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General geological characteristics and distribution of the Central Anatolian Ophiolites

Orta Anadolu Ofiyolitlerinin genel jeolojik özellikleri ve dağılımı

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ABSTRACT

Despite more or less well-known alpine ophiolitic belts in Turkey, numerous little-known and isolated ophiolitic bodies are exposed as thrust-slices especially in Central Anatolia. Those within the "Central Anatolian Crystalline Complex" are known as the "Central Anatolian Ophiolites".

The main group of Central Anatolian Ophiolites is representative of a somewhat dismembered, but partially preserved ophiolitic sequence consisting of metamorphic tectonites, cumulate and isotropic gabbros, plagiogranites, diabases of the sheeted dyke complex, pillow lavas and the Middle Turonian-Lower Santonian epi-ophiolitic cover. They are overthrusted onto the Central Anatolian Metamorphics and intruded by the Central Anatolian Granitoids. Detailed studied members of this group display typical features of ophiolites that have been generated by the partial melting of already depleted oceanic lithosphere in a supra-subduction zone (fore-arc basin) tectonic setting.

Based on the geological and petrological data it is suggested that the Central Anatolian Ophiolites were formed during the Middle Turonian-Early Santonian times in relation to an intraoceanic subduction zone in a fore-arc basin within the İzmir-Ankara Ocean. They have been emplaced towards south, onto the Central Anatolian Metamorphics, representing the passive margin of the Tauride-Anatolide platform between Post Early Santonian-Pre Late Maastrichtian times.

Key Words: Ophiolite, Central Anatolia

ÖZ

Türkiyede azçok bilinen alpin yaşlı ofiyolit kuşakları dışında, özellikle Anatolitlerde, tektonik dilimler halinde yeralan henüz araştırılmamış çok sayıda izole ofiyolitik kütleler yüzeylenmektedir. Bu ofiyolitik kütlelerden "Orta Anadolu Kristalen Kompleksi" içinde yer alanlar "Orta Anadolu Ofiyolitleri" adı altında toplanmıştır.

Orta Anadolu Ofiyolitleri, çoğun parçalanmış ancak ofiyolit istifi özelliğini korumuş metamorfik tektonitler, kümüla ve izotrop gabrolar, plajiyogranitler, levha-dayk kompleksine ait diyabazlar, yastık lavlar ve Orta Türoniyen-Alt Santoniyen yaşlı epi-ofiyolitik çökeller ile temsil edilir. Bu kayalar Orta Anadolu Metamorfitleri üzerinde tektonik dokanakla yeralırlar ve Orta Anadolu Granitoyitleri tarafından kesilmişlerdir. Ofiyolitlerin ayrıntılı olarak incelenmiş bölümleri dalma-batma zonu üstü (yay-önü) tektonik konumunda, daha önce tüketilmiş bir okyanusal litosferin kısmi ergimesi ile oluşan ofiyolitlerin tipik özelliklerini sunmaktadır.

Jeolojik ve petrolojik verilere dayanılarak, Orta Anadolu Ofiyolitlerinin Orta Türoniyen-Erken Santoniyen sırasında İzmir-Ankara Okyanusu içinde, okyanus içi bir dalma-batma zonu ile ilişkili olarak bir yay-önü basende geliştikleri öngörülmektedir. Ofiyolitler, güneye, Torit-Anatolit Platformunun pasif kenarını temsil eden Orta Anadolu Metamorfitleri üzerine Erken Santoniyen sonrası-Geç Maestriştiyen öncesinde yerleşmişlerdir.

Anahtar Kelimeler: *Ofiyolit, Orta Anadolu*

INTRODUCTION

Turkish Neotethyan ophiolites occupy a critical segment in the Alpine-Himalayan orogenic system where remnants of both the northern and southern segments of the Neotethyan oceanic basins crop out well along nearly east-west trending tectonic belts (Juteau, 1980). The northern branch includes:(a) a northern belt representing remnants of the Intra-Pontide Ocean, (b) a median belt representing allochthonous units derived from the Vardar-İzmir-Ankara-Erzincan Ocean, that separates the Anatolide-Tauride platform from the Cimmerian continent leaving a small, isolated block (the Sakarya micro-continent) within the northern branch (Şengör and Yılmaz 1981). The southern branch of Neotethys separates the Arabian Platform, that characterizes the main body of Gondwana-land, from the Tauride-Anatolide Platform (Şengör and Yılmaz, 1981). These ophiolitic belts exhibit different ages; for example, the Vardar-İzmir-Ankara-Erzincan and Intra-Pontide belts generally consist of different types of Jurassic-Cretaceous ophiolites mainly found as dismembered fragments in melanges whereas the southern belt ophiolites represent good examples of largely unfragmented supra-subduction zone-type oceanic crust of mid to late Cretaceous age (e.g. Antalya, Hatay; Robertson and Dixon, 1985).

The ophiolites of Intra-Pontide and the Vardar-İzmir-Ankara-Erzincan sutures have not been studied in detail, whereas those from the southern belt have undergone considerable investigation (e.g. references in Robertson and Dixon, 1985). Despite these more or less well-defined belts, numerous, little known and isolated ophiolitic bodies are exposed in the Central Anatolia Crystalline Complex (including Central Anatolian Metamorphics, Central Anatolian Ophiolites and the Central Anatolian Granitoids), just to the south of the Vardar-İzmir-Ankara-Erzincan suture (Fig. 1). The Central Anatolian Crystalline Complex (CACC) is a triangular wedge of metamorphic basement rocks which is considered to represent the northern passive margin of the Mesozoic Tauride-Anatolide Platform, facing the Vardar-İzmir-Ankara-Erzincan Ocean (Göncüoğlu et al., 1991). Isolated outcrops of ophiolitic rocks, termed the Central Anatolian Ophiolites (CAO), (Göncüoğlu et al., 1991, 1992, 1993, 1994, 1997) are found as allochthonous bodies in the CACC. They were initially derived from the Vardar-İzmir-Ankara-Erzincan Ocean and emplaced southwards onto the CACC. They are dismembered and partially preserved. However, they may represent a complete ophiolitic sequence.

The aim of this paper is to present the general geological characteristics of the ophiolites exposed within the CACC.

GEOLOGY OF THE CENTRAL ANATOLIAN OPHIOLITES

The CAO is constituted by dismembered and partially preserved ophiolitic rocks. The stratigraphic reconstruction reveals that they very probably exemplify a complete ophiolitic sequence. CAO is represented by tectonites (ultramafics), cumulates (ultramafics and layered gabbros), isotropic gabbros, plagiogranites, dolerite dyke complex, basaltic volcanics and epi-ophiolitic sedimentary cover (Fig. 2).

Ultramafics

Ultramafic rocks are exposed in the Northeast of the Niğde Massif (İçmeli and Yeşilhisar regions (Göncüoğlu, 1977; Salancı and İleri, 1977; Woldegiorgis, 1993) and mainly consist of peridotites (dunite, harzburgite ± lherzolite) and pyroxenites. The widespread ultramafic rocks with chromite deposits are observed around Karatepe - Dindomartepe - Ballıktepe regions which are situated at the east of İçmeli area. Here, ultramafics are mainly represented by peridotites and pyroxenites which are mainly serpentinized. These ultramafics are rarely intruded by isotropic gabbros, pegmatitic gabbros and dolerite dykes. Ultramafic rocks are also widely exposed north of İçmeli region, around Araplıköyü and Yeşilhisar area (see Fig. 1). Peridotites are mainly represented by an alternation of dunites and harzburgites. Lherzolitic ultramafics are rare and generally found as lenses within the cumulate gabbros around Northwest of Alimpınarı and Aktaş Dam to the west of Niğde. The ultramafics in the area to the Northeast of Niğde Massif are in thrust contact with the underlying high-grade metamorphic assemblages of the Central

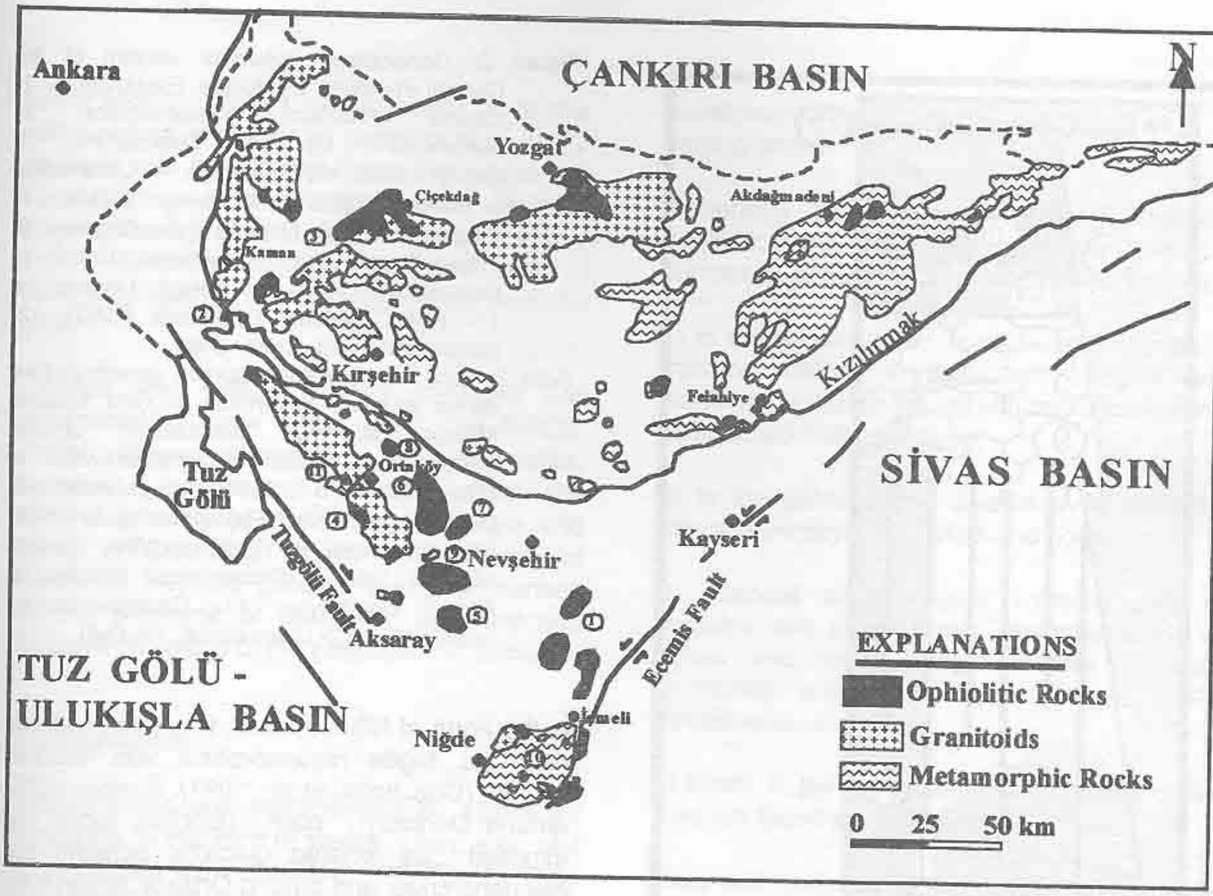

Figure 1- Distribution of the Central Anatolian Ophiolites in Central Anatolia. Locations of the main ophiolitic outcrops : 1- Yeşilhisar, 2- Hirfanlı Dam, 3- Kurançalı, 4- Ekecikdağı, 5-Mamasın Dam, 6- Sarıkaraman, 7- Karadağ, 8- Devedamı, 9- Alayhanı, 10- Aşıgediği, 11- Hacı İbrahimuşagı. The blank area represents the Late Maesrichtian-Quaternary cover units.

Şekil 1- Orta Anadolu da Orta Anadolu Ofiyolitlerinin dağılımı. Önemli ofiyolitik birimlerin lokasyonları: 1- Yeşilhisar, 2- Hirfanlı Barajı, 3- Kurançalı, 4- Ekecikdağı, 5-Mamasın Barajı, 6- Sarıkaraman, 7- Karadağ, 8- Devedamı, 9- Alayhanı, 10- Aşıgediği, 11- Hacı İbrahimuşagı. Üst Maastriştiyen-Kuvaterner yaşlı örtü birimleri boş bırakılmıştır.

Anatolian Metamorphics (CAM). In this part, Lower-Middle Eocene clastics and carbonates seal the thrust contact, thus indicating a pre-Eocene emplacement age. To the south of the Niğde Massif, however, the basal conglomerates of the Elmadere Formation of uppermost Maastrichtian age (Göncüoğlu, 1986) disconformably cover the metamorphics and the ophiolites, respectively.

In the north, around Ortaköy, pyroxenites occur as roof-pendants within the Ortaköy granitoids and as serpentinized blocks within the ophiolitic melange in the Kızılırmak valley to the Southwest of Felahiye.

Further north, north of Hirfanlı Dam, peridotites were also identified by Seymen (1982). Especially around Kurancalı peridotite and layered gabbro thrusted over the CAM with sub-ophiolitic metamorphics beneath them. Here, peridotites, layered gabbros and CAM were intruded by the late granite intrusions.

Gabbros

Gabbros are the most widespread ophiolitic units exposed within the CACC. They are chiefly isotropic gabbros but also contain microgabbros and pegmatitic gabbros. They are frequently intruded by the plagiogranitic rocks.

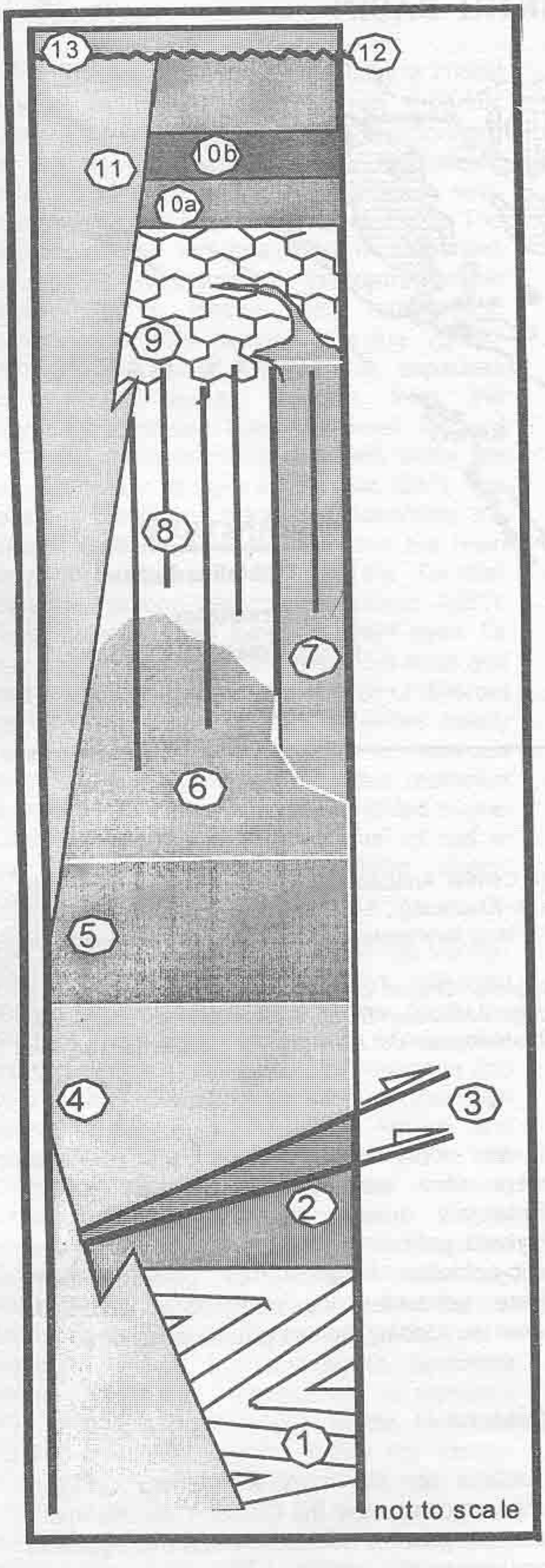

Figure 2- Generalized columnar section of the Central Anatolian Ophiolites. Explanations: 1- Central Anatolian Metamorphics, 2- Metamorphic Ophiolitic Olistostrome, 3- Subophiolithic Metamorphics, 4- Ultramafics, 5- Layered Gabbros, 6- Isotropic Gabbros 7- Plagiogranites, 8- Dolerite Dyke Complex, 9- Pillow Basalts, 10- Epi-ophiolitic Cover; a- Olistostromal Units, b- Pelagic Limestones, 11- Post-Collisional Granitoids (CAG), 12- Unconformity, 13- Cover Units.

Şekil 2- Orta Anadolu Ofiyolitlerinin genelleştirilmiş dikme kesidi. Açıklamalar: 1- Orta Anadolu Metamorfitleri, 2- Metamorfik ofiyolitli olistostrom, 3- Subofiyolitik metamorfitler, 4- Ultramafitler, 5- Tabakalı gabrolar, 6- İzotropik gabrolar 7- Plajiogranitler, 8- Dolerit dayk kompleksi, 9- Yastık bazaltlar, 10- Epi-ofiyolitik örtü, a- Olistostromal çökeller, b- Pelajik kireçtaşları, 11- Çarpışma-sonrası granitoyitler, 12- Uyumsuzluk, 13- Örtü

In the north of Niğde massif, they are observed over the Niğde metamorphics with tectonic contact (Göncüoğlu et al., 1991). Further north, around Derinkuyu plain, gabbroic rocks are exposed as isolated outcrops beneath the Neogene cover and around Ortaköy region they are mainly found as roof-pendant within the granitoid rocks. They are also observed around Kaman (Önen and Unan, 1988), Hirfanlı Dam (Seymen, 1982) and Çiçekdağı regions.

In all these locations, isotropic gabbros are dark green to black in colour. They are coarse to fine grained, frequently amphibolized and most readily distinguished in the field by the absence of cumulate layering. These gabbros can be uniform at mesoscopic scale but are more usually compositionally and/or texturally heterogeneous. They can be referred to as "high level gabbros" by virtue of their stratigraphic position. These gabbros can also been called "massive", "non-foliated" or "non-laminated" and "plated" gabbros.

The term "varitextured gabbro" can also be adopted for the gabbros based on textural criteria. Random or en-echelon pegmatite veins, pods and dykes are also common in the isotropic gabbros. Isotropic gabbros are particularly significant in the study of the plagiogranites at the upper part of the gabbros. In this portion, gabbros have leucocratic, often quartz bearing patches, veins or pods up to one metre across which have gradational to sharp contacts with the gabbro host. The veins are commonly associated with coarse, acicular amphiboles and gabbro pegmatites. Since they appear to have no feeders veins, they seem to have originated in situ by segregation from the gabbro.

Layered type gabbro is very restricted and determined in three areas within the CACC. Firstly, around Kurancalı over ultramafics, secondly, as tectonic slivers within the Kızılırmak valley to the west of Fethiye and thirdly in Çiçekdağı region to the north of Karafakılı. Layered gabbros are characterised by the presence of magmatic foliations and frequent intrusions of the plagiogranitic rocks.

Plagiogranites

Plagiogranites are characterised by significant intrusions, in the form of stocks, dikes, sills, and even veinlets within the CAO (see Fig. 2). They intruded into ophiolitic units but never into CAM. They generally show close association with the gabbroic parts of the CAO.

The plagiogranites vary from very fine to coarse grained and mainly occur at the boundary between the isotropic gabbro and the dyke complex, occupying a significant volume of the gabbroic part of Central Anatolian ophiolite. Plagiogranites are uniform at outcrop level, but overall are usually compositionally and/or texturally heterogeneous. They are laterally discontinuous and pass gradationally sidewards and downwards into gabbros and sidewards and upwards into dyke complex with sharp to diffused margins, without marginal chilling.

The plagiogranitic veins in the gabbroic part is usually characterised by well defined irregular to angular margins without marginal chilling but there is a gradation to diffused margin types. There is also a range in shapes and sizes from simple and narrow fracture infillings to wide complex zones of net-veining or agmatitic zones with numerous, partly assimilated enclaves of the host gabbros. These leucocratic patches, veins or pods between the gabbros and overlying plagiogranites is interpreted as the "stratigraphically lowest" occurrences of plagiogranites.

Traversing upwards in the Central Anatolian ophiolitic sequence, the plagiogranites exhibit a number of different emplacement relationships:

1) in the gabbros they occur as simple narrow fracture infillings to wide and complex net-veined or agmatitic zones with numerous, partly assimilated mafic enclaves,

2) in the gabbros and dolerite dyke complex, they are displayed as dykes and pods,

3) whereas in the upper volcanic units of massive and pillow lavas, they are found as dykes and bosses together with rhyolites, genetically related with them (Yalınız, 1996, Yalınız et al., in print),

4) finally, in the epi-ophiolitic sedimentary cover, they are found as olistrostromal blocks.

They are generally jointed with both the dyke margins and joints are frequently loci for epidotization.

Plagiogranitic bodies frequently occur within the gabbroic rocks especially around Ekecikdağı (Türeli, 1991; Göncüoğlu and Türeli, 1993), Mamasun Dam, Sarıkaraman (Yalınız, 1996), Karadağ, Devedamı and Ortaköy (Koçak and Leake, 1994) regions.

Dolerite Dyke Complex

Dolerite dyke complex is composed of entirely subvertical to vertical basic dykes. They are mostly hard, compact and massive. The dyke complex display typical "dyke in dyke" structure where dykes that formed later are being emplaced into the centre of previous ones, with a fine grained chilled margin forming against the coarser interior of the older dyke.

Dykes are usually sub-parallel to parallel up to 3 m in thickness and late-narrow discordant dolerites also occur. These are associated with zones of quartz and epidote veins and trend usually parallel to the strike of the dykes.

The dykes are characterised by "asymmetrical chilling" along their boundaries. The greater part of the dolerite dyke complex consists of parallel, steeply dipping dykes, the contact between dykes are mostly planar and parallel. The contacts between dolerite dyke complex and high level intrusives, and between lowermost pillow basalts and dolerite dyke complex are gradational over metres and indicate cogenetic relations. Dolerite dyke complex gives rise to a terrain of relatively sharp elongated ridges, for example, at Büvelektepe and Teyyaredamı locations in the Sarıkaraman area or around Yalıntaş Dam just to the south of the former location.

At its upper and lower contact, the complete sheeted nature of this complex gives way to lavas and high level intrusives over a vertical distance of tens of meters. On a local scale, the mutually intrusive relations between lower part of the dykes and the various members of high level intrusive suits vary considerably. The dykes become more abundant upwards in the high level gabbros and often have complex anastomosing shapes and blind-off shoots (for example, Bozkır Dam, west of Sarıkaraman area.). The lower part of the sheeted dykes is also intruded by later members of the high level intrusive suits, often by plagiogranite bodies that may contain abundant mafic enclaves.

A few late-narrow discordant and sinuous dolerite dykes are also seen to branch or die out vertically or laterally. At the upper contact, these dykes intruding also into the basaltic lavas.

The dyke-complex has clear and well preserved exposures in Sarıkaraman, around Çökelik Northwest of Çiçekdağı, Alayhanı, Bozkır Dam and Devedamı areas (see Fig. 1).

Basaltic Volcanics

The basaltic volcanics are mainly composed of pillow lavas interbedded with massive lava flows and occasionally pillow breccias. The pillow lavas form small to large, elongated to bun-shape pillows with a maximum diameter of 3 m. The massive flows often reach up to 5-6 m in thickness.

Both the pillow lavas and massive flows are characteristically reddish-brown to brown, dark-green to light green in colour. Around the margins of pillows the action of hydrothermal fluids produced a thin dark-green envelope of alteration minerals.

These units are largely vesicular to aphyric; vesicles are generally elongated and infilled with secondary mineral phases, in particular by radiating crystal aggregates of zeolite, epidote, calcite and quartz.

They are well observed at different parts of CACC, particularly with large exposures around Alayhanı, Devedamı, Sarıkaraman, South of Yozgat and Çiçekdağı areas (see Fig.1).

Epi-ophiolitic Sedimentary Cover

The para-autochthonous epi-ophiolitic sedimentary cover of the CAO has two different primary relationships with the uppermost portion of the basic volcanics: 1) passage into red coloured mudstone intercalated with the uppermost portion of the pillow lavas and 2) contact with pillow breccia above pillow lavas. The epi-ophiolithic cover represents the uppermost part of the CAO and mainly consists of volcanigenic olistrostromal units interbedded with pelagic sediments. Pelagic sediments are constituted by bedded pinkish cherty limestones, radiolarian cherts, manganiferous cherts, and micrites.

Type sections of the epi-ophiolitic cover is located in the Sarıkaraman area, however, intra-pillow pelagic pinkish cherty limestones were also dated at the south of Alayhanı and west of Çiçekdağı regions (Göncüoğlu et al., 1993).

CONTACT RELATIONS OF THE CAO WITH THE OTHER UNITS OF THE CACC

The CAO display various contact relationships with the Central Anatolian Metamorphics and Central Anatolian Granitoids of the CACC (Fig. 3a,b,c).

Contact Relation of the CAO with the Metamorphic Rocks

Members of the CAO are always in tectonic contact with the CAM. In some cases the primary tectonic relationship has not been too much effected by the latest Cretaceous extensional and Post-Eocene compressional events in Central Anatolia. In the following chapter the main types of these primary contacts are described.

Tectonic contact with sub-ophiolitic metamorphics

The earliest contact relations of the CAO with any kind of metamorphic rocks is depicted by the presence of "sub-ophiolitic metamorphics (SOM)" beneath them. These SOM's in the study area are interpreted as the metamorphic equivalents of the epi-ophiolitic units described above. The presence of the SOM's are very critical, as they indicate the earliest intraoceanic decoupling during the initial stage of an intra-oceanic subduction (Woodcock and Robertson, 1977).

SOM's are well exposed in the central part of the Niğde Massif, especially around Elmadere, west of Kuştepe, Aşıgediği-Haklık Tepe, Söğütdere area. Here, the thickness of the SOM's display a range from 20-30 m to 300-400 m. For example, at the west of Aşıgediği Tepe, the metamorphic succession directly underlying the serpantinized peridotites displays a well developed inverted metamorphism starting with garnet amphibolite at the bottom of ultramafics, followed by amphibolites alternating with piedmontite bearing quartz schists and marbles. The metamorphics in their lowermost part, in turn, are in thrust contact with the meta-olistostromal units that represent the uppermost part of CAM (Göncüoğlu et al., 1991, p.38, Fig. 10 and Fig. 3b). Further north in CACC, ophiolitic units with SOM's beneath them and overthrusting the uppermost sequences of the CAM were also observed in the west of Küçük Ekecikdağı (Northeast of Aksaray), between Dikmentepe and Keltepe (see Fig. 3b) and to the east of Kurancalı in Kaman region (see Fig. 1).

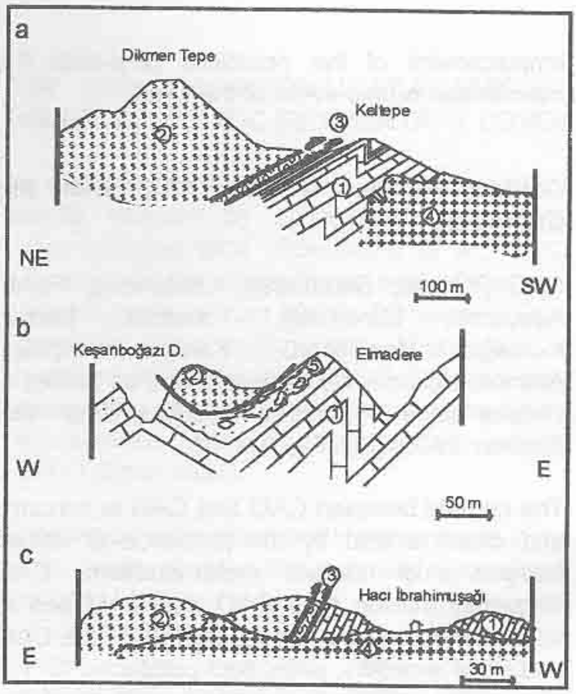

Figure 3- Structural relations of the Central Anatolian Ophiolites with other units of the CACC. a: E of Aksaray, Ekeciktol Village, b: Nigde, NE of Kılavuz Village, c: Ortaköy, Hacıilyasuşağı village. Explanations: 1- Central Anatolian Metamorphics, 2- Central Anatolian Ophiolites, 3- Sub-ophiolitic metamorphics, 4- Central Anatolian Granitoids; 5- Elmadere Olistostrome.

Şekil 3- Orta Anadolu Ofiyolitlerinin diğer Orta Anadolu Kristalen Kompleksi birimleri ile yapısal ilişkileri. Açıklamalar: 1- Orta Anadolu Metamorfitleri, 2- Orta Anadolu Ofiyolitleri, 3- Sub-ofiyolitik metamorfitler, 4- Orta Anadolu Granitoyitleri; 5- Elmadere Olistostromu.

Tectonic contacts with CAM

Commonly the contact between CAO and CAM is characterised by the presence of an extremely sheared tectonic mega-breccia, where lens-shaped bodies of each unit are embedded in a highly foliated serpantinite matrix. Representatives of such tectonic contacts can be very well observed around İçmeli to the east of Niğde, where ultramafic and mafic lithologies of the CAO are observed in thrust-contact with the marbles and gneisses of CAM. Another important feature of these contacts is the presence of retrograde dynamo-metamorphic assemblages in the shear-zones within the CAM, clearly indicating that the emplacement of the ophiolites post-date the main metamorphic event of the CAM.

Contact Relation of the CAO with the Granitoids

CAG (Yozgat, Baranadağ, Cefalıkdağ, Fakılı, Ağaçören, Ekecikdağ, Terlemez, Dedeli, Kuruağıl, Kesikköprü, Karaburna-Akçataş, Avanos, Üçkapılı etc.) are exposed as bodies of various sizes at several locations (Erler and Bayhan, 1995) (see Fig. 1).

The contact between CAO and CAG is intrusive and characterised by the presence of chilled margins and contact metamorphism. CAG frequently intrude both CAO and CAM and is characterised by the presence of both the CAO and CAM xenoliths, even, roof-pendants.
One of the striking evidences summarising the relation between CAO, CAM and CAG was given from the east of Hacı İbrahimuşagı area (see Fig. 3c), where granitoids intrude the CAM and CAO with the SOM's, tectonically overlying the former, respectively.

COVER UNITS

The CAO is unconformably overlain by the cover units of different ages varying from Late Maastrichtian to Neogene within the CACC. Although, the stratigraphic details of these units are out of the scope of this paper, the oldest cover unit overlying all the CACC units (CAO, CAM, CAG) is important for the interpretation of the emplacement age and mechanism of CAO.

The oldest unmetamorphic unit overlying CACC is represented by olistostromal sediments (Elmadere Olistostrome of Göncüoğlu et al. (1991) in the southern areas and Göynük Volcaniclastic Olistostrome of Göncüoğlu et al. (1993) and Köksal and Göncüoğlu (1997) in the central and northern areas) of Uppermost Maastrichtian- Lowermost Paleocene age.

The base of the olistostromal unit, wherever observed, is marked by red coloured clastics, it is overlain by yellowish-green olistostromal sandstone and siltstones. This sandstone and siltstones alternation is dominated towards top. The olistrostromal unit is characterised by the presence of huge olistoliths. The olistholiths are made up of marbles, ophiolites, amphibolites, cherts, volcanics (basic to felsic rocks and tuffs) and sedimentary rocks (pelagic sediments and siliciclastics) set in a very poorly sorted and clast supported, with a variable volcanigenic sandy or silty clayey matrix. The olistoliths range in size from a few cm. to several m. and represent more or less disrupted remnants of original stratified underlying sequences. Place to place the continuous deposition of olistrostromal units is interrupted by red coloured, structureless volcanigenic turbiditic mudstone alternations. This unit grades upward in intermediately bedded, reddish-greenish-yellowish coloured carbonate-bearing mudstone-siltstone alternation which are frequently interbedded with olistrostromal units having huge blocks of metamorphics, granitoids and ophiolitic units. The carbonate- rich mudstone-siltstone alternations grade laterally into marls and shallow-marine carbonates with benthic fossils, dated as Danian (Göncüoğlu et al., 1991), thus suggesting the upper age limit of the ophiolite emplacement.

PETROLOGY AND ORIGIN OF THE CAO

Geochemical studies carried out from different locations and different rock units of the CAO (Yalınız, 1996, Yalınız et al., 1994; 1995a,b) aim to understand the petrology and petrogenesis of the CAO and thus to interpret the geodynamic evolution of the oceanic basin to which CAO belongs to. For this purpose, approximately 300 samples were analysed on an a RL 8420 X-ray fluorescence spectrometer in the Department of Earth Science, University of Keele, UK., whereas the REE were determined by Instrumental Neutron Activation Analysis in Activation Laboratories Ltd., Canada. In the following chapter, the results of the geochemical work, partly published in different papers will be briefly summarised.

Gabbros

Gabbro samples taken from the Sarıkaraman, Ekecekdağı, Bozkır Dam, etc. (for locations see Fig.1) are characterised by the primary plagioclases having very high anorthite content, and secondary amphiboles rimming the low-Ti pyroxenes. Geochemically, they are characterised by the Low-Ti island-arc affinity (Yalınız, 1996; Yalınız et al., 1995b).

Plagiogranites

Plagiogranite samples taken from Sarıkaraman, Ekecekdağı, Bozkır Dam, Devedamı, Karadağ, Bozdağ, Mamasun Dam, north of Kurancalı, Çiçekdağı and Yozgat areas, petrographically, are characterised by the textures ranging from hypidiomorphic granular to granophyric. Geochemically, they show similar geochemical pattern with the Ocean-Ridge Granite on the basis of lower HFSE and relative enrichment of Th content (Göncüoğlu and Türeli, 1994; Yalınız, 1996; Yalınız et al., 1995a).

Basalts and Dolerites

Petrographically, the basalts are vesicular, aphyric and plagioclase-clinopyroxene phyric tholeiites. Some samples exhibit typical greenschist facies assemblages indicating to ocean-floor metamorphism.

All of the basalt outcrops exposed within the CACC are sampled and analysed for their major oxides. However, the REE analyses of all the samples have not been completed yet. Those completed are geochemically characterised by the following features;

a) They are subalkaline,
b) They have the geochemical characteristics of island-arc tholeiite,
c) They have the geochemical component from the underlying subduction slab,
d) They have depleted HFSE pattern indicating depleted mantle source.

Geochemical data indicate that the basalts and dolerites of the volcanic sequence and dyke complex have the geochemical affinities from an island arc setting rather than an oceanic spreading ridge. These chemical features are typical of supra-subduction zone ophiolites (Yalınız 1996, Yalınız et al., 1994, 1995b).

AGE AND DEPOSITIONAL FEATURES OF THE EPI-OPHIOLITIC SEDIMENTARY COVER

As explained in the previous chapters, CAO is directly overlain by epi-ophiolitic sediments. Paleontological data (Göncüoğlu et al., 1992) indicate that the depositional age of the epi-ophiolitic cover is from Middle Turonian to Early Santonian. The sedimentary succession is characterised by the repetition of slow and rapid depositions of the basal green volcanigenic olistrostromal levels intercalated with pelagic units (Yalınız, 1996).

The pelagic units which are typically found in the upper parts of the most ophiolitic sequences, provide strong evidence for deep-water submarine rifting for the lavas. Indeed, the marked high volume of volcanigenic olistrostromal sediment deposits intercalated with the pelagics is suggestive of an adjacent active arc volcanism (Underwood and Bachman, 1982).

Moores (1982) suggested that the type of the sedimentary sequences overlying the ophiolitic assemblages may allow marginal sea spreading ophiolites to be distinguished from those generated at mid-ocean ridges. It is further suggested that a marginal basin ophiolite might typically be overlain by volcaniclastic sequence, whereas a mid-ocean ridge ophiolite would typically be overlain by deep-sea pelagic sediments.

The volcanigenic sedimentary cover interbedded with Middle Turonian-Early Santonian pelagics in CAO confirm the presence of an adjacent active arc volcanism during the rifting of marginal basin leading to the formation of CAO within the Vardar-İzmir-Ankara-Erzincan Ocean. The presence of huge olistoliths composed of pyroclastics and intermediate volcanics within the Late Cretaceous melanges of the İzmir-Ankara Suture Zone in NW Anatolia (Çöğürler Ophiolitic Olistostrome of Özcan et al., 1989; around Kütahya region) and widespread felsic volcanics at the north of CACC (Çiçekdağı Massif; Göncüoğlu and Türeli, 1993) suggest the existence of such an island arc development during the closure of the Vardar-İzmir-Ankara-Erzincan Ocean.

Considering the formation age of the epi-ophiolitic cover and the age of the cover units, the emplacement age of the CAO was determined as Post-Early Santonian-Pre Late Maastrichtian (Yalınız et al., 1996). New K/Ar whole-rock ages (81-67ma) of post-collisional monzogranites cutting both the CAM and CAO in Sarıkaraman area (Yalınız et al., 1997), on the other hand, indicates that the emplacement ages can be confined between Early Santonian and Early Maastrichtian times.

CONCLUSIONS

The following conclusions are drawn:

1) CAO are characterised by a somewhat dismembered ophiolite body retaining a recognisable and well preserved complete magmatic pseudostratigraphy within the CACC.

2) CAO consist of the following sequence, starting from the bottom to the up: the metamorphic ultramafics, cumulates (ultramafic and mafic), isotropic gabbro, plagiogranite, dolerite dyke complex, basaltic volcanic sequence and Middle Turonian Early Santonian epi-ophiolitic sedimentary cover.

3) CAO are characterised by the presence of SOM's beneath them, generated during the initial intra-oceanic subduction and/or olistrostromal ophiolitic units formed during the emplacement over CAM that represent the passive northern margin of the Tauride-Anatolide Platform.

4) Even represented mainly by gabbroic rocks, CAO are characterised by the presence of significant amounts of oceanic plagiogranite intrusions and isolated diabase dykes which never intrude CAM, a critical feature to indicate their ophiolitic and allochthonous character.

5) Both field association and overall geochemistry suggests that some of the basalts of the CAO have been generated by the partial melting of already depleted oceanic lithosphere in a supra-subduction zone (fore-arc basin) tectonic setting.

Consequently, it is suggested that the Central Anatolian Ophiolites were generated during the Middle Turonian-Lower Santonian times in relation to an intraoceanic subduction zone in a fore-arc basin within the İzmir-Ankara Ocean. They have been emplaced towards south, onto the Central Anatolian Metamorphics, representing the passive margin of the Tauride-Anatolide platform between Post-Early Santonian-Pre Early Maastrichtian times.

Continuing work on the petrology and petrogenesis of the intra-oceanic island-arc magmatics to the north of the CACC and meta-ophiolites within the CACC will help to specify this general picture and thus the geodynamic evolution of the main oceanic branch of Neotethys in the its central part.

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