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A new pelagic conodont taxon of the Central Pontides (Turkey)

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Abstract: The Hallstatt-type limestones in the Central Pontides yield abundant conodonts of the genus *Gladigondolella* ranging throughout the entire studied sequence and indicating Anisian to Early Carnian ages. *Gladigondolella okayi* n. sp. is described.

Key words: Triassic, Pontides, *Gladigondolella*, conodont, biostratigraphy, taxonomy

1. Introduction

Among the many authors who have previously studied the Middle-Late Triassic in the Central Pontides (Turkey), Önder et al. (1988) and Kozur et al. (2000) reported conodonts in the Kayabaşı Limestone, while Okay et al. (2015), retracing the history of research and a summary of the biostratigraphy, including conodont genera *Gladigondolella* and *Neogondolella* and numerous foraminifers, also found *Monotis salinaria* in the Akgöl Flysch (Carnian-Norian). Kılıç et al. (2013) briefly reported the stratigraphically important Middle-Upper Triassic conodonts of the Kayabaşı Limestone that are presented here in detail, with the description of *Gladigondolella okayi* n. sp.

2. Geological framework

The basement of the Central Pontide Supercomplex (CPS; Figure 1) consists of Palaeozoic metaclastics (Okay et al., 2015). It is overlain by deformed Upper Triassic siliciclastic turbidites with olistoliths of Triassic limestone, the stratigraphic sequence of which is preserved. Okay et al. (2015) found the Norian bivalve *Monotis salinaria* in the turbidites. The low-grade metasediments of the CPS basement contain intrusions of Permian and Carboniferous granitoids. Above a presumed unconformity in the south, the CPS basement is overlain by the Upper Triassic turbidites of the Akgöl Flysch (Figure 2). The CPS comprises two terranes: the İstanbul Zone in the west and the Sakarya Zone in the east (Figure 1; Okay et al., 2015). Below the Upper Jurassic cover of both terranes, the İstanbul Zone consists at its base of Ordovician to Carboniferous sediments that are separated by an unconformity from the overlying Permian and Triassic red beds (Okay et al., 2015). In the Sakarya Zone, the poorly exposed crystalline basement consists, in the area near the Black Sea margin, of Permo-Carboniferous granitoids and metamorphics (Figure 1; Nzegge et al., 2006; Nzegge, 2007), while metamorphics, recently shown to be of Jurassic and Cretaceous age, extend over a large area in the southern part of the CPS (Figures 1 and 2; Okay et al., 2006, 2013).

In the south, the CPS Permo-Carboniferous granitoids are overlain by the orogenic Triassic volcano-sedimentary Küre Complex (Ustaömer and Robertson, 1994) that consists of Late Triassic turbidites. The Küre Complex and the Tauric Series are intruded by Middle Jurassic shallow level intrusions and are unconformably overlain by Upper Jurassic continental clastic rocks and limestones (Okay et al., 2015). The thick siliciclastic Upper Triassic turbidite sequence of the Küre Complex, named the Akgöl "Formation" by Ustaömer and Robertson (1994), is associated with basalt, gabbro, and serpentinite and indicates a period of uplift and erosion. Massive sulphide deposits of economic importance occur along the shale-basalt contacts. Within the flysch, blocks of Triassic limestone occur. The upper part of the Akgöl turbidites yield Triassic blocks derived from an earlier Triassic sedimentary sequence. The largest block, found by Blumenthal (1948, p. 109) northeast of Devrekani (Figure 2), was coined the Kayabaşı Formation by Önder (1988) and dated as "topmost Middle Triassic - Late Triassic" age using conodonts. For Okay et al. (2015), this unit is of palaeogeographic and stratigraphic importance, as it constitutes the only coherent marine limestone Triassic section in the Pontides besides that in the western part of the İstanbul Zone (Figure 1).

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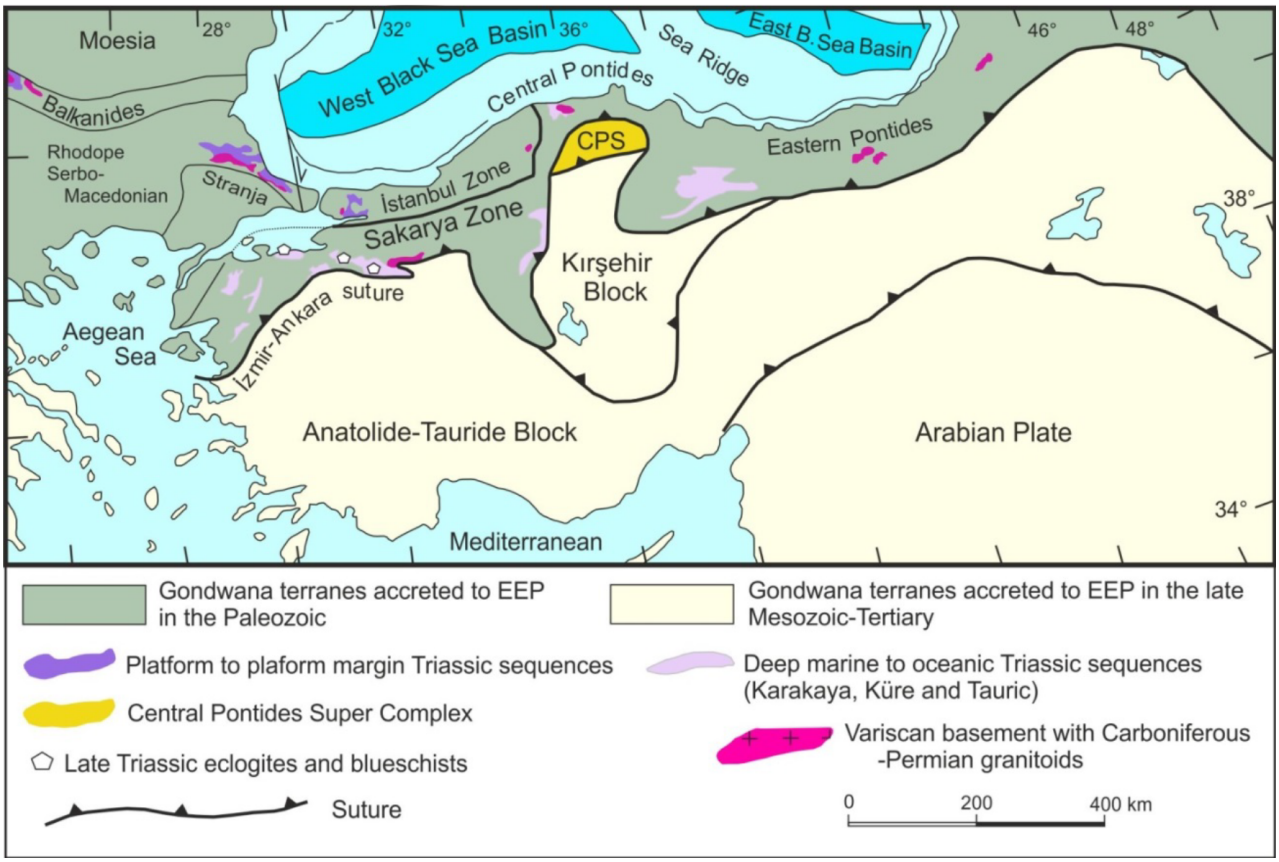

Figure 1. Tectonic map of the circum-Black Sea region showing the Triassic exposed north of the İzmir-Ankara suture (modified from Okay et al., 2015). Abbreviations: CPS, Central Pontide Supercomplex; Permo-Carboniferous granitoids: G, Gebze; Gm, Gümüşhane; K, Kürek; S, Söğüt.

The Kayabaşı Limestone block is approximately 550 m thick and 4 km long (Figures 3 and 4). Its northeast contact with the turbidites consists of a normal fault, while its southern contact is apparently stratigraphic (Okay et al., 2015). To the south the turbidites of the Akgöl Flysch contain more small blocks of Triassic limestone.

3. Stratigraphy within the Kayabaşı Limestone Block

Most of the Triassic rocks in the Central and Eastern Pontides consist of metavolcanics or highly deformed turbidite sequences. The Middle-Upper Triassic limestone block, floating in the Late Triassic Flysch, north of Devrekani (Kastamonu), known as the Kayabaşı Limestone Block and consisting mostly of Hallstatt limestone, is a rare example. Okay et al. (2015) subdivided the stratigraphic sequence in the Kayabaşı "Formation" into three members:

- Limestone Breccia Member (Anisian): Forming the base of the Kayabaşı Limestone succession, 200 m of limestone breccia along the ridge, east of Çal village (Okay et al., 2015), yielding biota that indicate an Anisian age. The light grey, 1- to 10-cm-large limestone breccia clasts are locally intercalated by thin micritic beds with a red micritic or sandy matrix.

- Hallstatt-type micritic limestone member (Anisian to Carnian): Up to 300 m thick, the middle part of the block is well exposed along the Kayabaşı ridge, east of Mermerli Stream (Figure 3; Okay et al., 2015). The basal part of the Hallstatt-type micritic limestone member consists of dark grey micritic limestones. These dark grey limestones pass upward into pinkish Hallstatt-type, slightly nodular micritic limestones, locally intercalated by grey medium-bedded calcarenite. Biota indicate an Anisian-Carnian age.

- Black limestone-shale member: With no exposed contact to the underlying Hallstatt-type micritic limestone member, consists of medium-bedded black limestone intercalated by abundant thin-shelled bivalve fragments (filaments) and thin black shale beds, exposed in the northernmost part of the limestone ridge.

The palaeontological data indicate Anisian to Carnian ages for the Kayabaşı Limestone. In terms of facies and age, it can be compared to a lesser degree with the Triassic in the western part of the İstanbul Zone (Özdemir et al., 1982; Kılıç, 2004).

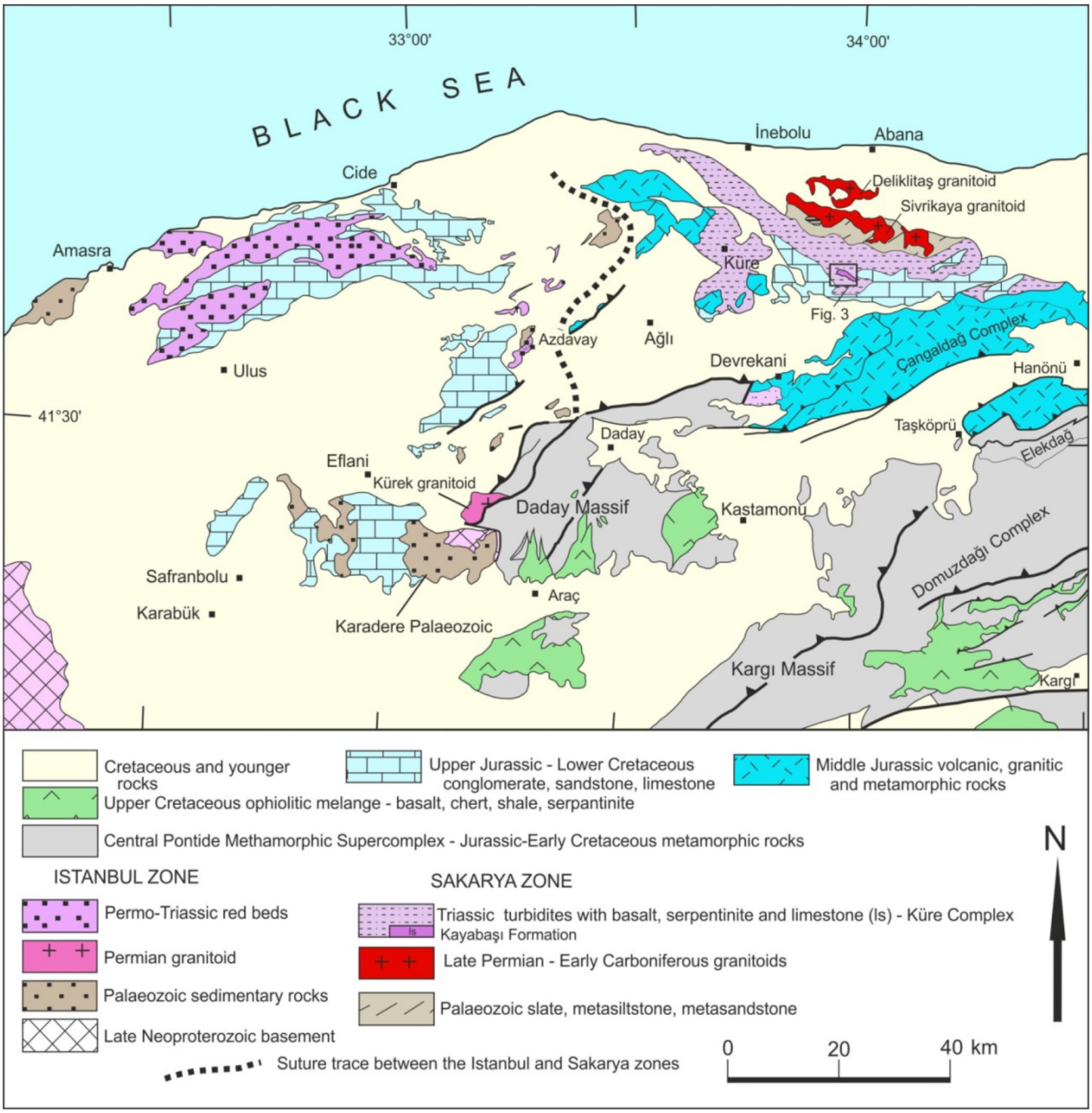

Figure 2. Geological map of the Central Pontides with outcrops of pre-Cretaceous units and Central Pontide Metamorphic Supercomplex (based on Okay et al., 2013; after Okay et al., 2015).

The sandstone beds above the Kayabaşı Limestone contain debris flows of Triassic limestone clasts. Lower-Middle Anisian foraminifera were determined in one of these clasts (Okay et al., 2015). Between İnebolu and Küre, Kozur et al. (2000) described similar Anisian limestone clasts within a debris flow within the Akgöl Formation.

The irregular contacts between turbidites of the Akgöl Formation and the large Kayabaşı Limestone (Figure 3) suggest that the limestone blocks slid into the turbidites. The in situ brecciation of the basal parts of the Kayabaşı Limestone most likely took place during the sliding phase of the block into the basin.

A few hundred meters north of the Kayabaşı Limestone, a different type of limestone was found within the Upper Triassic turbidites, not far from Softa (Figure 3) (Yılmaz and Boztuğ, 1987). It consists of ca. 20-m-thick, thickly bedded to massive, bluish grey bioclastic limestone with abundant brachiopod, bivalve, coral, algae, sponge spicule, and echinoid spine fragments, deposited probably in a fore-reef environment. The foraminifera indicate a Norian-

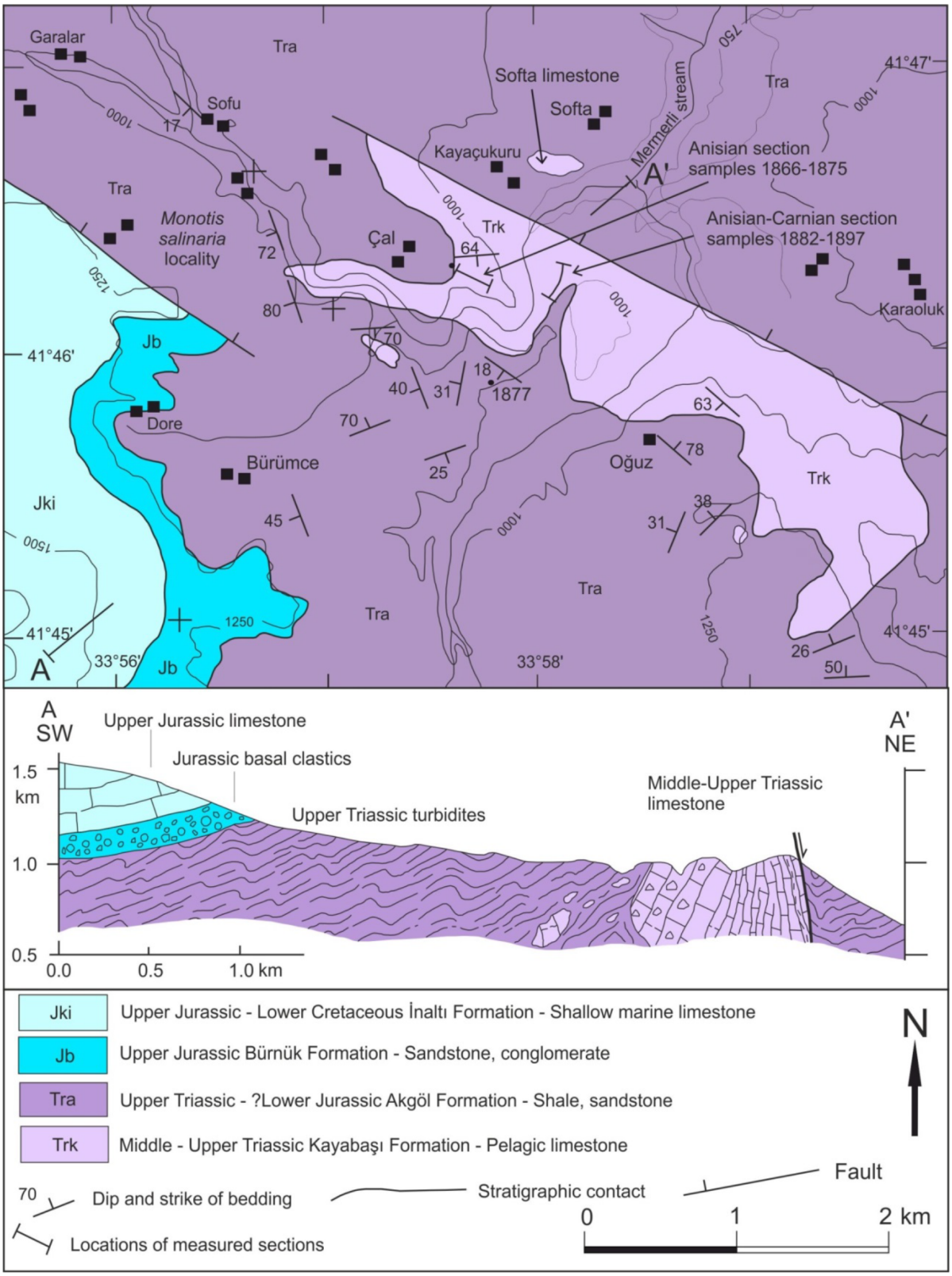

Figure 3. Geological map and cross-section of the Triassic limestones northeast of Devrekani (modified after Okay et al., 2015). For location see Figure 2.

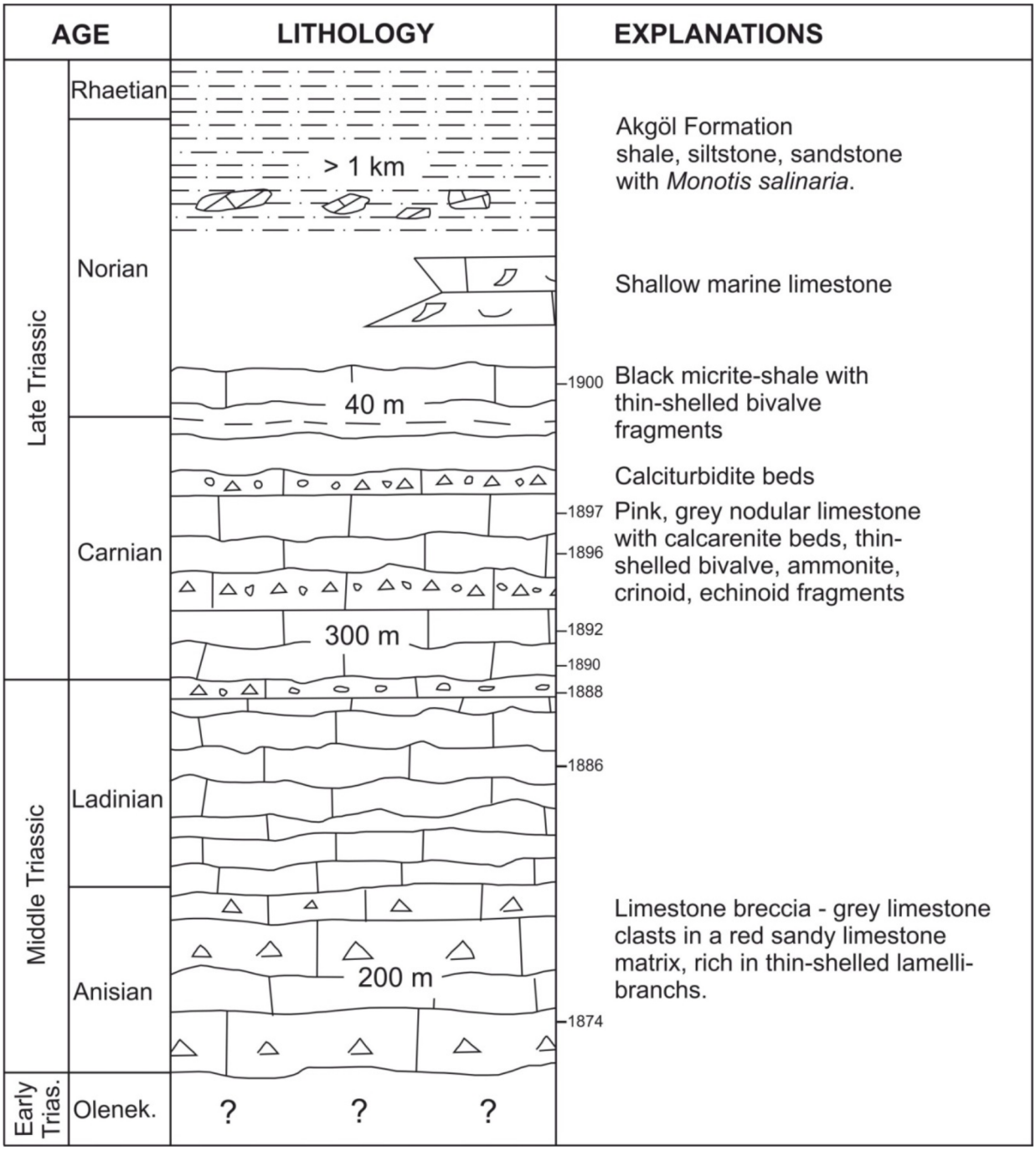

Figure 4. Composite stratigraphic section of the Kayabaşı Limestone and the overlying turbidites of the Akgöl Formation. Approximate positions of some important biostratigraphic samples are indicated (based on Okay et al., 2015).

Rhaetian age, although some agglutinating forms from the upper part of the block suggest the lowermost Jurassic. Finally, the 20-cm-large reddish limestone clasts, east of Çal village, also contain Norian-Rhaetian foraminifera (Okay et al., 2015).

The Upper Triassic - ?Lower Jurassic Akgöl turbidites that include the Middle-Upper Triassic limestone blocks consist of black shale intercalated with thin beds of dark siltstone and sandstone, forming a flysch sequence that reaches a thickness of over 2000 m, although difficult to determine because of strong deformation. The Akgöl Flysch is intruded by Middle Jurassic (Bathonian-Callovian) dacite-porphyries and granitoids (Yılmaz and Boztuğ, 1986; Okay et al., 2014), unconformably topped

by Upper Jurassic (Kimmeridgian)-Lower Cretaceous limestones.

The only precise palaeontological age data of the Akgöl Flysch are the Carnian-Norian trace fossil *Torlessia* sp. (Kozur et al., 2000) and the Late Norian bivalve *Monotis salinaria* (Okay et al., 2015). Clastic zircons are dominantly of Permian and Triassic age (Karslıoğlu et al., 2012).

4. Systematic palaeontology

Figures 5 and 6

Phylum Chordata Bateson, 1886

Subphylum Vertebrata Linnaeus, 1758

Class Conodonta Eichenberg, 1930

Order Ozarkodinida Dzik, 1976

Superfamily Gondolellacea (Lindstroem, 1970)

Family Gladigondolellidae Ishida and Hirsch, 2011

Genus *Gladigondolella* Müller, 1962

Type species *Polygnathus tethydis* Huckriede, 1958

Description: The platform element (P1) has a free blade; the basal keel extends over almost the entire element; the basal cavity is subcentral towards the posterior end, the basal pit is amygdaloid.

Differentiation between species is based on the length of the free blade and extent and size of the basal cavity. The octomembrate apparatus of the family Gladigondolellidae is comparable in number and positions to that of subfamily Neogondolellinae in the family Gondolellidae, but differs in the morphology of the elements. Reconstructions of the multielement apparatus of *Gladigondolella tethydis* were attempted by Mosher (1968), who recognised an octomembrate apparatus. For Ishida and Hirsch (2011) the octomembrate gladigondolellid apparatus consists of the following elements: P1 (platform), P2 (ozarkodinid): P2a (saginata) / P2b (cratognathodiform), M (cypridodelliform venusta), S0 (alate lautissima) or alternatively (*Anastrophognathus sagittalis* - sensu Kılıç, 2004), S1 (enanthiognathiform felsöörsi), S2 (cypridodelliform spengleri), S3 (pseudo-alate petraeviridis), S4 (hindeodelliform multihamata).

Stratigraphic range: The stratigraphic position of this subfamily of one genus is Late Spathian to Early Carnian; the volume of the genus consists of Spathian *G. carinata*, Anisian-Julian *G. tethydis*, and Late Ladinian-Early Carnian *G. malayensis*. In these species the basal amygdaloid pit, which becomes narrower during evolution, transferred from a posterior position (in *G. carinata*) to a central position (in *G. tethydis*) and back to a posterior position (in the expanded form *G. malayensis*).

Gladigondolella tethydis (Huckriede, 1958)

Figures 5.1 to 5.9; Figures 6.8 and 6.9

1958 *Polygnathus tethydis* n. sp.; in Huckriede (1958), pl. 12, fig. 38a and b; pl. 13, figs. 2–5

1980 *Gladigondolella tethydis* (Huckriede, 1958); in Kovacs and Kozur (1980), pl. 3, figs. 5 and 6

Material: Common throughout the section, abundant specimens in different growing stages, juvenile, adult, super-adult; in almost all samples abundant platforms and ramiforms.

Description: Relatively large and asymmetrical units showing thick-bulged reticular brims. Flat sculpture-free troughs persist laterally of the reduced carina that is characterised by discrete, roundish to oval-shaped denticles. The big and robust keel includes a small oval (amygdaloid) basal pit, mostly situated between mid-length and posterior third of the keel, often producing a laterally or downwards directed torsion of the platform as observed by Vrielynck (1987) and Mastandrea (1995). This occurs only in some specimens. The species, which is characterised by a very thin platform and a sharp keel, has approximately a triangular cross-section. Teeth on the carina are separated and nodular-shaped. The keel, having a short groove, extends over the lower surface of the element and generates the basal cavity (Hornung et al., 2006).

Stratigraphic range: Pelsonian – Julian.

Gladigondolella malayensis Nogami, 1968

Figures 5.2 and 6.1

1968 *Gladigondolella malayensis* n. sp.; in Nogami (1968), pl. 9, figs. 11-18, pl. 11, fig. 7

1973 *Neogondolella malayensis* (Nogami); in Koike (1973), p. 105, pl. 15, figs, 31-38

Material: Rare occurrence in the lower part of the section.

Original diagnosis (after Nogami, 1968): "The species is characterized by the following features: platform without lateral denticles, closely covered with finest pits; basal cavity eye-shaped, with two pointed ends and lying in the vicinity of platform end; denticles separated, main cusp isolated; free blade only rudimentarily".

Description: Unit bilateral subsymmetrical to slightly asymmetrical; platform greatly inflated; covered tightly with dimples and only slightly constricted; the lateral furrows next to the carina are rather indistinct. Carina with 7–11 separated teeth, main cusp is usually isolated at the end of the platform, often fused with penultimate denticle. The free blade is only rudimental. The basal cavity is eye-shaped and pointed on both sides, yet remains a short distance from the end of platform. The keel is very narrow and raises high. The basal cavity is extremely narrow and its adhesion to a quite wide flat at the basis. The platform is ellipsoidal in shape and its length about four times its width. Its widest point occurs at about mid-length. The unit is slightly arched in lateral view. The platform margins are upturned and are separated from the carina by troughs. Both the platform margins and the troughs possess a well-developed cancellous ornamentation. The central carina consists of seven to nine low rounded denticles,

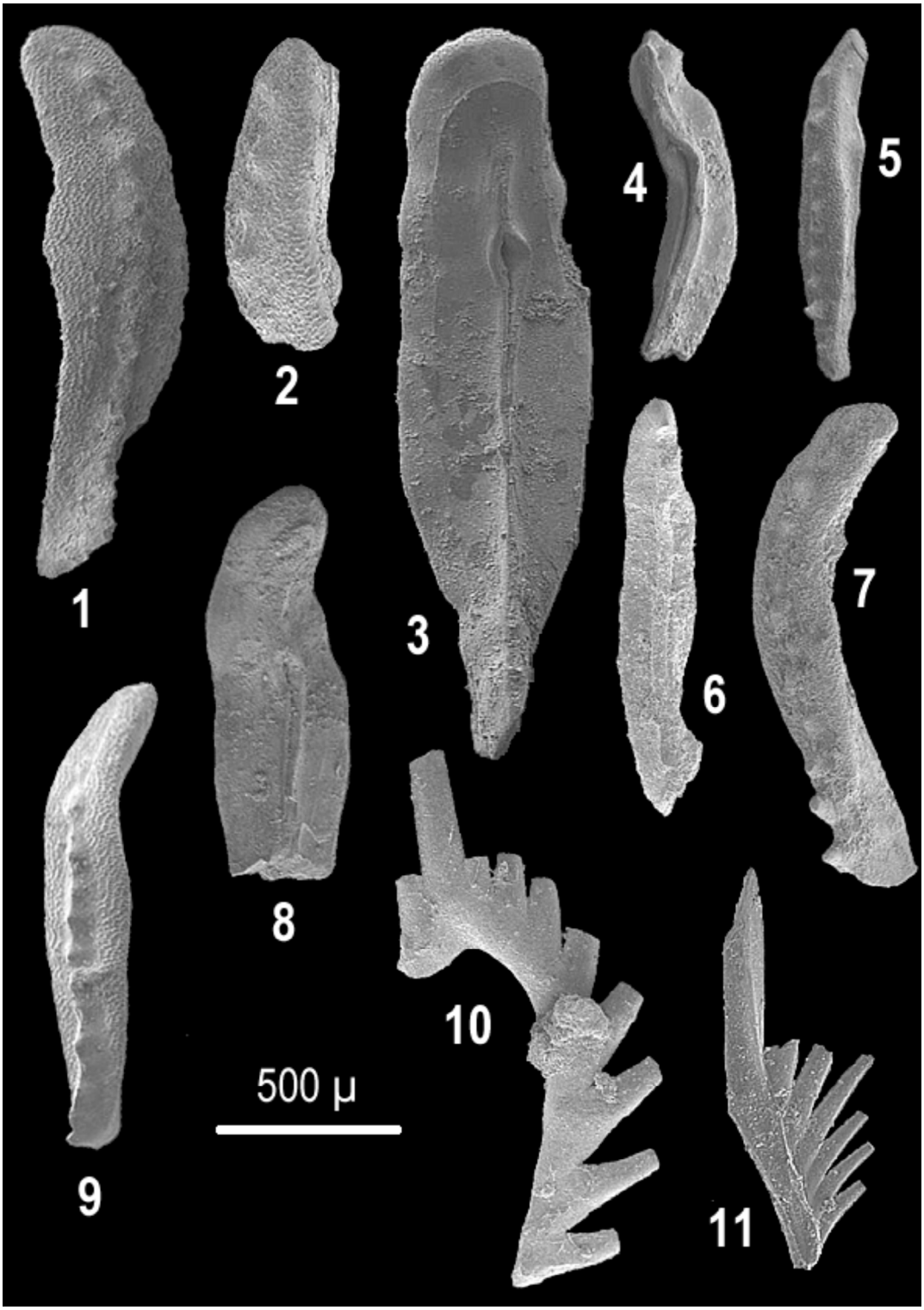

Figure 5. Electron microscope images of Anisian-Julian conodonts from the Central Pontides (north of Küre, Turkey). For location of the specimen see Figure 4. Bar scale is 500 microns. **5.1, 5.7–5.9** *Gladigondolella tethydis* (Huckriede); different stages of growth; **5.1–5.8** P1 element (sample 1889); **5.9** M element (sample 1889); **5.3–5.5** juvenile (sample 1889); **5.6** (sample 1892)**, 5.8** early adult (sample 1889); **5.1** (sample 1889), **5.7** adult (sample 1892); **5.2** senile (sample 1889). **5.2** *Gladigondolella* aff. *malayensis* Nogami (sample 1895). Revised after Okay et al. (2015).

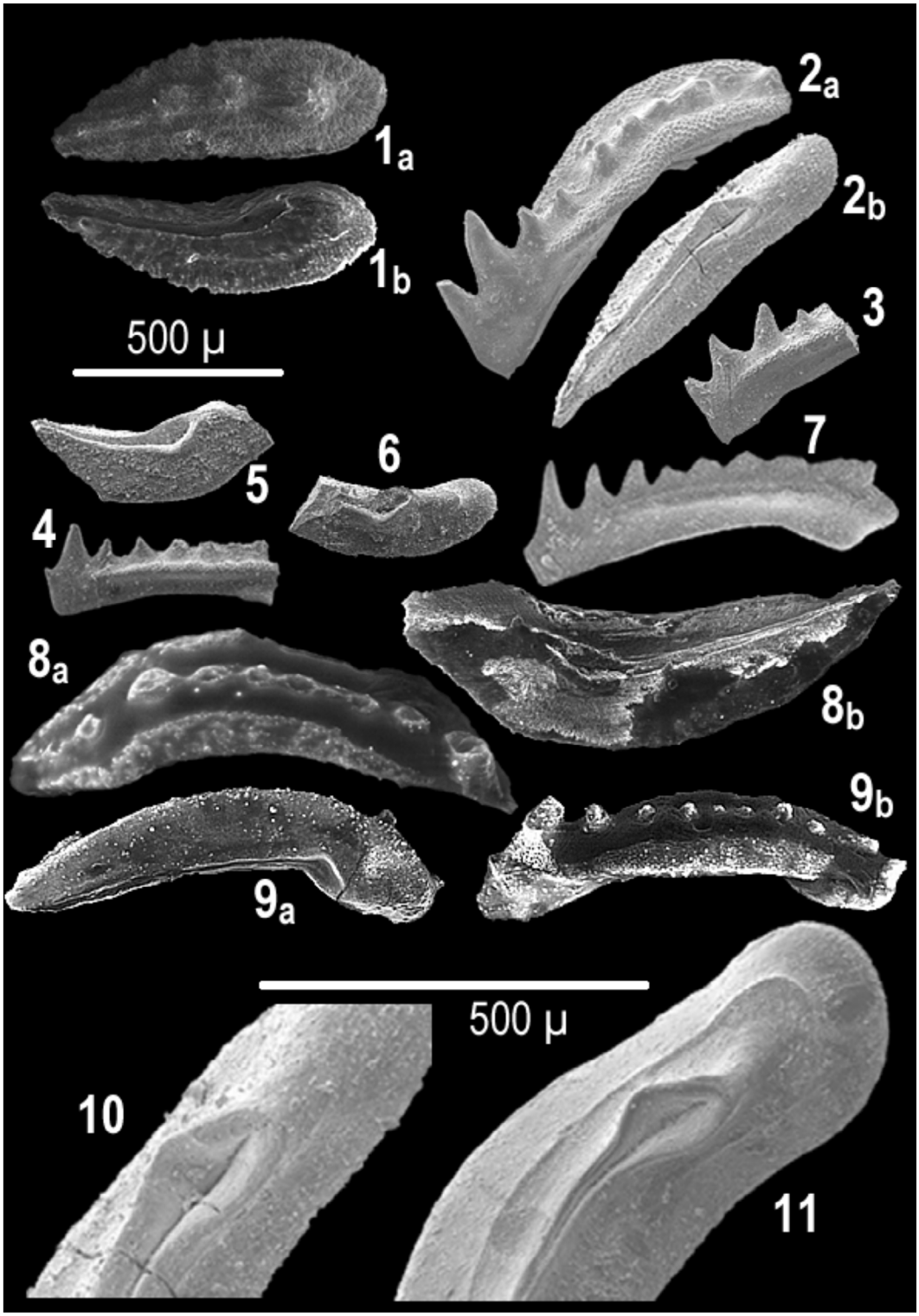

Figure 6. 6.1a–6.1b GSC 80506/24866, sample 1892. *Gladigondolella malayensis* cf. *G. malayensis budurovi* Kovacs and Kozur; **6.2–6.7**, **6.10–6.11** *Gladigondolella okay*i n. sp.; **6.2a–6.2b, 6.10 (holotype)**, GSC 80529/24914, sample 1896; **6.2a** oblique-upper, **6.2b** lower, **6.7** lateral views, **6.10** basal pit (detail); **6.3** GSC 80529/24914, sample 1897: distal fragment; **6.4–6.6** GSC 80498/24844, sample 1888: **6.4** distal fragment, **6.5–6.6** juvenile (?) fragments; **6.11** GSC 80529/24914, sample 1897: detail of basal pit; **6.8–6.9** GSC 80529/24914, sample 1896; *Gladigondolella malayensis* Nogami cf. *G. malayensis budurovi* Kovacs and Kozur, morphologically transitional to *G. tethydis* (Huckriede). Long scale bar is for 6.10 and 6.11. For location of the specimen see Figure 4.

the posterior-most denticle normally being the largest. Aborally the unit is strongly keeled. The small flaring basal cavity is situated about one-eighth the length of the unit from the posterior end and is extended anteriorly as a groove along the keel.

Remarks: The most important difference between *G. malayensis* and *G. tethydis* is the position of the eye-shaped basal pit that is posterior in *G. malayensis*, as seen in Figures 6.8 and 6.9, GSC 80529/24914, sample 1896, showing *G.* cf. *malayensis budurovi* Kovacs and Kozur, which is a transitional form to *G. tethydis* (Huckriede), compared to the advanced adult specimen of *G. tethydis* in Figure 5.2. The large, robust, but broken specimens with a low posterior carina that consists of four low denticles that stepwise decrease at mid-length of the carina into a very low ridge of fused, oval-shaped nodules, all show very flat, indistinct sculpture-less developed troughs along the nodules and a central keel that contains a terminal, eye-shaped basal pit. *G. malayensis* also differs from *G. tethydis* in that it has a larger and more thickened platform and stepped distinct roundish nodules. *G. tethydis* is more oblong; the nodules are oval-shaped and fused into a low carinal ridge. However, the defining characteristic of this species is its eye-shaped basal cavity, at the end of the platform as in the oldest *G. carinata*. In the Central Pontides, some specimens have a rounded posterior end of the platform. The amygdaloidal platform is broadest mostly in its posterior 2/3. The upper surface of the platform has cell-like ornamentations, with typical honeycomb structure. The "keel" is broad and deeply excavated. The margin of the basal cavity is protruded, as can be observed in lateral view. The end of the "keel" is rounded. The basal cavity is straight, deep, and narrow and does not have a protruding margin. The slightly, but never sigmoidal, bent carina has 6 or 7 discrete denticles. All denticles are hemisphere-shaped and increased posteriorly. The last denticle always strongly develops into a main cusp. A free blade is never developed.

Stratigraphic range: Late Lower Anisian (Bithynian), Pelsonian, and ?Illyrian.

Gladigondolella okayi n. sp.

Figures 6.2–6.4, 6.7, 6.10, 6.11

Origin of the name: In honour of Dr Aral Okay, İstanbul Technical University, Turkey.

Holotype: GSC 80529/24914, from sample 1896; Figures 6.2a, 6.2b, 6.10.

Material: 18 specimens (GSC 80506/24866 sample 1896; GSC 80529/24914 sample 1897; GSC 80498/24844 sample 1888).

Type horizon: Over 300 m between 80494/24723 and 80550/24982 in the Hallstatt limestones of the Kayabaşı Limestone, under the red ammonite beds, with *Gladigondolella tethydis* (Huckriede).

Type locality: Type section of the Kayabaşı Limestone, north of Küre (Kastamonu, Turkey).

Repository: OPT 1296 in the Balıkesir University Department of Geological Engineering.

Diagnosis: Characteristic for the species are basal cavity, keel, free blade, and platform. The basal cavity is eye-shaped but not eyelets-shaped, like in the generotype *G. tethydis*. The keel is clearly raised towards the anterior end. The free blade generally bears three strong, high, and isolated denticles. The slender unit's platform is devoid of lateral denticles, the platform surface having a honeycomb like appearance; the eye-shaped basal cavity, typical of the genus *Gladigondolella*, is situated towards the end, 1⁄4 unit length from the end of the platform base; the denticles are not fused; above the basal pit, the main cusp is not strongly developed; on the free blade that clearly expands, three strong and high isolated denticles appear, the penultimate being prominent, while the ultimate small denticle is not always preserved.

Description: The narrow platform extends only to two-thirds of the unit. There is a characteristic downward bending of the posterior half of the platform. The upper surface of the platform is closely covered with tiny pits. The slightly bent but never sigmoidal carina has 8 or 9, rarely 10, discrete denticles. The three anterior denticles are considerably stronger and higher than the others. Next to the isolated, discrete last denticle of the carina, on the elongated free blade, there appears a very large cusp. The basal cavity lies within the posterior quarter of the platform and the main cusp that is supposed to appear above the basal cavity is only developed in juveniles, while insignificant in grown specimens. Its margin is protruded and bent outwards; the keel is broad and deeply excavated. The posterior end of the keel is rounded with an elongated loop. The upwards protruded anterior keel ends by narrowing under the free blade.

Remarks: *G. okayi* n. sp. strongly resembles *G. malayensis*, but the latter has only a rudimentary blade. The rudimentary free blade is clearly elongated, consisting of three strong separated high raised denticles. *G. okayi* n. sp. has no inflation of the platform with lateral furrows bordering the carina. While the main cusp of *G. malayensis* is usually isolated at the end of the platform, often fused with the penultimate denticle, *G. okayi* n. sp. has a penultimate large cusp, well isolated from the last posterior denticle. While in *G. malayensis* the keel is very narrow, in *G. okayi* n. sp. it only narrows towards the anterior end. *G. okayi* n. sp. shows considerable similarity with the much smaller *G. malayensis budurovi* Kovacs and Kozur that is morphologically transitional to *G. tethydis* (Huckriede), both having an isolated main cusp, but the latter's being more strongly developed; *G. okayi* n. sp. has a rather short and very narrow platform that contrasts with the broad

one of G. *malayensis budurovi* that covers nearly 2/3 of the whole unit. *G. malayensis budurovi* has a clearly sideward bent posterior platform, while in *G. okayi* n. sp. such bending is flattened. In *G. malayensis budurovi* a short free blade develops one or two denticles, similar to *G. okayi* n. sp., but in *G. okayi* n. sp. the clearly elongated free blade is prominent with three distinct and high separate denticles. The keel of *G. malayensis budurovi* is broader and more deeply excavated than the anteriorly narrow one in *G. okayi* n. sp. *G. okayi* n. sp. has similar but considerably smaller platform and elongated loop than *G. tethydis*. The anterior denticles of *G. tethydis* are often fused at their base. Possibly derived from *G. tethydis*, *G. okayi* n. sp. differs from the latter by having a clear free blade. *G. carinata*, from the lowermost Anisian, has a much stronger and longer main cusp and high and discrete carina denticles, not found in *G. okayi* n. sp.

Stratigraphic range: *G. okayi* n. sp. seems restricted to the Julian.

5. Conclusions

a. This report presents the detailed conodont succession in the Küre Complex of the CPS.

b. The new conodont data indicate Anisian (Middle Triassic) to Carnian (Late Triassic) ages for the pelagic Hallstatt facies of the Kayabaşı Limestone.

c. The presence of *Gladigondolella tethydis* in the uppermost conodont-yielding sample ascertains ages not younger than Early Carnian.

d. The following question arises: may *G. okayi*, newly found in the CPS, represent a facies within the Hallstatt Kayabaşı that is so far unique in the Tethys?

Acknowledgements

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