termed the formation `Soğucak Limestone` by bringing it to the degree of formation. Kasar et al. (1983), Kasar (1987) and Sümengen et al. (1987) adopted the term of Soğucak Formation.

Soğucak Formation is conformable with underlying Koyunbaba Formation. It overlies other older formations where the Koyunbaba Formation is absent. Soğucak Formation is conformably overlain by Ceylan Formation. In the case of absence of Ceylan

Formation, Soğucak Formation is overlain by Mezardere Formation (Siyako, 2006) (Figure 2.2.1.1).

Soğucak Formation constitutes mostly shelf carbonates. Limestones are abundant with fossils and have white, yellowish colour with vuggy pores. Locally observable patch reefs is more common around Pınarhisar locality. Sandstone and marl layers are interbedded within the formation. It has been determined from well-log data that pelagic micritic limestones of Soğucak Formation with tuffaceous sediments occur in basinal settings of Thrace basin. Soğucak Formation is of Middle to Upper Eocene age in Southern Thrace, Bozcaada and Gökçeada and Biga Peninsula (Siyako, 2006). At the foothills of Strandja Sill as well as Northern Thrace basin, Soğucak Formation has

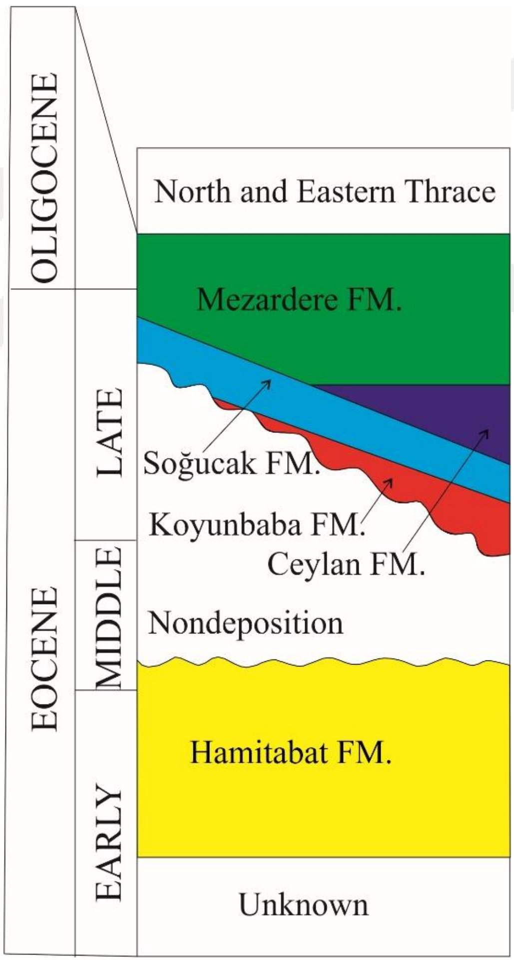


Figure 2.2.1.1 : Soğucak Formation and its relationship with other rock units in the Northern Thrace Basin.

Upper Eocene age (Siyako, 2006). The formation occurs in the form of strips at the foothills of Strandja Sill and has exposures over wide area (Siyako, 2006).

2.2.2 Ceylan Formation

Ünal (1967), firstly termed Ceylan Shale in the formation stage. Keskin (1974) defined it as a Ceylan Formation. Örencik Member is located within the Ceylan Formation. Its cross-section is clearly seen in petroleum wells such as, Karacaoğlan, Hamitabat, Umurca opened in deep part of Thrace basin (Siyako et al., 2006).

Ceylan Formation is mostly conformable with Soğucak Formation (Figure 2.2.1.1). It is shown that Ceylan Formation overlies with unconformity Soğucak Formation in the neighborhood of Karaburun on the Black Sea coast (Siyako et al., 2006). Same analogue was observed in Bozcaada. Ceylan Formation is overlain conformably by Mezardere Formation (Siyako et al., 2006).

Ceylan Formation comprises of pelagic shale, marl, micritic limestone, turbiditic sandstone-shale which guides mapping of subsurface units and locally silicified tuffites. Limestones belonging to Soğucak Formation, Çetmi Ophiolitic Melange lithologies-olistoliths and olistostromes are observed at the base of the formation in the Southern Thrace, Gelibolu and Biga Peninsula (Siyako et al., 2006).

Late Eocene age has been determined for Ceylan Formation in eastern Thrace owing to foraminiferas, whereas ostracods show Late Eocene-Early Oligocene age for this formation. Early Oligocene age is suggested for Ceylan Formation with respect to foraminiferas in the Karaburun region on the Black Sea coast (Siyako et al., 2006).

Ceylan Formation has exposures in the south of Ganos fault Mürefte-Şarköy region in the southern Thrace, to the north of Mecidiye in southwestern Thrace, from Terkoz and Çekmece lakes to Gelibolu and Biga Peninsula, Gökçeada and Bozcada in the eastern Thrace. According to well data, Ceylan Formation is deposited throughout the central and northern Thrace except some paleohighs (Siyako et al., 2006).

2.2.3 Ergene Formation

Ergene Formation is firstly termed by (Boer, 1954) in context of formation. In his review paper, Miocene-age rocks except the Çekmece Group in the north of Ganosdağ-Korudağ-Hisarlıdağ paleohigh is described within the context of Ergene Formation. Ergene Formation is not well exposed in the region with regard to its unconsolidated lithology. It doesn`t have consistent vertical sequence in the Thrace Basin.

Duman et al.(2004) indicates that Ergene Formation is conformable with underlying Çantaköy Formation. Apart from that, the formation is unconformable with other older formations and overlying Kırcasalih Formation (Figure 2.2.3.1). Ergene Formation is the product of fluvio-lacustrine environment. It constitutes siltstone, claystone and sandstone riched in plant and vertebrate fossils and planar cross-bedded conglomerate and sandstone (Siyako et al, 2006). According to Çağlayan and Yurtsever (1998), the thickness of Ergene Formation reaches up to 40-60 metres and 350-400 metres at basin margins and at basin centres, respectively. Umut et al. (1983), Çağlayan and Yurtsever (1998) suggested Middle-Upper Miocene age for Ergene Formation. However, Umut (1988) and Imik (1988) proposed a Upper Miocene for the formation. Ergene Formation has a wide exposures in the larger areas of central Thrace Basin. Ergene

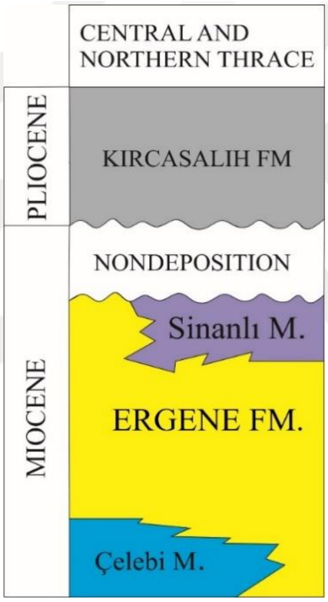


Figure 2.2.3.1 : Ergene Formation and its relationship with other lithostratigraphic units in central and northern shelf province of Thrace Basin. FM: Formation, M: Member.

Formation has two members: Çelebi member and Sinanlı Member. Both of them are not located in our study area (Siyako et al., 2006).

2.2.4 Quaternary

Quaternary age beach deposits crop out on the coasts of Black Sea in the study area, particularly in the north of Terkoz lake and between Yeniköy and Akpınar villages. Beach deposits as a narrow strips occur along the coast. In the vicinity of Çiftalan and Kumköy it is widely distributed. Dunes are produced from landward migration of beach deposits by dominant northly winds of Black Sea. Beach deposits has lower vegetation and owns economic importance in some places.

2.2.5 Stratigraphy of the Thrace Basin

As it is mentioned before, Thrace basin formed and rapidly accumulated sediments since the Eocene time. Gaziköy Formation, which comprises fine-grained sandstone, siltstone, silicified tuffs, dark grey shales overlies the Çetmi Ophiolitic Melange on top of crystalline basement. Following that, Keşan Formation, which is mainly sandstone, Soğucak Formation consisting of gray micritic limestone and reefal carbonates, Ceylan Formation comprising sandstone, clayey limestone, gray shale with interbedded tuffites appears respectively (Şengüler et al, 1992) (Figure 2.4.1).
Oligocene age stratigraphy begins with greenish gray shales, marn, tuffs of Mezardere Formation. Overlying Osmancık Formation comprising sandstone, shale, localized gravels, limestone, thin lignitic bands underlies Danışmen Formation, which consists of gray greenish clay, sandstone, gravel, lignite. Danışmen formation is renamed a lignitic sandstones in previous studies of the basin. Boer (1954) and Beer and Wright (1960) not only used the name of this formation, but also Osmancık Formation is covered in this classification. Ünal (1967) defined Danışman shale with distinguishing Osmancık Formation in his studies. Kasar and others (1983), changed it to Danışmen formation because of nonhomogenous lithology (Siyako, 2005).
At the base of Miocene age rocks, Hisarlıdağ volcanic rocks composing volcanic tuffs and aglomerates are found. Above them Çanakkale Formation consisting of claystone, sandstone, siltstone lithology and Ergene Formation comprising mudstone, sandstone, marn, limestone lithology appears in order (Şengüler et al., 1992).

In the Thrace Basin, Pliocene stratigraphy is represented by Thrace Formation consisting of unconsolidated gravel, conglomerate, sandstone, localized claystone. Quaternary age rocks with unconsolidated sandstone containing carbonates and gravel overlie almost all litostratigraphic units in the basin (Şengüler, 1992).
There are two members of the Thrace formation, namely Çelebi and Sinanlı member. Çelebi member crops out to the south of Uzunköprü around Dereikebir village (Umut and others, 1984). It overlies Armutburnu member with angular unconformity in the Dereikebir village (Umut and others, 1984). Its clastical deposits are transitional both laterally and vertically to base of the Ergene Formation. In the south of Uzunkopru it

consists of white, gray, greenish lacustrine limestones. It covers medium limestone beds with occasional clay and sandstone layers (Umut and others, 1984). Its thickness is around 40 metres (Imik, 1988).

Çelebi member being vertically and laterally transitional to Ergene Formation is in Middle to Upper Miocene age like Ergene Formation. Çelebi member in the south of Uzunköprü and north of Çorlu are mapped in outcrops below the Ergene Formation (Umut and others, 1983). In the 1:500000 scale geological map done by Umut (1988) Çelebi Member is equivalent to the Kurtdere Member.

Kırcasalih member is also found in type locality-Uzunköprü. It is widespread and to certain extent laterally equivalent to the Çelebi Member. It consists of many-coloured gravelly sands with interbedded clays. Gravels contain fragments of quartzite, tuff, chert and limestone. Chalky limestones encounter to the north of outcrops. Depositional environment is continental. The Çelebi Member is deposited in lagoonal and lacustrine environments, however successive Kırcasalih member indicates an upward change into alluvial channels and fan.

Age	Formation	Thickness, m	Lithology	Depositional Environment
Quaternary	Alluvial deposits		sandstone, clay and silt.	Recent deposits
Pliocene	Thrace Formation	50	gravel and sandstone	fluvial environment and alluvial fan
Miocene	Ergene Formation	100-500	sandstone, siltstone, claystone	brackish lake and fluvial environment
	Çekmece Formation	100-200	mudstone, sandstone, marl	fluvio-lacustrine environment
	Çanakkale Formation	40-100	claystone, sandstone, siltstone	fluvial, lake, lagoon, shelf and offshore environment
	Hisarlıdağ volcanics	?	Tuffites, agglomerate	volcanic eruption
Oligocene	Danışmen Formation	200-600	Grey green claystone, sandstone, tuffite and lignite	fluvial environment interdistributary bay deltaic environment
	Osmancık Formation	300-600	sandstone, shale, locally gravel.limestone, and thin lignitic bands.	delta, fluvial and lacustrine environment
	Mezardere Formation	500-1200	greenish grey shale, marl and tuffite.	delta and foreshore environment.
Eocene	Ceylan Formation	400-1000	tuffite intercalated grey marl, shale, sandstone, micritic limestone	marine and turbidit environment
	Soğucak Formation	40-300	grey-beige micritic with locally reefal limestone	shelf and paleohigh
	Keşan Formation	500-1500	marl, shale and sandstone	fluvio-lacustrine, delta and turbiditic
	Gazıköy Formation	600-1000	dark-grey black shale and sandstone.	turbidite and deep marine

Figure 2.2.5.1 Generalized stratigraphic cross-section of Thrace basin.

2.2.6 Depositional Environment of the Thrace Basin

Stratigraphy of the Thrace basin is characterized by shallowing-upward succession of Middle Eocene to the Oligocene age. Tuffaceous turbidites were deposited in the middle Eocene to early Oligocene. Continental and shallow marine clastics and carbonates with subordinate clastics were accumulated on the basin margins and bathymetric highs (Doust and Arıkan 1974; Görür, 1996) (Figure 2.2.6.1). In Middle-Oligocene age, shallow marine and marginal marine environment dominated in the basin, shown as thick beds of fine-grained clastics and shales. Shales occur with siltstones and silty sandstones. Lacustrine environment appeared in late Oligocene to Lower Miocene age. The whole Oligocene age are represented by thick clastic sediments with mostly shale. Upper Oligocene and Lower Miocene sequences have a thick coal deposits in a whole basin. Significant uplift and erosion happened in Middle to late Middle Miocene times. Sedimentary rocks were eroded along the margins of the basin. In the Upper Miocene, marine waters entered the basin through south-western border of the basin, represented by a thick sequences of shallow marine clastics as repeation of sheet and deltaic sand and claystones (Turgut et al., 1991) (Figure 2.2.6.1). Deformation occurred throughout the Pliocene and Pleistocene on the basin margins. (Turgut et al., 1991).

The Thrace Basin has been subdivided into three sedimentary provinces; southern shelf of the basin, the central shelf of the basin, the northern shelf of the basin, and the Kuleli ridge (Doust and Arıkan, 1974). Our study area lies on the northern shelf of the

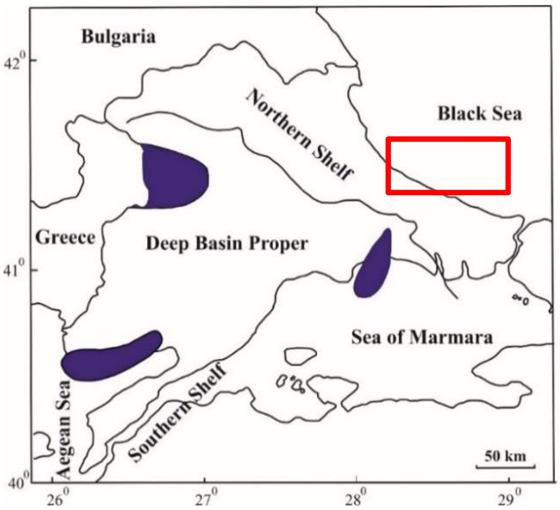


Figure 2.2.6.1 : Modern sedimentary provinces of the Thrace basin.

Thrace Basin (Figure 2.2.6.1). Marine siliciclastic sediments were deposited on the center of the basin in all depositional history of the basin. They are the largest part of the Thrace Basin. Wide northern shelf of Thrace basin is lens-shaped and the intra-basinal palaeo-highs occur in the modern basin. In Figure 2.2.6.1, Circled violet areas refer to palaeohighs on the basin margins, such as Silivri paleohigh in the eastern margin of the basin, Mecidiye paleohigh in the southwestern margin of the basin as well as Kuleli Ridge in the northwestern part of basin. Red rectangle refers to the study area. Study area is located in the northern shelf of Thrace Basin. Tectonic activity of the North-Anatolian transform fault has effected largely the southern shelf. The Gallipoli Peninsula only experienced shelf sedimentation in the southern shelf.

2.2.7 Tectonic Evolution of Thrace Basin

It has been proposed that Thrace basin was developed as a forearc basin based on its position between Pontide magmatic arc to the south and subduction complex of the Intra-Pontide suture zone to the north (Figure 2.2.7.1). There are various evidences to prove this hypothetis. The basin shows coarsening upward sequences of turbidites into marginal marine to terrestrial sediments. Additionally, petrographic analyses indicate unroofing and dissection of adjacent arc massif and subduction complex (Görür and Okay, 1996).

At the beginning of the Eocene time, Intra-Pontide ocean was still open, however its eastern part became a narrow canal owing to the arrival of Istanbul zone from the north (Görür, 1996). Istanbul zone previously was attached to the Moesian platform, migrated south in the Upper Cretaceous to Palaeocene time with two transform faults, dextral west Black Sea, sinistral west Crimean faults (Okay, 1994). It struck with Sakarya zone in the Lower Eocene time in the south. As a result, the eastern part of Intra pontide oceanin the south of Istanbul zone was destroyed completely by continental collision. Western part of Intra-Pontide Ocean was still open, kept subducting northward whole Eocene (Okay and Görür, 1995) (Figure 2.2.7.1). Shrinkage regarding to oceanic subduction could not be relieved between interlocked Istanbul and The Sakarya zones. In response to shrinkage, Rhodope-Pontide magmatic arc began to rift and became elongated, therefore forming the Thrace basin. Traces of calc-alkalic volcanic bearing marine sedimentation in the basin into the Oligocene reveals that consumption of the Intra-Pontide oceanic crust and next collision proceeded up to the Oligocene age (Okay and Görür, 1995). Following the collision, folding and erosion occurred in the basin and Middle Miocene to Quaternary continental to shallow marine sediments lied unconformably over the basin. Also it overlies suture along the Dardanelles strait (Doust and Arıkan, 1974). Miocene aged molasse rocks doesn`t relate to previous forearc basin and deposited in west-north-west to east-south-east trending troughs (Doust and Arıkan, 1974). Pliocene to Quaternary age rocks deposited under fluvial, lacustrine environments accumulated in graben structures. They are the product of wrench tectonics in the basin, as a result of post-collisional compression which caused strike-slip regime at the time of North Anatolian transform fault in Upper Miocene to Pliocene on the southern margin of the basin (Şengör et al., 1979). The post-collisional deformation was not severe in the basin. Three important parameters of the arch-trench system, such as the subduction complex, forearc basin and the magmatic arc crops out as in their natural position. There are two explanations for this phenomenan, i.e. diachronous closure of Intra-Pontide ocean and the neotectonic strike-slip regime. The accretionary melange formed around the southern margin of the basin may have played a cushion role between the colliding zones. Therefore, Thrace basin wasn`t damaged by intense compression. The neotectonic strike slip regime aided to preserve natural tectonic structures of the basin, as following compression was stopped by strike slip movement along North-Anatolian fault zone (Görür, 1996).

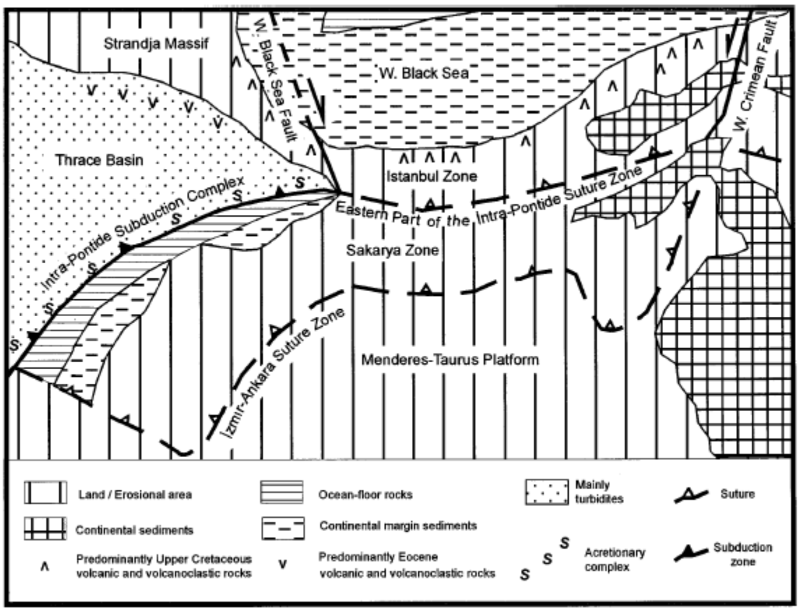


Figure 2.2.7.1 : Upper Eocene palaeogeographic map of Northwestern Turkey.

3. METHODS

3.1 Sampling

Spot sampling was used so that sedimentological conditions and origin of sediments would be determined. We tried to take a representative samples from exposures. Totally, twenty-two samples have been recovered from outcrops in Karacaköy, Karamandere, Akpınar. Nine of them belong to Karacaköy, eight and five samples are from Akpınar and Karamandere, respectively.

3.2 Preparation of Samples for Grain-Size Analysis

The goal of grain size analysis is to obtain the grain size of the clastic particles in a condition of their deposition. This can be difficult because of grain over growths or tough aggregates in the form of hard sandstones and finally chemically precipitated materials which contribute to the size of cementing materials. Apart from that clay minerals because of their flaky character and surface electrical charges tend to cluster in lamps. The idea of disaggregation and dispersion is to separate all of the individual grains without smashing any of them, and to remove all chemically-precipitated substances. Grain-size analysis of fine-grained materials is not very satisfactory, since there are a lot of problems. Our primary goal is to measure the size of individual particles not clay lumps. Negatively charged clay flakes attract positive ions around them. If we add a HC lor NaCl to the solution, then the solution becomes conductor. As a result, clay flakes flocculate into chains and large clumps. For this reason, dispersants i.e. calgon is used in our muddy samples. Three samples from Akpınar and one sample from Karamandere. In addition, solution was made using 100 ml distilled water per 10 gr of calgon. To achieve a solution for grain size analysis in Laser Particle Sizer Analysette Fritsch 22, samples are stirred and kept in beaker for 24 hours. Then, few drops of sample were entered to the particle-size analyzer. All of measurements have been accomplished in General Geology Lab and Emcol Sedimentology&Geochemistry Lab.

3.3 Sieve analysis

A sieve analysis is the procedure used to assess grain size distribution of granular material. To do sieve analysis, 9 samples from Karacaköy, 4 samples Karamandere, 3 samples Akpınar were recovered from corresponding outcrops. Totally, fifteen samples which contained mainly gravel and sand size grains were allocated for sieve analysis, whereas muddy and silty samples assigned for Laser Particle Sizer Analysette Fritsch 22 Nanotec Sieve analysis have been conducted in Retsch sieve screens (Figure 2.4.1). For this purpose, eight stack of sieve screens and a pan were used in sieve analysis, namely, -1ϕ, 0 ϕ, 1ϕ, 2 ϕ, 3 ϕ, 4 ϕ, 4.5 ϕ. Frame sizes have 200 x 50 mm dimension.

Samples weighed in precision laboratory scales about 150 gr, have been selected for sieve analysis. Besides, seven sets of sieve screens have been utilized. All sieve experiments took 15 minutes. And also, samples have been dried in oven around 80℃ before sieve analysis. The main purpose of sieving is to classify sediments on the basis of Folk`s (1974) grain size nomenclature.

3.4 Grain-size analysis

Efficiency of sieve analysis is confined to sand-size specimen. Therefore, muddy samples have been studied using Laser Particle Sizer Analysette Fritsch 22 Nanotec. The Analysette 22 Nanotec employs the Fritsch patent of Reverse Fourier design which has been adopted by nearly all manufacturers. Four samples from Akpınar with one from Karamandere were studied in the particle-size analyzer.

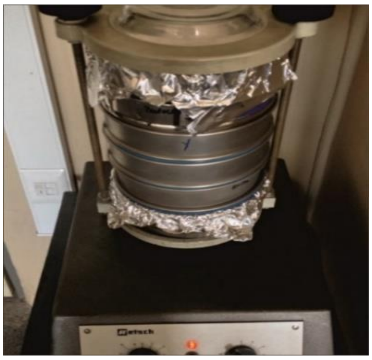


Figure 3.4.1 : Stack of sieve sets for sieve analysis from ITU-General Geology Laboratory.

4. RESULTS

4.1 Sedimentological Studies

In the study area, three localities have been selected for sedimentologic observations, namely Karacaköy, Karamandere, and Akpınar villages (Figure 1.1). In Karacaköy location, we studied three different outcrops in the north of Karacaköy village, which are presented in this study as Area- 1A, 1B and 1C . The sedimentary sequences in these outcrops consist of siliciclastics of the Ergene Formation that was dated as the upper Miocene to Pliocene (Boer, 1959). In Karamandere location, only one outcrop was studied for sedimentologic properties of the Ergene Formation. In this study, we measured vertical sedimantary sections of each outcrop in order to document macroform geometry and lithologic variations through the sedimentary sequences. Macroform architectures of the sedimentary sequences from the studied outcrops have been differentiated by using Miall’s classification (1996). Hence, various sedimentary facies and related sedimentary environments have been defined in this study.

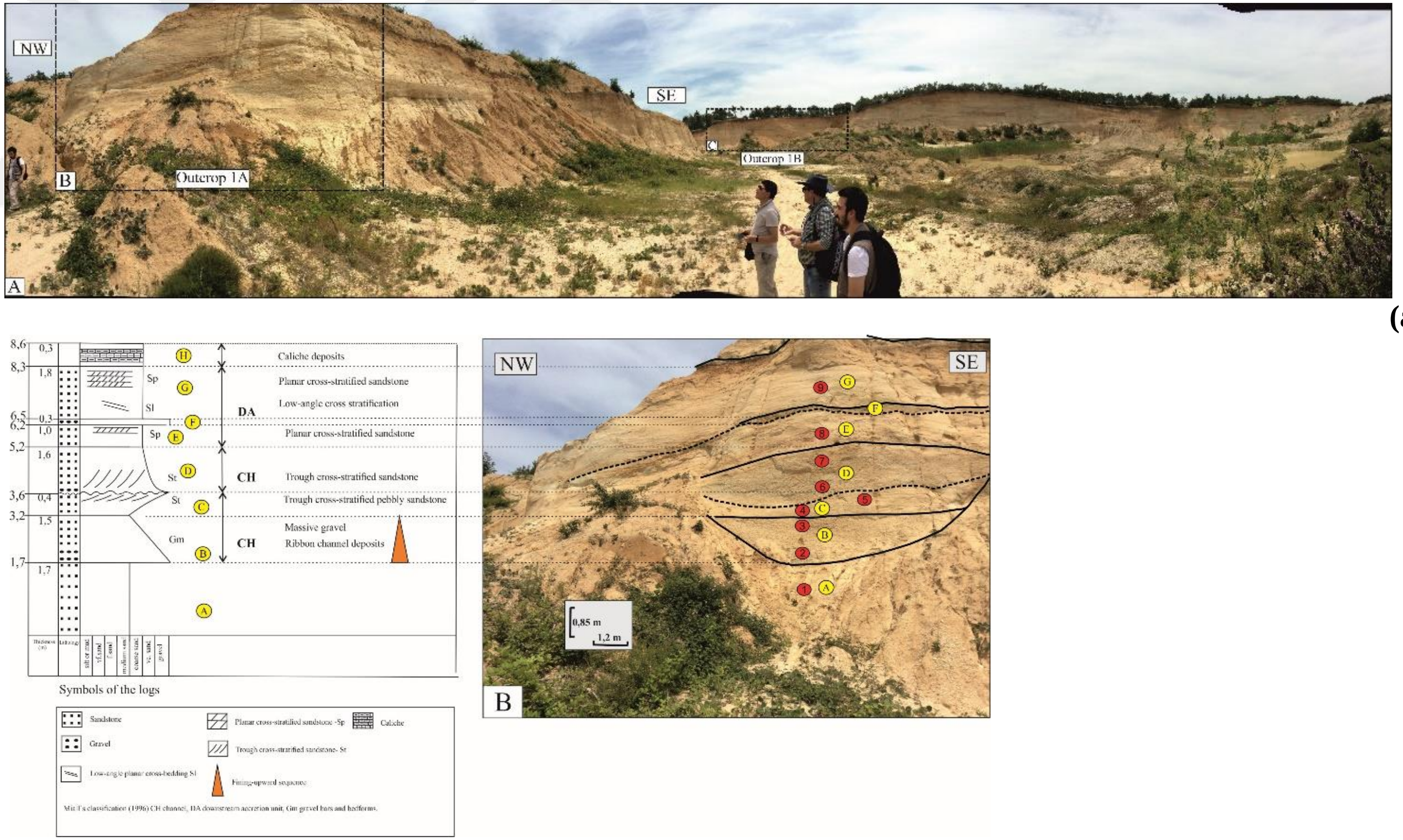
We collected sedimantery rock samples from three outcrops in the studied locations for the purpose of sedimantery and petrographic analyses.. In order to classify sedimentary rocks observed in all logged outcrops, regarding to the Folk`s (1974) grain-size nomenclature, sieve analysis has been conducted in ITU-EMCOL sedimantology laboratory. As a result, quantities of gravel, sand, mud have been determined. Besides, sediments containing sufficient mud were analysed in particle size analyser utilizing laser diffraction method.

4.1.1 Field Description

4.1.1.1 Area-1A, Karacaköy Village (N 41°24`47.02`` E 28°24`46.96``)

This outcrop is located at the sand quarry on the northeast Karacaköy Village of Çatalca town in Istanbul. This outcrop is represented by fluvial sediments of the Ergene Formation. We measured approximately 8 m of vertical section of the outcrop and collected nine samples for further petrographic and sieve analyses. The main macroforms observed in this outcrop are summarized in detail below this chapter. Lithologic variations through the outcrop together with classification of macroform architectures on the basis of Miall`s classification reveal changes in regime of the existent fluvial system around the region during the Upper Miocene to Pliocene.

Unit-A composes slightly gravelly muddy sandstone-(g)mS which marks the base of Outcrop-1A in Karacaköy (Figure 4.1.1.1.1) (Table 4.1.2.1.1). This unit is overlain by Unit-B, representing horizontally bedded channel lag deposits with a sharp erosional top (Figure 4.1.1.1.1). They consist of pebbly sandstones with better sorting, that characterizes bed-load deposition from stream flows (Miall, 1996). In addition, Unit-B fines upward to clastics of Unit-C. In the vertical section, Unit-C indicates coarsening upward sequence and constitutes mostly medium sandstone with trough cross-bedding (St) and partly horizontal stratification. Unit-C is overlain by Unit-D along an erosional surface. The channel deposits of Unit-D comprise gravel to medium-grained pebbly sandstones showing trough cross beddings. The youngest depositional layer of the vertical section in this outcrop is Unit-E that begins at the base with planar cross-stratified sandstones, then interrupted by thin wedge of gravel deposits of Unit-F. Unit-G is dominated by low angle cross stratification, which passes upward to planar cross-stratified sandstone. The uppermost section of sequence is represented by caliche deposits of Unit E.

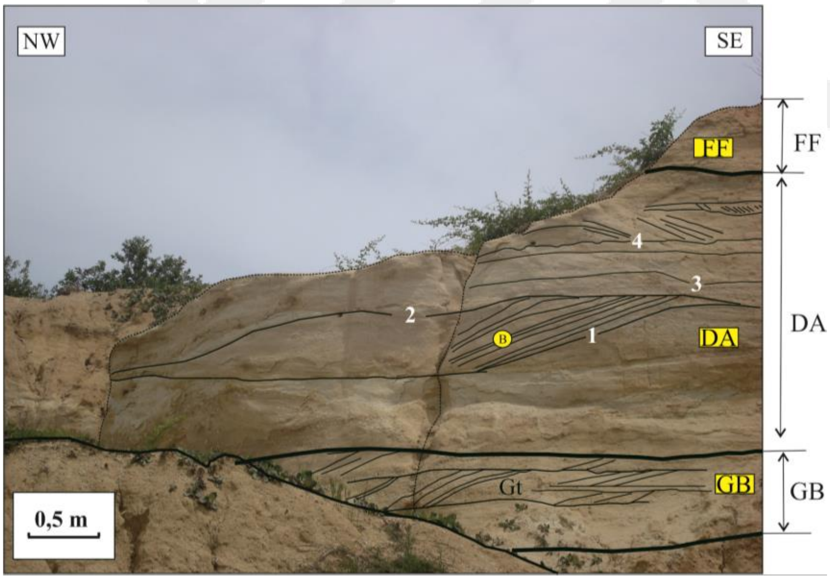


(a)

(b)

Figure 4.1.1.1.1 : Stratigraphic cross-section of Area-1A,Karacaköy. (a) NW-SE panoramic photograph (with location of photograph of Figure B and C). (b) View showing stratigraphic units Area-1A, Karacaköy. Solid and dotted lines are for sharp and erosional stratigraphic boundaries. Red circled numbers show recovered samples and yellow circled letters refer to stratigraphic unit**.**

(a)



(b)

Figure 4.1.1.1.2 : (a) Lateral continuation of Area-1A, Karacaköy. (b) 1; 2; 3; 4 refer to hierarchical reactivation surfaces in the bar formation. Element Codes by Miall (1996): DA downstream accretion, CH channel, FF floodplain, GB gravel bar and bedforms. Yellow circled letter `B` refers to mid-channel bar formation. Miall`s lithofacies classification (1985): Gt trough cross-stratified sandstone.

Downstream Accretion Units (DA)

In the vertical section in Area-1A, downstream accretion unit (DA) appear at the top of the sequence by overlying channel complex (Figure 4.1.1.1.2). The thickness and length of this macroform in the outcrop are 2,2 m and 8 m, respectively. This type of macroform is characterised by large sets of cross bedding. These structures can be formed by large transverse or linguid bars that are mostly bank-attached or of mid-channel origin (Reading et al, 1996). Smaller successive sets of planar cross-bedding can also be seen towards the top of outcrop. Arabic consecutive numbers 1, 2, 3 and 4 refer to reactivation surfaces in the outcrop (Figure 4.1.1.1.2). Reactivation surfaces are generated by erosion or changing flow strength before the resuming of forward migration of the foreset (Reading et al., 1996). The overall architectural features indicate existence of downstream accretion units in this outcrop related to bar migration (Figure 4.1.1.1.2).

Channel (CH)

On the basis of Miall's classification on architectural elements, we observed multistorey ribbon channels in Area-1A that appear between 1,7 m and 5,2 m. The upper channel (Unit-D in Figure 4.1.1.1.1) has convex upwards relief with large sets of trough cross bedding, which consists of medium-grained sandstone with few pebbles (g)sM (Table 4.1.2.1.1). However, the lower channel (Unit-C in Figure 4.1.1.1.1) has a flat and sharp upper erosional boundaries. Furthermore, the lowermost channel (Unit B in Figure 4.1.1.1.1) contains horizontal stratification suggesting deposition either on top of braid bars or as lags on channel floors (Reading et al., 2002). With respect to its geometry, the channel complex has a width of 10-20 m and height of 2 m. It is in agreement with the definition of ribbon channel, according to width versus height ratio of channel (Friend, 1979). The channels in Unit-C and Unit-D can be regarded as multistorey ribbon channels. These channels are overlain by mudstone containing some sand. Additionally, thin wedge of gravel deposits (Unit-F) which record chute channels in the outcrop appear on top of massive sandstones. Chute channels are mostly formed during low discharges on waning flow regime (Reading et al, 1996).

Element GB: Gravelly bars and bedforms

Trough cross beds of gravel can be observed as a lateral continuation of a channel to the west in Area-1A, Karacaköy (Figure 4.1.1.1.2). They can be interpreted as a minor channel fills or longitudinal bars. During high water stage, diffuse gravel sheets grow upward and downstream by the addition of clasts to form longitudinal bars (Miall, 1985).

Floodplain (FF)

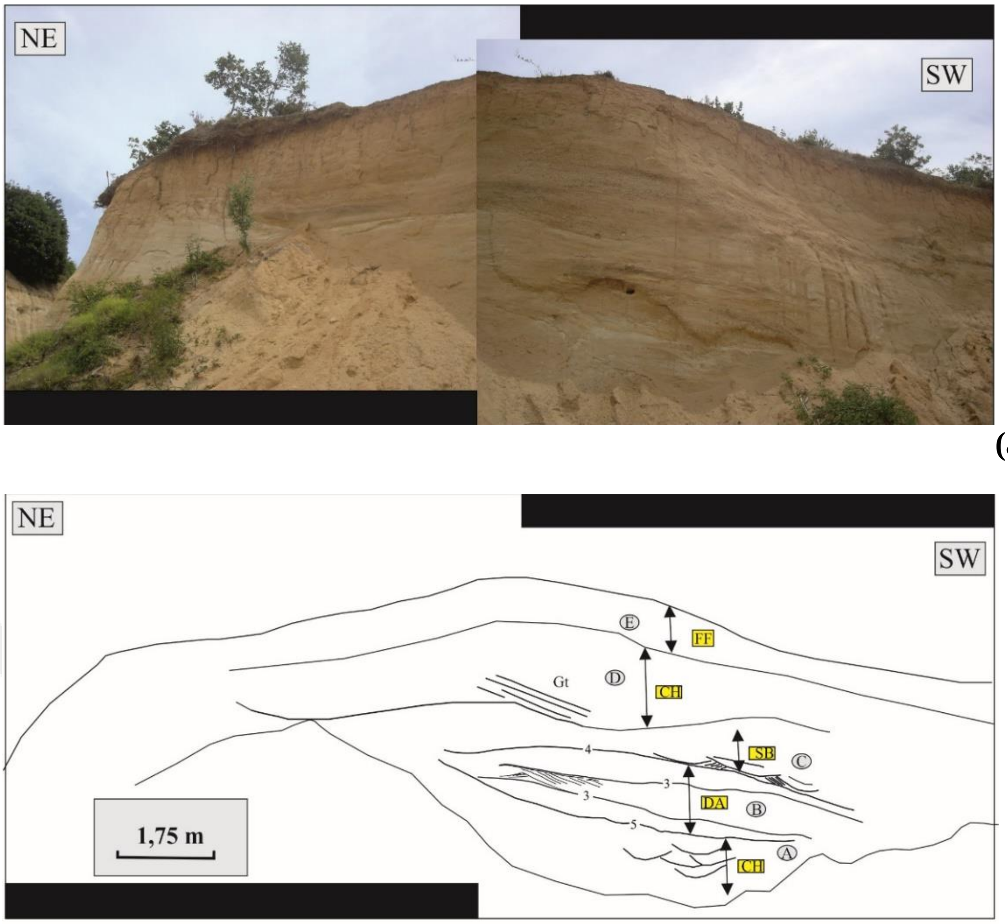
Floodplain sediments are less preserved in Area-1A of Karacaköy. These sediments are represented by thin (max.30 cm) caliche deposits at the top of the outcrop (Figure 4.1.1.1.1 and Figure 4.1.1.1.2). The floodplain sediments are laterally continous for a more than 300 m. Preservation of floodplain sediments in braided rivers are known to be less in comparison with meandering rivers (Reading et al., 1996).

4.1.1.2 Area-1B, Karacaköy village (N41°24'41.77", E 28°24'53.81")

Area-1B Karacaköy is situated near the front part of Area-1A in Karacaköy. Unit-A constitutes the trough cross-bedded sandstone, which occupies the lowermost part of vertical section of Area-1B, Karacaköy. Following Unit-B shows low-angle cross stratification and internal planar cross-bedding (Figure 4.1.1.2.1). Unit-C is dominated by trough cross-bedded sandstone with set thickness of 15-20 cms. Unit-D which overlies Unit-C represents a channel deposits with concave-up erosional bases. Trough cross-beds of gravel occurs at the base of channel (Unit-D). Flood plain deposits (Unit-E) appear at the top of vertical section (Figure 4.1.1.2.1).

Downstream Accretion Elements (DA)

Downstream accretion elements (Unit-B in Figure 4.1.1.2.1) is marked by its horizontal basal bounding surfaces (5th order) and upper bounding surfaces (4th order) frequently with convex-upwards relief (Reading et al 1996) (Figure 4.1.1.2.1). In addition, third-order bounding surfaces above 5th order bounding surface divide the cross-bedded sets by inclining downcurrent (Figure 4.1.1.2.1) (Miall, 1994; Reading et al, 1996). This unit has been formed by downstream migration of simple or compound bars.



(a)

(b)

Figure 4.1.1.2.1 : Outcrop photograph of Karacaköy Area-1B. Element Codes: CH channel, DA downstream accretion units, SB sandy bedform. Lithofacies: cross stratified gravel (Miall, 1988). Numbers on figure refer to 3rd, 4th, 5th order bounding surfaces on the basis of Miall`s classification (1988).

Sandy Bedforms (SB)

Sandy bedforms usually develop on bar tops and point bars lacking lateral accretion. Because of their tabular cross bedding, they are diagnostic of low sinuosity fluvial channels in comparison to channels developed by trough cross bedding (Jackson, 1976).

4.1.1.3 Area-1C, Karacaköy Village (41°24'42.34"N 28°24'55.94" E)

It is located in the Karacaköy village to the east of outcrop in Area-1A, Karacaköy. This outcrop is 50 m wide and 4 m thick trending northwest-southeast. Two adjacent channel complexes occur in outcrop, namely, channel 1 (CH1) and channel 2 (CH2) (Figure 4.1.1.3.1).

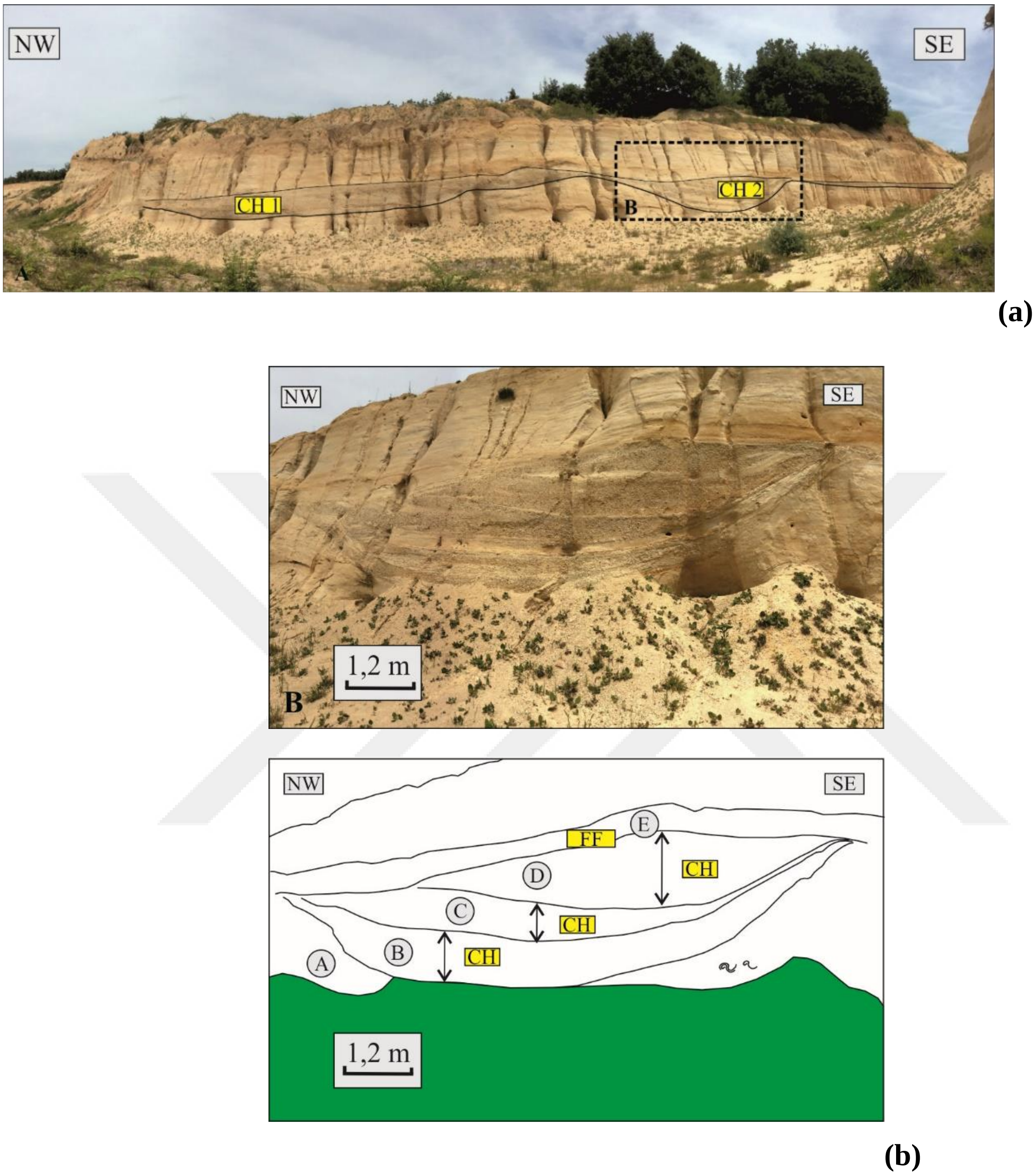


Figure 4.1.1.3.1 : Facies interpretation of Area-1C,Karacaköy. (a) Panoramic view of Area-1C, Karacaköy, (b) Close-up of Channel 2 (CH 2) and sketch of outcrop. Element Codes: CH channel, FF floodplain (Miall, 1996).

Unit-A constitutes medium sandstones and shows locally convoluted bedding indicating high depositional rate. Unit-B, which in turn overlies the Unit-A constitutes clast supported gravels with horizontal stratification. Unit-B owns concave-up erosional bases and tops. Unit-C has the more or less same dimensions as Unit-B. It constitutes clast supported gravels with moderate sorting. Thin strip of sandstone occurs between Unit-B and Unit-C, which shows the abandonment during channel switching. Unit-D composes clast supported gravels and has a lens shape geometry. The uppermost section of outcrop is dominated by floodplain deposits of Unit-E (Figure 4.1.1.3.1 b).

Channels (CH)

Description of Channel 1 (CH 1)

Unit-B, Unit-C and Unit-D are regarded as multistorey channel deposits. Unit-B has a width of 7.2 metres and thickness of 0.6 metres. Therefore, it is regarded as a ribbon channel based on its geometrical properties (Friend, 1983). Both Unit-C and Unit-D has a similar geometry like Unit-B. In general, channels are termed succession-dominated ribbon channels rather than erosion dominated ones because of preservation of complete channel fills (Gibling et al., 2006) (Fig 4.1.1.3.1b).

Description of Channel 2 (CH 2)

Channel 2 (CH 2) is up to 12 metres wide and 0.6 metres thick and can be regarded a sheet-like channel (Folk, 1983). It has poorly defined channel margins. Channel 2 comprises clast-supported gravels with horizontal stratification. Furthermore, the channel has a flat top and partly concave-up channel base and is overlain by floodplain sediments (Figure 4.1.1.3.1 a).

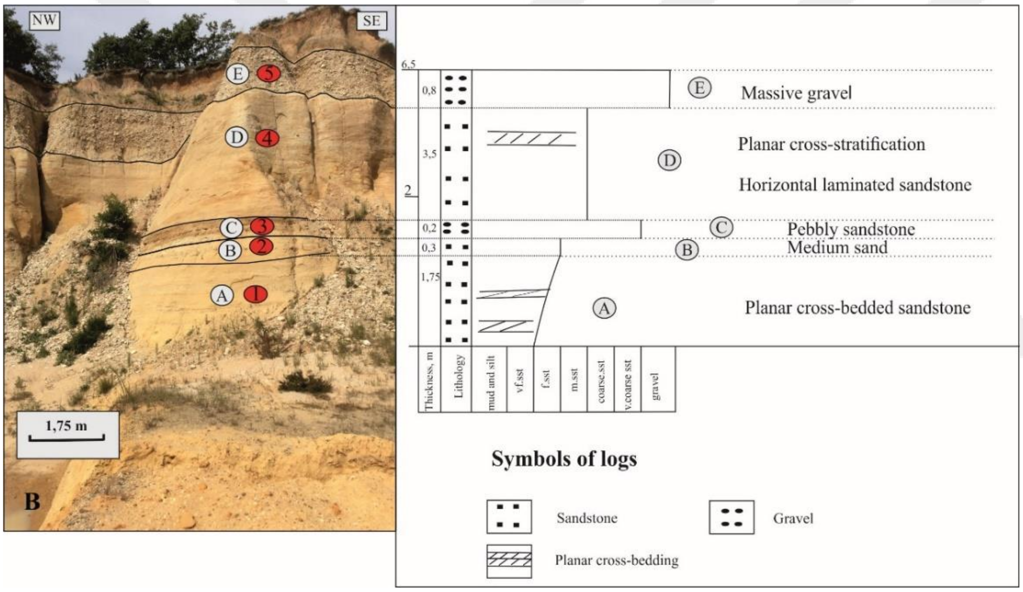
Floodplain (FF)

Floodplain deposition overlies the channel sequence. It has a red colour which shows a good drainage and oxidizing early diagenetic regime (Fig 4.1.1.3.1 a) (Reading et al, 1996).

4.1.1.4 Area-2, Karamandere (N 41°24'0.76", E 28°21'13.12")

Unit-A constitutes slightly gravelly sand (g)S with planar cross-bedding. Unit-B represents sandy mudstone (sM) (Figure 4.1.1.4.1). Unit-C, which consists of thin layer of pebbly sandstones (mG) successively lies above the medium sandstone.

(a)



(b)

Figure 4.1.1.4.1 : (a) Panoramic view of Area-2,Karamandere. (b) Vertical profile of an Area-2, Karamandere. Solid and dotted lines represent sharp and erosional stratigraphic boundaries in vertical section.

Unit-D composes planar cross stratified sandstone. Horizontal lamination is also seen at the base of the unit. It has a thickness of 3.5 metres. The uppermost layer of the outcrop is Unit-E, which comprises poorly sorted conglomerate. It represents unchannelized flow or ephemeral seasonal floods.

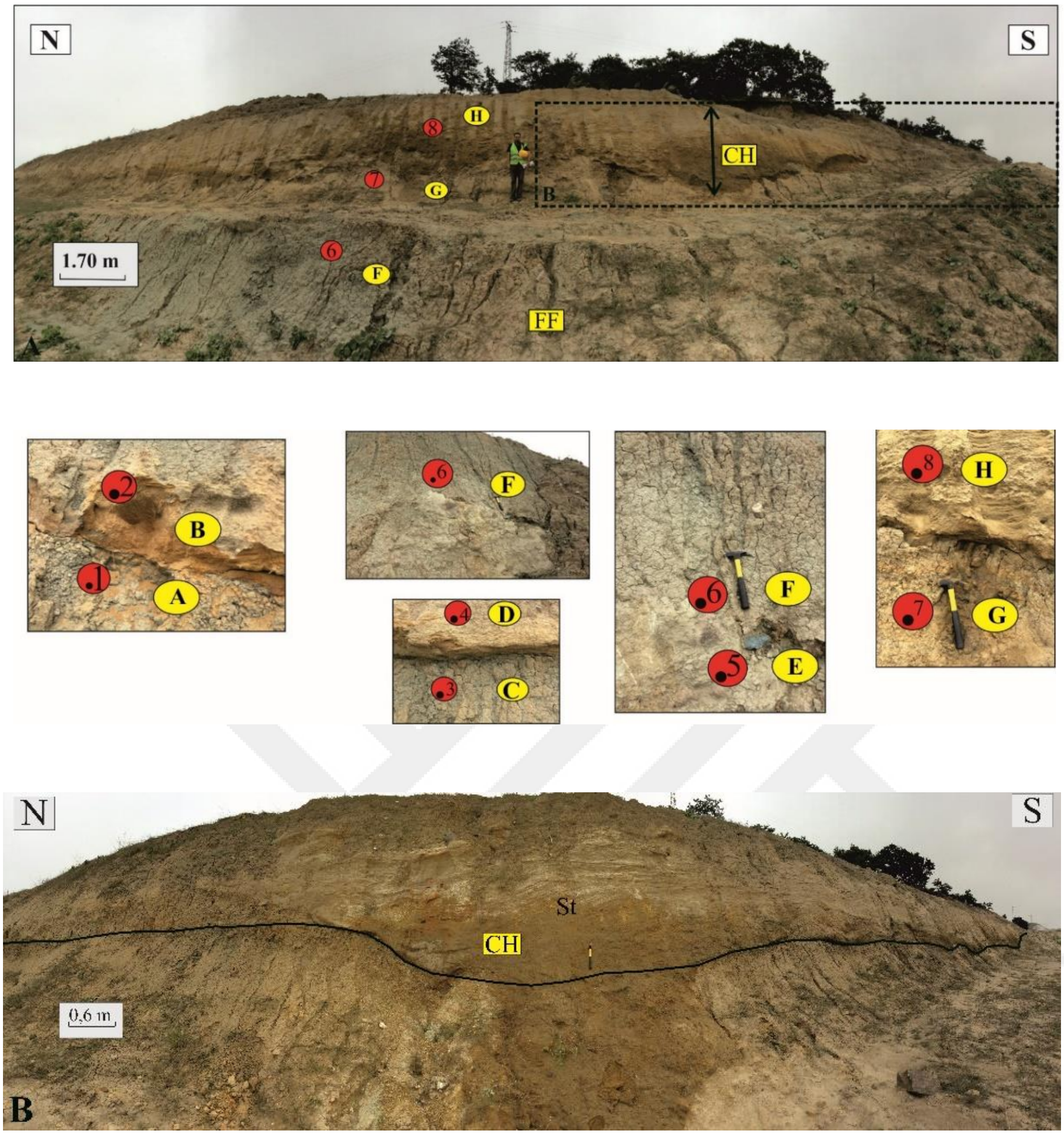
4.1.1.5 Area-3, Akpınar (N 41°16'46.64", E 28°49'4.77")

It is located in the vicinity of coal quarry in the Akpınar village of Eyub district, Istanbul. Sandstone units alternate with clay units throughout the vertical section. Unit-

A is termed a mud (M) on the basis of Folk`s grain-size nomenclature (Table 4.1.2.3.1). Unit-B, which is equivalent to muddy sandstone (mS) overlies the Unit A with erosional boundary (Table 4.1.2.3.1). It contains parallel lamination with some pebbles. Unit-C constitutes mud (M) with upper erosional top. However, Unit-D can be regarded as a channel deposit, which overlies sample 3 with erosional base (Figure 4.1.1.5.1). Unit-E composes clay minerals, which have bluish colour. Unit-F consists of pebbly sandstones with convex-up tops. It is bounded by bluish clays above and below. Unit-G has a thickness of 3 metres and composes clay-size sediments. Unit-H unconformably overlies Unit-G. It shows trough cross-bedding and parallel lamination. Several channels are observed within Unit-H at this level of outcrop (Figure 4.1.1.5.1).

Channels (CH)

Laterally extensive channel unit, which has lower erosional boundary overlies the whole stratigraphy in Akpınar. It has a width of 50 metres and height of 1.8 metres, therefore it can be considered a sheet channel with respect to channel geometry (Friend, 1983). The maximum thickness of channel is approximately 4 metres (Figure 4.1.1.5.1).



(a)

(b)

Figure 4.1.1.5.1 : (a) Outcrop photograph of Akpınar. Circled white numbers refer to rock samples recovered from the outcrop. Lower boxes belong to stratigraphic units within the outcrop. (b) Zoom on the upper section of the outcrop. Elemental codes: CH channel. Lithofacies: St trough cross stratified sandstone (Miall, 1988).

4.1.2 Grain-Size analysis

4.1.2.1 Area-1A, Karacaköy Village (N 41°24`47.02`` E 28°24`46.96``)

During field investigation, nine samples were recovered from Area-1A Karacaköy for futher sedimentologic and petrographic analysis. To determine the grain size distribution of samples, sieve and grain size analysis have been conducted using -1 ϕ, 0 ϕ, 1 ϕ, 2.0 ϕ, 3.0 ϕ, 4.0 ϕ and 4.5 ϕ wire meshes in all samples with exception of Sample 2, in which -1.75 ϕ and 0.5 ϕ wire mesh were used, additionally. Weight percentages of each grade were given in the table below (Table 4.1.2.1.1). Each rock sample is defined on the basis of grain size nomenclature of Folk (1974) (Table 4.1.2.1.2).

To put a specimen in one of the fifteen major groups, only two properties should be determined: (1) proportion of gravel (material coarser than 2 mm)—boundaries at 80, 30, 5 per cent, and a trace; (2) the ratio of sand to mud (silt plus clay) with boundaries at 9:1, 1:1, and 1:9. Gravel content of specimen indicates the highest current velocity at the time of deposition. Therefore, proportion of gravel is highly significant. Using Folk`s (1974) classification, a specimen composing more than 80 percent gravel is termed `conglomerate`, from 30 to 80 per cent gravel `sandy conglomerate` or `muddy conglomerate`; from 5 to 30 per cent gravel, `conglomeratic sandstone` or `conglomeratic mudstone`, from a trace (0.01 per cent) up to 5 per cent gravel, ``slightly conglomeratic sandstone``or ``slightly conglomeratic mudstone`` and a sample constituting no gravel totally may range from sandstone through mudstone, according to sand: mud ratio.

The proportion of sand to mud is the next feature to be defined, showing the amount of winnowing at the site of deposition. Four ranks are defined based on the sand: mud ratio; in a nonconglomeratic tier, these are sandstone (ratio of sand to mud over 9:1), muddy sandstone (ratio 1:1 to 1:9) , sandy mudstone (ratio 1:9 to 1:1), and eventually, mudstone (ratio under 1:9).

Table 4.1.2.1.1 : Results of sieve analysis of an Area-1A, Karacaköy.

Area: 1A Karacaköy	Gravel	Very coarse sand	Coarse sand		Medium sand	Fine Sand	Very Fine Sand	Silt or Mud
Sieve sizes	2 mm	1 mm	500μ	425 μ	250 μ	125 μ	63 μ	45 μ
Sample 1	3%	3%	13%	1%	44%	28%	6%	1%
Sample 2	4%	1%	2%	3%	5%	1%	0%	0%
Sample 3	2%	6%	50%	18%	15%	5%	3%	1%
Sample 4	2%	4%	16%	10%	47%	15%	5%	2%
Sample 5	63%	9%	15%	3%	5%	3%	2%	1%
Sample 6	11%	42%	33%	1%	4%	3%	4%	1%
Sample 7	3%	6%	25%	13%	36%	9%	4%	2%
Sample 8	4%	16%	55%	5%	8%	7%	4%	2%
Sample 9	4%	16%	37%	11%	22%	6%	3%	1%

Table 4.1.2.1.2 : Major textural classes on the basis of Folk`s (1974) grain-size nomenclature.

Area:1A, Karacaköy	Major textural class
Sample 1	Slightly gravelly muddy sand (g)mS.
Sample 2	Gravel
Sample 3	Slightly gravelly muddy sandstone (g)mS.
Sample 4	Slightly gravelly muddy sandstone (g)mS.
Sample 5	Muddy Gravel mG.
Sample 6	Gravelly mud gM.
Sample 7	Slightly gravelly sandy mud (g)sM.
Sample 8	Slightly gravelly sandy mud (g)sM.
Sample 9	Slightly gravelly muddy sand (g)mS.

4.1.2.2 Area-2 Karamandere (N 41°24'0.76", E 28°21'13.12")

As a whole, four rock samples recovered from Area-2, Karamandere were sieved using -1.0 ϕ, 0.0 ϕ, 1.0 ϕ, 2.0 ϕ, 3.0 ϕ, 4.0 ϕ, 4.5 ϕ size sieve meshes, with exception of Sample 2 (Table 4.1.2.2.1). Rock samples weighing 150-200 grams were assigned for sieve analysis. Following sieve analysis, rock samples were classified on the basis of Folk`s (1974) grain size nomenclature (Table 4.1.2.2.2 and Table 4.1.2.2.3). On the other hand, Sample 2 was analysed by mastersize grain-size analyser, because of its mud content. Different classification scheme has been used for Sample 2. In this classification scheme, textural class depends on the relative proportion of silt versus clay. To do so, a threefold division is proposed: if the mud fraction comprises more than 67 per cent silt, the material then called `silt` or `silty`; if more than 67 per cent clay is present, it will be called `clay` or `clayey` and for intermediate mixtures, the class `mud` or `muddy` is suggested (Folk, 1974).

Table 4.1.2.2.1 : Sieve analysis (gr) of Area-2, Karamandere.

Area- 2, Karamandere	2 mm	1 mm	500 µ	425 µ	250 µ	125 µ	64 µ	45 µ	>45 µ
Sample 1	1.42	1.58	40.7	53.32	127.37	86.4	16.03	7.12	3.2
Sample 3	234.19	102.77	43.09	12,89	27.62	23.77	12.40	5.83	2.4
Sample 4	0.3675	2.54	36.71	30.94	51.37	8.96	10.69	1.75	0.72
Sample 5	118.90	45.01	47.59	34.71	69.63	29.35	20.63	4.17	2.37

Table 4.1.2.2.2 : Major textural classes of samples based on Folk`s (1974) grain-size nomenclature.

Area- 2, Karamandere	Major textural class
Sample 1	Slightly gravelly sand (g) S.
Sample 3	Muddy Gravel mG.
Sample 4	Sand S.
Sample 5	Muddy Sandy Gravel msG.

Table 4.1.2.2.3 : Grain-size analysis of Sample 2, Area-2 Karamandere.

Area-2, Karamandere	Clay	Silt	Sand	Major textural class
Sample 2	13,625 %	55,809 %	30,565 %	Sandy mudstone sM.

4.1.2.3 Area-3 Akpınar (N 41°16'46.64", E 28°49'4.77")

Three samples, i.e. Sample 2, Sample 4, Sample 8 were sieved using -1.0 ϕ, 0.0 ϕ, 1.0 ϕ, 2.0 ϕ, 3.0 ϕ, 4.0 ϕ, 4.5 ϕ size wire meshes. Because of its significant mud content, Sample 1, Sample 3 and Sample 7 were analysed by Mastersize grain-size analyser at Istanbul Technical University EMCOL sedimentology lab. Rock samples have been classified according to Folk`s (1974) grain-size nomenclature.

Table 4.1.2.3.1 : Results of grain-size analysis of rock samples from Area-3, Akpınar.

Area-3, Akpınar	Clay	Silt	Sand	Sorting	Textural class
Sample 1	19,46 %	54,13 %	26,40 %	0.51	Mud M.
Sample 3	11,68 %	56,36 %	31,95 %	1.11	Mud M.
Sample 7	15,57 %	55,25 %	29,17 %	0,8	Mud M.

Area-3, Akpınar	2 mm	1 mm	500 µ	425 µ	250 µ	125 µ	64 µ	45 µ	>45 µ
Sample 2	11.08	93.59	138.99	23.80	45.47	10,1	7,2	5,1	3,1
Sample 4	19.13	34.01	25.08	10.31	33.73	66.48	78.61	3.05	0.67
Sample 8	0	0.64	4.82	4.54	61.54	171.21	53.05	15.25	4.66

Table 4.1.2.3.2 : Equivalent textural classes of Area-3, Akpınar according to Folk (1974).

Area-3, Akpınar	Textural classes
Sample 2	Muddy sandstone mS.
Sample 4	Muddy Sandstone mS.
Sample 8	Muddy Sandstone mS.

4.1.3 Petrography

Overall, twelve samples were selected for thin section analysis under the plane polarized microscope. The percentages of main constituents of sandstone, such as quartz, feldspar and rock fragments have been determined and summarized below.

4.1.3.1 Area-1A, Karacaköy

Sample 1: Quartz is the major component with 60 % of whole thin section in the sample (Table 4.1.3.1.1). Feldspars are estimated to be only 5 percent. Quartz grains show nonundulatory extinction, therefore it can be assumed that they are derived from volcanic rocks. Rock Fragments (RF) are mainly metamorphic in origin with 10-15 %, and sedimentary rock fragments are estimated to be 3-5 %. Quartz grains are mostly polycrystalline, whereas lesser amount of them is monocrystalline. Sample 1 can be classified as a sublitharenite according to Folk`s (1974) classification (Figure 4.1.3.1.1).

Sample 5: Quartz is the most common constituent in the specimen. Feldspar is of minor significance. In addition, quartz grains show slightly undulose extinction. Rock fragments constitute 25% of the sample. Sample 5 like Sample 1, can be assumed a sublitharenite on the basis of Folk`s (1974) sandstone classification (Figure 4.1.3.1.1).

Sample 7: Monocrystalline quartz grains is dominant throughout the thin section (Figure 4.1.3.1.2). In addition, feldspar increased in comparison to sample 5. Opaque minerals also occur in thin section. For instance, well-rounded biotite minerals were observed in specimen. Feldspar showing albite twinning occurs in the specimen. Sample 7 can be considered a litharenite based on Folk`s (1974) classification (Figure 4.1.3.1.1).

Sample 8: Quartz is the most abundant mineral in thin section. Albite (potassium feldspars), pericline are identified in cross polarized light. Biotites is also present in the sample. Felspar content of sample 8 is higher than that of sample 7 (Table 4.1.3.1.1). Quartz grains contain some inclusions. Sample 8 can be classified as subarkose according to Folk`s (1974) sandstone classification (Figure 4.1.3.1.1).

Table: 4.1.3.1.1 : Results of petrographic analysis of Area- 1A, Karacaköy on the basis of Folk`s (1974) sandstone classification.

Area-1A, Karacaköy	Quartz	Feldspar	Rock Fragments
Sample 1	60 %	5 %	35 %
Sample 5	60 %	15 %	25 %
Sample 7	35 %	15 %	60 %
Sample 8	65 %	25 %	15 %

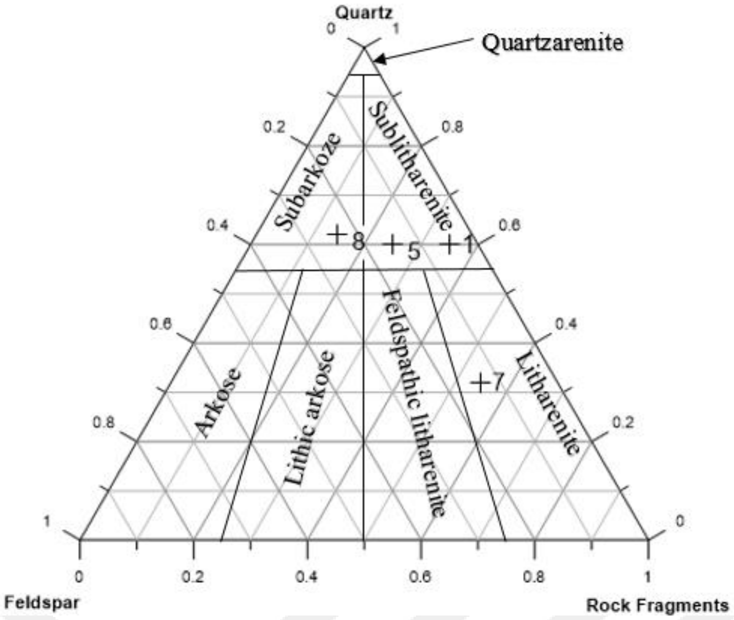
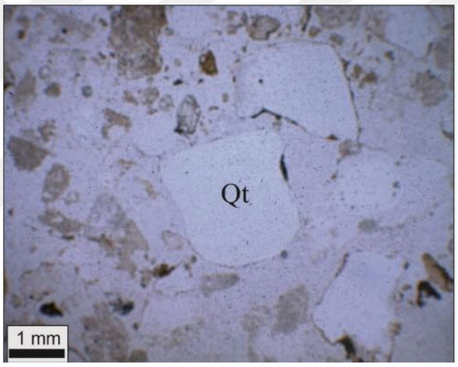
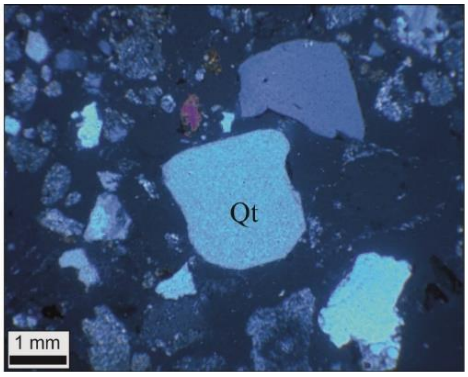


Figure 4.1.3.1.1 : Ternary plot for rock samples recovered from Area-1, Karacaköy on the basis of Folk`s (1974) sandstone classification.



(a)



(b)

Figure 4.1.3.1.2 : Photomicrograph of quartz grains in Area-1A, Karacaköy. Sample 5. (a) is under plane polarized light (PPL) (b) is view from cross-polarized light (XPL).

4.1.3.2 Area-2, Karamandere

Sample 1: Quartz constitute the significant proportion of the sample. Rock fragments is the second dominant component in thin section, whereas feldspar is rarely found (Table 4.1.3.2.1).

Sample 3: Quartz accounts for half of the whole specimen. Feldspar makes up a 10% of the sample. The rest of sample is represented by rock fragments. Quartzs are mainly monocrystalline, but few polycrystalline quartzs are also seen in thin section (Figure 4.1.3.2.2).

Sample 4: Quartzs make up 70% of the specimen. Monocrystalline quartz is more abundant than polycrystalline quartz. Rock Fragments account for 20 % of the thin section. Quartz grains mostly show undulatory extinction (Figure 4.1.3.2.1).

Table 4.1.3.2.1 : Results of petrographic analysis of Area-2, Karamandere andternary diagram on the basis of Folk`s (1974) sandstone classification.

Area-2, Karamandere	Quartz	Feldspar	Rock Fragments
Sample 1	60%	10%	30%
Sample 3	50%	10%	40%
Sample 4	70%	10%	20%

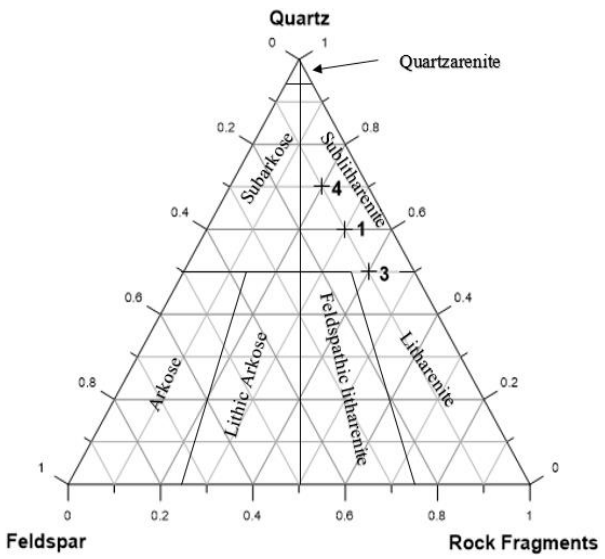
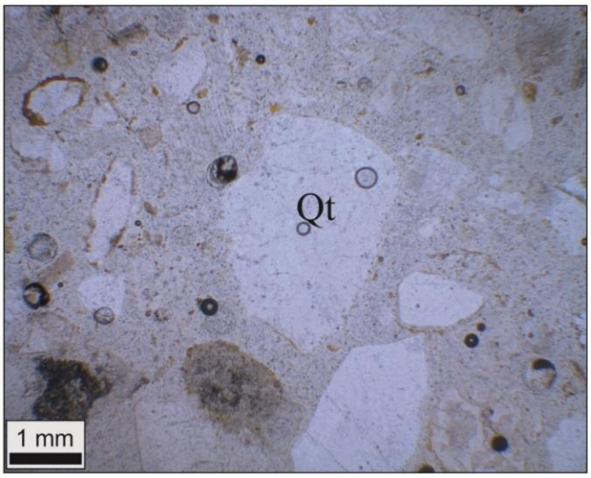
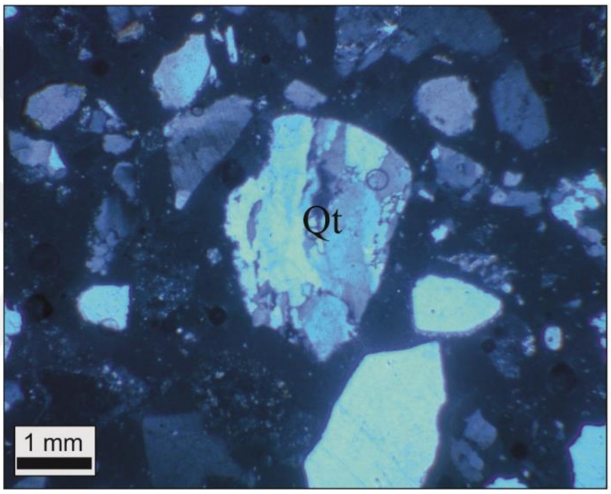


Figure 4.1.3.2.1 : Ternary plot of Area-2, Karamandere based on the Folk`s (1974) sandstone classification.



(a)



(b)

Figure 4.1.3.2.2 : Photomicrograph of Area-2, Karamandere, Sample 4. (a) is under plane polarized light (PPL). (b) is view from cross-polarized light (XPL).

4.1.3.3 Area-3, Akpınar

Sample 2: Quartz is the dominant constituent of the specimen. Half of the quartz grains are monocrystalline and one third of them is polycrystalline. Quartz grains show slightly undulatory extinction. Rock Fragments are mainly of metamorphic origin. Feldspars only account for 10% of the sample (Figure 4.1.3.3.1 and Figure 4.1.3.3.2).
Sample 3: Quartz makes up the half of the sample. They show mostly undulatory extinction. Rock Fragments account for 40% of the sample. Pyroxenes and hornblende minerals are found in thin section. The rest is represented by feldspars (Figure 4.1.3.3.1).

Sample 4: Quartz constitutes 40% of the thin section. Rock fragments comprises the half of the sample. Rodlike biotites were seen in the specimen. Feldspars make up only 10% of the sample.

Sample 8: Quarz is the main mineral in the thin section. Rock Fragments represent 30 % of the specimen. They are mainly metamorphic in origin. Feldspar only contain 10% of whole sample (Table 4.1.3.3.1).

Table 4.1.3.3.1 Results of petrographic analysis of Area-3, Akpınar and ternary diagram on the basis of Folk`s classification (1974).

Area-3, Akpınar	Quartz	Feldspar	Rock Fragments
Sample 2	55%	10%	35%
Sample 3	50%	10%	40%
Sample 4	40%	10%	50%
Sample 8	50%	20%	30%

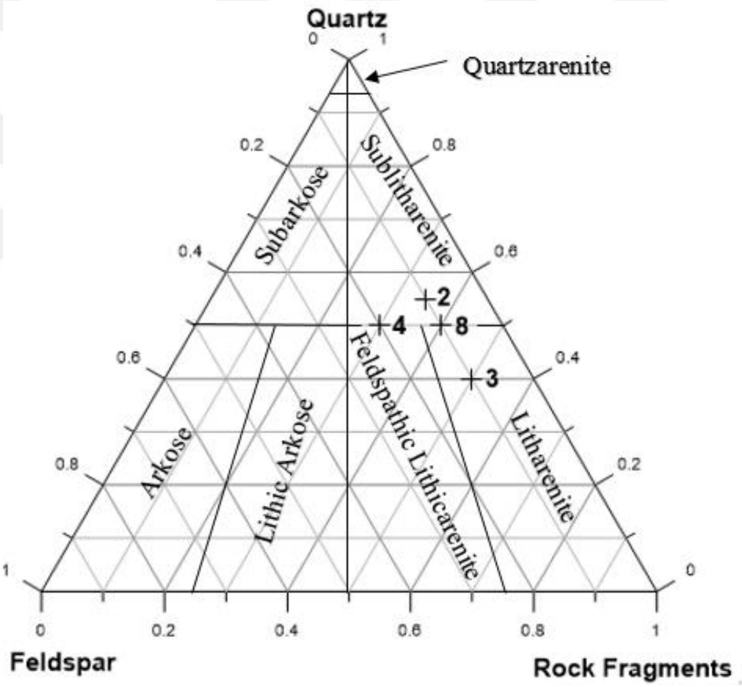
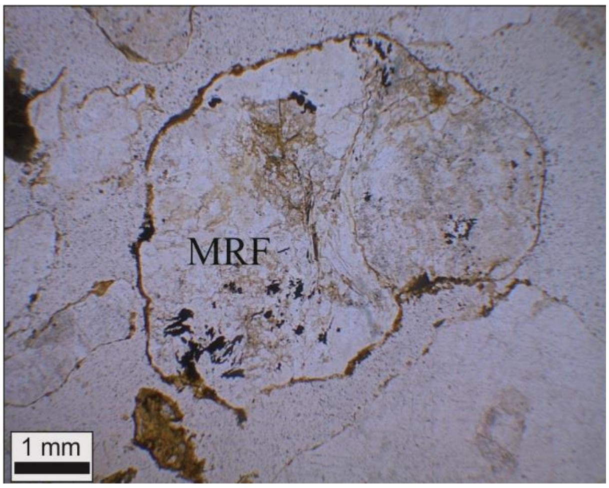
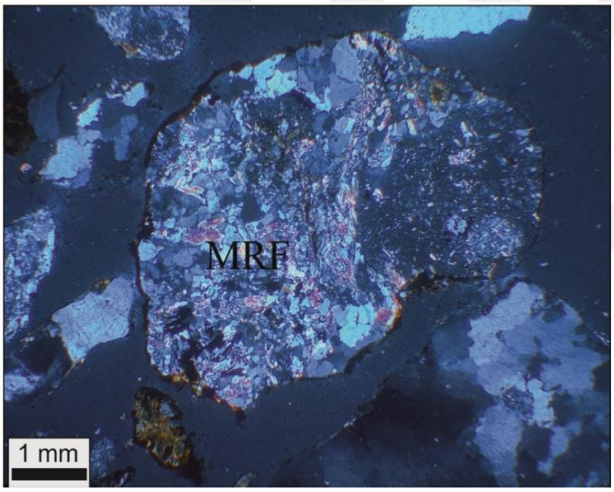


Figure 4.1.3.3.1 : Ternary plot of samples recoved from Area-3, Akpınar on the basis of Folk`s (1974) classification.



(a)



(b)

Figure 4.1.3.3.2 Photomicrograph of Area-3, Akpınar; Sample 2. (A) is under plane polarized light, (B) is view from cross-polarized light (XPL). MRF refers to metamorphic rock fragments in the thin section.

4.1.3.4 Maritsa river

Sample-1 (N 41°38`1.75`` *E 26*°34`14.64``)*:* Quartz is the major component of the sample. Rounding of quartz grains is subanglular. Quartz grains with straight extinction is dominant in the thin section. All of quartz grains are almost monocrystalline. Rock samples make up the 30% of the sample. Felspars is only 10% and show albite twinning (Figure 4.1.3.4.3). Sample 1 is classified as sublithicarenite according to Folk`s (1974) sandstone classification (Figure 4.1.3.4.1 and Figure 4.1.3.4.2).

Table 4.1.3.4.1 : Results of petrographic analysis of Maritsa river Sample 1 and ternary diagram on the basis of Folk`s sandstone classification (1974).

Maritsa River	Quartz	Feldspar	Rock Fragments
Sample-1	60%	10%	30%

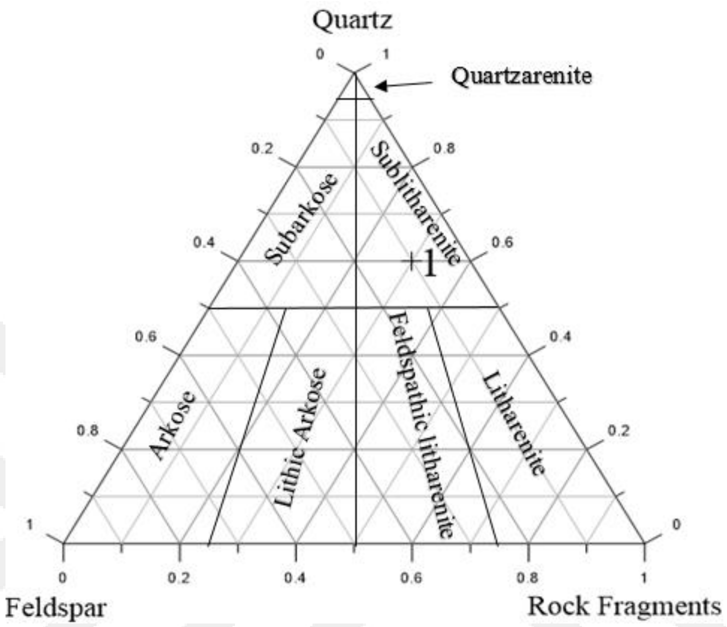
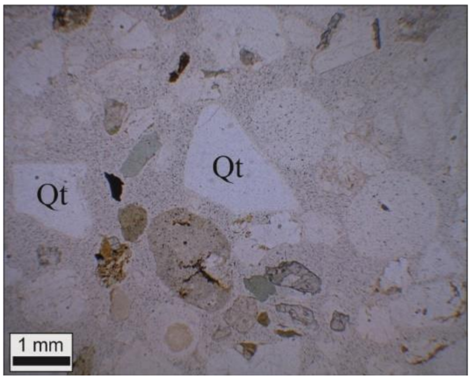
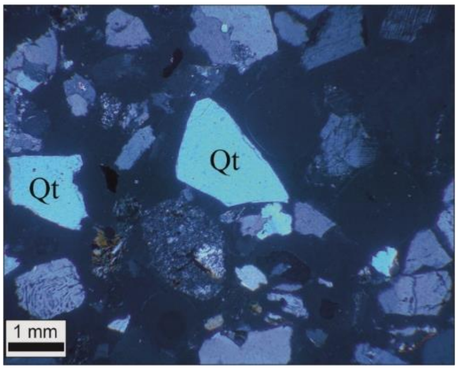


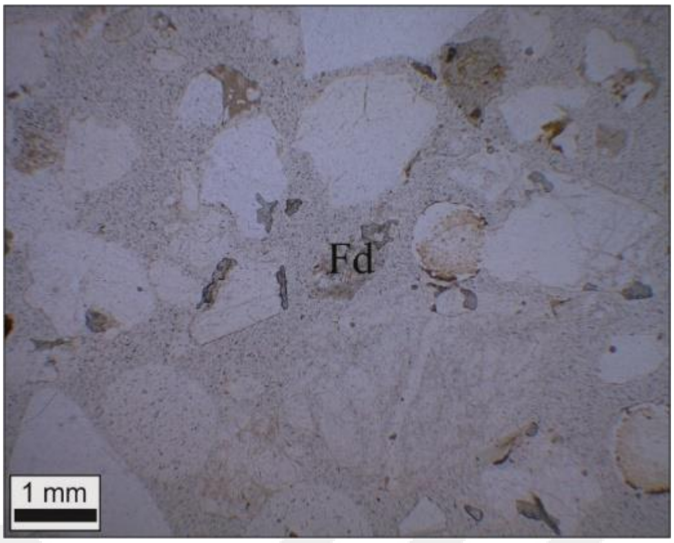
Figure 4.1.3.4.1 : Ternary plot for Maritsa river-Sample 1 based on Folk`s (1974) sandstone classification.



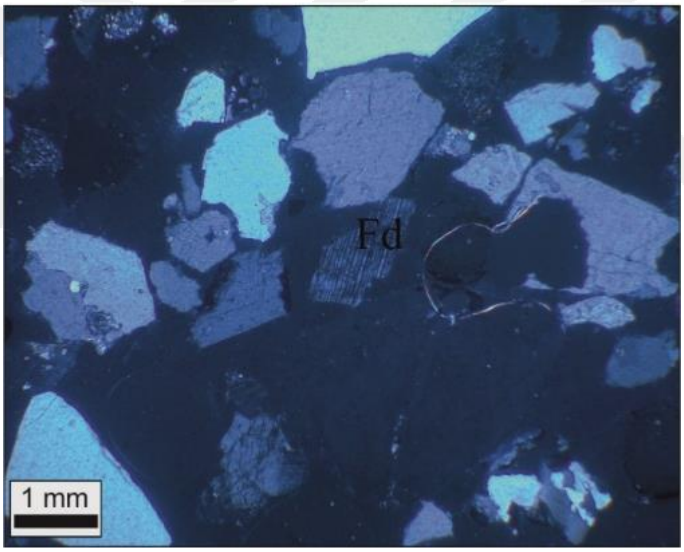


(a) **(b)**

Figure 4.1.3.4.2 : Photomicrograph of Maritsa River-Sample 1. (a) is under plane polarized light, (b) is view from cross-polarized light (XPL). Qt refers to quartz grain in the thin section.



(a)



(b)

Figure 4.1.3.4.3 : Photomicrograph of Maritsa River-Sample 1. (a) is under plane polarized light, (b) is view from cross-polarized light (XPL). Fd refers to feldspar grain in the thin section.

5. DISCUSSION

5.1 The Provenance of the Ergene Fluvial Network

Samples recovered from Karacaköy village lies in the realm of sublitharenite according to Folk`s sandstone (1974) classification. In these samples, quartz grains show generally uniform extinction, which is diagnostic of granitic origin. Undulosity is a function of grain size and strain (Folk, 1974). Therefore, schists which are fine-grained rocks, constitute mostly quartz grain with straight extinction. Tekedere Formation being the basement rocks of Strandja Sill, is composed of garnet schists, biotite schists, gneiss and amphibolite schist. In addition, the Tekedere formation is exposed widely close to the study area in the Strandja Sill. In the light of above findings, we can assume that source rock for the samples of Karacaköy village can be the Tekedere Formation. However, Samples collected from the Karamandere village show a relatively higher amount of metamorphic rock fragments and quartz with only undulose extinction. Polycrystalline quartz grains are abundant in these samples. Massive granitoid rocks, which yields subequal amount of monocrystalline and polycrystalline quartz grains can contribute to larger amount of quartzs with undulatory extinction. Therefore, Kırklareli Group rocks, which occurs as a plutonic intrusions in the Strandja Sill can be considered a source rock for the samples recovered from Karamandere. In the samples recovered from Akpınar, grains are enriched with pyroxenes, hornblendes, biotites and other mafic minerals. Provenance of samples recovered from Akpınar can be the basement rocks of Strandja Sill . Maritsa river Sample 1 shows similar composition as Karacaköy rock samples. Therefore, we can assume that Karacaköy and Maritsa River have a same source rock derived from northward Rhodope Massif.

5.2 Late Miocene-Pliocene Evolution of Fluvial Sediments in the Northern Thrace Basin.

In the Thrace Basin, few previous investigations documented geological evidences for fluvial network that deposited siliciclastics of the Ergene Formation during the Upper Miocene (Suc et al., 2015). Existence of the Ergene fluvial network together with a Maritsa River was coincided with the incision of the Karamandere paleo-gorge and deltaic offshore deposits in the Black Sea (Suc et al., 2015). Incision along the Karamandere palaeo-gorge has been considered as a consequence of sea-level drop in the Black Sea during the Messinian Salinity Crisis (MSC) (Suc et al., 2015; Gillet et al., 2007). The erosional surface seen in the offshore seismic profiles was attributed to a significant sea-level fall in the Black Sea as a consequence of the Messinian Salinity Crisis in the Mediterranean (Gillet et al., 2007). This interpretation was supported by the stratigraphic subdivision of several petroleum exploration wells (Gillet et al., 2007) from the Black Sea. The sediments overlying the erosional surface are allocated to Pliocene as evidenced by the İğneada-1 well projected on the seismic profile (Gillet et al., 2007). Along the erosional surface, the overlying sediments are precisely dated (Popescu et al., 2010) that allows to consider this surface as the Messinian Erosional Surface (MES), as proposed by Gillet et al. (2007). Ergene fluvial network contributed a great amount of siliciclastic rocks into the Black Sea during the peak of the MSC (5.5 Ma). Following the sea-level rise around 5.45 Ma, the Karamandere paleogorge converted into river mouth with its delta on the coast of the Black Sea (Succ et al.,2015). Melinte-Dobrinescu et al. (2009) described at Enez a very weak Messinian fluvial cutting and a thin post-reflooding sedimentary filling, indicating that only a small river would have existed there at the time of the MSC. This suggests that the Ergene fluvial network, possibly augmented with a catchment of the Maritsa River, could have been directed towards the Black Sea. Such a river could have been responsible for the incision of the Karamandere gorge and offshore valley and subsequent deposition of the large deltaic infill (Succ et al., 2015).

Okay and Okay (2002) proposed that the palaeo-Maritsae Ergene network flowed into the northern Marmara Sea domain prior to the Early Quaternary. Succ et al. (2015) proposed that, during the Late Miocene and Early Pliocene, the Maritsa-Ergene fluvial system was directed towards the Black Sea, but later progressively shifted to its present-day course as a result of the uplifting Strandja Sill (Sakınç et al., 1999; Sakınç and Yaltırak, 2005) and, probably, effect of the Mediterranean glacio-eustatic lowstands during the Quaternary. On the basis of recent investigation of Succ et al. (2015) from the Thrace Basin, evidences of the Messinian fluvial erosion in the Karamandere palaeogorge implies that there must have been a river incision during the MSC. They concluded that the Ergene fluvial network with a catchment of the Maritsa River may have flown to the Black Sea at the peak of the MSC (Suc et al., 2015). At the mouth of the river in the Black Sea coast, the fluvio-deltaic sediments were well observed that are equivalent of incised channel-fills in the seismic data from the Black Sea coast (Succ et al., 2015). In this study, to examine the sedimentary deposits of this fluvial network maintained in the Thrace Basin during the upper Miocene, particular attention has been paid into macroform architecture together with sedimentologic properties of the Ergene Formation in three different locations in Karacaköy, Karamendere and Akpınar villages (Figure 5.2.1). In this context, we documented evidences of fluvial macroform sedimentology to examine facies characteristics and changes in fluvial regimes during the upper Miocene (Messinian). Evolution of this fluvial system around the study area might have been affected by the external and internal causes such as global eustacy, climate and tectonics during the Messinian, therefore, different fluvial facies in the Ergene Formation are expected along its network in the Thrace Basin. The changes during the MSC in the existent fluvial regimes can be documented by classifying the main macroforms on the basis of Miall`s (1996) architectural elements classifications and also Friend`s (1983) classification for the fluvial channel macforms. The widest outcrops of the Ergene Formation in the studied area appears in Karacaköy village (Area-1 and Area-2) that contains various types of fluvial macroforms including channels and downstream accretion bars and gravelly bedforms. Two main types of channels are observed in these outcrops as multi-storey ribbon channels on the basis of architectural macroform characteristics (Miall, 1996). On the basis of channel morphology together with related downstream accreationary bar deposits strongly indicate that the fluvial system during the formation of the Ergene Formation would have been a braided river with few channels separating the longitudinal bars. The Width/Height ratio of the channel and coarser grained channel-fills together with larger-scale cross-stratifications in the channels imply that the discharge of the existent river must be very high comperative to the present Karamandere River in the region. The existence of multistorey channels also indicates that the vertical channel migration occurred due to unstable river profile at the time of deposition. This can be related to both changes in the base-level due to sea-level changes and tectonic adjustment around the region during the Upper Miocene-Pliocene. The most important external force on the fluvial system in the region during that time is the existence of Messinian Salinity Crisis (MSC). On the other hand, uplifting of the Strandja Sill continued during the upper Miocene that must be considered as important effect on the hinterland of the fluvial network, giving rise to changes in the fluvial regime through the time in the basin. In Karacaköy village, the measured outcrop (Area-1) of the Ergene Formation indicates the existence of ribbon-type fluvial channel. This finding suggests the fluvial network around the Karamendere village was associated with a low-sinuous braided channel that implies a lower discharge related to its energy. In Karamendere village, the vertical measured outcrop reveals the existence of sheet-flood deposits with unchannelized macroform geometries. The vertical sequence of Area-2 indicates coarsening-upward from cross-stratified sands passing into the crudely bedded congolomerates at the top. The sedimentological properties together with geometries of macroforms imply that this outcrop is associated with the Entrenchment phase during the deposition of the Ergene Formation. Entrenchment was most vigorous upstream where the local gradient was steep enough for trenching. The initiation of the river system across the region corresponds to the fluvial facies assemblage in this outcrop (Karamendere Village). This assemblage accumulated as a result of sheet-flood processes on a depositional lobe located on the lower part of the alluvial fan. The facies display mainly progradational stacking throughout the study area indicating the slow creation rate of accommodation space and a high velocity flow regime. Moreover, the high gradient and low volume and calibre of these sediments imply that a semi-arid to arid climate prevailed in the basin during the Upper Miocene-Pliocene. Tectonic rejuvenation at the fan apex due to the uplift of Strandja Sill caused a change in the fluvial style. The increases in sediment grain-size in the measured vertical section may be caused by the uplift being higher than basin subsidence at the fan apex. To the west in Karacaköy village, channels composing open-framework clast-supported gravels which are deposited under high bed shear stress is assigned to the low-sinuosity slightly gravelly channel streams (Reading et al, 1987). Moreover, channel examples in Karacaköy constitutes the distal braidplain part of alluvial fan.

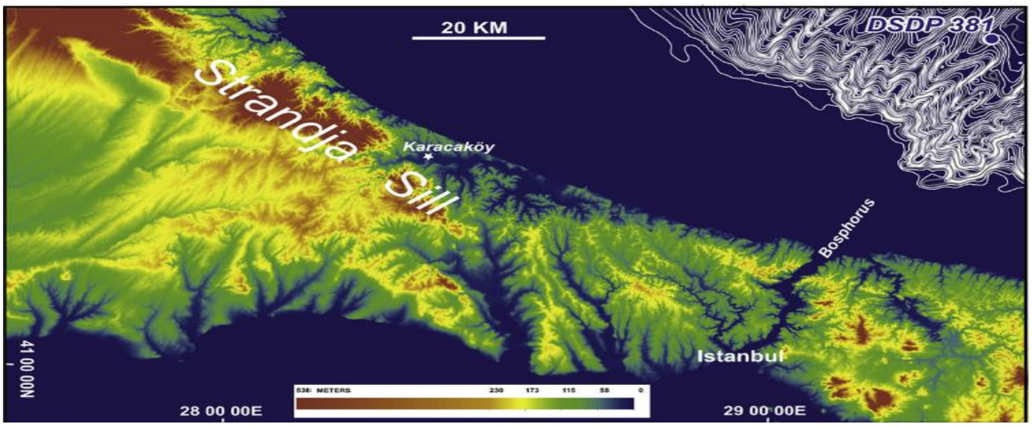


Figure 5.2.1 : 30 m digital elevation model of south-western part of the Black Sea showing the relation of Strandja Sill to the Black Sea.

6. CONCLUSION

1. Rock samples were collected from Karacaköy, Karamandere, Akpınar localities to construct vertical stratigraphic sections and conduct thin section analysis for the purpose of revealing the fluvial regime and style existing at the time of Messinian Salinity Crisis (MSC). Sedimentary facies in the Karamandere and Karacaköy villages comprises two types of alluvial sequences, semi-arid fans and low sinuosity braided rivers, respectively.
2. Sedimentary facies in the Karamandere and Karacaköy villages comprises two types of alluvial sequences, semi-arid fans and low sinuosity braided rivers, respectively. These broad sequences are intergradational similar to modern environments. Coarsening upward sequence in the Karamandere village can be formed as a result of uplift of the Strandja Massif. Channel complexes are regarded as low-sinuosity braided rivers in Karacaköy village. Thin section analysis show that mineralogic composition of Karacaköy and Maritsa river samples are identical , therefore continuation of the Ergene Fluvial Network beyond the Strandja Sill can be proved during the Messinian Salinity Crisis (MSC).
3. Source rock for the rock samples of Karacaköy and Akpınar village can be Tekedere Formation, based on mineralogic composition and texture. For the samples recovered from Karamandere village, Kırklareli group plutonic rocks can be potential source rocks.

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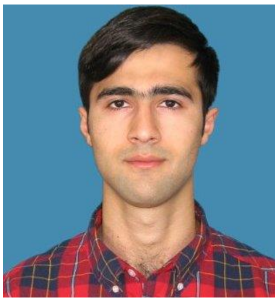

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