GEOLOGICA CARPATHICA, JUNE 2010, 61, 3, 235–253 doi: 10.2478/v10096-010-0014-3

Devonian in Turkey — a review

M. NAMIK YALÇIN and ISAK YILMAZ

Istanbul University, Faculty of Engineering, Department of Geological Engineering, TR-34850 Avcılar-Istanbul, Turkey;
mny@istanbul.edu.tr; iyilmaz@istanbul.edu.tr

(Manuscript received August 13, 2009; accepted in revised form December 11, 2009)

Abstract: The Devonian Period is represented in Turkey by almost complete non-metamorphic sections of more than 1000 meters, which exhibit varying lithofacial associations. They are parts of thick Paleozoic sedimentary successions in the Pontides, Taurides and Arabian Plate. The tectonic setting and the paleogeographical origin of these terranes is different. Therefore, the litho- and biostratigraphy and facies characteristics of these Devonian successions would enable a comparison and a paleogeographical assignment of these tectono-stratigraphic units. Devonian successions of the Arabian Plate and of the Taurides are represented by facies associations ranging from tidal flat to a deep shelf. Whereas, those of the Istanbul and Çamdağ-Zonguldak areas in the Pontides by a deepening upward sequence from a shallow shelf into a basin and a stable shelf, respectively. The Devonian of the Arabian Plate and the Taurides can surely be assigned to Gondwana. A Peri-Gondwanan (Avalonian) setting is suggested for the paleogeographic position of the Devonian of the Pontides.

Key words: Devonian, Turkey, paleogeography, depositional environment, biostratigraphy, lithostratigraphy.

Introduction

The geological and tectonic frame of Turkey, located in the Alpine-Himalayan Orogenic Belt, is mainly formed by the Alpine orogeny. Accordingly, a number of E-W trending tectono-stratigraphic units are defined, which consist of terranes of different tectonic settings ranging from oceanic basins to active and passive continental margins. The tectono-stratigraphic units as distinguished by many previous authors from north to south as Pontides, Sakarya Continent, Menderes and Kırşehir Blocks, Taurides and the Arabian Plate (Fig. 1), generally represent continental terranes separated by suture zones. The suture zones are in general composed of ophiolitic and volcanic rocks of oceanic origin (Ketin 1966; Şengör & Yılmaz 1981; Göncüoğlu 1997). Not only the tectonic setting of these terranes is different, but also the geological age of the incorporated units reflects a wide spectrum from Infra-Cambrian to Tertiary.

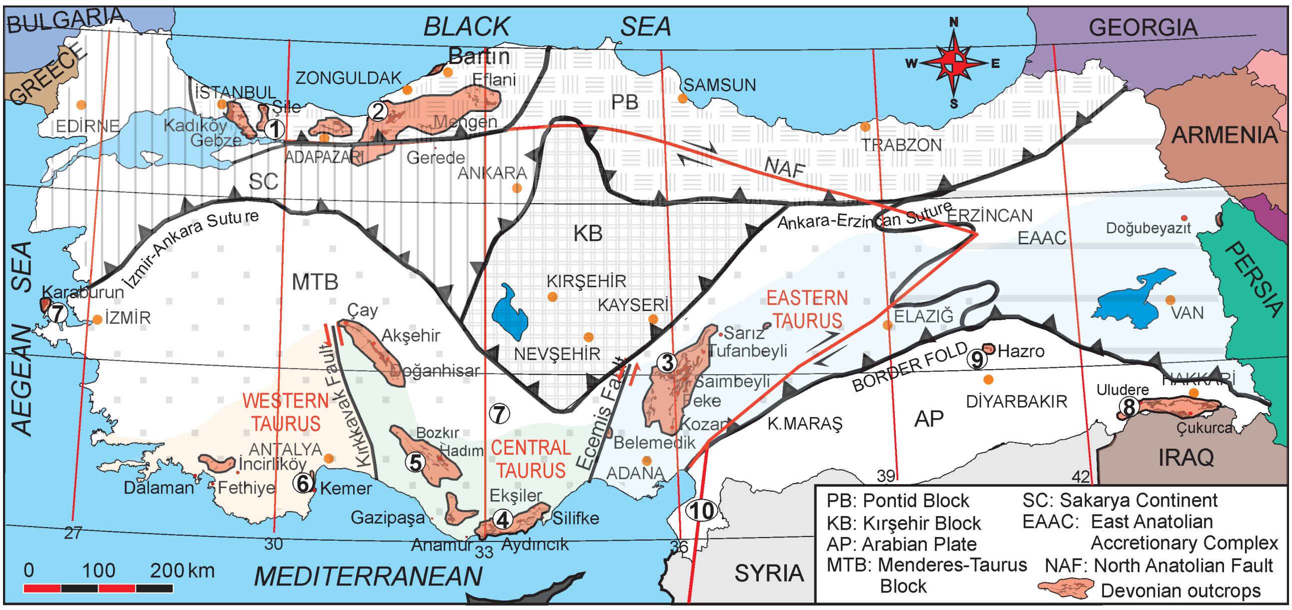

Fig. 1. Tectonic map of Turkey showing the major blocks/terranes and the bounding suture zones. Distribution of Devonian succesions are also shown and those, which are discussed in detail, are indicated by numbers. **1** — Istanbul Zone, **2** — Çamdağ area, **3** — Eastern Taurides, **4** — Central Taurides, **5** — Aladağ and Bolkardağ Units in Taurides, **6** — Western Taurides, **7** — Karaburun area, **8** — Hakkari area of Arabian Plate, **9** — Hazro area of Arabian Plate, **10** — Amanos area of Arabian Plate. (Modified from Şengör & Yılmaz 1981 and Elmas & Yiğitbaş 2001.)

Devonian units of different litho-types and of different paleogeographic origin are parts of thick Paleozoic sedimentary successions of the Pontides, Taurides and Arabian Plate. Some minor occurrences of sedimentary Devonian are also reported from the Karaburun area and Aegean Islands in westernmost Turkey relatively early by Ktenas (1925) (Fig. 1). This region was studied then by many scientists because of the complicated stratigraphy and tectonics (Höll 1966; Lehnert-Thiel 1969; Konuk 1979; Erdoğan et al. 1990; Kozur 1995; Kaya & Rezsu 2000; Rosselet & Stampfli 2002; Eren et al. 2004; Çakmakoğlu & Bilgin 2006; Okay et al. 2006). A relatively thick succession bearing also Devonian units is interpreted by Çakmakoğlu & Bilgin (2006) as autochthonous. The same succession was considered by Kozur (1995, 1997) and Rosselet et al. (2003) as an allochthonous sedimentary melange. Most recent studies however showed that Devonian rocks in the Karaburun area are allochthonous blocks and olistolith within the Carboniferous flysch (Robertson & Ustaömer 2009).

Metamorphic Devonian units are reported from parts of the Central Anatolian Massif, Menderes Massif in western Turkey and in eastern Turkey from the Bitlis Massif (Göncüoğlu & Turhan 1983).

The aim of this paper is to give an overview of the Turkish autochthonous and non-metamorphic Devonian. Hereby, based mainly on the data obtained from previous studies, the geographical distribution, general geological setting, litho- and biostratigraphy and facies characteristics of these Devonian successions will be addressed on the basis of the tectonostratigraphic subdivision of Turkey.

Devonian of the Arabian Plate in Southeastern Anatolia

The Devonian of the Arabian Plate is represented in Southeastern Anatolia by sedimentary sequences observed from west to east in the Amanos Mountains, Hazro High and Hakkari area. Furthermore, they are encountered in some wells around the Diyarbakır area (Fig. 1). The Devonian of the northerly located Hazro area is represented by Lower to Upper Devonian, while the Devonian of the other two regions consists of only Upper Devonian (Bozdoğan et al. 1987; Yılmaz & Duran 1997). But, in both geological settings the underlying units are similar. A thick Pre-Cambrian to Upper Ordovician continuous sedimentary sequence forms the pre-Devonian basement in both settings (Fig. 2). The Silurian-Devonian Dadaş Formation, outcrops only in Diyarbakır in the Hazro High and is also encountered in some wells there. According to observations and records in Kayayolu-2 well this unit was deposited after a regional break in sedimentation (Bozdoğan et al. 1987; Yılmaz & Duran 1997). Therefore it is inferred, that the Dadaş Formation lies with an angular unconformity on the Bedinan Formation (Fig. 2). The alternation of sandstones and shales, in the uppermost part of the Dadaş Formation in the Hazro area (Dadaş III Member of Bozdoğan et al. 1987) grades into the sandstones of Hazro Formation (Perinçek et al. 1991). According to Bozdoğan et al. (1987) the age of the Dadaş Formation is Early Silurian–Early Devonian. Consequently, the Silurian/Devonian (S/D) boundary has to be located within the uppermost part of the Dadaş Formation. Some recent efforts to localize the S/D boundary in Hazro area along the measured stratigraphic section Fetlika and in the well Fetlika-1 showed that the boundary cannot be localized only by palinomorphs (Mann et al. 2001; Kranendonck 2004; Brocke et al. 2004). In the Amanos area and in the Hakkari area, respectively to the west and east of Southeastern Anatolia, Silurian is not represented (Yılmaz & Duran 1997). Consequently, Upper Devonian Yığınlı and Köprülü Formations lie with an angular unconformity on the Ordovician Bedinan Formation (Fig. 2).

Litho- and biostratigraphy of the Devonian in the Hazro area

The Devonian succession in the Hazro area north of Diyarbakır (Fig. 1) is named as the Diyarbakır Group and is composed of the Dadaş, Hazro and Kayayolu Formations (Bozdoğan et al. 1987) (Fig. 2). The Kayayolu Formation is only encountered in wells, whereas outcrops of Dadaş and Hazro Formations are represented in the so-called Hazro High. The total thickness of these units on the surface varies between 70 and 217 m (Sungurlu 1974; Bozdoğan et al. 1987). In the subsurface they can be up to 500 m thick (Bozdoğan et al. 1987). Within the Dadaş Formation, three subunits (members) are distinguished based on different lithological composition, which are reflected in log characteristics (Bozdoğan et al. 1987). The Dadaş I Member consists of dark coloured, organic rich shales with some limestone interbeds; the Dadaş II Member is composed of similar shales alternating with some sandstones and the Dadaş III Member consists of an alternation of sandstones, marls and calcareous siltstones. The Dadaş Formation lies unconformably on the Middle–Upper Ordovician Bedinan Formation and is overlain conformably by the Devonian Hazro Formation (Bozdoğan et al. 1987; Perinçek et al. 1991). The Dadaş Formation is rich in fossils of palinomorphs, brachiopods, bryozoans, graptolites, conodonts, crinoids, corals and ostracods. Fossil assemblages reported by different authors (Çoruh et al. 1997 and references there in) from the middle and upper parts of the Dadaş Formation are listed in the Appendix. According to these fossils and to detailed palinological studies by Bozdoğan et al. (1987), Ertuğ et al. (1998), Brocke et al. (2004), Bozdoğan et al. (2005) a Late Silurian–Early Devonian age is assigned to the Dadaş Formation. As mentioned before, the exact location of Silurian/Devonian boundary is still not determined. The Dadaş Formation was deposited on a restricted inner shelf, which was developed on the irregular paleotopography of the eroded Bedinan Formation. The respective shelf became shallower and was gradually converted to a tidal flat towards the top of the sequence (Yılmaz & Duran 1997).

The following Hazro Formation consists in general of an alternation of cross-bedded sandstones and siltstones. A 6–8 m thick dolomitic limestone interval exists in the middle part of the unit as a marker bed (Bozdoğan et al. 1987). The Hazro Formation is approximately 110–150 m thick. It is overlain in the subsurface by the dolomites of the Kayayolu Formation conformably and on the surface in the Hazro area unconform-

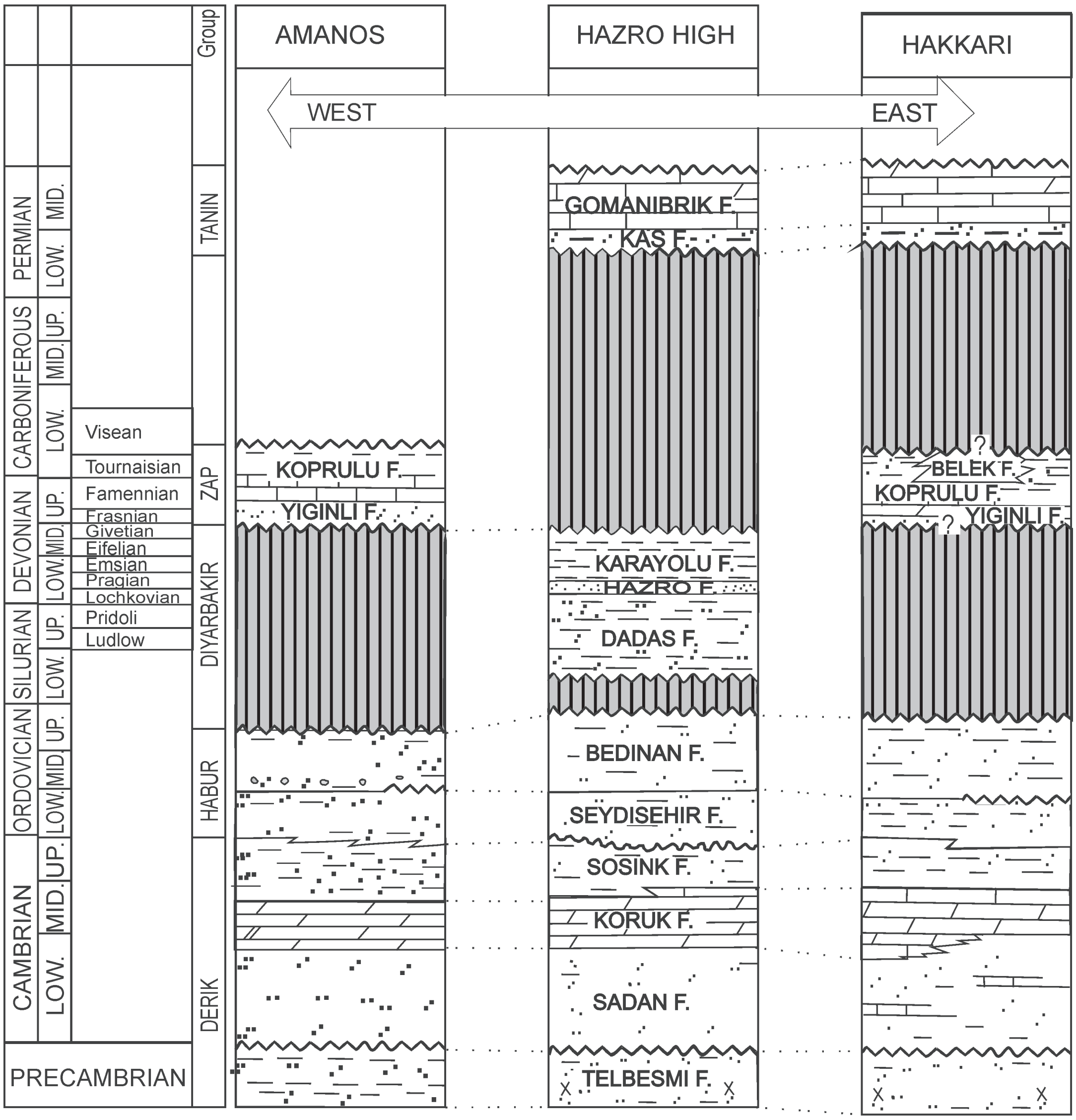

Fig. 2. Generalized stratigraphic sections of the Hakkari, Hazro and Amanos areas of the Arabian Plate. Note that Devonian stratigraphy of Hazro area, which is paleogeographically located further north differs from the Hakkari and Amanos areas (modified from Yılmaz & Duran 1997).

ably by the Permian Kaş Formation (Fig. 2). This unit includes only some few spores, acritarchs and chitinozoa and some very sparse shells. Based on the palynomorph assemblages (spores and acritarchs), it is suggested that the age of this unit is Pragian (in original Gedinnian)–Emsian (Bozdoğan et al. 1987). The lithofacies of the Hazro Formation indicates deposition on a tidal flat, with some lagoons and sand bars (Bozdoğan et al. 1987).

The Kayayolu Formation named by Bozdoğan et al. (1987) is composed in its lower parts of grey sandstones and beige dolomites, with anhydrite nodules. In the upper parts an alternation of dolomites, dolomitic marls, red-green sandstones, siltstones and shales is present. In some wells it is up to 147 m thick. It is overlain to the east of Diyarbakır by the Permian Tanin Group and west of Diyarbakır by the Cretaceous Mardin Group by an angular unconformity (Bozdoğan et al. 1987; Perinçek et al. 1991; Yılmaz & Duran 1997; Bozdoğan et al. 2005). In the Silvan-Hazro area Tolun (1949) and Lebküchner (1976) have reported corals, bryozoans, brachiopods and crinoids. According to these macro fauna and to the palynomorph assemblages (spores) reported by Bozdoğan et al. (1987, 2005) the age of the unit is determined as Eifelian–Frasnian (Middle–Late Devonian). The depositional environment of the Kayayolu Formation is interpreted by Bozdoğan et al. (1987) as a very shallow lagoon, inter to supratidal area and a tide-dominated delta plain.

Litho- and biostratigraphy of the Devonian in the Amanos and Hakkari areas

The Upper Devonian–Lower Carboniferous successions in the Amanos area to the west and in the Hakkari area to the east of the Hazro High are distinguished as the Zap Group. The Yığınlı and Köprülü Formations are the two lithostratigraphic units forming this group (Perinçek et al. 1991). These lithostratigraphic units are lying in both areas on Ordovician aged units with an angular unconformity (Fig. 2). In the Amanos area they are overlain by Jurassic carbonates and in the Hakkari area by Permian clastics (Perinçek et al. 1991).

The Yığınlı Formation, named first by Açıkbaş (1978), consists of pink, dark red-coloured, cross-bedded, quartzitic sandstones, which occasionally alternate with yellowish green, grey mudstones and shales. Its thickness varies in the Amanos Mountains area between 3–575 m (Yalçın 1980); in Kahramanmaraş between 20–25 m (Demirkol 1988); in Hakkari-Çukurca between 200–295 m (Perinçek et al. 1991). As mentioned above it overlies the Ordovician Bedinan Formation with an angular unconformity and passes gradually into the Köprülü Formation of upper Strunian–lower Tournaisian age (Perinçek et al. 1991). The Yığınlı Formation is poor in fossils. In its middle to upper parts some spores, ostracods and brachiopods indicate a late Famennian to early Tournaisian age. In the Hakkari area, ostracods, brachiopods and gastropod shells are identified (Çoruh et al. 1997). Here, in the transition zone to the Köprülü Formation, spores and pollens of *Retisospora lepidophyta-Vallatisporites* Zone are identified, indicating a late Famennian–early Tournaisian age (Bozdoğan et al. 1987, 2005). Janvier et al. (1984) have reported fishes which suggest a Strunian age. Considering the unfossiliferous lower parts, an Late Devonian age can be assigned to the Yığınlı Formation (Perinçek et al. 1991; Bozdoğan et al. 2005). According to the lithofacies, sedimentary structures and fossil content the depositional environment of this unit is determined as intra-littoral to shallow marine (Bozdoğan et al. 2005).

The Köprülü Formation is composed of dark grey, clayey and dolomitic limestones in its lower parts and of greenish, micaceous shales interbedded with some sandstones and thin nodular limestones in the upper parts. It is approximately 200 m thick and is conformably underlain and overlain by the Yığınlı and Belek Formations, respectively. The nodular limestones in the upper parts are rich in fossils. A Late Devonian age is assigned according to foraminifers, palinomorphs and brachiopods (Appendix) (Perinçek et al. 1991). The depositional environment of this unit is also determined as intra-littoral to shallow marine (Bozdoğan et al. 2005).

Devonian of the Taurides

Two major NE-SW trending strike-slip faults namely the Ecemiş and the Kırkkavak faults form the geographical boundaries between the Eastern and Central Taurides, and between Central and Western Taurides, respectively (Fig. 1). Devonian successions in Taurides will be reviewed on the one hand based on this geographical subdivision of this Alpine mountain chain and on the other hand based on the tectonostratigraphic units suggested by Özgül (1976).

The continuity of the Paleozoic units in Southern Turkey, which were deposited on the northern margin of northeastern

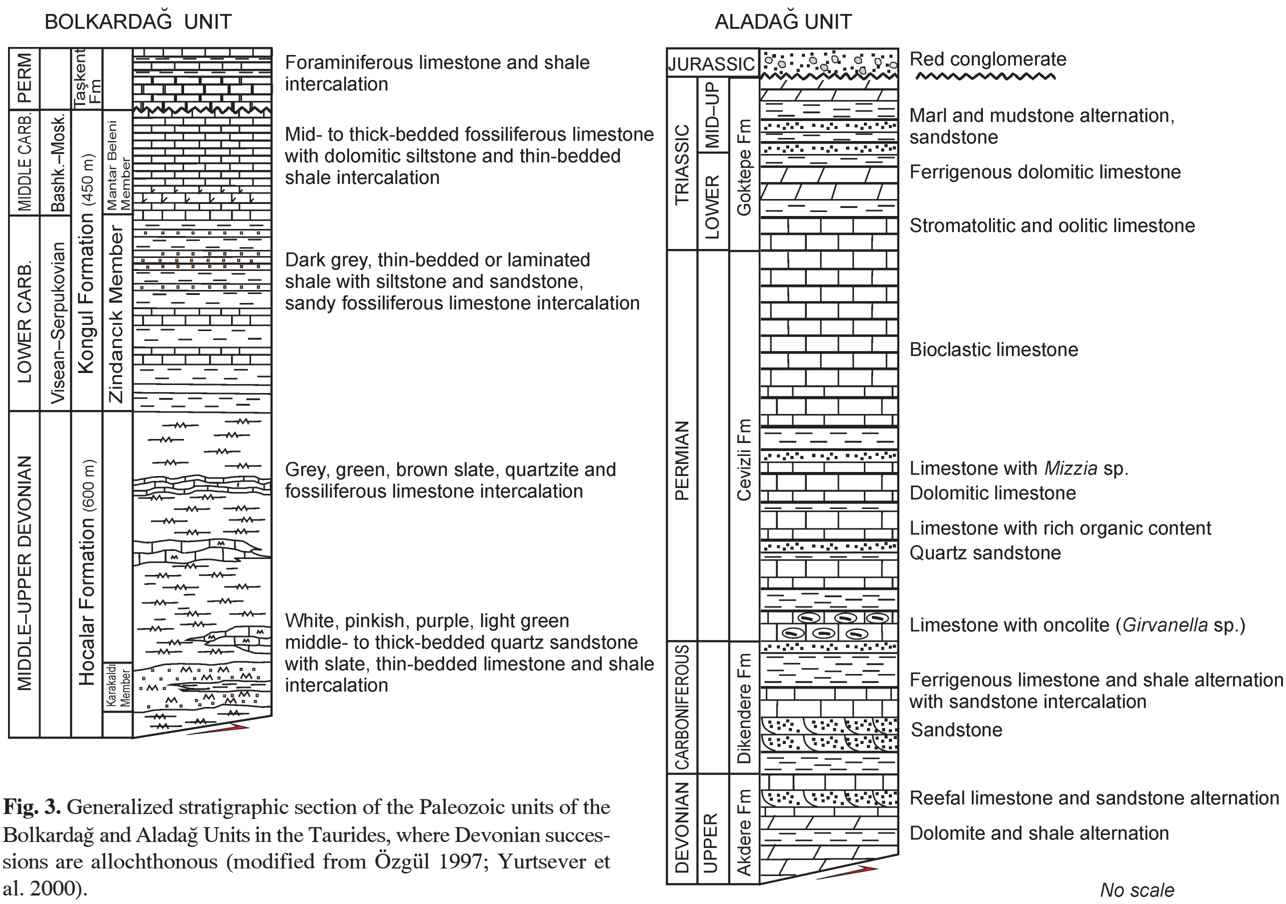

Fig. 3. Generalized stratigraphic section of the Paleozoic units of the Bolkardağ and Aladağ Units in the Taurides, where Devonian successions are allochthonous (modified from Özgül 1997; Yurtsever et al. 2000).

Gondwana, ended at the beginning of the Mesozoic due to the opening of the Neotethys Ocean. The south eastern part of the former Paleozoic terrane remained on the northern margin of the Arabian Plate to the south of the new ocean, while the Taurus and Menderes Blocks attained a position north of it. The closure of the Neotethys Ocean by subduction and the subsequent collision resulted in imbrications of the Taurus-Menderes Block and a very complicated geology (Fig. 1). In the Taurides the tectono-stratigraphic units, the Geyikdağ, Aladağ, Bolkardağ, Bozkır, Alanya and Antalya Units, have been differentiated with regard to the litho- and tectono-stratigraphical characteristics of the sequences (Özgül 1976). The Devonian is represented in the Geyikdağ, Aladağ, Bolkardağ and Antalya tectono-stratigraphic units. In the Aladağ and Bolkardağ tectono-stratigraphic units, Devonian successions are bounded at their base by major tectonic features and are incomplete (Fig. 3). Therefore, only Devonian successions in the Geyikdağ and Antalya tectono-stratigraphic units will be presented in detail.

Litho- and biostratigraphy of the Devonian in the Western Taurides

In the Western Taurides to the west of the Kırkkavak fault, Paleozoic sequences are encountered within the Lycian and Antalya Nappes, which are thrusted over the Beydağları autochthon from the northwest and southeast, respectively (Poisson 1977; Marcoux 1979; Özgül 1984; Şenel 1984). The Paleozoic sequences are represented by different units of Ordovician to Permian age, which consist of terrestrial to marine clastics and carbonates. They belong to the Antalya tectono-stratigraphic unit according to Özgül (1976) and are thrusted from south to north, therefore they are allochthonous. Some low angular unconformities exist between Silurian/Devonian and Lower/Upper Permian (Fig. 4). In the Tahtalıdağ region a remarkable gap exists between Ordovician and Mesozoic carbonates, as also observed in the Middle Taurides (Monod 1967; Haude 1972; Marcoux 1979; Şenel et al. 1981; Gedik 1988). To the north of Alanya, Göncüoğlu & Kozur (2000) described early to middle Lochkovian conodonts in the lower part of a sandstone-dolomite dominated succession unconformably overlying Silurian rocks. To the north of Kemer in the same region, Devonian is represented by the Hocanınsuyu Formation which is composed of detritic and evaporitic rocks (Fig. 4). Light grey to brown thin-bedded mudstones, siltstones, sandstones and dolomites at the base of the Devonian sequence pass into thick-bedded, pink-coloured gypsum beds and thin-bedded, red-coloured mudstones. A channel-fill deposit with some sandstone and gypsum pebbles and the following mud- and sandstone alternation exhibits high-angle cross-bedding. Some yellowish grey, medium-bedded limestone beds also exist in this particular interval. The uppermost part of this succession consists of grey, brown, thick-bedded, cross-bedded, quartzitic sandstones with typical wave ripple-marks. The ripple marks are asymmetric and the cross-bedding is high angular. Within the sandstones a six meter thick diabase sill exists (Şenel et al. 1981). The thickness of the Devonian Hocanınsuyu Formation is 190 m at its type locality. It lies unconformably on Silurian limestones and passes gradually into Carboniferous sandstones. Fish fossils (Appendix) found in red-coloured mudstones by Janvier & Marcoux (1977), indicate a Devonian age. According to the mentioned sedimentary structures and fossil content, the depositional environment of the unit is determined as terrestrial, particularly estuarine (Şenel et al. 1981; Gedik 1988). Towards the top of the Devonian sequence wave-induced ripple-marks and low angle cross-bedding suggest a marine depositional environment, supported by the lack of terrestrial plant remnants and plant roots at this level.

Litho- and biostratigraphy of the Devonian in the Central and Eastern Taurides

The para-autochthonous Geyikdağı Unit with its Cambrian–Lower Carboniferous succession includes most of the Paleozoic units in this region. The carbonate and clastic sediments within this succession generally consist of terrestrial, shallow and occasionally deeper marine environments (Tutkun 1984; Metin 1984; Yılmaz 2004).

The Devonian rocks in the Geyikdağı Unit are represented in terms of lithostratigraphic units by the Sığırcık, Büyükeceli and Akdere Formations in the Central Taurides and by the Ayı Tepesi, Şafak Tepe and Gümüşali Formations in Eastern Taurides (Fig. 5). Although they have been named differently, differences in lithological composition and facies characteristics are minor. Hence, these units can easily be correlated. Al-

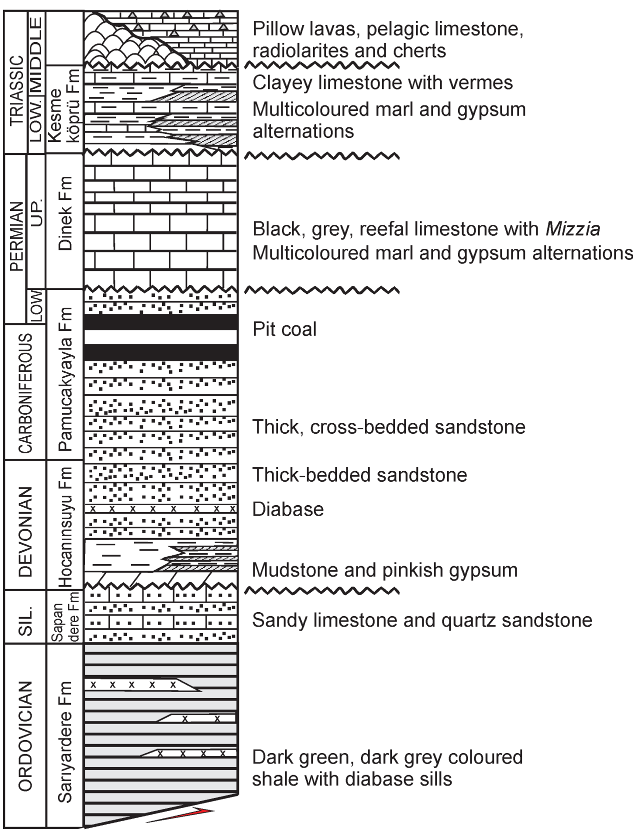

Fig. 4. Generalized stratigraphic section of the Paleozoic units of the Western Taurides (modified from Senel et al. 1981).

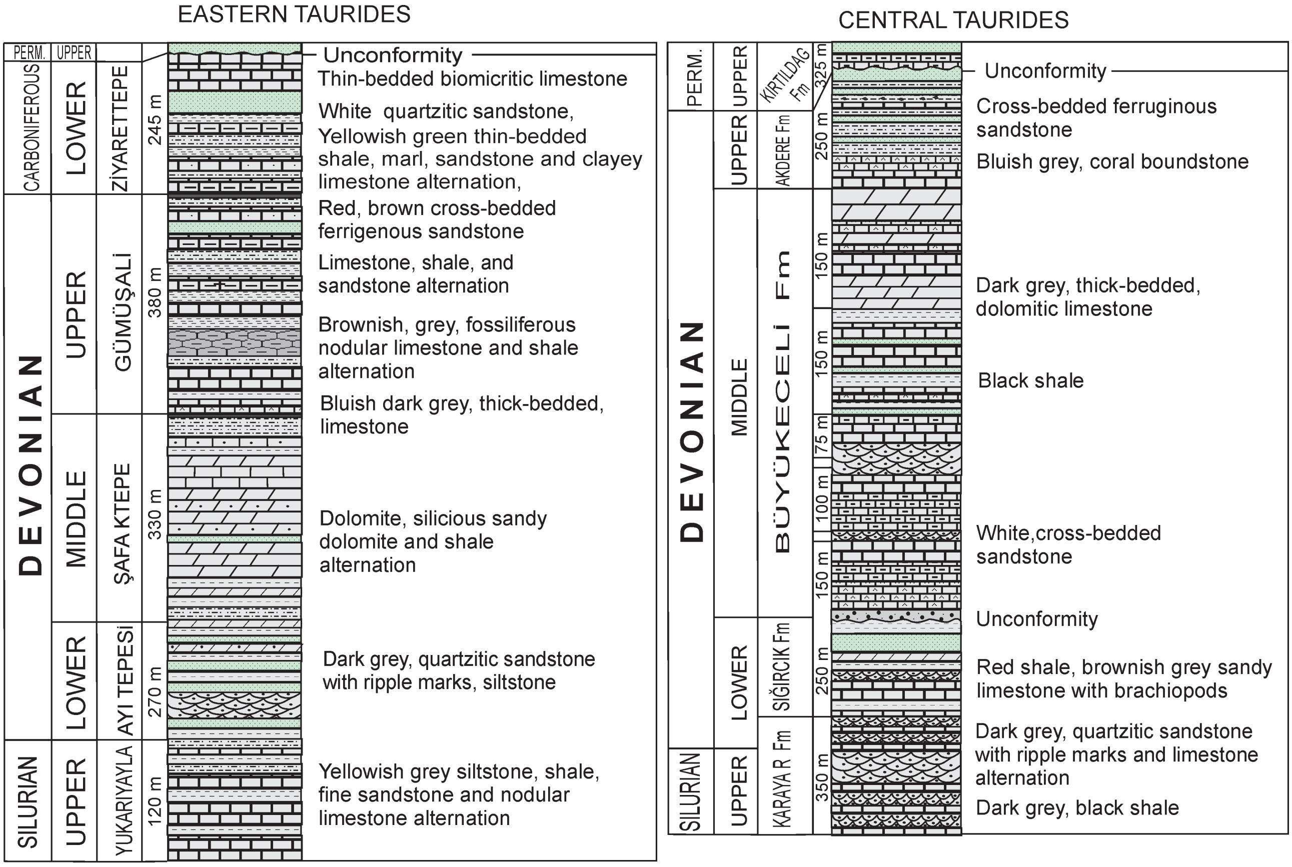

Fig. 5. Generalized stratigraphic section of Paleozoic units in the Central and Eastern Taurides. Devonian successions are part of the para-autochthonous Geyikdağ Unit (modified from Demirtaşlı 1984; Yılmaz 2004).

though Demirtaşlı (1984) in the Central Taurides and Göncüoğlu et al. (2004b) in the Eastern Taurides mentioned that the Silurian is unconformably overlain by the Lower Devonian; it is generally believed that the Silurian/Devonian boundary is transitional (Metin 1983; Uğuz 1989; Özgül & Kozlu 2002; Yılmaz 2004).

The Lower Devonian succession, first distinguished by Özgül et al. (1973) and named as the Ayı Tepesi Formation commences with sandstone, shale and dolomite (especially in the uppermost levels) alternation, where quartzitic sandstones predominate (Fig. 5). The first 140 m of the 450–500 m thick unit consists of laminated, dark coloured shale and siltstones, which alternates with thin nodular limestone intervals. In the following 150 m thick part, an intercalation of sandstone, siltstone, shale and limestone is present, where an abundant bioturbation caused by vermiculites is typical. The following 80 m thick interval consists of well-bedded, yellow, carbonate-cemented sandstones, which are formed mainly by quartz (70 %), feldspars (15 %) and some mica, chlorite and tourmaline. The uppermost parts are composed of dolomitic limestones, some bioturbated siltstones and thick-bedded fossiliferous limestones. In different regions of the Eastern Taurides and particularly in the Central Taurides, dolomites or dolomitic limestones predominate. Fossil content is poor and many sedimentary structures such as load, pillow and ball structures, ripple marks, vertical borings, cross-bedding, desiccation cracks and imprints of rain-drops exist in the clastic beds (Yılmaz et al. 2007). The Ayı Tepesi Formation was deposited in a tidal-supratidal environment during the Early Devonian. It deepened gradually towards the uppermost levels of the succession. Metin (1983) reported an Early Devonian age according to the brachiopods (Appendix).

Ayı Tepesi Formation passes conformably into the Middle Devonian aged Şafak Tepe Formation (Fig. 5). The Şafak Tepe Formation (Demirtaşlı 1967) consists of medium to thick, well-bedded, grey and black, dolomite, dolomitic limestone, recrystallized limestone with thin shale and occasionally siliceous sandstone alternation. Laterally, the lithology changes to dolomite-dominated sequences or reefoidal limestones. *Amphipora ramosa* Philips is observed at the bottom and top of the sequence as marker horizons. It is either accompanied by corals or brachiopods, gastropods, bryozoans and crinoids. Webster et al. (2008) determined *Arachnocrinus sarizensis* n.sp. in the lower levels of the formation in the Eastern Taurides and suggested that *A. sarizensis* would have been living paleogeographically in a passive margin environment of the Oldreidia continental mass along the southern edge of the Paleotethys at approximately 42 degrees south latitude.

The Şafak Tepe Formation exhibits varying thickness and lithofacies in the Central and Eastern Taurides. It is 230 m thick in Tufanbeyli, 380 m in Feke and approximately 500 m in the Ovacık area. Within the Şafak Tepe Formation two major lithofacies are present, namely a dolomite and a carbonate facies, which are observed in a lateral transitional relation. Dolomitic facies is formed in a tidal flat, whereas carbonate facies is formed in a subtidal environment representing a higher water level. These carbonates are thick-bedded, massive, bioclastic storm deposits alternating with fine-crystallized dark coloured limestones (Varol 1992). *Amphipora ramosa* Philips found in different areas of the Central and Eastern Taurides (Özgül et al. 1972; Demirtaşlı 1984; Metin et al. 1986; Göncüoğlu & Kozur 1998; Göncüoğlu et al. 2000, 2005a) indicates a Middle Devonian age. Özgül et al. (1973) also suggested the same age according to corals; Sayar et al. (2005, 2008) an Eifelian–Givetian age according to brachiopods; Göncüoğlu et al. (2004b) an Eifelian–late Givetian age according to conodonts (Appendix).

These platform carbonates of the Şafak Tepe Formation are conformably overlain by the Gümüşali Formation, which comprises a massive limestone, nodular limestone and shale and sandstone alternation, bearing a very rich fossil fauna (Fig. 5). The lower parts of this 600–650 m thick unit are composed of dark coloured, reefoidal, very thick-bedded to massive limestones, which pass into fossiliferous (brachiopods, corals, gastropods and bryozoans), thin- to medium-bedded, nodular limestone and dark coloured shale alternation. Towards the top the ratio of detritic rocks increases and an intercalation of siltstones, fine sandstones, shales and some limestones predominates. Hummocky-type bedding, ripple-marks, trace fossils and bioturbation are very abundant sedimentary structures observed in these levels. A two–three meter thick, fossiliferous, oolitic, ferrigenous sandstone horizon (Fig. 5), which can be observed almost in the entire Taurides, is one of the marker horizons of the Devonian sequence in Taurides. The uppermost section of the Gümüşali Formation consists of nodular, wavy-bedded, bioturbated, fossiliferous (brachiopods, trilobites), bioclastic limestones, marls and siltstones.

The very rich fauna in different parts of the Taurides is reported in many paleontological studies, where aspects of Devonian biofacies are discussed (Blumenthal 1944; Ünsalaner 1945, 1951; Demirtaşlı 1967; Özgül et al. 1972, 1973; Tutkun 1984; Çapkınoğlu 1991; Nalcıoğlu 2004; Yılmaz 2004; Gourvennec 2006). Sayar et al. (2005, 2009) have reported from the Gümüşali Formation a Frasnian brachiopod fauna and in the uppermost 30 meters of this unit a Famennian brachiopod fauna (Appendix). Göncüoğlu et al. (2004b) suggested a Middle Givetian to Frasnian age according to the shallow water conodont fauna found in reefoidal limestones of the Gümüşali Formation. Çapkınoğlu & Gedik (2002) pointed out that the conodont fauna of the Gümüşali Formation indicates a nearshore environment with its polygnathid-icriodid biofacies. Furthermore, they have determined three new taxa (Appendix). In a more recent study Yılmaz & Demircan (2005) have determined in the upper parts of the formation trace fossils such as *Cruziana* isp., *Rusophycus* isp. (trilobite trace), *Planolites* isp., *Palaeophycus* isp. A rich coral fauna (Appendix) from the lower parts of the unit is reported by Hubmann (1991). Akyol (1980) have found two new species of *Auriculimembranispora*, namely *A. radiata* and *A. undulate*.

The above mentioned fauna, biofacies characteristics and sedimentological properties show that the Upper Devonian sequence in Central and Eastern Taurides have been deposited in a reefoidal to storm-affected supratidal environment. This unit is conformably overlain by the Lower Carboniferous Ziyarettepe Formation (Fig. 5).

Devonian of the Pontides

The Devonian in the Pontides is represented by sedimentary sequences observed in the Istanbul area in the west and in Çamdağ-Zonguldak area in the east (Figs. 1 and 6). This particular area in the Western Pontides belongs to the so-called Rhodope-Pontide fragment of Şengör & Yılmaz (1981), to the Istanbul Zone of Okay (1989) or to the Istanbul and Zonguldak Terranes of Göncüoğlu et al. (1997). Okay et al. (1994) have suggested, that this continental sliver was originally located further north between the Moesian platform and Crimea as part of the Odessa shelf prior to the Albian. During the opening of the Western Black Sea basin during the Albian to Early Eocene it drifted southward along two major transform faults (Fig. 6). Göncüoğlu (1997) on the other hand suggested a Peri-Gondwanan origin for these terranes. The Devonian successions here are embedded within a thick Paleozoic sedimentary sequence of Ordovician to Carboniferous age. The Cadomian basement of this Paleozoic sequence is exposed to the south and east of the Istanbul Zone, in the Armutlu Peninsula and in the Bolu Massif, respectively. The Cadomian basement consists of a high-grade metamorphosed supra-subduction ophiolite complex, an arc-type volcanic and volcanoclastic sequence. It is dated to 570–590 Ma (Kozur & Göncüoğlu 1998; Ustaömer 1999; Chen et al. 2002; Yigitbaş et al. 2004).

Devonian in the Pontides was first reported in the Istanbul area in the mid 19th century (Tchihatcheff 1867) and has been studied since then intensively (Penck 1919; Paeckelmann 1925, 1938; Abdüsselamoğlu 1963; Haas 1968; Kaya 1973; Kullmann 1973; Babin 1973; Carls 1973; Sayar 1979; Gedik 1981; Önalan 1987/1988; Çapkınoğlu 1997, 2000; Derman 1997; Gedik & Önalan 2001; Herten et al. 2004). A comprehensive summary of these studies describing the litho- and biostratigraphy of the Devonian successions in the Pontides is presented in the following. The Istanbul and Çamdağ-Zonguldak areas are addressed separately here.

Litho- and biostratigraphy of the Devonian in the Istanbul area

The Devonian in the Istanbul area is probably represented by the upper horizons of the Dolayoba Formation and surely by the Istinye, Kartal and Büyükada Formations (Önalan 1987/1988). The exact position of the S/D boundary is a matter of debate. Information on the uppermost Silurian (Ludlow) comes from the upper parts of Dolayoba Formation and on the lowermost Devonian (Lochkovian) from the Gebze Member of the Istinye Formation (Fig. 7). There are no fossil findings so far in the upper sections of Dolayoba Formation and in the entire Sedefadası Member of Istinye Formation. Consequent-

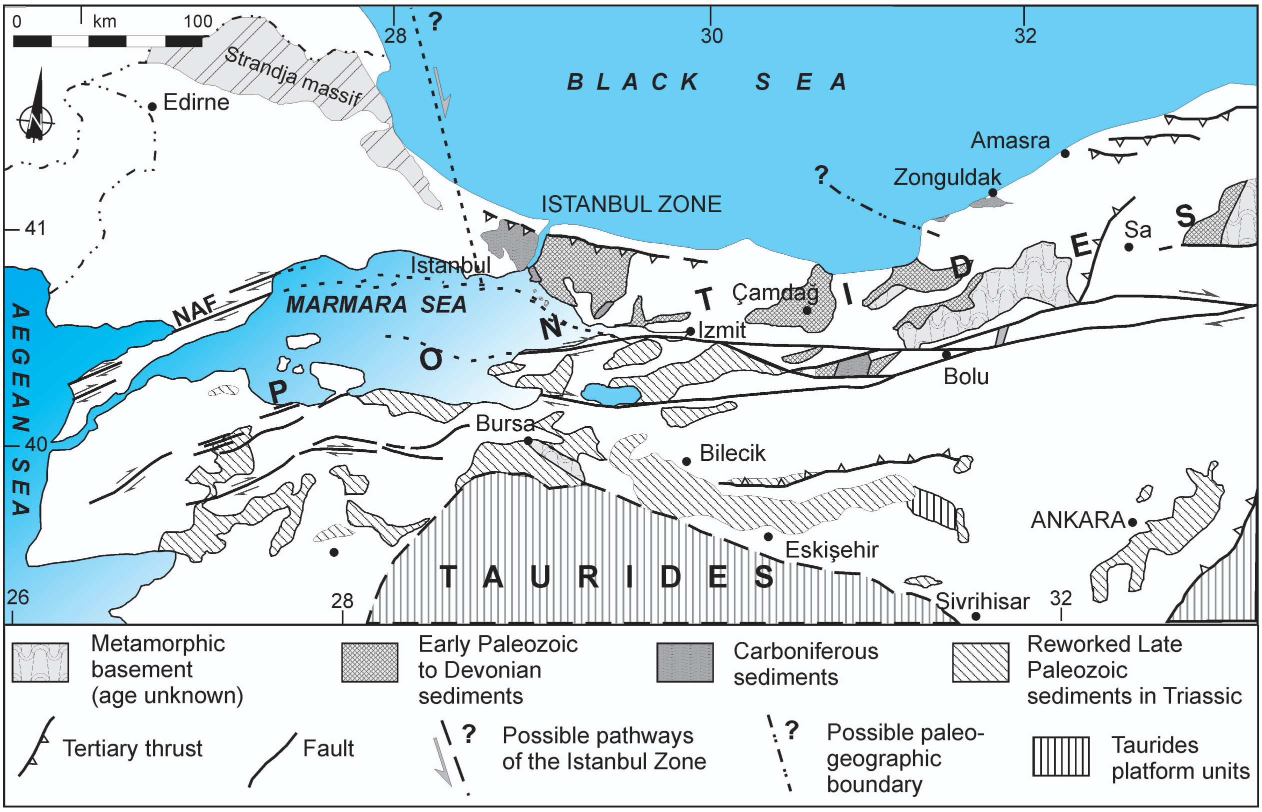

Fig. 6. Map showing distribution of Lower Paleozoic and Devonian outcrops in the Western Pontides where the Istanbul Zone and Çamdağ area bear most of the Devonian successions (modified from Görür et al. 1997).

ly, the boundary should be somewhere within this approximately 100 m thick interval. It is set by Önalan (1982, 1987/88) and by Gedik et al. (2005) at the base of the Sedefadası Member, by Herten et al. (2004) according to a chemostratigraphic assessment at a certain level to the higher parts of the Dolayoba Formation in the Esenyalı well. Haas (1968) prefers a position in the Gebze Member of Istinye Formation. Accordingly, it can be concluded that the Devonian in the Istanbul area is represented by the Dolayoba Formation (upper parts), Istinye Formation (Sedefadası, Gebze, Kaynarca Members) and Büyükada Formation (Bostancı, Yörükali, Ayineburnu Members).

Dolayoba Formation consists of mainly reefoidal limestones, which are greyish blue, pink, beige-coloured, medium–thick-bedded to massive and partly nodular. The thickness of the Dolayoba Formation varies between 100–150 m. The reefoidal lower parts are rich in corals, stromatoporoids and bryozoans (Kaya 1973). Haas (1968) has reported from the so-called Tavşantepe, Bağlarbası, Cumaköy, Çakıllıdere and Pelitli beds of its Akviran Series, which is the equivalent of the Halycites-Kalke of Paeckelmann (1938), a rich conodont fauna (Appendix). A Wenlock age has been assigned to it. From the higher parts of the Dolayoba Formation he reported brachiopods, trilobites and conodonts (Appendix), which were also reported by Paeckelmann (1938). He defined Upper Ludlow as the upper limit for the age of the Dolayoba Formation. Önalan (1982) has also assigned a Wenlock–Ludlow age according to fossils, he found in the Yayalar Member of the Dolayoba Formation. According to these fossils the age of the Dolayoba Formation is determined as Late Silurian (Wenlock–Ludlow) to Early Devonian (Lochkovian) (Haas 1968; Önalan 1982; Herten et al. 2004; Boncheva et al. 2005; Göncüoğlu et al. 2006).

Lithological properties, oolitic, ferrigenous intervals at the lower zones of the unit, small patch reef formations and well-bedded intra-reefs, together with a limestone facies represented by wackestones, packstones, boundstones and mudstones suggest deposition in a shallow, relatively high energy marine environment, where some small patchy reef developments were also present (Önalan 1982, 1987/1988). Quartz grains and some intraclastic beds indicate periods of intensified material transport into the shallow ramp/shelf area, where in general a reef facies dominates.

The lower member of Istinye Formation, the Sedefadası Member is formed by dark blue-black, fine-laminated, thin-medium-bedded limestones, which alternate with pink coloured, thin-bedded, calcareous shales. The lower and upper contacts of this member are both transitional with the Dolayoba Formation and Gebze Member, respectively (Fig. 7). The thickness of Sedefadası Member varies between a few meters and 80 meters. Until 2005 no fossils were found in this unit. Boncheva et al. (2005) found conodonts of the *woschmidti* Zone in the lower parts of the Sedefadası Member indicating an early Lochkovian age. However, the lithostratigraphical assignment of this finding has to be reconsidered, as it may also represent according to its lithofacies the uppermost part of the

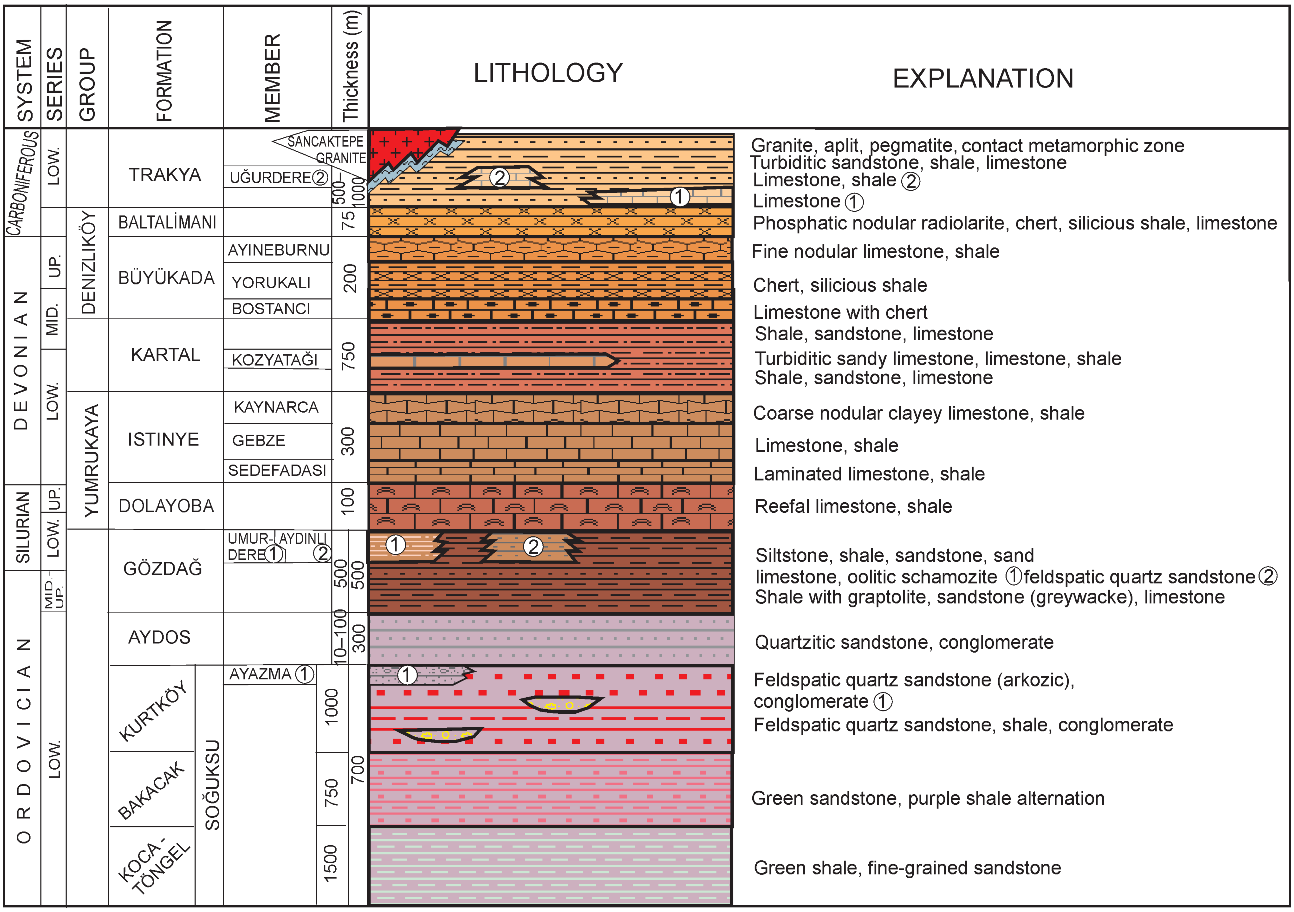

Fig. 7. Generalized stratigraphic section of Paleozoic units of the Western Pontides in the Istanbul area (modified from Gedik et al. 2005).

Dolayoba Formation. The age of the Sedefadası Member was defined according to its stratigraphic position by Haas (1968) as Late Silurian (Late Ludlow), by Kaya (1973) and by Önalan (1987/1988) as Early Devonian (Lochkovian, in the original Gedinian). According to more recent studies an Early Devonian age is more likely (Herten et al. 2004; Boncheva et al. 2005).

Dark coloured, thinly parallel-laminated carbonate mudstones suggest a deepening, which is probably caused by a sea-level rise. However, the uneven thickness of the unit also indicates formation of small-scale depressions of varying size. Hence, the depositional environment of Sedefadası Member can be described as small basinal depressions on the ramp/shelf area, which were relatively well restricted and less oxygenated. Slump structures reported in the lower parts (Görür et al. 1997) may be related to the deposition on the margins of these depocenters. Pink coloured calcareous shales, which alternate with carbonate mudstones, indicate that some clastic material was also transported into these depocenters. Hence the depocenters were not far from the land area, which supports the view that, deposition occurred in depressions on the shelf rather than in an offshore deep basin.

The thick- and well-bedded, dark blue, grey, partly dolomitic limestones with few thin-bedded marl and shale intercalations are typical lithologies of the conformably overlying Gebze Member. The thickness varies between 100 and 150 m (Önalan 1987/1988). It passes gradually into the nodular limestones of the Kaynarca Member (Fig. 7). Haas (1968) argued that its rich brachiopod and conodont fauna (Appendix) shows an uppermost Ludlow–Lochkovian (Gedinnian in original). A similar age is also suggested by Abdüsselamoğlu (1977), whereas Paeckelmann (1938), Baykal & Kaya (1963), Kaya (1973), Önalan (1987/88) suggested a Lochkovian (in original Gedinnian) age which should be considered as more likely for the Gebze Member of the Istinye Formation. Thin-bedded, dark coloured carbonate mudstones in the lower parts of this unit and the transitional nature of its contact with the underlying Sedefadası Member show that the depositional conditions were very similar to those of the Sedefadası Member in the beginning. As indicated by the increasing thickness of beds and by lithologies such as fossiliferous carbonate wackestones, intraclastic pack- and grainstones suggest a transition towards a ramp/shelf environment (Önalan 1987/1988). Some patch reef developments and grainstones in the upper parts show that the ramp was a relatively shallow one, also supported by thin marl and calcareous shales in its upper parts. The shallowing may be related to a sea-level fall during the Early Devonian.

The grey, nodular, thick-bedded limestones of the Kaynarca Member transitionally overlie the Gebze Member. The thickness varies and ranges between 20 and 75 m (Fig. 7). A rich fauna of brachiopods, corals, conodonts, gastropods and trilobites (Appendix) suggests a Lochkovian-Pragian age (Haas

1968). Abdüsselamoğlu (1977) mentioned according to conodonts a Late Ludlow–Lochkovian age and Önalan (1982) a Pragian (Siegenian in original) age after *Pleurodictyum constantinopolitanum* Roemer, reported first by Bey (1867). Boncheva et al. (2005) suggested for the nodular limestones of the Kaynarca Member even a Pragian–early Emsian age based on conodonts. Thick-bedded nodular carbonate mud- and wackestones and a rich fauna are interpreted as indications of deposition on a carbonate shelf/ramp environment, which probably started to get deeper during the earliest Emsian.

The limestones of the Kaynarca Member pass into calcareous siliciclastics of the Kartal Formation, which also contains some lensoidal limestone beds in its basal part. The siliciclastics of the Kartal Formation are mainly yellowish brown, grey, thin- to medium-bedded, sandy siltstones and shales. Calcareous shales and limestone interbeds are common in the middle parts of this unit, which is distinguished as the Kozyatağı Member by Önalan (1987/1988). Towards the top, the sequence is mainly formed again by thin-bedded, yellowish brown shales (Önalan 1987/1988). The Bostancı Member of the Büyükada Formation overlies the Kartal Formation conformably. The thickness of the Kartal Formation varies between 600 and 800 m (Fig. 7). Calcareous shales and siltstones are very rich in brachiopods, corals, trilobites, cephalopods and ostracods. According to trilobites (Appendix) Gandl (1973) assigned an Emsian–Eifelian age. Kullmann (1973) reported a late Emsian–early Eifelian goniatit fauna (Appendix). Whereas Kaya (1973) suggested according to some corals (Appendix) a Pragian (in original Siegenian) — Emsian age, Babin (1973) favoured an Emsian age on the basis of a rich pelecypod fauna (Appendix). Carls (1973) determined also early Emsian brachiopods (Appendix). Conodont fauna (Appendix) from the Kartal Formation reported by Gedik et al. (2005), by Boncheva et al. (2005) and by Saydam & Çapkınoğlu (2005) indicate an Emsian–Eifelian age.

The siliciclastic nature of the sequence together with arenitic rocks and the existence of sparitic, bioclastic carbonate wacke- and grainstones suggest deposition in a clastic shelf environment. It was in general a relatively deep shelf as indicated by sedimentary structures like lamination and fossil content. However, bioclastic intervals, sparitic cement and arenitic beds show that parts of the shelf were affected by currents and storm waves. Furthermore, micaceous material such as sericite, which is very abundant in silty and sandy intervals, is an indication of a close erosional land area and relatively short transportation distance. The fining-upward character of the sequence represented by thin-bedded, laminated shales is probably related to a deepening of the shelf area either due to a sea-level rise or due to a flexure of the continental lithosphere during the early Eifelian.

The Kartal Formation is overlain conformably by bluish grey, black thin- to medium-bedded, nodular limestones, which alternate with some thin light brown shales of the Bostancı Member of the Büyükada Formation. The thickness of this member varies between 10 and 50 m (Fig. 7). According to goniatites, trilobites, conodonts, ostracods and corals (Appendix) an Eifelian–Givetian age is assigned to the lower part of this member (Haas 1968; Kullmann 1973; Gandl 1973). Abdüsselamoğlu (1963) reported an Emsian–Frasnian age after conodonts and ostracods. Recently Gedik et al. (2005) confirmed the Eifelian age based on new conodont findings (Appendix). The limestones represented mainly by micritic carbonate mudstones and partly laminated shale interbeds, small scale slump structures and well preserved fossils indicate deposition in a low-energy marine environment. In the light of the facial properties of underlying and overlying units it is concluded that the deep shelf was converted into a continental slope during the Eifelian.

The overlying Yörükali Member, which is first described by Kaya (1973), consists of cherts and silicified shales with some radiolarites. The cherts are grey to black, the silicified shales grey to red. Both are thin-bedded, brittle and include some small slump structures. The boundary with the underlying Bostancı and overlying Ayineburnu Member is transitional. The Yörükali Member may be up to 100 m thick (Fig. 7). According to ostracods (Appendix), Nazik et al. (2007) assigned a late Frasnian age. Lithological association and sedimentary structures suggest a deposition in a slope to basinal setting, that is in a deep marine environment.

The Yörükali Member is conformably overlain by the Ayineburnu Member, consisting of an alternation of blue to grey nodular limestones and silicified shales. Chert bands and nodules are also present. It passes into the silicified shales and radiolarites of the Baltalimanı Formation. The thickness is approximately 50 m (Fig. 7). Abdüsselamoğlu (1963) suggested a late Frasnian–Famennian age according to the conodonts (Appendix). Gandl (1973) reported on the basis of the trilobites (Appendix) an early Frasnian age. Çapkınoğlu (2000) however indicated a Famennian age according to the conodonts of the Upper *expansa* Zone. Similarly, Gedik et al. (2005) also suggested Famennian according to new conodont findings (Appendix). In contrast, Göncüoğlu et al. (2004a) extended the upper age limit up to the middle Tournaisian based on conodont data and argued for the Devonian/Carboniferous boundary being located within the Ayineburnu Member. Further detailed biostratigraphic studies will be required in order to determine the exact age, but a Frasnian–Famennian age is surely confirmed, since the silicified black shales, cherts and lydites of the overlying Baltalimanı Formation are of Tournaisian age (Noble et al. 2008). The litho- and biofacies suggest a deposition in a deep basin. Hence, during the Eifelian to Famennian period the shelf area changed gradually from a proximal deep ramp into a basin.

Litho- and biostratigraphy of the Devonian in the Çamdağ-Zonguldak area

In the Çamdağ-Zonguldak area the Ordovician sequence up to the marker horizon, the Aydos Formation, is similar to that in the Istanbul area (Fig. 6), (Dean et al. 1997, 2000; Göncüoğlu 1997; Kozur & Göncüoğlu 1998; Gedik & Önalan 2001). The differences mentioned by Gedik & Önalan (2001) in the southern block of the Çamdağ area can be considered small and can be ascribed to lateral facies changes. However, the overlying Ordovician–Lower Devonian succession in the Çamdağ area is remarkably different than that in the Istanbul area. This part is represented by the Fındıklı Formation and consists of grey to brown shales and sandstones with some limestone interbeds. Brachiopods in the upper parts indicate an Early Devonian age (Gedik & Önalan 2001), which was confirmed recently by Yalçın et al. (2007). Hence the Silurian/Devonian boundary has to be located somewhere within the Fındıklı Formation. As in the lower parts of this unit no indication of a depositional break is observed, the Silurian/Devonian boundary here has to be considered conformable as also stated by Gedik & Önalan (2001). This contradicts the previous observations of a disconformity at the Silurian/Devonian boundary (Görür et al. 1997; Kozur & Göncüoğlu 1998; Göncüoğlu et al. 2005b).

Devonian in this area was reported very early by Berg (1910) based on the occurrence of *Orthis* and *Atrypa* in an alternating sequence of shales, sandstones and limestones. He also pointed out the similarity of this sequence with the Devonian in the Istanbul area, probably with the Kartal Formation. The Çamdağ region was an area of interest mainly because of an oolitic iron occurrence within the Devonian succession (Kleinsorge & Wijkerslooth 1940; Kipman 1974; Gedik & Önalan 2001). Furthermore within the framework of regional studies on Paleozoic stratigraphy some aspects of the Devonian units were also addressed (Aydın et al. 1987; Kaya & Birkenheide 1988; Derman 1997; Dean et al. 1997; Görür et al. 1997; Kozur & Göncüoğlu 1998; Gedik & Önalan 2001; Kozlu et al. 2002; Göncüoğlu & Sachanski 2003; Göncüoğlu et al. 2005b; Yalçın et al. 2007). The Devonian in the Çamdağ area is represented by the uppermost parts of the Fındıklı Formation, by the Ferizli Formation and lower parts of the Yılanlı Formation (Gedik & Önalan 2001). The boundary with the Carboniferous is located within the lower part of the Yılanlı Formation (Okuyucu et al. 2005).

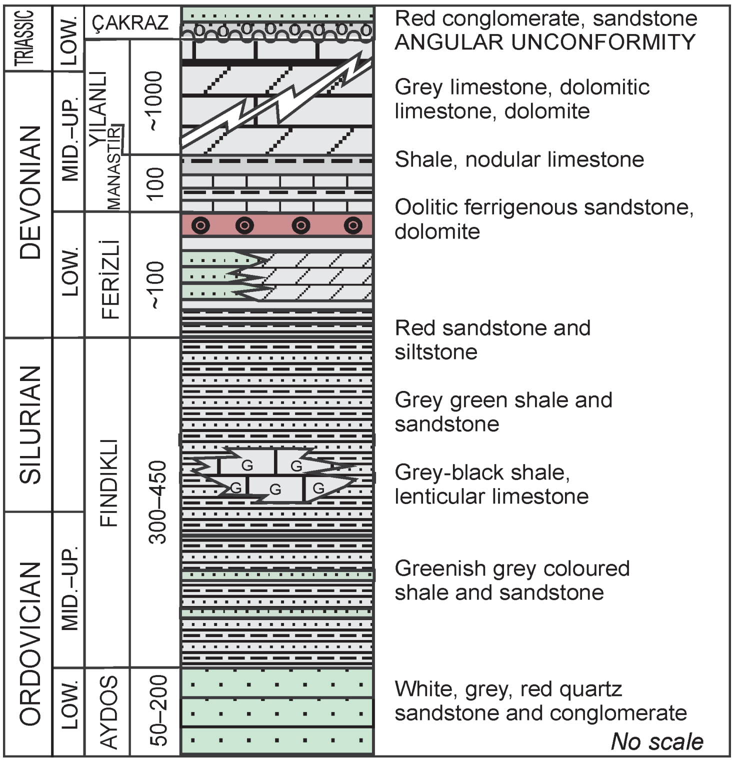

Fig. 8. Generalized stratigraphic section of Paleozoic units of the Western Pontides in the Çamdağ area (modified from Gedik & Önalan 2001).

The Fındıklı Formation in its upper parts consists of an alternation of grey, light brown, thin- to medium-bedded, shales, siltstones and cross-bedded, laminated sandstones. The sequence becomes more calcareous upwards. It is represented by calcareous siltstones and mudstones, which locally alternate with blue, grey, medium-bedded, fossiliferous limestones. The entire Fındıklı Formation is 300 to 450 m thick (Fig. 8). The thickness of Devonian part is approximately 100 m. Brachiopods (Appendix) in this part of this unit suggest an Early Devonian age (Gedik & Önalan 2001). From the lower parts graptolites, conodonts and nautolids of Silurian age are reported (Yanev et al. 2006). Recently Boncheva et al. (2009) confirmed an age span of Silurian–Early Devonian on the basis of graptolites from the lower part, of acritarchs from the middle part and of the conodonts from the upper part. Hence, for the entire Fındıklı Formation a Silurian–Devonian age is sure. Whereas Göncüoğlu et al. (2005b) suggest an unconformable boundary between the shallow marine Lochkovian sandstones of the Fındıklı Formation and the underlying Pridoli black shales with Orthoceras-limestones, Gedik & Önalan (2001) support a continuous deposition without any break between black shales and sandstones. Facies characteristics of the Fındıklı Formation show a deposition on a shallow mixed (clastic-carbonate) shelf during the Early Devonian, which even gets shallower upwards, as indicated by cross-bedded sandstones.

The Fındıklı Formation is overlain by red, grey, fine- to medium-bedded siltstones, shales and reddish, greenish, well and thick-bedded, fine-grained, cross-bedded sandstones of the Ferizli Formation. The sequence continues upwards with thick-bedded calcareous siltstones and sparitic, iron-rich algal limestones. The thickness of the unit is approximately 100 m (Fig. 8). This unit is rich in fossils. Gedik & Önalan (2001) suggest an Early Devonian (Pragian, in original Siegenian) age according to fossils such as *Hysterolides* and *Rhyconellides*, but, Kipman (1974) argued on the basis of brachiopods, *Uncinulus* sp. and *Megastrophia* sp. and with red algae *Solenopora* for a Middle Devonian age. For the overlying Manastır Member of the Yılanlı Formation a middle Eifelian age is reported in the light of a rich coral fauna (Kaya & Birkenheide 1988) and a Pragian–Emsian age by Göncüoğlu et al. (2005b). Therefore, the age of the Ferizli Formation can be considered as Pragian–Emsian. Oolitic ferrigenous ore deposits, a typical occurrence within the Ferizli Formation, cross-bedded red coloured sandstones show that the shelf area was getting shallower during the late Early Devonian, where high energy conditions were found. However, probably due to a break of detritic material transport into the shelf area marine conditions could prevail and the mixed shelf was gradually converted into a carbonate shelf. The transition is represented by calcareous silt to mudstones on top of the Ferizli Formation in the Kabalakdere section (Yalçın et al. 2007).

An alternation of nodular limestones, siltstones and shales, greenish-yellowish white and thin- to medium-bedded, are distinguished as the Manastır Member of the Yılanlı Formation (Kipman 1974; Gedik & Önalan 2001). This member bears a very rich coral fauna, which is studied by Kaya & Birkenheide (1988) and yielded an Eifelian age. As the Manastır Member represents the basal part of the Yılanlı Formation, Eifelian can be considered as the lower age limit of the Yılanlı Formation. The Yılanlı Formation consists of grey, dark grey, black, medium- to thick-bedded limestones, dolomitic limestones and dolomites, which locally alternate with thin-bedded, black, and calcareous shales. The total thickness of the unit is more than 1000 m. The lower and upper boundaries, respectively with the Ferizli and Alacaağzı Formations are transitional (Gedik et al. 2005). The overlying Alacaağzı Formation is Namurian in age. Hence the age of the Yılanlı Formation is Eifelian–Visean, that is Middle Devonian–Early Carboniferous. This is confirmed by the fossil findings (Appendix) of Aydın et al. (1987). The transitional upper boundary with the Alacaağzı Formation is limited to the Zonguldak area. To the west and south of Zonguldak in the Çamdağ area, upper parts of Yılanlı Formation are eroded and it is overlain either by the Permo-Triassic or younger units with an angular unconformity (Fig. 8). The depositional environment of the Yılanlı Formation was a typical marine carbonate platform/shelf, which lasted from Middle Devonian until Early Carboniferous.

Devonian deposits are also reported from the Karadere-Zirze area near Eflani (Fig. 1). Here, the Devonian units are represented by conglomeratic quartzitic sandstones at the base (Dean et al. 1997, 2000; Derman 1997), which disconformably cover the Silurian part of the Fındıklı Formation. According to Derman (1997) these sandstones are unconformably overlain by greenish grey shales and red-coloured mudstones, sandstones and siltstones, also Devonian in age. This clastic sequence is also unconformably overlain by Middle Devonian–Lower Carboniferous carbonates of the Yılanlı Formation. However, Yanev et al. (2006) reported in the Karadere area only one unconformity, which is at the base of the Devonian. These unconformities have been related to sea-level changes by Derman (1997). This Devonian succession with several unconformities, at the base and within the unit itself, can be only partly correlated with the Devonian of the Çamdağ area.

The stratigraphy of the Devonian in the Istanbul and Çamdağ-Zonguldak areas are different from each other. The Lochkovian–Pragian in the Istanbul area is represented by the carbonates of the Dolayoba and Istinye Formations, whereas during the same period the mainly detritic lithologies of the Fındıklı and Ferizli Formations were deposited in the Çamdağ-Zonguldak area. The lithological properties of the following Emsian–Eifelian period are also different in the two areas. The Kartal Formation in Istanbul was deposited on a clastic shelf and upper parts of the Ferizli Formation and lower parts of the Yılanlı Formation in the Çamdağ-Zonguldak area on a carbonate shelf. Also during the Givetian–Famennian remarkable differences in facies of the two terranes resulted in different lithological associations. This particular period of the Devonian in the Istanbul area is characterized by a deepening upward sequence, whereas it exhibits a stable shallow carbonate platform/shelf environment in the Çamdağ-Zonguldak area (Yalçın et al. 2007). This remarkable difference indicates different paleogeographical settings of these two areas, which will be discussed later.

Discussion and conclusions

The remarkably thick sedimentary successions of the Devonian in Turkey are imbedded within an almost complete Paleozoic sequence, ranging from Cambrian or Ordovician to Carboniferous. Consequently, an almost complete Devonian stratigraphy is represented at locations of different geological settings in Turkey. Whereas the Devonian of the Arabian Plate and of the Taurides exhibits some similarities, that of the Pontides is quite different. The differences are caused by varying facies, which has also affected the lithological associations.

The Devonian of the Arabian Plate, observed both on the surface and in several oil wells in Southeastern Anatolia, is either eroded at their top as in the Hazro High, so that the Upper Devonian is often missing or it overlaps older units, as in the Amanos Mountains and Hakkari, so that the Lower Devonian is missing. Hence, the Devonian of the Arabian Plate is not so thick as in the Taurides or Pontides. Devonian sequences at both localities on the Arabian Plate consist of lithological associations representing a shallow shelf to tidal flat facies.

In the Taurides of Southern Turkey the Devonian is represented by a more than 1000 m thick sequence. Its contact with the Silurian at the base and with the Carboniferous at the top is transitional. Furthermore, within the Devonian sequence no indications of significant depositional breaks are observed. Hence, a complete Devonian sequence is represented. In general a shallow marine facies ranging from inter- to supratidal during the Early Devonian to a deep shelf during the Late Devonian is found. Mainly during the Middle Devonian some reefoidal carbonates were also deposited.

The Devonian in the Pontides of northwestern Turkey, represented by the so-called Paleozoic of Istanbul and by the Paleozoic of the Çamdağ-Zonguldak area, exhibits remarkable differences. The Devonian in the Istanbul area clearly indicates a deepening upward sequence from a shallow shelf into a basinal facies from the Middle Devonian to Carboniferous, whereas that the Çamdağ-Zonguldak area suggests a stable shelf environment.

The Devonian of Taurides and the Arabian Plate is an integral part of a thick and almost continuous sequence ranging from Cambrian to Carboniferous. There are some facies changes from north to south and from east to west, but, these slightly different Devonian successions can be correlated from the Taurid-Anatolid Block in the north to the Arabian Plate in the south. As the Paleozoic of the Arabian Plate can surely be assigned to Gondwana, the Devonian of the Taurides and of Southeastern Turkey can also be identified as Gondwanan in origin. Consequently, it can be concluded that the Devonian of Southern Turkey was deposited on the northern margin of Gondwana.

The paleogeographic position of the Devonian successions in the Istanbul and Çamdağ-Zonguldak areas, however, is a matter of debate. The proposed models involve a Laurussian (e.g. Görür et al. 1997) or Peri-Gondwanan (e.g. Göncüoğlu 2001) origin as discussed in detail by Yanev et al. (2006). Some indicators such as the type and age of the Neoproterozoic basement of the Istanbul-Zonguldak Terrane (Okay et al. 2006), affinity of the Ordovician trilobites with Central Europe, rather than with Baltica (Dean et al. 1997; Dean et al. 2000) support a Peri-Gondwanan origin. However, a completely different Devonian lithostratigraphy and lithofacies, absence of the Ordovician glaciomarine deposits, which are represented both in the Taurides and in the Arabian Plate (Monod et al. 2003), close similarity of the Devonian-Carboniferous stratigraphy and facies of the Zonguldak area with that of the Moesian platform (Kozur & Göncüoğlu 1998) support a non-Gondwanan origin for the Devonian–Carboniferous of the Istanbul and Zonguldak area. Therefore, the Devonian successions of the Pontides must have been deposited on a terrane located north of the Paleotethys, as recently discussed by Yalçın et al. (2008). Accordingly, Pontides may have been drifted from Gondwana either by the opening of the Rheic Ocean during the Ordovician together with Avalonia or Amazonia (Ustaömer et al. 2008, 2009) or later in the Silurian by the opening of Paleotethys as a part of one of the Superhun Terranes (Stampfli 2000; Stampfli & Borel 2002; Stampfli & Kozur 2006). Observations, such as that the Ordovician fauna of the Istanbul Zone with Avalonian affinities during the Early Ordovician and a closer affinity to Baltica and Siberia/Laurentia during the Late Ordovician (Kalvoda 2003; Kalvoda et al. 2008), that the Devonian ostracod fauna (Dojen et al. 2004; Nazik & Gross-Uffenorde 2008) and the brachiopod fauna from the Emsian in the Istanbul Zone (Jansen & Nalcıoğlu 2008) have both a Peri-Gondwanan and Laurussian affinity support a Peri-Gondwanan (Avalonia and/or Amazonia) origin and the existence of a narrow seaway between these two terranes during the Devonian.

Acknowledgments: This paper is a contribution to the project "Paleoecology and Paleoclimate of Turkey-DEVEC-TR", which is supported by TÜBITAK-Turkey (Project Nr. 104Y218) and BMBF-Germany (Project Nr. TUR04/009). Both institutions are kindly acknowledged for funding the project. It is a contribution to the Project IGCP-499 'Devonian land-sea interaction — Evolution of ecosystems and climate', supported by UNESCO and IUGS. We also acknowledge the support of Istanbul University Research Fund, Projects UDP-2777 and UDP-1312. We also thank Drs M.C. Göncüoğlu and P. Königshof for their constructive comments and suggestions, which helped very much to improve the quality of the paper.

References

Abdüsselamoğlu Ş. 1963: New stratigraphical and paleontological observations on the Paleozoic outcrops on the eastern side of Bosphorus. *Bull. Min. Res. Exp.* 60, 1–7 (in Turkish).

Abdüsselamoğlu M.Ş. 1977: The Palaeozoic and Mesozoic in the Gebze region: excursion guidebook. 4th Colloquium on Geology of the Aegean Region. Excursion 4: Western Anatolia and Thrace. *ITU Maden Fak. Publication,* Istanbul, 1–16.

Açıkbaş D. 1978: Geology and hydrocarbon potential of the Çukurca, Köprülü, Yığınlı (Hakkari Province) Area. *MSc Thesis, Istanbul University, Dept. of Geological Engineering*, 1–52 (in Turkish).

Akyol E. 1980: Auriculimembranispora A novel spore obtained from the Upper Devonian Section in Düzağaç (Kozan–Adana). *Bull. Min. Res. Exp.* 91, 35–38 (in Turkish).

Aydın M., Serdar H.S., Şahintürk Ö., Yazman M., Çokuğraţ R., Demir O. & Özçelik Y. 1987: Geology of the Çamdağ (Sakarya)-Sünnicedağ (Bolu) Region. *Bull. Geol. Soc. Turkey* 30/1, 1–4 (in Turkish).

Babin C. 1973: Bivalvia of the Kartal formation of Devonian age, Istanbul, Paleozoic of Istanbul. *Ege Üniversitesi Fen Fakültesi Kitaplar Serisi* 40, 37–89 (in Turkish).

Baykal F. & Kaya O. 1963: Allgemeine Stratigraphie des Karbons in der Umgebung von Istanbul. *Bull. Min. Res. Exp.* 61, 1–10.

Berg G. 1910: Geologische Beobachtungen in Kleinasien. *Z. Dtsch. Geol. Gesell., Abh. Bd.* 62.

Bey A. 1867: Note relative a une collection des fossiles recueillis dans le terrain devonien du Bosphore. *C.R. Acad. Sci. LXIV,* 6, Mai, 914, Paris.

Blumenthal M.M. 1944: The Permocarboniferous of the Taurides between Kayseri Province and Malatya. *Bull. Min. Res. Exp.* 31, 105–118 (in Turkish).

Boncheva I., Sachanski V., Gedik I., Özgül N., Göncüoğlu M.C. & Okuyucu C. 2005: Devonian in the Keishte and Istanbul Units in Bulgaria and Turkey: Review and recent data. *International Workshop Depositional Environments of the Gondwanan and Laurasian Devonian. Abstracts and field trip guidebooks*. ISBN: 975-6395-45-1, 9–10.

Boncheva I., Göncüoğlu M.C., Leslie S.A., Lakova I., Sachanski V., Saydam G., Gedik I. & Königshof P. 2009: New Conodont and palynological data from the Lower Paleozoic in Northern Çamdağ, NW Anatolia, Turkey. *Acta Geol. Pol.* 59, 2, 157–171.

Bozdoğan N., Bayçelebi O. & Willink R. 1987: Paleozoic stratigraphy and petroleum potential of the Hazro area, S.E. Turkey. *The 7th Biannual Petroleum Congress of Turkey, 6–10 April 1987,* Ankara, 117–130 (in Turkish).

Bozdoğan N., Aliţan C. & Ertuğ K. 2005: Devonian deposition in the Southeastern Anatolia. *International Workshop Depositional Environments of the Gondwanan and Laurasian Devonian. Abstracts and field trip guidebooks.* ISBN: 975-6395-45-1, 19–20.

Brocke R., Bozdoğan N., Mann U. & Wilde V. 2004: Palynology of the Silurian/Devonian Boundary interval at the northern margin of the Arabian Plate (Hazro area, SE Turkey). *Polen* 14, 164–165.

Carls P. 1973: Strophomenids of the Lower Devonian Kartal formation, Istanbul, Paleozoic of Istanbul. *Ege Üniversitesi Fen Fakültesi Kitaplar Serisi* 40, 1, 90–94.

Chen F., Siebel W., Satır M. & Terzioğlu M.N. 2002: Geochronology of the Karadere basement (NW Turkey) and implications for the geological evolution of the Istanbul zone. *Int. J. Earth Sci.* 91, 469–481.

Çakmakoğlu A. & Bilgin Z.R. 2006: Pre-Neogene stratigraphy of the Karaburun peninsula. *Bull. Min. Res. Exp.* 132, 33–62 (in Turkish).

Çapkınoğlu Ş. 1991: A new *Pelekysgnatus* species from the Lower Famennian of the Taurides, Turkey. *Boll. Soc. Paleont. Ital.* 30, 349–353.

Çapkınoğlu Ş. 1997: Conodont fauna and biostratigraphy of the Famennian of Büyükada, northwestern Turkey. *Boll. Soc. Paleont. Ital.* 35, 165–185.

Çapkınoğlu Ş. 2000: Late Devonian (Famennian) Conodonts from Denizlikoyu, Gebze, Kocaeli, Northwestern Turkey. *Turkish J. Earth Sci.* 9, 91–112.

Çapkınoğlu Ş. & Gedik I. 2002: Late Devonian Conodont Fauna of the Gümüşali Formation, the Eastern Taurides, Turkey. *Turkish J. Earth Sci.* 9, 69–89.

Çoruh T., Yakar H. & Ediger V.Ş. 1997: The biostratigraphy atlas of the autochthonous sequence of Southeastern Anatolia. *Educational Publications of the Research Group of Turkish Petroleum Corporation* 30, 509 (in Turkish).

Dean W.T., Martin F., Monod O., Demir O., Rickards R.B., Bultynck P. & Bozdoğan N. 1997: Lower Paleozoic stratigraphy, Karadere-Zirze area, central Pontides, northern Turkey. In: Göncüoğlu M. & Derman A.S. (Eds.): Early Paleozoic evolution in NW Gondwana. IGCP Project No. 351, II. International Meeting, November 5–11, 1995, Ankara, Turkey. *Spec. Publ. Turkish Assoc. Petrol. Geol.*, Ankara 3, 32–38.

Dean W.T., Monod O., Rickards R.B., Demir O. & Bultynck P. 2000: Lower Palaeozoic stratigraphy and palaeontology, Karadere-Zirze area. Pontus Mountains, northern Turkey. *Geol. Mag.* 137, 555–582.

Demirkol C. 1988: Stratigraphy, structural geology and geotectonic evolution of Amanos Mountains West of Türkoglu, K. Maraş. *Bull. Min. Res. Exp.* 109, 25–36 (in Turkish).

Demirtaşlı E. 1967: Lithostratigraphic units and petroleum potential of the Pınarbaţı-Sarız-Mağara region. *MTA Report No. 3489*, Ankara (in Turkish).

Demirtaşlı E. 1984: Stratigraphy and tectonics of the area between Silifke and Anamur, central Taurus Mountains. In: Tekeli O. & Göncüoğlu M.C. (Eds.): *Proceedings International Symposium on the Geology of the Taurus Belt*, Ankara, 101–119.

Derman A.S. 1997: Sedimentary characteristics of Early Paleozoic rock in the Western Black Sea region, Turkey (Early Paleozoic Evolution in NW Gondwana). IGCP Project No. 351, III International Meeting, November 5–11, 1995. *Turkish Assoc. Petrol. Geol., Spec. Publ.*, Ankara 3, 24–31.

Dojen C., Özgül N., Göncüoğlu Y. & Göncüoğlu M.C. 2004: Early Devonian Ostracods of Thuringian Ecotype from NW Anatolia (Turkey). *Neu. Jb. Geol. Paleont., Mh.* 12, 733–748.

Elmas A. & Yiğitbaş E. 2001: Ophiolite emplacement by strike-slip tectonics between the Pontide Zone and the Sakarya Zone in Northwestern Anatolia, Turkey. *Int. J. Earth Sci. (Geol. Rundsch.)* 90, 257–269.

Erdoğan B., Güngör T. & Özer S. 1990: Stratigraphy of the Karaburun Peninsula. *Bull. Min. Res. Exp.* 111, 1–20 (in Turkish).

Eren Y., Kurt H., Rosselet F. & Stampfli G.M. 2004: Palaeozoic deformation and magmatism in the Northern Area of the Anatolide Block (Konya), witness of the Palaeotethys Active Margin. *Eclogae Geol. Helv.* 97/2, 293–306.

Ertug K., Bozdoğan N., Miller M. & Wood G. 1998: Silurian palynostratigraphy of the southeast Anatolia, Turkey. *CIMP Symposium News Letter*, Italy, 55, 14.

Gandl J. 1973: Trilobites from the Devonian of Istanbul, Paleozoic of Istanbul. *Ege Üniversitesi Fen Fakültesi Kitaplar Serisi* 40, 95–96.

Gedik I. 1981: Some observations on the stratigraphic position and of *Hadimopanella* Gedik, 1977 and on it's microstructure. *Bull. Earth Sci. Geol. Karadeniz Technical University* 1/2, 159–163 (in Turkish).

Gedik I. 1988: A paleogeographic approach of the Devonian of Turkey. *Proceedings of the Second International Symposium on the Devonian System Calgary*, Canada, 557–567.

Gedik I. & Önalan M. 2001: A new approach to the Paleozoic stratigraphy of the Çamdağ (Sakarya province). *Istanbul Univ. Engineering Faculty's Earth Sci. Rev.*, Istanbul, 14, 61–76 (in Turkish).

Gedik I., Pehlivan Ş., Timur E. & Duru M. 2005: Geological maps of Turkey, 1:50,000 scaled, No. 12, Istanbul F23d sheet. *MTA Publ.*, Ankara (in Turkish).

Gourvennec R. 2006: Upper Devonian Brachiopods from Eastern Taurus (Turkey). *Geol. Croatica* 59/1, 1–17.

Göncüoğlu M.C. 1997: Distribution of Lower Paleozoic units in the Alpine Terranes of Turkey. Paleogeographic constrains. In: Göncüoğlu M.C. & Derman A.S. (Eds.): Lower Paleozoic evolution in northwest Gondwana. *Turkish Assoc. Petrol. Geol., Spec. Publ.*, Ankara 3, 13–24.

Göncüoğlu M.C. & Kozur H.W. 1998: Facial development and thermal alteration of Silurian rocks in Turkey. In: Guiterrez-Marco J.C. & Rabano I. (Eds.): Proceedings, 1998 Field-Meeting, IUGS Subcomission on Silurian Stratigraphy. *Temas Geologico-Mineros ITGE* 23, 87–90.

Göncüoğlu M.C. & Sachanski V. 2003: The first record of Late Llandoverian (Telychian) graptolites from the Çamdağ Area, NW Turkey. *C.R. Acad. Sci. Bulgaria* 56/3, 37–42.

Göncüoğlu M.C. & Turhan N. 1983: New results on the age of Bitlis Metamorphics. *Bull. Min. Res. Exp.* 95/96, 1–5.

Göncüoğlu M.C., Dirik K. & Kozlu H. 1997: General characteristics of pre-Alpine and Alpine Terranes in Turkey: Explanatory notes to the terrane map of Turkey. *Ann. Geol. Pays Hellen.* 37, 515–536.

Göncüoğlu M.C., Turhan N., Senturk K., Ozcan A. & Uysal S. 2000: A geotraverse across NW Turkey: tectonic units of the Central Sakarya region and their tectonic evolution. In: Bozkurt E., Winchester J. & Piper J.A. (Eds.): Tectonics and magmatism in Turkey and the Surrounding Area. *Geol. Soc. London, Spec. Publ.* 173, 139–161.

Göncüoğlu M.C., Boncheva I. & Göncüoğlu Y. 2004a: First finding of Middle Tournaisian conodonts in the Griotte-type limestones of the "Palaeozoic of Istanbul": Implications for the Variscan evolution. *Rev. Ital. Paleont. Stratigr.* 110, 431–439.

Göncüoğlu M.C., Göncüoğlu Y., Kozlu H. & Kozur H.W. 2004b: Geological evolution of the Taurides during the Infra-Cambrian to Carboniferous period: a Gondwanan perspective based on new biostratigraphic findings. *Geol. Carpathica* 55, 6, 433–447.

Göncüoğlu M.C., Göncüoğlu Y., Kozlu H. & Kozur H.W. 2005a: Palaeozoic stratigraphy of the eastern Taurides, Turkey: Implications for Gondwanan Evolution. *Geol. Carpathica* 66, 433–447.

Göncüoğlu M.C., Boncheva I., Gedik I., Lakova I., Sachanski V., Saydam G., Okuyucu C., Özgül N. & Yanev S. 2005b: Perigondwanan versus Laurussian Origin of the NW Anatolian Paleozoic Terranes: A correlation of Mid-Paleozoic Events in Istanbul and Zonguldak. *International Workshop Depositional Environments of the Gondwanan and Laurasian Devonian. Abstracts and field trip guidebooks*. 15–16.

Göncüoğlu M.C., Yalınız K. & Tekin U.K. 2006: Geochemical features and radiolarian ages of volcanic rocks from the Izmir-Ankara Suture Belt, Western Turkey. *Proc. Int. Symp. Mesozoic Ophiolite Belts of the N Balkan Peninsula* (*Belgrade–Banja Luka, 11 May–6 June, 2006*) 41–44.

Göncüoğlu Y. & Kozur H. 2000: Early Silurian sea-level changes in southern Turkey: Lower Telychian conodont data from the Kemer area, Western Taurides. *Records of the Western Australian Museum, Suppl.* 58, 293–303.

Görür N., Monod O., Okay A.I., Sengör A.M.C., Tüysüz O., Yigitbas E., Sakinc M. & Akkök R. 1997: Paleogeographic and tectonic position of the Carboniferous rocks of the western Pontides (Turkey) in the frame of the Varican belt. *Bull. Soc. Géol. France* 168, 197–205.

Haas W. 1968: Das Alt-Paläozoikum von Bithynien (Nordwest Turkei). *Neu. Jb. Geol. Palaeont., Abh.* 131–2, 178–242.

Haude H. 1972: Stratigraphie und Tektonik des südlichen Sultan Dağ (SW-Anatolien). *Z. Dtsch. Geol. Gesell.* 123, 411–421.

Herten U., Mann U. & Yalçın M.N. 2004: Chemostratigraphic localization of the Silurian/Devonian Boundary in the Palaeozoic of Istanbul (Esenyali, Pendik-Istanbul). By stable carbon isotopic composition. *Proceedings of The International Symposium of Earth System Sciences, Istanbul-Turkey, Istanbul University, Institute of Marine Sciences and Management & Department of Geography*, 321–334.

Höll R. 1966: Genese und Altersstellung von Vorkommen der Sb-W-Hg Formation in der Türkei und auf Chios-Grichenland. *Bayer. Acad. Wiss. Math., Naturwiss. Kl., Abh.* 127, 118.

Hubmann B. 1991: Alveolitidae, Heliolitidae und Helicosalpinx aus den Barrandeikalken (Eifelium) des Grazer Devons. *Jb. Geol. B.-A.*, Wien 134/1, 37–51, 5 Abb., 3 Taf.

Jansen U. & Nalcıoğlu G. 2008: Silurian and Devonian brachiopods from Turkey. *20th International Senckenberg Conference & 2 nd Geinitz Conference, From Gondwana and Laurussia to Pangaea: Dynamics of Oceans and Supercontinents, September 30–October 10, 2008*, Frankfurt, Germany, 58–59.

Janvier P. & Marcoux J. 1977: Les gres rouges d'Armutgözlek Tepe leur faune de Poissons (Antiarches, Arthrodireset Crossopterygiens) d'âge deevonien superieur (Nappes d'Antalya, Taurides occidentales-Turquie). *Geol. Mediterraneenne, Tome IV*, 3, 183–188.

Janvier P., Lethiers F., Monod O. & Balkas Ö. 1984: Discovery of a vertebrate fauna at the Devonian–Carboniferous Boundary in SE Turkey (Hakkari Province). *J. Petrol. Geol.* 7, 147–168.

Kalvoda J. 2003: Carboniferous foraminiferal paleobiogeography in Turkey and implications for plate tectonic reconstructions. *Rev. Ital. Paleont. Stratigr.* 109, 255–266.

Kalvoda J., Babek O., Fatka O., Leichmann J., Melichar R., Nehyba S. & Spacek P. 2008: Brunovistulian terrane (Bohemian Massif, Central Europe) from late Proterozoic to late Paleozoic: a review. *Int. J. Earth Sci.* 97, 497–518.

Kaya O. 1973: The Devonian and Lower Carboniferous stratigraphy of the Istinye, Bostancı and Büyükada subreas, Paleozoic of Istanbul. *Ege Üniversitesi Fen Fakültesi Kitaplar Serisi* 40, 1–36.

Kaya O. & Birkenheide R. 1988: Contributions to the stratigraphy of Middle Devonian in the Surroundings of Adapazarı, Northwest Turkey. *Bull. Min. Res. Exp.* 108, 118–124.

Kaya O. & Rezsü U. 2000: Mesozoic and Paleozoic stratigraphic-structural entities of the Karaburun Peninsula, Western Turkey. *Int. Earth Sci. Colloquium on the Aegean Region (IESCA)* 2000, Izmir–Turkey, 15.

Ketin I. 1966: Tectonic units of Anatolia. *Bull. Min. Res. Exp*. 66, 22–34.

Kipman E. 1974: Geology of the marine iron deposits of Sakarya Çamdağ (Kestanepınar-Yassıgeçit villages). *Istanbul Üniversitesi Fen Fakültesi Monografi Serisi* 25, 72 (in Turkish).

Kleinsorge H. & Wijkerslooth P. 1940: Devonian oolitic iron deposits in Çamdağ around Adapazarı (Kocaeli province). *Bull. Min. Res. Exp*. 20, 319–334.

Konuk Y.T. 1979: Stratigraphy and tectonics of the Northwestern part of Karaburun peninsula. *Habilitation Thesis*, *Ege Üniv. Earth Sciences Faculty, Inst. of Marine Sciences and Technology,* Izmir, 85 (in Turkish).

Kozlu H., Göncüoğlu Y., Sarmiento G.N. & Göncüoğlu M.C. 2002: First finding of Late Silurian conodonts from the "Orthoceras Limestones", Çamdağ area, NW Turkey: Preliminary constraints for the paleogeography. *Geol. Balcanica* 31, 3–12.

Kozur H. 1995: New stratigraphic results on the Paleozoic of the western parts of the Karaburun Peninsula, Western Turkey. *Int. Earth Sci. Colloquium on the Aegean Region (IESC)* 9–14 October 1995, Izmir-Güllük, Turkey: Proceedings, V.I, 289–307.

Kozur H. 1997: First discovery of Muellerisphaerida (inc. sedis) and Eoalbaillella (Radiolaria) in Turkey and the age of the siliciclastic sequence (clastic series) in Karaburun peninsula. *Freiberger Forschungsheft*, C 466, 33–59.

Kozur H. & Göncüoğlu M.C. 1998: Main feaures of the pre-Variscan development in Turkey. *Acta Univ. Carol., Geol.* 42, 3–4, 459–464.

Kranendonck O. 2004: Geo- and biodynamic evolution during Late Silurian/Early Devonian time (Hazro area, SE Turkey). *Schriften des Forschungszentrums Jülich, Reihe Environment* 49, 1–268.

Ktenas C.A. 1925: Contribution â l'etude geologique de la presqu'île d'Erythree (Asieineure). *Ann. Sci. Faculte Sci., Athen*, Al. s., 1–57.

Kullmann J. 1973: Goniatite-coral associations from the Devonian of Istanbul, Turkey, Paleozoic of Istanbul. *Ege Üniversitesi Fen Fakültesi Kitaplar Serisi* 40, 97–116.

Lebküchner R. 1976: Beitrag zur Kenntniss des paleozoischen Kerns von Hazro Antiklinale in Südost Anatolien. *Bull. Min. Res. Exp*. 86, 1–13.

Lehnert-Thiel K. 1969: Geologisch-Lagerstaettenkundliche Untersuchungen an dem Zinnobervorkommen Kalecik und dem Nordöstlichen Teil der Halbinsel Karaburun, Westl. Türkei. *Bull. Min. Res. Exp*. 72, 43–73.

Mann U., Herten U., Kranendonck O., Poelchau H.S., Stroetmann J., Vos H., Wilkes H., Suchy V., Brocke R., Wilde V., Muller A., Ebert J., Bozdoğan N., Soylu C., El-Hassani A. & Yalçın M.N. 2001: Dynamics of the Silurian/Devonian boundary sequence: sedimentary cycles vs. organic matter variation. *Terra Nostra* 4, 44–48.

Marcoux J. 1979: General features of Antalya Nappes and their significance in the paleogeography of Southern Margin of Tethys. *Bull. Geol. Soc. Turkey* 14, l, 1–9 (in Turkish).

Metin S. 1983: Geology of Derebaşı (Develi), Armutalan and Gedikli (Saimbeyli) villages in Eastern Taurus. *Istanbul Univ. Engineering Faculty's Earth Sci. Rev.* 4 (1–2), 45–66 (in Turkish).

Metin S. 1984: Geology of Develi and Saimbeyli region in Eastern Taurus. *Istanbul Univ. Engineering Faculty's Earth Sci. Rev.* 16 (1), 82–100 (in Turkish).

Metin S., Ayhan A. & Papak I. 1986: Geology of the Western part of Eastern Taurus belt. *Bull. Min. Res. Exp.* 107, 1–13 (in Turkish).

Monod O. 1967: Presence d'une faune Ordovicienne dans les schistes de Seydişehir a la base des calcaires du Taurus occidental. *Bull. Miner. Res. Explor. Inst. Turkey* 69, 79–89.

Nalcıoğlu E.G. 2004: The Frasnian Braichopod fauna from late Devonian Gümüşali formation in Saimbeyli region (Adana-Eastern Taurus). *Bull. Min. Res. Exp.* 129, 57–68.

Nazik A. & Groos-Uffenorde H. 2008: Devonian Ostracode assemblages from NW Anatolia (Turkey) and their paleogeographic implications. *IGCP 497 The Rheic Ocean: Its Origin, Evolution and Correlatives" and IGCP 499 "Devonian Land-Sea Interactions: Evolution of Ecosystems and Climate" (DEVEC), 20th International Senckenberg Conference & 2nd Geinitz Conference: From Gondwana and Laurussia to Pangea: Dynamics of Oceans and Supercontinents* Frankfurt, Germany, Abstract and Programme, 113.

Nazik A., Groos-Uffenorde H. & Nalcıoğlu G. 2007: Beyrichiacean Ostracodes from NW Turkey and their palaeogeographical relations. *19th International Senckenberg Conference, Europeans Ostracodologist's Meeting VI*, Abstract Volume, 35.

Noble P.J., Tekin U.K., Gedik I. & Pehlivan Ş. 2008: Middle to Upper Tournaisian Radiolaria of the Baltalimanı Formation, Istanbul. *J. Paleontology* 82, 1, 37–56.

Okay A.I. 1989: Tectonic units and sutures in the Pontides, northern Turkey. In: Sengör A.M.C. (Ed.): Tectonic evolution of the Tethyan Region. *Kluwer Acad. Publ*., 109–116.

Okay A.I., Sengör A.M.C. & Görür N. 1994: The Black Sea: a kinematic history of opening and its effect on the surrounding regions. *Geology* 22, 267–270.

Okay A.I., Satır M. & Siebel W. 2006: Pre-Alpide orogenic events in the Eastern Mediterranean region. In: Gee D.G. & Stephenson R.A. (Eds.): European Lithosphere Dynamics. *Geol. Soc. London, Mem*. 32, 389–405.

Okuyucu C., Djenchuraeva A.V., Neyevin A.V., Saydam G.D., Çakırsoy Ö.B., Vorabiev T., Çörekçioçlu E. & Ekmekçi E. 2005: The biostratigraphic correlation of Paleozoic successions in Krygzhistan and Turkey. *MTA Report* 10746, 1–94.

Önalan M. 1982: Geology and sedimentary features of the Pendik region and Prince Islands. *Habilitation Thesis, Istanbul Univ., Faculty of Earth Sci., Dept. Geol. Engineering* 1–156 (in Turkish).

Önalan M. 1987/1988: Sedimentological properties of Devonian sequence in Istanbul. *Istanbul Univ. Engineering Faculty's Earth Sci. Rev.* 6, (1–2), 93–108 (in Turkish).

Özgül N. 1976: Some geological aspects of the Taurus orogenic belt. *Bull. Geol. Soc. Turkey* 19, 65–78 (in Turkish).

Özgül N. 1984: Geology of the Alanya tectonic window and its western part. *Ketin Simpozyumu, Türkiye Jeoloji Kurultayı*, 97–120 (in Turkish).

Özgül N. 1997: Stratigraphy of the tectonostratigraphic units around Hadım-Bozkır-Taşkent region (Northern part of the Central Taurids — Turkey). *Bull. Min. Res. Exp.* 119, 117–174.

Özgül N. & Kozlu H. 2002: Data on the stratigraphy and tectonics of the area between Kozan-Feke-Mansurlu. *Bull. Petrol. Geol. Turkey* 14/1, 1-36 (in Turkish).

Özgül N., Metin S. & Dean W.T. 1972: Stratigraphy and faunas of the Eastern Taurus Mountains in the Tufanbeyli region, Southern Turkey. *Bull. Min. Res. Exp*. 79, 9–16.

Özgül N., Metin S., Göğer E., Bingöl I., Baydar O. & Erdoğan B. 1973: Cambrian-Tertiary rocks of the Tufanbeyli region; Eastern Taurus, Turkey. *Bull Geol. Soc. Turkey* 16, 82–100 (in Turkish).

Paeckelmann W. 1925: Beiträge zur Kenntnis des Devons am Bosphorus, insbesondere in Bithynien. *Abh. Preuss. Geol. Landesanstalt, Neue Folge Heft.*, *Berlin* 98, 152.

Paeckelmann W. 1938: Neue Beiträge zur Kenntnis der Geologie, Paläontologie und Pétrographie der Umgegend von Konstantinopel (2. Geologie Thraziens, Bithyniens und der Prinzeninseln). *Abh. Preuss. Geol. Landesanstalt, Neue Folge Heft*., *Berlin* 186, 202.

Penck W. 1919: Grundzüge der Geologie des Bosporus Veröff: Inst. Meeresk, N. S., 4, 71, Berlin.

Perinçek D., Duran O., Bozdogan N. & Çoruh T. 1991: Stratigraphy and paleogeographical evolution of the autochthonous sedimentary rocks in Southeast Turkey. In: Turgut S. (Ed.): Tectonics and hydrocarbon potential of Anatolia and surrounding regions. *Ozan Sungurlu Symposium, Proc*. *Turkish Petrol. Corporation, Turkish Assoc. Petrol. Geol.,* 274–305 (in Turkish).

Poisson A. 1977: Recherches geologiques dans les Taurides occidentales (Turquie). *These, Üniversite de Paris-Sud Faculte des Sciences d'Orsay,* Orsay, 1–795.

Robertson A.H.F. & Ustaömer T. 2009: Upper Palaeozoic subduction/accretion processes in the closure of Palaeotethys: Evidence from the Chios Melange (E Greece), the Karaburun Melange (W Turkey) and the Teke Dere Unit (SW Turkey). *Sed. Geol.* doi:10.1016/j.sedgeo.2009.06.005.

Rosselet F. & Stampfli G.M. 2002: The Paleotethys siliciclastic sequence in Karaburun. *EGS/AGU-EUG Joint Assembly*, *Abstr*., EAE03-A-09770.

Rosselet F., Beccaletto L. & Stampfli G.M. 2003: Tethyan evolution of the Aegean Domain from Paleozoic to Late Triassic: Examples from Turkey. *2003 AAPG International Conference & Exhibition*, Barcelona, Spain.

Sayar C. 1964: Ordovician Conulariids from the Bosphorus Area, Turkey. *Geol. Mag*., London 101, 193–197, pl. IX.

Sayar C. 1979: Brachiapod-Diplograptid Zones in the Lower Paleozoic Successions in Istanbul. *Altınlı Simpozyumu (6–7 Mart 1979), Türkiye Jeol. Kur*. & *Ist. Üniv. Yerbilimleri Fak. Jeoloji Bölümü,* 27–35 (in Turkish).

Sayar C., Yilmaz I. & Bargu S. 2005: The stratigraphical and paleontological features of Devonian-Carboniferous sequence, Saimbeyli, South of Turkey. *International Workshop Depositional Environments of the Gondwanan and Laurasian Devonian. Abstracts and field trip guidebooks*, 42–43.

Sayar C., Yilmaz I. & Bargu S. 2009: Stratigraphy and fossils of Middle, Upper Devonian and Carboniferous from Saimbeyli, Eastern Taurides, Turkey. *Türkiye Jeoloji Kurultay* 62, 664–665.

Saydam D.G. & Çapkınoğlu Ş. 2005: Conodont Fauna of the Early–Middle Devonian successions in Beykoz, Şile and Kurtdoğmuş Region, Istanbul, Northwestern Turkey. *International Workshop Depositional Environments of the Gondwanan and Laurasian Devonian. Abstracts and field trip guidebooks*, 46.

Stampfli G.M. 2000: Tethyan oceans. In: Bozkurt E., Winchester J.A. & Piper I.D.A. (Eds.): Tectonics and magmatism in Turkey and the Surrounding Area. *Geol. Soc. London, Spec. Publ*. 173, 1–23.

Stampfli G.M. & Borel G.D. 2002: A plate tectonic model for the Paleozoic and Mesozoic constrained by dynamic plate boundaries and restored synthetic oceanic isochrones. *Earth Planet. Sci. Lett.* 196, 17–33.

Stampfli G.M. & Kozur H.W. 2006: Europe from Variscan to the Alpine cycles. In: Gee D.G. & Stephenson R.A. (Eds.): Europaean lithosphere dynamics. *Mem. Geol. Soc. London* 32, 57–82.

Sungurlu O. 1974: Geology and petroleum potential of the northern part of Petroleum District-VI. *Proceedings of the Second Petroleum Congress of Turkey, 22–25 January 1974, Ankara,* 85–107 (in Turkish).

Şenel M. 1984: Discussion on the Antalya nappes. In: Tekeli O. & Göncüoğlu M.C. (Eds.): *Proceedings International Symposium on the Geology of the Taurus Belt*, *26–29, Sept.*, Ankara, 41–52.

Şenel M., Serdaroğlu M., Kengil R., Ünverdi M. & Gözler M.Z. 1981: The geology of the SE part of the Teke Taurus (SW Turkey). *Bull. Min. Res. Exp.* 95/96, 13–43.

Şengör A.M.C. & Yılmaz Y. 1981: Tethyan evolution of Turkey: A plate tectonic approach. *Tectonophysics* 75, 81–241.

Tchihatcheff P.De. 1867: Asie Mineure, Description Physique de cette contree, quatrième partie. *Géologie I*, Paris.

Tolun N. 1949: Geologic notes on the Silvan ve Hazru area. *Bull. Geol. Soc. Turkey* 02/1, 65–89 (in Turkish).

Tutkun S.Z. 1984: Stratigraphy of Saimbeyli (Adana) Area. *Cumhuriyet Univ., Bull. of the Faculty of Engineering, Earth Sci.* 1 (1), 31–40 (in Turkish).

Uğuz M.F. 1989: The geology of the Silifke-Ovacık-Gülnar (Içel) area. *Istanbul Univ., PhD. Theses*, *Dissertation*, Istanbul (in Turkish).

Ustaömer P.A. 1999: Pre-Early Ordovician Cadomian arc type granitoids, the Bolu Masif, West Pontides, northern Turkey: geochemical evidence. *Int. J. Earth Sci.* 88, 2–12.

Ustaömer P.A., Ustaömer T., Gerdes A. & Zulauf G. 2008: Detrical zircon ages from Ordovician quarzites of the İstanbul exotic terrane (NW Turkey): Evidence for Avalonian–Amazonian affinity. *20th International Senckenberg Conference & 2nd Geinitz Conference, From Gondwana and Laurussia to Pangaea: Dynamics of Oceans and Supercontinents*, *September 30–October 10, 2008*, Frankfurt, Germany, 240–241.

Ustaömer P.A., Ustaömer T., Gerdes A. & Zulauf G. 2009: Detrital zircon ages from a Lower Ordovician quartzite of the Istanbul exotic terrane (NW Turkey): evidence for Amazonian affinity. *Int. J. Earth Sci. (Geol. Rundsch.).* DOI 10.1007/s00531-009-0498-1.

Ünsalaner C. 1945: Upper Devonian fauna of the region between Alaylıdağ and Beydağları. *Bull. Min. Res. Exp.* 34, 401–406.

Ünsalaner C. 1951: Some Upper Devonian corals and stromatoporoids from South Anatolia. *Bull. Geol. Soc. Turkey* 3, 131–146 (in Turkish).

Varol B. 1992: Petrography and origin of the Middle Devonian dolomites (Safaktepe Formation) in the Geyikdag Unit (East Taurus, Tufanbeyli-Saimbeyli). *Bull. Min. Res. Exp.* 114, 37–47.

Webster G.D., Yilmaz I. & Kozlu H. 2008: A new Middle Devonian gasterocomid crinoid from Central Turkey and revision of the Gastrecomidae. *Palaeoworld* 17, 12–20.

Yalçın N. 1980: Lithological characteristics of the Amanos Mountain range and it's significance on the tectonic evolution of Southeast Turkey. *Bull. Geol. Soc. Turkey* 23 (1), 21–30 (in Turkish).

Yalçın M.N., Bozdoğan N., Brocke R., Gedik I., Janssen U., Karslıoğlu Ö., Königshof P., Nazik A., Nalcıoğlu G., Saydam G., Uguz M.F. & Yılmaz I. 2007: Stratigraphy and facies development of the Devonian of northwestern Turkey. Devonian land-sea interaction: evolution of ecosystems and climate. *Field Meeting IGCP 499, 84–86, May, 2007*, San Juan, Argentina.

Yalçın M.N., Yılmaz I., Wilde V., Wehrmann A., Schindler E., Özkan R., Nazik A., Nalcıoğlu G., Königshof P., Jansen U. & Brocke E. 2008: Paleogeographical setting of Devonian successions of Turkey — A Gondwanan vs. Laurussian comparison. *20th International Senckenberg Conference & 2nd Geinitz Conference, From Gondwana and Laurussia to Pangaea: Dynamics of Oceans and Supercontinents*, *September 30–October 10, 2008*, Frankfurt, Germany, 141–142.

Yanev S., Göncüoğlu M.C., Gedik I., Lakova I., Boncheva I., Sachanski V., Okuyucu C., Özgül N., Timur E., Maliakov Y. & Saydam G. 2006: Stratigraphy, correlations and palaeogeography of Palaeozoic terranes of Bulgaria and NW Turkey: a review of recent data. In: Robertson A.H.F. & Mountrakis D. (Eds.): Tectonic development of the Eastern Mediterranean Region. *Geol. Soc. London, Spec. Publ.* 260, 51–67.

Yiğitbaş E., Kerrich R., Yılmaz Y., Elmas A. & Qianli X. 2004: Characteristics and geochemistry of Precambrian ophiolites from the Western Pontides, Turkey: following the missing chain of the Precambrian South European Suture Zone to the East. *Precambrian Res.* 132/1–2, 179–206.

Yılmaz E. & Duran O. 1997: Nomenclature of autochthonous and allochtonous units in Southeastern Anatolia — 'Lexicon'. *Türkiye Petrolleri Anonim Ortaklıgı, Araştırma Merkezi Grubu Başkanlığı Eğitim Yayınları* 31, 1–460 (in Turkish).

Yılmaz I. 2004: Geology and tectonic features of the Mansurlu-Saimbeyli (Adana) area in the Eastern Taurus. *Istanbul Univ., Ph.D. Theses*, *Dissertation,* 1–194 (in Turkish).

Yılmaz I. & Demircan H. 2005: Geology and trace fossils between Saimbeyli and Feke, Eastern Taurus. *International Workshop Depositional Environments of the Gondwanan and Laurasian Devonian. Abstracts and field trip guidebooks*. ISBN: 975-6395-45-1, 22–23.

Yılmaz I., Yalçın M.N., Wilde V., Wehrmann A., Uguz M.F., Schindler E., Saydam G., Özkan R., Mann U., Nazik A., Nalcioglu G., Kozlu H., Königshof P., Karslioglu Ö., Jansen U., Gedik I., Ertug K., Brocke R., Bozdoğan N. & Bahtiyar I. 2007: The Devonian of Turkey-an attempt for comparison of Laurussian and Gondwanan continental margins. *IUGS — Subcommission on Devonian Stratigraphy, Rapid Global Chang*e, *9–17 September 2007*, Eureka, Nevada, USA, 89–90.

Yurtsever Ş., Bora G. & Demirel H.I. 2000: Depositional envinroment and hydrocarbon source rock potential of the Upper Devonian–Triassic sequence of the Aladağ Unit — Middle Taurides, Turkey. *Geol. Bull. Turkey* 43, 1, 33–57.

SOUTHEASTERN ANATOLIA

Hazro Area

Dadaş Formation:

Conodonts: *Lonchodina greilingi* Walliser, *Trichonodella inconstans* Walliser, *T. excavata* Walliser, *Neoprioniodus excavatus* (Branson & Mehl), *Spathognathodus inclinatus* (Rhodes), *Ligonodina* sp., *Plectospathodus extensus* Rhodes, **Çoruh et al. 1997 and references therein**

Ostracods: Beyrichiacea, Pachydomellidae, *Eridoconcha* sp., **Çoruh et al. 1997 and references therein**

Bryozoa: *Rhombotrypa* sp., **Çoruh et al. 1997 and references therein**

Graptolits: Monograptidae, **Çoruh et al. 1997 and references therein**

Corals: *Aulopora tubaeformis* Goldfuss, *Diplophylum*? sp., *Fistulopora* sp., *Thamnopora cervicornis* (de Blainville), **Çoruh et al. 1997 and references therein**

Brachiopods: *Strophochonetes* sp., *Microsphaeridiorhynchus* sp., *Howellela* sp., *Fardeina* sp., *Athyris* cf. *concentrica*, *Atrypa reticularis* (Linnaeus), *Aulacella* sp., *Camarospira* sp., *Cleiothyridina* sp., *Cyrtina biblicata* Hall, *Dalmanella eifeliensis* de Verneuil, *Hypothyridina* sp., *Katunia* sp., *Leptostrophia* sp., *Levenea* sp., *Nucleospira concinna* n.sp., *Uncinulus elongatus* Ünsalaner, *Wilsoniella* sp., **Çoruh et al. 1997 and references therein**

Mollusc (Gastropods): *Nowackia* sp., **Çoruh et al. 1997 and references therein**

Crinoids: *Cyathocrinites* sp., **Çoruh et al. 1997 and references therein**

Kayayolu Formation:

Bryozoa: *Rhombotrypa*, **Tolun (1949)**

Corals: *Thamnopora cervicornis* de Biainville, *Aulopora tubaeformis* Goldfuss, *Fistulipora* sp., Monticuluporidae Ulrich, ?*Diplophyllum*, **Tolun (1949), Lebküchner (1976)**

Brachiopods: *Dalmanella eifeliensis* de Verneuil, *Aulacella* sp., *Leptostrophia* sp., *Hypothyridina* sp., *Camarotoechia* sp., *Uncinulus elongatus* Ünsalaner, *Atrypa reticularis* (Linnaeus), *Spirifer* (*Cyrtospirifer*) *verneuili* Murch, *Spirifer silvaniensis* Ünsalaner, *Nudeospira concinna* Hall, *Camarospira* sp., *Tylothyris* sp., *Cleiothyridina* sp., *Athyris concentrica* von Buch, *Cyrtina biplicata* Ünsalaner, *Rhynchospirina* sp., **Tolun (1949), Lebküchner (1976)**

Crinoids: *Cyathocrinites* Miller, **Lebküchner (1976)**

Amanos and Hakkari Area

Kayayolu Formation:

Ostracods: *Jonesina craterigera* (Brady), *Chamishaella* aff. *tumidus* (Kummerow), *Geffenina* aff. *aspinifera* Green, **Tanyol et al. (1997)**

Fish: *Ctenacanthus* cf. *crenulatus* McCoy, *Strepsodus* sp., *Chirodipterus* sp., *Groenlandaspis* sp., Acanthodidae, **Janvier et al. (1984)**

Köprülü Formation:

Foraminifers: *Umbella ovate*, *U.* cf. *nana*, *U.* cf. *shahrudensis*, *Hypeammina* sp.**, Perinçek et al. (1991)**

Palinomorphs: *Hymenozonotrilites lepidophytus*, *Vallatisporites pusillites* Kedo, “HL-VP Zone”, **Perinçek et al. (1991)**

Brachiopods: *Ptychomaletoechia* sp., *Spirifer* aff. *tornacensis* Koninck, *Rugosochonetes* sp., *Asyrinxia* sp., **Perinçek et al. (1991)**

TAURIDES

Western Taurides

Hocanınsuyu Formation:

Fishs: *Bothriolepsis canadensis*, *Holonema* Newberry, *Groenlandaspis seni* Janvier & Ritchie, *Gyropthius* sp., **Janvier & Marcoux (1977)**

Central and Eastern Taurides

Ayı Tepesi Formation:

Brachiopods: *Strefedonta* sp., **Metin (1983)**

Safak Tepe Formation:

Conodonts: *Icriodus* cf. *brevis* Stauffer, *Polygnathus* cf. *webbi* Stauffer, *P.* cf. *parawebbi* Chatterton, **Göncüoğlu et al. (2004b)**

Corals: *Amphipora ramosa* (Phillips), *Thamnophyllum trigemme* Quenstedt, *Coenites* sp.**,** *Calceola sandalina* Lamarck, **Özgül et al. (1973)**

Brachiopods: *Cyrtospirifer aperturatus* (Schlot), *Spinatrypa* cf. *dorsata* Biernat, *Spinatrypa* aff. *asperoides* Biernat, *Crytospirifer* aff. *schelenicus* Nalivkin, *Stringocephalus* sp., **Sayar et al. (2005, 2009)**

Gümüşali Formation:

Conodonts: *Icriodus brevis* Stauffer, *Ancyrodella pristina* Khalimbadzha & Chernysheva, *Polygnathus stylus* Stauffer, **Göncüoğlu et al. (2004b);** *Icriodus adanaensis* n.sp., *Icriodus fekeensis* n.sp., *Polygnathus antecompressus* n.sp., **Çapkınoğlu & Gedik (2002)**

Palinomorphs: *Auriculimembranispora* (*A. radiata* and *A. undulate*), **Akyol (1980)**

Corals: *Alveolites edwardsi* Lecompte, *Alveolites fecundus* Lecompte, *Alveolites intermixtus minor* (Iven), *Alveolites* sp., *Thamnopora reticulata* (de Blainville), *Thamnopora* sp., **Hubman (1991)**

Brachiopods: *Hypothyridina cuboides* (Sowerby), *Cyrtospirifer verneuili* Murchison, *C. verneuili echinosus* (Lyashenko), *C. verneuili* var. *lonsdalii* (Murch), *C. verneuili* var. *grabaui* Paeck, *C.* aff. *quadratus* Nalivkin, *Desquamatia* sp., *Cyphoterorhynchus arpaensis* (Abramian), *Rhipidomella penelope* Imbrie, *Laminatia* sp., *Cyrtospirifer* sp., *Athyris* cf. *concentrica* (von Buch), *Whidbornella caperata* (Sowerby), *Mesoplica praelonga* (Sowerby), *Schelwienella* cf. *percha* (Steinbrook), **Sayar et al. (2005, 2009)**

Trace fossils: *Cruziana* isp., *Rusophycus* isp. (trilobit trace), *Planolites* isp., *Palaeophycus* isp., **Yılmaz & Demircan (2005)**

PONTIDES

Istanbul

Dolayoba Formation:

Conodonts: *Carniodus*?, *Carinthiacus* (Walliser), *Pterospathodus amorphognathoides* Walliser, *Hadrognathus staurognathoides* Walliser, *Ozarkodina gaertneri* Walliser, *Carniodus carinthiacus* Walliser, *Neoprioniodus costatus* Walliser, *siluricus* and *eosteinhornensis* Zones, *Polygnathoides siluricus* Branson & Mehl, *Spathognathodus steinhornensis eosteinhornensis*, *Spathognathodus primus* (Branson & Mehl), *Spathognathodus inclinatus* (Rhodes), *Ozarkodina denckmanni* Ziegler, *Trichonodella* sp., **Haas (1968)**

Brachiopods: *Howellella crispa* (Hisinger), *Conchidium pseudoknighti* (Tschernyschew), *Dayia navicula* (Sowerby), *Platyorthis cimex* (Kozlowski), *Howellella* cf. *nucula* (Barrande), *Delthyris magnus* (Kozlowski), **Haas (1968)**
Trilobits: *Proetus barrangus* n.sp., *Calymene arotia* n.sp., *Encrinurus brevispinosus* n.sp., **Haas (1968)**

İstinye Formation (Gebze Member):
Conodonts: *Icriodus woschmidti* Ziegler, *Ozarkodina denckmanni* Ziegler, *Spathognathodus steinhornensis remscheindensis* Ziegler, *Spathognathodus wurmi* Bischoff & Sannemann, *Spathognathodus steinhornensis eosteinhornensis* Walliser, *Trichonodella insconstant* Walliser, **Haas (1968)**
Brachiopods: *Shaleria* sp., *Howellella nucula* (Barrande), *Rhynchonella* sp., *Syringopora* sp., *Bollia* sp., *Atrypa reticularis* (Linnaeus), **Haas (1968)**

İstinye Formation (Kaynarca Member):
Conodonts: *Ancyrodelloides trigonica* Bishoff & Sannemann, *Icriodus woschmidti* Ziegler, *Icriodus latericrescens* Branson & Mehl, *Spathognathodus wurmi* Bishoff & Sannemann, **Haas (1968)**
Corals: *Pleurodictium constantinopolitanum* Roemer, **Bey (1867), Önalan (1982)**
Molluscs (Gastropods): *Loxonema* sp., *Cyclonema striatum* (Hissinger), *Raphistoma* sp., **Haas (1968)**
Trilobits: *Cheirurus (crotalocephalus) copiosus* n.sp., *Spiniscutellum larviferum* n.sp., *Cornuproetus regulus* n.sp., **Haas (1968)**

Kartal Formation:
Conodonts: *Polygnathus dehiscens* Philip & Jackson, *Polygnathus gronbergi* Klapper & Johnson, *Polygnathus serotinus* Telford, *Belodella* sp., *Polygnathus linguiformis linguiformis* Hinde, *Icriodus corniger* Wittekindt, **Gedik et al. (2005);** *serotinus*, *patulus* and *partitus* Zones, **Boncheva et al. (2005), Saydam & Çapkınoğlu (2005)**
Ostracods: *Zygobeyrichia roemeri*, *Gibba schmidti*, *Zygobeyrichia subcylindrica*, **Nazik & Groos-Uffenorde (2008)**
Corals: *Pleurodictyum problematicum* (Goldfuss), *P. constatinopolitanum* Roemer, *P. bithynicum* Weisserm, **Kaya (1973)**
Brachiopods: *Leptaenopyxis* sp., *Strophodonta*? *clausa* (Verneuil), *Leptostrophia explanata* (Sowerby), *Leptostrophia* cf. *couviensis* (Asselbergs), *Mesodouvillina* sp., **Carls (1963)**
Molluscs (Cephalopods): *Anarcestes lateseptatus* (Beyrich), *Pinacites jugleri* (Roemer), *Mimagoniatites kayai* Kullmann, **Kullmann (1973)**
Molluscs (Pelecypods): *Praectenodonta elegans* (Khalfin), *Nuculoidea grandaeva* (Goldf), *Nuculoidea* cf. *curvate* (Maurer), *Nuculites truncates* (Steininger), *Nuculites* cf. *triqueter* (Conrad), *Nuculites ellipticus* (Maurer), *Phestia securiformis* (Goldf), *Palaeoneilo*? cf. *beushauseni* (Kegel), *Pterinea concentrica* (Roemer), *Leiopteria gervillei* (Oechlert), *Leiptria* cf. *globosa* (Spriestersbach), *Actinopteria costata* (Goldf), *Paracyclas marginata* (Maurer), *Paracyclas* cf. *belgica* (Maillieux), *Paracyclas* cf. *rugosa* (Goldf), *Paracyclas* cf. *carinata* (Kegel), *Cypricardinia crenistria* (Sandberger), *Cimitaria acutirostris* (Sandberger), *Orthonota* sp., *Grammysia* sp., *Cimitaria acutirostris* (Sandberger), **Babin (1973)**
Trilobits: *Pseudocryphaeus* cf. *proteus* (Haas), *Metacanthina asiatica* (Verneuil), *Metacanthina hammerschmidti* (Richter), *Acastoides (Talus)* n.sp., *Trimerus fornix* (Haas), *Paramalonutus gervillei* (Verneuil), *Kayserops astiferus* (Haas), *Phacops pantichionensis* (Haas), *Centauropyge pronemenaea*, **Haas (1968);** *Phacaops* cf. *turco praecedens* (Haas), **Gandl (1973)**

Büyükada Formation (Bostancı Member):
Conodonts: *Polygnathus linguiformis* Hinde, *Polygnathus pseudofoliata* Wittekind, *Polygnathus webbi* Stauffer, *Polygnathus xyla* Stauffer, *Palmatolepis deliculata* Branson, *Palmatolepis deliculata clarki* Ziegler, *Palmatolepis guadrantinodosalobata* Sannemann, *Palmatolepis triangularis* Sannemann, *Diplodella* sp., *Hindoedella* sp., *Bryandotus* sp., **Haas (1968)**; *Polygnathus costatus costatus* (Klapper), *Polygnathus costatus patulus* (Klapper), **Gedik et al. (2005)**
Corals: *Sringaxon bosporianicus* (Weissermel), **Kullmann (1973)**
Brachiopods: *Reticulariopsis* sp., **Haas (1968)**
Molluscs (Cephalopods): *Gyroceratites gracilis* Bronn, **Haas (1968)**; *Latanarcestes noeggerati* (Buch), *Mimagoniatites* cf. *kayai* Kullmann, *Anarcestes lateseptatus* (Beyrich), **Kullmann (1973)**
Trilobits: *Acastoides paeckelmanni* (Richter & Richter), *Phacops turco turco* (Richter & Richter), *Phacops turco praecedens* n.sp., *Latanarcestes* sp., *Acastoides consobrinus asinarius*, *Pinacites jugleri* (Roemer), **Haas (1968)**

Büyükada Formation (Ayineburnu Member):
Conodonts: *Palmatolepis minuta* Branson & Mehl, *Ozarkodina* cf. *arcuata* Branson & Mehl, *Ozarkodina arcuata* Branson & Mehl, *Palmatolepis glabra* Branson & Mehl, *Palmatolepis distorta* Branson & Mehl, **Abdüsselamoğlu (1963)**; Upper *expansa* Zone, **Çapkınoğlu (2000);** *Palmatolepis quadrantinodosalobata* Sannemann, *P. glabra prima* Ziegler & Huddle, *P. glabra pectinata* Ziegler, *P. minuta minuta* Branson & Mehl, *P. subperlobata* Branson & Mehl, *P. rugosa ampla* Müller, *Polygnathus glaber glaber* Ulrich & Bassler, *Icriodus altematus altematus* Branson & Mehl, *Mehlina strigosa* Branson & Mehl, *Bispathodus costatus* (Branson), *Bispathodus ultimus* (Bischoff), *Branmehla bohlenana* (Helms), **Gedik et al. (2005)**; *Bispathodus stabilis* (Branson & Mehl), *Siphonodella lobata* (Branson & Mehl), *sandbergi* Zone, **Göncüoğlu et al. (2004a)**
Ostracods: *Entomoprimitia sartenaeri* Zone, **Nazik & Groos-Uffenorde (2008)**
Trilobits: *Trimerocephalus mastophthalmus* Richter, **Gandl (1973)**

Çamdağ-Zonguldak

Fındıklı Formation:
Brachiopods: *Atrypa reticularis* (Linnaeus), *Howellella* sp., *Amphystrophia* sp., *Leptostrophia* sp., *Aulacella* sp., *Eospirifer* sp., *Delthyris* sp., *Rhynchonella* sp., *Dalmanella* sp., *Rhipidomella* sp., *Stropheodonta* sp., **Gedik & Önalan (2001)**

Ferizli Formation:
Brachiopods: *Uncinulus* sp., *Megastrophia* sp., **Kipman (1974)**; *Hysterolites* sp., *Rhynchonelloidea* sp., **Gedik & Önalan (2001)**

Yılanlı Formation:
Alge: *Girvanella* cf. *wetheredi* Chapman, *Radiosphaera* sp., *Parathurammina dagmarera* Suleymanov, **Aydın et al. (1987)**
Foraminifers: *Endothyra* sp., *Calcisphaera* sp., **Aydın et al. (1987)**
Corals: *Lithostrotion irregulare* (Phillips), *Hyperammina* sp., **Aydın et al. (1987)**
Brachiopods: *Spirifer* sp., *Syringopora* sp., **Kaya (1973)**; *Athyris concentrica* (von Buch), *Productella subaculate*, **Aydın et al. (1987)**
Molluscs (Cephalopods): *Anetoceras solitarium* (Barrande), *Mimagoniatites* cf. *zorgensis* Kullmann**, Kaya (1973)**

Note: Some of the fossil names, the validity and age-ranges of some fossils are no longer valid at present. However, they have been used in their original form in order to maintain the originality of the respective cited publications.