

TECTONOSTRATIGRAPHY AND NEOTECTONIC CHARACTERISTICS
OF THE SOUTHERN MARGIN OF MERZİFON-SULUOVA BASIN
(CENTRAL PONTIDES, AMASYA)

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We certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy in Geological Engineering.



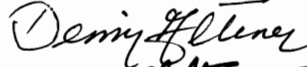
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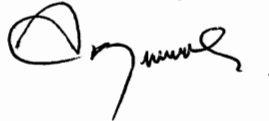
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ABSTRACT

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The study area is located in the Central Pontides (Amasya Region, Turkey) between the North Anatolian Fault Master Strand to the north and the Ezinepazarı Fault to the south.

The main units in the Amasya region are the Paleozoic low-grade metamorphics (Tokat Complex), Jurassic-Lower Cretaceous platform carbonates (Amasya Group), Upper Cretaceous ophiolitic melange (North Anatolian Ophiolitic Melange), Campanian-Maastrichtian forearc sequences (Karatepe and Kışlacık groups), Lutetian "flysch" sequence (Cindere group), post-Lutetian dacitic intrusions (Moramlı dacite), neotectonic basin fill units of molassic nature (Suluova group), and Holocene fluvial sediments and travertines.

Tectonic structures of the region are classified into two categories: (1) pre-Pliocene paleotectonic and (2) Plio-Quaternary neotectonic structures.

The main stratigraphical gaps are represented by the pre-Liassic, pre-Callovian, pre-Aptian, pre-Campanian, pre-Lutetian, pre-Pliocene and pre-Holocene unconformities.

The large-scale overthrusts are subdivided into two groups: (1) the pre-Jurassic, and (2) Late Cretaceous-Paleogene overthrusts. The youngest overthrusting verges towards north, post-Lutetian - pre-Pliocene in age.

The neotectonic structures that sculptured the recent configuration of the Merzifon-Suluova basin are the folds and mainly the strike-slip faults with normal components. Based on kinematics, they were named as the Y-shear trending in $N80^{\circ}W$, Reidel shear (R) in $N50^{\circ}W$, conjugate Reidel shear (R') in $N20^{\circ}E$, P-shear in E-W and poorly developed tensional fractures (T) striking in $N25^{\circ}W$ directions. The cumulative resultant principal stress axis direction obtained from the analysis of above-mentioned elements is $335^{\circ}N$ which well fits with the $330^{\circ}N$ principal stress axis direction obtained from fault plane solution.

The E-W trending, 55 km long, 20 km wide and rhomboidal Merzifon-Suluova composite pull apart basin with an infilling of over 510 m initiated to develop during Early Pliocene-Pliestocene.

Key words: Central Pontides, Amasya, Tectonostratigraphy, Ophiolitic Melange, Forearc, Neotectonic, Reidel Shear, Pull Apart Basin.

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ÖZET

MERZİFON-SULUOVA HAVZASININ GÜNEY KENARININ TEKTONOSTRATİGRAFİSİ VE NEOTEKTONİK ÖZELLİKLERİ (ORTA PONTİDLER, AMASYA)

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Çalışma alanı Orta Pontidler'de (Amasya bölgesi, Türkiye), Kuzey Anadolu Ana Fayı'nın güneyinde, Ezinepazarı Fayı'nın kuzeyinde yer alır.

Amasya bölgesinde yüzeyleyen ana birimler: Paleozoyik yaşlı düşük dereceli metamorfikler (Tokat Kompleksi), Jura-Erken Kretase yaşlı platform karbonatları (Amasya Grubu), Geç Kretase yaşlı ofiyolitli melanj (Kuzey Anadolu Ofiyolitli Melanjı), Kampaniyen-Maastrichtiyen yaşlı yay önü istifisi (Karatepe ve Kışlacık grubları), Lütesiyen yaşlı "fliş" istifisi (Cindere grubu), Lütesiyen sonrası yaşlı dasit sokulumları (Moramıl dasiti), neotektonik molas karakterli havza dolgusu birimleri (Suluova grubu), ve Holosen akarsu çökelleri ve travertenlerdir.

Bölgenin tektonik yapıları iki gruba ayrılır: (1) Pliyosen öncesi paleotektonik ve (2) Pliyo-Kuvaterner neotektonik yapılar.

Başlıca stratigrafik boşluklar Liyas öncesi, Kalloviyen öncesi, Apsiyen öncesi, Kampaniyen öncesi, Lütesiyen öncesi, Pliyosen öncesi ve Holosen öncesi uyumsuzluklar ile temsil edilir.

Büyük ölçekli sürüklenimler iki grupta toplanır: (1) Jura öncesi, ve (2) Geç Kretase-Paleojen sürüklenimleri. En genç sürüklenim kuzeye yönelimli olup Lütesiyen sonrası-Pliyosen öncesi yaşlıdır.

Merzifon-Suluova Havzasının güncel biçimini şekillendiren neotektonik yapılar; kıvrımlar ve esas olarak düşey bileşene sahip yanal atımlı faylardır. Kinematik olarak bu faylar $K80^{\circ}B$ yönelimli Y-makaslaması, $K50^{\circ}B$ yönelimli Reidel makaslaması (R), $K20^{\circ}D$ yönelimli eşlenik Reidel makaslaması (R'), D-B yönelimli P-makaslaması, ve iyi gelişmemiş $K25^{\circ}B$ yönelimli gerilme çatlaklarıdır (T). Yukarıda bahsedilen fay sistemlerinden elde edilen ana sıkışma ekseninin doğrultusu $335^{\circ}K$ 'dır. Bu değer fay çözümünden elde edilen $330^{\circ}K$ değeri ile de uyumludur.

D-B uzanımlı, 55 km uzunluğunda, 20 km genişliğinde, eşkenar dörtgen şekilli ve 510 metreden fazla dolguya sahip olan Merzifon-Suluova birleşik çek ayır havzası Pliyosen-Pleyistosen'de oluşmaya başlamıştır.

Anahtar Sözcükler: Tektonostratigrafi, Orta Pontidler, Amasya, Ofiyolitli Melanj, Yayönü, Neotektonik, Reidel Makaslamaı, Çek Ayır Havza.

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This thesis is dedicated to beloved,
lieutenant pilot CÜNEYT ORKUN,
who lost his life in a war game in Merzifon region.

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CHAPTER I INTRODUCTION

1.1. Purpose and Scope

Most of the well-known large scale strike-slip fault zones are superimposed on geologically complicated suture zones. Some of them are the San Andreas Fault of California, the Alpine Fault of New Zealand and the North Anatolian Fault of Turkey. The latter is an intracontinental transform fault between the Eurasian plate to the north and Anatolian "Block" to the south (Figure 1). It is a seismically active, morphologically distinct, 1500 km long and few hundreds to 40 km wide dextral fault zone made up of numerous parallel to subparallel fault segments.

A number of basins are located in and around the North Anatolian Fault Zone (NAFZ). Due to the tectonic conditions peculiar to the strike-slip regions and the superimposition of NAFZ on Cretaceous-Early Tertiary suture zones, namely Intrapontide and Erzincan sutures, the basins, inherited from the earlier tectonic regime, are geologically very complicated. One of such kind of basins is the Merzifon-Suluova (Amasya) depression. It is a composite strike-slip basin located on several southwestward splaying fault segments of the North Anatolian Fault in Central Black Sea region (Figure 2). This study aims to solve the

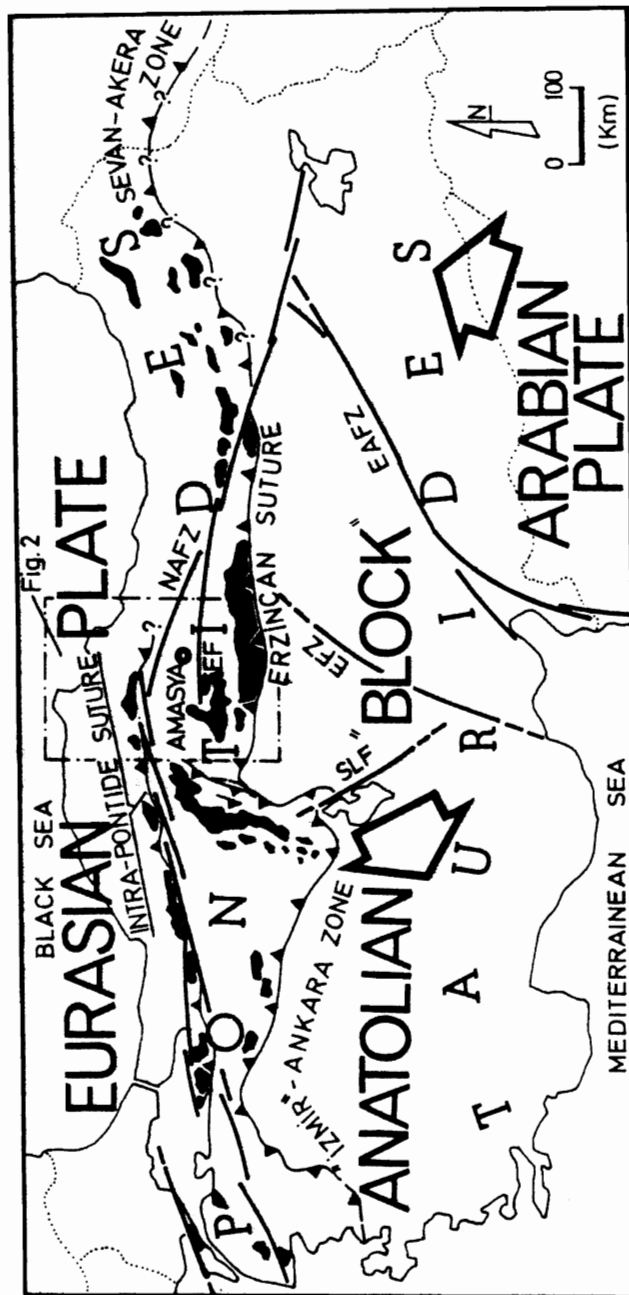


Figure 1. Simplified tectonic map showing some major tectonic elements of Turkey and northern ophiolitic units and related melanges (black areas). NAFZ.North Anatolian Fault Zone, EAFZ. East Anatolian Fault Zone, EF. Ezinepazarı Fault, EFZ.Ecemiş Fault Zone, SLF.Salt Lake Fault Zone. Arrows indicate the relative plate motion directions of the Anatolian "Block" and the Arabian Plate. Modified and simplified from MTA 1:500 000 Geological Map Set and Koçyiğit et al.,1988.

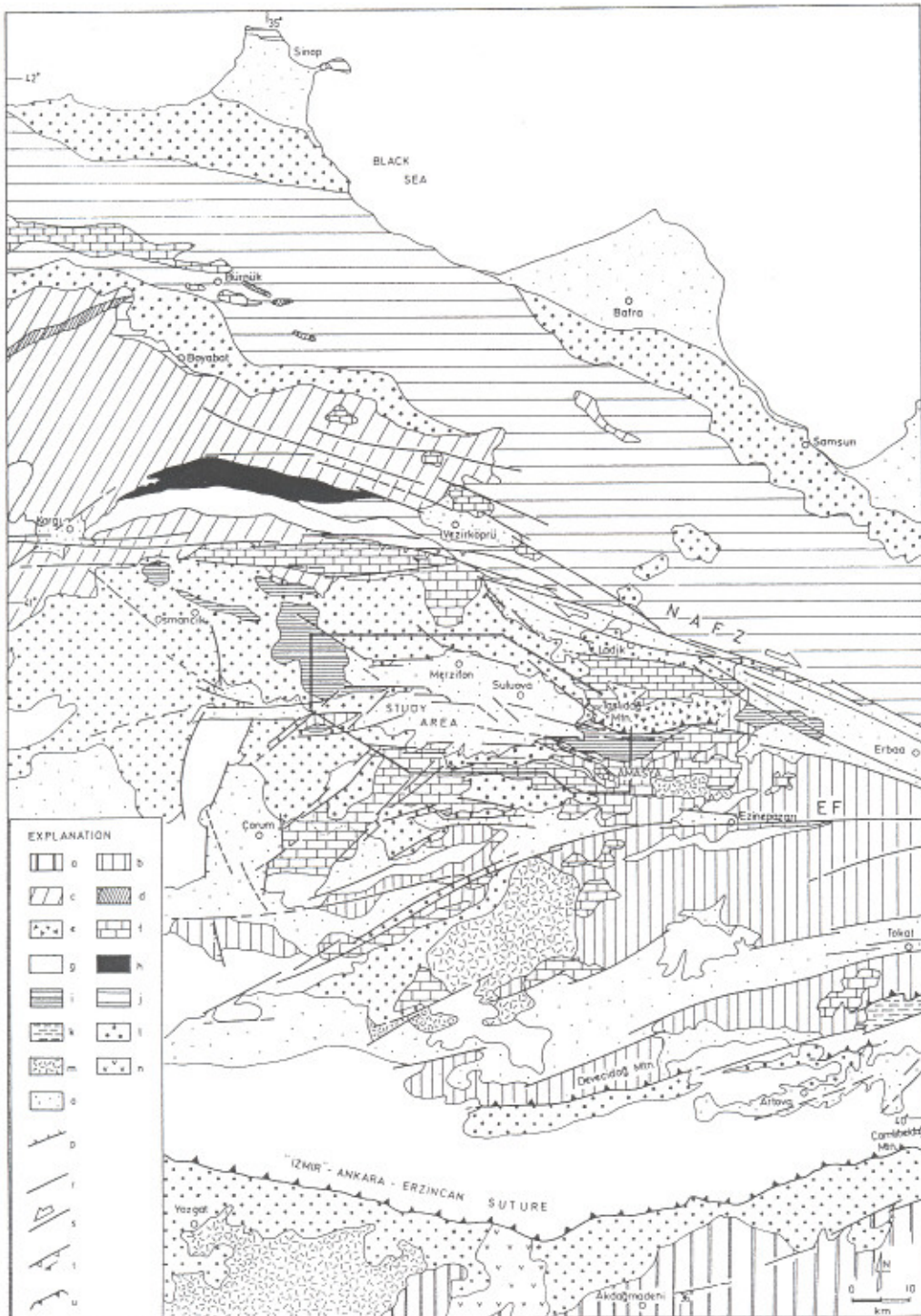


Figure 2. Simplified geological map of the Central Pontides (Inset map in figure 1). a.high P-T metamorphic rocks, b.low-grade metamorphic rocks, c."northern metamorphic belt", d."paleo-ophiolitic unit", e.Triassic "melange", f.Jurassic-Cretaceous carbonates, g.Cretaceous ophiolitic melanges, h.Neo-Tethyan ophiolitic units, i.Upper Cretaceous flysch sequence of Osmançik-Amasya area, j.Upper Cretaceous intraarc to backarc flysch sequence, k.southernmost outcrop of the Upper Cretaceous sequences, l.Eocene sequences, m.Central Anatolian granites, n.Central Anatolian volcanics, o.Neogene-Quaternary molassic units, p.normal faults, r.strike-slip faults, s.master fault strands, t.strike-slip faults with reverse component (from Dirik,1991), u.overthrust, NAFZ.North Anatolian Fault Zone and EF.Ezzinepazari Fault. Modified from MTA 1:500 000 Geological Map Set and tectonic lineaments plotted by means of studying 1:60 000 scale aerial photos.

complicated geology and the neotectonic evolution of the Merzifon-Suluova basin.

1.2. Geographic Setting

The study area is located in the Central Black Sea region between latitudes $40^{\circ}38'00''\text{N}$ - $40^{\circ}48'30''\text{N}$ and longitudes $35^{\circ}30'00''\text{E}$ - $35^{\circ}52'30''\text{E}$. The geologically mapped terrain lies in 1:25 000 scale Çorum topographic maps of G34b3, G35a4, G35a3, G35b4, G35c1, G35d2 and G35d1 which approximately covers an area of 600 square kilometers (Figure 3). The neotectonic study was carried out in various segments of the Merzifon-Suluova basin and adjacent areas covering G33, G34, G35, G36 and G37 topographic maps of 1:100 000 scale whereas the stratigraphy and tectonics of the basement of Merzifon-Suluova basin was carried out at its southern margin.

The main settlements in and around the study area are Gümüşhacıköy and Merzifon to the north, Suluova to the east, Amasya and Doğantepe to the south and Sarıbuğday to the west (Figure 3).

Some major highlands are Tavşandağı mountain (1830m) to the north, İnegöl (1875m) and Kandil (1320m) mountains to the west, Kırklar mountain (880m) to the south and Akdağ (Taşlıdağ) mountain (2058m) to the east of Merzifon-Suluova basin, where the basin and mountains are deeply dissected by Tersakan and Yeşilırmak rivers (Figure 3).

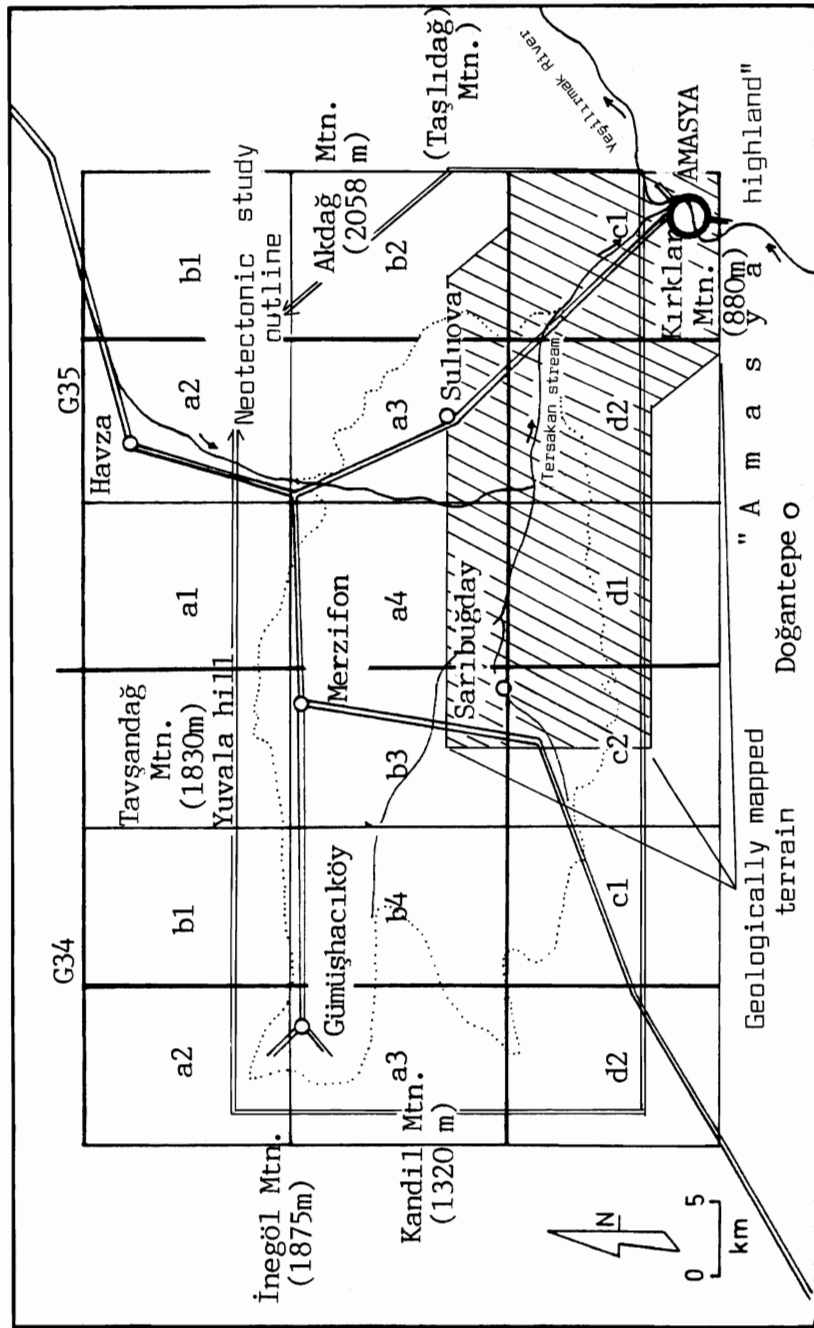


Figure 3. Map showing the geographic location of the study area and the boundary of Merzifon-Suluova Basin.

1.3. Method of Study and Terminology

The study has been carried out on office and field study basis.

Initially, the 1:60 000 and 1:35 000 scale aerial photographic study was plotted onto 1:100 000 and 1:25 000 scale topographic maps, respectively. During aerial photographic study, the major lineaments and significant geological structures were detected and plotted onto topographic maps.

Previous studies were read, and important, critical observations were noted.

The field study was carried out during 1986-1988 summer sessions, totally for 7 months. The field data were plotted onto 1:25 000 scale topographic maps.

A great part of the study has been concentrated on the analysis of megascopic tectonic features and measurement of both, type and reference stratigraphic sections. 1500 thin sections of rock samples were examined and defined under the microscope.

Units exposing in the study area were mapped and named as lithostratigraphic and lithodemic units (North Am. Com. on Str. Nom., 1983).

The term " Neotectonic" is being described in many publications with various meanings (Dennis, 1967; IAEA

safety series,1979; Bates and Jackson,1980; Vita-Finzi,1986; Winslow,1986; Pavlides,1989). However,the best and well meaningful definition, on which this text is based, was reported by Şengör(1980).

Classification of neotectonic basin was based on the studies of Quennell (1958), Crowell (1974), Reading (1980), Aydın and Nur (1982), Mann et al.(1983), Christie-Blick and Biddle (1985) and Sylvester (1988).

The concept of melanges and related broken formations were carried out on the basis of Abbate et al.'s (1970), Hoedmaeker's (1973), Hsü's (1974), Silver and Beutner's (1980), Closs's (1982; 1984), Raymond's (1978, 1984) and Cowan's (1985) definitions and classifications.

In the identification of clastic and carbonate rocks, Pettijohn (1975), Folk (1962) and Dunham (1962) classifications; for metamorphic rocks, Winkler (1965) and for igneous rocks, Streckeisen (1967) were used.

The microfossils of Jurassic to Paleocene were identified by Dr.D.Altıner (M.E.T.U.), Campanian-Maastrichtian benthic microfossils by Res. Asst. E.Özcan (M.E.T.U.), Eocene microfossils by Dr.S.Örçen (M.T.A.) and Pliocene-Quaternary gastropods by A. Inal (M.T.A.).

The metamorphic petrography was carried out by the help of Dr.C.Göncüoğlu (M.E.T.U.) and the igneous petrography by the help of Dr.T.Lünel (M.E.T.U.).

At the end of the study, eight groups with thirty rock units were differentiated. A generalized tectono-stratigraphic columnar section of the study area was prepared in terms of thirty type and reference sections.

Consequently, the thesis was presented in three main chapters, namely the Stratigraphy, Structural Geology and Geological Evolution chapters.

1.4. Previous Studies

There are a number of studies on the North Anatolian Fault Zone (NAFZ) and its segments, however the studies concerning directly the study area are very rare. These studies can be grouped under three titles: i) ore deposits, ii) basic geology, and iii) neotectonics of the NAFZ and its segments.

The studies focused on ore deposits were mainly carried out by the General Directorate of the Mineral Research and Exploration of Turkey (MTA). These studies concentrate on coal, lead-zinc, gold deposits and clay-lime raw materials.

The second group of studies were focused on basic geology, stratigraphy and geotectonic evolution of the region. The first classical work was carried out by Blumenthal (1950) and followed by others (Alp, 1972; Öztürk, 1976, 1979; Özcan et al., 1980). The basic Neogene stratigraphy of the region was carried out by Irrlitz (1971)

at Pontide scale. Various studies carried out in Pontide belt can be correlative on chronostratigraphic and lithostratigraphic basis (Figure 4).

The third group of studies were focused on NAFZ and its segments. These studies can be grouped under two main titles as geophysical and geological surveys. The geophysical studies were focused on magnitude, time and epicenter distribution of earthquakes, seismic risk and hazard analysis, fault plane solutions, and crustal and upper mantle structure studies from seismic waves. The geological studies were mostly carried out after each catastrophic earthquake and focused on the initiation age, total displacements and morphotectonic features of the faults, neotectonic evolution of basins and kinematics of the NAFZ system.

The geological studies concerning directly the study area are rare. The first basic classical work was carried out by Blumenthal (1950) and covers Vezirköprü-Havza-Ladik-Destek-Erbaa-Niksar-Almus-Tokat-Turhal-Zile-Amasya-Merzifon areas. In his study, the basic stratigraphy and tectonics of the region is set and the following are reported: (1) Paleozoic basement is differentiated into four units as Taşlıdağ, Tokat, Devecidağ and Çamlıbeldağ massifs, (2) Jurassic-Lower Cretaceous carbonates are named as "Amasya Kalke", (3) a chaotic unit is recognized and named as "Bunte zone", (4) Dogger is missing, (5) the area is

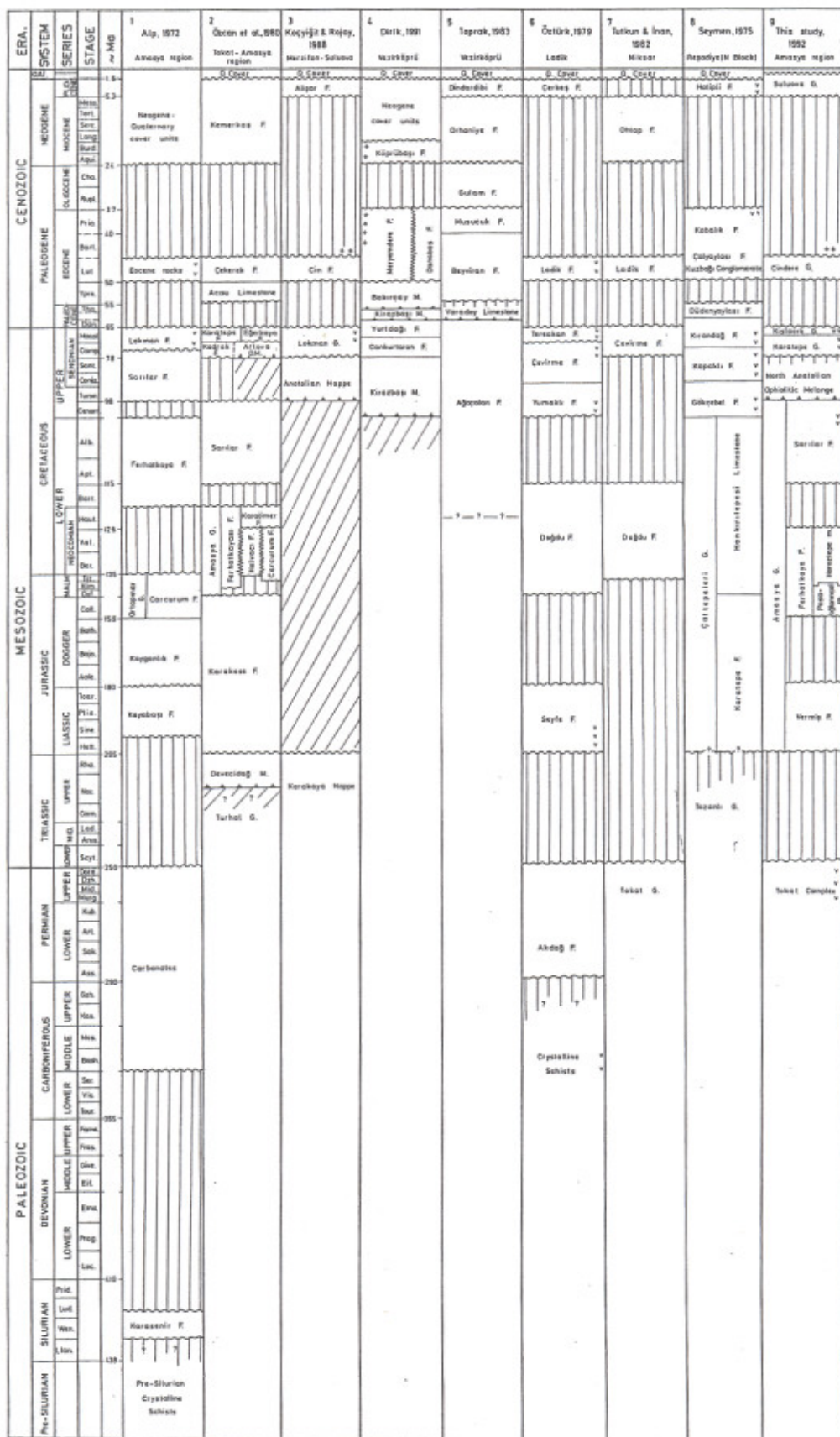


Figure 4. Correlation chart showing lithostratigraphic units in Amasya region and adjacent areas. G. Group, F. Formation, m. Member, M. Melange, O.M. Ophiolitic Melange, +. Acidic intrusives, v. Volcanics.

tectonically differentiated into two zones as "northern Anatolian belt" and "Pontide zone", and (6) the dominance of WNW-ESE trending and southward vergent tectonic lineaments and structures.

As a PhD thesis, Alp (1972) studied the stratigraphy and tectonics of the south of the Tersakan and Yeşilırmak rivers including Amasya city. He is the first who applied the stratigraphic nomenclature to the rock units in the region. According to his observations, a few critical points should have to be mentioned; (1) Pre-Silurian low-grade metamorphic rocks overlain by the Middle Silurian "Karasenir Formation" and Permo-Carboniferous units were recognized, (2) two different Liassic sequences were differentiated; allochthonous Domerian-Toarcian sequence and autochthonous Sinemurian-Domerian sequence overlying Paleozoic, (3) Dogger-Malm units are completely allochthonous, (4) Lower Cretaceous, Turonian-Campanian, Campanian-Maastrichtian, Lutetian, Neogene and Quaternary units were distinguished, (5) the area was affected by four orogenic phases, namely the pre-Middle Silurian (probably "Taconic"), Middle Silurian-Permo-Carboniferous, Hercynian and Alpine events.

Another research, as a part of the PhD study, was carried out by Öztürk (1976, 1979, 1980) in an area covering Havza-Ladik to the northwest and Destek-Taşova to the southeast. Some important observations in his study are as

follows: (1) Permian carbonates (Akdağ Formation) overlies unconformably "crystalline schists", and they are altogether overlain by Liassic units, (2) Dogger is missing, (3) Cenomanian-Maastrichtian, Lutetian, Aquitanian, Pliocene and Quaternary units are differentiated, (4) the area was affected by both Hercynian and Alpine events and folds almost have E-W trend because of the N-S directed stresses. Later, he focused his study on NAFZ and reported its initiation as the Late Miocene along a "paleo-fault" with dextral sense. He also mapped the 1943.10.27 earthquake rupture and observed 1.5-3 meters right-lateral offset with 40-50 cm vertical component.

Özcan et al.(1980) carried out a stratigraphic research in an extensive area covering Çorum, Amasya, Tokat, Sivas and Akdağmadeni region. Their study was carried out in two different regions with different tectonic histories. In the north, the low grade metamorphic rocks (Turhal Group) and Triassic melange (Devecidağ melange) are overlain unconformably by Liassic units. Liassic-Dogger, Upper Jurassic-Lower Cretaceous, "Middle" Cretaceous, Campanian-Maastrichtian, Ypresian-Lutetian and Mio-Pliocene units were distinguished. The northern ophiolitic melange was named as "Artova Ophiolitic melange". To the south, high grade metamorphic rocks (Akdağmadeni Group) were differentiated from northern units and overlain by Lutetian units. The rest of the southern area covered with plateau basalts.

Another team study was carried out by State Hydraulic Works (Atalay and Altuğ, 1973). The hydrogeological investigation was focused on the Neogene-Quaternary deposits and the faults in Merzifon-Gümüşhacıköy plain. In this study, the maximum thickness of Neogene units was reported over 400 meters, estimated from subsurface data.

Local studies concentrated on specific geological problems were carried out by Arpat and Şaroğlu (1975), Koçyiğit and Rojay (1988), and Koçyiğit et al. (1988).

Arpat and Şaroğlu (1975) pointed out an active fault traversing the Merzifon-Suluova basin in E-W direction based on aerial photograph studies.

Koçyiğit and Rojay (1988) studied neotectonic evolution of Merzifon-Suluova basin and interpreted the basin as an active, parallelogram-shaped, complex ramp basin. Later, they interpreted the basin as a composite basin (Koçyiğit and Rojay, 1991).

Finally, the relation of the Upper Cretaceous forearc sequence with the Upper Cretaceous melange in Amasya region was studied by Koçyiğit et al. (1988). The forearc basin was interpreted as a constructed type forearc basin of Campanian-Paleocene age.

1.5. Regional Geological Setting

The study area is located in the Central Pontides, where the NAF splays into many branches in WNW and WSW directions and makes a northward convex pattern. The study area is approximately bounded by the NAF Master strand to the north and the Ezinepazarı Fault to the south (Figure 2).

Main units exposing in Central Pontides are, from oldest to youngest: (1) pre-Triassic low-grade metamorphic rocks, (2) northern metamorphic rocks, (3) Triassic melange, (4) pre-Jurassic ophiolite, (5) Jurassic-Cretaceous carbonates, (6) Cretaceous ophiolitic melange, (7) Upper Cretaceous flysch sequence of Osmancık-Amasya area, (8) Upper Cretaceous intraarc to backarc flysch sequences of Pontides, (9) southernmost outcrop of the Upper Cretaceous sequence, (10) Tertiary sequences, (11) Neogene-Quaternary continental sequences, and (12) Neogene volcanic rocks (Figure 2).

The oldest rock units cropped out in the Amasya region are the metamorphic series which are composed of greenschists-slates-graywackes, graphitic schists, meta-volcanics and meta-radiolarites of Pre-Triassic age. The metamorphic sequence is unconformably overlain by Liassic rocks. The evolution of the Jurassic basin continued with the deposition of Jurassic-Lower Cretaceous carbonate sequence as a part of the Neo-Tethyan Ocean. The closure of the northern branch of Neo-Tethyan ocean resulted in the

obduction of ophiolites, ophiolitic "melanges" and related broken formations. The evolution of sedimentary-volcanosedimentary "flysch" sequence of Campanian-Maastrichtian age in an arc-bounded basin was followed by the migration of so called basins with the accumulation of continental to pelagic sediments during Middle Eocene. The dacitic units intruded as a result of crustal thickening during post-Eocene. Regional uplift and retreat of sea towards east resulted in the deposition of Oligocene-Pleistocene continental units in various tectonic settings. Finally, since the Pliocene, the region was shaped under strike-slip regime of the North Anatolian fault system.

CHAPTER II

STRATIGRAPHY

Units exposing in the study area were differentiated into two categories: (1) pre-Campanian basement and (2) cover rocks. Basement consists of pre-Triassic Tokat Complex, Liassic-Cenomanian Amasya Group and Upper Cretaceous North Anatolian Ophiolitic Melange. Cover units are Campanian-Maastrichtian Karatepe group, Maastrichtian-Paleocene(?) Kışlacık group, Lutetian Cindere group, Pliocene-Pleistocene Suluova group, and Holocene units (Figure 5).

2.1. Tokat Complex (Pzt)

Definition: Tokat Complex is one of the basement units of the Mesozoic sequences in Pontides. The unit consists mainly of low-grade metamorphic rocks of greenschist facies. The term "Tokat Massif" was first informally introduced by Blumenthal (1950) and later adopted by Koçyiğit (1979), Tutkun and Inan (1982), Yılmaz (1983), Rojay (1985), and Bozkurt, (1990) for low-grade metamorphic units exposing along the northern side of the Neotethyan suture as the Tokat Group. Lately, the term "Tokat Group" was adopted to be the Tokat Complex by Koçyiğit (1992).

Geologic Relations and Thickness: The Tokat Complex has a widespread distribution within the region along the

AGE	THICKNESS (m)	LITHOLOGY	DESCRIPTION		UNIT (GROUP)	
Plio.-Qua.	>160			Molasse	COVER ROCKS	SULUOVA
Pre-Neogene			Unc.	Ophiolitic Mélange		NAOM
Eocene	240		TB	Flysch sequence		CİNDERE
			Unc.			
Campanian-Maastrichtian	1600			Fore-arc flysch sequence		KIŞLACIK
				Rudistic Build-ups	KARATEPE	
Pre-Campanian			Unc.	Ophiolitic Mélange	BASEMENT ROCKS	NORTH ANATOLIAN OPHIOLITIC MELANGE
			TB			
Apt.-Ce.	>31		Unc.	Pelagic carbonates	AMASYA	
Callovian-Valanginian	2100			Platform carbonates		
				Ammonitico Rosso		
Liassic	30		Unc.	Marine clastics	TOKAT Complex	
Paleoz.	>310		Unconformity	Basement (Green schists)		

Figure 5. Simplified tectonostratigraphic columnar section of the Amasya Region. NAOM.North Anatolian Ophiolitic Melange, Unc.Unconformity, TB.Tectonic Boundary (Overthrust).

deeply dissected valleys, especially along Yeşilırmak valley (Plate 1). The bottom of the unit does not expose within the vicinity of the study area. However, it displays variable contact relations with the younger cover rocks. The Amasya Group overlies unconformably the Tokat Complex to the SE of Çavşak ridge, S of Kediayağı Ridge and to the north of Ferhatkayası hill where the contacts are disturbed. However, within short distances, same units are overthrust onto the Tokat Complex (Plate 1). In contrast, the Upper Cretaceous Karatepe group, the Eocene Cindere group and the Neogene Suluova group units overlies unconformably the Tokat Complex. The NAOM and its different components are overthrust onto the Tokat Complex in various directions, dominantly NW to SE and SW to NE directions at various localities such as Vermiş village-Amasya city-Şehcui village to Selderesi line, N and E of Kırklar mountain, N of Kürtler-Taşlıyurt villages, S of Alabedir-W of Arucak-Gödeles villages (Plate 1). The Tokat Complex is also overthrust onto Eocene units (Cindere group) to the south of Yuvala and west of Arucak villages with a vergence from SSE to NNW (Plate 1). Different facies of the Tokat Complex were incorporated as olistoliths into the Upper Cretaceous volcano-sedimentary sequence (Karatepe and Kışlacık groups) and as blocks into the NAOM to the N of Kırklar mountain and S of Gödeles village. The Tokat Complex is intruded by dacitic intrusions (Moramıl dacite) along the Uzun ridge-Kürtler-Taşlıyurt-N of Alabedir-N of Gödeles villages line

and diabase dikes at Karasanlar ridge (Plate 1). Within and between members of the Tokat Complex, the imbricated thrusts are the most widespread internal structures (Plate 1).

Minimum observable thickness of the Tokat Complex is about 310 m.

Lithology and Measured Reference Section: The Tokat Complex consists dominantly of metavolcanic, metapyroclastic and metavolcaniclastic rocks, metaclastic rocks and metacarbonates-silicates. The unit is differentiated into two subunits depending upon their colors and protolithologies (Figure 6). However, due to their chaotic structures, at some localities, they could not be differentiated. The subunits of the Tokat Complex are: (1) Grayish-black schists and slates with quartz boudins and veins, (2) Green schists and slates.

The Tokat Complex is well exposed to the east of Amasya, along the southern slope of Karasanlar ridge where the reference section is measured. The reference section is dominated by metavolcanics, metatuffs with minor amounts of metaclastic limestone and meta-radiolarian cherts (Figure 6). The section was carried out within the greenschists/slates where grayish-black schists form the base of the sequence. In places, where the pre-metamorphic texture is well preserved, it is very difficult to add "metamorphic facies name", for this reason, prefix "meta" is added to the original rock name.

AGE	UNIT	THICKNESS (m)	LITHOLOGY	DESCRIPTION	METAMORPHIC MINERAL ASSOCIATION	PROTO-LITHOLOGY	
J ₁				Crinoidal-echinoidal sands			
Pre-Triassic	Tokat Complex	>10	887	Unconformity			Sequence of basaltic lava and tuff alternation with limestone boudins/blocks
			886	White marble block/boudin	cc schist		
			889a	Green laminated/foliated slates-schists	chl-ep-act-ab schist		
			889b	Grayish-yellowish white marble block	ep-chl-Na amph. schist		
		67	890	TB(Overthrust?)			
			891	Grayish-white to yellow, banded calc-schist boudins	cc schist		
			892	Light green-green, foliated slates-schists	ep-act-chl schist		
			893	Alternation of grayish green to white, thin bedded, banded, mylonitized marble bands with green slates	ep-act-chl schist cc schist	Alternation of limestones and tuffaceous clastics	
		21	894			Tuff	
		20	895	Light green to green, foliated slates	ep-act-chl schist		
		10	896	Alternation of green, laminated to thin bedded marble-slate sequence	chl-q-alb-cc-opaque+ep schist	Alternation of limestone-shale sequence	
		40	897	Alternation of green, laminated to thin bedded siliceous marble-slate sequence	q-mu-chl+apatite schist ep-act-chl schist	Alternation of siliceous limestone (radiolarite?) and shale-tuff sequence	
50	898	Dominantly green to yellowish green-white, laminated to massive marble-slate alternation	ep-act-chl schist cc schist	Alternation of tuff and limestone sequence			
	899						
~60	900	Light green to green, foliated schists-slates intruded by diabasic sills and dykes (late intrusions)	chl-act-ep-mu-alb schist	Tuff Diabase intrusion (late intrusions)			
	901						
	902	White to yellowish, banded metatuffaceous rocks	stilpnomelane-chl-ep-alb schist	Tuff			
	903	TB (Overthrust)					
	904						
>40	880	Black to gray, "platy" schist-slates with silica (quartz) bands and boudins	mu-chl-cc-q-alb schist with zr, tourmaline, bio "clasts". q-alb-mu schist, mu-seri-cc-alb schist, ...	Clastic Sequence Siltstone, calcareous siltstone, ...			

Figure 6. Measured reference section of the Tokat Complex. J₁. Liassic. Numbers indicate sample locations (Locality: Southern slope of Karasanlar ridge, E of Amasya City).

In the Karasanlar section, the sequence starts with light green-green foliated slates (chlorite-actinolite-epidote-muscovite-albite schist with schistose texture) with a metatuffaceous unit (Stilpnomelane-chlorite-epidote-albite schist with schistose texture) and is followed by dominantly green-yellowish green-white massive to laminated marble-slate alternation (epidote-actinolite-chlorite schist with nematoblastic texture in chlorite-Na-amphibole minerals). Green, thin-bedded to laminated siliceous marble and marble alternating with green slates (epidote-actinolite-chlorite schist, quartz-muscovite-chlorite \pm apatite schist and chlorite-quartz-albite-calcite \pm epidote \pm opaque schist with schistose texture) grades upward into green foliated schists (epidote-actinolite-chlorite schist with nematoblastic texture) and to thin laminated, banded, mylonitized marble bands (chlorite-albite-calcite \pm pyrite calc-schist with schistose structure) alternating with green slates (epidote-actinolite-chlorite \pm albite schist with schistose texture). The top of the sequence consists dominantly of green-light green thin bedded-laminated schists-slates (chlorite-epidote-actinolite-albite \pm leucoxene schist rich in Na-amphiboles with nematoblastic texture, epidote-chlorite-Na-amphibole and epidote-actinolite-chlorite schists with nematoblastic texture) with grayish white-yellow marble blocks and/or boudins.

In other sections along the southern margin of Bademli ridge (NE of Şehcui village) and southeastern slope

of Horoz hill (SW of Şehcui village), the following paragenesis are obtained: green biotite bearing chlorite-actinolite-calcite-albite±epidote±sphene schist with schistose structure (meta-tuff), green biotite-bearing epidote-actinolite-albite-sphene schist with lepidoblastic texture (meta-diabase), chlorite-actinolite-albite±epidote±sphene schist with porphyroblastic texture (meta-tuff), epidote-actinolite-albite±muscovite±sphene schist with lepidoblastic texture (meta-gabbro), epidote-chlorite-actinolite-albite±sphene schist with lepidoblastic texture (meta-diabase), actinolite-albite-epidote±biotite±sphene (few) schist with lepidoblastic texture (meta-"gabbroic" rock), epidote-actinolite-albite ±green biotite±sphene ±chlorite schist with schistose texture (meta-volcanic rock), actinolite-epidote-albite±sphene±green biotite ±chlorite schist with relict volcanic texture (albite-epidote filled amygdaloids) (meta-pillow basalt). In addition to above mentioned protoliths, green meta-cherts (some are radiolarian cherts with poorly preserved radiolaria tests) are significant facies of the metabasics. Radiolarian (some of them could be diatoms or foraminifers as well) cavities are filled with fibrous to blocky, secondary sparry calcite or quartz.

The grayish black and intensely deformed schists-slates are included in muscovite-chlorite-calcite-quartz-albite schist having zircon, tourmaline and biotite clasts experienced a schistose texture (meta-clastic), muscovite

bearing quartz schist, quartz-muscovite±albite±chlorite schist with schistose texture (meta-chert), quartz-albite-muscovite schist with schistose texture (meta-pelitic rock) and tourmaline bearing chlorite-sericite-calcite-albite schist with slaty cleavage (meta-carbonate siltstone), paragenesis. This facies is characterized by the presence of slaty structure and quartz (silica) boudins.

Structures: The Tokat Complex displays various tectonic mega-and-mesostructures in addition to their preserved primary sedimentary and magmatic structures. These are rotated crystals (Figure 7), elongated quartz grains parallel to schistosity and foliation, multilayer banded structures, microshear planes subparallel to schistosity (Figure 8), single and double hinge folds, chevron folds, kink bands, Z-shaped small scale folds, mostly similiar, asymmetrical and disharmonic folds, conjugate, various types of micro faults, schistosity planes subparallel to original bedding, and limestone (marble) boudins. The schistose texture is observed in meta-tuffs and meta-sedimentary rocks, lepidoblastic texture in meta-diabasic-gabbroic rocks, porphyroblastic texture in meta-tuffs and nematoblastic texture in chlorite-Na-amphibole minerals. The pillow structures of the basalts are well preserved.

Age Relations, Correlation and Interpretation: By correlating the Tokat Complex with the northwestern Anatolian low-grade metamorphic rocks, the age of the

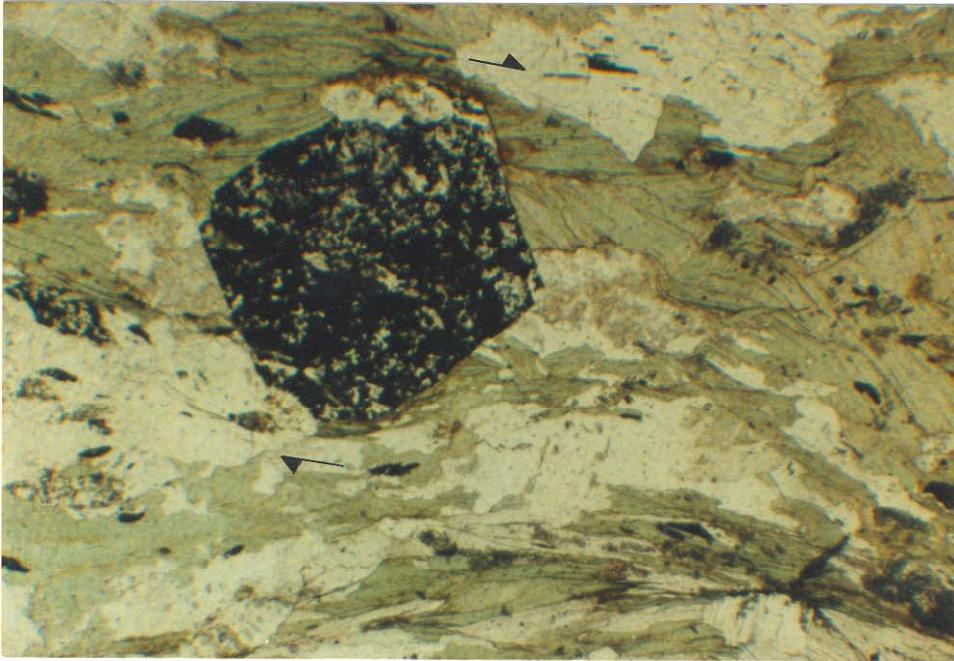


Figure 7. Photomicrograph of dextrally rotated crystal in black schist subunit of the Tokat Complex (Sample No:904, X 50).

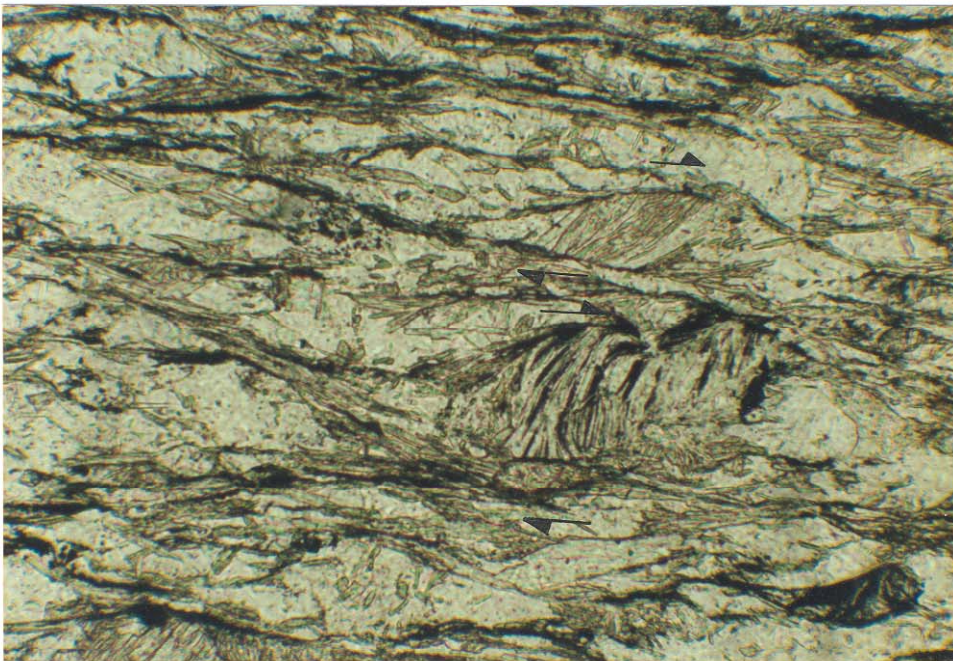


Figure 8. Photomicrograph of sinistral microshear planes parallel to the schistosity in the Tokat Complex (Sample No:880, X160).

Complex will be Pre-Triassic (Krushensky et al. 1980; Genç et al. 1986; Yılmaz et al. 1989; Koçyiğit et al. 1991). Exposures of the Tokat Complex are widespread in the Pontide belt extending from Biga peninsula in the west to Artvin City in the east (Şengör et al. 1980; Tekeli, 1981; Güvenç and Konuk, 1981; Okay, 1984; Şengör et al. 1984; Koçyiğit, 1987; Okay et al. 1990). As a result, various names were used for these low-grade metamorphic rocks at different localities within this belt, from W to E namely as, Karakaya Formation (Bingöl et al., 1975), Karakaya Group (Bingöl, 1978), Kalabak Formation (Krushensky et al. 1980; Okay, et al. 1990), Karakaya Complex (Okay, 1989) and Nilüfer unit of Karakaya Complex (Okay et al. 1990), metamorphic rocks of North Anatolian Belt (Tekeli, 1981), Sorgunderere metamorphics (Genç et al. 1986), Bozüyük metamorphics (Ayaroğlu, 1979), İznik metamorphics (Göncüoğlu et al. 1987), Alabağlar Group (Koçyiğit and Rojay, 1988), Söğüt metamorphics of Orta Sakarya complex unit (Şentürk and Karaköse, 1981), Yenişehir Metamorphic Assemblage (Yılmaz et al. 1989), Emir Formation of Ankara Group (Akyürek et al. 1984), Tuğla formation (Erk, 1975), Dikmen graywacke (Erol, 1956), Metamorphic Blocky Melange (Norman, 1973), Tokat Group of Upper Karakaya Nappe (Koçyiğit, 1987), Tokat Massif (Blumenthal, 1950), Turhal Group (Özcan et al. 1980), Karakaya Nappe (Koçyiğit and Rojay, 1988), Tokat Group (Koçyiğit, 1979; Tutkun and İnan, 1982; Yılmaz, 1983; Rojay, 1985; Bozkurt, 1990), Tozanlı Group (Seymen, 1975), Agvanis Schist Body (Nebert, 1961),

Agvanis Group (Okay, 1983), Tokat Nappe (Koçyiğit and Rojay, 1984), Pular massif (Korkmaz and Baki, 1984) and Karpuzsuyuderesi metamorphics (Özer, 1984). Consequently, the Tokat Complex is a correlative unit along northern Anatolia on the basis of degree and type of metamorphism, protolithostratigraphy, tectonic and stratigraphic setting. However, the controversial, confusive and misuse of the nomenclature, especially the "Karakaya" terminology, cease most of the studies from a regionwide correlation.

Depending on the protolithology of the sequence (Figure 6), various facies of the Tokat Complex were deposited in a basin where intense basaltic volcanism was active. The extensive distribution of mafic volcanics with pillow basalts and pelagic influx may manifest a deep sea depositional setting in an active continental marginal basin (Dickinson and Selley, 1981). The Tokat Complex was interpreted as a magmatic arc related basinal sequence by Okay (1984). The Tokat Complex was resulted from a regional dynamothermal metamorphism in green schist facies. By the presence of chlorite and epidote, it is possible to set this facies in Barrovian type, B.1.1. facies (Winkler, 1965 and Turner, 1966), or in Scottish way of saying, "chlorite zone".

2.2. Amasya Group (JKa)

Amasya Group is a thick predominantly carbonate sequence. The Amasya Group is exposed along the northern

margin of the Izmir-Ankara-Erzincan-Sevan-Akera Suture (northern Neo-Tethyan suture), from Biga to the west and Artvin to the east. It was first informally named as the "Amasya kalke" by Blumenthal (1950) and later adopted to be the Amasya Group by Özcan et al (1980). In this study, the Amasya Group was differentiated into three formations and four members: (1) Vermiş formation, (2) Ferhatkaya Formation with the Paşaoğlanınçal and Horoztepe members; (3) Sarılar Formation with Gezilikdere and Yavru members.

2.2.1. Vermiş Formation (Jav)

Definition: The Vermiş formation consists predominantly of bioclastic conglomerates and sandstones. It was named as Vermiş formation where type section was measured to the north of Vermiş village (Plate 1). The Vermiş formation is a part of the Kayabaşı Formation of Alp (1972).

Stratigraphic Relations and Thickness: The Vermiş formation has a limited distribution within the study area. It crops out along the Kediayağı ridge, to the south of Paşaoğlanınçal hill and to the northwest of Ferhatkayası hill where it overlies unconformably the Tokat Complex (Plate 1). Except Paşaoğlanınçal hill locality, the boundaries are tectonized and hardly recognized, and the lateral continuity of the formation could not be traced. The Vermiş formation is overlain unconformably by ammonite rich limestones of the Paşaoğlanınçal member of the Ferhatkaya

Formation. However, some other Liassic sequences are also recognized in the study area where their lithologic aspects are different (e.g. Kırklar Mountain, N of Moramıl, W and S of Dereağıl localities, Plate 1). Thickness of the Vermiş formation was measured to be 30 m in the Paşaoğlanınçal hill section.

Lithology and Type Section: The type section of the Vermiş formation was measured from the southwestern slope of Paşaoğlanınçal hill (1 km N of Vermiş village) (Plate 1). In this measured section, the sequence starts with green-grayish green, massive conglomerates, bioclastic calcareous conglomerates and bioclastic detrital limestones (arenaceous, echinoidal-crinoidal packstone to grainstone or biocalcirudite) (Figure 9). The echinoidal and crinoidal debris with less amount of rock fragments are cemented by drussy sparry calcite (Figure 10). The rock fragments are mainly quartz and metamorphic rocks. Quartz fragments are mainly of metamorphic in origin (Folk, 1974). The biodebris is made up of echinoids, crinoids, echinoid spines, bryozoa and lamellibranchiata fragments all of which are rounded and well sorted. Above this level, green, massive to thick-bedded arenaceous bioclastic carbonates alternating with green calcareous conglomerate lenses and green calcareous sandstone beds are present (Figure 9). Crinoids, echinoids and lamellibranchiata are the abundant fossil fragments with minor metamorphic rock and quartz fragments, all of which are cemented by drussy sparry calcite. The sequence grades

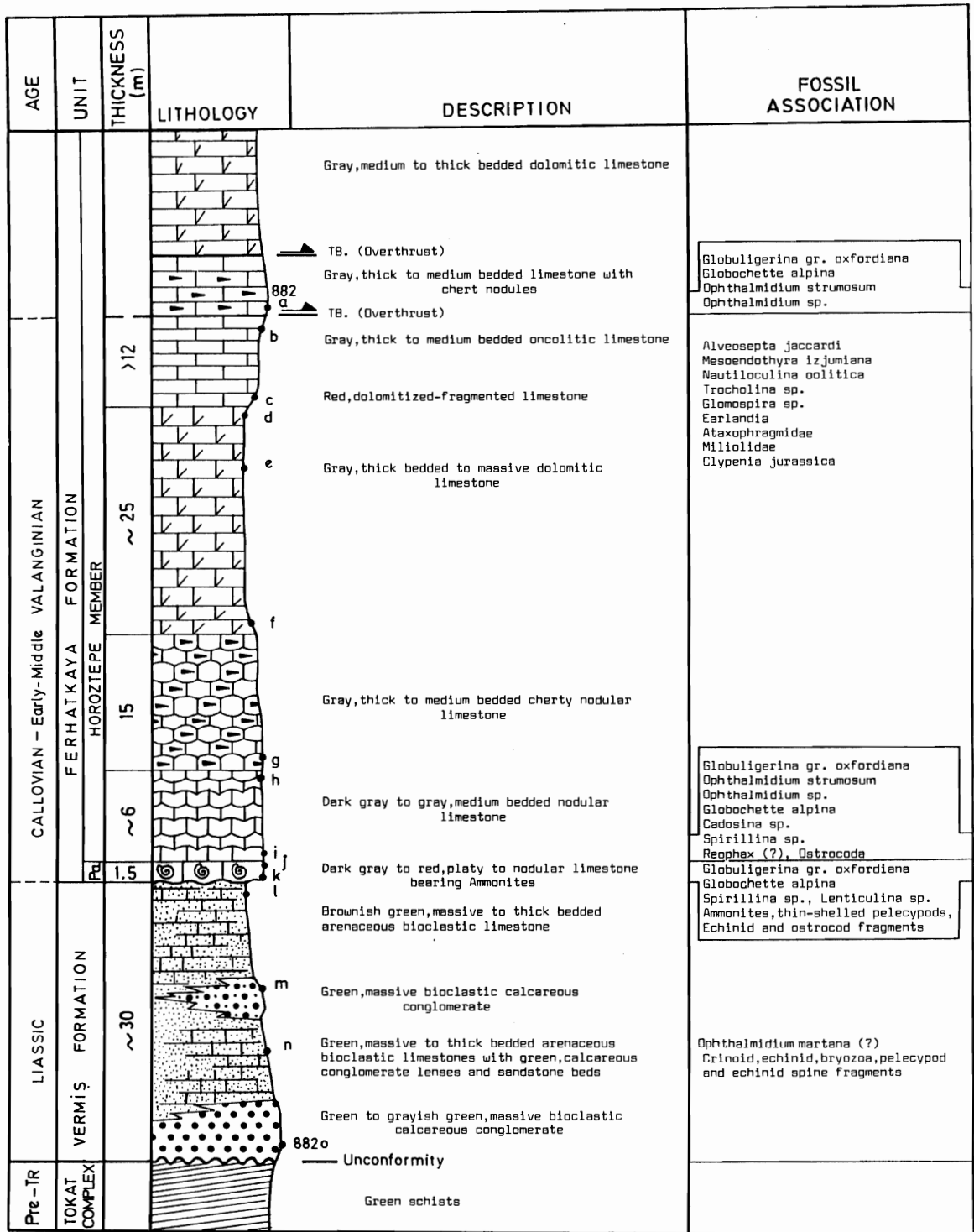


Figure 9. Measured stratigraphic columnar section of the Vermiş formation, Paşaoğlanınçal (Pa) and lower part of the Horoztepe members of the Ferhatkaya Formation. 882a to 882o are sample locations (Locality: Paşaoğlanınçal hill, N of Vermiş village).

upwards into brownish green, massive to thick bedded, arenaceous, bioclastic carbonates or carbonate sandstones (arenaceous, echinoidal-crinoidal grainstone or biocalcirudite) (Figure 9).

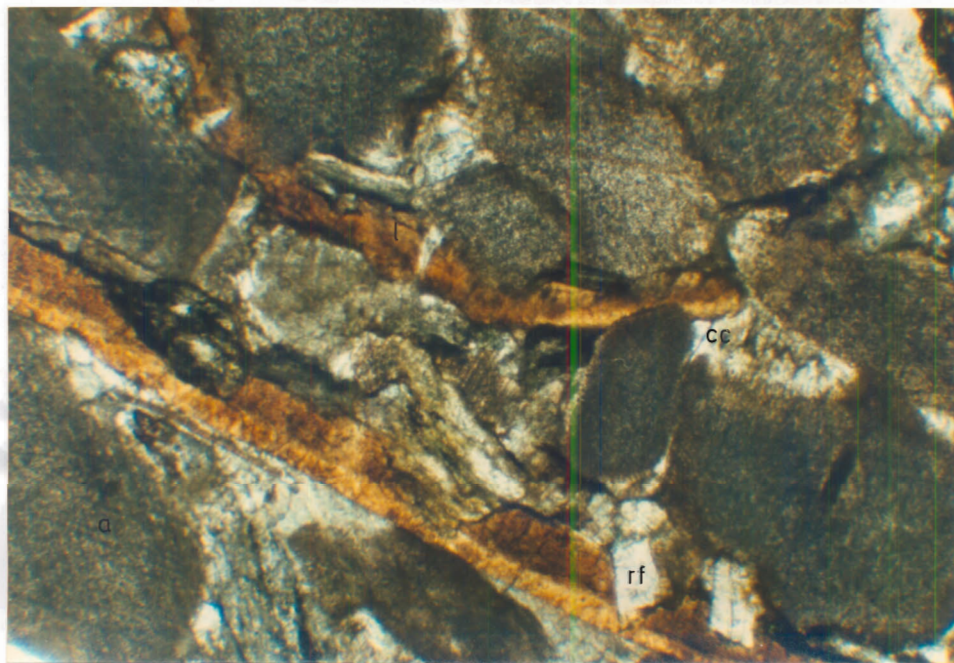


Figure 10. Photomicrograph of echinoidal-crinoidal sands (biosparites) of the Vermiş formation Note echinoid-crinoid grains (a), lamellibranchiata fragments (l), rock fragments (rf) and sparry calcite cement (cc) (Sample No: 882n, X 50).

Paleontology and Age: There is not any index fossil that will date the sequence. However, Ophthalmidium martana (?), Nodosarids and fragments of crinoids, echinoids, echinoid spines, bryozoa, and lamellibranchiata were identified. The probable age of the Vermiş formation is Late Triassic-Liassic.

The field relations and paleontological studies show that the age of the sequence is pre-Callovian, but not older

than Liassic. Depending on the regional geological conjuncture, the age of the sequence should be Liassic (Blumenthal, 1950; Alp, 1972; Öztürk, 1979; Özcan et al. 1980).

Correlation: The Vermiş formation will have various time equivalent units in the Pontides. These can be the Bayırköy Formation (Granit and Tintant,1960; Eroskay,1965; Şentürk and Karaköse,1981; Genç et al.,1986; Altıner et al., 1989) in northwestern Anatolia, the Söğütçük Formation (Koçyiğit,1987) and Hasanoğlan Formation (Akyürek et al., 1984; Koçyiğit,1987) in Ankara Region, Kayabaşı and Seyfe Formations (Alp,1972; Öztürk,1979) in Amasya Region (Figure 4). Although, the Vermiş formation can be time correlative, it is hard to make lithofacies correlation due to distant position of the outcrops in the region.

Depositional Setting: The carbonate detritus is of subaqueous origin and consists mainly of fossil fragments which is an evidence for current-transport and sorting, and mechanical deposition. These biofragmental units are mainly deposited as carbonate sands where sparry calcite cement indicates a high energy environment (Irwin, 1965). The presence of metamorphic quartz and metamorphic rock fragments in fragmental parts indicates a continental source which is probably the underlying Tokat Complex.

2.2.2. Ferhatkaya Formation (JKaf)

The unit was first named by Alp (1972) for shallow marine carbonates in Amasya region (Figure 11). The formation was subdivided into two members, namely the Paşaoğlanınçal and Horoztepe members.



Figure 11. General view of the Ferhatkaya Formation of Amasya Group (JKaf) where "Rock Tombs of the Kings" (Strabon,1987) were carved, Amasya City.

2.2.2.1. Paşaoğlanınçal member

Definition: The member consists of dark gray to red, ammonite-rich clayey limestone. Throughout the Alpine belt this facies is known as the Ammonitico Rosso Facies (Farinacci and Elmi,1981). A type section is measured from the southern slope of Paşaoğlanınçal hill (Plate 1). This

Ammonitico Rosso facies was previously included in the Kayabaşı Formation (Alp, 1972).

Stratigraphic Relations and Thickness: The Paşaoğlanınçal member has limited distribution within the study area. It crops out along the Kediayağı ridge, to the south of Paşaoğlanınçal hill and in the Vermiş village ,and grades upward into platform carbonates of the Horoztepe member (Figure 9). Thickness of the Paşaoğlanınçal member was measured to be 1.5 m along the Paşaoğlanınçal hill section.

Lithology and Type Section: The Paşaoğlanınçal member consists of dark gray to red, platy to nodular, ammonite-belemnite-thin shelled lamellibranchiata and foraminifera bearing limestone (biomicrite or fossiliferous "mudstone" to wackestone) (Figure 12,13).

Paleontology and Age: The Sinemurian-Toarcian age was assigned to the Paşaoğlanınçal member by Alp (1972) based on ammonites and other fossils collected from SW of Paşaoğlanınçal hill. However, foraminiferal fauna listed below indicates that the age of the Paşaoğlanınçal member should be Callovian-Oxfordian. Globuligerina gr. oxfordiana, Globochete alpina, Spirillina sp., Lenticulina sp., thin-shelled pelecypoda fragments, Bivalves, Echinids, Ostracods, Ammonites (Figure 13). This is an equivalent-correlative biostratigraphic zone to Globuligerina gr. oxfordiana Zone (Altıner, 1991) in Bilecik region.



Figure 12. Close-up view of the Ammonitico Rosso facies of the Paşaoğlanınçal member of Ferhatkaya Formation (Locality: Southern slopes of Paşaoğlanınçal hill).

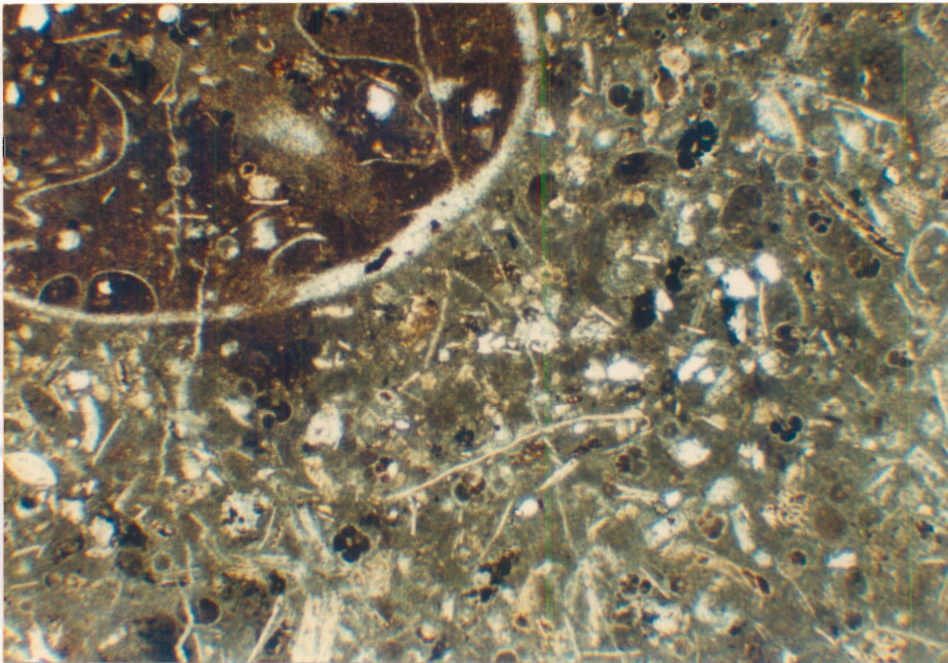


Figure 13. Photomicrograph of the Ammonitico Rosso biomicritic facies. Ammonite, at right-hand corner with fluted septa, thin-shelled pelecypoda and Globuligerina gr. oxfordiana set in a micritic matrix (Sample No: 882k, X 50).

Correlation: The Paşaoğlanınçal member can be correlated with the Ammonitico Rosso facies at the bottom of the Bilecik Limestone (Granit and Tintant, 1960; Eroskay, 1965; Altıner et al.,1989) in the northwestern Anatolia, the bottom of the Doğdu Formation (Öztürk, 1979; Tutkun and Inan, 1982) in the central Pontides and with the bottom of the Berdiga Formation (Pelin, 1977; Rojay, 1985) in the Eastern Pontides.

Depositional Setting: The matrix and the faunal assemblage are apt to be a relatively deep, stagnant and pelagic depositional setting on an emerged pelagic plateau. However, the irregularity, fragmentation and heterogeneity of the fossil distribution (Figure 13) indicate a current action during the deposition. The depositional setting is an epicontinental sea which can be chiefly bound to emerged pelagic plateau (Aubouin,1965; Jenyken and Hsü,1974; Farinacci and Elmi,1981). This is an equivalent level of the Ammonitico Rosso facies of latest Dogger age (Callovian).

2.2.2.2. Horoztepe member

Definition: This member consists predominantly of shallow marine platform carbonates that have extensive distribution in both the study area and Pontides. It was informally named as the Horoztepe member where composite section is constructed in order to define the member (Paşaoğlanınçal hill and Sel creek sections). The member was

also previously included in the Ferhatkaya Formation of Alp (1972).

Stratigraphic Relations and Thickness: The Horoztepe member has an extensive distribution within the study area as a parautochthonous unit and/or a block of NAOM (Plate 1). It overlies unconformably the Vermiş member at certain localities (e.g. Paşaoğlanınçal hill). It is overlain unconformably by the Gezilikdere member of the Sarılar Formation. On the other hand, the Horoztepe member also occurs as blocks of differing size in the NAOM or as isolated tectonic slices on the top of the Tokat Complex. The maximum preserved thickness of this member is over 1250m in the Horoztepe section.

Lithology and Combined Stratigraphic Section: The section measured along the western slope of Horoztepe hill (Sel creek) (Figure 14, Plate 1) has the maximum preserved thickness. The bottom and top of the sequence are missing. By using the lithological and paleontological similarities and successions recognized in the other complementary sections, a combined section is prepared and used to define the member (Figure 14). In the sequence exposed along Paşaoğlanınçal hill, the Horoztepe member starts with a dark gray to gray, medium bedded, nodular limestone (oobiopelmicrite or pelagic oolite and pellet-rich packstone) and grades upward into gray, thick to medium bedded, cherty, nodular limestone (oointramiticrite or

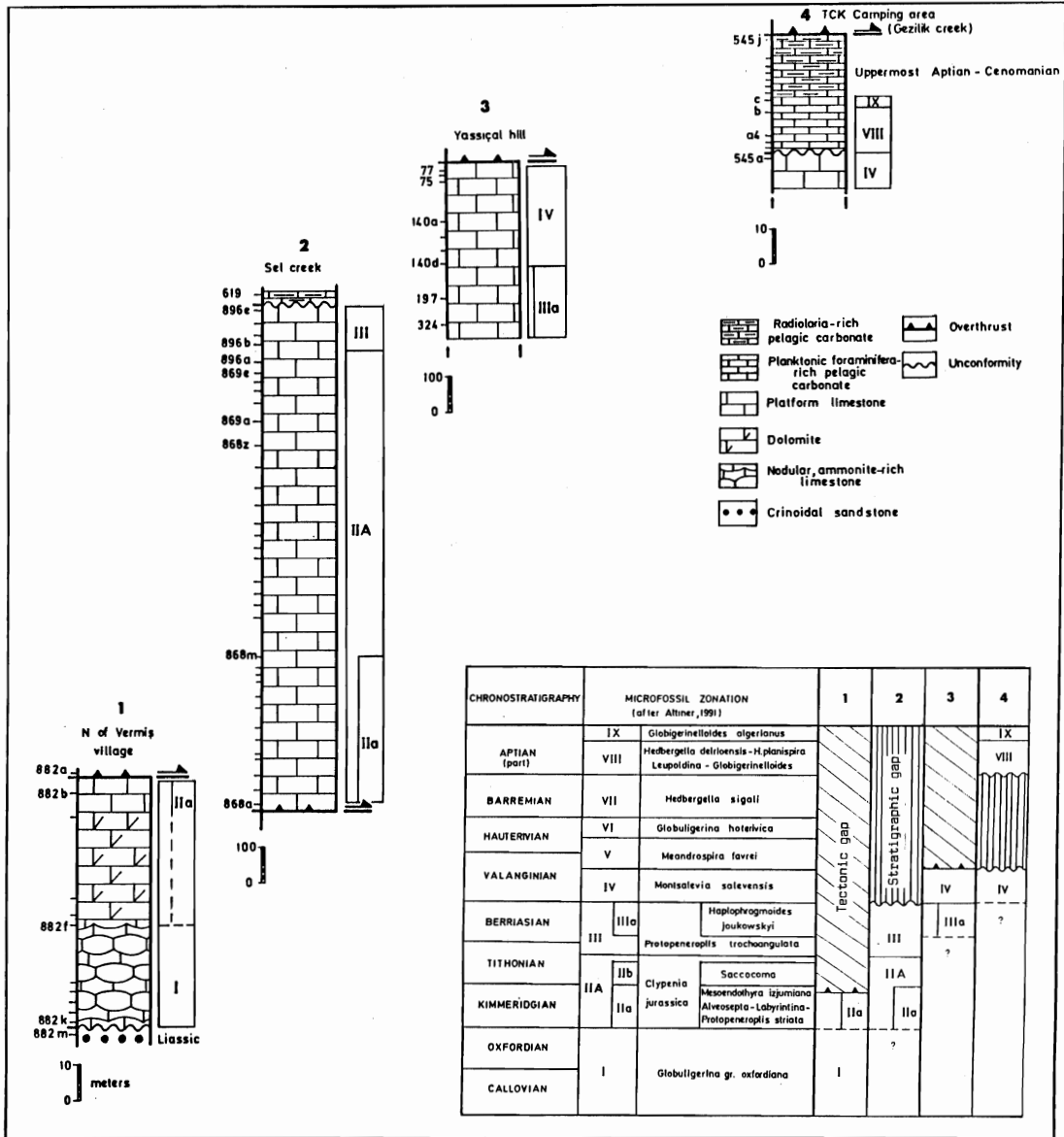


Figure 14. Biostratigraphic correlation of the measured stratigraphic sections of the Amasya Group. Composite stratigraphical columnar section is set after the data. Each measured section is correlated on the basis of Altner's study (1991) which is slightly modified by replacing Zone II of Altner (1991) with Clypeina Jurassica Zone (Zone IIA).

intraclast rich packstone). Cherty limestone sequence grades into thick bedded to massive, dolomitic limestone sequence and to gray, thick to medium bedded, oncolitic limestone (oncolitic wackestone) which is partly dolomitized. Tectonically repeated section is combined with the Horoztepe section by using oncolitic limestone level, which is a paleontologically and lithologically correlative key horizon. The creamy to light gray, medium to thick bedded, oolitic and oncolitic limestone sequence grades into creamy to beige, medium to thick bedded, gastropoda rich oncolitic limestone (gastropoda rich wackestone with intraclasts, or intrabiomicrite) and to red, gray to cream, medium to thick bedded limestone (dismicrite to pelbiomicrite or pelletoidal laminated bindstone to mudstone and intraclastic packstone to fossiliferous grainstone). After a characteristic yellowish cream, thin bedded, gastropoda rich, oolitic, oncolitic limestone horizon, the sequence continues upward with gray, medium bedded limestone, oncolitic limestone, and gray to cream, massive to thick bedded limestone. The sequence is capped with a white to light gray, medium to thick bedded, biomicritic limestones. In addition to the microfacies types recognized along the succession, blocks within the melange also show some variations in bio- and lithofacies. However, lack of marker horizons makes difficult to detect their stratigraphic positions in the composite columnar section.

Paleontology and Age: The following fossil assemblages and related biozones (Altiner, 1991) are identified in the Horoztepe member (Figure 14, 15). Zone I is characterized by Globuligerina gr. oxfordiana, Globochete alpina, Ophthalmidium strumosum, Ophthalmidium spp., Miliolina, Spirulina sp., Cadosina sp., Lenticulina sp., Reophax (?) sp., Ostracoda and Echinoid fragments. The Clypeina jurassica Zone (Zone IIA) consists of Alveosepta jaccardi, Mesoendothyra izjumiana, Glomospira sp., Ammobaculites sp., Litoulidae, Haplophragmoides sp., Pseudocyclamina sp., Trocholina alpina, Trocholina sp., Earlandia sp., Rectocyclamina sp., Miliolina, Pelecypoda, Gastropoda, Ostracoda, Coral, Dacycladacean algae, Cayeuxia sp., Clypeina jurassica, Salpingoporella annulata, Thaumatoporella parvovesiculifera. Zone III includes Protopeneroplis trochoangulata, Trocholina alpina, Trocholina odukpaniensis, Ataxopharagmiidae, Textularia sp., Earlandia sp., Siphovalvulina sp., Pseudocyclamina sp. (agglitunated), Hecthina sp., Quinqueloculina cf. robusta, Miliolina, Dacyclacean algae, Gastropoda, Ostracoda. Zone IV is characterized by: Haplophragmoides joukowskyi, Montsalevia salevensis, Protopeneroplis trochoangulata. Callovian to Early-Middle Valanginian is assigned to the Horoztepe member and Zone I to Zone IV (Altiner, 1991) are identified and correlated with the NW Anatolian Jurassic-Lower Cretaceous sequences.

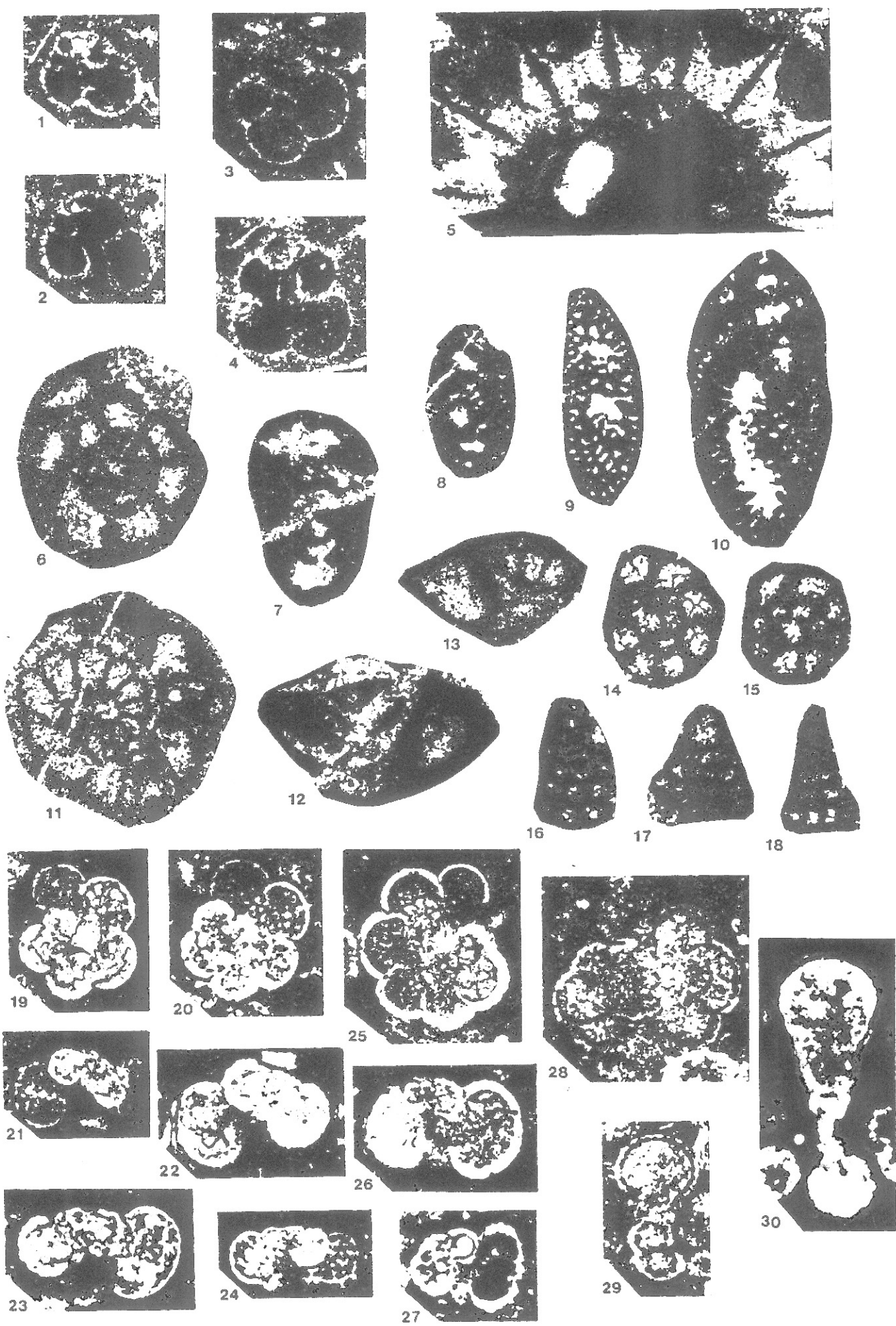


Figure 15. Major microfossil groups used in the biozonation of the Amasya Group.

- 1-3. *Globuligerina* gr. *oxfordiana* (Grigelis) (Sample No:882k, X 200)
4. *Globuligerina* sp. (Sample No:882b, X 200)
5. *Clypeina jurassica* (Favre) (Sample No:868w, X 90)
- 6-7. *Mesoendothyra izjumiana* Dain (Sample No:868c,d, X 110)
- 8-10. *Alveosepta* gr. *jaccardi* (Schrodt) (Sample No:882b, 868b, X 60)
- 11-13. *Protopeneroplis trochoangulata* Septfontaine (Sample No:545o,b, X100)
- 14-15. *Haplophramoides joukowskyi* Charollais, Brönnimann and Zaninetti) (Sample No:545o,a, X 110)
- 16-18. *Montsalevia salevensis* (Charollais, Brönnimann and Zaninetti) (Sample No:545o,a, X 110)
- 19-22. *Hedbergella delrioensis* (Carsey) (Sample No:545b,e, X 110)
23. *Hedbergella* sp. (Sample No:545b, X 200)
- 25-26. *Hedbergella planispira* (Tappan) (Sample No:545b,c, X 200)
27. *Hedbergella gorbachikae* Longoria (Sample No:545b, X 200)
- 28-29. *Globigerinelloides ferreolensis* (Moullade) (Sample No:545b, X 200)
30. *Globigerinelloides algerianus* Cushman and Ten Dam (Sample No:545b, X 200)

Correlation: Jurassic to Lower Cretaceous shallow marine carbonates have extensive and correlative distribution in the Pontide belt. The Alancık Formation (Bingöl et al. 1973) and the Bilecik Limestone (Granit and Tintant, 1960; Eroskay, 1965; Altıner et al. 1989) in NW Anatolia, the Doğdu Formation (Öztürk, 1979; Tutkun and İnan, 1982) and possibly the İnaltı Formation (Ketin and Gümüş, 1963) in northern central Pontides and the Berdiga Formation (Pelin, 1977; Rojay, 1985) in the eastern Pontides are some of the well-known correlative lithostratigraphic names worth to mention.

Depositional Setting: Predominance of intrabio- and oomicrites suggest that deposition occurred in a wide, protective lagoon behind some form of barrier or on an open shelf experiencing only moderate to low wave action (Irwin, 1965). The virtual absence of frame-building massive colonial corals, and the presence of dasyclacean alga and encrustating dasyclacean alga indicate that algal-foraminiferal banks may have been the most common organic buildups. Fossil evidence indicates a wide range of depositional setting which is restricted lagoon to open sea carbonate platform. Shallow marine detritus, fragments of gastropods, echinoids and lamellibranchiata are probably swept off from the platform by underwater currents.

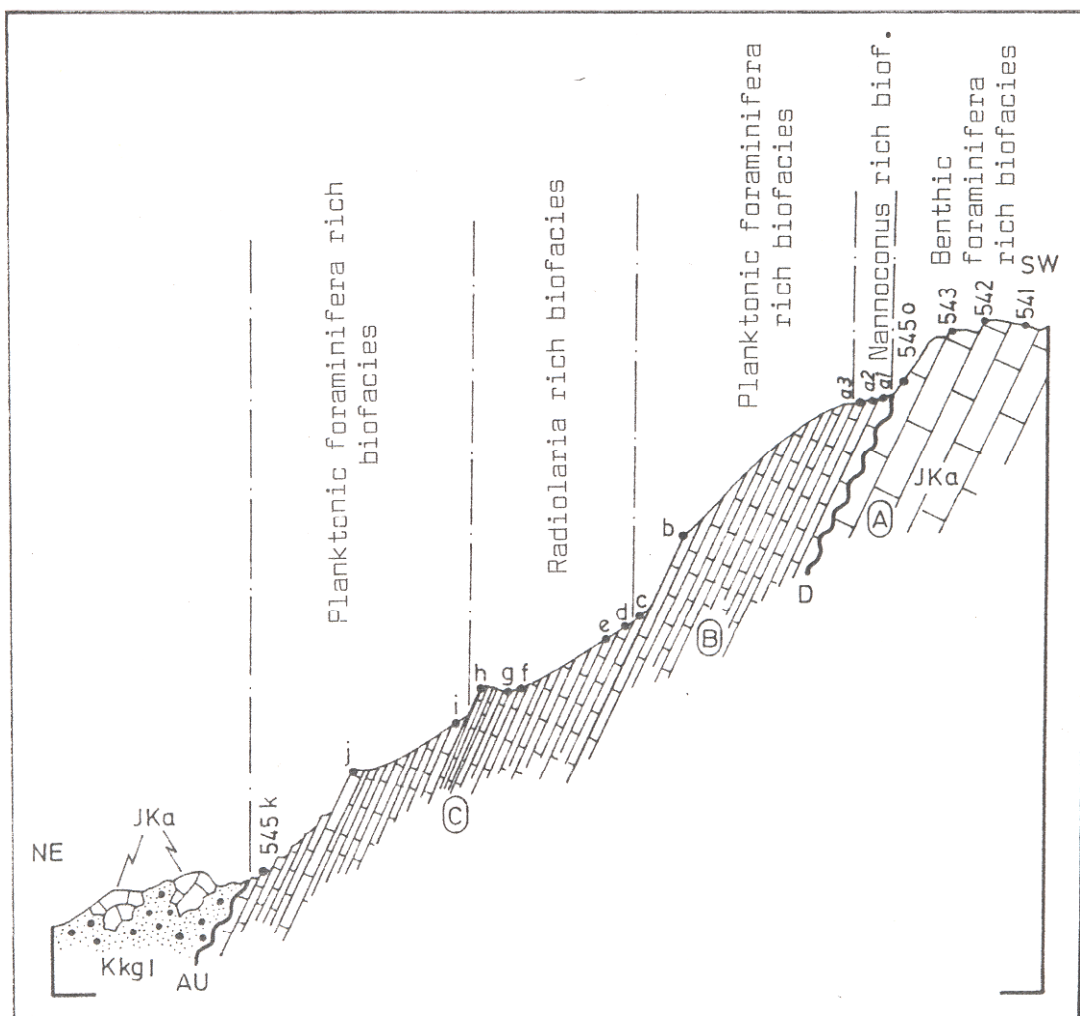


Figure 16. Sketch geological cross section of the Gezilikdere member of the Sarılar Formation. A.white-gray, medium to thick bedded limestones of the Amasya Group (JKa), B.red, thin bedded argillaceous micritic limestones, C.beige-red-cream-light green, thin bedded argillaceous micritic limestones, Kkg 1.red conglomerates of the Geyiközü Formation of Karatepe Group, AU.Angular Unconformity, D.Disconformity. Numbers and small letters indicate sample locations (Locality: Northwestern slope of Gezilik creek,SE of Fındıklı village).

biomicritic lobes are observed at various levels of the sequence.

Paleontology and Age: A Nannoconus-rich biomicritic facies rest on the top of the platform carbonates (Figure 16). This facies is followed by a sequence which is rich in Globigerinelloides algerianus, Globigerinelloides ferrolensis, Hedbergella trochoidea, Hedbergella planispira, Hedbergella delrioensis. This sequence is gradually overlain by radiolaria rich levels and continue with a sequence which is again rich in planktonic foraminifers including Praeglobotruncana turbinata, Praeglobotruncana stephani and advanced rotalipora (Figure 15,16). The lower part of the sequence is Aptian in age and correlated with the Zone IX (Altıner, 1991) in NW Anatolia. The top of the sequence including Radiolaria and planktonic foraminifera rich facies should be ranging from latest Aptian to Cenomanian.

Correlation: It is hard to correlate the Gezilikdere member due to lack of complete section, lack of faunal control and regional terminological problems. However, the Soğukçam Limestone or Formation (Altınlı,1975; Yılmaz et al., 1981; Altıner et al., 1989; Koçyiğit et al., 1990) in northwestern Anatolia, the Çamtepe Formation (Koçyiğit, 1987) and the Akbayır Formation (Akyürek et al., 1984; Koçyiğit, 1987) in Ankara Region, the Sarılar Formation (Alp, 1972; Özcan et al.,1980) in Amasya Region and some other undifferentiated radiolaria-bearing lithostratigraphic

units in eastern Pontides (personal field observations, 1984). Alp (1972) used the term "Sarılar Formation" for the units which includes all the thin bedded radiolaria-bearing sequences. However, the paleontological and sequential stratigraphy point out that radiolaria bearing units should be separately mapped and named. Especially, the radiolarites and radiolaria bearing limestones and related turbiditic clastics should be differentiated.

Depositional Setting: The planktonic fauna and lithology indicate a deep sea pelagic depositional environment (Bernoulli and Jenkyns, 1974). The sharp contact of platform carbonates with the deep sea pelagics indicates a possible sudden subsidence and sea level rise during the pre-Aptian period (Rojay and Altiner, 1992). Lack of the erosional features and benthic foraminiferas with restricted amount of platform carbonate clasts on the platform carbonates may indicate a non-depositional period ("sweeping period") or sudden deepening due to "block faulting".

2.2.3.2. Yavru member

Definition: The Yavru member consists of radiolaria bearing limestones and marl-sandstone-siltstone alternation. Its type section was measured to the south of Yavru village (Figure 17). The Yavru member can be partially correlated with the Sarılar Formation (Alp, 1972).

Stratigraphic Relations and Thickness: The Yavru member has an extensive but patchy distribution in the study

2.2.3. Sarılar Formation (Kas)

The unit was first named by Alp (1972) for radiolaria bearing rocks. The Sarılar Formation was subdivided into two members, namely the Gezilikdere and Yavru members.

2.2.3.1. Gezilikdere member

Definition: The Gezilikdere member consists predominantly of deep sea pelagic carbonates. It was named as the Gezilikdere member where its type section was measured to the north of Aydıntarla ridge along Gezilik creek (Plate 1).

Stratigraphic Relations and Thickness: The Gezilikdere member has limited distribution within the study area. It overlies unconformably the Horoztepe member along Gezilik creek, near the Amasya Castle and around Zincirlikaya, and is overlain unconformably by Karatepe group along Gezilik creek. It is also present within NAOM as tectonic inclusions. At some localities, it is overthrust by the Horoztepe member (N of Amasya Castle) and the NAOM. The Gezilikdere member has 30 m observable thickness in Gezilikdere creek section.

Lithology and Type section: At the type section, the member is composed of cream, yellow to red, thin bedded to laminated argillaceous limestones (biomicrites) (Figure 16). Microslump structures and microturbiditic arenaceous

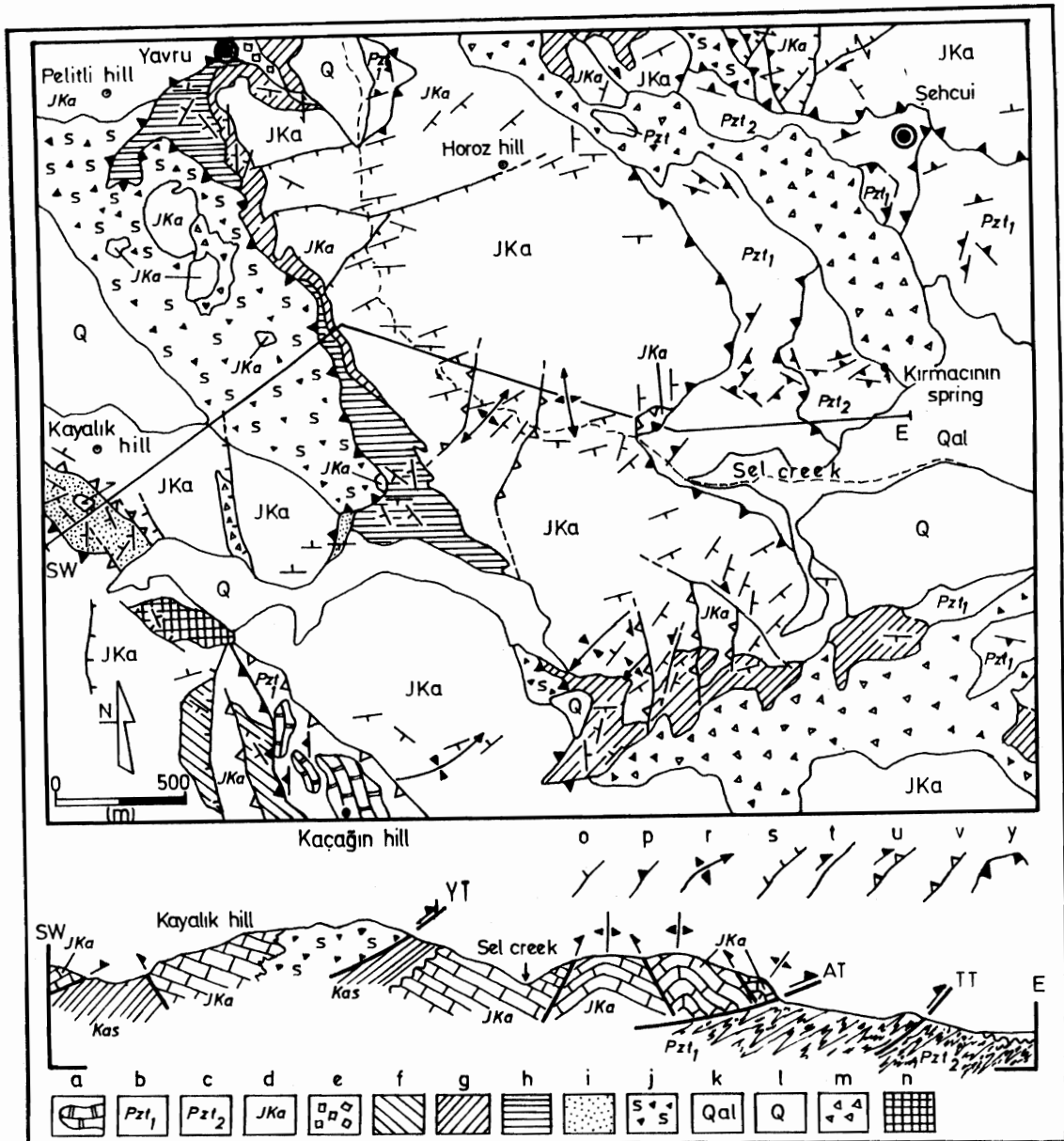


Figure 17. Geological map and Sketch geological cross section showing a series of overthrusts, namely, Yavru overthrust (YT), Amasya overthrust (AT) and Tokat overthrust (TT). a.marble blocks in the Tokat Complex, b. green schists and c. black schists of the Tokat Complex, d.Amasya Group, e. brecciated and reamalgamated Amasya Group of rocks, f. undifferentiated pelagic carbonates of the Sarılar Formation, g.pelagic carbonates of the Yavru member, h.pelagic turbidites of the Yavru member, i.tuffaceous pelagic carbonates of the Yavru member, j.North Anatolian Ophiolitic Melange, k.Holocene alluvial plain sediments, l.Holocene fluvial sediments, m.talus breccias, n.travertine, o.attitude of bedding plane, p.schistosity plane, r.folds confined to the Amasya Group, s.normal fault, t.strike slip fault, u.strike slip fault with reverse component, v.reverse fault, y.overthrust (Locality: Inset map in Plate 1).

area. Continuous and well-observable stratigraphic relations of outcrops are exposed between Yavru village and Yeşilirmak stream (Figure 17). The Yavru member overlies unconformably the Horoztepe member to the S of Yavru village. It is overthrust by the NAOM to the S of Yavru village and occurs within the NAOM as tectonic inclusions (Figure 17,18,19). Thickness of the member is over 59 m in the measured section.

Lithology and Type Section: The Yavru member starts with cream to yellow and red, thin bedded, laminated, argillaceous limestones (biomicrites) with marly levels (Figure 18). Then the sequence continues upwards with green to dark green to black, thin to medium bedded intensely deformed marl-siltstone-sandstone-tuffaceous sequence with wavy bedding, slump structures and lenses of turbiditic sandstones (Figure 18,20).

Fossil Content and Age: The Albian-Cenomanian age is assigned to the Yavru member according to following fauna: Praeglobotruncana turbinata, Praeglobotruncana stephani, Rotalipora appeninica, Rotalipora sp., Radiolaria.

Correlation: Although, the sequence can be correlative with a part of the Sarılar Formation (Alp, 1972), it should be differentiated from the Sarılar Formation. Lack of faunal control, incomplete section and regional terminological problems ceased study from having a healthy correlation at regional scale. However, the member may have

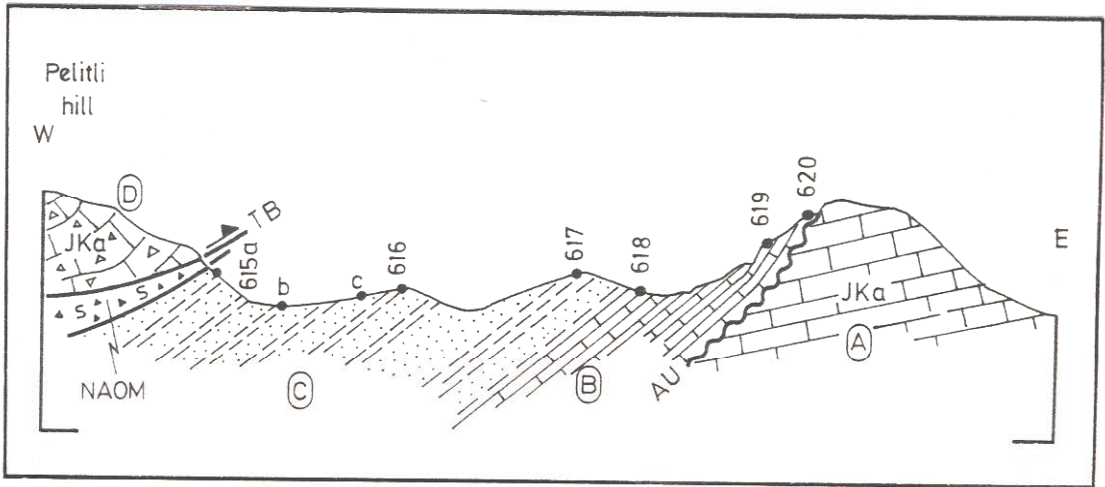


Figure 18. Sketch geological cross section of the Yavru member of the Sarılar Formation. A. cream to light gray, medium to thick bedded limestones of the Amasya Group (JKa), B. cream-yellow to red, thin bedded, argillaceous limestones with minor marl beds, C. green to dark green, medium to thick bedded marl-sandstone alternation with minor conglomerate lobes and turbiditic sandstones, D. brecciated, blocky limestones of the Amasya Group, NAOM. North Anatolian Ophiolitic Melange, AU. Angular Unconformity, TB. Tectonic boundary (overthrust). Numbers indicate sample locations (Locality: S of Yavru village).



Figure 19. General view of the Yavru member (Kas) overlying unconformably the Ferhatkaya Formation (JKaf). The Yavru member is overthrust by the NAOM. Qal. alluvium (Locality: S of Yavru village).

the same time stratigraphic equivalents in the Pontides as the Gezilikdere member.

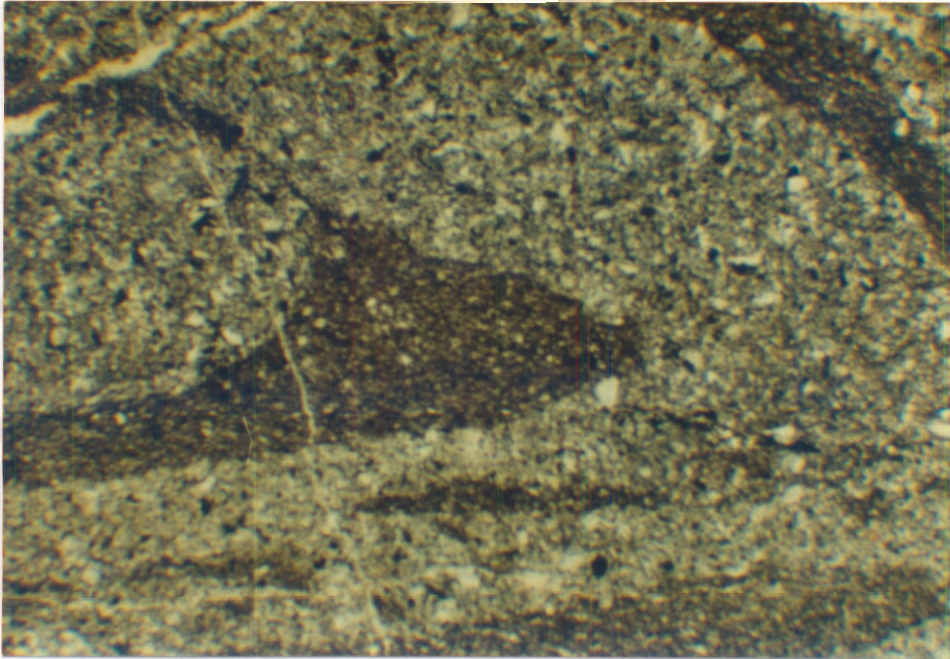


Figure 20. Photomicrograph showing turbiditic microslump structure developed to the top of the Yavru member of the Sarılar Formation (Sample No: 617, X 50).

Depositional Setting: The planktonic fauna and lithology with its own sedimentary structures (wavy bedding, slump folds) indicate an active, deep sea depositional setting (Reineck and Singh, 1975; Bernoulli and Jenkyns, 1982). The direct onlap and overlapping relations of the unit with platform carbonates and "terrestrial fragments" indicate a sudden deepening, sea level rise and a progressive sediment supply through probable deep sea canyons onto subsided carbonate platform as a result of block faulting.

2.3. North Anatolian Ophiolitic Melange (NAOM)

Definition: In the Mesozoic Tethys area, the ophiolites, chaotic ophiolitic units and Jurassic-Lower Cretaceous platform carbonates attracted many scientists and researchers since 1950 (Bailey and McCallien, 1950). Chaotic ophiolitic units occur within the northern Neotethyan Sutures where so called "Ankara Melange" lies on (Bailey and McCallien, 1950). These units display a significant tectonic belt in northern Anatolia which is a continuous belt from "Vardar Zone" (Aubouin, 1958; Mercier, 1960; Brunn, 1960; Aubouin et al., 1970) to the far west through "İzmir-Ankara-Erzincan Suture" (Brinkman, 1972; 1976; Şengör and Yılmaz, 1981) to "Sevan-Akera Zone" to the east (Knipper, 1971; 1980; Adamia et al., 1977; 1981) (Figure 1). The term "North Anatolian Ophiolitic Melange" was used to define a tectonic, continuous and correlative belt in northern Anatolia (Koçyiğit and Rojay, 1984). This suture belt was previously named as "facies tectonique brouille" or "facies tectonique Paphlagonien" of "Mesozoïque de l'Anatolie septentrionale" (Blumenthal, 1941a,b) at regional scale. The chaotic ophiolitic unit, in Amasya region, consists predominantly of ophiolitic material (serpentinite, diabase-gabbro, pillow basalt and radiolarite) and Jurassic to Lower Cretaceous limestone blocks set in an ophiolitic argillaceous-arenaceous matrix which is usually scaly and sheared.

Distribution and Stratigraphic Position: The NAOM has an extensive distribution between Amasya City and Gerne village where it occurs in continuous, parallel belts. Continuous parallel belts are situated, from north to south, between Ağıl settlement and Amasya City, and between Gerne village and Amasya City within a 7 km wide-30 km long zone (Plate 1). The youngest unit overthrust by NAOM is the Eocene flysch sequence (Cindere group) (Plate 1). The tectonic transport direction of the overthrusting is from south to north to the W of Taşlıyurt and Arucak villages and S of Yuvala village (Plate 1). The oldest unit overlying the NAOM is the Campanian-Maastrichtian Geyiközü Formation at the SW of Ağıl settlement (Figure 21). The NAOM is intruded by dacitic intrusions (Moramıl dacite) around Moramıl, Kürtler, Taşlıyurt and Alabedir villages (Figure 22, Plate 1).

Components: The NAOM contains a wide variety of blocks. Most common ones are the ophiolitic rocks and Jurassic-Lower Cretaceous limestones. Main ophiolitic blocks are ultramafics (serpentinite), gabbroic units (mostly diabase), pillow basalts and intensively folded, bedded radiolarites. Other rock types are the Jurassic-Lower Cretaceous limestone blocks of the Amasya Group and the metamorphic blocks of the Tokat Complex. However, the blocks of metamorphic rocks are present in small numbers.

Serpentinites are mostly serpentized peridotites-harzburgites. These tectonically deformed rocks were



Figure 21. General view of red clastics(c) of the Geyiközü Formation (Kkg) on the top of the North Anatolian Ophiolitic Melange (NAOM) and gradational boundary relation with the overlying neritic-clastic sequence(nc). Siliceous radiolarites (r) rest on the top of the pillow basalts (β). rb. radiolarite breccias, T.thrust (Locality: N of Tüllüçal hill, W of Amasya City).

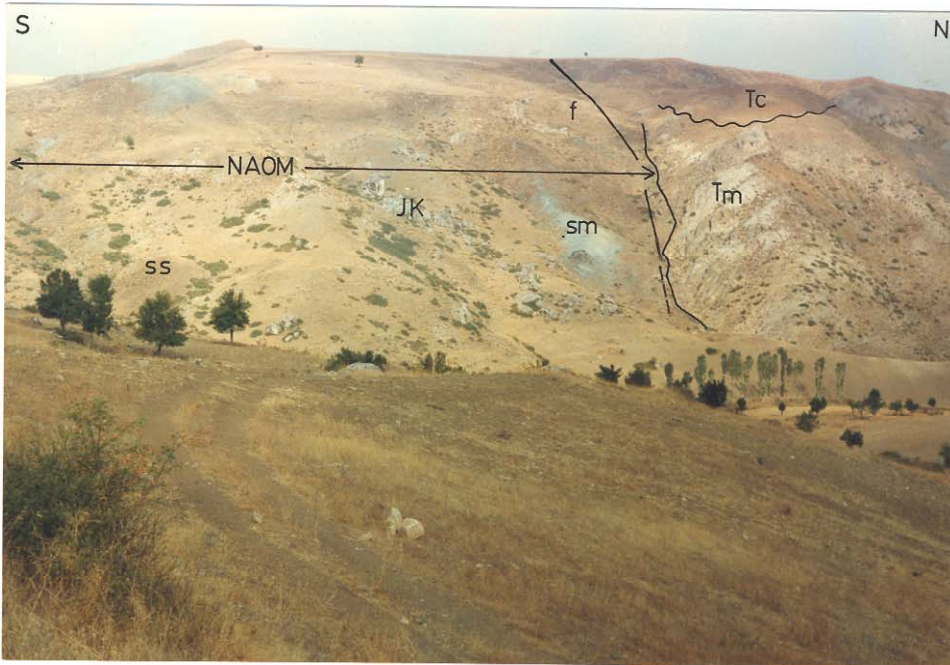


Figure 22. General view of the North Anatolian Ophiolitic Melange (NAOM) intruded by the Moramıl dacite (Tm). JK.Jurassic-Cretaceous carbonate blocks, ss.ophiolitic rocks, sm. brecciated matrix, Tc. Cindere group, f.fault (Locality: E of Kürtler village).

originally harzburgites. Petrographically, harzburgites composed of serpentized olivine (with mesh texture), pyroxene (with bastite texture), serpentine and opaque minerals. Exsolution-lamelli are observed in addition to cross- and slip-fiber texture. The opaque minerals are the rounded to subrounded chromite grains.

Diabases are mostly fragmented, brecciated and sheared. They are hornblende-microgabbros (hornblende, diopsidic clinopyroxene, opaque minerals with plagioclase laths and microlites, a few green biotite phenocrysts set in a fine grained groundmass of hornblende, clinopyroxene and plagioclase microliths).

Pillow basalts are well-preserved only at a few outcrops and mostly altered. These dark green to dark purple mafic rocks with pillow structures are in basaltic composition (albite, chlorite, olivine, titanite and opaque minerals set in a fine grained plagioclase-augite-glassy groundmass). Amygdules are filled with calcite and zeolite minerals. Tectonic overprint is not observed in these rocks as in diabases.

Pelagic blocks are common and consist of radiolarites and radiolaria bearing micritic limestones. Thinly bedded radiolarites are typically green to greenish white; others are red, and some are orange-yellow to cream in color. These units include thin shale interbeds which are rich in radiolaria. Some of the radiolarites occur at the top of pillow lavas without showing any interbedding relations

(Figure 21). Radiolarite breccias, made up of only radiolarite clasts, are very rare. Clasts, which are usually 1 to 15 cm in size, are significantly bigger than those in typical mafic breccias. Radiolarite blocks are mostly intensely folded, jointed and fragmented in places. Greenish white to cream, thin bedded, intensely folded, radiolaria bearing micritic limestones occur as isolated blocks without any stratal continuity and relation with pillow lavas. These are also rich in radiolaria. The Albian-Cenomanian age is assigned to these blocks based on their fossil content including Praeglobotrucana turbinata, Praeglobotruncana stephani and Rotalipora sp. (advance form).

Various carbonate blocks are present in the melange mass in addition to the limestone blocks of Amasya Group (JKa) in which are fragmented - re-amalgamated in places (Figure 23). Some of the significant limestone blocks are Permian and Tithonian-Berriasian in age. Permian limestone blocks are very few, scattered, dark gray to brownish gray, medium to thick bedded, intensely deformed limestones (biomicrites) with randomly oriented calcite-filled veins. Asselian-Sakmarian age is assigned to these blocks based on their fossil content, namely Tubiphytes obscurus, Climacammina sp., Pseudofusulina sp., Rugosofusulina sp., Diplespherina inaequalis, Tuberitilina conili (Figure 24).

Tithonian-Berriasian limestone blocks are mostly small outcrops consisting of white to gray, thin bedded limestones (biomicrites). They are intensely deformed,



Figure 23. Close-up view of fragmented-reamalgamated Amasya Group carbonates (Locality: N of Yağmur village).

fractured and comixed with platform limestone blocks of the Amasya Group (JKa). They crop out at various locations in small numbers, however, their widespread outcrops are observed within the melange body to the N of Uzun ridge (Plate 1). The Latest Tithonian to Early Berriasian age is assigned to these blocks based on their fossil content, namely, Cadosina sp., Calpionella alpina (spherical forms), Crassicollaria brevis, Crassicollaria parvula (bottom of Zone B); Calpionella alpina (spherical forms), Tintinopsella carpathica, Remaniaella sp., Crassicollaria parvula, Radiolaria (upper part of Zone B) and Calpionella alpina (spherical forms), Calpionella elliptica and Tintinopsella carpathica (Zone C) (Figure 25).

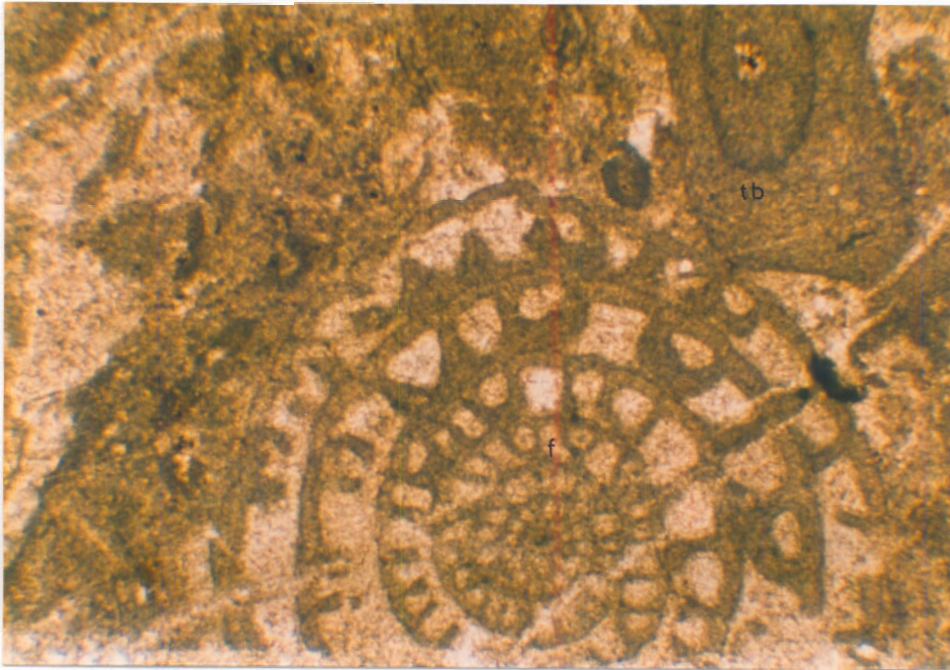


Figure 24. Photomicrograph taken from a Permian limestone block in the NAOM showing a large schwagerinid fusuline (f) with keriotheca and Tubiphytes obscurus (tb) in a micritic matrix (Sample No:808, X 50).

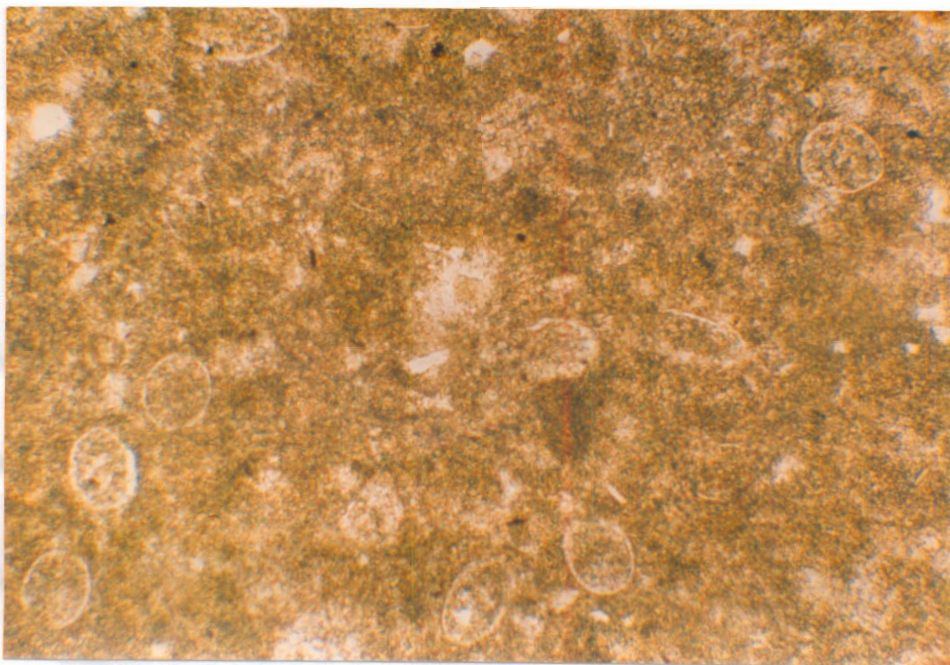


Figure 25. Photomicrograph showing calpionellid facies (Zone B) from blocks of the NAOM (Sample No: 34, X 160).

Matrix: The matrix of the NAOM is made up predominantly of red to dark green massive argillaceous-arenaceous, ophiolitic clastics with diabasic-mafic and serpentinite breccias. Some parts of the matrix are pervasively deformed and sheared (Figure 26), and gained scaly structure which is made up of small, thin flakes and scales of sheared, powderized serpentinite. Those can be evidence for a progressive deformation and fragmentation or can be zones of thrust faults. Other important binding material is diabasic-mafic breccias which are clast supported and consist largely of angular diabase clasts, in places, some consist of subangular to angular clasts of basalts and gabbros (Figure 27). Breccias are poorly sorted. Clast size ranges from micron to centimeter. Clasts, which are larger than 10 cm, are rare. Monogenetic serpentinite breccias are lesser and display a matrix relation with the other components of the melange. At some localities, these monogenetic serpentinite breccias have radiolarite clasts in variable proportions. Breccias seem to be tectonic in origin and the clasts are fractured, striated and sheared.

Age of Initiation and Emplacement: Paleontological dating of the NAOM is somewhat uncertain, because no age dating done from so called "matrix". However, Aptian-Cenomanian age (dated highest age in this study) has been identified from limestone blocks and Turonian-Campanian probable age has been reported from radiolarite-radiolaria bearing limestone blocks (Alp, 1972). The NAOM is overlain

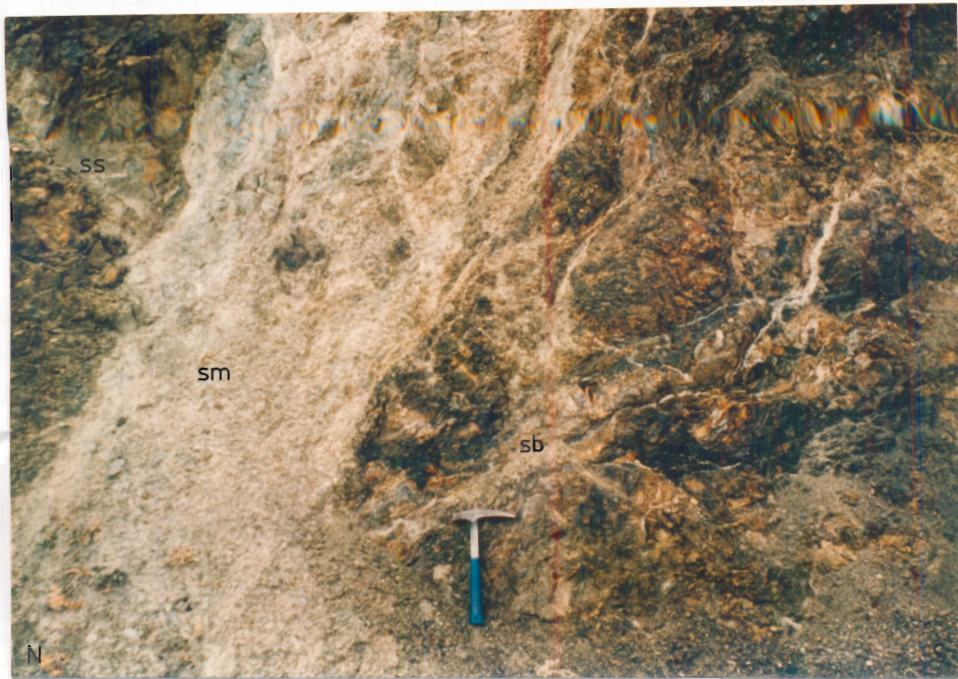


Figure 26. Close-up view of pervasively deformed and sheared ophiolitic microbreccias with scaly-mylonitic structure (sm). ss. ultramafics and sb. fractured-brecciated ultramafic (Locality: NW of Şehcui village).



Figure 27. Close-up view of monogenetic ophiolitic breccias (Locality: N of Yağmur village).

unconformably by the Middle Campanian-Maastrichtian "fluvial" clastics of a forearc sequence in the Amasya region (Koçyiğit and Rojay, 1988; Koçyiğit et al. 1988; Rojay,1991). The initiation age of the subduction will be contemporaneous with the initiation age of the development of NAOM and related broken formations which is accepted to be post-Cenomanian-Turonian period (Şengör and Yılmaz, 1981). Therefore, continuous subduction is resulted in continuous accretion of the melanges since Cenomanian-Turonian through Campanian-Paleocene(?) and ended at pre-late Miocene time in northern Anatolia along the Northern Neo-Tethyan Sutures (Koçyiğit,1988; 1990). The emplacement age of the chaotic unit onto the northern active continental margin is post-Eocene to pre-Late Miocene. The speculative ages of the ophiolitic units in this belt are Triassic (Bailey and McCallien, 1953), Jurassic to Late Cretaceous (Ketin, 1962), Jurassic to Neocomian (Boccaletti et al. 1966a,b), pre-Albian (Knipper, 1971; Knipper and Sokolov, 1976; Knipper, 1980), pre-Triassic (Kaya, 1976), Permian (Bergougnan and Parrot,1981) and pre-Liassic (Koçyiğit, 1990;1991a).

Correlation: The Upper Cretaceous ophiolitic melanges are widespread extending from Vardar Zone (Aubouin, 1958; Mercier, 1960; Brunn, 1960; Aubouin et al. 1970) to the far west through Izmir-Ankara Zone (Brinkman, 1972; 1976) and Erzincan suture (Şengör and Yılmaz, 1981) to Sevan-Akera Zone (Adamia et al. 1977; Knipper,1980; Adamia et al. 1981).

Within Anatolia, from west to east, Çetmi Melange (Okay et al. 1990) in Biga peninsula; Dağküplü Melange (Şentürk and Karaköse, 1979), Ovacık Tectonic Melange (Koçyiğit et al. 1991) in Bilecik-Eskişehir region, a part of Ankara Melange (Bailey and McCallien, 1950; 1953; Boccaletti et al. 1966b; Norman, 1975), Irmak Formation (Norman, 1972), Aktepe-Gökdere Formation (Çapan and Buket, 1974), Dereköy Formation (Batman, 1978; 1981), Kırıkkale Melange (Özkaya, 1982), Eldivan Ophiolite Complex (Akyürek et al. 1984), Anatolian Nappe (Koçyiğit and Lünel, 1987; Koçyiğit et al. 1988) and renamed as Anatolian Complex (Koçyiğit, 1991) in Ankara region; Beşören Ophiolitic Complex (Koçyiğit, 1979), Artova Ophiolitic Melange (Özcan et al. 1980), Tekelidağ Melange (Yılmaz, 1981;1983) and Anatolian Nappe (Koçyiğit and Rojay, 1988; Koçyiğit et al. 1988) in Amasya-Tokat region, Gülen Formation and related units (Tatar, 1975), Karayaprak Nappe and Erzincan Peridotite subzone (Bergougnann, 1976), Tanyeri Ophiolitic Melange (Bektaş, 1982), Erzincan Nappe (Karayaprak Melange and Refahiye Complex) (Yılmaz, 1985), Anatolian Ophiolitic Melange (Koçyiğit and Tokay, 1985; Rojay, 1985), Anatolian Nappe (Koçyiğit, 1989) and Anatolian Complex (Koçyiğit, 1990) in Susehri-Erzincan region; North Anatolian Melange (Koçyiğit and Rojay, 1984) and Anatolian Ophiolitic Melange (Koçyiğit, 1985) in Erzurum-Kars region and serpentinite melanges of Zangezur and Sevan-Akera zones (Knipper, 1971; 1980) in Lesser Caucasus are correlative with the North Anatolian Ophiolitic Melange in İzmir-Ankara-

Erzincan-Sevan-Akera sutures (Figure 1). However, another belt of Upper Cretaceous ophiolitic melange runs to the north of this belt (Figure 1), that goes through Gelibolu peninsula (Şarköy melanges: Kopp et al. 1969; Şentürk and Okay, 1984), Gemlik-İzmit line (Bakacak olistostrome: Göncüoğlu et al. 1987; Neo-Tethyan Ophiolite Association: Yılmaz, 1990), Bolu region (Abant Complex: Yılmaz et al. 1981), Gerede-Ilgaz region (Zone de l'Arkotdağ: Blumenthal, 1941a,b; Arkotdağ Formation: Tokay, 1973) and northern central Pontides (Neo-Tethyan Ophiolite: Şengör and Yılmaz, 1981; Kızılırmak Group and Kirazbaşı Melange of Kargı unit :Tüysüz, 1990; Yılmaz, 1990; Dirik, 1991; Kargı Ophiolite Association :Yılmaz and Tüysüz, 1991).

Tectonic Setting: Collectively, the following observations on the ophiolitic units suggest a melange formation at convergent margin in Amasya domain:(1) the character of the incorporated clasts (Hsü, 1968; 1974; Berkland et al. 1972; Gansser, 1974; Blake and Jones, 1974; Raymond, 1984), (2) Various fragmented and mixed blocks of different depositional-tectonic setting such as serpentinites, Jurassic-Cretaceous platform carbonates, Cretaceous pelagic units and continental fragments (low-grade metamorphics), (3) the huge, mountain size of blocks (Hsü, 1968) such as Jurassic-Cretaceous platform carbonates floating in melange (Plate 1), (4) the presence of deformation in the internal structure of the blocks, (5) the lack of stratal continuity (Rigo de Righi and Cortesini,

1964; Hsü, 1968; 1974; Cowan, 1974; Raymond, 1978; 1984), (6) the presence of fine grained, in places, pervasively sheared ophiolitic matrix (Hsü, 1968; 1974; Cowan, 1974; Beutner, 1975; Silver and Beutner, 1980), (7) the tectonic nature of block/matrix relation, (8) the mappability on a reasonable scale (Hsü, 1968; Berkland et al. 1972; Silver and Beutner, 1980; Raymond, 1984) which is 1:25.000 in this study, (9) the presence of the turbidity current deposits flowing down the axis of paleotrench (Leggett, 1980) and (10) the regional consideration (Dewey and Bird, 1970; Dewey, et al. 1973; Blake and Jones, 1974; Hsü, 1974; Kay, 1976; Raymond, 1984; Şengör and Yılmaz, 1981).

However, lack of eclogite, peridotite (with high P/T minerals) or blue-schist metamorphic clasts and not totally pervasively sheared matrix led to interpret it as a melange formed in an accretionary wedge model in Amasya domain. Although there are some eclogites, peridotites and blue-schists in northern belt, their position is speculative. Some of these subduction related real exotic bodies which might be closely associated with NAOM and some of which are older than the NAOM, namely are, the Denizgören Ophiolite (Okay et al. 1990), Elliayak Eclogite (Okay et al. 1990), Seyitali Mafic-Ultramafic (Koçyiğit et al. 1991), Karabayır Metaophiolites (Kulaksız, 1981) in northwestern Anatolia, Elekdağ section of Küre Nappe (Şengör et al. 1980; 1985) and Bakımlıdağ Complex (Bozkurt, 1990) in Central Pontides, Karaoluk Ultramafics (Seymen, 1975), Refahiye Serpentinite

Zone (Nebert, 1961), Karadağ Nappe (Koçyiğit and Tokay, 1985; Koçyiğit, 1990), Kopdağı Ophiolite (Bektaş et al. 1984) in eastern Pontides and Vedi Ophiolites with the ophiolites of Zangezur and Sevan-Akera zones (Knipper, 1971; Knipper and Sokolov, 1976; Knipper, 1980) in Lesser Caucasus.

2.4. Karatepe group (Kk)

It consists of a very thick "forearc" sequence which is an isolated basin between a dynamic accretionary prism to the south and Pontide volcanic arc to the north during Middle Campanian to Maastrichtian time. The Karatepe group is characterized by a large variety of depositional systems, namely continental to deep marine setting. The Karatepe group is informally named, referring to Karahill (N of Amasya City).

The group consists of two units with various members or sub-sequences; (1) Geyiközü Formation and (2) Fındıklı Formation.

2.4.1. Geyiközü Formation (Kkg)

The unit was first named by Koçyiğit et al. (1988) and consist of three sedimentary sequences. From bottom to top, these are, (1) clastic sequence, (2) neritic-clastic sequence, and (3) "flysch" sequence. The reference section was measured through NE of Tüllüçal hill to Tepesidelik hill and to Tersakan stream (Section line B in Figure 28).

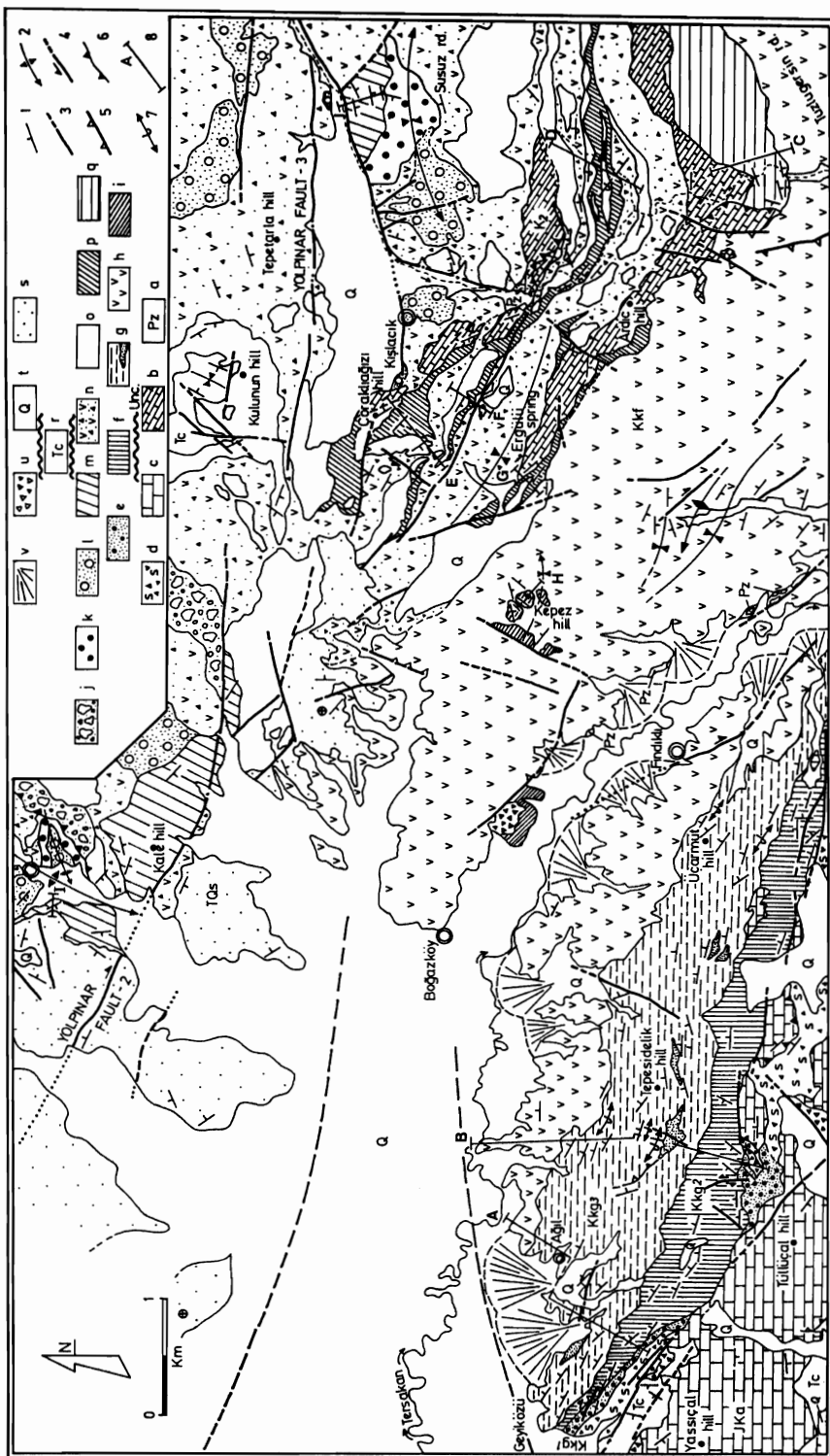


Figure 28. Geological map showing the members and formations of the Karatepe and Kışlacık groups unconformably overlying the North Anatolian Ophiolitic Melange (NAOM). a.Paleozoic schists, b.Cretaceous pelagic carbonates, c.the Amasya Group platform carbonates, d.NAOM, e.clastic sequence of the Geyiközü Formation, f.neritic-clastic sequence of the Geyiközü Formation, g.flysch Formation of the Geyiközü Formation with black sandstones, h.the Fındıklı Formation with rudistic buildups (i.the Kepeztepe member), j.chaotic assemblage of various rocks, k.red,polygenetic massive conglomerates, l.the Susuz formation, m.the Kaletepe formation, n.the Tepetarla formation, o.the Kulunun formation, p.the Çoraklıağzı formation, q.the Tuzlugersin formation, r.the Cindere group, s.the Suluova group, t.Holocene fluvial sediments, u.talus breccias, v.alluvial fan sediments, 1.attitude of bedding plane, 2.folds confined to Upper Cretaceous rocks, 3.fault, 4.strike slip fault, 5.reverse fault, 6.overthrust, 7.synsedimentary folds, 8.measured sections, Unc. Unconformity, rd.ridge (Locality: Inset map in Plate 1).

The clastic sequence consists predominantly of red conglomerates and sandstones (Figure 21,29) with limited patchy distribution in the study area. It overlies unconformably the NAOM (N of Köle cemenry, NE of Yanıklıçal, Tüllüçal and Yasıçal hills) and grades upward into clastics and neritic carbonates (Figure 21,28). The maximum thickness of the sequence is 34 m. The red, massive, polygenetic, clast or and arenaceous matrix supported conglomerates interbedded with red, polygenetic, coarse grained sandstones-siltstones, having the same lithological source as red conglomerates. The clasts are made up of dominantly poorly sorted, rounded to subrounded, diabase, pillow basalt, radiolarite and elongated Jurassic-Lower Cretaceous limestone (Amasya Group) fragments with a minor influx of metamorphic and quartz fragments (Figure 30). To the top of the sequence, a faint fining upward gradation is observed in grain size distribution. Besides some rudist and red algae fragments, the sequence is paleontologically barren. Depending on its stratigraphic position and the components of conglomerate, it is younger than radiolaria-bearing facies (Cenomonian) but older or coeval with the overlying Middle Campanian pelagic units. It is not feasible to use it as a correlative key horizon due to its local and limited distribution. The red color, poorly sorted, rounded to subrounded pebbles, arenaceous matrix, polygenetic character indicate a restricted, active, "continental" depositional setting which was probably a alluvial fan

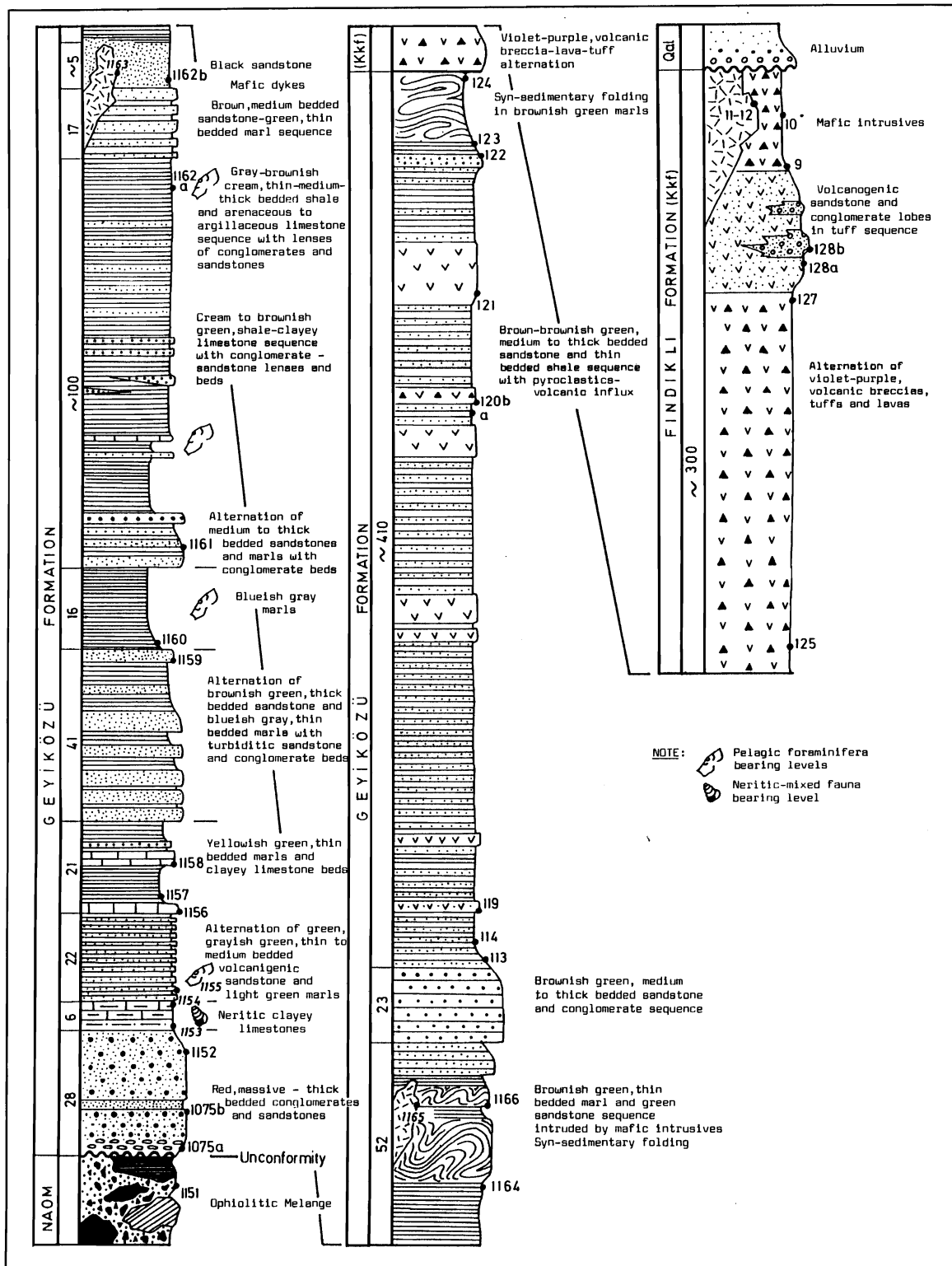


Figure 29. Measured stratigraphic columnar section of the Geyiközü and lower part of the Fındıklı Formations. NAOM. North Anatolian Ophiolitic Melange, Qal. Quaternary alluvium. Numbers indicate sample locations (Locality: Measured section B in figure 28).



Figure 30. Close-up view of deformed Jurassic-Cretaceous limestone clasts in red clastics of the Geyiközü Formation (Kkg) (Locality: N of Tüllügal hill, W of Amasya City).

or the subareial part of a fan-delta. Lack of glauconite, marine fossils, and shaly parts support continental depositional setting (Selley, 1980). The possible source, which supplied the basin, is an advancing and emerging accretionary prism.

The neritic-clastic sequence consists predominantly of alternation of neritic limestones and marls (Figure 29). It shows long and continuous lateral distribution (Figure 28). Red clastics grade transgressively upward into sandstones and to neritic limestones (Figure 29). The neritic limestones grade laterally and vertically into grayish green, glauconitic sandstones and conglomerates.

Limestones overlies unconformably the components of the NAOM in the case of lacking of red conglomerate sequence. Thickness of the sequence ranges between 6 to 22 m. The sequence also consists of light green to yellow, thin to medium bedded marl and yellow, nodular, fossiliferous argillaceous limestone (biosparites) alternation. Limestones are rich in gastropods, nerinea, ostrocods, corals, pelecypods and charophytes which are embedded in a sparry calcite cement. Index fossils are absent to calibrate the age of the member. However, depending on its stratigraphic position, the probable age of the neritic-clastic sequence will be younger than the radiolaria-bearing facies (Cenomanian) but older or coeval with the overlying Middle Campanian pelagic units. The neritic-clastic sequence can be correlative within the limits of Amasya forearc basin. Depending on its fossil content, color and lithofacies, the neritic-clastic sequence might have been deposited in an active, restricted lagoonal to open marine environment.

The flysch sequence is the most widespread facies of the Geyiközü Formation, and characterized by the alternation of various lithologies such as shale, argillaceous limestone, turbiditic clastics, volcanic and intrusive rocks (Figure 29). The flysch sequence has a widespread distribution from Geyiközü locality to Ziyaret village (Plate 1) with a lateral and vertical gradational transgressive boundaries with the underlying neritic carbonates and marls. The flysch sequence is overlain

conformably by andesitic-basaltic volcanic rocks of the Fındıklı Formation (Figure 28,29). The thickness of the sequence is over 717 m. The measured section of the sequence begins with grayish green-green, medium to thick bedded volcanogenic sandstones and coarse grained sandstones to conglomerates, and continues upward with the alternation of above mentioned grayish green- green clastics with blueish green-gray, thin bedded marls (Figure 29). Clastics contain rudist fragments. Marls grade upward into alternation of white-beige-light green, thin to medium bedded marls and argillaceous limestones (micrites) with high clastic influx. These levels grade upward into clastic rocks that are composed predominantly of alternation of brownish, thick bedded sandstone-conglomerate with grayish blue, thin bedded marls. Marly levels are interbedded with lobes and lenses of turbiditic sandstones and conglomerates. At the bottom of marly levels, the first volcanic influx is a crystal tuff. After a thick, white-gray to grayish blue, thin bedded marls, the sequence continues with gray-brownish cream, thin-medium to thick bedded marl and argillaceous-arenaceous limestone alternation with significant brownish yellow, medium to thick bedded conglomerate to sandstone lenses and intercalations (Figure 29). The flysch sequence displays wavy bedding with flute casts, horizontal borings and trails, and conglomerate-sandstone lenses with rudist fragments . The sequence continues with black to dark green, massive-structureless turbiditic volcanigenic sandstones

which are intruded by the basaltic dykes trending in N60°E direction (Figure 31). The overlying brownish green, thin to medium bedded marl-siltstone alternation is also intruded by basaltic dykes . This part of the sequence is intensely folded (synsedimentary-gravity induced folding) (Figure 28,29,32). The topmost part of the sequence consists of brown-brownish green, medium to thick bedded siltstone to conglomerate and thin bedded siltstone-marl alternation in which the conglomerate lenses pinch out towards southeast and siltstones-marls are silicified. There is an quite increase in influx of volcanics with pyroclastics. At the top of the sequence, the marly levels are folded (synsedimentary folding) at the gradational contact of flysch sequence with volcanic rocks. Laterally and vertically the sequence grades into volcanic sequence to the W of Ziyaretköy (Figure 33, Plate 1). The Middle Campanian - Maastrichtian age is assigned to the flysch sequence in addition to the documented material in Koçyiğit et al. (1988). Identified fossil assemblage within the flysch sequence is Globotruncana bulloides, Glt. arca, Glt. linneana, Globotruncanita stuartiformis, Heterohelix globulosa, Calcispherula sp. and Globigerinelloides sp. The flysch sequence can be correlated with most of the Upper Cretaceous flysch sequences in the Pontide belt regardless of their geographic and tectonic setting (Ketin and Gümüş, 1963; Eroskay, 1965; Altınlı et al.,1970; Pelin, 1977; Yılmaz et al., 1981; Kaya et al.,1984; Akyürek et al., 1984;



Figure 31. General view of black turbiditic sandstones (sst) which are intruded by basaltic dykes (β) (Locality: SW of Tepesidelik hill).



Figure 32. General view of a large-scale slump fold within the flysch sequence of the Geyiközü Formation (Kkg). Note the horizontal attitude of bedding at the bottom and top of the folded part and fault (f) (Locality: SW of Tepesidelik hill, W of Amasya City).

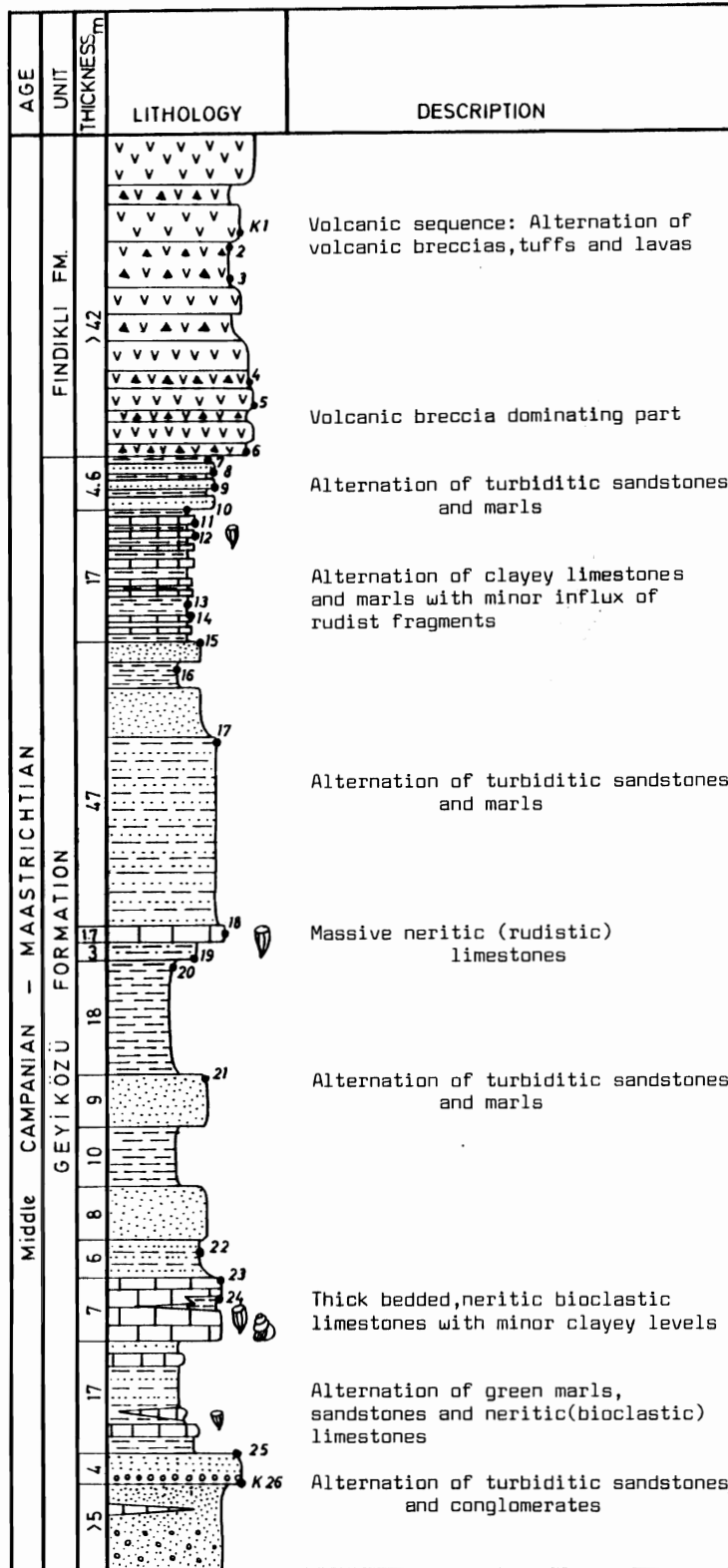


Figure 33. Measured stratigraphic columnar section showing different lithofacies of the Geyiközü Formation and its transitional contact relation with the Fındıklı Formation. Numbers indicate sample locations (Locality: Southern slope of Karşıbayır hill, W of Ziyaret village).

Gedik and Korkmaz, 1984; Genç et al., 1986; Rojay, 1985; Koçyiğit et al., 1988; Toprak, 1989; Okay et al., 1990; Dirik, 1991). However, the lithostratigraphic evolution of the Upper Cretaceous flysch sequences in the northern belt of the Pontides differ from the flysch sequence of the Geyiközü Formation (Ketin and Gümüş, 1963; Pelin, 1977; Gedik and Korkmaz, 1984; Kaya et al., 1984; Rojay, 1985). The flysch sequence of the Geyiközü Formation is correlative with the flysch sequences of Gümüşhacıköy-Osmancık area (personal field observation, 1987). The pelagic fauna, turbiditic accumulations, sequential stratigraphy, flute casts, horizontal borings and trails, huge gravity induced (syn-sedimentary) slump folds indicate a tectonically active, deep-sea depositional setting over an area extending from the continental slope to the edge of an "abbyssal" plain (Reading, 1980) where basaltic volcanism was active.

2.4.2. Fındıklı Formation (Kkf)

The Fındıklı Formation consists predominantly of andesitic-basaltic volcanic rocks and reefal-detrital carbonates. It was previously named as the Fındıklı Formation by Koçyiğit et al. (1988) in Amasya region. The Fındıklı Formation was divided into two members, namely the Karainiğdere and Kepeztepe members.

2.4.2.1. Karainiřdere member

Definition: The Karainiřdere member consists of volcanic rocks and their derivatives. Sections are measured along southern margin of Merzifon-Suluova plain and northern slopes of Tersakan river, along Karainiř creek (Figure 28). The member is informally named as Karainiřdere referring to Karainiř creek where the sequence is deeply dissected and well-exposed.

Stratigraphic Relations and Thickness: The Karainiřdere member has an extensive distribution from Osmancık to Tařova (Figure 2). It overlaps transgressively the Geyiközü Formation at various localities, e.g. N of Tepesidelik hill, N of Uęarmut hill, N of Oklukaya hill (Figure 28). The Karainiřdere member grades laterally and vertically into the Kıřlacık group. The Upper Jurassic to Lower Cretaceous carbonates (Amasya Group) are overthrust onto both the Geyiközü Formation and the Karainiřdere member, at the N of Oklukaya hill (Plate 1). The Upper Jurassic to Lower Cretaceous carbonates of the Amasya Group, recrystallized limestones and metamorphic rocks of the Tokat Complex are also present within the sequence as olistoliths (Figure 28,34, Plate 1).

Lithology: The unit consists predominantly of volcanic rocks and their derivatives. At the bottom, the Karainiřdere member begins with the alternation of violet to purple tuff, breccia and lava sequence (Figure 29,33). The

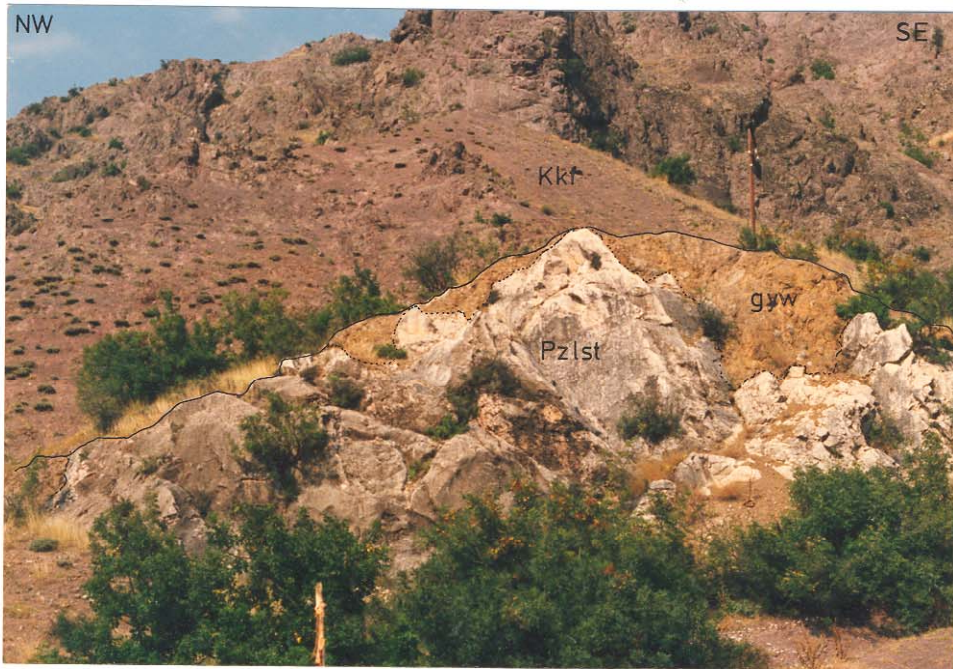


Figure 34. General view of an olistolith within the Fındıklı Formation (Kkf). Recrystallized limestone (Pzlst) formerly enclosed by graywackes (gyw) and lately, by volcanic breccias/conglomerates of the Fındıklı Formation (Locality: E of Fındıklı village, along the northern margin of the Tersakan river).

tuffs, lava flows and volcanic breccias are basaltic to alkali basaltic in composition. Tuffs are lithic to crystal and vitric in nature. Lithic to crystal tuffs consist of phenocrysts of pyroxene (diopsidic in composition), biotite, analcime, and lesser amounts of plagioclase phenocrysts with volcanic, pumice and crystal fragments set in a plagioclase-glassy groundmass. The vitric tuffs consist of phenocrysts of pyroxene, a few quartz and opaque minerals set in a groundmass of plagioclase-biotite-pyroxene microlites bearing glassy groundmass. Lavas are olivine basaltic lava flows consisting of olivine, bowlingite, and analcime phenocrysts set in a groundmass of devitrified glass-

plagioclase and analcime. Basaltic lava flows composed of pyroxene, biotite and zoned plagioclase phenocrysts set in a fine-grained groundmass of plagioclase microlites. Volcanic breccias have the same volcanic components with lithic to crystal tuffs. A volcanoclastic sequence, which is made up dominantly of volcanic conglomerates-breccias and tuffs, get rest upon the volcanic sequence. The conglomerates-breccias are violet to dark purple, massive, locally bedded and almost monogenetic (only volcanic fragments of the same source) (Figure 35). The volcanoclastic sequence is followed by basaltic volcanics and their derivatives. This part of the Karainidere member contains olistoliths of the Amasya Group and the Tokat Complex. In places, pillow lavas occur at different stratigraphic levels. Frequent lateral and vertical facies change between volcanic rocks and volcanoclastics, and mafic dyke intrusions (hornblende-gabbros and dolerites, biotite basalts) make the member much more complex.

Age, Correlation and Environmental Setting: The volcanoclastic parts of the Karainidere member contain Globotruncana fragments however could not be accurately dated. Due to the stratigraphic position of the member, Maastrichtian age can be assigned to the member. The member can be time-stratigraphic equivalent of most of the Upper Cretaceous volcanic member of flysch sequences in the Pontide belt regardless of their geographic and tectonic setting as previously mentioned. The member is equivalent of

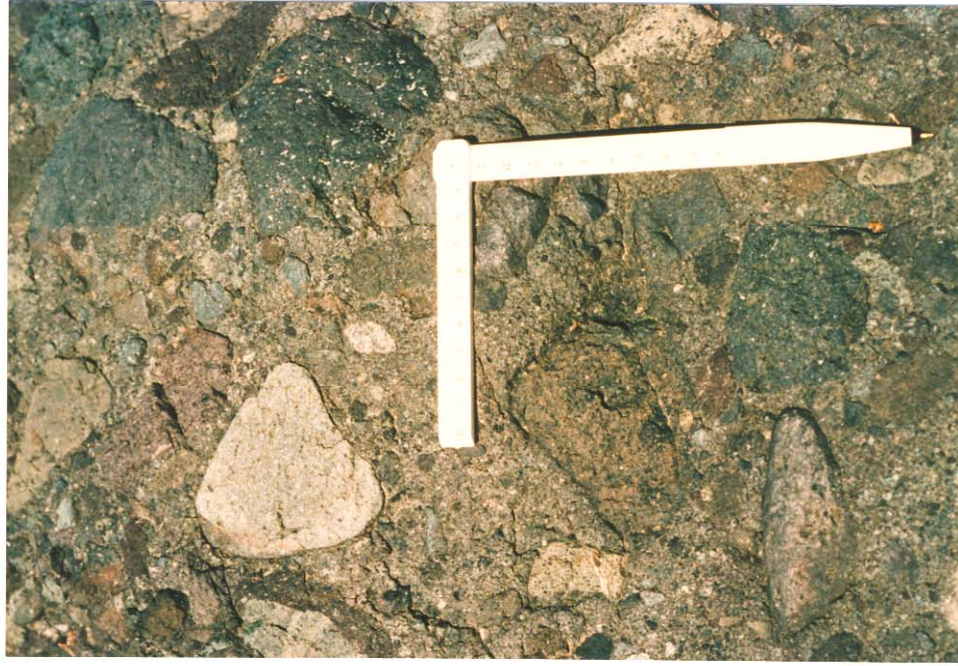


Figure 35. Close-up views of the volcanic breccias/conglomerates of the Karainişdere member of Fındıklı Formation (Kkf) (Locality: Karainiş creek, N of Amasya City).

the volcanic-volcaniclastic sequence exposing in the Osmancık-Gümüşhacıköy region. The pillow basalts which are alkali basaltic to basaltic in composition suggest an magmatic arc related, subaqueous environmental setting (Cas and Wright, 1988). Frequent lateral and vertical facies change in volcanic rocks, volcanoclastics and presence of huge olistoliths indicate a tectonically active margin .

2.4.2.2 Kepeztepe member .

Definition: The Kepeztepe member consists of rudistid limestones and their detritus, mixed with basaltic volcanics.

Stratigraphic Relations and Thickness: The Kepeztepe member has very limited autochthonous distribution in the study area around the Kepez hill (Figure 28). The Karainışdere member gradually passes to the Kepeztepe member. The thickness of the unit is 9 m.

Lithology: The Kepeztepe member consists predominantly of rudistid reefal limestones. At the bottom, the member starts with the alternation of arenaceous, biotrital limestones and volcanoclastics to volcanic rocks which grades upward to gray, medium to thick bedded, arenaceous rudistid limestones (arenaceous biosparites) (Figure 36).

Age, Correlation and Depositional Setting: The Maastrichtian age is assigned to the member with the

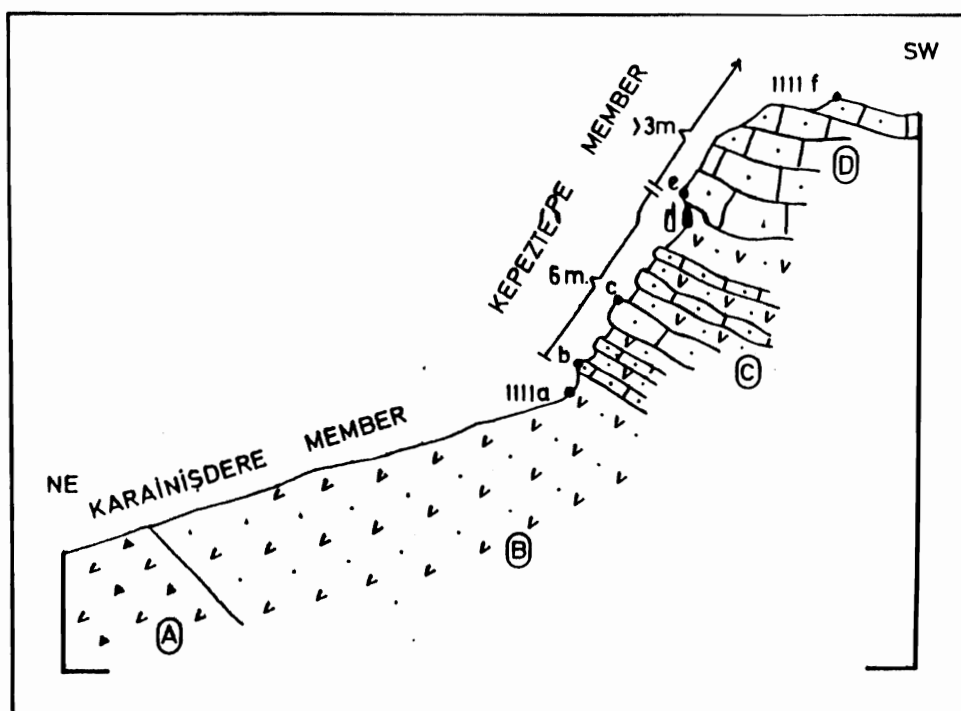


Figure 36. Sketch geological cross section of the Keppeztepe member showing transitional contact relation with the Karainişdere member. A. red to violet andesitic volcanics and their breccias, B. green, massive to thick bedded volcanigenic sandstones, C. alternation of gray, medium to thick bedded arenaceous-biotrital rudistic limestones and green, massive volcanigenic sandstones, D. gray, massive to thick bedded arenaceous-biotrital rudistic limestone. Numbers indicate sample locations (Locality: Measured section H in figure 28, NE of Fındıklı village).

following fossil assemblage Siderolites calcitraphoides, Orbitoides sp., Orbitoides hottingeri(?), Lepidorbitoides sp. (L. socialis (?)), Rotalia sp., Calcisphaerulidae, rudist, crinoid, echinoid, red algae and coral fragments. This locally developed "reef" can be time-stratigraphic equivalent of some of the rudistid build-ups in the region. The fauna, detrital character and sparry calcite cement indicate an active, shallow marine depositional setting, which is a reefal build-up due to the presence of in situ rudist fauna, red algae and corals. The stratified part, which alternates with volcanoclastic rocks may be the biostromal section of the reefal build-up.

2.5. Kışlacık group (KTK)

The group consists of various lithologies and sequences in a disordered stratigraphic manner. The dominant lithologies incorporated to this disordered system are basaltic volcanic rocks and their derivatives, rudistid limestones, shallow marine to lagoonal deposits and olistostromal masses with Cretaceous pelagic carbonate, metamorphic and rudistid limestone olistoliths. As a whole, the Kışlacık group displays both lateral and vertical gradational boundary relations with the Fındıklı Formation, and is subdivided into six lithostratigraphic units at the rank of formation, namely, the Tuzlugersin, Çoraklıağzı, Kulunun, Kaletepe, Susuz and Tepetarla formations .

2.5.1. Tuzlugersin formation (Kkt)

Definition, Stratigraphic Relations and Thickness: The formation consists of two transgressive cycles of clastics to neritic carbonates. It crops out only to the N of Tuzlugersin ridge where the Tuzlugersin formation overlies Cretaceous pelagic limestones with an unconformity and grades into the Fındıklı Formation (Figure 28,37). The measured thickness of the formation is 212 m along Değirmen creek.

Lithology and Type Section: In the type section, the formation begins with red, massive, polygenetic

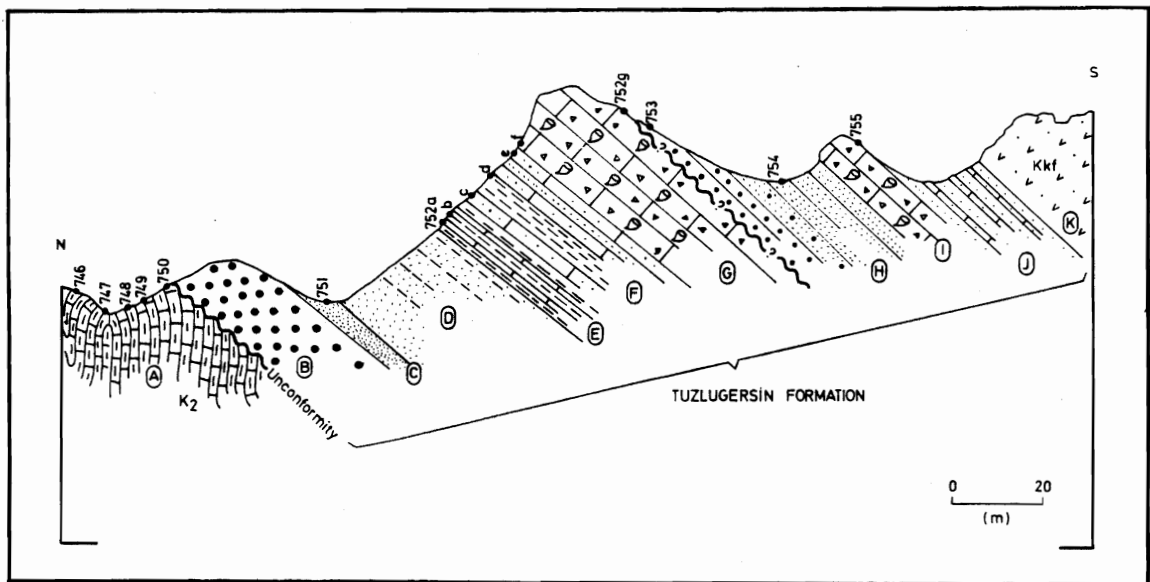


Figure 37. Sketch geological cross section of the Tuzlugersin formation showing measured type section. A.intensely folded, argillaceous limestone-cherty limestone-radiolarite and marl alternation (K2), B.red, rounded to subrounded, heterogeneous, poorly sorted, structureless conglomerates, C.green, coarse sandstones, D.red, volcanigenic sandstone-siltstone-dark gray marl alternation, E.dark gray, thin to thick bedded marl dominating, marl-argillaceous limestone sequence, F.dark gray to green, arenaceous to bioclastic limestone sequence, G.yellow to cream, thick bedded to massive, arenaceous rudistic limestone to biocalciturbiditic limestone, H.red to brownish yellow, medium to thick bedded conglomerate to sandstone alternation, I.massive arenaceous to bioclastic limestone, J.alternation of gray to beige, yellow medium bedded sandstone-marl and gray, medium bedded arenaceous rudistic limestones, K.light gray to purple, andesitic breccias of the Fındıklı Formation (Kkf). Numbers indicate sample locations (Locality: N of Tuzlugersin ridge, along Değirmen creek, measured section C in figure 28).

conglomerates and green, massive, coarse sandstones (Figure 37). The red to green clastic rocks are made up of rounded to subrounded, poorly sorted and heterogeneous, polygenetic clasts derived dominantly from mafic volcanic rocks and Cretaceous limestones. The clastic rocks continue with the alternation of red, thin to thick bedded volcanigenic sandstone, siltstone and dark gray to green, thin bedded marl, and grade upward into a sequence of yellowish green to gray limestone-marl alternation (Figure 37). Marls dominate the bottom of the sequence and grade into limestones. The marl-dominating part consists of dark gray, thin to thick bedded argillaceous limestones and dark green to green, thin bedded marls. The limestone-dominating part consists of dark gray, bioclastic arenaceous limestones, dark gray, turbiditic argillaceous limestones and green sandstone to bioclastic limestones with marly levels (Figure 37). The sequence grades into yellow to cream, thick to massive arenaceous limestone to biocalciturbiditic limestone (Figure 38). With a probable discontinuity, the sequence continues upwards with red, medium to thick bedded conglomerates with minor calcareous sandstone levels. This second transgressive cycle also continues with massive, bioclastic, arenaceous (volcanic grains dominant) limestones and alternation of yellow sandstone-marl with rudistid limestone beds. The gray to beige, yellow, medium bedded sandstones are rich in volcanic influx. The overlying gray, medium bedded arenaceous



Figure 38. Close-up view of rudistid limestone of the Tuzlugersin formation of Kışlacık group. ru.rudists, sp.cc. arenaceous sparitic groundmass (Locality: NE of Tuzlugersin ridge, along Değirmen creek).

limestones are rich in rudist fragments and grades into the volcanics of the Fındıklı Formation (Figure 37).

2.5.2. Çoraklıağzı formation (Kkç).

Definition, Stratigraphic Relations and Thickness:
The formation consists dominantly of red to yellow clastic rocks with rudistid masses and crops out to the S and W of Kışlacık village, along the Acıkiraz and Kadrak creeks and along the southern slopes of the Çoraklıağzı hill (Figure 28,39). The measured thickness of the formation is over 378 m along the Çoraklıağzı hill section.



Figure 39. General view of the Çoraklıağzı formation (Kkç) showing the transitional contact with the Tepetarla formation (Kkt). ru.rudistid limestone horizon (Locality: Kadrak creek, S of Kışlacık village).

Lithology and Type Section: At its type locality, the formation begins with red clastic rocks and continues upward with the alternation of red and yellow clastic rocks (Figure 40). Red clastic rocks (sandstone-siltstone alternation with conglomerate lenses) are made up of rounded to subangular, sorted and polygenetic clasts of radiolarites (Fe-enriched and different than Cretaceous radiolarites), mafic volcanic rocks, Cretaceous limestones, less metamorphic rocks and cherts, and remnants of pyroxene, plagioclase and quartz crystals embedded in a Fe-stained argillaceous matrix. Yellow to brownish orange clastic rocks (dominantly sandstones and conglomerates) are made up of rounded to subangular, sorted and polygenetic clasts of metamorphic

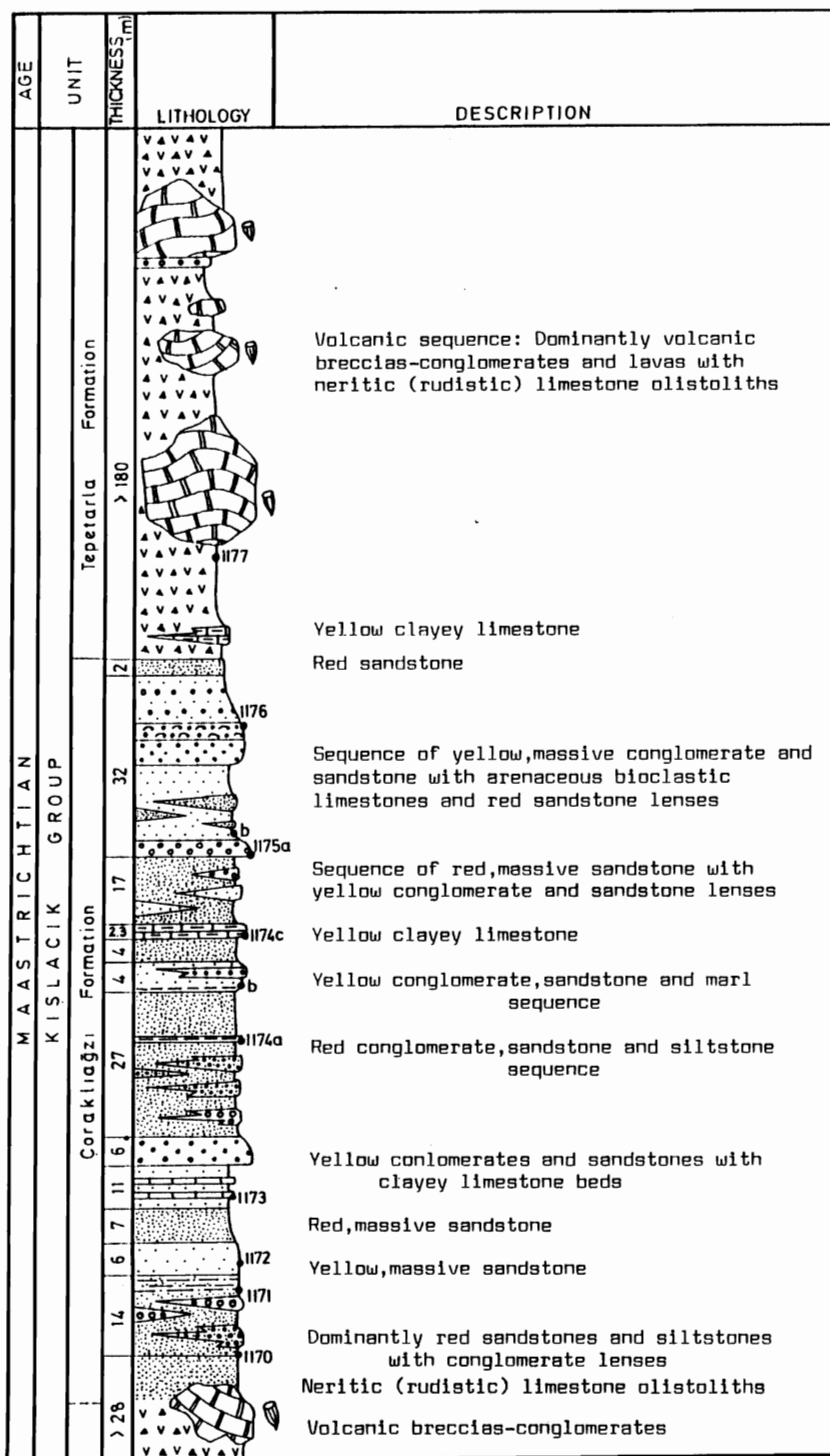


Figure 40. Measured stratigraphic columnar section of the Çoraklıağzı formation showing its transitional contact relation with the Tepetarla formation. Numbers indicate sample location (Locality: Measured section E in figure 28, W of Kışlacık village).

rocks (graphitic and green schists), marbles and cherts embedded in a blocky sparry calcite and dolomite groundmass. The Çoraklıağzı formation contains argillaceous limestone, bioclastic arenaceous limestone, vitric tuff and marl beds at different stratigraphic levels (Figure 40). The top of the formation consists of basaltic volcanic rocks displaying a matrix/block relation with the rudistid limestone olistoliths (Figure 28,40). Stratigraphically above this blocky level , another clastic sequence alternating with rudistid, arenaceous limestones crops out (Figure 41). This sequence has some probable discontinuity surfaces manifested by the presence of Fe-oxidation surfaces (Figure 41). At the topmost, the Çoraklıağzı formation terminates with the basaltic to andesitic volcanic rocks composed of hornblende, pyroxene and plagioclase phenocrysts embedded in a groundmass of plagioclase microlites and dusted opaque minerals.

2.5.3. Kulunun formation (Kkk)

The formation consists of yellow to orange, medium to thick bedded, arenaceous rudistid limestones (arenaceous bioclastic sparites) resting on the top and within the volcanic rocks to the N of Kışlacık village, along the Kulunun hill (Figure 28). The limestone masses reach up to 85 meters. Some of these masses occur as olistoliths within the volcanic sequence.

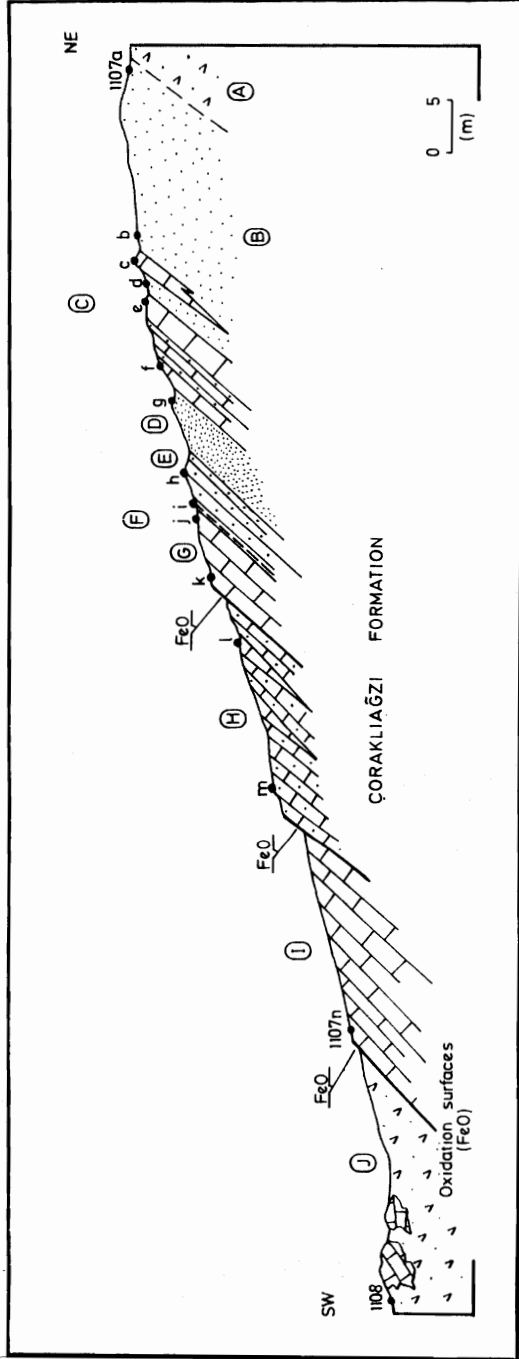


Figure 41. Sketch geological cross section depicting the top part of the Çoraklıağzı formation. A. andesitic volcanics, B. brownish yellow, medium to thick bedded sandstone-siltstone sequence with biotrital limestone lenses, C. brownish yellow, medium to thick bedded calcareous sandstone-rudistic limestone sequence, D. red, volcanic sandstone-conglomerate sequence, E. yellow fossiliferous sandstone, F. green marl, G. yellowish to gray, medium to thick bedded rudistic limestone, H. yellowish brown, medium to thick bedded arenaceous limestone with rudistic limestone lenses, I. gray, thick to medium bedded detrital limestone, J. andesitic volcanic breccias and volcanics with rudistic limestone olistoliths. Numbers indicate sample locations (Locality: Measured section F in figure 28, SW of Kışlacık village).

2.5.4. Kaletepe formation (Kkka).

Definition, Stratigraphic Relations and Thickness:
The formation consists predominantly of green, grayish green to red, sandstone, conglomerate and marl alternation, and crops out to the NE of Kışlacık village and S of Değirmendere village (Figure 28). The measured thickness of the formation is over 142 m.

Lithology and Section: The Kaletepe formation begins with a coarsening upward sequence of sandstones to conglomerates in the Keşkel creek measured section (Figure 42). The sequence continues with red to green, structureless polygenetic conglomerates. The conglomerates are made up of rounded to subangular clasts of Cretaceous platform and pelagic limestones, radiolarites, green marls and mafic volcanic rocks. The rest of the sequence consists of red sandstones and marls displaying a fining upward sequence (Figure 42). Flute casts are observed in this sequence to the S of Değirmendere village.

2.5.5. Susuz formation (Kks)

The formation consists mainly of orange to yellowish brown, structureless and massive conglomerates. It is well-exposed around Kışlacık and Değirmendere villages (Figure 28). These polygenetic conglomerates are made up of angular to subrounded, metamorphic rock (graphitic and green schists), chert, quartz, radiolarite, volcanic rock,

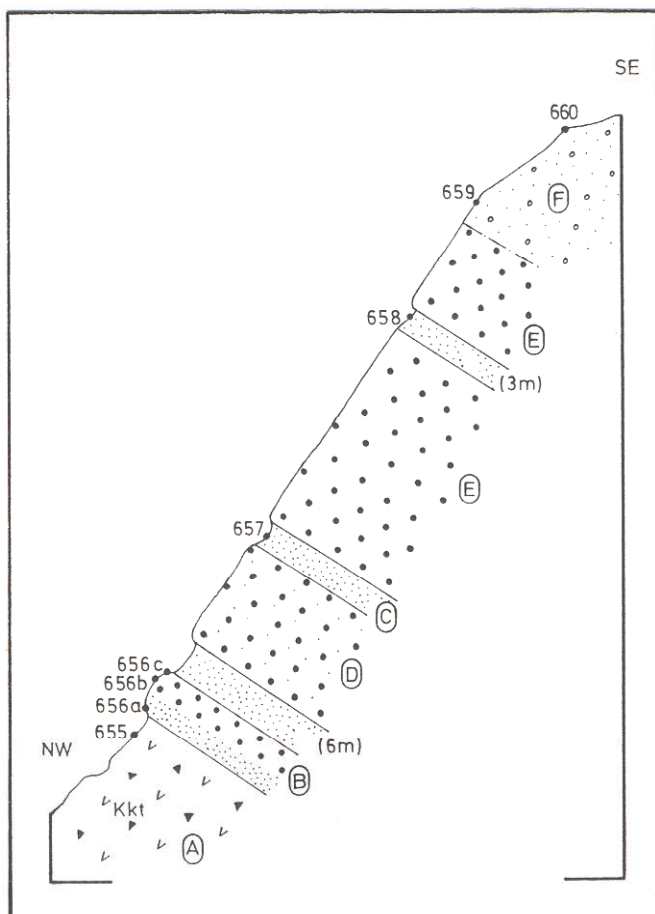


Figure 42. Sketch geological cross section of the Kaletepe formation. A.purple, andesitic volcanic breccias of the Tepetarla formation (Kkt), B.coarsening upward sequence of green sandstone to green-red conglomerate with sandstone lenses, C.red, marl-siltstone sequence, D.green-red,conglomerate with sandstone lenses, E.green to red, massive conglomerate, F.fining upward sequence of yellowish brown structureless conglomerate with sandstone-siltstone beds. Numbers indicate sample locations (Locality: Measured section J in figure 28,E of Kışlacık village).

recrystallized limestone and Cretaceous limestone clasts embedded in an arenaceous matrix. However, the dominant components are schist, quartz and recrystallized limestones fragments where in places, these conglomerates are grain supported.

2.5.6. Tepetarla formation (KTkt)

Definition and Stratigraphic Relations: It is composed of subaqueous basaltic volcanic rocks and their derivatives. It is very hard to differentiate the Tepetarla formation from the Fındıklı Formation on the basis of field appearance, volcanic structures and compositional variations. The formation displays somewhat a matrix relation with all the other formations of the Kışlacık group (Figure 28,43).

Lithology: The sequence characterizing the Tepetarla formation consists of violet to purple, pillow lavas, volcanic breccias, tuffs and volcanoclastics, in which the dominant lithology is the volcanic breccias resulting of mixture of two magmas. The volcanic breccias are composed of clinopyroxene (aegerine) and sanidine crystals, pumice, trachytic volcanic, mafic volcanic and monzodioritic rock fragments embedded in a matrix of devitrified glass carrying fine grained plagioclase microliths. The pillow lavas are made up of titan augite phenocrysts embedded in opaque minerals, albitic microliths and chlorite spherules bearing groundmass. The amygdules are filled with calcite, chlorite



Figure 43. General view of olistoliths within the Tepetarla formation (Kkt). Klst. arenaceous, biotrital rudistid limestone (Locality: NW of Kışlacık village).

and zeolite minerals. These spilitic basalts are widespread within the Tepetarla formation . The formation contains abundantly red clastics which are made up of volcanic rock fragments and remnants of pyroxene, plagioclase, quartz, sanidine and biotite crystals embedded in an argillaceous to arenaceous matrix.

2.5.7. Age, Correlation and Depositional Setting of the Kışlacık group:

The Maastrichtian age is assigned to the Kışlacık group based on fossil assemblages obtained from its different stratigraphic levels. These fossils are: Orbitoides sp., primitive Orbitoides (O. hottingeri), Eponides sp., Goupillaudina sp., Heterohelix sp.,

Lepidorbitoides sp., Montcharmontia sp., Calcisphaerulidae and rudist fragments . The group can be chronostratigraphic and partially lithostratigraphic equivalent of the Osmancık-Gümüşhacıköy Upper Cretaceous "flysch sequence". The Tuzlugersin formation was deposited in a "fan delta" to "reefal" environmental setting during two cyclic depositional period. The Çoraklıağzı formation was deposited in a terrestrial to reefal environmental setting. During its deposition , the sea level fluctuated frequently and the area was uplifted and fed from a metamorphic terrain and a volcanic source located nearby the basin . The Tepetarla formation indicates a subaqueous volcanic setting (Cas and Wright, 1988). The Kulunun formation was built up in a reefal depositional setting indicated by the presence insitu rudists. The Kaletepe formation was deposited in a deep marine environment as a flysch sequence indicated by the flute casts and turbiditic sandstones (Selley, 1980; Reineck and Singh, 1975). The Susuz formation is a typical olistostrome resulted from the underwater mass-wasting processes indicated by the gross layering and its close relations with the olistoliths (Abbate et al., 1970; Hoedemaeker, 1973). As a whole, the Kışlacık group was deposited in a tectonically active basin fed from metamorphic and volcanic terrains from which various olistoliths were transported to the basin by the gravity forces and volcanic activities. Sudden vertical and lateral

facies change indicate a sudden fluctuation in sea level and a change in supplying material source.

2.6. Cindere group (Tc)

The group consists of various lithostratigraphic sequences at different localities. However, the generalized sequence of the group consists predominantly of red conglomerates, carbonates and "flysch" sequence. It was initially named as Cin Formation (Koçyiğit and Rojay,1988) and renamed as the Cindere group in this study, based on the type section measured along the Cin creek, N of Gödeles village (Figure 44). The Eocene Cindere group was divided into three units, namely the Kızıldere, Çaltepe and Suludere formations (Figure 45).

2.6.1. Kızıldere formation (Tck)

Definition: It consists predominantly of continental red conglomerates and sandstones. The Kızıldere formation was named referring to its type locality where it has extensive distribution and displays a significant contact relations with the other units to the NE of Yuvala village, along Kızıl creek (Plate 1).

Stratigraphic Relations and Thickness: The Kızıldere formation has an extensive distribution from Alişar village in the west to Taşlıyurt village in the east (Plate 1). It overlies unconformably the Tokat Complex (Pzt) and the Amasya Group (JKa) (e.g. at Kızıl creek, Cin creek)

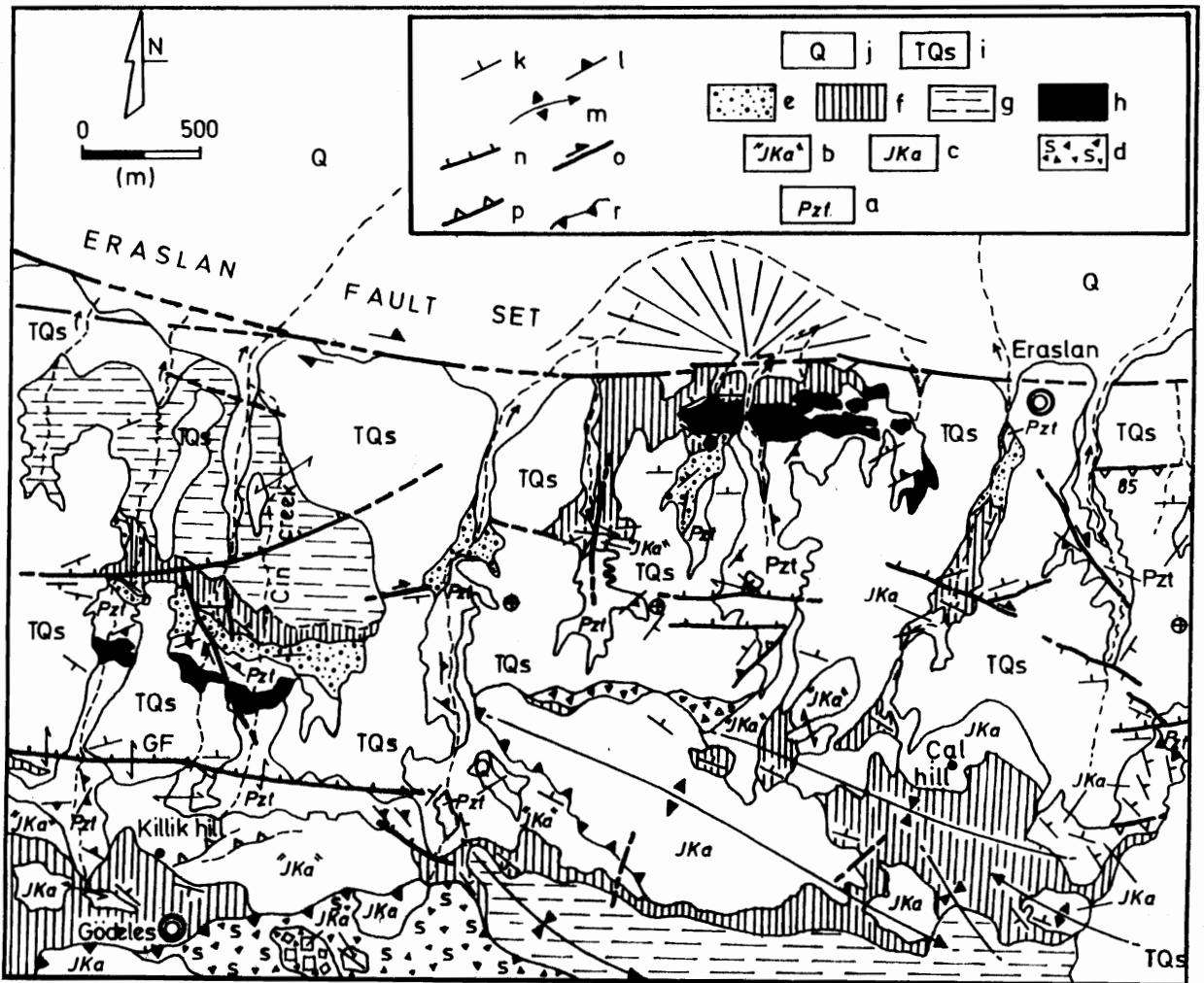


Figure 44. Geological map showing the distribution of the Cindere group and their contact relations with the North Anatolian Ophiolitic Melange (NAOM) and the Moramıl dacite. a. Tokat Complex (Pzt), b. Amasya Group equivalent rocks ("JKa"), c. Amasya Group (JKa), d. NAOM, e. Kızildere formation (Tck), f. Çaltepe formation (Tcç), g. Suludere formation (Tcs), h. Moramıl dacite (Tm), i. Suluova group (TQs), j. Holocene deposits, k. attitude of bedding plane, l. schistosity plane, m. folds confined to the Cindere group, n. oblique fault, o. strike slip fault, p. reverse fault, r. overthrust, GF. Gödeles fault (Locality: Inset map 28 in Plate 1).

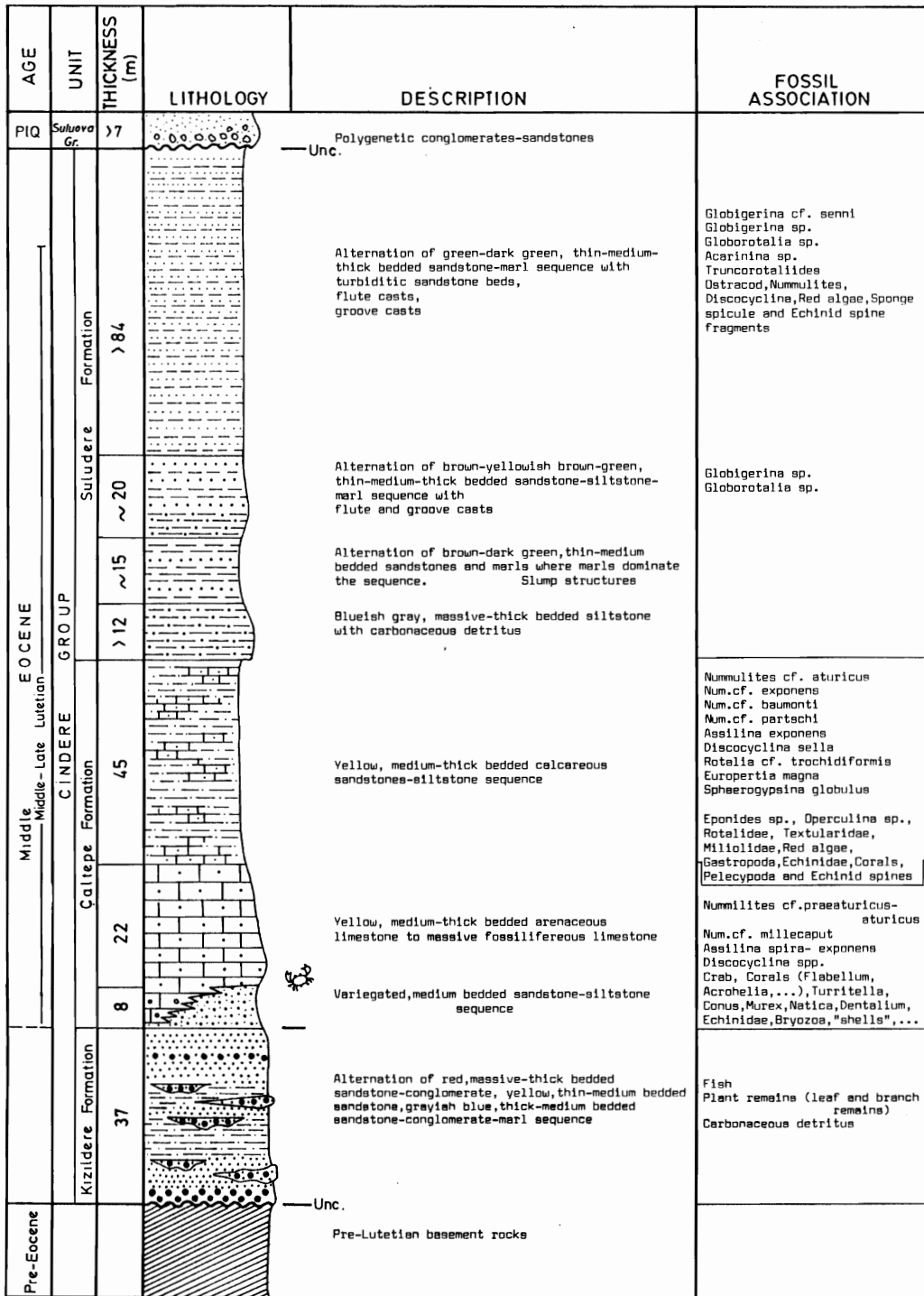


Figure 45. Composite stratigraphical columnar section of the Cindere group. PIQ. Plio-Quaternary, Unc. Unconformity (Locality: Measured sections from NE of Yuvala and N of Gödeles villages).

(Figure.44,46,47). At the top,the formation grades upward into calcareous sandstones to arenaceous limestones of the Çaltepe formation (Cindere section) and is thrust by the Amasya Group and the Suludere formation. In addition,it is intruded by the Moraml dacite (Figure 48). The maximum thickness of the formation is around 75 m.

Lithology and Type Section: The type section of the Kızıldere formation was measured along Kızıl creek where the sequence consist predominantly of red to yellowish clastic rocks (Figure 49,50). The Kızıldere formation is composed of red, massive to thick bedded, subangular to rounded,heterogeneous clast-rich conglomerates and sandstones in the lower part of the type section. Conglomerates are rich in metamorphic fragments. This part is followed by yellow, medium to thin bedded sandstones with conglomerate lobes and lenses (Figure 50). Conglomeratic sequence contains sandstone concretions (nodules). Above this level, a gray, medium to thin bedded, irregularly bedded conglomerate-marl-sandstone-siltstone alternation is exposed including fish, leaf and root remains (Figure 50,51) and sandstone concretions. Towards the top, it continues with repetition of the previously mentioned lithologies. At the topmost of the sequence, yellow, thick to medium bedded conglomerates and calcareous sandstones grade into yellow, thick to medium bedded nummulitic, arenaceous limestones of the Çaltepe formation (Figure 50).

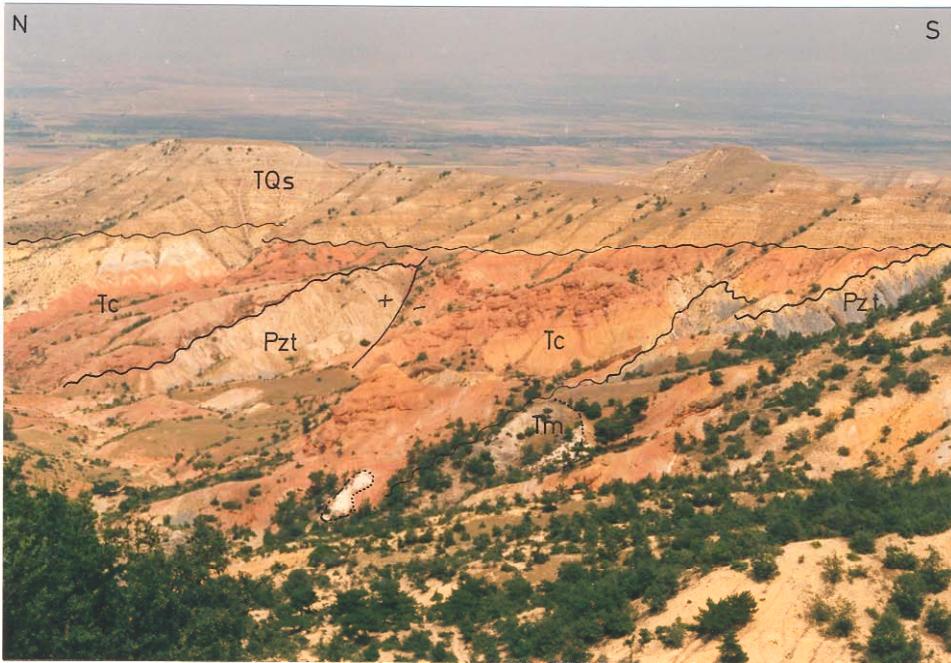


Figure 46. General view of the unconformity planes between the Cindere group (Tc) and the Tokat Complex (Pzt), and between the Cindere group and the Suluova group (TQs). Note the dacitic intrusions (Tm: Moramil dacite) (Locality: along Kızıl creek, NE of Yuvala village).



Figure 47. Close-up view of the nonconformity between the Kızıldere formation (Tck) and the Tokat Complex (Pzt). Note small scale faults (f) (Locality: along Kızıl creek, NE of Yuvala village).



Figure 48. General view of the Moramıl dacite (Tm) intruded into the Kızildere formation (Tck). Note the disturbed beds of the Kızildere formation at the contact and the Tokat Complex (Pzt) (Locality: far NNE of Alabedir village).



Figure 49. General view of the Kızildere formation (Tck), unconformably overlying the Tokat Complex (Pzt) at the base and transgressively grades upward to the Çaltepe formation (Tcc) at the top. f. small-scale fault (Locality: Kızıl creek, NE of Yuvala village where type section is measured).

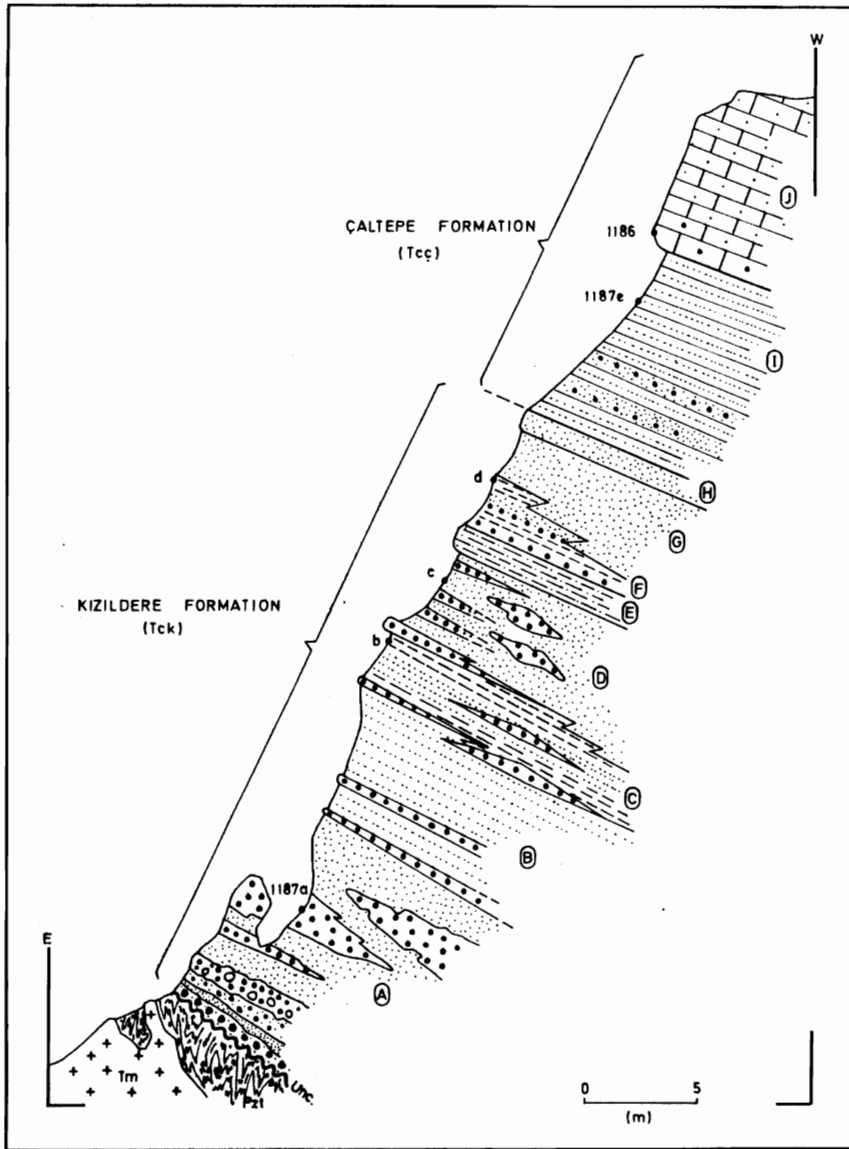


Figure 50. Sketch geological cross section showing the transitional contact between the Kizildere and Çaltepe formations. A.red, massive to thick bedded conglomerate-sandstone sequence with conglomerate lobes, B.yellow-orange, medium to thick bedded sandstone-conglomerate sequence with sandstone "nodules", C.gray, medium to thin bedded sandstone-siltstone-marl sequence with conglomerate lobes (fish, leaf and plant root fragments), D.yellow, medium to thick bedded sandstone-conglomerate sequence with conglomerate lobes, E.red siltstones, F.gray, thick to medium bedded conglomerate-sandstone-marl alternation, G.red sandstones, H.gray sandstone, I.yellow, thick to medium bedded calcareous sandstones with conglomerate beds, J.yellow, thick to medium bedded arenaceous nummulitic limestones rich in gastropods and echinids, Pzt.Tokat Complex, Tm.Moramıl dacite, Unc.Unconformity. Numbers indicate sample locations (Locality: Western slope of Kızıl creek, N of Yuvala village).



Figure 51. Close-up view of a fish fossil (f) within the Kızıldere formation (Locality: Kızıl creek, 600 m NE of Yuvala village).

Age, Correlation and Depositional Setting: Except for the fish, leaf and root remains, the clastic rocks are barren. However, the stratigraphic relations with the other units indicate that the Kızıldere formation is younger than Maastrichtian and older or coeval with the Çaltepe formation of Lutetian age. The time and lithologically correlative equivalents of the Kızıldere formation are very widespread in Pontides (Blumenthal, 1950; Alp, 1972; Seymen, 1975; Öztürk, 1979; Terlemez and Yılmaz, 1980; Şenalp, 1981; Tutkun and İnan, 1982; Özcan et al., 1985; Dirik, 1991). Color, faunal assemblage and lithologies suggest a continental environment. The coarse clastics and their red color indicate a highly oxidizing depositional environment with

temperature controlled at low latitudes (Pettijohn, 1975). The gray to black color, organic material, root, leaf and fish remains indicate a moderately anaerobic lacustrine depositional setting (Pettijohn, 1975; Reading, 1982). The conglomeratic lobes or lenses indicate a fluvial depositional environment (Reading, 1982).

2.6.2.Çaltepe formation (Tcç)

Definition: The Çaltepe formation consists predominantly of shallow marine carbonates. The Çalhill is the type locality where the formation is well and extensively exposed (Figure 44).

Stratigraphic Relations and Thickness: The Çaltepe formation is exposed in the area between Alişar village to the west and N of Kışlacık village to the east (Plate 1). The Çaltepe formation displays a transgressive and conformable boundary relations with the underlying Kızıldere formation, and grades upward into yellow, medium bedded sandstones and siltstones of the Suludere formation. Due to the overlapping and transgressive boundary relations, the Çaltepe formation displays various stratigraphic relations with the underlying pre-Eocene units (Figure 52). The formation is thrust by the Amasya Group and Tokat Complex along the S of Tüllüçal hill-Yassıçal ridge line and NE of Aruçak village. The Çaltepe formation is also typically intruded by the Moramıl dacite to the W of Eraslan village

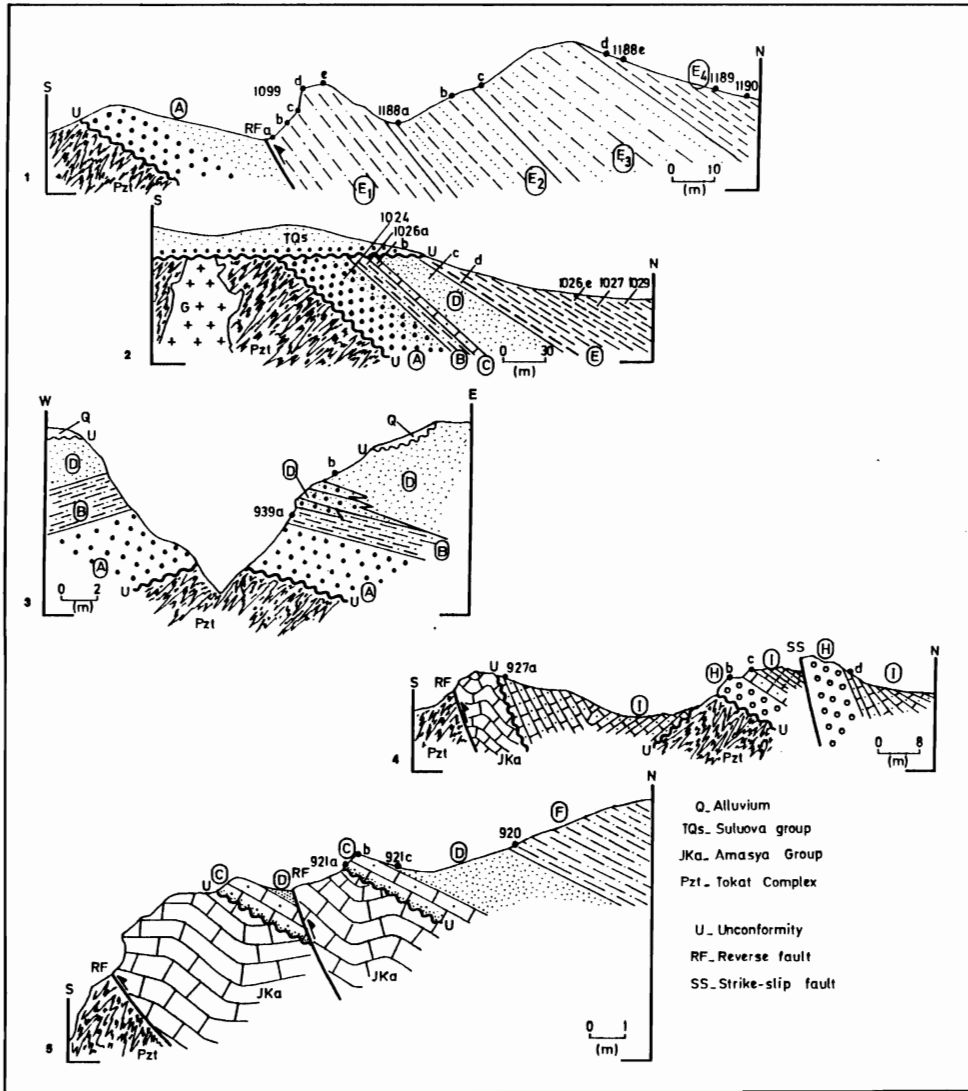


Figure 52. Sketch geological cross sections illustrating vertical and lateral facies changes in the Cindere group at different localities: 1.Kızıldere, 2.Cindere, 3.Arucak, 4.Harapköy and Alabedir sections. A.red,massive structureless polygenetic conglomerate-sandstone sequence, B.variegated,medium bedded sandstone-siltstone sequence with gypsum and carbonaceous material and rich in Nummulites and gastropods, C.yellow,medium bedded nummulitic, arenaceous limestone, D.yellow,medium bedded sandstone-siltstone sequence with conglomerate lenses and arenaceous limestones, E.grayish blue to green,thick to thin bedded marl-sandstone sequence, E1.blueish gray,thick bedded siltstones with carbonaceous material, E2.brown to dark green,thin to medium bedded sandstone-marl dominating sequence, E3.brown-green-yellowish brown,thin to thick bedded sandstone-marl alternating sequence where sandstones dominate, E4.green to dark green,thin to medium bedded sandstone-marl sequence with flute casts, F.white-light green, thin to medium bedded sandstone-marl sequence with conglomerate beds, G.Moramıl dacite, H.reddish-white, mono- to polygenetic breccias to conglomerates, I.yellow,medium to thick bedded arenaceous nummulitic limestones. Numbers indicate sample locations.

(Figure 44). The measured thickness of the Çaltepe formation is about 30 m along the Cindere section.

Lithology: The Çaltepe formation consists dominantly of calcareous sandstones and arenaceous limestones. The yellow, medium to thick bedded nummulitic calcareous sandstones of the formation grades upwards into yellow, medium to thick bedded arenaceous limestones (fossiliferous grainstone or arenaceous biosparites). The arenaceous biosparites to biosparites are rich in Nummulites, corals, echinids and gastropods with quartz and rock fragments (Figure 53).

Age, Correlation and Depositional Setting: The Middle-Late Lutetian age is assigned to the formation based on the following fossil assemblages; Middle Lutetian age with Nummulites millecaput (A and B forms where B forms dominates), Num. cf. millecaput (B form), Num. praeaturicus (B forms), Assilina spira (A and B forms) and Discocyclina spp.; Middle-Late Lutetian age with Nummulites cf. praeaturicus-aturicus transitional forms, Num. cf. millecaput (a few B forms) and Assilina spira-exponens transitional forms; Late Lutetian age with Nummulites cf. aturicus (A and B forms), Num. cf. exponens and Discocyclina sella group forms. From various lithostratigraphically equivalent levels, Nummulites cf. baumonti (A form), Num. cf. partschi, Assilina exponens, Sphaerogypsina globulus, Europertia magna, Europertia sp.,

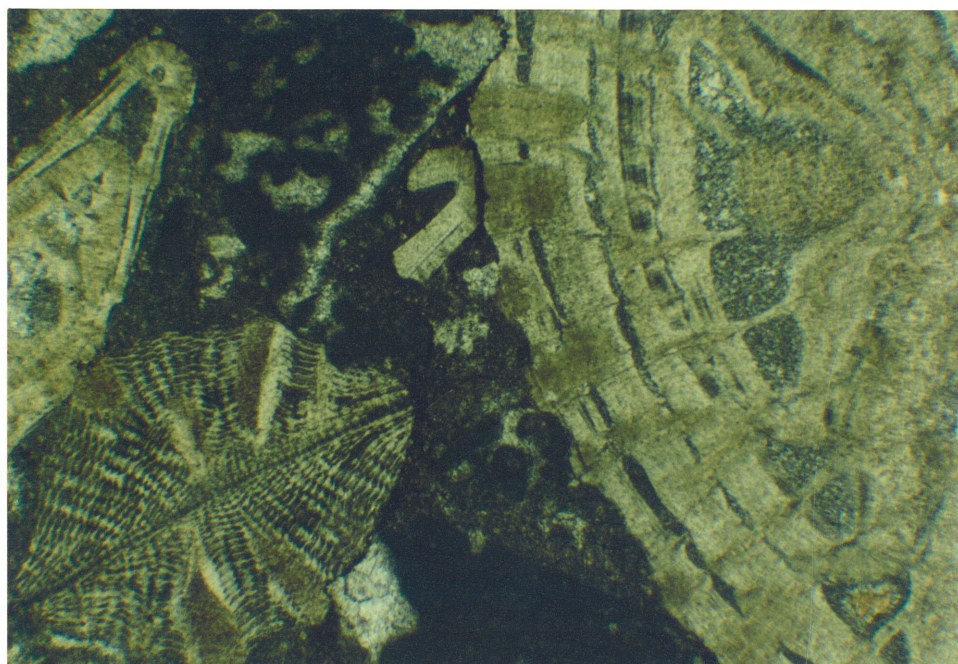


Figure 53. Photomicrograph of the Çaltepe formation. Fossils (Nummulites (n), Discocyclina (d) and algae (a)) are embedded in a sparry calcite cement (Sample No: 1186, X 50).

Eponides sp., Operculina sp., Rotalia cf. trochidiformis, Gypsina sp., Textularidae, Rotalidae, Miliolidae, Echinid spines, Lamellibranchiata and red algae fragments are recorded within the arenaceous limestones. A crab probably belong to section Brachyrhyncha of infraorder Brachyura (Glaessner in Moore, 1969) is recorded and dated to be Middle-Late Lutetian by correlating with the above foraminiferal fauna. Cementation of fragmental material (rock and fossil fragments) with sparry calcite indicates a high energy environment (Irwin, 1965). The presence of shallow marine benthic fauna with corals, crab, echinids and gastropods support a shallow marine depositional setting of back reef to reef (Glaessner in Moore, 1969; Hottinger,

1973; Selley,1980). The Çaltepe formation is correlative with the Eocene carbonates exposing in the region on the basis of lithology and age (Blumenthal, 1950; Alp, 1972; Seymen, 1975; Pelin, 1977; Öztürk, 1979; Terlemez and Yılmaz, 1980; Şenalp, 1981; Tutkun and Inan, 1982; Özcan et al, 1985; Toprak, 1989; and Rojay,1985).

2.6.3. Suludere formation (Tcs)

Definition: The Suludere formation consists predominantly of marl-sandstone alternation. It was named as the Suludere formation based on the type locality, namely Sulu creek, where the formation is well-exposed and has a considerable amount of thickness to the W of Yuvala village (Plate 1).

Stratigraphic Relations and Thickness: The Suludere formation displays various bottom relations with the underlying units. It has a transgressive and conformable contact relations with the underlying Çaltepe formation. However, the Suludere formation overlaps unconformably the pre-Eocene rocks, and is overlain unconformably by the Plio-Quaternary Suluova Group with an angular unconformity. In addition, the NAOM and Tokat Complex is overthrust onto the Suludere formation at various localities such as N of Kürtler village, S of Taşlıyurt and Alabedir villages, W of Arucak village, Gödeles village and S of Yuvala village (Figure 44,52, Plate 1).The thickness of the formation is over 176 m.

Lithology: The Suludere formation begins with a yellow, medium to thick bedded calcareous sandstones and siltstones at the bottom and grades upwards into blueish gray, massive to thick bedded siltstones (Figure 45). Siltstones are rich in organic material. In the alternation of brown-dark green, thin to medium bedded sandstones and marls, the dark green marls dominate the sequence. This sequence is followed by the alternation of brown-yellowish brown to green, medium to thick bedded sandstones, siltstones and green, thin bedded marls with flute and groove casts and slump structures (Figure.45,52,54). The sandstones and siltstones are turbiditic in character. Towards top, the formation continues with thick, almost uniform sequence of green-dark green, thin-medium to thick bedded sandstone-marl alternation with turbiditic sandstones and siltstones with flute and groove casts (Figure 52).

Age, Correlation and Depositional Setting: The Middle-Late Lutetian age is assigned to the Suludere formation based on the following fossil assemblages; Globigerina cf. senni, Globigerina sp., Globorotalia sp., Acarinina sp., Truncorotalides, Ostracoda, Nummulites, Discocyclina with red algae fragments, echinid spines and sponge spicules. Disregarding the stratigraphic relations, lithostratigraphy and tectonic position, the Suludere formation can be equivalent with the Eocene flysch sequences in the Central Anatolia Region (Ankara-Çorum-Çankırı), Tokat and eastern Pontides (Blumenthal, 1950; Alp, 1972; Seymen,

1975; Öztürk, 1979; Terlemez and Yılmaz, 1980; Şenalp, 1981; Tutkun and İnan, 1982; Özcan et al, 1985; Koçyiğit and Tokay,1985; Rojay, 1985; Toprak,1988; Bozkurt,1990; Dirik, 1991).The planktonic fauna, dark green color, turbidites, flute and groove casts and slump structures indicate a deep-sea pelagic depositional setting (slope to edge of the slope).



Figure 54. Close-up view of a slump structure (syndimentary folding) developed in the Suludere formation (Tcs). Note the horizontal attitude of beds at the bottom and top of the folded part (Locality: along Kızıl creek, NE of Yuvala village).

2.7. Moramıl dacite (Tcm)

Definition: The acidic rocks of dacitic composition were named as the Moramıl dacite based on the type locality, namely Moramıl village, where it is widely and well-exposed.

Distribution and Geologic Relations: The Moramıl dacite has a very extensive, E-W trending linear distribution from N of Kırklar mountain to the east to Yuvala village to the west (Plate 1). It shows a cross-cutting relation with various rock units at different localities. The Tokat Complex (N of Kırklar mountain, along Uzun ridge, N of Alabedir village, W of Eraslan village and NE of Yuvala village), the Amasya Group and the NAOM (N of Kırklar mountain, NE of Yavru and around Kürtler villages (Figure 55), and the Cindere Group (NE of Kürtler, N of Alabedir, W of Eraslan and NE of Yuvala villages) are intruded by the Moramıl dacites (Plate 1). The Moramıl dacite is overlain unconformably by the Plio-Pleistocene Alişar Formation (NE of Alabedir village).

Lithology: The Moramıl dacites are grayish white to white in color, highly jointed and are differentiated as hornblende and biotite dacites. The hornblende dacites are made up of euhedral quartz, euhedral zoned plagioclase, biotite and hornblende phenocrysts set in a fine grained matrix of feldspars and thin flakes of biotite microliths with a glomeroporphyrotic texture. Apatite, sphene and opaque minerals are accessory components. The biotite-dacites are made up of magmatic corroded quartz and plagioclase phenocrysts and biotite microphenocrysts set in a matrix of medium grained quartz, feldspar and biotite with a glomeroporphyrotic texture. Apatite, zircon and opaque



Figure 55. Close-up view of the Moramıl dacite (Tm) intruded into the NAOM. Note the baked zone (bz) (Locality: on a road-cut between Yavru and Şehcui villages).

minerals are accessory components. The Moramıl dacites contain xenoliths of quartz and Tokat Complex.

Age, Correlation and Interpretation: Based on the above-mentioned cross-cutting relations and the Plio-Quaternary cover, a relative age between post-Lutetian and pre-Pliocene can be assigned to the Moramıl dacite. The dacites are widely observed at various localities of Pontides at different speculative stratigraphic positions (Blumenthal, 1950; Alp, 1972; Seymen 1975; Rojay, 1985; Yılmaz, 1985; Bozkurt, 1989; Dirik, 1991). In the study area, the Moramıl dacites occur in a hair-like outcrop pattern and shows a E-W trending linear distribution (Figure 44, Plate 1). Due to the intrusion of the Moramıl dacite,

the metamorphic basement was uplifted and some of the Cindere group were tilted and deformed (Figure 48).

2.8. Suluova group (TQs)

The neotectonic basin fill was named as the Suluova group. It has been divided into four formations, namely the Değirmendere, Yolpınar, Alişar and Yedikır formations (Figure 56). The Suluova group consists predominantly of

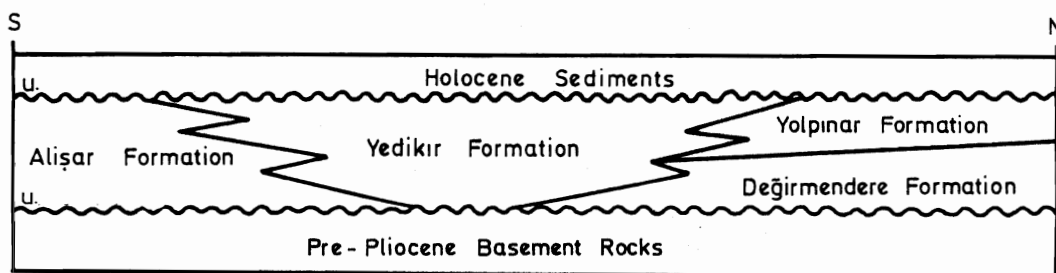


Figure 56. The probable lithostratigraphic relations of the formations included in the Suluova group (TQs). Note: U.Unconformity.

fluvial to lacustrine deposits. They are widely exposed within the Merzifon-Suluova basin from Gümüşhacıköy in the west to Akdağ mountain in the east and from Merzifon city in the north to "Amasya Highland" in the south (Figure 3). The Suluova group overlies unconformably all the pre-Pliocene rocks. The thickness of the group is over 140 m. However, from subsurface data of various State Hydraulic Department (DSİ) and MTA reports, the maximum thickness of the Suluova

group reaches up to 400 m (Atalay and Altuğ, 1973). The Suluova group which was previously named as Alişar Formation (Koçyiğit and Rojay,1988) can be correlated with the sediments of the basins situated on North Anatolian Fault Master Strand (Nebert, 1961; Irrlitz, 1971; Tokay, 1973; Öztürk, 1979; Koçyiğit, 1989; Dirik,1991).

2.8.1. Değirmendere formation (TQsd)

Definition: The Değirmendere formation consists predominantly of red conglomerates and sandstones. It was named as the Değirmendere formation based on its type locality, namely Değirmendere village, where it is well and widely exposed (Plate 3).

Stratigraphic Relation, Distribution and Thickness: The formation has an extensive distribution, restricted to eastern margin of the Merzifon-Suluova basin (Plate 3). The formation overlies unconformably the Karatepe, Kışlacık and Cindere groups. However, it has questionable lateral and vertical transitional contact relations with the Yedikır formation. The Değirmendere formation displays both lateral and vertical graditional contact relations with the Yolpınar formation to the NE of Yolpınar village, and is overlain unconformably by the Holocene sediments (Figure 57). Its maximum observable thickness is 64 m.

Lithology: The Değirmendere formation begins with red to purple, medium to thick bedded, locally cross-bedded



Figure 57. Gradual transition from the underlying Değirmendere formation (TQsd) to the Yolpınar formation (TQsy) (Locality: N of Yolpınar village).

sandstone-siltstone alternation including some red, polygenetic conglomerate lenses (Figure 57,58,59), and continues upward with the alternation of red, medium to thick bedded, locally cross-bedded sandstone-siltstone with red, medium to thick bedded polygenetic conglomerates. Clasts of the polygenetic conglomerates range from boulder to millimeter in size, poorly sorted, angular to subrounded and they are set in a grain-supported to argillaceous matrix (Figure 59). Other fine-grained clastic rocks have the same lithological components and properties. The red channel conglomerates and other clastic rocks are dominant within the sequence (Figure 60). At the topmost, the Değirmendere formation grades into yellow sandstones-conglomerates of the Yolpınar formation.

Age, Correlation and Depositional Setting: Based on the stratigraphic position and relative age of the Yedikır and Alişar formations which are time equivalent of the Değirmendere formation, the age of the Değirmendere formation can be accepted to be Plio-Quaternary. It can be time-stratigraphic equivalent of the Pontus Formation (Irrlitz,1971). The red colored, polygenetic, subrounded to angular, boulder to mm size, heterogenous pebble distribution may indicate a continental depositional setting without any stagnant water input (Reineck and Singh,1975; Selley,1980). The channel conglomerates (Figure 60), cross-beddings (Figure 60) and conglomerate lobes (Figure 59) are typical additional indications of the continental

AGE		UNIT	THICKNESS (m)	LITHOLOGY	DESCRIPTION
Q ₂			>2	—Unc.	Terrace conglomerates
PLIOCENE — QUATERNARY		SULUOVA GROUP	FORMATION	9	Alternation of yellow-yellowish brown, medium to thick bedded sandstones and yellowish brown polygenetic conglomerates with grayish white conglomerate and sandstone beds
				0.4	
				8	
				4	White, massive conglomerate
				2	Reddish brown, medium bedded sandstone
				1	Red, massive, polygenetic conglomerate
				18	Alternation of yellow, medium to thick bedded siltstone sandstone and conglomerate sequence with grayish white thick bedded conglomerate and reddish brown conglomerate
				3	Minor gypsum beds with coal concentrations
				4	Grayish white, polygenetic conglomerate with sandstone a fining upward sequence
				7	Reddish brown polygenetic conglomerate
				8	Dominantly yellow, medium bedded sandstone with polygenetic conglomerates
				8	Dominantly yellow, massive, polygenetic conglomerates alternating with yellow sandstones
				1.5	Red, massive polygenetic conglomerate
				8	Reddish brown marl sequence
1.5	Red, massive polygenetic conglomerate				
8	Dominantly yellow sandstone with yellow, thick bedded polygenetic conglomerates				
PLIOCENE — QUATERNARY		SULUOVA GROUP	FORMATION	21	Alternation of red, medium bedded, cross-bedded sandstone-siltstone sequence and red, medium bedded conglomerate, red to purple, massive, structureless, polygenetic conglomerate sequence with red, conglomerate lobes/lenses
				7	
				19	Red, channel conglomerates
				9	Red to purple, massive, structureless, polygenetic conglomerates with red, medium to thick bedded sandstone-siltstone sequence
				>7	
PLIOCENE — QUATERNARY		SULUOVA GROUP	FORMATION	>4	? — Unc.? Brownish green to light green marls with siltstone beds and lenses

Figure 58. Measured stratigraphic columnar section of the Değirmendere and the Yolpınar formations. Q₂.Holocene (Locality: Southeastern slope of Sivri hill, E of Kurnaz village)



Figure 59. Close-up view of conglomerate lobes within the Değirmendere formation (Locality: N of Yolpınar village)



Figure 60. Close-up view of a well-developed channel conglomerate within the Değirmendere formation (Locality: E of Yolpınar village).

depositional setting which is possibly a meandering river system where possible meandering river roughly trends in NW-SE direction (Reineck and Singh,1975; Pettijohn,1975; Walker,1979). As a whole, the Değirmendere formation is a molassic sequence which is affected by syn-sedimentary small-scale faults (Figure 61).

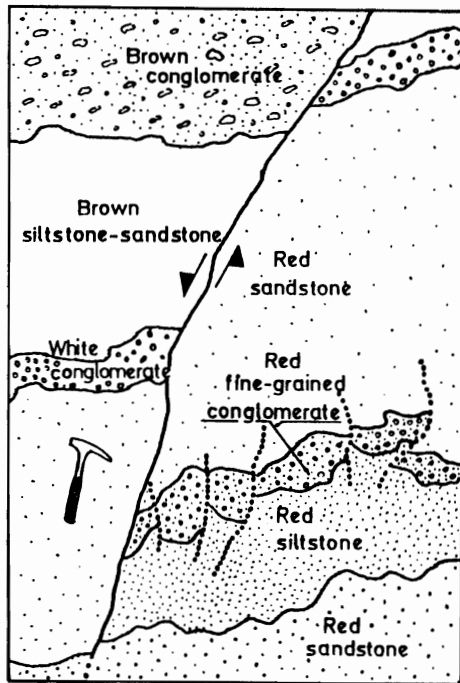


Figure 61. Sketch of syn-sedimentary faults developed within the Değirmendere formation (Locality: E of Yolpınar village).

2.8.2. Yolpınar formation (TQsy)

Definition: The formation consists predominantly of yellow to red sandstones and conglomerates, and has a widespread, thick outcrops to the north of Yolpınar village (Plate 3).

Stratigraphic Relations and Thickness: The Yolpınar formation has a restricted distribution at the eastern margin of the Merzifon-Suluova basin. The formation has a conformable contact relation with the Değirmendere formation indicated by the color change in the field. It is overlain unconformably by the Holocene sediments. Maximum measurable thickness of the formation is over 83 meters.

Lithology: The Yolpınar formation starts with yellow sandstones including yellow, thick bedded, polygenetic conglomerate intercalations, and grades upward into the reddish brown marls (Figure 58). They are followed by red, massive, polygenetic conglomerates. Towards top, yellow, massive, polygenetic conglomerate alternating with yellow sandstones grades upward into yellow, medium bedded sandstone sequence. It continues with the alternation of yellow-yellowish brown, medium to thick bedded, sandstone, siltstone and conglomerate alternation containing grayish white conglomerate, sandstone, minor reddish brown, medium bedded sandstone and conglomerate intercalations. Minor amount of gypsum layers and some coal measures are observed within the sequence.

Age, Correlation and Depositional Setting: The Yolpınar formation is younger than the Değirmendere formation and can be time equivalent of the Yedikır and Alışar formations. Therefore, probable age of the Yolpınar formation is Plio-Quaternary. The formation is the time

equivalent of the Pontus Formation (Irrlitz,1971). Red to yellow color, polygenetic, subrounded to angular, boulder to mm size, heterogeneous pebble distribution, horizontality in bedding structures, gypsum layers with coal concentrations, channel conglomerates and conglomerate lobes indicate a continental depositional setting of both lacustrine and fluvial environment (Reineck and Singh,1975; Selley,1980; Pettijohn,1975; Reading,1982; Walker,1979).

2.8.3. Yedikır formation (TQsye)

Definition: The Yedikır formation consists predominantly of light green marls and cross-bedded sandstones-siltstones exposing widely around the Yedikır dam (Plate 3).

Stratigraphic Relations and Thickness: The Yedikır formation has widespread outcrops from Oymak-Sarıbuğday villages in the west to Yedikır dam site and to Suluova town in the east in the Merzifon-Suluova basin (Plate 3). The bottom of the Yedikır formation could not be observed in the study area. However, along an active fault, namely Oymak-Uzunyazı-Yenice line, probable outcrops of the Karatepe group can be observed at the base of the formation. At the top, the Yedikır formation grades into the clastic rocks of the Alişar, Değirmendere and Yolpınar formations to the S of Sarıbuğday village and along the Suluova-Değirmendere line. At the topmost, it is overlain unconformably by the Holocene

sediments. The measurable thickness of the Yedikır formation is over 19 meters.

Lithology: The Yedikır formation begins with light green marls with partly cross-bedded sandstone influx (Figure 62). The gastropod and plant remains bearing marly sequence is followed by brownish green to brown-brownish yellow clastic rocks which were consist of fining upward, cross-bedded sandstones with minor marly influx at the bottom. They are followed by a coarsening upward sequence of brownish yellow, medium bedded sandstones and conglomerates with cross-bedded structure. Clasts of the conglomerate are subangular to rounded, well sorted, almost uniform size (a few cm to mm), and argillaceous matrix supported. At the topmost, the Yedikır formation ends with green to yellow, thin bedded marls with minor influx of silty-sandy material.

Age, Correlation and Depositional Setting: Gastropoda and plant remains included marls are recognized at few localities, namely the Cibliye hill (SE of Kurnaz village) and Uzunkır hill (NE of Çayırözü village). The Pliocene-Recent age is assigned with Valvata cf. (Cincinna) piscinalis, Hydrobia sp., opercule and gastropod fragments. The stratigraphic relations of the Yedikır formation support Pliocene-Pliestocene age. The Yedikır formation can be lithologically correlative with the marly sequence exposing in the Elgazi region to the south of the study area (personal field observations, 1988). The marly sequence with

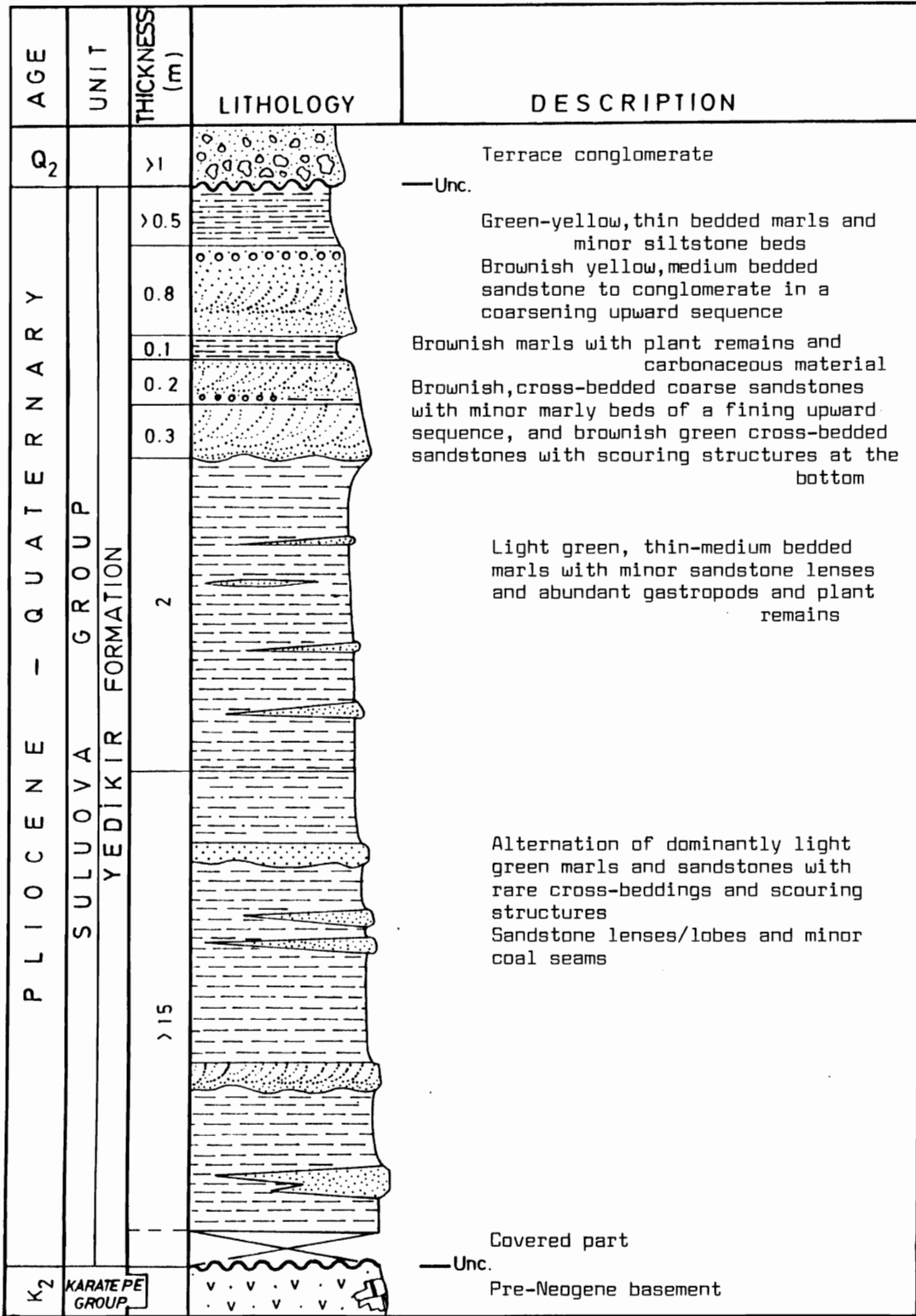


Figure 62. Measured stratigraphic columnar section of the Yedikir formation. K₂.Late Cretaceous, Q₂.Holocene, Unc.Unconformity (Locality: NE of Yedikir dam).

light colors, gastropoda, plant remains, carbonaceous material, and cross-bedded structures manifest a moderately anaerobic, lacustrine depositional setting with minor current influx (Reineck and Singh,1975; Selley,1980).

2.8.4. Alişar Formation (TQsa)

Definition: The Alişar formation consists predominantly of light colored clastic rocks and has a widespread distribution around Alişar village, where the Alişar formation rests on the Cindere group with an angular unconformity (Figure 63, Plate 1).

Stratigraphic Relations and Thickness: The Alişar formation has an extensive distribution at the southern margin of the Merzifon-Suluova basin (Plate 3). It overlies unconformably all the pre-Pliocene rocks (Figure 63, Plate 1) and is overlain unconformably by the Holocene sediments. The formation displays a probable lateral and vertical gradational contact relations with the marly sequence of the Yedikır formation. The maximum measured thickness of the formation is over 39 meters.

Lithology: The Alişar formation begins with a basal conglomerate with the erosional surface at the base on pre-Neogene rocks. Color and type of the pebbles of the basal conglomerates change from place to place depending on the supplying sources (Figure 64). Clasts of the polygenetic conglomerates are rounded to subrounded, almost uniform in



Figure 63. Angular unconformity between the Cindere group (Tc) and the Alişar Formation (TQsa). Note the Moramil dacite (Tm) intruded into the Cindere group (Locality: far NNE of Alabedir village).

size (a few cm to mm), well sorted and matrix to grain supported. It continues with a fining upward sequence consisting of white-yellowish, wavy and cross-bedded coarse sandstones to siltstones and to light gray, massive polygenetic conglomerates (Figure 64). The Alişar formation almost shows a uniform stratigraphic evolution starting with white, medium to thin bedded sandstone to yellow, medium bedded siltstone-sandstone alternation. It is followed by a white-grayish white, thick bedded sandstone-conglomerate and white, light gray to green, medium to thick bedded sandstone-siltstone alternation. Towards the top, it is composed of yellowish to light green, medium to thick,

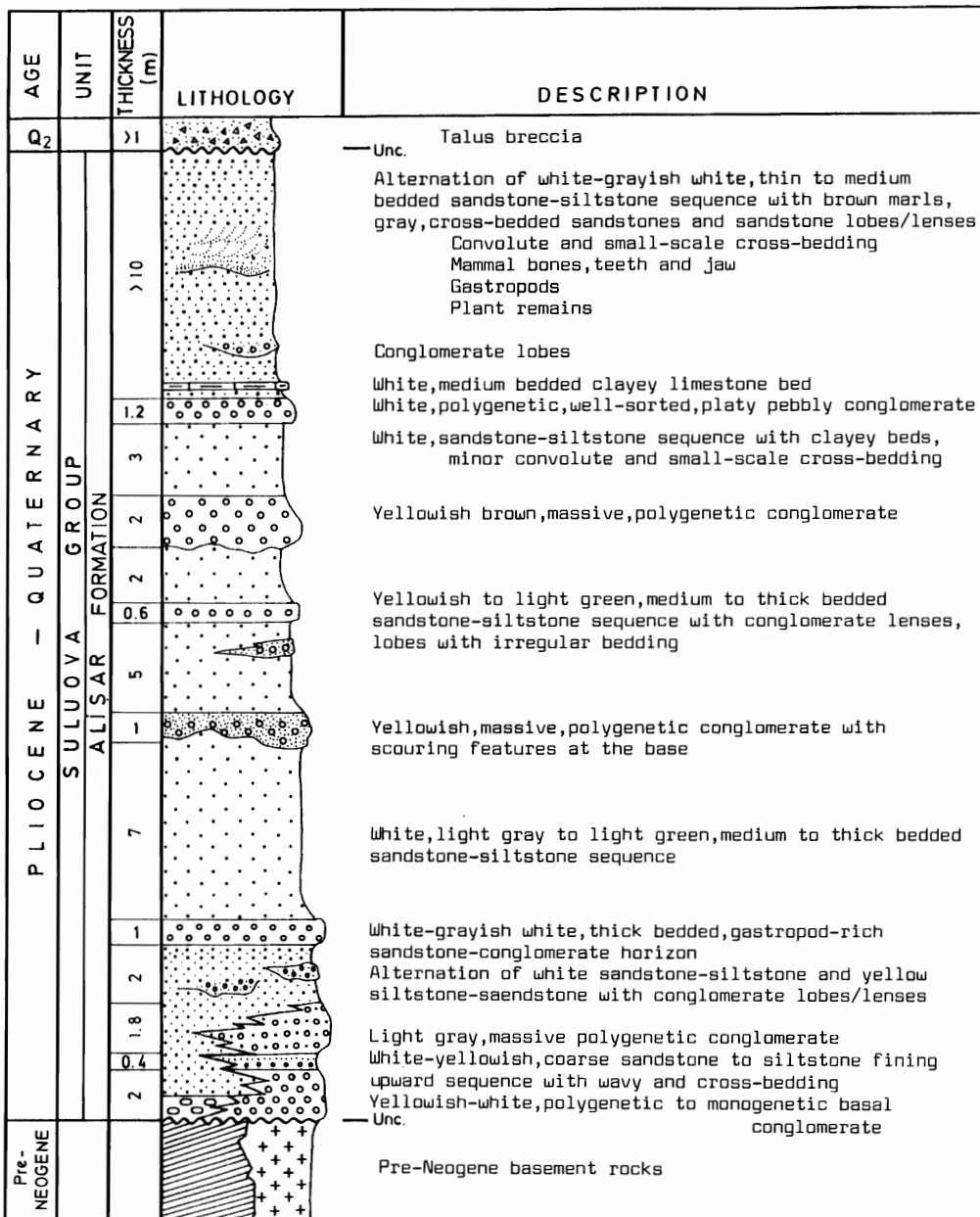


Figure 64. Composite stratigraphical columnar section of the Alisar Formation. Q₂.Holocene, Unc.Unconformity (Locality: Measured sections from N of Yuvala, W of Alisar and NE of Alabedir villages).

irregularly bedded sandstone-siltstone sequence with yellowish, massive, polygenetic conglomerate lenses/lobes (Figure 64). At the topmost, this sequence grades upward into an alternation of white, grayish white, thin to medium bedded sandstone-siltstone sequence with brown marls, gray, cross-bedded sandstone, sandstone and conglomerate lobes, and a white, medium bedded arenaceous-argillaceous limestone. The sequence is characterized by convolute bedding and small scale cross-beddings, mammalian bones, teeth and jaw, plant remains and gastropods.

Age, Correlation and Depositional Setting: The age of the Alişar formation is probably Pliocene-Quaternary based on the Valvata sp. and other gastropods, and mammalian teeth and jaw (Şükrü Genç (MTA), personal communication, 1989). Its stratigraphic relations with other rocks, support a Pliocene-Pleistocene age. The Alişar formation can be correlative with the rocks exposing in the Elgazi region (personal field observations, 1988). The primary sedimentary structures, lithologies, especially the coarse clastics, presence of gastropods, mammalian bones, teeth and jaw, plant remains with carbonaceous material are the indicators of a continental environment. Light colors, horizontality in bedding attitudes, carbonaceous material indicate a lacustrine depositional environment (Reineck and Singh, 1975; Selley, 1980). Micro cross-bedding, convolute bedding and irregular wavy bedding also indicate a periodically active environment. Well rounded and sorted, platy pebbly, almost

polygenetic conglomerates are indication of an active lake shoreline depositional setting (Pettijohn,1975). Channel conglomerates and sandstones indicate a river flowing into a lake environment. Consequently,the Alişar formation was deposited at the north-facing margin of a lake which was periodically affected by the basement faults.

2.9. Holocene Units (Q)

The Holocene sediments consist of talus breccias and seasonal fluvial sediments, alluvial fan sediments, braided meandering river-plain sediments, terrace conglomerates and swamp deposits which all are presumed to be time equivalent. The thickness of the Holocene basin fill may change from a few meters up to 10 m at the southern margin of Merzifon-Suluova basin. Travertines are also Holocene in age, but today,they do not continue their accumulation. The Holocene sediments overlies unconformably all the pre-Holocene rocks.

Talus breccias and seasonal fluvial sediments: Talus breccias are mostly observed on the hanging blocks of the faulted margins and intertongue with the seasonal fluvial clastic sediments. Talus breccias and clastic sediments are composed of angular to subangular, unsorted, boulder to mm size, polygenetic where the clasts partly grain supported or poorly cemented with calcite.

Alluvial fan sediments: These deposits are dominantly developed at the northern, southern and western margins of

the Merzifon-Suluova basin (Plate 3). Some of the fans combine and form extensive alluvial aprons. Areal distribution of the fans varies from a square kilometer to tens of square kilometers. At the northern margin of the basin, alluvial fans are overlapped on each other. These huge, thick alluvial fans are deeply dissected by creeks. The slope of the alluvial fan surfaces range from 1° to 4°. Most of the fans consist of structureless, unsorted, block to mm size, angular to subangular pebbly sandy and silty sediments that grade into finer material at the proximal parts of fans. Flood plain deposits are widespread on the alluvial fan surfaces.

Braided river plain sediments: In the Merzifon-Suluova basin, at two areas, active braided river system is observed. One of them is the E-W trending Gümüşsuyu creek system that flows towards east in the area between Çetmi and Karatepe villages. Other one is the N-S trending Tersakan river system that flows southward between Çeltek and Kapanıcı settlements (Plate 3). Besides, these two long and narrow river valleys, the basin is filled by the meandering river, older braided river and flood plain deposits.

Meandering river sediments: The predominant active meandering river system occurs in an E-W trending pattern at the southern-central margin of the Merzifon-Suluova basin (Plate 3). The total length of the meandering Tersakan river and its western tributary (Gümüşsuyu creek) which is flowing

to the east between Sarıbuğday and Boğazköy villages is 25 km (Plate 3).

Terrace conglomerates: These are dominantly located at the center of the Merzifon-Suluova basin between Çayırözü and Kapancı settlements and at the western slopes of eastern margin (Plate 3). Conglomerates are strongly cemented or grain supported and exposed at 30-40 m above the today's valley bottom. The thickness of the conglomerates varies from 0.5 to 2 m.

Swamps: A widespread swamp development is observed at the southeastern margin of the Merzifon-Suluova basin. The N-S flowing Tersakan river is shifted in E-W direction between Kapancı and Boğazköy settlements and results in a swamp occurrence (Plate 3). It covers totally an area of 15-20 square km. At some other localities, swamps also occur which are closely associated with faults.

Travertines: At few localities, namely the Alican hill (NE of Harap settlement), Dereağıl settlement and the Sığırevleği ridge, some travertine occurrences which are not active today, are observed (Plate 3). In general, travertines are grayish white, porous to compact, massive calcareous tufa with a maximum thickness of 7 m.

CHAPTER III

STRUCTURAL GEOLOGY

The study area, which lies in "Pontides", was affected by the pre-Tethyside and Tethyside (Cimmeride and Alpidic) orogenic systems (Şengör, 1984; 1985). However, the structural geology of the study area was based on paleo- and neotectonic periods. The paleotectonic period is characterized by a compressional-contractional regime, while the neotectonic period by a compressional-extensional regime (Şengör, 1980) in "seno-lato" view. Geological structures are grouped as unconformities, folds and faults under the "paleo- and neotectonic structures" headings.

3.1. Paleotectonic structures

The structures developed within pre-Pliocene - Pliocene rocks are presumed to be the paleotectonic structures, on which, neotectonic events were superimposed. The paleotectonic structures are grouped as unconformities and folds, thrust faults and mesoscopic faults.

3.1.1. Unconformities and folds

Totally, six paleo-tectonic phases were recorded in the study area, namely the pre-Liassic, pre-Callovian, pre-Aptian, pre-Middle Campanian, pre-Lutetian and pre-Pliocene

periods. Each folding was followed by an unconformity except the case in pre-Aptian.

Pre-Liassic period: Within the limits of study area, the pre-Mesozoic basement (Tokat Complex) was affected by the pre-Triassic and pre-Liassic events. The Tokat Complex was foliated and intensely deformed. It is hard to obtain a regional deformational pattern, however, the dominant attitude of the foliation, in which bedding planes are mostly parallel to foliation, is $N80^{\circ}W$ in the green schist subunit of the Tokat Complex.

The first regional unconformity was recognized at the base of the Liassic rocks. Attitude of this non-conformity ("angular unconformity") plane is $N70^{\circ}W$ to E-W with 19° to $30^{\circ}N$ dip amounts. Along these structures, underlying low-grade metamorphic rocks (Tokat Complex) dip 29° to $52^{\circ}N$ on the southwestern slope of the Paşaoğlanınçal hill (Plate 1). The time gap between the overlying Liassic rocks and metamorphic rocks is at least 50 Ma (Global stratigraphic chart, 1989).

Pre-Calloviaian period: It is hard to measure the attitude of the Liassic rocks due to intense deformation, except Paşaoğlanınçal hill locality. Liassic rocks have an E-W, $30^{\circ}N$ attitude below the Callovian rocks with $N65^{\circ}W, 18^{\circ}$ - $28^{\circ}N$ attitude. It is a low-angle, angular unconformity. The time gap from Pleinsbachian to Callovian will be around 30 Ma (Global Stratigraphic Chart, 1989).

Pre-Aptian period: It is not feasible to discuss the attitudes of Callovian-Valanginian sequence whose distribution was related to NAOM emplacement. There are various types of tectonic folds with different attitudes resulted from thrusting of the Callovian-Valanginian rocks with the NAOM (Plate 1). The base of the Aptian is drawn by a paraconformity surface. The non-depositional or erosional period prevailed for approximately 8 Ma, from Valanginian to Aptian (Global stratigraphic chart, 1989). The underlying platform carbonates are somewhat tilted beneath the overlying pelagic carbonates as proposed in the Bernoulli and Jenkyns model (1974).

Pre-Middle Campanian period: The Aptian-Cenomanian sequence was folded at the top of tilted Callovian-Valanginian carbonate platform. The dominant attitude of the Aptian-Cenomanian sequence is $N40^{\circ}W$. However, they are fragmented and mixed in NAOM, and altogether overlain unconformably by the Middle Campanian forearc sequence with a nonconformity (or "angular unconformity"), trending dominantly in $N45^{\circ}-60^{\circ}W$ directions. The time gap resulted from the accretion of the NAOM is 8 Ma (from Cenomanian to Middle Campanian) (Global stratigraphic chart, 1989).

Pre-Lutetian period: The Middle Campanian-Maastrichtian sequence was folded at the top of the NAOM. The main trend of fold axis is $N70^{\circ}W$. However, at localities where NAOM overthrusts onto Middle Campanian-Maastrichtian

flysch sequence, the plunging asymmetrical anticlines trend in E-W direction (N of Oklukaya hill, N of Amasya City). At a regional scale, the forearc sequence has a curvilinear attitude changing from N45°W (Ağıl location) through E-W (N of Ortaçal hill) to N60°W (N of Oklukayahill) and to N70°W (N of Ziyaret village) trend (Plate 1). The probable stress direction operated on pre-Lutetian sequences was NE-SW.

Lutetian rocks overlie unconformably older rocks with an almost E-W trending angular unconformity and nonconformity plane of different attitudes. The Lutetian Cindere group overlies the Tokat Complex with a nonconformity, and the Amasya, Karatepe and Kışlacık groups with an overlapping angular unconformity. The uppermost dated age of the Kışlacık group is Maastrichtian. Therefore, the time gap between the Lutetian Cindere group and the underlying Kışlacık group is about 20 Ma (Global stratigraphic chart, 1989).

Pre-Pliocene period: The pre-Pliocene rocks were folded and faulted during post-Lutetian, due to the compressional-contractional tectonic regime. Various folds observed within the Eocene sequences have different fold axis directions changing from N15°W to E-W directions. However, dominant fold axis trend is in N50°W direction. The probable stress direction, which was responsible for the folding was NE-SW.

Paleotectonic and neotectonic periods are differentiated from each other by angular unconformity at the base of Pliocene rocks in Amasya region (Figure 5).

3.1.2. Thrust faults

The most striking paleotectonic structures are the overthrust faults which were related mostly with the Mesozoic-Paleogene orogenies. However, the overthrust faults confined to the metamorphic rocks of the Tokat Complex are presumed to be pre-Jurassic in age and might have been reactivated during Late Cretaceous. The overthrusts are divided into two time dependent categories, namely the pre-Jurassic overthrusts and Late Cretaceous-Paleogene overthrusts, which were called as the "Tokat" and "North Anatolian" Overthrusts, respectively.

3.1.2.1. Tokat Overthrusts (pre-Jurassic overthrusts)

These overthrusts are significant and distinguishable in the area between Yavru village to the west and Vermiş village to the east (Plate 1). In general, green schist subunit is overthrust onto grayish-black schist subunit and indicated by the intense deformation and imbricated structural pattern in the grayish-black schist subunit (Plate 1). Overthrust planes dip at 20° to 48° N in various strike directions, where dominant set is $N60^{\circ}-80^{\circ}$ W to the east (Amasya-Vermiş area) and $N20^{\circ}-40^{\circ}$ E to the west (Şehci area). The general pre-Jurassic vergence is from N to S.

3.1.2.2. North Anatolian Overthrusts (Late Cretaceous-Paleogene overthrusts)

These overthrusts are significant and distinguishable between SW of Yuvala village to the west and Vermiş village to the east. They were originated from the emplacement of accretionary prism of the accreted melanges. This overthrust zone is maximum 6km wide, and longer than 32 km in the study area. It was constructed on various duplex thrust sheets verging dominantly south, rarely north. Some of the well defined overthrusts are the Asarçalıtepe, Karababaçeşme, Taşlıyurt, Yavru, Oklukayatepe and Amasya overthrusts (Plate 1).

Asarçalıtepe overthrust: The Asarçalıtepe overthrust is observed to the north of the Asarçalı hill, NW of Gerne village (Figure 65, Plate 1). The Amasya Group (JKa) thrust onto the Tokat Complex (Pzt) and altogether are thrust onto the Cindere group (Tc) along a low angle overthrust plane dipping south (Figure 65,66). The overthrust plane is nearly horizontal, where it dips at a few degrees south. The underlying Cindere group (Tc) dip 24° to 63° S (Figure 65). This overthrust belt extends in the $N68^{\circ}$ E direction for 3 km within the study area. Its northeastern segment terminates under recent deposits, while western segment continues into the neighbourhood areas outside the study area.

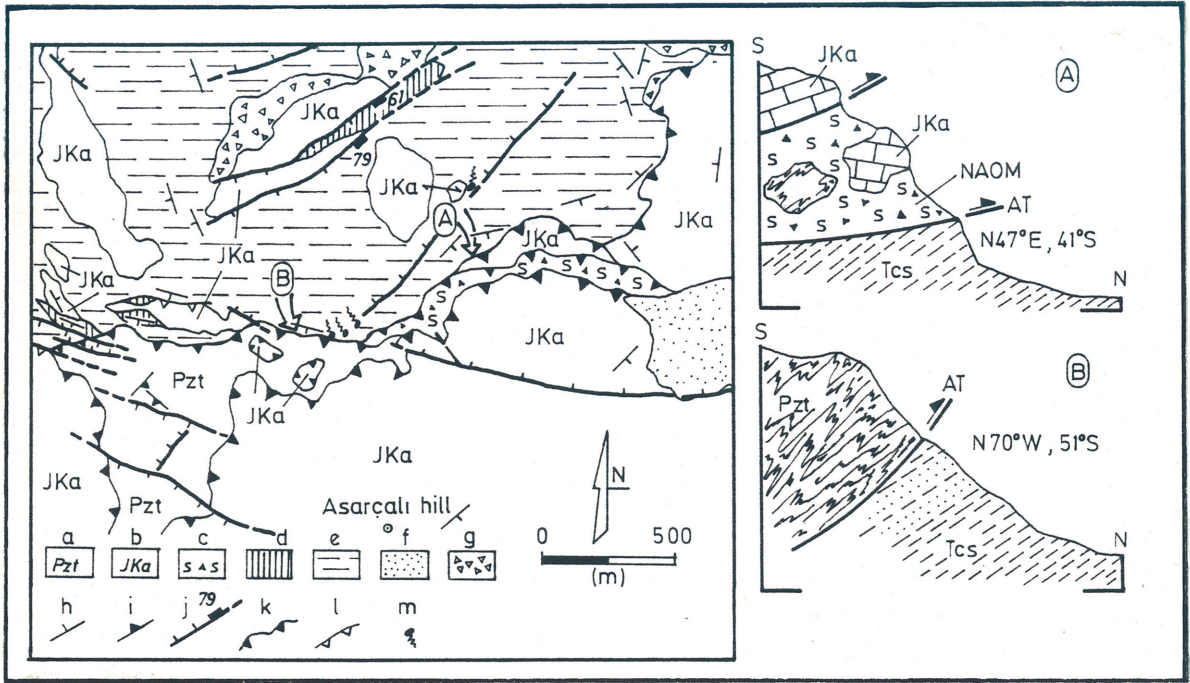


Figure 65. Geological map and sketch geological cross section showing the Asarçalıtepe thrust (AT). a.Tokat Complex (Pzt), b.Amasya Group (JKa), c.North Anatolian Ophiolitic Melange (NAOM), d.Çaltepe formation (Tcç) and e.Suludere formation (Tcs) of the Cindere group, f.Holocene cover, g.talus breccia, h.attitude of bedding plane, i.schistosity plane, j.fault with normal component (tick on the hanging wall, black rectangle illustrates the fault scarp), k.overthrust, l.reverse fault, m.spring (Locality: Inset map in Plate 1).



Figure 66. General view of the Asarçalı overthrust (AT). The Suludere formation (Tcs) is thrust by the NAOM (Locality: N of Asarçalı hill, SE of Yuvala village, A in figure 65).

Karababaçeşme overthrust: The Karababaçeşme overthrust runs from Soma to Arucak villages for 4 km in N42°E direction where the Amasya Group (JKa) is thrust onto the Tokat Complex (Pzt) and then altogether with NAOM, they overthrust onto the flysch sequence of the Cindere group (Tc) (Figure 67). This low-angle overthrust fault plane slightly dips south. Beneath the overthrust fault plane, folds have 20°-30°S and 85°N dipping flanks forming S to N verging asymmetrical folds (Figure 67). The northeastern tip of the overthrust fault is overlain by Quaternary sediments (Figure 67).

Taşlıyurt overthrust: About 1 km SW of Taşlıyurt village, the NAOM is thrust onto flysch sequence of the Cindere group (Tc) and Tokat Complex (Pzt) (Figure 68). It is the continuation of the Karababaçeşme overthrust and extends from the south of Alabedir village to Taşlıyurt village and to northeast of Kürtler village (Figure 68). The overthrust belt extends for 7 km almost in E-W direction with a curvilinear outcrop pattern. A tectonic window observed one km south of Taşlıyurt village, indicated at least one km northward tectonic transport (Figure 68, Plate 2).

Yavru overthrust: The Yavru overthrust extends from Yavru village to Kaçağın hill for 3.5 km in N36°W trend (Figure 17,18). The NAOM and its components are overthrust onto the Yavru member(Kasy) on a southwestward dipping

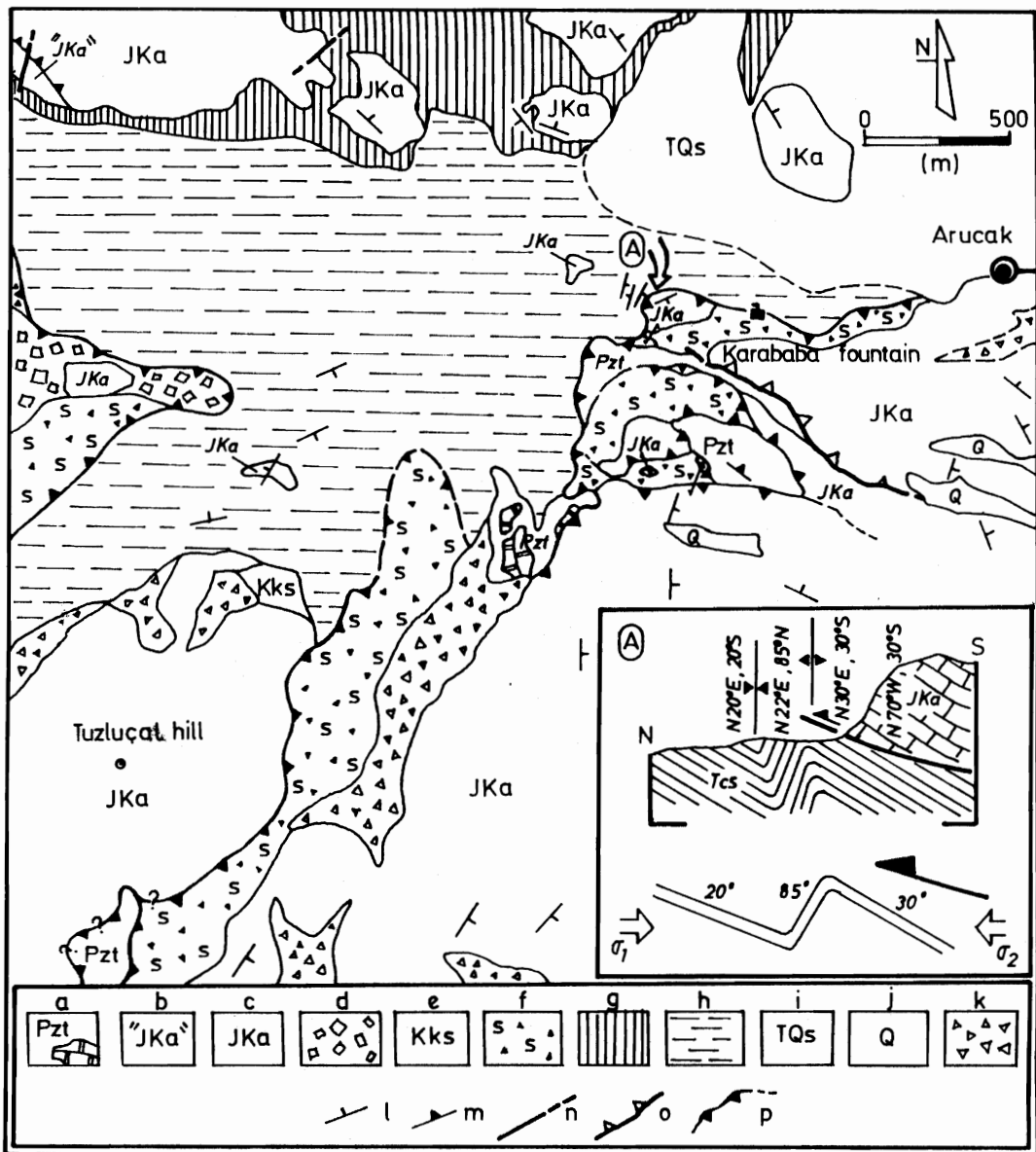


Figure 67. Geological map and Sketch geological cross section showing the Karababaçeşme overthrust and possible post-Lutetian tectonic transport direction. a.Tokat Complex with marble blocks, b.Amasya Group equivalent rocks, c.Amasya Group, d.blocks of brecciated Amasya Group, e.Sarilar Formation, f.North Anatolian Ophiolitic Melange, g.Çaltepe and h.Suludere formations of the Cindere group, i.Suluova group, j.recent seasonal plain sediments, k.talus breccia, l.attitude of bedding plane, m.schistosity plane, n.fault, o.reverse fault, p.overthrust, σ_1 and σ_2 are principal stresses (Locality: Inset map in Plate 1).

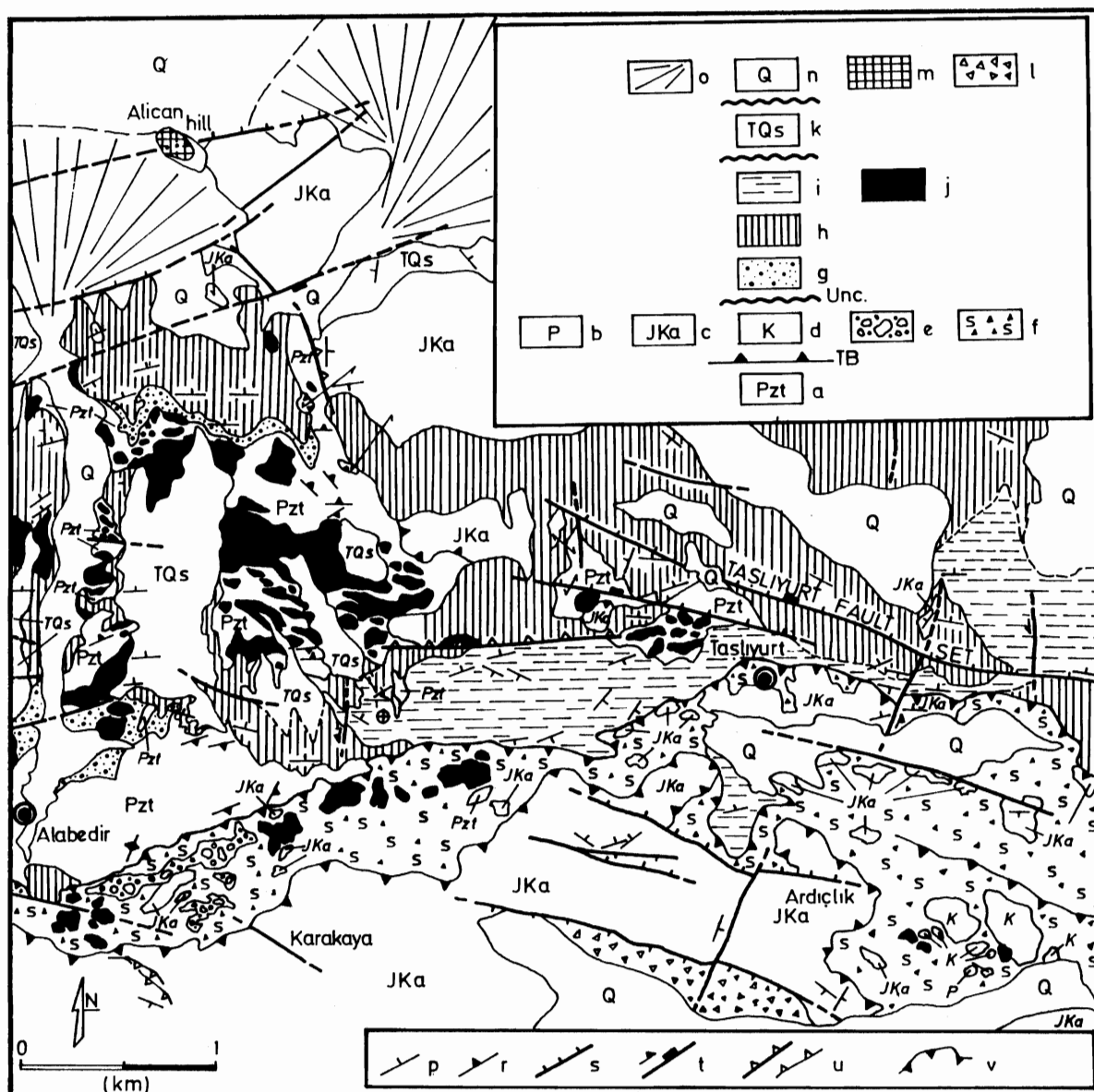


Figure 68. Geological map showing the Taşliyurt overthrust, the ophiolitic melange and distribution of the Cindere group. a.Tokat Complex, b.Permian limestone block, c.Jurassic-Cretaceous platform carbonate block (Amasya Group), d.Cretaceous pelagic limestone, e.possible "paleo-trench" sediments, f.North Anatolian Ophiolitic Melange, g.Kızıldere formation, h.Çaltepe formation, i.Suludere formation, j.Moramıl dacite, k.Suluova group, l.talus breccia, m.travertine, n.Holocene fluvial sediments, o.Holocene alluvial fan, p.attitude of bedding plane, r.schistosity plane, s.oblique slip fault, t.strike slip fault, u.reverse fault, v.overthrust, TB.tectonic boundary, Unc. unconformity (Locality: Inset map in Plate 1).

thrust plane. The curvilinear and irregular outcrop pattern manifests at least one km overriding of the NAOM on the Yavru member (Kasy) along the Yavru overthrust fault plane (Figure 17,18). As a result of NAOM overthrusting, the Amasya Group (JKa) are thrust and overthrust onto the Yavru member (Kasy) (NE of Kavaklı spring to W of Yavru village) and Tokat Complex (Pzt) (along Sel creek), respectively (Figure 17,69).

Oklukayatepe overthrust: About two km N of Amasya city, the Amasya Group (JKa) is thrust onto both the Geyiközü and Fındıklı Formations of Karatepe group (Kk) (Plate 1,2). This E-W striking low-angle overthrust fault dips south in an imbricated mass. The underlying Geyiközü Formation (Kkg) was intensely deformed (folded and faulted) due to at least one kilometer tectonic transportation of the Amasya Group (JKa)(Plate1,2). The northwestern end of the Oklukayatepe overthrust is transcuted by a N24°E trending strike-slip fault, while its western and eastern ends terminate under recent alluvial fan sediments.

Amasya Overthrusts: One of the largest and extensive overthrust fault zone consists of Amasya overthrust faults. The overthrust zone is characterized by a series of klippen and tectonic windows (Plate 1,2). Along these faults, the slices of the Amasya Group (JKa) and NAOM are thrust onto the Tokat Complex (Pzt) along Sel creek, N and NE of Şehcui village, N of Amasya castle, E of Kırklar mountain, along



Figure 69. Close-up view of an overthrust indicated by the mylonitic zone at the base (green schist subunit of the Tokat Complex(Pzt)) and intensely folded-partly recrystallized limestones of the Ferhatkaya Formation of Amasya Group (JKaf) at the top (Locality: along Sel creek, SW of Şehcui village).

Zincirlikaya ridge and SW of Vermiş village (Figure 70, Plate 1). General vergence direction is from SW to NE and NW to SE where overthrust planes dip southwest and northwest, respectively. The extend of the fault zone is over 10 km along which at least 5 km tectonic transportation was occurred (Plate 1, 2).

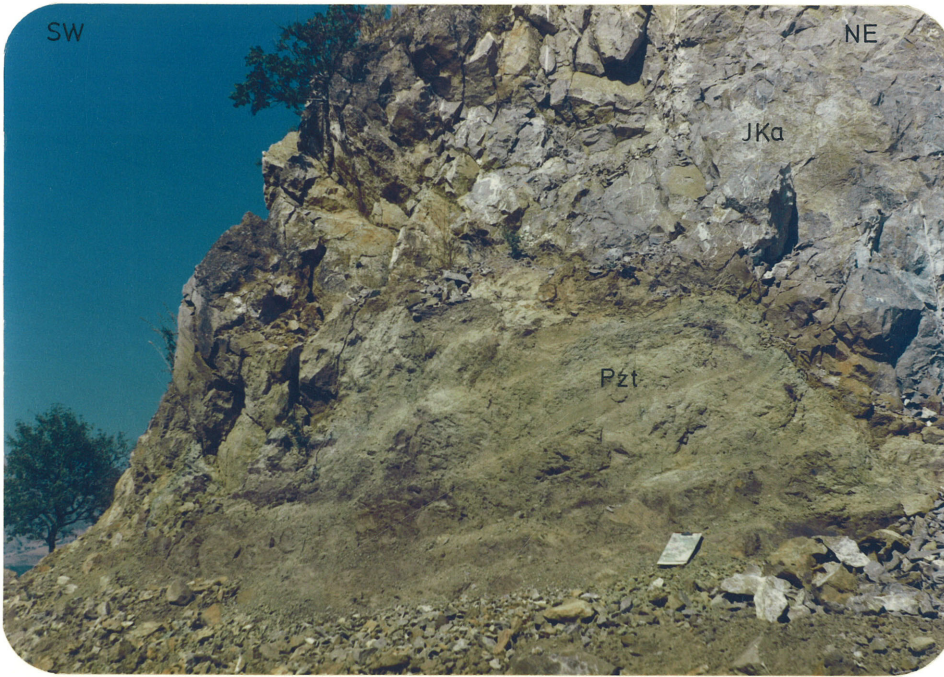


Figure 70. Close-up view of the mechanical contact (Amasya thrust) between the Amasya Group (JKa) and the green schist subunit of Tokat Complex (Pzt) (Locality: W of Amasya City).

3.1.3. Mesoscopic faults.

There are various and different types of discontinuous faults confined to a single stratigraphic unit while some of these were reactivated during later neotectonic regime. The faults confined to the Tokat Complex

(Pzt) are mostly small scale structures as it was defined in the foregoing stratigraphy chapter. The faults confined to Amasya Group (JKa) are mostly oblique strike-slip faults and thrust faults with duplex structures (Figure 71, Plate 1). The vertical faults, which were reactivated during Quaternary period, controlled the deposition of talus breccias and seasonal fluvial clastic sediments (Plate 1,3). The faults confined to the Karatepe group (Kk) are mostly characterized by reverse faults. They occur to the NW of Ziyaret village having an average trend of N40°W and dip 45° to 85°S (Figure 72,73, Plate 1). Some of the faults confined to the Cindere group (Tc) trend in N70°-80°W and N50°-60°E directions. The Cindere group (Tc) was affected by both the reverse faults trending in N70°-75°E and strike-slip faults trending in N20°-30°W (Plate 1,2).

3.2. Neotectonic Structures

The structures developed in the Pliocene-Pleistocene Suluova group and the Holocene sediments are presumed to be the neotectonic structures which are mostly strike-slip tectonic (compressional-extensional) regime in nature. The neotectonic structures are grouped as unconformities and folds, and faults.

3.2.1. Unconformities and folds.

Within the limits of the study area, two neotectonic periods, which are differentiated by a low angle angular

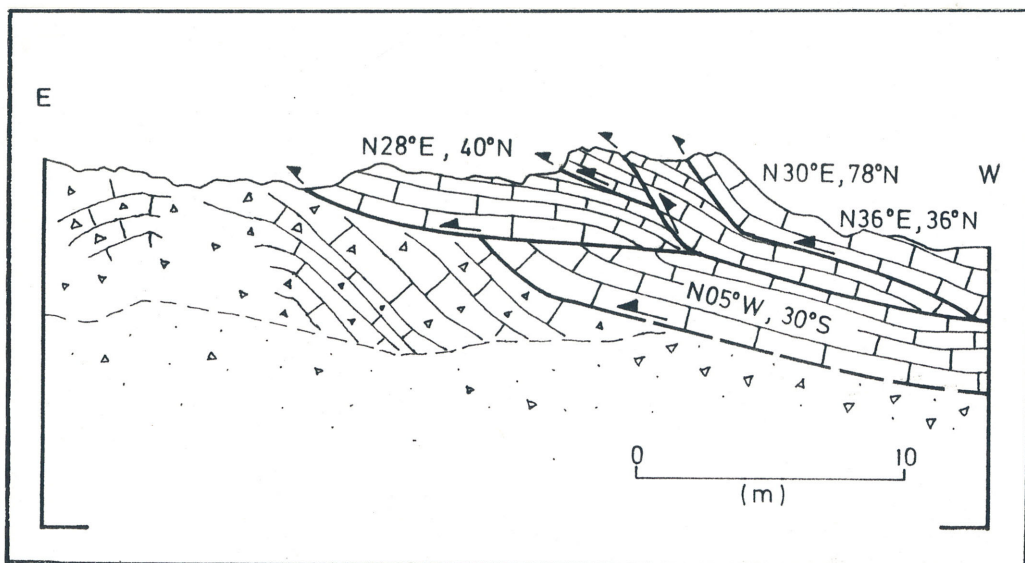


Figure 71. Sketch geological cross section from above photograph depicting a set of thrust faults and related duplex structure developed in the Amasya Group (Locality: NE of Amasya City).

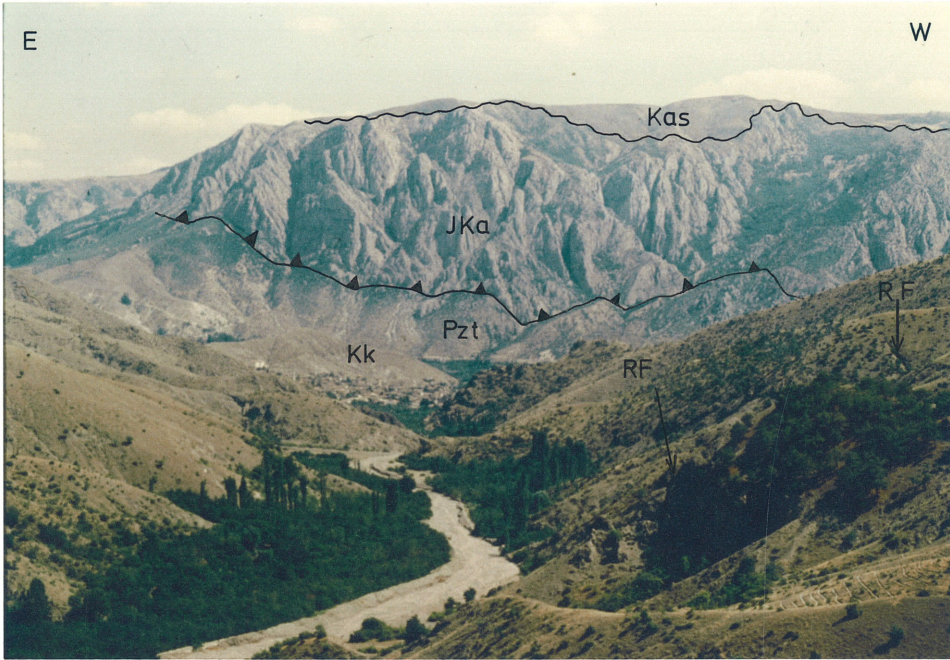



Figure 72. General view of the mesoscopic reverse faults (RF) developed within the Karatepe group (Kk). Note, the Tokat Complex (Pzt), the Amasya Group platform carbonates (JKa), the Sarılar Formation (Kas), Unc.Unconformity,  overthrust (Locality:NE of Amasya City).



Figure 73. Close-up view of a mesoscopic reverse fault developed within the Karatepe group (Locality: NW of Ziyaret village).

unconformity, were distinguished and studied. These are, namely, the pre-Holocene and Holocene tectonic periods.

Pre-Holocene period: The Pliocene-Pleistocene rocks strike dominantly in the $N70^{\circ}-80^{\circ}E$ direction with several gentle and open to tight folds. Based on the trend of fold axes, three groups of folds were distinguished. First group of folds were observed at the central and southern margins of the basin and strike $N80^{\circ}-85^{\circ}E$ and $N80^{\circ}E$, respectively (Plate 3). They are characterized by gentle, slightly plunging to non-plunging, asymmetrical to symmetrical folds. The second group of folds were observed at the eastern margin of the basin with axial trends of $N65^{\circ}-70^{\circ}W$. They are characterized by gentle, non-plunging, mostly asymmetrical folds. However, relatively older, the third group of folds trend $N10^{\circ}-20^{\circ}E$, and are characterized by open to tight, plunging and asymmetrical folds. They are observed to the east of Alişar village and west of Kutlu village, at the southern and eastern margins of the Merzifon-Suluova basin (Plate 3). The third group of folds might have been developed during the initial period of the neotectonic regime.

The Plio-Pleistocene Suluova group is overlain unconformably by the Holocene terrestrial sediments.

Holocene period: Holocene sediments filling the basin are mostly fault bounded and tilted up to 10° at several locations.

3.2.2. Faults

The faults, which sculptured the basin, are mostly vertical faults. They are manifested by sudden changes/breaks in the morphology, triangular facets, fault-controlled valleys, aligned springs, sag ponds and swamps, pressure ridges, diverted topographic ridges, offset/diverted stream channels, disappeared streams, straight fault traces, en echelon faults, tilted and folded Plio-Pleistocene to Holocene sediments, tectonic juxtaposition of neotectonic units with the paleotectonic rocks, step-like morphology, alluvial fan/apron sediments, elevated terrace conglomerates, topographic trenches, fault scarps and brecciated rocks along the linear zones. Faults bordering and dissecting the basin will be discussed as groups (fault sets) and sometimes as single faults, namely, Uzunyazı fault set, Kapancı fault set, Yolpınar fault set, Eraslan fault set, Dereağıl fault set, Tüllüçal fault, Çaybaşı fault set, Bayazıt fault set, Gödeles fault, Harız fault set, Arucak fault set, Taşlıyurt fault set, Moramil fault, Alican fault set, and Tersakan fault set (adopted from Koçyiğit and Rojay,1988).

Uzunyazı fault set: This fault set was previously recognized by DSI team (Atalay and Altuğ, 1973). Later, Şaroğlu and Arpat (1975) interpreted it as an active earth-fracture based on the aerial studies. The set extends from Yeşil hill to Yalnız village in E-W direction and bends

southward at 25° with a $N64^{\circ}W$ trend (Figure 74). Total length of this bifurcating fault set is about 12 km. The Uzunyazı fault set consists of 8 fault segments. The main fault (U-1, U-2, U-3 and U-4) extends from Yeşil hill to Çayırözü village in E-W directions and then disappears under recent alluvial plain deposits. The E-W trending Uzunyazı fault set bifurcates into 3 subbranches at 250 m SE and 1 km NE of Çayırözü village. From N to S, the fault segments trend E-W for 4 km (U-5 and U-6), $N66^{\circ}W$ for 2 km (U-7) and $N64^{\circ}W$ for 3.5 km (U-8) (Figure 74). Diagnostic features related to each fault are the diverted curvilinear topographic ridges which are oblique or perpendicular to the fault (along U-1 fault); right-laterally offset streams and dense vegetation along the faults (along U-2 fault); fault parallel aligned springs, marshes (swamps), topographic trenches, offset stream, pressure ridges and throws upto 0.5-2.0 m (along U-3 faults, Figure 75,76); pressure ridges, curvilinear fault pattern, intensely deformed and brecciated basement rocks which were brought to the surface by active faults (along U-4 faults); swamps, pressure ridge, elevated terrace conglomerates which lie 20 to 40 m above the recent alluvial plain deposits, intensely deformed Plio-Pleistocene Yedikır formation (along U-5 and U-6 faults); springs, elevated terrace conglomerates (upto 20 meters), sudden break in slope amounts (along U-7 fault); and springs, landslides, elevated and "tilted" terrace conglomerates (upto 40 meters), sudden break in slope amounts, intense

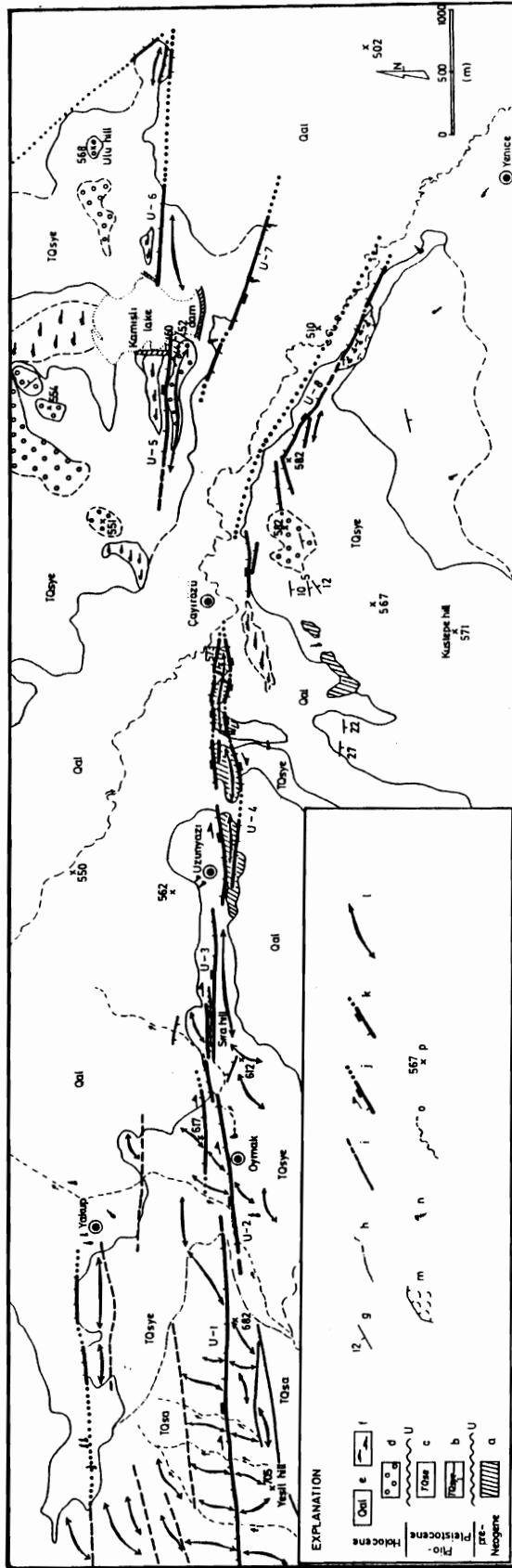


Figure 74. Geological map showing the Uzunyazi fault set (U1 to U8) and related neotectonic features. a.paleotectonic basement rocks, b.the Yedigöller formation (concealed), c.equivalent rocks of the Alisar Formation, d.terrace conglomerates, e.Holocene alluvial plain sediments, f.swamp, g.attitude of bedding plane, h.stratigraphic contact (probable), i.fault (probable), j.strike slip fault with normal component (rectangle and ticks on hanging wall) (concealed), k.fault with normal component, l.pressure and diverted topographic ridges, m.landslide, n.spring, o.stream, p.elevation point, U.unconformity (Locality: Inset map in Plate 3).



Figure 75. General view of a pressure ridge caused by the segment 3 (U-3) of the Uzunyazi fault set where the southern block was uplifted by an amount of 0.5 to 2.0 m. (Locality: W of Uzunyazi village).



Figure 76. General view of a pressure ridge caused by the segment 3 (U-3) of the Uzunyazi fault set where the northern block was uplifted by an amount of 1.8 m. (Locality: W of Uzunyazi village).

vegetation along fault lines, intensely deformed Yedikır Formation (along U-8 faults). The U-7 and U-8 faults control the Gümüşsuyu stream valley (Figure 74). The southern blocks of the U-1, U-2, U-3, U-4, U-5 and U-8, and the northern blocks of the U-6 and U-7 were uplifted. The Uzunyazı fault set disappears under recent alluvial plain sediments and probably dissects Kapancı fault set which trends obliquely to the Uzunyazı fault set (Plate 3). As a whole, this active fault set displays a right-lateral, oblique strike-slip character.

Kapancı fault set: It consists of two-right overstepped faults (K-1 and K-2) trending N32°W. They are 4.5 km and 3.5 km in length with a 750 m wide zone. Both faults control the development of Ortaova-Yalnız plains (Plate 3). The Pliocene-Pleistocene Yedikır formation was deformed by these faults. The southwestern block of the K-1 segment was uplifted by about 30-40 m which is manifested with the elevated terrace conglomerates. Along K-2 segment, the northeastern block was uplifted. Uplifted and "tilted" Holocene terrace conglomerates and sudden break in the slope amounts suggest that the Kapancı fault set is active. Uplifted and "tilted" Holocene terrace conglomerates and sudden break in the slope amounts are co-characteristics of these faults.

Yolpınar fault set: It extends from W of Kurnaz village to the Kenan hill (NE of Kışlacık village) for 17 km

in N82°W to N64°W and to N86°W trend (Plate 3). The Y-1 fault segment trends N82°W for 8 km. This segment consists of several stepovers, subparallel to parallel vertical faults resulting in a 700 m wide subzone (Figure 77). Diagnostic features are tectonic juxtaposition of the Plio-Pleistocene Suluova group with recent sediments, tilting of the Suluova group upto 80° and terrace conglomerates upto 11°, shifted topographic ridges, offset creeks, springs, topographic trenches, pressure ridges, triangular facets and sudden break in topographic slopes. The Y-2 fault segment, which is a vertical fault, extends for 4 km in N64°W direction. It is characterized by the tectonic juxtaposition of various rocks, triangular facets (Figure 78), offset creeks, the tilted Suluova group of rocks upto 21° and pressure ridges. The Y-3 fault segment is the possible continuation of the former two faults segments. The Kışlacık depression is situated to the south of the Y-3 fault segment (Figure 79). This segment extends for 7 km dominantly in a trend of N86°W direction within the study area. The Y-3 fault segment is characterized with the triangular facets (Figure 79), fault-parallel aligned springs, fault bounded Holocene depressions, elevated terrace conglomerates (upto 40 m), tectonic juxtaposition of various rocks and fault controlled Keşkel creek (Plate 3). The northern block of the Yolpınar fault set was uplifted. The Kışlacık depression was resulted from the divergence of the right lateral oblique strike-slip Yolpınar fault set (Plate 3).

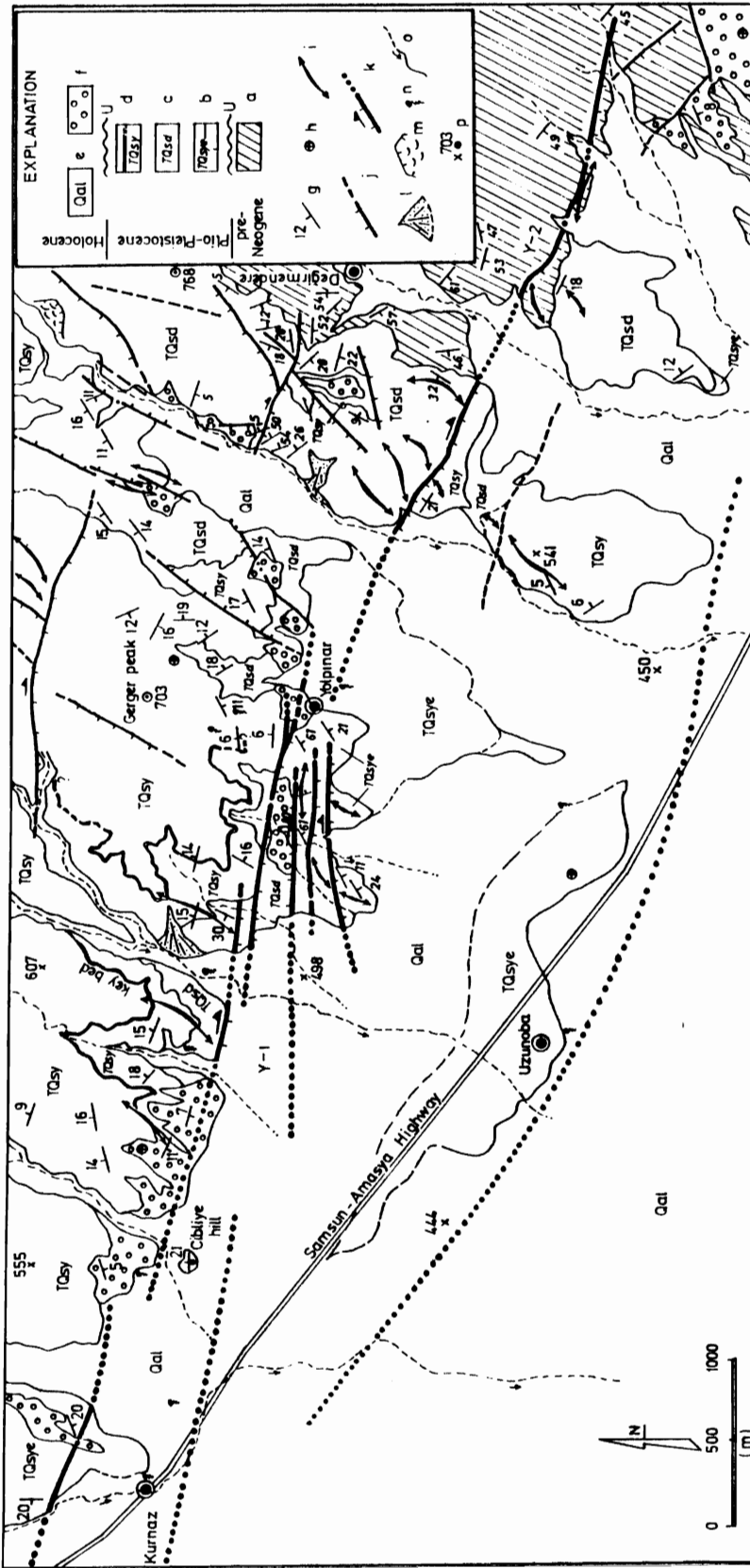


Figure 77. Geological map showing the Yolpınar fault set (Y1, Y2) and related neotectonic features. a. paleotectonic basement rocks, b. the Yedikir formation (concealed), c. the Degirmendere formation, d. the Yolpınar formation with a key horizon, e. Holocene alluvium plain sediments, f. terrace conglomerates, g. attitude of bedding plane, h. horizontal bed, i. pressure and topographic ridges, j. fault with normal component (probable), k. strike slip fault with normal component (concealed), l. alluvial fan, m. landslide, n. spring, o. stream, p. elevation point, U. unconformity (Locality: Inset map in Plate 3).



Figure 78. General view of Y-2 segment of the Yolpınar fault set which controls the NE margin of the Merzifon-Suluova basin.



Figure 79. General view of Y-3 segment of the Yolpınar fault set. Note the triangular facets and Kışlacık depression (KD). The northern block was uplifted (Locality: N of Kışlacık village).

Eraslan fault set: This fault set borders the southern margin of the Holocene part of the Merzifon-Suluova basin between Gelingiraz village and SE of Harap settlement where it trends N82°W for 11 km (Plate 3). The Eraslan fault set consists of 3 main segments, namely the Gelingiraz, Eraslan and Harap fault segments. The Gelingiraz fault segment (E-1) consists of several faults affecting the Plio-Pleistocene Suluova group and recent sediments. This segment extends for 2.5 km in the N86°W direction. Fault scarps, sudden break in slope amounts, step like topographic morphology, linear dense vegetation and triangular facets are the diagnostic morphotectonic features of the segment. The main fault segment, (Eraslan fault segment, E-2), consists of right-overstepped faults which are affecting the Eocene Cindere group, the Plio-Pleistocene Suluova group and recent sediments. It extends for 7 km in the N80°W direction where its southern block was uplifted. Triangular facets, right lateral bending in creek courses, scarps, broad alluvial fans/aprons, sudden change in slope amounts and disappearance of creeks along the fault lines are diagnostic morphotectonic features of the Eraslan fault segment. The Harap fault segment (E-3) is the right-laterally overstepped continuation of the Eraslan fault segment (E-2) with a trend of N64°W and extends for 2.7 km. Along the further east continuation of the Harap fault segment, a right lateral, pure strike-slip manifestations are recorded on a N82°W trending, 80°N dipping fault plane. The

Amasya Group (JKa) was tectonically juxtaposed with the Cindere group (Tc) of rocks. As a whole, this fault segment displays a right lateral, oblique-slip character. Especially the E-2 segment displays a tectonically young morphology.

Dereağıl fault set: It consists of several minor faults which are presumed to be connecting Taşlıyurt fault set to the Tüllüçal fault (Plate 3). Two km long, N60°W trending D-1 fault affected recent sediments deposited in a narrow fault valley (Figure 80). Rocks of the Amasya Group



Figure 80. General view of a segment of Dereağıl fault set (D-1) showing closed-fault parallel depression. JKa. limestones of Amasya Group, Qal.alluvium (Locality: N of Taşlıyurt village).

(JKa) were intensely deformed and fractured by several segments of the Dereağıl fault. Due to the uplifted northern block, talus breccias were widely deposited on its southern hanging block. The N65°W trending D-2 and D-3 fault segments intensely sheared the Amasya Group (JKa). At the edges of the uplifted southern blocks, the Plio-Pleistocene Suluova group was tilted upto 10°. Talus breccias, thick and broad alluvial fans with aprons were deposited on the downthrown blocks of D-2 and D-3 fault segments. Within the Dereağıl fault set, a travertine, whose natural formation has been already stopped, is observed along N-S trending right-lateral strike-slip fault.

Tüllüçal fault: It extends from SW of Geyiközü to S of Ortaçal hill for 3.8 km in the N60°W direction (Plate 3). Along this fault, some fresh fault-related features are observed in recent deposits to the west of Ortaçal hill. The Tüllüçal fault juxtaposes tectonically the Cindere group (Tc), the Amasya Group (JKa) and the North Anatolian Ophiolitic Melange (NAOM). Both ends of the fault disappear under recent sediments. Fe-oxidation zones and intense brecciations are observed in rocks, especially within the Amasya Group (JKa) rocks and topographic trenches are developed within the NAOM. The Tüllüçal fault can be accepted as the continuous segment of the Dereağıl fault set.

Caybaşı fault set: It runs for over 14 km from SW of Caybaşı village to NE of Sarıbuğday village with an average trend of $N49^{\circ}E$. The fault sets are dissected by E-W trending faults which are the possible continuation of the Bayazıt fault set. The faults control the valley of Bulanık stream. The diagnostic features are diverted creeks, die out of creeks along faults, uplifted blocks, sudden changes in topographic slopes, deeply dissected Bulanık stream valley, steep slope alluvial fans, aligned springs, landslides, triangular facets, step-like morphology and tectonic juxtaposition of different rocks at fault scarps.

Bayazıt fault set: It consists of stepovers and parallel faults with a trend of $N75^{\circ}W$ to E-W and extends for 2.5 km to the S of Bayazıt village (Plate 3). Three stepover faults with an average trend of $N75^{\circ}W$, are situated to the north of the Gürgenli hill. These faults affected the Plio-Pleistocene Suluova group resulting in tilting upto 24° . Segment 2 of the Bayazıt fault set (B-2) controls and probably offsets right-laterally Köy creek by about 80 m. The southern blocks of the fault segments (B-1, B-2, B-3) were uplifted. Segment 4 (B-4) trends $N85^{\circ}E$ and runs for 2 km to the S of the Gürgenli hill, where northern block is uplifted. Landslides and Fe-oxidation zones are observed along the fault line. Sudden break in the slope of topography, abrupt change in strikes and dip amounts of the rocks, landslides, juxtaposition of the Eocene Cindere group with the Plio-Pleistocene Suluova group, Fe-oxidation zones,

intense deformation in rocks near the fault lines and elevation differences of upto 50 m in the rocks of the Suluova group along the segment 2 (B-2) indicate that the Bayazıt fault set is active.

Gödeles fault: It is probably the continuation of the Bayazıt fault set. The Gödeles fault trends in the E-W direction for 4.1 km from NW of Yuvala village to NE of Gödeles village (Plate 3). The Plio-Pleistocene Suluova group is hanged on uplifted southern block of the Gödeles fault with a fresh fault scarp forming triangular facets to the N of Gödeles village. On the fault line, the Suluova group (TQs) was tilted upto 24° . Basement rocks were mylonitized and brecciated along the Gödeles fault. Due to lack of any direct evidence for its lateral movement besides its vertical motion, its character is under discussion.

Arucak fault set: It is a $N75^{\circ}W$ trending fault set consisting of several subparallel faults. The Arucak fault set runs for 4 km from E of Arucak village to SE of Alabedir village (Plate 3). The main fault segment is concealed with talus and terrace conglomerates. The Arucak fault set cuts the Amasya Group (JKa), the Cindere group (Tc) and the NAOM mass. The southern blocks of the fault segments were uplifted. Sudden break in the slopes of topography, fault aligned springs, thick talus breccias, brecciation and Fe-oxidized zones in the Amasya Group of rocks are some of the indications of the fault set. However, there is not any

direct evidence for the activity of the fault, especially for a right-lateral movement except overstepping of faults. This fault set is probably the continuation of the Bayazıt fault set and Gödeles fault which links them to the Taşlıyurt fault set (Plate 3).

Taşlıyurt fault set: This fault set consists of several subparallel, parallel and stepover faults with an average trend of $N70^{\circ}W$. It runs for 6.5 km from NW of Taşlıyurt village to W of Moramıl village where the Dereağıl fault set and Taşlıyurt fault set meet and disappear beneath recent alluvial sediments. The probable southeastern continuation of these two fault sets is the Moramıl fault (Plate 3). It continues toward east for 2 km in the $N75^{\circ}W$ direction. The Taşlıyurt fault set is well-developed in the Eocene Cindere group and the NAOM. Dominantly the southern blocks of the fault segments were uplifted and dissected by N-S to $N10^{\circ}W$ trending right-lateral oblique-slip faults (Figure 68, Plate 3).

Moramıl fault: It extends for 2 km from Moramıl village to Uzun ridge in a trend of $N75^{\circ}W$ (Plate 3). Diagnostic features of the Moramıl vertical fault are the fault parallel aligned springs, tectonic juxtaposition of rock units, topographic trenches, intense deformation and brecciation of the basement rocks, sudden changes in strike and dip of the Cindere group (Tc) along the fault lines and active landslides (Plate 3).

Harız fault set: This is one of the vertical fault set exposing further south within the study area. It extends from SW of Selimiye village to the SE of Gödeles village in the $N78^{\circ}E$ direction for over 12 km in three main segments (Plate 3). The Harız fault set affected the Amasya Group (JKa), the Cindere group (Tc), the Tokat Complex (Pzt) and the NAOM mass. A topographic trench developed in the Cindere group, landslides, fault controlled valley of Köy creek, fault parallel aligned springs, long and narrow depressions which were filled by recent alluvial sediments, Fe-oxidation and brecciation in the Amasya Group are the evidences for the activity of the Harız fault set. There is not any direct evidence for the sense of movement of the Harız faults. In its western segment the southern block, and in its eastern segment the northern block were uplifted.

Alican fault set: This fault set trends obliquely to the Eraslan and Dereağıl fault sets. It consists mainly of 3 fault segments with uplifted southern blocks which display a well-developed north facing step like morphology (Plate 3). Segments of the Alican fault set run in $N80^{\circ}E$, $N67^{\circ}E$ and $N69^{\circ}E$ trends with 4 km, 3km and 3.1 km lengths, respectively (Plate 3). The Suluova group (TQs), the Cindere group (Tc) and the Amasya Group (JKa) were deformed, and alluvial sediments, talus sediments and travertine accumulations were controlled by the Alican faults. The diagnostic fault-related features are right-lateral diversion in streams, fault controlled alluvial fans, mechanical surfaces

(brecciation, recrystallization and Fe-oxidization) on the limestones of Amasya Group, tectonic juxtaposition of rocks, sudden break in topographic slopes, straight fault traces, talus breccias, disappearance of streams along the fault lines, and travertine occurrences at Alican hill whose natural formation has already been stopped. These faults might be the tensile bridges between the Eraslan and Dereağıl fault sets.

Tersakan fault set: It controls the Tersakan river gorge and follows a general trend of $N42^{\circ}W$ for 8.2 km starting from Boğazköy village and extending upto the SW of Ziyaret village (Plate 3). The Tersakan fault set consists of several subparallel to stepover faults of 1 to 2 km long exposing within a 750 m wide zone. Further southeastward, the Tersakan fault set bends in a counter-clockwise sense at 25° and runs in the $N70^{\circ}W$ direction for 2 km with reverse character (Plate 3). The diagnostic features of the Tersakan fault set are the steep-slope alluvial fans, fault-controlled streams and creeks, triangular facets, tectonically juxtaposed basement rocks and recent sediments, mechanic surfaces manifested by brecciation and Fe-oxidation on rocks and narrow Tersakan fault valley. A huge travertine occurrence whose natural formation has already been stopped, is observed within the fault set. The Tersakan fault set is probably a right lateral, oblique to reverse in character (Plate 3).

3.3. Neotectonic Characteristics and Origin of the Merzifon-Suluova Basin

The recent configuration of Turkey and the surrounding region is shaped by the continental escape of the Anatolian "Block" as a result of the post-collisional convergence of the African-Arabian plates and the Eurasian plate under N-S directed compressional system (McKenzie, 1972, Şengör, 1980; Şengör and Yılmaz, 1981). The neotectonic framework of Turkey is characterized by a great variety of deformational structures, the largest of which belong to strike-slip fault systems. These two major intracontinental "transform" faults shaping the neotectonic frame of Anatolia are the dextral North Anatolian and sinistral East Anatolian transform faults (Figure 1). The Anatolian "Block" moves westward relative to the Eurasian and African-Arabian plates along these transform faults (Figure 1). Several relatively narrow depressions are aligned parallel or subparallel to these fault zones. However, the basins situated at the interaction domains between the major splays and the North Anatolian Fault Master Strand are more complex and problematic as in the case of the Merzifon-Suluova basin (Figure 81). The Merzifon-Suluova basin is located to the north of the Ezinepazarı fault (Blumenthal, 1950; Ambraseys, 1970; Aktimur et al., 1990; Tatar et al., 1990) and to the south of the North Anatolian Fault Master Strand (NAFMS) (Blumenthal, 1945; 1950; Öztürk, 1980; Dirik, 1991) (Figure 81).

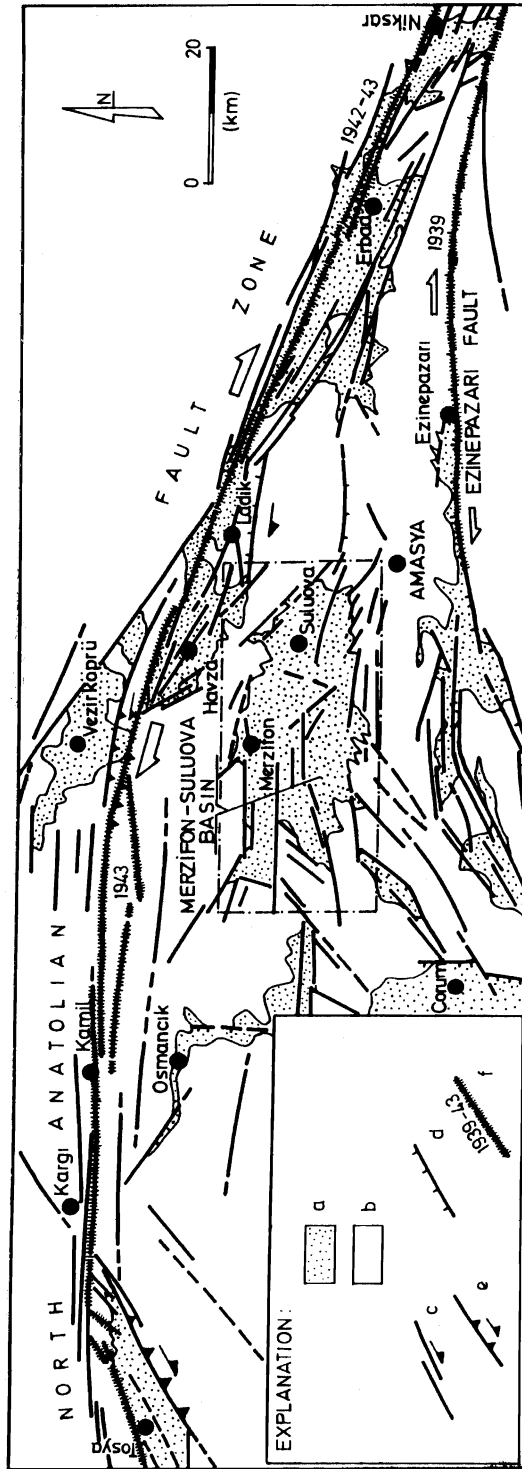


Figure 81. Simplified neotectonic map showing the location of the Merzifon-Suluova basin. a. neotectonic basins, b. paleotectonic basement, c. strike slip fault, d. probable normal faults, e. strike slip fault with reverse component, f. 1939-1943 earthquake ruptures. Modified from Blumenthal, 1943; 1945; 1950; Ambraseys, 1970; Öztürk, 1976; 1980; Allen, 1982; Barka, 1984; Dirik, 1991; MTA 1:500 000 Geological Map Set; and partially supported by Landsat and aerial photographic study.

Morphotectonics: The Merzifon-Suluova basin is a 50-55 km long and 15-20 km wide rhomboidal strike-slip depression with its long axis parallel to NAFMS (Figure 81,82). The basin is bounded and divided into several blocks by oblique strike-slip faults (Figure 82). Relative vertical and lateral movements between blocks increase the topographic slope amounts and elevation differences of the margins. At the northern margin of the basin, the highest peak (outside the study area, Yuvala hill, N of Merzifon town) reaches up to 1900 m and the lowest elevation at the northern margin of the basin is 884 m, where the resultant topographic elevation difference is 1016 m. By the same method, the topographic elevation difference at the western margin is 1123 m; at SW margin, 559 m; at the southern margin, 447 m and 671 m, and at the eastern margin it is 559 m. Slopes of the margins are 10° on the basement rocks and 2° on the neotectonic basinal part at the northern margin, 13° and 1.2° at the western margin, 7° and 1.7° at the southern margin and 9° and 3° at the eastern margin. The southern and eastern margin display a step-like morphology. The gentle slopes are the result of retreat of fault scarps and triangular facets, and well-developed alluvial fan/apron/plain interactions (Figure 82,83). These may indicate a relatively slow tectonic movement or high rate of erosion and sedimentation relative to fault activity or both.



Figure 82. Simplified neotectonic map of the Merzifon-Suluova basin. 1. Basement rocks, 2. Plio-Quaternary basin fill (Suluova group), 3. Holocene alluvial plain sediments, 4. recent depocenter, 5. fluvial sediments, 6. strike slip fault, 7. reverse fault, 8. and 9. alluvial fans with huge aprons or relatively older ones (9), 10. braided river pattern, 11. meandering river pattern, 12. earthquake epicenter, BFS: Bayazıt fault set, ÇFS: Çaybaşı fault set, DFS: Dereağıl fault set, EFS: Eraslan fault set, GF: Gödeles fault, HFS: Harız fault set, TFS: Taşlıyurt fault set, Tefs: Tersakan fault set, UFS: Uzunyazı fault set, YFS: Yolpınar fault set, Ç.Çetmi, Çe.Çetlek, E.Eraslan, G.Gödeles, K.Kışlacık, M.Moramıl, U.Uzunyazı, Y.Yolpınar, Ya.Yakup. (Modified from Koçyiğit and Rojay, 1988).

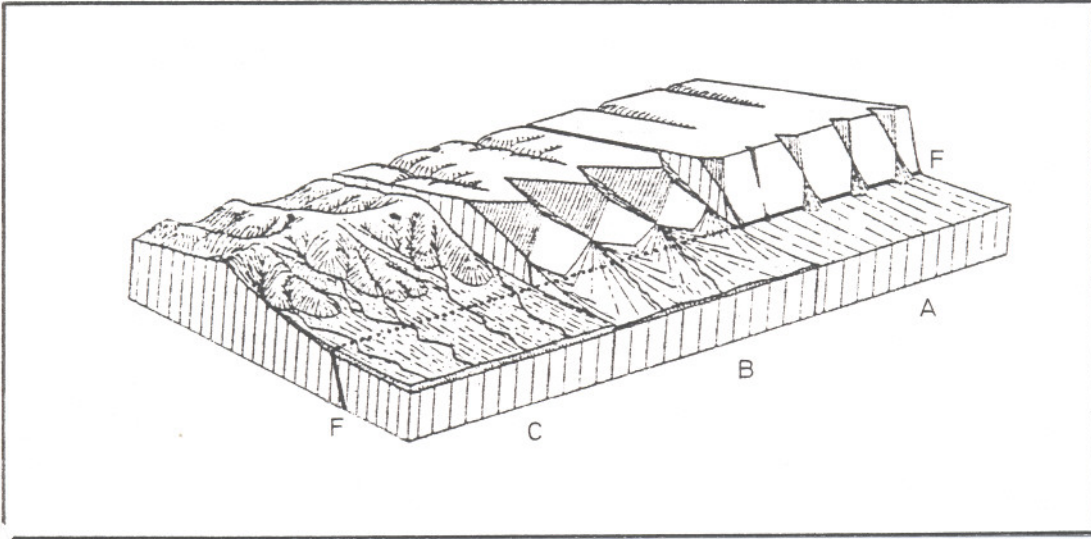


Figure 83. Retreat of fault scarps and related physiographic landforms developing along faults during the period of time. Letters A to C indicate younger to older morphologies, respectively. F.fault, dotted line is the continuation of fault beneath sediments.

There are several streams flowing from mountains and entering the basin. Most of these subsequent streams die out and leave their load in alluvial fans or along the fault lines. As they enter the basin, they are structurally controlled by faults. The drainage system in the basin is dominantly consequent which follows the fault valleys up to recent depocenter (Figure 82, Plate 2). The main drainage systems within the basin are Köselер stream, Keçiköy and Gümüşsuyu streams, Bulanık stream and Tersakan stream whereby each stream flows through fault valleys (Figure 82). The main drainage system, Tersakan stream, flows across the basin by entering from Çeltek area (N of Suluova town) and leaving the basin after Boğazköy village. Within the basin,

Tersakan stream flows in southward direction in a braided stream pattern for 15 km. It bends and flows in N75°W direction with a meandering stream pattern when it enters the recent depocenter (Figure 82). After Boğazköy village, Tersakan stream flows through a deeply dissected fault valley in the N45°W direction and finally joins Yeşilırmak river in Amasya City.

Basin fill: The basin is filled with the Plio-Pleistocene fluvial to lacustrine sediments (the Suluova group) and the Holocene fluvial sediments (Figure 82). The Plio-Pleistocene period fills are characterized by marginal and basinal units. Marginal units are coarse-grained clastics of alluvial to fluvial settings, which are the result of rapid sedimentation and having over 140 m thickness. The basinal units are fine-grained clastics with lacustrine deposits which are at least 20 m thick. However, the total thickness of the Plio-Pleistocene period fills is over 400 meters (Atalay and Altuğ, 1973). The Holocene period fills are characterized by marginal and basinal units, too. The marginal units are coarse-grained clastics of thick alluvial fans, aprons, active braided river plains, talus breccias, seasonal fluvial clastics and terrace conglomerates that are the result of rapid and seasonal sedimentation. The thickness of the marginal units is over 40 m. The basinal units are fine-grained clastics of alluvial plains, marshes, meandering river clastics and seasonal playa lakes with a thickness of over 10 m. The

total thickness of the basin fill is over 510 m (Atalay and Altuğ, 1973, and this study).

Pattern of Neotectonic Structures and Their Kinematic Interpretation: Major faults shaping the Merzifon-Suluova basin are in various lengths, directions and types. Three major fault groups co-operate in the development of the basin. They are the WNW to E-W, NW and NE trending faults. The Merzifon, Çetmi, Uzunyazı, Yolpınar, Eraslan, Bayazıt, Gödeles, Arucak and Taşlıyurt fault sets are the WNW and E-W trending faults; the Saraycık, Sallar, İmirler, Kapancı, Dereağıl, Tüllüçal and Tersakan fault sets are the NW trending faults; the Çitli and Çaybaşı fault sets are the NE trending faults (Figure 82). The İmirler, Sallar, Saraycık, Merzifon and Suluova fault sets control the northern and eastern margin of the Merzifon-Suluova basin. The earthquake epicenters are located on these fault sets (Figure 82). The faults within the basin display a system of stepover fault pattern and trend almost in the E-W direction. Southernmost stepover fault controls the development of southern margin. The first group of faults are parallel or subparallel to NAFMS (1939, 1942, 1943 earthquake rupture lineament of Blumenthal (1950)). Others are the secondary synthetic (R) and antithetic (R') faults. The NW trending ones are right lateral synthetic and NE trending ones are left lateral antithetic faults. The splay out faults (P-shear) are counted with master faults (Y-shear). Based on the length weighed rose diagram, whole of

the neotectonic structures of the mapped-study areas are reflected a well-developed dextral strike-slip fault system (Figure 84). According to the Reidel shear terminology (Tchalenko and Ambraseys, 1970), Y-shear trends in N80°W, Reidel shear (R) in N50°W, conjugate Reidel shear (R') in N20°E, P-shear trends in almost E-W and poorly developed tension fracture (T) trends in N25°W directions (Figure 84). The cumulative resultant principal stress axis is 335°N which is somehow diverted from actual compression directions, as 354°N obtained from fault plane solutions (Canitez, 1973) and 330°N from statistically measured (Dirik, 1991) based on the NAFZ earthquake rupture lineament which trends E-W to N76°W. Studies on a N60°W/90° trending oblique strike-slip fault plane with a rake of 19°S manifested that the direction of principal stress axis is 330°N (Figure 85A,86). The average fold axis direction is N85°E to E-W which was statistically calculated from the bedding attitudes of the Plio-Pleistocene units (Figure 85B).

Origin of the Merzifon-Suluova Basin: The Merzifon-Suluova basin is located to the south of the NAFZ and north of the Ezinepazarı fault zone (Figure 81). The 55 km long, 20 km wide rhomboidal Merzifon-Suluova basin has been segmented into several sub-basins by overstep and second order faults. Initially several small pull-apart basins (sub-basins) appeared as a result of initiation of faulting at the center of the Merzifon-Suluova basin. As the slip on

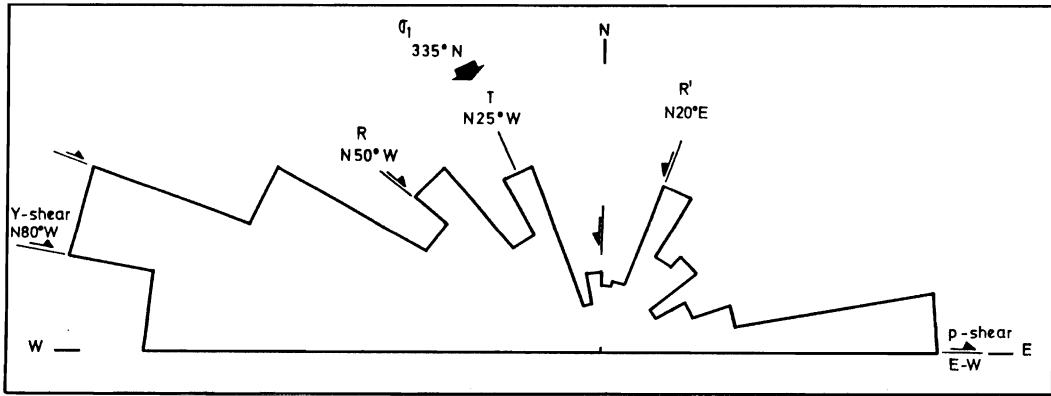


Figure 84. Rose diagram showing dominant trends of faults and major principal stress axis ($\sigma_1=335^\circ\text{N}$) operating during the evolution of Merzifon-Suluova basin.

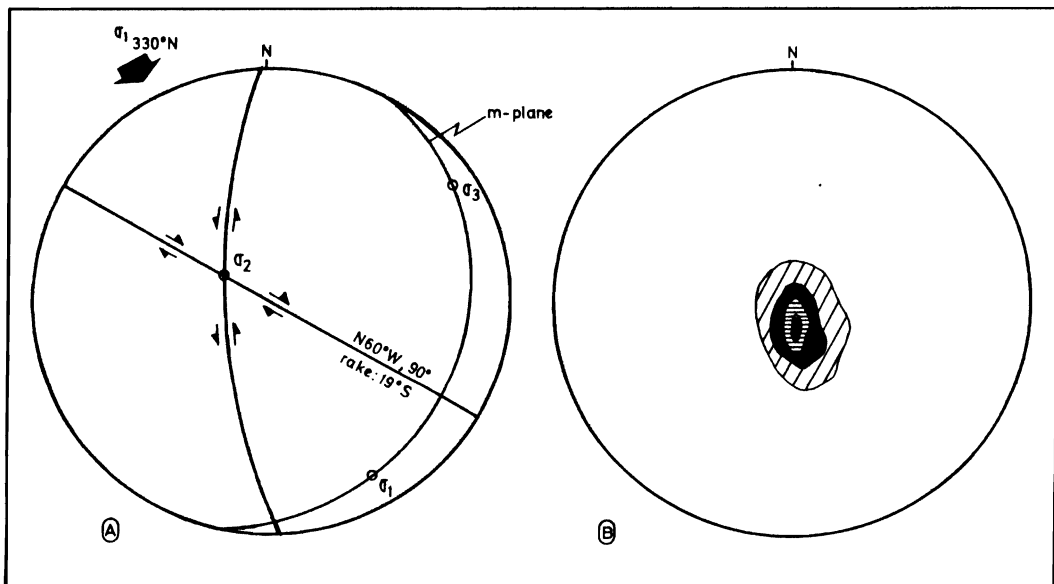


Figure 85. A. Equal area-lower hemisphere projection of an oblique-slip fault with an attitude of $\text{N}60^\circ\text{W}/90^\circ$ and a rake of 19°S . Orientation of the major principal stress (σ_1) operated on Yolpinar fault set and its conjugate is 330°N . B. a contour diagram prepared from 216 bedding planes of Plio-Quaternary rocks (Suluova group) points out a broad fold with axis trending at $\text{N}85^\circ\text{E}$ (equal area-lower hemisphere projection).



Figure 86. Close-up view of a $N60^{\circ}W/90^{\circ}$ trending fault plane with a rake of $19^{\circ}S$ on Y-1 segment of the Yolpınar fault set (Locality: Cibliye hill, SE of Kurnaz village).

the faults increases, each small pull-apart basin randomly began to coalesce into larger composite one, especially along the western and southern margins of the basin. A possible regional uplift cooperated the system by reactivating the paleo-faults. The northern domain (Tavşandağ and Akdağ mountains) and southern domain ("Amasya highland") were uplifted relative to the basin as a result of bending of the NAFMS (Koçyiğit and Rojay, 1988; Dirik, 1991). The random coalescence and interaction processes in subbasins resulted in complex arrangement of sub-basins and tectonic domains, and formation of a composite pull-apart basin (Garfunkel, 1981; Aydın and Nur, 1982; Koçyiğit and Rojay, 1988).

CHAPTER IV

GEOLOGICAL EVOLUTION

The Tethyan evolution of Pontides took place at two main phases, namely, pre-Tethyside and Tethyside (Cimmeride and Alpidic) orogenesis (Şengör, 1984; 1985) in which paleo-Tethyan and Neo-Tethyan evolution were discussed where partly overlap in time (Şengör and Yılmaz, 1981). The Paleo-Tethyan closure evolution was mainly governed by the "south" dipping subduction of Paleo-Tethys during Late Permian - Liassic interval (Şengör and Yılmaz, 1981). During Permian, Anatolia was a part of the northern margin of Gondwana Land (Şengör and Yılmaz, 1981; Şengör *et al.* 1988). A basin (Karakaya Basin) opened on Cimmerian Continent during Triassic period as a result of southward subduction which was closed by Earliest Jurassic times in Central Pontides (Şengör and Yılmaz, 1981; Koçyiğit *et al.* 1991). During Early Liassic, disintegration behind the Paleo-Tethyan magmatic arc gave rise to the birth of northern branch of Neo-Tethys with subbranches, namely the Intra-Pontide and Izmir-Ankara Oceans to the north which were possibly the eastern continuation of the Vardar Ocean (Şengör and Yılmaz, 1981). After the closure of the Paleo-Tethys, only Neo-Tethyan Oceans were left in Tethyan realm. The widening of the northern branch of the Neo-Tethys lasted by the end of Early Cretaceous (Şengör and Yılmaz, 1981; Koçyiğit *et al.* 1988; Altıner *et al.* 1989; Koçyiğit *et al.* 1991). Its progressive

contraction began and it was eliminated completely by a north dipping subduction resulting in a widespread ophiolite obduction on the Anatolian "Block" (Şengör and Yılmaz, 1981; Dixon and Robertson, 1984; Koçyiğit et al. 1988; Koçyiğit, 1991). Continuous subduction resulted in the amalgamation of tectonic units and closure of marginal basins until the end of Miocene. The earliest Pliocene was the beginning of a strike-slip tectonic regime in Turkey (Tokay, 1973; 1982; Barka and Hancock, 1984, Koçyiğit and Tokay, 1985; Koçyiğit and Rojay, 1988; Koçyiğit, 1989). The continuous N-S oriented compressional system resulted in the westward escape and counterclockwise rotation of the Anatolian Block along two main strike-slip faults, namely the North Anatolian Transform Fault (NATF) and East Anatolian Transform Fault (EATF), onto the ocean floor of eastern Mediterranean Oceanic realm (Molnar and Tapponier, 1975; Tapponier, 1977; Le Pichon and Angelier, 1979; Rotstein, 1984) (Figure 1).

4.1. Post-Triassic Evolution of the Central Pontides (Rhodope-Pontide Fragment) in Amasya Region.

Central Pontides are characterized by the presence of various imbricated piles of tectonic units belonging to the pre-Tethyside and Tethyside orogenic systems transcuted by the North Anatolian Fault Zone during Pliocene. Each orogenic phase was overprinted onto pre-existed one which gave rise to the complexity of the region. The main tectonic

units, which were distinguished by means of their age, lithostratigraphic evolution, internal organisation and tectonic position, are the Paleozoic metamorphic complex (Tokat Complex), the Triassic melange (Olukman complex of Karakaya Group of Koçyiğit et al. 1991), the Jurassic-Cretaceous carbonates (Amasya Group), the Upper Cretaceous ophiolitic melange (North Anatolian Ophiolitic Melange), the Upper Cretaceous forearc flysch sequence (Karatepe and Kışlacık groups), the Eocene flysch sequence (Cindere group), and the Plio-Pleistocene molasse deposits (Suluova group) (Figure 5).

The post-Triassic Neo-Tethyan evolution in the study area started with the Liassic carbonate-clastic deposition (Vermiş formation) on the pre-Triassic basement rocks (Tokat Complex) (A1 in Figure 87). The initial rifting failed and the platform was uplifted during post-Liassic - pre-Callovian period. The uplifted platform turned into an open-marine depositional realm where Ammonitico Rosso facies (Paşaoğlanınçal member of Ferhatkaya Formation) was deposited during Callovian (A3 in Figure 87). The open-marine depositional period was followed by a regressive platform carbonate deposition (Horoztepe member of Ferhatkaya Formation) during Callovian-Valanginian period. After a short period of non-deposition, the ongoing rifting continued with the deposition of deep-sea pelagics (Gezilikdere member of Sarılar Formation) and pelagic turbidites (Yavru member of Sarılar Formation) on the tilted

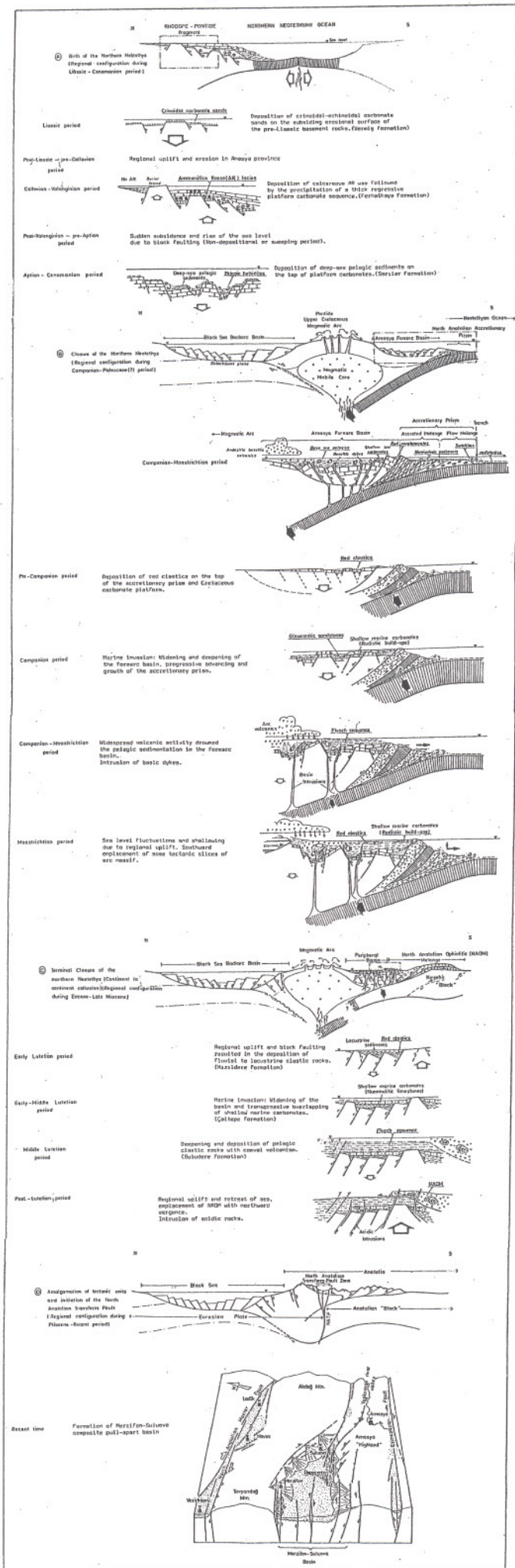


Figure 87. Tentative sketch cross sections depicting post-Triassic evolution of northern branch of the Neo-Tethys in Amasya region.

platform carbonates during Aptian-Cenomanian period (A5 in Figure 87). Thus, the passive margin was already destructed and turned into an active continental margin as a result of northward subduction of northern branch of the Neo-Tethyan oceanic crust beneath Rodop-Pontide "fragment" during post-Cenomanian - pre-Campanian interval. By the development of an accretionary prism to the south and related magmatic arc to the north, a constructive-type forearc basin (Amasya basin) was constructed both on the continental tectonic slices (Tokat Complex and Amasya Group) and mobile accretionary prism during Middle Campanian-Maastrichtian (Koçyiğit et al. 1988). Thermal doming beneath the future magmatic arc and tectonic transportation of accretionary prism resulted in rifting and deposition of fluvial to fan-delta sediments (red clastics of the Geyiközü Formation) on the edges of the elevated fault blocks (B1,B2 in Figure 87). Marine invasion followed the continental rifting, and narrow, restricted troughs were filled by the lagoon to shallow marine sediments (neritic-clastic sequence of the Geyiközü Formation) during Campanian (B3 in Figure 87). Growth and oceanward migration of accretionary prism accelerated the rate of rifting in the forearc basin. As a result, entire region was invaded by sea and opened to deep sea conditions during Middle Campanian-Maastrichtian interval (B4 in Figure 87). The successive deposition of a thick flysch sequence (flyschoidal part of the Geyiközü Formation) was intruded by basaltic dykes, and sudden slope

amount changes resulted in the development of huge gravity-induced slump folds and emplacement of olistoliths. Stratigraphically repeated slump structures are the records of continuous and long-term tectonic activity (growth of accretionary prism) in the basin during Middle Campanian-Maastrichtian interval. The initial arc volcanism was recorded during that time (B4 in Figure 87). Later on, sedimentation was dominated by the accumulation of widespread volcanic rocks, shallow marine carbonates and red clastics in the region during Maastrichtian (B5 in Figure 87). Whole of the area was almost covered by the andesitic-basaltic lavas, breccias, tuffs and volcanoclastic rocks (Karainışdere member of the Fındıklı Formation). Rudistid buildups (Kepeztepe member of the Fındıklı Formation) grew on uplifted hot marine areas such as the volcanic sea mounts and horsts. The basin was almost drowned by the arc volcanics in which caused sea to retreat. Sea level fluctuations, elevated terrains and tectonic activity caused periodic shallowing and deepening in the basin during Maastrichtian. As a result, continental to restricted lagoon to pelagic sediments were deposited and accompanied by widespread rudistid buildups and olistoliths (Kışlacık group)(B5 in Figure 87). Rudistid buildups alternated with clastic rocks (the Tuzlugersin formation) accumulated at the top of a south-facing elevated Upper Cretaceous pelagic carbonate sequence during Maastrichtian. The rudistid buildup - bearing sequence was followed by the accumulation of

volcanic breccias, and later on by the alternation of volcanic rocks, rudistid build-ups and red clastic rocks (the Çoraklıağzı formation). The paleo-slope activities caused rudistic build-ups, Upper Cretaceous carbonate and metamorphic rock olistoliths to slide into the basinal successions. Accordingly, southward-overthrusting of the tectonic slices of arc massif produced deposition of conglomerates (the Susuz formation) and emplacement of some metamorphic olistoliths into the basin during latest Maastrichtian-probably Paleocene(?) time interval (B5 in Figure 87). The continuous arc volcanic activity made the scheme of depositional setting much more complex. Ongoing emergence in the Amasya region and the cumulative amalgamation of the accretionary prism were followed by a newly arising extensional regime during Lutetian (C in Figure 87). The rifting was recorded by the deposition of red clastic rocks of fluvial to proximal fan origin (the Kızıldere formation) at the edges of faulted blocks (C1 in Figure 87). Deposition of red clastic rocks were followed by the sedimentation of distal fan clastic rocks to prodelta silty shales (C1 in Figure 87). As a result of sudden marine invasion, shallow-marine carbonates (the Çaltepe formation) overlap transgressively the pre-existing rocks during Early-Middle Lutetian (C2 in Figure 87). Transgressive overlapping of a flysch sequence (the Suludere formation) under prevailing open to deep marine depositional conditions took place during Middle Lutetian (C3 in Figure 87). The

retrocharrriage of accreted melange (North Anatolian Ophiolitic Melange) was followed by the dacitic intrusions (Moraml dacite) due to the thickening of crust beneath the basin (C and C4 in Figure 87). The entire region emerged under the control of a N-S directed compressional-contractional regime until the initiation of a new tectonic regime, namely the strike-slip tectonic regime. The conversion of compressional-contractional regime into compressional-extensional regime (strike-slip regime) led to the creation of a composite pull-apart basin, the Merzifon-Suluova basin, which is one of the diagnostic record of the neotectonic regime (Koçyiğit and Rojay, 1988) (D in Figure 87).

CHAPTER V
CONCLUSIONS

The tectonostratigraphy and tectonics of the Amasya Region and neotectonics of the Merzifon-Suluova basin were investigated based on the 1:25 000 scale geological mapping, and the following were concluded:

1. The tectonostratigraphy of the Amasya Region is set by the study of rocks in the interval of Paleozoic to Recent. Lithostratigraphic units consist of five groups, eighteen formations and nine members-subsequences. A complex, an ophiolitic melange and dacitic intrusions, were distinguished as lithodemic units. Holocene units were subdivided into seven sedimentary facies.

2. The low-grade (green schist facies) metamorphics were divided into two subsequences and interpreted as active continental margin volcanosedimentary sequence, which is probably an arc-related sequence, on the basis of protolithologies of pre-Liassic age.

3. Previously named Jurassic - Cretaceous platform carbonates ("Amasya Kalke") were renamed as the "Amasya Group" of Liassic-Cenomanian age.

4. The crinoidal-echinoidal detrital rocks were interpreted as skeletal sands and formally named as the "Vermiş formation".

5. Dogger is missing except Callovian stage.

6. The Jurassic-Cretaceous platform carbonates were subdivided into two members: (1) Paşaoğlanınçal and (2) Horoztepe members. A red, Ammonitico Rosso facies (Paşaoğlanınçal member) was recognized at the base of Jurassic-Cretaceous platform carbonates and dated Callovian in age, which was previously dated to be Sinemurian-Toarcian. Callovian-Middle Valanginian platform carbonates, deposited in regressive cycle, was named as the Horoztepe member.

7. The Jurassic - Cretaceous platform carbonates are overlain unconformably by Aptian-Cenomanian pelagics. These pelagics, which were previously named as the Sarılar Formation, were subdivided into two members, namely the Gezilikdere and Yavru members.

8. The chaotic mixture of various blocks of tectonic melange were studied in detail and renamed as the North Anatolian Ophiolitic Melange (NAOM). The matrix is made up predominantly of red to dark green massive argillaceous-arenaceous ophiolitic clasts with diabasic-mafic and serpentinite breccias. In addition to Jurassic-Cretaceous carbonate blocks, Asselian-Sakmarian, Uppermost Tithonian-

Lower Berriasian and Callovian-Middle Valanginian limestone blocks were also recognized within the melange.

9. The NAOM was interpreted as an accreted melange developed at a convergent margin.

10. The Upper Cretaceous flysch sequence was subdivided into two groups and named as the Karatepe and Kışlacık groups with newly introduced formations.

11. One of the widespread sedimentary sequences was dated to be Lutetian in age, and it was proved that it indicated a typical passive rift margin evolution. This sequence was named as the Cindere group with three newly distinguished formations.

12. A crab possibly belonging to section Brachyrhyncha of infraorder Brachyura was detected and dated Middle-Late Lutetian in age by correlating it with the benthic foraminifers.

13. Dacitic intrusions resulted from continental thickening were distinguished and dated post-Late Lutetian - pre-Pliocene in age.

14. The Plio-Quaternary neotectonic units were named as the Suluova group with four formations. The sequence was dated to be Pliocene-Pleistocene in age based on gastropods.

15. In addition to previously known stratigraphic gaps, two more regional unconformities were detected and

well-defined. These are the pre-Calloviaian and pre-Aptian unconformities.

16. The large-scale overthrusts were subdivided into two groups: (1) the pre-Jurassic, and (2) Late Cretaceous-Paleogene overthrusts. The youngest overthrusting verges towards north and is post-Lutetian - pre-Pliocene in age.

17. Two neotectonic fold groups were identified based on their relative ages; (1) the older (early) folds are open to tight, asymmetrical, and plunging with an axis of $N10^{\circ}$ - 20° E. (2) The younger folds are gentle, mostly asymmetrical, and non-plunging to slightly plunging with an axis of $N80^{\circ}$ - 85° E to $N65^{\circ}$ - 70° E.

18. Distribution of the faults suggests a dextral strike-slip fault system that shaped the study area during neotectonic period.

19. According to Reidel shear terminology, Y-shear trends in $N80^{\circ}$ W, Reidel shear (R) in $N50^{\circ}$ W, conjugate Reidel shear (R') in $N20^{\circ}$ E, P-shear in E-W, and poorly developed tensional fracture (T) trends in $N25^{\circ}$ W directions. Finally, based on the geometries of the strike-slip faults, the cumulative resultant principal stress must have operated in 335° N direction during neotectonic period. It well fits with principal stress direction (330° N) obtained from the results of fault plane solution on the Yolpınar fault-1.

20. The formation of Merzifon-Suluova composite pull apart basin initiated during Early Pliocene-Pleistocene period.

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APPENDIX

LIST OF PLATES

- Plate 1. Geological map of the southern margin of Merzifon-Suluova Basin, Amasya (in pocket).
- Plate 2. Geological cross sections of the southern margin of Merzifon-Suluova Basin, Amasya (in pocket).
- Plate 3. The neotectonic map of the southern margin of Merzifon-Suluova Basin, Amasya (in pocket).

PLATE 1 Geological Map of the Southern Margin of Merzifon-Suluova Basin, Amasya.

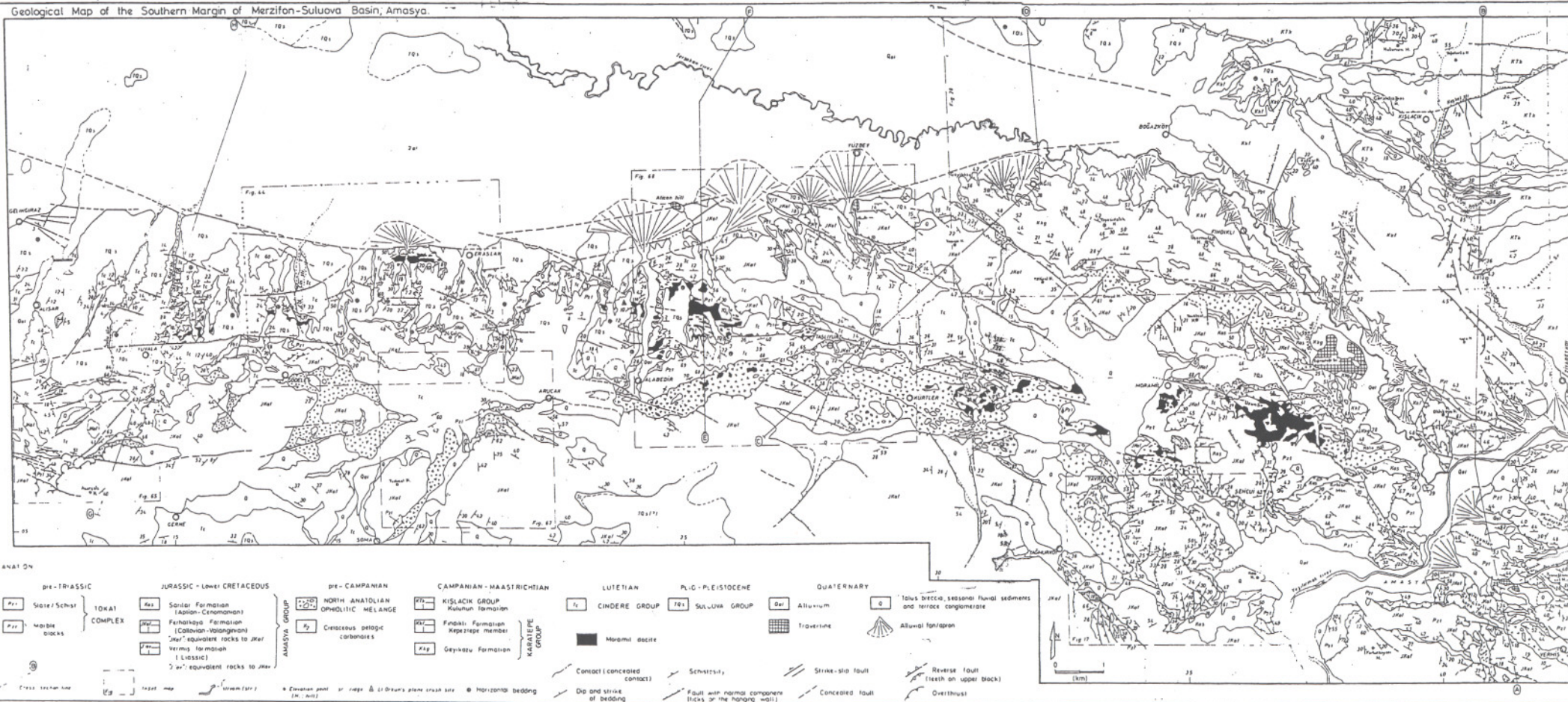
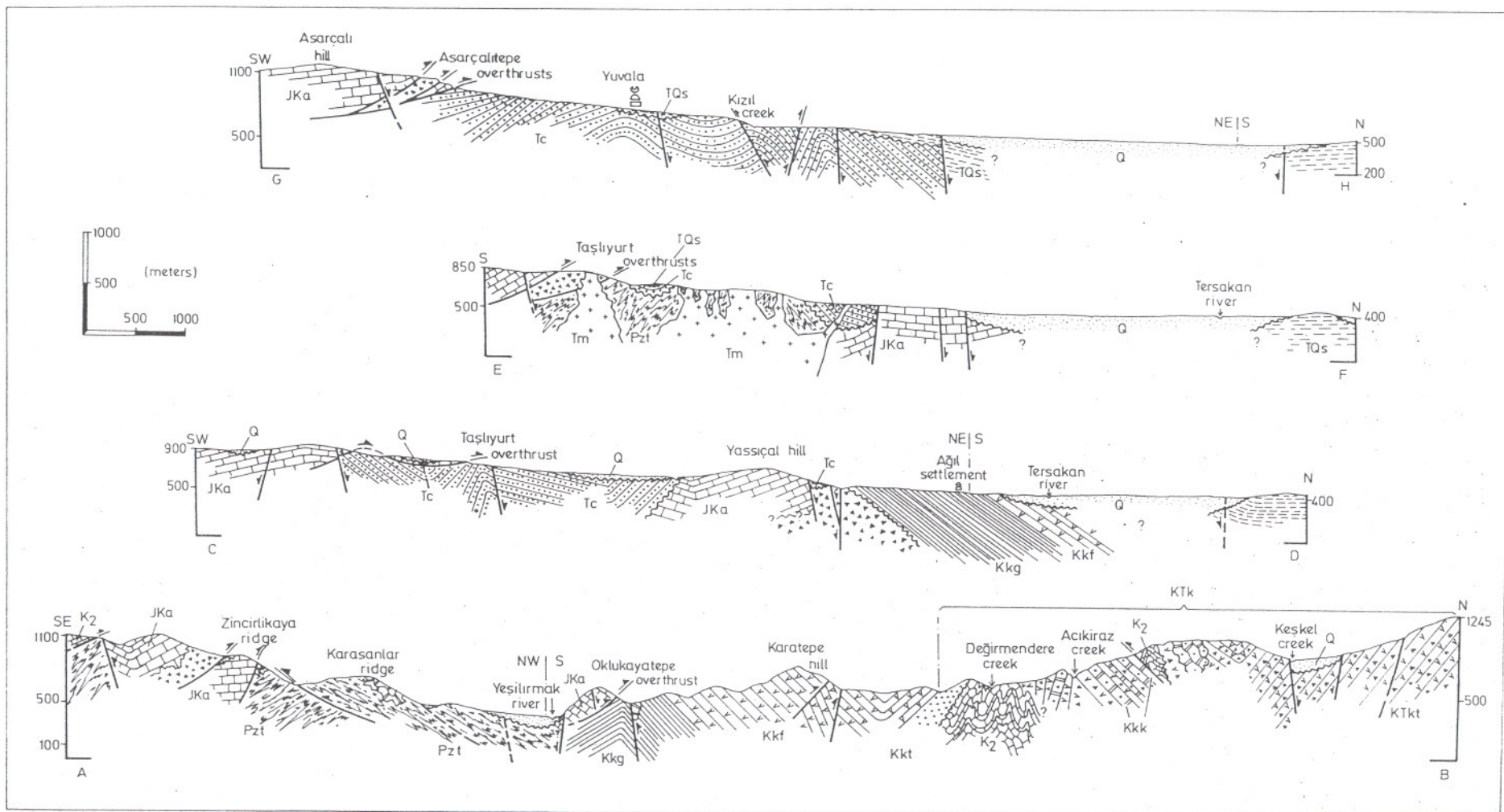


PLATE 2 Geological Cross Sections of the Southern Margin of Merzifon-Suluova Basin, Amasya.



Paleozoic	Jurassic-Lower Cretaceous	pre-Campanian	Campanian-Maastrichtian	Maastrichtian-Paleocene(?)	Lutetian	Plio-Quaternary	Quaternary
<p>Schists-Slates</p> <p>Marble blocks</p>	<p>Amasya Group</p> <p>Cretaceous pelagic carbonates</p>	<p>North Anatolian Ophiolitic Melange</p>	<p>Geyiközü Formation</p> <p>Fındıklı Formation</p>	<p>Tepetarla formation</p> <p>Tuzlugersin formation</p> <p>Kulunun formation</p>	<p>Cindere group</p> <p>Moramil dacite</p>	<p>Suluova group</p>	<p>Fluvial sediments</p>
Tokat Complex (Pzt)			Karatepe group (Kk)	Kışlacık group (KTK)			

VITA

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