THE AGE OF THE SILICICLASTIC SERIES ("KARAREIS FORMATION") OF THE WESTERN KARABURUN PENINSULA, WESTERN TURKEY

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Rich faunas of Paleozoic conodonts, radiolarians, ostracods, muellerisphaerids, sponge spicules, ammonoids, bivalves, brachiopods, crinoids, fish remains, and trilobites were found in the predominantly siliciclastic series ("Karareis Formation") of the Karaburun Peninsula, western Turkey. These deposits were formerly assigned to the Scythian–Anisian interval. Silurian to Lower Devonian shale-lydite sequences, lydite-rich turbidites, olistostromes with limestone, sandstone and chert olistoliths as well as Upper Devonian to Tournaisian lydite-rich turbidites, olistostromes with lydite and limestone olistoliths were dated by conodonts, radiolarians, and Muellerisphaerida. Limestone inclusions found within keratophyre tuffs were dated as Late Silurian by conodonts, muellerisphaerids, and ostracods. Underlying thick, very lowgrade metamorphic shales, siltstones, greywackes, and quartzites, exposed throughout the northwestern Karaburun Peninsula north of Küçükbahçe, are probably of Ordovician age. So far, these rocks have not yielded any fossils. This unit is herein named as the Küçükbahçe Formation. A transitional sequence from ammonoid- and brachiopod-bearing deep-water shales to the Serpukhovian–Bashkirian shallow-water Alandere Formation contains conodonts, fish remains, foraminifers, ostracods, radiolarians, and sponge spicules of late Viséan age. This sequence is herein named as the Dösemealti Formation. The Scythian–Ladinian rocks do not interfinger with the Paleozoic rocks, but instead represent tectonic slices. All Silurian to early Tournaisian conodonts have Conodont Alteration Index (CAI) of 4–5, whereas the tectonic slices of Scythian to Ladinian rocks within the siliciclastic series contain conodonts with CAIs of 1–1.5. The late Viséan conodonts have CAIs of 2–3. The Late Silurian turbidites and olistostromes and the probable absence of Middle Devonian deposits provide evidence for Caledonian movements in the area. The termination of Paleozoic deep-sea deposition close to the Viséan–Serpukhovian boundary, and the presence of the felsic to intermediate tuffs in the Dösemealti Formation indicate a Hercynian closing of an ocean that separated Gondwana from Eurasia. The oceanic to marginal oceanic Silurian to Lower Carboniferous Karaburun sequence is also present in Chios and continues eastward into the Kütahya-Bolkardag Belt, where until now only an Upper Silurian to Lower Devonian turbidite-olistostrome unit with felsic volcanics was dated.

Key words: Conodonta, Silurian, Devonian, Early Carboniferous, Karaburun Peninsula, Turkey.

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INTRODUCTION

The sedimentologic and tectonic setting of the Paleozoic deposits of Karaburun Peninsula is very complicated. Serious stratigraphic misinterpretations have occurred because of the previous scarcity of fossil data. Despite the fact that the Paleozoic of Karaburun Peninsula is very rich in microfossils, especially conodonts and radiolarians, the only known Paleozoic microfossils were Bashkirian foraminifers. Some paleontologic data from the Paleozoic were previously published from the Kalecik area in NNE Karaburun Peninsula, from the area north of Ildir in western Karaburun Peninsula (only Middle Carboniferous fossils were reported from this area), and from Tekekara Dag (Fig. 1) in northwestern Karaburun Peninsula [only Upper Carboniferous (to Lower Permian?) fossils were listed from the Tekekara Dag Limestone].

Professor O. KAYA (Izmir, Turkey) found the first Paleozoic conodonts in the limestone olistoliths within the siliciclastic series ("Karaeis Formation") of the western Karaburun Peninsula. He gave me this material for identification and publication. Further sampling produced conodonts from other olistoliths and also from the matrix (obtained from distal turbiditic lydites, less frequently from limestones of a series transitional to the overlying Alandere Formation, and rarely from shales of the turbidite-olistostrome sequences). In addition, limestone blocks from the Bornova Melange near Kalecik in northeastern Karaburun Peninsula also yielded rich conodont faunas.

In this paper, the ages of different types of Paleozoic rocks are discussed and a preliminary stratigraphic succession for the Paleozoic sequences of Karaburun Peninsula is reconstructed (Fig. 2). The complicated sedimentological and structural settings of the Paleozoic to Middle Triassic rocks of Karaburun Peninsula as well as other conodont, radiolarian and Muellerisphaerida faunas will be described elsewhere. Age determinations are mainly based on conodonts, with additional data based on radiolarians, muellerisphaerids and ostracods. The conodont ages have been primarily based on ZIEGLER's compilations (1973–1981), but newer zonations and revised ranges have been used for certain species (CAREY and BOLGER 1995; SANDBERG *et al.* 1989, 1994; SKOMPSKI *et al.* 1995; ZIEGLER and SANDBERG 1984, 1990).

The figured material is housed in the Geological Institute, Innsbruck University.

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PREVIOUS WORK

According to ERDOĞAN *et al.* (1995), Paleozoic rocks of the Karaburun Peninsula occur in two different tectonic settings: in the Karaburun succession of the western Karaburun Peninsula (investigated in this paper) and as blocks in the Maastrichtian–Danian Bornova Melange (mainly exposed around Kalecik in northeastern Karaburun Peninsula). The oldest dated rocks are blocks of Upper Silurian to Lower Devonian coral-bearing limestones around Kalecik (HÖLL 1966; LEHNERT-THIEL 1968; SÖZEN 1973; GUŠIĆ *et al.* 1984). The oldest dated rocks from the Karaburun succession, according to ERDOĞAN *et al.* (1990, 1995) of the entire Karaburun Peninsula, were Bashkirian shallow-water deposits of the Alandere Formation.

PHILIPPSON (1911) was first to state that the western part of the Karaburun Peninsula consists of Paleozoic rocks. KTENAS (1925) assigned the Kalecik Limestone of the Kalecik area (NE Karaburun Peninsula) to the Early Devonian. PAECKELMANN (1939) compared the Paleozoic sequence in Karaburun Peninsula with that of Chios. He assigned shales, greywackes, cherts, and fusulinid limestones to the Uralian (Late Carboniferous to Early Permian), and the underlying conglomerates, greywackes, cherts, and shales to the Westfalian (Middle Carboniferous). KALAFATÇIOĞLU (1961) doubted this two-fold

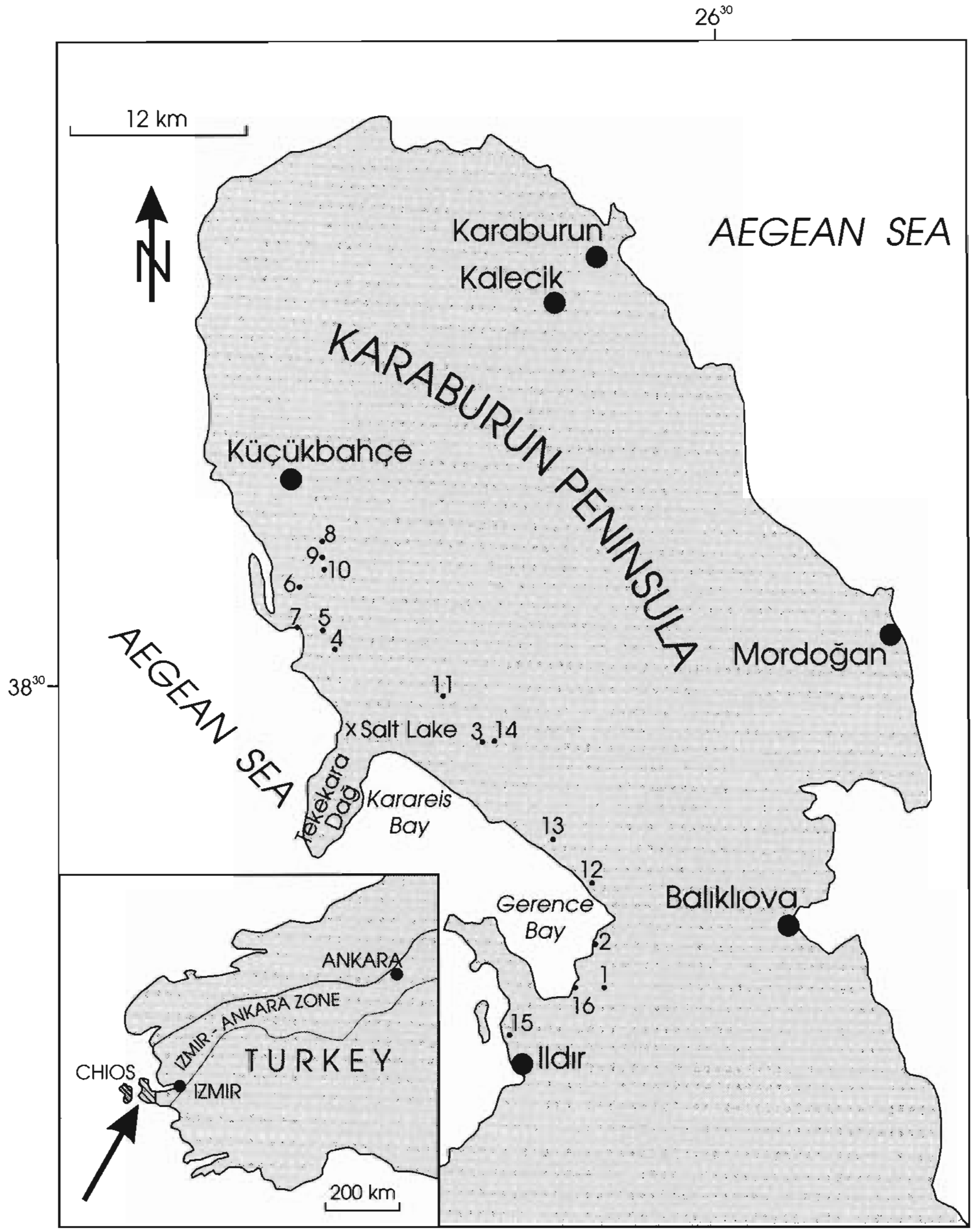

Fig. 1

Index map showing the investigated localities of the western Karaburun Peninsula. Except localities 1 and 2, only localities with conodont-bearing samples are indicated. The hatched area in the small index map is the Karaburun Zone. Abbreviations: 1 – roadcut of the Alandere Formation at the road NNE of Ildir; 2 – locality with discordant Scythian rocks on Carboniferous shallow-water limestones; 3 – samples K 1735-6; 4 – sample K 1751; 5 – sample K 1761; 6 – sample K 1762; 7 – samples K 2189-91, 8 – sample K 2226; 9 – sample K 2227; 10 – sample K 2228; 11 – samples K 2313-41; 12 – sample K 2432; 13 – sample K 2465; 14 – sample K 2468; 15 – samples K 2499, K 2499A, K 2552; 16 – samples K 2603-12, D 1-2, A 1-12.

subdivision and separated Lower Carboniferous limestones from the underlying clastic Devonian sequence. All these authors did not provide paleontological evidence for their stratigraphic subdivisions.

HÖLL (1966) found the first pre-Carboniferous fossils (brachiopods, corals) in Karaburun Peninsula within the Kalecik Limestone. He assigned, without fossil evidence, the Denizgiren beds of the Kalecik area to the Ordovician–Middle Silurian. Also, he assigned the fossil-bearing Kalecik Limestone and the Kalecik Beds (siliciclastic rocks, tuffs, tuffites, limestones) to the Late Silurian. HÖLL (1966) assumed a Late Caledonian discordance between the Denizgiren Beds and the Kalecik Limestone.

LEHNERT-THIEL (1968) agreed with the Silurian age of the Kalecik Limestone but regarded the Kalecik Beds (tentatively assigned to the Ordovician–Silurian without fossil data) as older than the Kalecik Limestone. He assumed (also without fossil data) that the Denizgiren Beds are Middle Devonian in age and are separated from the Kalecik Limestone by a discordance. According to LEHNERT-THIEL (1968), the area was not affected by Late Caledonian orogeny, but rather by Hercynian orogeny.

SÖZEN (1973) assumed a Silurian to Early Devonian age for the Kalecik Limestone because the fossils reported by HÖLL (1966) and LEHNERT-THIEL (1968) may range from Silurian to Early Devonian. According to SÖZEN (1973), corals and brachiopods sampled by him, range in age from the Early to Middle Devonian.

GUŠIĆ *et al.* (1984) demonstrated that a part of the beds formerly assigned to the Kalecik Limestone is Triassic in age. They restricted the Kalecik Limestone sensu stricto to the Paleozoic part of the former Kalecik Limestone *sensu lato* and assumed that the known macrofauna from this limestone is Early Devonian in age. According to their data, Silurian and older beds were paleontologically unproven in the Karaburun Peninsula.

GARRASI and WEITSCHAT (1968), when studying the Tekekara Dağ Limestone of Tekekara Dağ, reported *Linoproductus* ex gr. *cora*, *Linoproductus* sp., *Juresania* spp., *Taenioceras*? sp., fish scales and algae determined as *Anatolipora carbonaria* KONISHI. Although the algae might suggest Viséan age of these deposits, they seemingly represent mainly *Anthracoporella* indicating Late Carboniferous or Early Permian age as indicated by brachiopods.

According to GÜMÜS (1971), greywackes and limestones in the western part of middle Karaburun Peninsula (N and NE of Ildir) are Early Carboniferous in age (mainly Viséan), and may perhaps include the early Late Carboniferous. This interpretation was based on brachiopods, corals, and foraminifers from the limestones of the Alandere Formation, but the turbidites were not dated by fossils.

BRINKMANN *et al.* (1972) assigned the turbiditic greywackes, shales, and lydites of the same area to the Carboniferous and assumed that they are overlain by fossiliferous Carboniferous limestones (Alandere Formation). They assumed a Viséan age for the limestones (Kohlenkalk) and largely Early Carboniferous age for the turbidites, but without fossil evidence.

According to ERDOĞAN *et al.* (1990, 1995), the fossil-rich Carboniferous limestones, subordinate shales, sandstones, and conglomerates, designated by them as the Alandere Formation, are the oldest rocks of the Karaburun Peninsula. Thus, they rejected the Silurian to Early Devonian age of the Kalecik Limestone, which was dated paleontologically by HÖLL (1966), LEHNERT-THIEL (1968), SÖZEN (1973) and GUŠIĆ *et al.* (1984) (see above). They listed foraminifers from the upper part of the Alandere Formation, among them *Eostaffella postmosquensis* KIREEVA, a Bashkirian fusulinid zonal index species. On the base of the foraminifers, ERDOĞAN *et al.* (1990) placed the Alandere Formation in the Bashkirian. Subsequently, ERDOĞAN *et al.* (1995) dated the formation as Early Carboniferous to Bashkirian in age.

ERDOĞAN *et al.* (1990, 1995) assigned the siliciclastic rocks, that cover the largest part of the western half of the northern Karaburun Peninsula, to the "Scythian–Anisian Karareis Formation". According to these authors, the formation interfingers with their Gerence Formation that consists of Lower and Middle Triassic grey and red limestones, red cherts and some intermediate volcanics (placed by these authors also in the Scythian–Anisian). The fossil-rich Upper Carboniferous (? to Lower Permian) Tekekara Dag Limestone of GARRISI and WEITSCHAT (1968) was mapped by ERDOĞAN *et al.* (1990, 1995) as contemporaneous limestone intercalation of their "Scythian–Anisian siliciclastic Karareis Formation". The "Karareis Formation" (?Ordovician, Silurian to Lower Carboniferous siliciclastic rocks, see below) and the Gerence Formation [Olenekian (middle to upper Scythian) to Ladinian] were grouped together by ERDOĞAN *et al.* (1990, 1995) as the Denizgiren Group of assumed Scythian–Anisian age.

The rich occurrence of lydites in the assumed Sythian–Anisian "Karareis Formation" would be unique in the world. Therefore, the age of the "Karareis Formation" was especially investigated. Neither the Scythian–Anisian age of the lydites within the "Karareis Formation" (all dated radiolarites are Silurian to Early Devonian and Late Devonian to Early Carboniferous in age) nor the interfingering of the "Karareis Formation" with Early to Middle Triassic rocks could be confirmed. In the frame of these investigations, KAYA and KOZUR (1995) reported for the first time Lower and Upper Devonian conodonts from limestone olistoliths of the siliciclastic series, but as the matrix was still not dated, they did not reject a Triassic age of the siliciclastic series ("Karareis Formation"). KOZUR (1997a) recognized a Paleozoic age of the siliciclastic series ("Karareis Formation"), presented a first subdivision of this series, and reported Silurian, Devonian and Lower Carboniferous microfaunas (conodonts, foraminifers, muellerisphaerids, ostracods and radiolarians) and Lower Carboniferous macrofaunas (ammonoids, brachiopods and crinoids). KOZUR

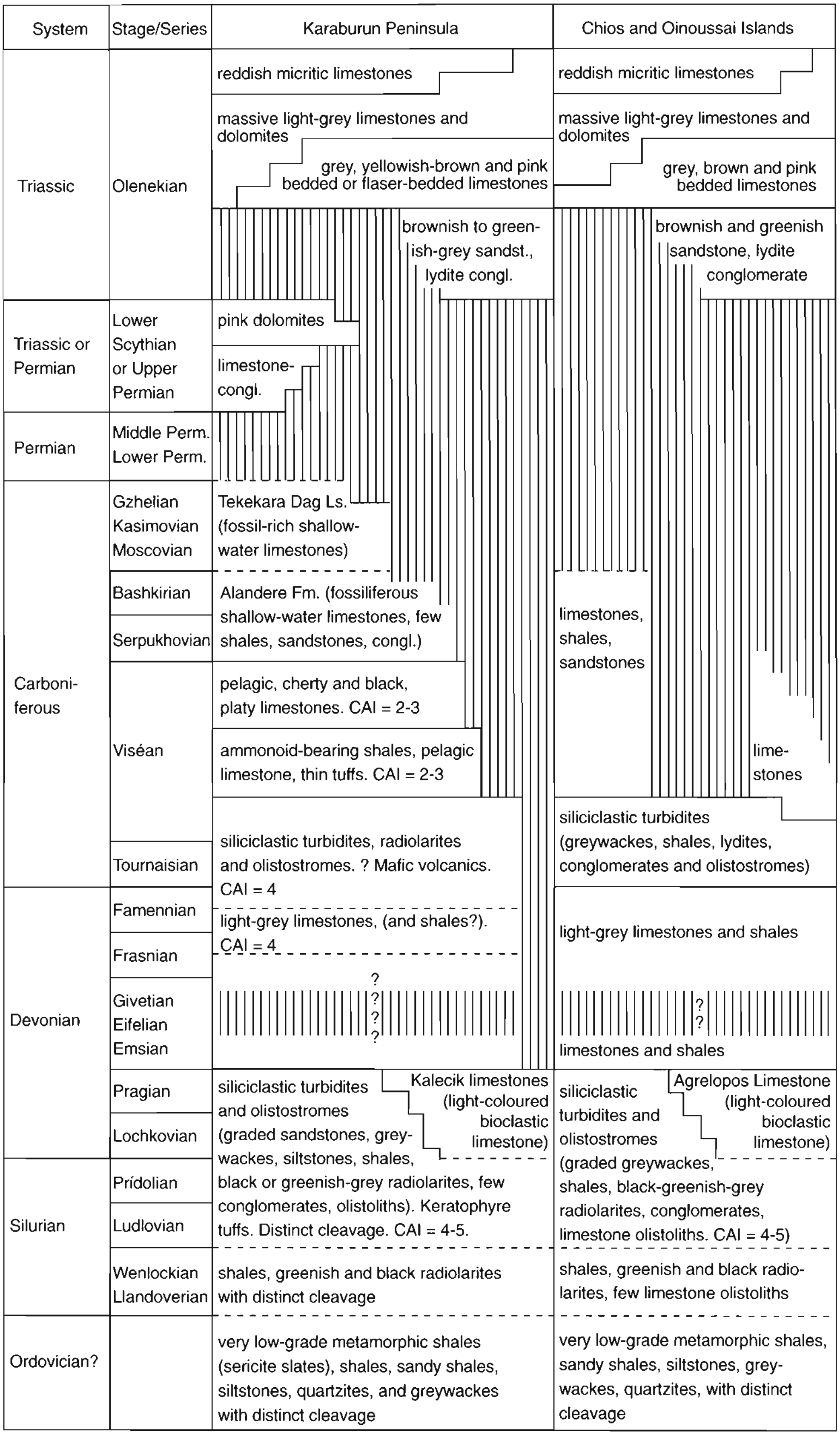

Fig. 2
Composite Paleozoic to Scythian sequences of Karaburun Peninsula and Chios (not to scale). The pre- and post-Middle Devonian parts of the siliciclastic series may represent two units that were tectonically juxtaposed.

(1997c) described Silurian and Lower Devonian muellerispherids and radiolarians from radiolarites and limestone olistoliths of the middle part of the siliciclastic series.

CARIDROIT *et al.* (1997) reported conodonts, foraminifers, fish remains, ostracods, and radiolarians from the uppermost part of the siliciclastic series adjacent to the Alandere Formation. This fauna is identical with that of the here defined Döşemealti Formation of the uppermost siliciclastic series. Only Lower Carboniferous *Albaillella* was not found by CARIDROIT *et al.* (1997), but also in my material this genus is much less common than the other radiolarians. CARIDROIT *et al.* (1997), based on the assumed presence of *Protognathodus meischneri* ZIEGLER, assigned the Karareis Formation fauna to the uppermost lower Tournaisian. However, that species was misidentified and represents in fact *Lochriea commutata* (BRANSON *et* MEHL). Moreover, the fauna also includes *Gnathodus bilineatus* (ROUNDY) that does not appear before the middle Viséan. CARIDROIT *et al.* (1997) regarded the limestone with the Viséan ("lower Tournaisian") fauna as an olistolith within the "Karareis Formation". They interpreted the formation as Early Triassic in age.

LITHOLOGIC CHARACTER AND AGE OF THE INVESTIGATED PALEOZOIC ROCKS

The siliciclastic "Karareis Formation" (ERDOĞAN *et al.* 1990, 1995) includes various lithologic and tectonostratigraphic units and cannot be regarded as a formation. It consists of several formations; the lowermost and the uppermost of which are named herein. The siliciclastic turbidites and olistostromes with keratophyre volcanics are in a very complicated tectonic setting. Because they contain a Middle Silurian shale-lydite sequence, Upper Silurian and Lower Devonian turbidites and olistostromes, as well as Upper Devonian to Tournaisian (?Lower Viséan) turbidites and olistostromes, but so far no dated Middle Devonian (as in Chios), the following explanations for the geological setting of the turbidite-olistostrome unit(s) can be offered: (1) The turbidite-olistostrome unit belongs to one subduction-related accretionary complex that formed at the active margin of a huge ocean separating Gondwana from Eurasia during the Early Paleozoic to Early Carboniferous indicating a long lasting subduction interval (Late Silurian to Early Carboniferous). In the original setting, the Upper Devonian to Lower Carbonifeorus turbidites-olistostromes were deposited north of the Upper Silurian–Lower Devonian ones (southwards-directed subduction), and underthrust them by subduction processes. These original relations were later destroyed or modified by a strong Alpidic overprint. (2) A continent-microcontinent collision occurred at the end of the Early Devonian, and subduction started at the northern margin of the microcontinent. In such setting two different turbidite-olistostrome units, but related to the closure of the same ocean, were present. They were later juxtaposed by the Alpidic overprint. (3) A Caledonian closure (Late Silurian to Early Devonian) was followed by a new, Late Devonian opening and (late) Famennian to Early Carboniferous closure. In this case two different turbidite-olistostrome units were present but they were related to the closure of two different oceans.

Because there is no thermal alteration difference between the Upper Silurian–Lower Devonian flysch and the Upper Devonian–lowermost Carboniferous flysch (both have conodonts with CAIs = 4–5), a long-lasting subduction, with or without continent-microcontinent collision, is most probable (models 1 or 2). However, the third variant cannot be excluded as long as neither Middle Devonian rocks can be found nor a Middle Devonian unconformity can be proven. For this reason, it is not clear whether the turbidite-olistostrome sequence represents one lithostratigraphic unit of a very long duration or two similar lithostratigraphic units separated by a Middle Devonian unconformity, or juxtaposed during the Alpine orogeny. Therefore, the Silurian to Lower Devonian and Upper Devonian to Lower Carboniferous turbidites and olistostromes cannot yet be formally named.

The most consistent Paleozoic unit of the Karaburun Peninsula occurs in the western part of northern Karaburun Peninsula, from north of Küçükbahçe village to near the northern coast, where it is overthrust by ophiolites of the Ankara-Izmir Zone. It is a very thick (ca. 2000 m) monotonous sequence of shales, siltstones, greywackes, and quartzites. It has a distinct cleavage and is generally slightly metamorphosed (sericite slates). It corresponds to the thick mudstone sequence of the "Scythian–Anisian Karareis Formation" by ERDOĞAN *et al.* (1990, 1995). As it is obviously older and lithologically different from the rest of the "Karareis Formation," it is considered a separate formation. It is named herein the Küçükbahçe

Formation for its occurrence north of Küçükbahçe village. No fossils were found in the Küçükbahçe Formation. However, sericite slate pebbles found in Bashkirian conglomerates of the Alandere Formation along the Ildir-Gerence Bay road north of Ildir (Fig. 1, loc. 1) probably were derived from the Küçükbahçe Formation. This makes it unlikely that the formation is Scythian–Anisian in age, as assumed by ERDOĞAN *et al.* (1990, 1995). Because sericite slates do not occur in the dated Silurian to Viséan interval (see below), a pre-Silurian, probably Ordovician (or Cambro–Ordovician) age, is assumed for this monotonous siliciclastic sequence.

The oldest dated rocks (Silurian) are from a shale-lydite unit and a siliciclastic turbidite-olistostrome unit. These siliciclastic units are well exposed in western N-Karaburun Peninsula, from about 3 km south of Küçükbahçe to northern Gerence Bay, and in some outcrops along the western coast of middle Karaburun Peninsula in the vicinity of Ildir (Fig. 1, locs 3–15).

About 3 km south of Küçükbahçe, the shale-lydite sequence is well exposed along the road to Küçükbahçe. The outcrops begin south of a west-trending fault that is mostly covered by Neogene andesites and lacustrine deposits. In contrast to most of the other lydite-bearing siliciclastic sequences, neither graded sandstones nor olistoliths are present. Because no conodonts were found in this lithological unit, the investigated localities were not indicated in Fig. 1. Initial processing for radiolarians produced only Entactinaria, mostly new species. Most of the Early to Middle Paleozoic Entactinaria species are long-ranging or their ranges are unknown. Consequently, Entactinaria alone cannot yet be used for exact age determinations of Paleozoic rocks. Therefore, the lydite-shale sequence 3 km south of Küçükbahçe can only be assigned to a Silurian to Early Carboniferous age. However, because both Albaillellacea and Ruzhencevispongacea are missing, the sequence is more likely to be Silurian to Early Devonian than younger in age. Further paleontologic studies of these radiolarites are needed.

About 4 km south of Küçükbahçe, the turbidites and olistostromes first crop out. They are widely exposed in the western part of middle Karaburun Peninsula, southward until the northern shore of Gerence Bay and occur also in several outcrops near Ildir. Localities 3–15 are located within the turbidites and olistostromes. The turbidites and olistostromes consist of unmetamorphosed graded sandstones, siltstones, shales, black to greenish-grey radiolarites (mostly fine-graded distal turbidites), and some conglomerates. The olistoliths consist of all of the rocks listed above. In addition, they include slope limestones. The turbidites and olistostromes are sedimentologically and tectonically very complex. The structural complications (intensive folding and slicing) become stronger eastward towards the thick Mesozoic carbonate sequence. The turbidites and olistostromes are thermally slightly altered (CAI 4–5) and have a distinct cleavage.

Some radiolarites of the turbidite sequences yielded Late Silurian, sometimes also Early Devonian, radiolarians and muellerisphaerids (KOZUR 1997c). In the roadcut at Gerence Bay, and in the outcrops located uphill, several samples were taken immediately below the contact with Lower Triassic limestones and marls. They yielded entactinarian radiolarians of varying preservation. In sample K 2465 (loc. 13), *Eoalbaillella lilaensis* FENG *et* LIU is common (KOZUR 1977c). This species is an idex taxon for the Early Devonian of western Yunnan, China, where it occurs together with graptolites ranging in age from the *Monograptus uniformis* Zone to *M. yukonensis* Zone of Lochkovian to Pragian age (FENG QINGLAI and LIU BENPI 1993, but see remarks by KOZUR 1997c, about a possible Late Devonian age of *Eoalbaillella*). Sample K 2468 (loc. 14) yielded rich Late Silurian to lowermost Devonian Muellerisphaerida faunas with *Papinochium kayai* KOZUR, *P. costatum* KOZUR, and *Tersisphaera sannemanni* KOZUR. Conodonts are missing or rare in the lydites and mainly represented by long-ranging coniform conodonts.

Sample K 2552 (loc. 15), from a dark-grey, micritic limestone olistolith, yielded the conodonts *Panderodus unicostatus* (BRANSON *et* MEHL), *Oulodus elegans detorta* (WALLISER), and *Ozarkodina excavata* (BRANSON *et* MEHL) indicating a Late Silurian to earliest Devonian age. This sample contains also some ostracods, detritus of graptolites, and few well preserved Muellerisphaerida, *Karaburunella conispina* KOZUR and *Papinochium dubium* (DEFLANDRE *et* TERS), which indicate a Late Silurian age. This limestone olistolith contains tuffitic material of the same type as the keratophyre tuffs that often accompany the siliciclastic turbidites or limestone blocks in it. At the Fatih College Campus, in several outcrops between localities 5 and 6, limestone inclusions in a thick keratophyre-keratophyre tuff sequence yielded only ostracods (Bairdiidae, Bairdiocyprididae, early Tricorninidae, Pachydomellidae, Primitiopsidae and Thlipsuridae) with Silurian and, longer ranging, Silurian–Early Devonian species. The limestones are contemporaneous with, or older than, the keratophyres/keratphyre tuffs. These two lines of evidence indicate a strong Silurian keratophyre volcanism. However, many volcanics that are adjacent to siliciclastic turbidites are not yet dated. As siliciclastic turbidites with both Silurian–Lower Devonian and Upper

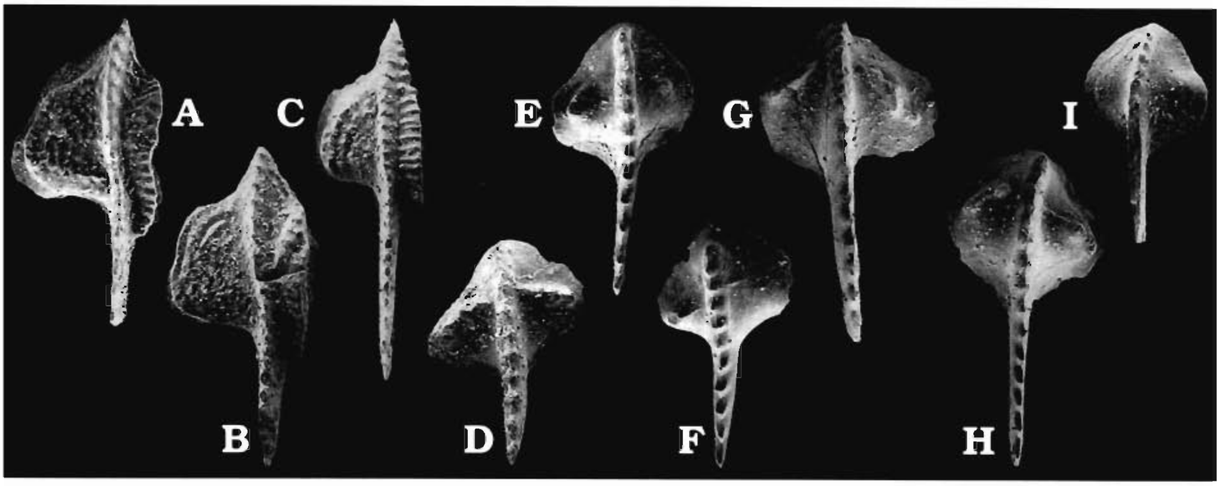

Fig. 3
Conodonts from the type locality of upper Döşemealti Formation. The locality is situated on the steep coast of the Döşemealti embayment in southern Gerence Bay (locality 16, Fig. 1). Section D (see appendix). Upper Viséan. All magnifications × 50. **A**. *Gnathodus bilineatus* (ROUNDY), sample K 2603, ammonoid-bearing limestone 2 m below the top of the Döşemealti Formation, rep.-no. 16-2-96/II-13. **B**. *Gnathodus bilineatus* (ROUNDY), sample K 2612, black platy limestone, 3.50 m above its base, rep.-no. 16-2-96/II-19. **C**. *Gnathodus bilineatus* (ROUNDY), sample K 2603 (see **A**), rep.-no. 16-2-96/II-3. **D**. *Lochriea cruciformis* (CLARKE), sample K 2612 (see **B**), rep.-no. 16-2-96/II-18. **E**. *Lochriea nodosa* (BISCHOFF), sample K 2603 (see **A**), rep.-no. 16-2-96/II-10. **F**. *Lochriea mononodosa* (RHODES, AUSTIN *et* DRUCE), sample K 2603 (see **A**), rep.-no. 16-2-96/II-7. **G**. *Lochriea* cf. *cruciformis* (CLARKE), transitional to *L. nodosa* (BISCHOFF), sample K 2603 (see **A**), rep.-no. 16-2-96/II-11. **H**. *Lochriea* cf. *cruciformis* (CLARKE), transitional to *L. nodosa* (BISCHOFF), sample K 2603 (see **A**), rep.-no. 16-2-96/II-9. **I**. *Lochriea commutata* (BRANSON *et* MEHL), sample K 2603 (see **A**), rep.-no. 16-2-96/II-14.

Devonian to Lower Carboniferous radiolarites are present, keratophyre volcanism may also have been present in Late Devonian to Early Carboniferous times.

Sample K 1761 (limestone olistolith, loc. 5, outcrop ca. 1 km SE of the Fatih College Campus) yielded *Dapsilodus obliquicostatus* (BRANSON *et* MEHL), *Dapsilodus* sp., *Ozarkodina* sp., *Panderodus unicostatus* (BRANSON *et* MEHL), *Pseudooneotodus beckmanni* (BISCHOFF *et* SANNEMANN), and calcified radiolarians. This is a Silurian, deep-water conodont fauna (Pl. 1: 1–6).

The above mentioned Silurian rocks are the oldest well-dated rocks on Karaburun Peninsula. Silurian macrofossils were also reported from the Kalecik Limestone (HÖLL 1966; LEHNERT-THIEL 1968), which, until now, was the oldest dated rock. However, SÖZEN (1973) stated that these macrofossils range in age from Late Silurian to Early Devonian, and GUŠIĆ *et al.* (1984) assigned the Kalecik Limestone to the Early Devonian. The dating of the Kalecik Limestone is not the topic of this paper (therefore, the investigated localities are not indicated in Fig. 1). Nevertheless, in order to gain a regional perspective, samples from the Kalecik area were also investigated. In the roadcut about 2 km N of Kalecik, micritic limestone blocks with abundant large, orthocone nautiloids (samples KT 96-782–784) are exposed. The blocks are found within the Upper Cretaceous(?) matrix (micaceous grey shales, siltstones, sandstones, without cleavage) of the Bornova Mélange. The blocks contain a rich Silurian conodont fauna that consists mostly of coniform conodonts (*Dapsilodus obliquicostatus* and other *Dapsilodus* species, *Panderodus* sp.) and few juvenile *Ozarkodina* sp. The blocks represent a basinal facies. Other basinal facies of Late Silurian age, are represented by pelagic micritic limestone blocks (KT 96-785–787, KT 96-792,793) with radiolarians and the same conodont fauna as in the nautiloid-bearing limestones, and very few small blocks of lydite. The slope facies of the same age is represented by crinoidal limestones (KT 96-788–791, 794) with the same coniform conodonts and some *Ozarkodina* spp. About 1 km southward, another roadcut contains blocks of dark crinoidal limestones (KT 96-796) and reef-debris limestones (sample KT 96-797) with many tabulate corals, rugose corals, and other reef fossils as well as a few spiriferid brachiopods. The crinoidal limestones yield Silurian conodonts, such as *Dapsilodus obliquicostatus*. The old mercury ore quarry at Kalecik consists of limestones strongly altered (silicified, mineralized) by hydrothermal processes. The unit includes patches of less altered dark crinoidal limestones (KT 96-798) that contain the same Silurian conodont fauna as sample KT 96-796. Surprisingly, no Early Devonian conodonts were found. However, this does not exclude the possibility that Lower Devonian limestone blocks are also present; but suggest that they were rarer than the Upper Silurian blocks.

In the lydite-rich siliciclastic series of the western Karaburun Peninsula, Silurian slope limestones are rare and occur only as olistoliths in the siliciclastic turbidites and olistostromes. Silurian coral-bearing shallow-water limestones and pelagic nautiloid-bearing limestones are as yet unknown as olistoliths. On the other hand, lydites are very rare in the Bornova Melange in the outcrops examined north of Kalecik. Therefore, the source area for the blocks in the Bornova Melange north of Kalecik was apparently the shelf and slope of the oceanic siliciclastic turbidite-radiolarite-olistostrome sequence that is exposed in the western part of Karaburun Peninsula.

Several limestone olistoliths in the turbidite-olistostrome unit of western Karaburun Peninsula consist of Lower Devonian (Lochkovian–Pragian) slope limestones. Samples K 2189 and K 2190 (loc. 7), richest in conodonts, contain Lochkovian conodonts (Table 1) of the *A. deltus* Zone. Sample K 1762 (locality 6) from an outcrop ca. 700 m NNW of the Fatih College Campus contains upper Pragian (?Emsian) conodonts (Table 1, Pl. 1: 7–26). The Lochkovian and (lower) Pragian limestone olistoliths are contemporaneous with the lydites from the turbidite-olistostrome sequence that yielded Lower Devonian radiolarians (KOZUR 1997c). Upper Pragian and Emsian lydites and deep-water limestone were not found. Apparently, the lydites of the Late Silurian–Early Devonian turbidite-olistostrome sequence ranges only up to the (lower?) Pragian.

A very important change, because, as discussed above, an other part is Silurian to Early Devonian part of the siliciclastic turbidites with lydites must be of late Famennian to post-Devonian age because there are also Late Devonian olistoliths within siliciclastic turbidites with lydites. This was confirmed by dating the matrix in loc. 15, which contains a few Silurian limestone olistoliths (see above): shale sample K 2499A yielded a juvenile *Palmatolepis* sp. indet. that proves a Late Devonian age of the matrix.

The lydites in the siliciclastic turbidites with Late Devonian limestone blocks have not yet been investigated, but sample K 2432 (loc. 12), collected from a greenish-grey radiolarite in siliciclastic turbidites without olistoliths, contains fragments of *Gnathodus* sp. that indicates an Early Carboniferous age.

The conodont-bearing Upper Devonian olistoliths are mainly light-colored, bioclastic, slope limestones from the *P. triangularis* Zone to *P. marginifera* Zone interval (early Famennian); most of the olistoliths belong to the *P. crepida* and *P. rhomboidea* zones.

The conodont-rich, Upper Devonian samples (Table 1, Pl. 1: 27–46) were assigned to the following levels: (1) K 1736 (loc. 3), K 2228 (loc. 10), K 2314 and K 2325 (both loc. 11): *P. crepida* Zone; (2) K 2191 (loc.7) and K 2341 (loc. 11): interval from the *P. crepida* Zone to the *P. rhomboidea* Zone; (3) K 2326 (loc. 11): interval from the upper *P. crepida* Zone to the *P. marginifera* Zone; (4) K 1751 (loc. 4), K 2226 (loc. 8), and K 2227 (loc. 9): *P. rhomboidea* Zone; (5) K 2320 (loc. 11): boundary interval of the *P. rhomboidea* Zone and *P. marginifera* Zone; and (6) K 2313 and K 2327 (loc. 11): *P. marginifera* Zone. Other samples yielded Famennian faunas that can only be assigned to the *P. triangularis–P. marginifera* zonese interval. The late Famennian *P. rugosa trachytera* Zone to *S. praesulcata* Zone interval is not documented by fossils from limestone olistoliths. This may indicate a more basinal development for this time interval.

After this paper was completed, two interesting limestone olistoliths were found. One of them yielded *P. linguiformis* MÜLLER, the species indicative of the highest Frasnian. The other one yielded *Siphonodella sulcata* (HUDDLE) indicating that even during the earliest Carboniferous *S. sulcata* Zone, olistoliths of slope limestones were still being transported into the deep-sea basin.

Previously, the best dated rocks of the Karaburun succession were from the Alandere Formation which consists of dark to light-grey, bioclastic, often crinoidal limestones with intercalations of shales, sandstones, and conglomerates. The macrofauna and the presence of fusulinids indicate a shallow-water evironment. The fusulinid *Eostaffella postmosquensis* KIREEVA and other foraminifers from the upper part of the formation indicate a Bashkirian age for the upper Alandere Formation as already determined by ERDOĞAN *et al.* (1990, 1995).

The lower boundary of the Alandere Formation can be dated in locality 16 (Fig. 1). In this outcrop several shorter and longer sections are present (sections A–D of the appendix). As a whole, about 48 m of a transitional sequence between the deep-water siliciclastic turbidites and olistostromes (deposited below the CCD) and the shallow-water limestones of the Alandere Formation is exposed. For this transitional sequence, the Döşemealti Formation is introduced herein. It is named after its type section locality (locality 16, Fig. 1). Whereas the transition to the overlying Alandere Formation is well exposed, the transition to the underlying deep-sea turbidites and olistostromes is not exposed. However, in poorly

Table 1
Conodont distribution in Devonian limestones from western Karaburun Peninsula.

species	sample number (K ....) and locality number #															
	2189	2190	1762	1736	228	2314	2325	2191	2341	2326	1751	2226	2227	2320	2313	2327
	#7	#7	#6	#3	#10	#11	#11	#7	#11	#11	#4	#8	#9	#11	#11	#11
Ancyrodelloides asymmetricus	****	****														
A. transitans	****	****														
Belodella devonica			****													
B. resima			****													
B. sp.			****													
Ozarkodina buchanensis			****													
O. excavata tuma	****	****														
O. remscheidensis			****													
O. stygia	****	****														
O. sp.			****													
Panderodus sp.	****															
Pandorinella steinhornensis			****													
Pedavis palmatus			****													
Pedavis sp.			****													
Palmatolepis glabra distorta														****	****	****
Pa. glabra lepta, early forms				****	****	****	****									
Pa. glabra lepta								****	****					****		
Pa. glabra pectinata				****	****	****	****			****	****	****	****	****	****	****
Pa. glabra prima				****	****	****	****									
Pa. minuta				****	****	****	****									
Pa. minuta, long, slender form											****	****				
Pa. minuta loba				****	****	****	****									
Pa. minuta minuta								****	****							
Pa. perlobata perlobata								****	****							
Pa. perlobata schindewolfi										****						
Pa. poolei											****		****			
Pa. quadrantinodosalobata								****	****		****	****	****			
Pa. quadrantinodosalobata, morphotype I				****	****	****	****									
Pa. cf. *regularis*											****		****			
Pa. rhomboidea											****	****	****			
Pa. subperlobata								****	****		****	****				
Pa. tenuipunctata				****	****	****	****				****	****	****			
Pa. triangularis				****	****	****	****									
Polygnathus glaber bilobatus															****	****
P. glaber medius															****	
P. lagowiensis				****		****	****									
P. cf. *nodocostatus*				****												
P. planirostratus				****	****	****	****				****	****	****	****		

exposed shales, below section A, a single lydite olistolith was found indicating that section A may begin not too far above the Lower Carboniferous deep-sea turbidites and olistostromes (deposited below the CCD).

The Döşemealti Formation in its type locality (see appendix) begins with shales that contain a few thin intercalations of pelagic limestones and altered, felsic to intermediate tuffs. Some shales are rich in ammonoids (e.g. *Goniatites* sp. of late Viséan age), brachiopods, crinoids, bivalves, and trilobites. Most of the fossils are well preserved moulds (e.g., with suture lines in the ammonoids). Acid treatment of the intercalated thin pelagic limestones yielded well-preserved Viséan radiolarian faunas, deep-water ostracods, and sponge spicules, but no conodonts. Entactinaria and primitive Ruzhencevispongacea are present, e.g., the Viséan *Latentifistula turgida*? (ORMISTON *et* LANE). A thicker, nodular limestone occurs somewhat below the base of the overlying black, platy limestones. It contains a very rich radiolarian fauna with *Curvalbaillellela* cf. *ishigai* (CHENG), numerous primitive Ruzhencevispongacea, and Entactinaria. It corresponds to the radiolarian association P-5 *sensu* CHENG (1986). This association was not discriminated in the Early Carboniferous radiolarian zonation in Germany (BRAUN 1990); it is situated between the *Curvalbaillella cartalla* and *C. rockensis* Zone of the radiolarian zonation by BRAUN (1990). This corresponds to the upper, but not uppermost, Viséan. Apart from radiolarians, only a few ramiform conodonts, foraminifers, sponge spicules, and fish remains are present.

The overlying platy, dark, pelagic limestones contain foraminifers, ostracods, fish remains, numerous poorly preserved entactinarian Radiolaria, and a rich conodont fauna with *Gnathodus bilineatus* (ROUNDY) and *Lochriea cruciformis* (CLARKE). This is a typical fauna of the late Viséan *Lochriea nodosa* Zone.

The dark platy limestones are overlain by partly fossil-rich, locally ammonoid-bearing, grey cherty limestones, with shallow-water clasts in the upper part. The ammonoids are indeterminable, but the ammonoid-bearing limestones contain very rich conodont faunas with *Gnathodus bilineatus* (ROUNDY), *Lochriea commutata* (BRANSON *et* MEHL), *L. cruciformis* (CLARKE), *L. mononodosa* (RHODES, AUSTIN *et* DRUCE), and *L. nodosa* (BISCHOFF). This fauna also corresponds to the late Viséan *L. nodosa* Zone. According to SKOMPSKI *et al.* (1995), this fauna characterizes the latest Viséan and the Viséan–Serpukhovian transition interval.

The immediately overlying shallow-water limestones of the Alandere Formation have not yielded conodonts but according to the conodont data from the subjacent beds, their deposition began in the latest Viséan or earliest Serpukhovian. Consequently, the Alandere Formation comprises the (latest Viséan), Serpukhovian, and Bashkirian.

The youngest dated Paleozoic rocks (Late Carboniferous to earliest Permian) of Karaburun Peninsula belong to the Tekekara Dağ Limestone that was dated by GARRASI and WEITSCHAT (1968). This limestone is present only very locally. Scythian marls and limestones mainly overlie discordantly the Alandere Formation. However, the transgressive overlap of Scythian rocks on karstified Carboniferous limestones along road ca. 2 km northeast of Ildir (mentioned by ERDOĞAN *et al.* 1990, 1995) cannot be confirmed. The karst pockets of the Carboniferous limestones at this locality are filled with ostracod-rich Neogene sediments. The lighter limestones in the upper part of the section have not been documented as Triassic, but instead contain the same fauna (including the same crinoids) as the underlying Carboniferous limestones and thus belong to the Alandere Formation.

An impressive section with transgressive Scythian deposits overlying shallow-water limestones of the Alandere Formation is exposed along the beach in loc. 2 (Fig. 1). Dark Carboniferous (Pennsylvanian) limestones are deeply karstified and overlain by a basal conglomerate in the karst pockets. The conglomerate consists of limestone pebbles in a shaly-marly matrix. This conglomerate is overlain by a yellowish-brownish-weathering pink dolomite that directly overlies the Pennsylvanian limestone, in the topographically higher part of the paleokarst surface. The dolomite is discordantly overlain by a Scythian, flaser-bedded limestone. When the dolomite is eroded, this Scythian limestone rests directly on the basal conglomerate or on the Pennsylvanian limestone. The age of the basal conglomerate and dolomite is uncertain. It may be early Scythian (indicating an initial short ingression before the main transgression) or on Late Permian. In the latter case, a Late Permian transgression must have been followed by a local uplift or sea-level drop proceding the Early Triassic transgression.

Further northward, the Scythian mainly overlays siliciclastic Paleozoic turbidites with lydites. Already in loc. 2, the Pennsylvanian shallow-water limestones below the base of the Scythian are only about 30–40 m thick. At a coastal section, near a salt lake NW of Karareis Bay (Fig. 1), Paleozoic turbidites are overlain by Scythian sandstones with a lydite conglomerate. They are succeeded by shales, marls, and marly, partly dolomitic, bluish-grey, brownish-weathered limestones with bivalves, gastropods, and ostracods. The bivalves include *Costatoria costata* with 8 extra-areal ribs, characteristic of the late Scythian of the Alpine Triassic. Because the Scythian basal siliciclastic, nonfossiliferous sediments consist of reworked siliciclastic Paleozoic rocks (sandstones, lydite pebbles), their sedimentological separation from the underlying turbidite-olistostrome unit may be difficult in this intensely intensely tectonized area. However, these basal siliciclastic rocks of a Scythian age are not turbiditic and contain marly and limestone beds. Such beds are not present in the Paleozoic siliciclastic units (except of the upper Viséan Döşemealti Formation). The lithologic similarity between the Paleozoic siliciclastic units with lydite olistostoliths or lydite conglomerates and overlying Lower Triassic siliciclastic beds with lydite conglomerates may have been the reason that all siliciclastic rocks of the western part of middle and northern Karaburun Peninsula where placed in the Scythian–Anisian "Karareis Formation" by ERDOĞAN *et al.* (1990, 1995). Only the Scythian was paleontologically dated, whereas the siliciclastic rocks representing different levels within the Ordovician(?), Silurian to Early Carboniferous interval had not yielded fossils before this investigations.

DISCUSSION AND COMPARISON WITH ADJACENT AREAS

Fossil-dated sequences and olistoliths allow for a preliminary reconstruction of the Paleozoic succession in Karaburun Peninsula (Fig. 2). The assumed oldest beds are pre-Silurian, nonfossiliferous, very low-grade metamorphic, thick shales, siltstones, greywackes, and quartzites of probable Ordovician age. The dated Silurian deposits consist of a basinal, shale-lydite sequence. The Late Silurian–Early Devonian (up to the Pragian) is represented by a siliciclastic turbidite-lydite sequence with some Silurian to Lower Devonian limestone olistoliths. The sequence consists of graded sandstones (greywackes), siltstones, shales, and black and greenish-grey radiolarites. The radiolarites are mostly distal turbidites. Strong keratophyre volcanism occurred during the Late Silurian. This presumed sequence indicates a strong deepening during the Silurian, accompanied by mafic volcanism, and a high submarine relief (?subduction) during the Late Silurian and Early Devonian indicated by turbidity currents and transport part of limestone blocks from the slope and other shelf into the basin. The Upper Silurian–Lower Devonian turbidites and olistostromes may indicate Caledonian movements. This is confirmed by a distinct cleavage, slight thermal alteration (CAI 4–5), and, in the assumed Ordovician part of the sequence, very low-grade metamorphism. However, the thermal alteration and the cleavage may have been caused by early Hercynian movements, because Late Devonian conodonts also have a CAI of about 4. These movements were surely not younger than early Hercynian, because upper Viséan and younger rocks lack cleavage and have a very low thermal alteration (CAI 2–3 in the late Viséan and 1–1.5 in the Triassic).

The upper Pragian (and Emsian?) consists of limestones (?and shales) deposited in shallow to moderately deep water environments. The Middle Devonian to early Frasnian interval is not documented by fossils. This may indicate a gap associated with Caledonian movements. However, given the present stage of our knowledge, the presence of undated Middle Devonian rocks (e.g., unfossiliferous sandstones and shales) cannot be excluded. As Middle Devonian deposits are also not known in Chios, the presence of a regional gap associated with Caledonian movements is possible.

The upper Frasnian and lower Famennian consists of light-grey bioclastic limestones and shales. Siliciclastic turbidites with lydites, and olistostromes characterize the Upper Famennian to Lower Carboniferous deposits. They commonly contain shallow-water to slope limestone olistoliths that are lower Famennian (*P. triangularis* Zone to *P. marginifera* zones) and, rarely, upper Frasnian (*P. linguiformis* Zone) and lowermost Carboniferous (*S. sulcata* Zone, only slope to basinal limestones) in age. The late Famennian is not yet documented in limestone olistoliths and may therefore be a time of widespread basinal deposits (shale and lydite). Mafic volcanics may also be present in the Famennian to Early Carboniferous because in many places such volcanics are adjacent to undated turbidite-olistostrome sequences that may be Late Silurian–Early Devonian or Famennian–Early Carboniferous in age.

The late Viséan is characterized by a rapid shallowing. At first, the sea bottom rose from below the CCD to above the CCD, indicated by the deposition of fossiliferous, deep-water shales and siltstones (containing ammonoids, brachiopods, crinoids, few trilobites, and bivalves) with intercalations of thin pelagic marls and limestones. The first limestone intercalations contain only radiolarians, foraminifers, and sponge spicules, subsequently also conodonts are present. These deposits rapidly change into shallow-water bioclastic limestones (throughout the interval of about 25 m of limestones with rich conodont faunas, the amount of radiolarians decreases). Several thin horizons of felsic to intermediate tuffs are intercalated within the Upper Viséan deposits. Upper Viséan rocks lack cleavage and have a very low thermal alteration (CAI = 2–3).

The Serpukhovian, Pennsylvanian, and perhaps the Early Permian are represented by fossil-rich, shallow-water carbonates with some intercalations of shales, sandstones, and conglomerates. Since that time, Karaburun Peninsula was a part of the Eurasian, shallow-water shelf or foreland of the Tethys. This is also indicated by Permian fusulinid faunas from the Eurasian shelf in the Middle and Late Permian of the Karakaya Zone (north of the Izmir-Ankara Zone).

There was no Carboniferous-Middle Permian Paleotethys between Karaburun Peninsula and Eurasia, although the Paleotethys deposits have been documented slightly further to the east, with a westernmost occurrence near the middle part of the Black Sea coast, north of the Küre Basin (KOZUR and MOCK 1997). Consequently, the Late Paleozoic oceanic continuation of the eastern and central Tethys to the west must have been restricted to the area located south of the Taurides (pelagic Serpukhovian to Permian in the Phyllite Unit of Crete Island and Peloponnesus, and Early Permian to Dorashamian deep-sea sediments in Sicily, southern Italy). This is also indicated by totally different contemporaneous Dorashamian radiolarian faunas of the Karakaya Zone and western Sicily (KOZUR 1997b). Moreover, no pelagic Permian rocks older than upper Dzhulfian are known from the Karakaya Zone (KOZUR and KAYA 1994; KOZUR 1997b).

The Paleozoic succession reconstructed herein nearly perfectly mirrors the "autochthonous" Paleozoic succession of Chios (BESENECKER *et al.* 1968) (Fig. 2). The striking similarities between the two successions continue into the Triassic.

Thes currently known very low-grade metamorphic Paleozoic of the Kütahya-Bolkardağ Belt (ÖZCAN *et al.* 1990) is very similar. Coral crinoid, and algal-bearing Upper Silurian (to Lower Devonian?) limestones (Bozdag Limestone) correspond to the Kalecik Limestone of the same age and also contain the same type of mercury ores as in the Kalecik area. The initial results of the ongoing project (GÖNCÜOĞLU and KOZUR in preparation) show that Upper Silurian–Lower Devonian turbidites are widely distributed in the Kütahya-Bolkardağ Belt. They contain layers of felsic to intermediate tuffs, when considered together with the widespread siliciclastic turbidites and olistostromes, most likely indicate Caledonian subduction (Caledonian flysch). The Early Carboniferous age of turbidites, radiolarites, and olistostromes with volcanics, assumed by ÖZCAN *et al.* (1990), is not documented by fossils. Limestones, sandstones, and shales with Early Permian fusulinids may correspond to the Tekekara Dag Limestone of Karaburun Peninsula. As in the case of the Karaburun Peninsula succession, the Scythian lies unconformably partly on Upper Paleozoic rocks and partly on Upper Silurian siliciclastic turbidites and olistostromes with numerous lydites (GÖNCÜOĞLU and KOZUR in preparation). However, the Scythian–Middle Triassic sequence of the Kütahya-Bolkardag Belt is characterized by shallower facies than that of Karaburun Peninsula. This indicates that the Kütahya-Bolkardag Belt was slightly farther south than Karaburun Peninsula.

A very similar lithological succession is known in the nearly unfossiliferous metamorphic Paleozoic of the Menderes Massif (DÜRR *et al.* 1995). The assumed Ordovician is very similar to the Ordovician(?) in Karaburun Peninsula, the assumed Silurian is represented by dark shales, the assumed Devonian by limestones and mudstones, the assumed Early Carboniferous by a flyschoid series, lydites, and mafic volcanics, and the Late Carboniferous to Early Permian by limestones, mudstones, and sandstones. Only the Early Permian is dated by fusulinids.

Hercynian siliciclastic deep-sea turbidites with many lydites and olistostromes (dated by conodonts as Early Carboniferous) were found also in the Tavas Nappe of the Lycian Nappes in southwestern Turkey (KOZUR *et al.* in press). They are lithologically identical with the Lower Carboniferous turbidites and olistostromes of Karaburun Peninsula. However, the overlying shallow-water carbonates range up to the Middle Permian (Guadalupian). Older beds are not yet known from the Tavas Nappe.

Seemingly, a wide Caledonian ocean was present in the area from Chios through the Karaburun-(Menderes)-Kütahya-Bolkardag Belt. South of this ocean, a typical Perigondwana Cambro–Ordovician sequence is present. It consists of Lower Cambrian archaeocyathan limestones, overlain by platy and subsequently nodular, yellowish, pink, and reddish Middle Cambrian limestones, followed by siliciclastic rocks (mainly shales and siltstones) of Late Cambrian to Arenig age, in which small intercalations of pinkish to reddish, nodular limestones with rich upper Arenig conodont faunas occur. This succession (very similar to the sequences in Sardegna) is known from the Sultandağ and originally southwards adjacent units, but is not documented from the areas north of the Karaburun-Bolkardag Ocean and is also missing from deposits of this ocean itself. The Hercynian, Upper Devonian to Lower Carboniferous deep-sea turbidite-olistostrome unit indicates the presence of a Hercynian Ocean in the Karaburun Unit. As shown by the deep-sea flysch of the Tavas Nappe (Lycian Nappes), these Hercynian oceanic rocks also had a wide distribution south of the Izmir-Ankara Belt. The felsic to intermediate volcanics that occur in the Late Viséan sequences of Karaburun Peninsula indicate a southward-directed subduction of the Hercynian ocean. Possibly triggered by this subduction, the Carboniferous to Permian South Tethys opened south of the Taurides (Oman-Crete-Sicily oceanic Belt).

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Appendix
Detailed sequence of the type locality of the Dösemealti Formation (locality 16, 1).

In section A, the lower and middle parts of the Dösemealti Formation are well exposed, whereas the upper part is poorly exposed. In section D, the upper part of the Dösemealti Formation and the base of the overlying Alandere Formation are exposed. The lowermost exposed bed of section D (bed D1) corresponds to bed A 16 of section A. In the short B and C sections, the middle part of the Dösemealti Formation is exposed. Section C is laterally separated from the lowermost bed of section D by a short covered interval and can be well correlated with section A (bed C3 = bed A 14; bed C2 = bed A13; bed C1 = bed A 12). The correlation of the upper part of section B with section A is more difficult. Beds B4-7 may correspond to beds A8-10, bed B3 = bed A7, bed B2 = bed A6 and bed B1 corresponds ot the upper part of bed A5.

Section D

Alandere Formation:

22. > 50 m, grey to dark-grey, fossiliferous limestones (brachiopods, bryozoans, crinoids, algae).

Dösemealti Formation:

21. 15 m, medium- to thick-bedded, rarely thin-bedded, bituminous cherty limestone: in the lower part dark-grey, often with large chert nodules, partly with intraformational breccias; in the upper part grey, with numerous small (around 1 cm) chert nodules and shallow-water clasts. Crinoids and indeterminable ammonoids; the shallow-water clasts of the upper part also contain bryozoans and algae. Sample K 2603 from an ammonoid-bearing limestone, 2 m below the top of the Dösemealti Formation. Sample K 2604 from limestone with intraformational breccia, ca. 5 m below the top of the Dösemealti Formation. Sample K 2605 from crinoid limestone, 4 m below the top of the Dösemealti Formation. Sample K 2606 from cherty limestone, 3 m above unit 20.
20. 7 m, thin- to medium-bedded dark-grey, partly black and bituminous, platy limestones with minor thin shale intercalations. Few indeterminable ammonoids and crinoids. Sample D3 at 2.50 m above the base. Sample 2612 at 3.50 m above the base.
19. 0.10–0.20 m, dark, marly shale.
18. 0.50 m, white, bentonitic finesandstones (altered felsic to intermediate tuffs). Sample D2.
17. 0.50 m, finely laminated, brown to light-grey, finesandstones.
16. 0.70 m, light- to dark-grey, carbonatic sandstones and siltstones.
15. 0.10 m, light-grey, carbonatic finesandstones with few thin (~1 mm), white, bentonitic layers (altered felsic to intermediate tuffs).
14. 0.20–0.30 m, grey limestone.
13. 0.03–0.10 m, shales and marls.
12. 0.10 m, grey, radiolarian-bearing limestone, in the upper part yellowish and weathered, upper surface with crinoids. Sample D1.
11. 0.03–0.04 m, marls and shales.
10. 0.60 m, limestone with few, irregular bedding planes. In the lower part, this limestone is grey and yellowish-weathered; in the upper part, dark-grey and light-grey-weathered.
9. 0.05 m, shale and white bentonites (altered felsic to intermediate tuffs).
8. 0.10 m, platy, marly limestone, brownish, weathered.
7. 0.30 m, yellowish-brownish, weathered siltstone.
6. 1.70 m, yellowish-weathered, medium- to thin-bedded, slightly dolomitic, silty limestone.
5. 3 m, shales, with some hard bands, yellowish- or brownish-weathered; upper 0.40 m, beige-weathered shales.
4. 1 m, yellowish-weathered shales.
3. 0.15 m, nodular limestones.
2. 1.20 m, shales with few marls.
1. 1.50 m, nodular, radiolarian-rich limestones with shale and marl intercalations. Sample K 2608.

Section C

30 m to the north of Section D it is a small, but highly fossiliferous section, separated laterally from the lowermost exposed bed of Section D only by about a 3 m thick covered interval.

3. 1 m, greenish, hard, vertically disintegrating shales with ammonoids, brachiopods, and bivalves.
2. 0.07–0.1 m, hard marls.
1. > 0.70 m, yellowish-weathered, thin- to medium-bedded siltstones, shales, and finesandstones.

Section B

Section B is situated 25 m to the north of Section C.

8. 0.60 m, thin-bedded, yellowish-weathered shales, siltstones with nodular or platy marls.
7. 0.50 m, thin-bedded, yellowish-weathered shales.
6. 0.40 m, platy, partly nodular marly limestones.

5. 0.70 m, medium-bedded marly limestones and yellowish shales.
4. 1 m, yellowish shales with few marls and marly limestones.
3. 0.10–0.20 m, marly limestones. Sample K 2607.
2. 1.50 m Yellowish-weathered shales with a few hard marl intercalations.
1. > 0.20 m Nodular limestone.

Section A

Section A is situated 25 m to the north of Section B. The upper limb of a lying fold is measured. This fold dips 300° NW.

18. > 10 m, poorly exposed marls, platy limestones, cherty limestones.
17. 1.80 m, marls, marly limestones.
16. 2 m, grey, light-grey to yellowish-weathered, partly silty limestones, massive to nodular or thick-bedded.
15. 3 m, mostly yellowish-weathered, partly grey-weathered shales, siltstones, rarely finesandstones.
14. 1 m, greenish, hard shales, vertically disintegrating shales with ammonoids, brachiopods, and bivalves. Sample A12.
13. 0.10 m, hard, grey, yellowish-weathered marls.
12. 1.20 m, yellowish-weathered shales, siltstones, fine sandstones with few crinoids, bivalves, brachiopods, and very rare bryozoans. Sample A11.
11. 0–0.13 m, lenticular, marly, radiolarian-bearing limestone, yellowish-weathered. Sample A10.
10. 2 m, partly poorly exposed, yellowish-weathered shales and grey, silty marls.
9. 0.42 m, medium-bedded platy or nodular marls, marly and silty limestones. Sample A9.
8. 0.25 m, platy shales and hard, clayey marls with "*Posidonia*", ammonoids, crinoids, trilobites, and brachiopods. Sample A8.
7. 0.10–0.13 m, brownish-grey hard, marly limestones. Sample A7.
6. 1.40 m, yellowish-weathered shales with up to 0.06 m thick, hard, platy marls that become more numerous and thicker in the upper part. Crinoids, trilobites, few ammonoids, bivalves, brachiopods, and radiolarians. Sample A6 (30 cm below the top).
5. 0.50 m, grey, partly yellowish-weathered, nodular limestones. Sample A5.
4. 3 m, yellowish-weathered shales and siltstones with few harder beds. Crinoids, brachiopods, and bivalves. Sample A4.
3. 0.40 m, yellowish-weathered shales with three hard marls and marly limestones that change laterally into 0.02–0.13 m flaser-bedded marly limestones. Crinoids, radiolarians, and few ammonoids. Sample A3.
2. 0.40 m, very thin-bedded shales, partly grey, partly yellowish-weathered, with few thin (2 mm–2cm) bentonitic layers (weathered felsic to intermediate tuffs). Sample A2.
1. 1 m, yellowish-weathered shales and siltstones with white (tuffitic?) limestones and white bentonitic layer (altered felsic to intermediate tuffs). Sample A1.

THE AGE OF THE SILICICLASTIC SERIES ("KARAREIS FORMATION")
OF THE WESTERN KARABURUN PENINSULA, WESTERN TURKEY

PLATE 1

The figured specimens have been derived from the following samples and localities. *1–6* sample K 1761 (loc. 5), Silurian limestone olistolith within siliciclastic turbidites, outcrop ca. 1 km SE of the Fatih College Campus. *7–26* sample K 1762 (loc. 6), Lower Devonian (upper Pragian, Emsian?) limestone olistolith within siliciclastic turbidites with Lower Carboniferous lydites, outcrop 700 m NNW of the Fatih College Campus. *27–34* sample K 1736 (loc. 3), a limestone olistolith (Upper Devonian, Lower Famennian, *crepida* Zone) within siliclastic turbidites, outcrop ca. 600 m E of Iris Lake. *35* sample K 1735 (loc. 3), limestone olistolith (Upper Devonian, Famennian, *P. triangularis* Zone to *P. rugosa trachytera* zones) within siliclastic turbidites with Lower Carboniferous lydites, outcrop ca. 600 m E of Iris Lake. *36–46* sample K 1751 (loc. 4), limestone olistolith (Upper Devonian, Lower Famennian, lower *P. rhomboidea* Zone) within siliciclastic turbidites with Lower Carboniferous lydites, outcrop ca. 2 km SE of the Fatih College Campus.

1. *Panderodus unicostatus* (BRANSON *et* MEHL), rep.-no. 4-8-95/III-9; *1a* × 50, *1b* detail of lower part, × 200.
2. *Dapsilodus obliquicostatus* (BRANSON *et* MEHL), rep.-no. 4-8-95/III-7, × 50.
3. *Pseudooneotodus beckmanni* (BISCHOFF *et* SANNEMANN), rep.-no. 4-8-95/III-12, × 100.
4. *Dapsilodus* sp., rep.-no. 4-8-95/III-8, × 50.
5. Ozarkodinid Pb element, rep.-no. 4-8-95/III-10, × 50.
6. *Dapsilodus obliquicostatus* (BRANSON *et* MEHL), rep.-no. 4-8-95/III-11, × 75.
7. *Pedavis palmatus* OLIVIERI *et* SERPAGLI, rep.-no. 4-8-95/III-85, × 50.
8. *Pandorinella* sp., oblique upper view, rep.-no. 4-8-95/III-90, × 50.
9. *Pandorinella steinhornensis* (ZIEGLER), rep.-no. 4-8-95/III-81, × 50.

10–12. *Pedavis* sp., **M2** element; *10* rep.-no. 4-8-95/III-94, × 50; *11* rep.-no. 4-8-95/III-95, × 75; *12* rep.-no. 4-8-95/III-79, × 50.

13. *Pedavis* sp., rep.-no. 4-8-95/III-88, × 50.
14. ?*Ozarkodina remscheidensis* (ZIEGLER), rep.-no. 4-8-95/III-93, × 50.
15. *Belodella devonica* (STAUFFER), rep.-no. 4-8-95/III-89, × 50.
16. *Ozarkodina buchanensis* (PHILIP), rep.-no. 4-8-95/III-83, × 50.
17. *Belodella* sp., rep.-no. 4-8-95/III-97, × 50.
18. *Belodella devonica* (STAUFFER), rep.-no. 4-8-95/III-86, × 30.

19, 21. *Belodella resima* (PHILIP), × 50; *19* rep.-no. 4-8-95/III-84; *21* rep.-no. 4-8-95/III-81.

20. *Ozarkodina* sp., rep.-no. 4-8-95/III-87, × 50.

22, 23. Undetermined coniform conodonts, × 50; *22* rep.-no. 4-8-95/III-80; *23* (?icriodid coniform element): rep.-no. 4-8-95/III-96.

24. *Pedavis* sp., rep.-no. 4-8-95/IV-1, × 50.
25. *Ozarkodina remscheidensis* (ZIEGLER), rep.-no. 4-8-95/III-92, × 50.
26. *Panderodus* sp., rep.-no. 4-8-95/III-82, × 50.
27. *Palmatolepis quadrantinodosalobata* SANNEMANN, morphotype 1 *sensu* SANDBERG and ZIEGLER (1973), rep.-no. 4-8-95/III-71, × 50.
28. *Palmatolepis* cf. *triangularis* SANNEMANN, rep.-no. 4-8-95/III-73, × 25.
29. *Palmatolepis glabra prima* ZIEGLER *et* HUDDLE, rep.-no. 4-8-95/III-75, × 30.
30. *Palmatolepis glabra lepta* ZIEGLER *et* HUDDLE, early form, rep.-no. 4-8-95/II-15, × 50.
31. *Polygnathus* cf. *nodocostatus* BRANSON *et* MEHL, rep.-no. 4-8-95/III-68, × 40.
32. *Palmatolepis minuta* BRANSON *et* MEHL, long, slender form *sensu* SANDBERG and ZIEGLER (1973); rep.-no. 4-8-95/III-72, × 25.
33. *Polygnathus planirostratus* DREESEN *et* DUSAR, rep.-no. 4-8-95/III-77, × 50.
34. **Pb** element of *Palmatolepis*, rep.-no. 4-8-95/III-35, × 50; 8 a: upper view, 8 b: lateral view.
35. *Palmatolepis rhomboidea* SANNEMANN, rep.-no. 4-8-95/III-69, × 50.
36. *Palmatolepis* cf. *regularis* COOPER, rep.-no. 4-8-95/III-23, × 50.

37, 38. *Palmatolepis subperlobata* BRANSON *et* MEHL; *37* rep.-no. 4-8-95/III-25, × 30; *38* rep.-no. 4-8-95/III-33, × 50.

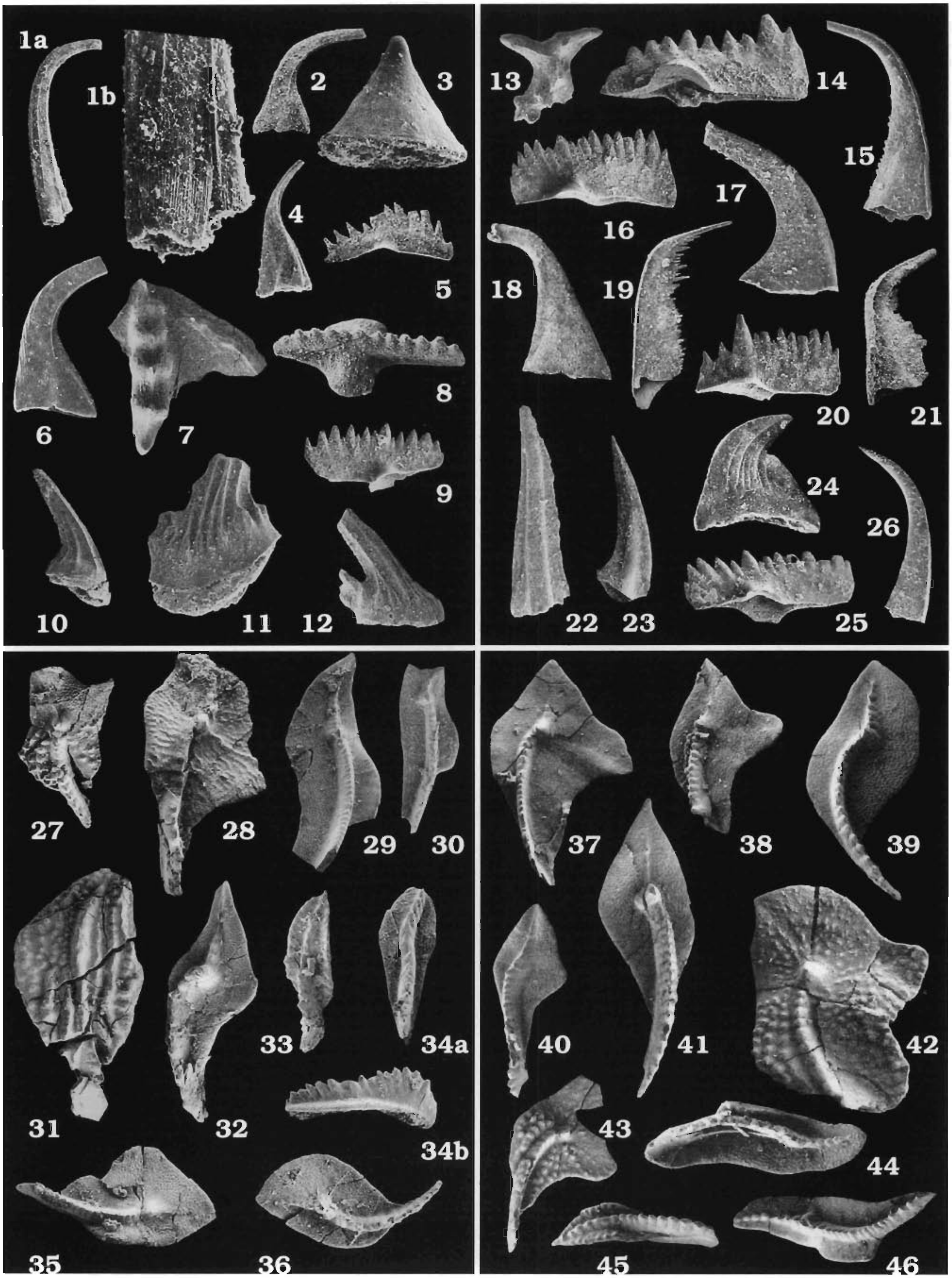
39. *Palmatolepis* cf. *regularis* COOPER, rep.-no. 4-8-95/III-39, × 50.

40, 41. *Palmatolepis minuta* BRANSON *et* MEHL, long, slender form *sensu* SANDBERG and ZIEGLER (1973); *40* rep.-no. 4-8-95/III-31, × 40; *41* rep.-no. 4-8-95/III-78, × 50.

42. *Palmatolepis poolei* SANDBERG *et* ZIEGLER, rep.-no. 4-8-95/III-26, × 50.
43. *Palmatolepis quadrantinodosalobata* SANNEMANN, rep.-no. 4-8-95/III-30, × 50.

44, 46. *Palmatolepis glabra pectinata* ZIEGLER; *44* rep.-no. 4-8-95/III-24, × 50; *46* rep.-no. 4-8-95/III-40, × 30.

45. *Polygnathus planirostratus* DREESEN *et* DUSAR rep.-no. 4-8-95/III-32, × 50.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