METU JOURNAL OF PURE AND APPLIED SCIENCES
Vol. 21, No. 1–3, pp. 221-235 *April–December 1988*

GEOLOGICAL CHARACTERISTICS AND STRUCTURAL EVOLUTION OF THE OPHIOLITIC UNITS AROUND SAKALTUTAN DAĞI (ERZURUM)

A. YILMAZ, İ. TERLEMEZ and Ş. UYSAL

General Directorate of Mineıal Research and Exploration

Abstract. The units in the study area are the products of different environments, and they are divided into three structural units. From bottom towards top, these are metamorphics, ophiolitic melange with a cover and ophiolitic nappes.

The parent rock assemblage of the metamorphics is a pelagic volcano–sedimentary sequence of partially Triassic age which has undergone greenschist metamorphism. The ophiolitic melange is composed of volcano–sedimentary matrix and a mixture of diverse blocks of different age (Triassic to Cenomanian). The melange rests stratigraphically on the metamorphics, and passes upward into the units in which the pelagic limestone of Campanian age is predominant. Ophiolitic nappes are made up of serpentinite, peridotite, gabbro and diabase dikes and overthrust the above–mentioned first two units. In places, these ophiolitic units are cut by the granitoids.

According to both areal distribution and boundary relationship of the ophiolitic units, it can be concluded that the ophiolitic melange might have been formed due the contraction and slicing of the oceanic crust duıing Cenomanian to Campanian.

The Maastrichtian to Eocene units with the olistostromal levels made up of material derived from the ophiolitic units, rest on the ophiolitic nappes with a local unconformity. They are also overthrusted by the ophiolitic nappes and cut by diorite–gabbro intrusions in places. All of the units mentioned up to here are overlain unconformably by the continental deposits of probably Early Oligocene age.

During the time interval between Mastrichtian and Eocene, the ophiolitic units have been compressed, uplifted and transported again into the new younger basins. At the begining of Oligocene they completely emerged.

I. INTRODUCTION

The studied area is located in southeast of Erzurum and lies on the ophiolite belt delimiting the Pontides in the south. (Fig. 1)

Previous works in the study area were first carried out by Mercier [1], Erentöz [2, 3, 4] and Altınlı [5, 6]. As a result of these studies, the general stratigraphy and major rock units have been identified. Later on, many studies for different purposes and at 1 / 25.000 scale were carried out [7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20]. In these recent studies, ophiolitic units were considered either as an ophiolite [18] or as a melange [19, 20]. On the other hand, some hypothesis will be put forward related to the probable basement of the Eastern Anatolia. The studied area is in one of the critical regions in which the ophiolitic units widely crop out and important features of these units can be observed. The purpose of this study is to differentiate the ophiolitic units and investigate their stuctural evolution.

II. REGIONAL GEOLOGY

In general, metamorphics constitute the basement of the Eastern Anatolia. They occur in two different facies. In the central and southern parts of the Eastern Anatolia, a pre–Maastrichtian metamorphic assemblage exposen. It displays the amphibolite facies, and is composed of gneiss, amphibolite, schist and marble, In the northern parts of the study area, the pelagic volcano-sedimentary sequence of partly Triassic age and greenschist facies contitutes the metamorphic basement. The relationship between these two metamorphic rock assemblages can not be seen and examined.

The ophiolitic melange is composed of some limestones olistoliths, ranging in age from Triassic to Cenomanian, slightly metamorphosed volcano-sedimentary matrix and ophiolites. The melange conformably

---

Figure 1. Location and geologic map of the study area 1. Akdağ metamorphics; 2. Karataştepe metamorphics; 3. Bozyokuştepe melange; 4. Üzümpınar Formation; 5. Şahvelet ophiolites; 6. Gabbro; 7. Granitoides; 8. Maastrichtian-Eocene units (Aziziye group); 9. Eocene gabbro; 10. Eocene volcanics; 11. Oligocene clastics and shale; 12 Miocene marine carbonates; 13. Miocene marls; 14. Miocene volcanics; 15. Miocene pyroclastics; 16. Upper Miocene-Pliocene molasse; 17. Pliocene carbonates and clastics; 18. Pliocene fluviatile deposits; 19. Plio-Quaternary volcanics; 20. Slope breccia; 21. Ancient alluvial deposits; 22. Recent alluvial deposits; 23. Contact; 24. Fault; 25. Strike-slip fault; 26. Pliocene-Recent overthrusts; 27. Ancient overthrusts; 28. Axis of anticline; 29. Axis of syncline; 30. Overturned fold; 31. Streams. Previous studies [12,13,14,18] were used for the preparation of the map.

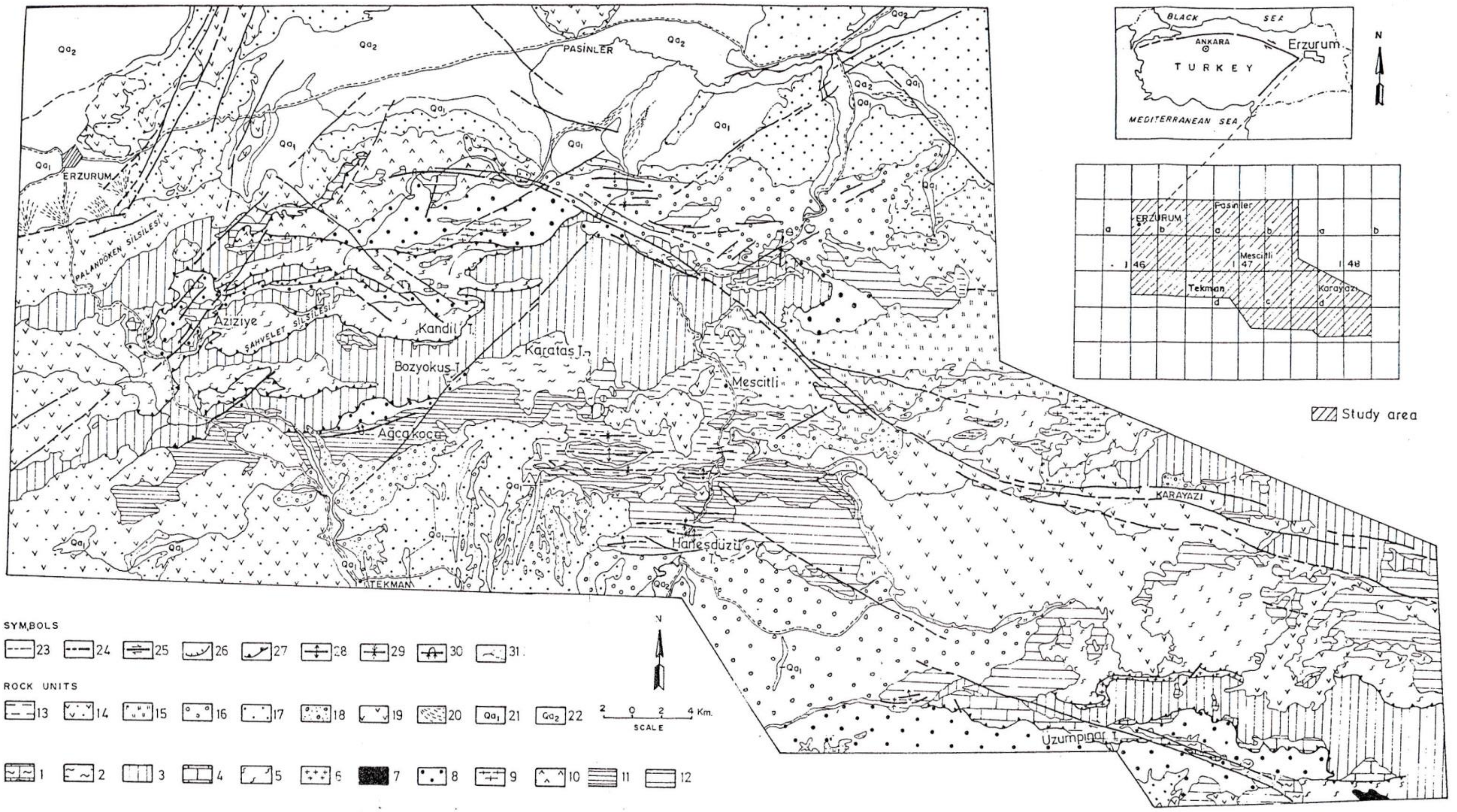

Figure 1. For explanation see dipnote at page 222.

overlies the metavolcano–sedimentary sequence and gradually passes upwards into the pelagic cover units of Campanian age. The ophiolite, which consists mostly of serpentine, peridotite, gabbro and diabase dykes, tectonically overlies the foregoing older units and forms a cover nappe. Metamorphics and ophiolites are locally intruded by granitoids.

The Maastrichtian and Pliocene rocks are composed of the alternating transgressive and regressive sequences. They cover uncorformably the older units (Fig. 2). The studied area is subjected to subaerial conditions during the Middle (?)–Late Miocene times.

The cover sequence consists of Eocene, Oligocene and Miocene–Pliocene deposits. The Eocene deposits are intruded by gabbros, which are overlain by andesites. The Oligocene deposits contains some andesitic bazalt interlayers, and the Miocene–Pliocene deposits also contain the dacitic to andesitic volcanics.

Due to the compressional events took place in the Late and post Miocene times, NW–SE–trending right–lateral and SW–NE–trending left–lateral fault zones, and approcimately E–W trending folds and overthrusts were developed. During the same period, new basins are developed under the control of the oblique slip fault zones in which the lateral offset is dominant.

III. OPHIOLITIC UNITS

The ophiolitic units of study area were named by Erdoğan and Soytürk [18] as "Sakaltutan Ophiolites", by Koçyiğit [19] as "Anatolian Ophiolitic Melange", by Gedik [20] as "Şahvelet Ophiolitic Melange", Yılmaz et al. [21] preferred the term "Sakaltutan Group" taking into account the composite nature of these units (Fig. 2). In this study, it is revealed that the ophiolitic units can not be designated as a single melange or an ophiolite as a whole, and thus the term "Sakaltutan Group" is, in principle, accepted and it is divided into four formations (Fig. 3). These four formations are. (1) Karataştepe metamorphic, which is the lowest metavolcano-sedimentary sequence; (2) Bozyokuştepe melange, which is the ophiolitic mixture overlying the metamorphis; (3) Üzümpınar formation, which comprises the Companian pelagic limestones conformably overlying the ophiolitic melange, and (4) Şahvelet ophiolites representing the cover nappe on the other units. Metamorphic and ophiolites are locally intruded by granitoid intrusions [21].

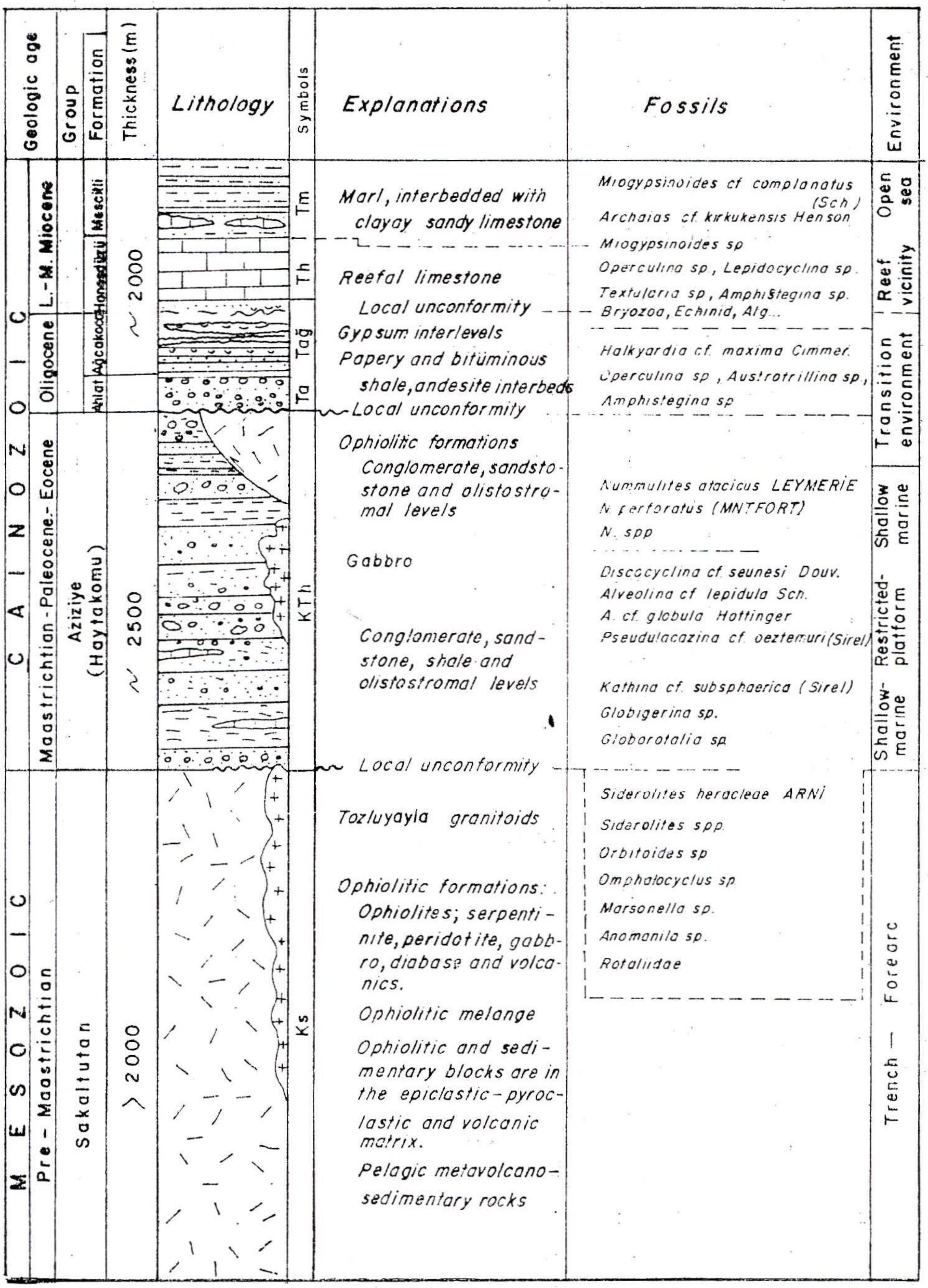

Figure 2. Generalized columnar section of the area (After [21]).

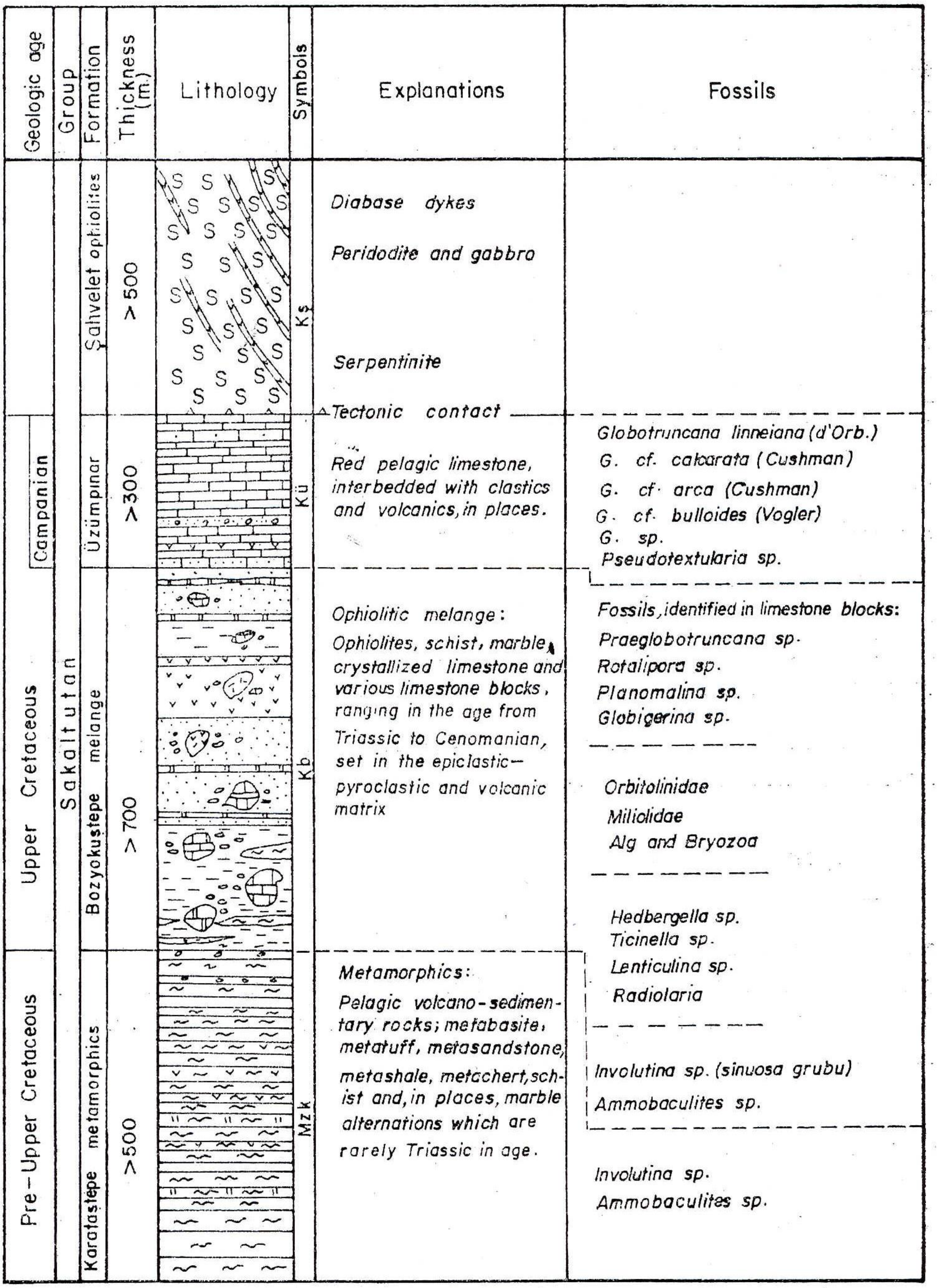

Figure 3. Columnar section of the ophiolitic units.

Karataştepe Metamorphics

The type locality of this unit is Karataştepe on the southern flanks of Sakaltutan mountain where a metavolcano-sedimentary sequence well exposes, therefore, it was named as the Karataştepe metamorphic. These metamorphics differ from the Akdağ metamorphics of Erdoğan [16] and Yılmaz et al. [21] in stratigraphical order and degree of metamorphism.

The Karataştepe metamorphics consist mainly of schist, metabasite, metatuff, metasandstone, metashale and metachert with local metacarbonate interbeds. In the garnet–mica schists which occassionally can be found, abundant feldspar, minor quartz and muscovite and locally turmaline, zircon rutile are the major constituents. Foliation is well developed in the metavolcanics in which the original texture is usually destroyed. The metaclastic rocks are composed of feldspar (generally plagioclase), quartz, volcanic clasts and uralitized pyroxene set in a matrix of coarse sand and chlorite.

In the metacarbonate interbads of the metavolcanosedimentary sequence exposed along Pasinler–Hınıs highway to the north of Mescitli, *Involutina* sp. and *Ammobaculites* sp. are found and at least some parts of this sequence are dated to be Triassic (Fig. 3).

Karataştepe metamorphics of greenschist facies, constitutes the lowermost unit of the study area.

Bozyokuştepe Melange

The mixture of various blocks set in a volcanic sandy matrix was named as the Bozyokuştepe melange. This unit corresponds to some parts of the units named as a melange by Koçyiğit [19] and Gedik [20]. A new name is proposed in order not to lead a confusion in terms of both structure and content.

The volcanics and clastics, which form the matrix of the melange, show signs of a low degree metamorphism. Especially in the lower levels of the mixture a weak foliation is observed. In the pillow lavas, actinolite with glaucophanic imprints, pyroxene symplectite, altered (carbonated) feldspars and opaque minerals are seen. In the clastic levels, a weak foliation is locally seen. There are locally oriented quartz, feldspar, pyroclasts, pyroxene, chert and limestone clasts within the clayey sandy matrix of these rocks. The matrix of this mixture also contains the polygenic conglomerate intercalations, which may indicate debris flow processes coeval with the sedimentation of mixture. Some sedimentary and tectonic features, such as graded bedding, current structures, overturned folds mylonites and breccias are frequently seen at the outcrops of the Bozyokuştepe melange. Therefore, this unit is interpreted as a sedimentary mixture developed under the control compressional events.

In the ophiolitic melange, blocks of serpentinite, peridotite, gabbro, diabase, schist, marble and limestone (Triasic to Cenomanian in age) are in position of floating in the matrix. Especially the sizes of ophiolitic blocks increase towards the upper levels. Mylonitization and squeezing along the lower contacts of the blocks are obvious. The blocks are up to 100 m long and generally lenticular.

In some limestone blocks of the ophiolitic melange exposed along the Pasinler–Hınıs highway to the north of Mescitli, *Involutina* sp. (sinuosa group), *Ammobaculites* sp., *Hedbergella* sp., *Ticinella* sp., *Lenticulina* sp., and radiolaria are found. Therefore the ages of these blocks range from Triassic to Aptien–Cenomanian.

In the southeast of the study area, and in the northeast of Kösehasan Village, some limestone blocks include *Orbitoline* sp., Orbitolinidae, Millolidae, Algae, Bryozoa, *Praeglobotruncana* sp., *Rotalipora* sp., *Planomalina* sp., and *Globigerina* sp. Therefore the ophiolitic melange is dated to be Early Upper Cretaceous (Fig. 3).

The Bozyokuştepe melange overlies the Karataştepe metamorphics with a conformable and gradational contact. Therefore, the formation age of the melange is younger than the metamorphism of the Karataştepe unit.

Üzümpınar Formation

The Upper Campanian–Lower Maastrichtian sequence, which consists mainly of reddish pelagic limestones with clastic intercalations was named as the Üzümpınar Formation by Erdoğan and Soytürk (18).

The reddish, locally grey or greenish, medium and thin, regular bedded limestones are fractured. Locally claystone and sandstone intercalations are observed within the Üzümpınar formation. These clastics are more frequent in the lower levels, and show an ophiolitic olistostromal character.

In the southeast of the study area, to the north of Aydınsı (Kaprik) Village, the limestone of Üzümpınar Formation, which overlie conformably the ophiolitic melange, include *Globotruncana limnneiana* (d'Orb.), *G.* cf *calcarata* (Cushman), *G.* cf. *arca* (Cushman), *G.* cf. *bulloides* (Vogler), *G.* sp. and *Pseudotextularia* sp. This fossil content of the Üzümpınar Formation yields a Late Senonian (probably Campanian) age for the formation (Fig. 3).

Şahvelet Ophiolites

The ophiolites, made up of serpentinite, peridotite, gabbro and diabase dykes well, crop out in the Şahvelet area, therefore, the ophiolites in the study area were named as the Şahvelet ophiolites.

Serpentinite is the most widespread lithology. It contains locally bastitized orthopyroxene and clinopyroxene grains and chromite. The peridotite is composed of olivine, clinopyroxene, orthopyroxene and spinel, and it has a wehrlitic composition. Gabbro is locally of cumulate nature and can be named as gabbronorite or olivine gabbronorite. It consists of minor olivine, augite (locally uralitized), equigranular feldspar, titanite and spinel. Diabase has an intersertal or ophitic texture. Its main constituents are thin and long albite lamellae, pyroxene and opaque minerals set in a microlitic and glassy matrix. The pillow lavas, which display a well–developed flow texture, contain olivine, uralitized pyroxene and plagioclase. This content of the pillow lavas may correspond to the volcanics of ophiolites. But, the contacts between the different facies of the ophiolite are of tectonic. Only the diabase cuts the lower units. Therefore, these units are accepted as the different facies of a tectonic slice rather than a regular ophiolitic sequence.

Ophiolites show a prominent metamorphism. For instance Mg chlorite, actinolite, zoisite and hipschite are developed in gabbros; plagioclose is altered; pyroxene is amphibolized and locally epidote and chlorite are developed in diabase. These minerals of the greenschist facies might have developed in their primary environment. Along the basal contact of ophiolite nappes, a pronounced cataclastic metamorphism is observed. For example in Şahvelet area and to the east of Yataklarbaşı Hill in the north, the clastic levels of the melange, which underlie the ophiolite nappes, show a schistose structure. In these levels actinolite is partly converted into the glaucophane; plagioclase is altered; epidote and chlorite are formed. In the tuffs of the same region includes chloritized, carbonatized and hyrogarnetized grains.

IV. COVER ROCKS

The Maastrichtian–Eocene transgressive to regressive rock sequence, composed of sandstone, claystone and shale alternation, is named as the Aziziye (Haytakomu) group, which unconformably overlies the Şahvelet ophiolite in the study area. At the top, this formation is followed by the Oligocene terrigeneous conglomerates of the Ahlat formation, shales of the Agcakoca formation, Lower Miocene carbonates of the Haneşdüzü formation and the shales of the Mescitli formation [20, 21]. The study area was a terrestial environment during Middle (?)–Late Miocene. On the other hand, the sedimentation of the Aziziye group is accompanied by the andesitic volcanism during Eocene, then andesitic to basaltic volcanism during Oligocene, dacitic to andesitic volcanism and later on andesitic-basaltic pyroclastics during Miocene–Pliocene periods.

V. STRUCTURAL EVOLUTION OF THE OPHIOLITIC UNITS

When the rock units, exposed in the study area, are examined as a whole, it is seen that the following major units are of great importance in the evolution of the study area: (1) regular and pelagic meta-volcano–sedimentary sequence, which forms the lowest part of the basement; (2) olistostromal melange, which overlies the first unit and was deposited under the control of compressional events; it also shows weak greenshist facies; (3) pelagic limestones, which conformably overlie the second unit, display olistostromal facies in its lower part, and are overturned type of folded; (4) ophiolite, which forms the cover nappes on the first three units, and (5) granitoid, which intrudes both the ophiolite and underlying metamorphics (units 1, and 2). The similar lithologies related to the ancient and modern subduction zones were also reported by Conelly [22] and Jones et al. [23] These lithologies are especially reported from the fore–arc environments of ensimatic island arcs [24, 25, 26].

At the regional scale, it is considered that the pre–Late Cretaceous time is the spreading or tentional phase, whereas the Late Cretaceous is characterized by the compressional or subduction events [27, 28, 29]. This approach is supported by the newly obtained field data in this study. According to the new field data, the oceanic crust must have been sliced and caused to the formation of an island arc in a somewhere near the subduction zone. Thus the oceanic crust emplaced into its new position as the ophiolite and ophiolitic melange (Fig. 4).

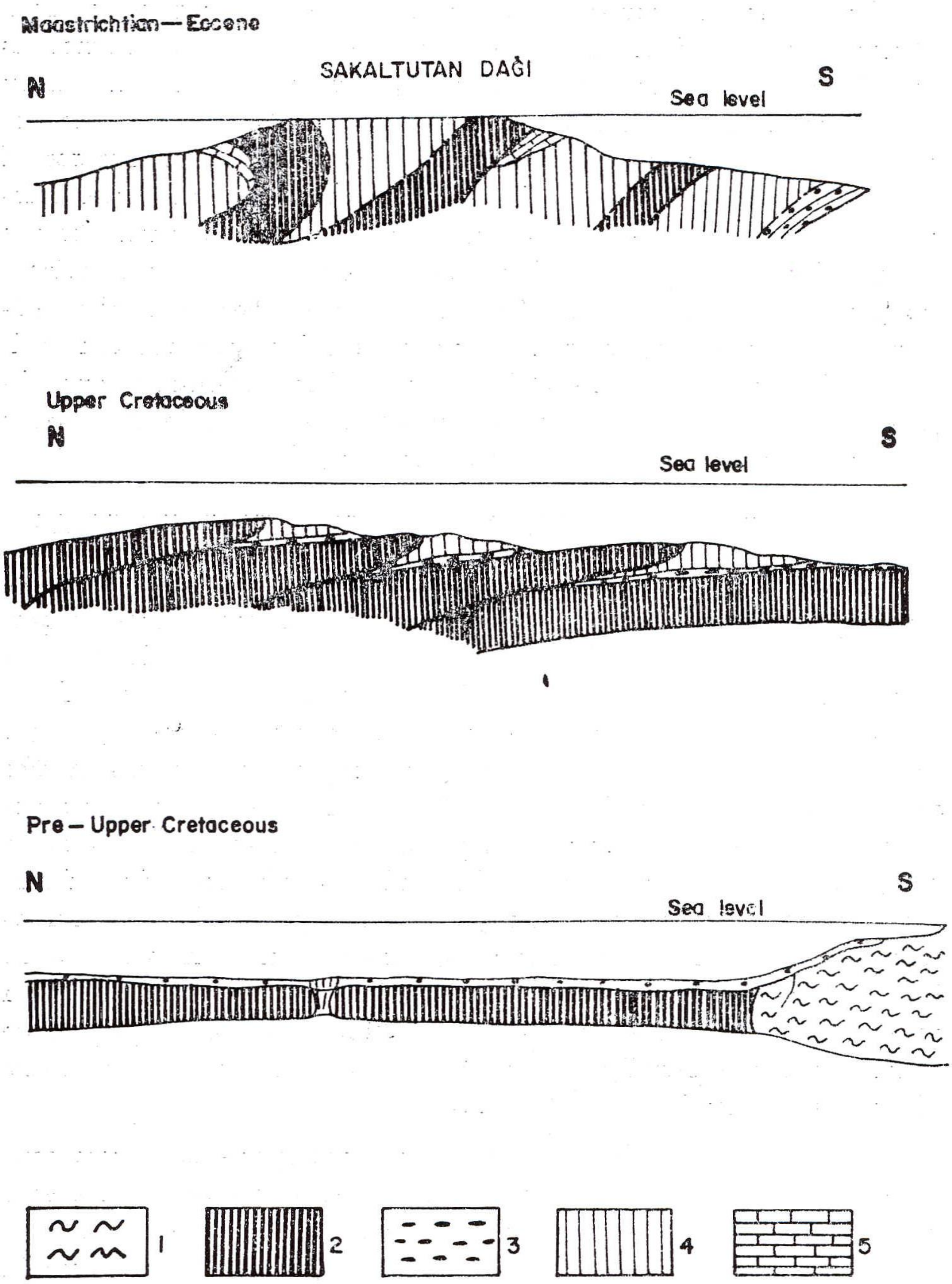

Figure 4. Sections of the structural evolution of the ophiolitic units. 1. Continental crust; 2. Oceanic crust (Ophiolites); 3. Pelagic volcano-sedimentary sequence; 4. Ophiolitic melange; 5. Campanian pelagic limestone and olistostromes.

Before Maastrichtian, due to the increasing compressive processes, ophiolites were uplifted and emerged. After the first emplacement of the ophiolitic unit (the post Maastrichtian time), the overthrusts were steepened and transformed into partly northvergent and partly southvergent thrustings, which resulted in the overturnings in the younger units.

VI. DISCUSSION AND CONCLUSIONS

In the Sakaltutan mountains, the metamorphic ophiolitic melange and ophiolites were first differentiated. In addition to the new age determinations, the data, related to the obduction of ophiolites coeval with the formation of the ophiolitic melange is presented as well.

The basement rock units of the Eastern Anatolia are overlain by the younger formations, therefore they crop out in a limited area. This causes some contradicting approaches in the interpretation of crustal structure of the Eastern Anatolia. For instance Seymen [30] proposes that the melange overlies the metamorphic crystalline basement. On the other hand, in general, the basement of Eastern Anatolia is accepted as a melange [31, 32, 28, 29]. But if the data presented here and observations made in the other ophiolite exposures, such as Özalp [33], Kağızman or Hınıs [21] in the Eastern Anatolia, are reviewed, it can be proposed that the Easter Anatolia has a napped structure and the ophiolites constitute the uppermost nappe. The formations of ophiolitic melange is related to the ophiolite napping and the volcano sedimentary cover on the basement were deposited during Maastrichtian –Quaternary.

ÖZET

SAKALTUTAN DAĞI (ERZURUM) DOLAYLARINDAKİ OFİYOLİTLİ BİRİMLERİN JEOLOJİK ÖZELLİKLERİ VE YAPISAL EVRİMİ

İnceleme alanında, ofiyolitli birimler farklı ortamların ürünü üç yapısal birime ayırtlanmıştır. Bunlar, alttan üstte doğru; metamorfitler, ofiyolitli karışık ve karışığın örtüsü ile ofiyolit napları olmak üzere sıralanabilir.

Metamorfitlerin köken kaya topluluğu, bir bölümü Triyas yaşlı pelajik metavolkanotortul dizi niteliğinde olup yeşil şist fasiyesinde bir metamorfizma geçirmişlerdir. Ofiyolitli karışık ise çoğun volkano –tortul bir hamur ve yaşı Triyas ile Senomaniyen arasında değişen farklı kökene sahip bloklardan oluşur. Karışık, metamorfitlerin üzerinde stratigrafik ilişkili olarak yer almakta ve üste doğru Kampaniyen yaşlı pelajik kireçtaşının egemen olduğu birime de uyumlu olarak geçer. Ofiyolit napları ise başlıca serpantinit, peridodit, gabro ve bunları kesen diyabaz dayklarından oluşur ve yukarıda sunulan birimlerin üzerinde yer alır. Ofiyolitli birimler yer yer granitoidler tarafından kesilir.

Birimlerin sahadaki yayılımı ve ilişkileri de gözetildiğinde, ofiyolitli karışığın, Senomaniyen-Kampaniyen aralığında, okyanus kabuğunun sıkışıp dilimlenmesine bağlı olarak oluştuğu ve buna koşut olarak ofiyolit naplarının yerleştiği ileri sürülebilir.

Maestrihtiyen–Eosen yaşlı, yer yer gereçleri ofiyolitli oluşuklardan türemiş olistostromal düzeyler kapsayan birimler, ofiyolit naplarının üzerinde yerel uyumsuzlukla yer alır. Ofiyolitli birimler de daha sonra yer yer Maestrihtiyen–Eosen birimlerine bindirmiştir. Maestrihtiyen –Eosen birimleri bazı yerlerde diyorit–gabro sokulumları tarafından kesilmiştir. Olasılıkla Alt Oligosen yaşlı karasal tortular ise yukarıda sunulan tüm birimlerin üzerinde bulunur.

Ofiyolitik birimler, Maestrihtiyen–Eosen sırasında yeniden sıkışıp yükselirken, bu dönemde oluşan havzaya da yeniden aktarılmış ve Oligosen başında tümüyle su yüzü olmuşlardır.

REFERENCES

[1] Mercier, J., 1948, Hınıs 65 / 2 paftasının raporu (The report of Hınıs 65 / 2 sheet). M.T.A. Report No. 2258 (Unpublished), Ankara.

[2] Erentöz, C., 1949, Hınıs 65 / 2 paftasının raporu (The report of Hınıs 65 / 2 sheet). M.T.A. Report No. 2159 (Unpublished), Ankara.

[3] Erentöz, C., 1954 a, Oltu 31 / 4, Kars 32 / 3 ve Hasankale 48 / 2 1 / 100.000 ölçekli jeoloji paftalarına ait memuar (the information about 1 / 100.000 scaled geologic maps of Oltu 31 / 4, Kars 32 / 3 and Hasankale 48 / 2). M.T.A. Report No. 3159 (Unpublished).

[4] Erentöz, C., 1954b, Aras Havzasının jeolojisi (Geologie du Bassin de l'Aras). Geol. Soc. Turkey, Bull., V, 1–2, 1–53.

[5] Altınlı., I.E., 1963, 1 / 500.000 scaled Geologic Map of Turkey, Explanatory text of Erzurum. M.T.A. Publ., Ankara.

[6] Altınlı, I.E., 1964, 1 / 500.000 scaled Geologic Map of Turkey, Explanatory text of Van. M.T.A. Publ., Ankara.

[7] Akkuş, M.F., 1965, Pasinler (Hasankale) havzasının 1 / 25.000 ölçekli detay petol etüdü raporu (the 1 / 25.000 scaled detailed petroleum study report of Pasinler (Hasankale) basin. M.T.A. Report No. 4037 (Unpublished), Ankara.

[8] Arpat, E., 1965, Ilıca–Aşkale (Erzurum ili) arasındaki sahanın ve kuzeyinin genel jeolojisi ve petrol imkanları (General geology and petroleum possibilities of the area between Ilıca–Aşkale (Erzurum province) and northern of it). M.T.A. Report No. 4040 (Unpublished), Ankara.

[9] Tokel, S., 1965, Erzurum–Hasankale Bölgesi Erzurum I 46 b_2, Tortum H 46 c_2 paftalarına ait jeolojik rapor (The geologic report of Erzurum–Hasankale area, Erzurum 146 b2, Tortum H 46 c3 Sheet). M.T.A. Report No. 4118, (Unpublished), Ankara.

[10] Tütüncü, K., 1965, Erzurum I 46a2, Tortum H 46 c4, d3 paftalarının detay jeoloji raporu ve petrol imkanları (The detailed geologic report and petroleum possibilities of Erzurum I 46 a2, Tortum H46 c4, d3 sheets). M.T.A. Report No. 4297, (Unpublished), Ankara.

[11] Rathur, A.Q., 1965, Pasinler–Horasan (Erzurum) sahasına ait genel jeolojik rapor (H 47 c3, c4; H48 c4, d3, d4; I 47 b1, b2, b3, I 48 a1, a2, b1) [The general geologic report of Pasinler–Horasan (Erzurum) area (H 47 c3, c4; H48 c4, d3, d4; I 47 b1, b2, b3, b4; I 48 a1, a2, b1)] M.T.A. Report No. 4168, (Unpublished), Ankara.

[12] İlker, S., 1966, Erzurum bölgesinde Erzuıum I 47 c1, c2, d2, d3 paftalarının detay petrol etüdü hakkında rapor (The report about detailed petroleum study of Erzurum I 47 c1, c2, d2, d3 maps in the Erzurum area). M.T.A. Report No. 4236, (Unpublished), Ankara.

[13] Sungurlu, O., 1971, 1 / 50.000 ölçekli I 47 a paftasının jeolojisi (The geology of 1 / 50.000 scaled I 47 a map). T.P.A.O. Report, unnumbered (Unpublished), Ankara.

[14] Aziz, A., 1971, Erzurum I 46 b4 ve I 46 c1 paftalarının detay jeolojisi ve petrol olanakları (The detailed geology and petroleum possibilities of Erzurum I 46 b4 and I 46 c1 sheets). M.T.A. Report No. 5222, (Unpublished), Ankara.

[15] Tanrıverdi, K., 1971, Erzurum (Söylemez) yöresinin jeolojisi ve petrol olanakları (The geology and Petroleum possibilities of Erzurum (Söylemez) area). M.T.A. Report No. 6239, (Unpublished)

[16] Erdoğan, T., 1972, Erzurum–Karayazı bölgesinin Jeolojisi ve petrol imkanları (Erzurum I 47 cl, c2, ve Karaköse I 48 dl, d4) [The geology and petroleum possibilities of Erzurum–Karayazı area (Erzurum I 47 cl, c2 and Karaköse I 48 dl, d4)]. M.T.A. Report No. 4845, (Unpublished), Ankara.

[17] Havur, E., 1972, Erzurum I 47 cl, c2, d2, d3, paftalarının jeolojisi ve petrol imkanları (The geology and petroleum possibilities of Erzurum I 47 cl, c2, d2, d3 sheets). M.T.A. Report No. 4851, (Unpublished), Ankara.

[18] Erdoğan, T. and Soytürk, N., 1974, Tekman baseni jeolojisi ve hidrokarbon imkanları raporu (The report of hydrocarbon possibilities and the geology of Tekman basin). T.P.A.O. Report No. 870, (Unpublished), Ankara.

[19] Koçyiğit, A., 1985, Karayazı fayı (Karayazı fault) Geol. Soc. Turkey, Bull. 28, 67–72.

[20] Gedik, A., 1986, Tekman (Erzurum) Havzasının jeolojisi ve petrol olanakları [The geology of Tekman (Erzurum) basin and petroleum posibilities]. M.T.A. Bull., 103 / 104, 1–24.

[21] Yılmaz, A., Terlemez, İ., Uysal, Ş.! 1986, Erzurum Güneydoğusunda Yer Alan Hınıs, Tekman ve Karayazı Arasının jeolojisi (The geology of the area between Hınıs, Tekman and Karayazı, southeasten part of Erzurum). M.T.A. Report No. 8089, (Unpublished), Ankara.

[22] Conelly, W., 1978, Uyak Complex, Kodiak Islands, Alaska: A Cretaceous Subduction Complex. Geol. Soc. of America Bull., 89, 755–769.

[23] Jones, D.L., Blake, M.C., Bailey, E.H and Mc Laughlin, RJ., 1978, Distribution and Character of Upper Mesosoic Subduction Complexes along the west Coast of North America. Tectonophysics, 47, 207–222.

[24] Moore, J.C. and Karig, D.E., 1980, Structural geology of Nias Island: Implications for Subduction zone tectonics. American Journal of Science, 280, 193–223.

[25] Bogdanov, N.A., Vishnevskaya, V.S., Sukhov, A.N., Fedorchuk, A.V. and Chekhovich, V.D., 1982, Oceanic Olistostromes of the Western Shores of the Aleutian Basin (Bering Sea). Geotectonics, 16 / 5, 397–402.

[26] Storey, B.C. and Meneilly, A.W., 1983, Melange within Subduction–accuretion complex rocks of Fredriksen Island, South Orkney Island. Geological Magazine, 120, 6, 555–566.

[27] Yılmaz, Y., 1980, Atlantik Tip Bir Kıta Kenarının Pasifik Tip Bir Kıta Kenarına Dönüşümüne Türkiyeden Örnek (An Example from Turkey, on the transformation from Atlantic Type Continental Margin to Pasific type continental Margin). Geol. Soc. Turkey Publ., Ankara.

[28] Şengör, A.M.C and Yılmaz, Y., 1981, Tethyan evolution of Turkey: A plate tectonic approach. Tectonophusics, 75, 181–241.

[29] Koçyiğit, A. and Rojay, B., 1984, Doğu Anadolu Bölgesinin yeni tectonic çatısı ve Horasan–Narman Depremi 1983 (Neotectonic outline of East Anatolia Region and Horasan–Harman Earthquake of 1983). I National Earthquake Symposium of North Anatolia, papers, Erzurum, 248–265.

[30] Seymen, İ., 30 Ekim 1983, Horasan–Narman Depreminin Oluş Mekanizması Açısından Deprem Fayı ve Bölgesinin Kabuk Yapısı Üzerine Bor Yaklaşım (An Approach to the Horosan–Narman (Erzurum–NE Turkey) Earthquake fault and the crustal structure of the area in accordance with its faulting mechanism). I. National Earthquake Symposium of North Anatolia, papers, Erzurum, 248–265.

[31] Arni, P., 1939, Tektonische Grundzüge Ostanatoliens und benachbarter Gebiete: Veröff. Inst. Lagerstattenfosch. Turkei, Ser. B., 4, 90. p.

[32] Ketin, I., 1977, Van Gölü ile İran sınırı arasındaki bölgede yapılan jeoloji gözlemlerinin sonuçları hakkında kısa bir açıklama (A brief report on the result of geological observations made in the area between Lake Van and Iranian border). Geol. Soc. Turkey, Bull. 20, 79–85.

[33] Şenel, M., 1987, 1 / 100.000 ölçekli açınsama nitelikli Türkiye Jeoloji haritaları serisi, Başkale–H38 paftası (1 / 100.000 scaled explorative series of Turkey geologic maps, Başkale–H38 sheet). M.T.A. Publ., Ankara.

General Directorate of Mineral Research and Exploration (MTA), Department of Geological Research, Ankara, TURKEY.