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Original article

Late Triassic and Lower Jurassic Foraminifera of the carbonate platform of the Beyaz Aladağ Group (Eastern Taurus, Turkey): New stratigraphic implications☆

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ABSTRACT

Foraminifera have proven to be reliable biostratigraphic indicators. Accordingly, Triassic and Early Jurassic benthic Foraminifera allow us to define a biostratigraphic zonation within the carbonate platform of Kayseri (Yahyalı), Göksun (Kahramanmaraş) and Sivas (Deliktaş) regions in the Eastern Taurus (Ceviz, Aladağ, Kaman and Felfan Mountains). Seven new stratigraphic sections are described in detail and the first precise inventory and illustration of the benthic foraminifer assemblages from the Triassic successions are presented over a large geographic area. The stratigraphic and palaeontological features of the Lower Mesozoic carbonate units of these mountains include several synchronous transgressive–regressive events that suggest continuity of the Lower Mesozoic environments over a large parautochthonous Taurus zone. Palaeogeographic considerations about the Eastern Taurus carbonates are given, evidencing three stages of development underwent by the studied area: 1) a stable continental margin from Lower Triassic to Lower Cretaceous; 2) a dismantling of the continental margin and first emplacement of ophiolites in the Upper Cretaceous; and 3) a deformation of the continental margin and emplacement of the Peridotite Nappe in the uppermost Cretaceous (Maastrichtian).

1. Introduction

The Anatolide-Tauride block, to which the study area belongs to, is part of a large platform that shows close stratigraphic analogies with the Arabian platform (Ricou et al., 1975; Ricou, 1980; Okay and Tüysüz, 1999; Fig. 1). From a palaeogeographic point of view, some authors (Stampfli, 2000; Stampfli and Borel, 2002; Moix, 2010) subdivide the composite Anatolides-Taurides domain into two distinct terranes: the Anatolian and the Taurus. Based on their different geodynamic histories, they recognise the existence of a common platform from the Upper Triassic. Structurally, the Taurids Alpine chain consists of the so-called Gondwana derived parautochthonous nappes that imbricate with Neothetyan ophiolite mélange nappes. The edifice is a consequence of several superposed nappes, their final shape resulting from intense Palaeogene tectonic phases.

The studied areas of Yahyalı, Göksun and Deliktaş are located in Eastern Taurus (Fig. 2). The Aladağ range crosses the nearly barren plains south of Yahyalı. East of Aladağ range, the Ceviz Mountains are part of the Aladağ tectonic unit (= Hadim Nappe) that includes the Bozkir ophiolite unit and an ophiolitic mélange under a Tertiary cover (Özgül, 1976). The stratigraphical and palaeontological features of the Lower Mesozoic carbonate units of the Ceviz Mountains (Yahyalı area; Kayseri, east of Aladağ range) extend further east to the Göksun (Kahramanmaraş) and Deliktaş (Ulaş-Sivas) areas (Fig. 2). Several synchronous transgressive–regressive events suggest continuity within the stratigraphy of a large zone of the Taurus chain.

Consisting of the Yahyalı-Munzur-Malatya nappes (Şenel, 1999), the study area was intensely investigated at the end of the 20th century (Dağer, 1975; Aksay, 1980; Tekeli, 1980; Tekeli and Erler, 1980; Işık, 1981; Tekeli, 1981). Blumenthal (1952), and 30 years later Tekeli et al. (1981, 1983), identified original carbonate units that underwent renewed interest with the investigation of the Göksun and Deliktaş regions by Yümün and Kılıç (2006) and the discovery of microfossils, especially benthic Foraminifera, prompting the present study in the Yahyalı area. The three study areas in Eastern Taurus cover a total surface of 450 km^2 (Fig. 2).

The main aims of this paper are:

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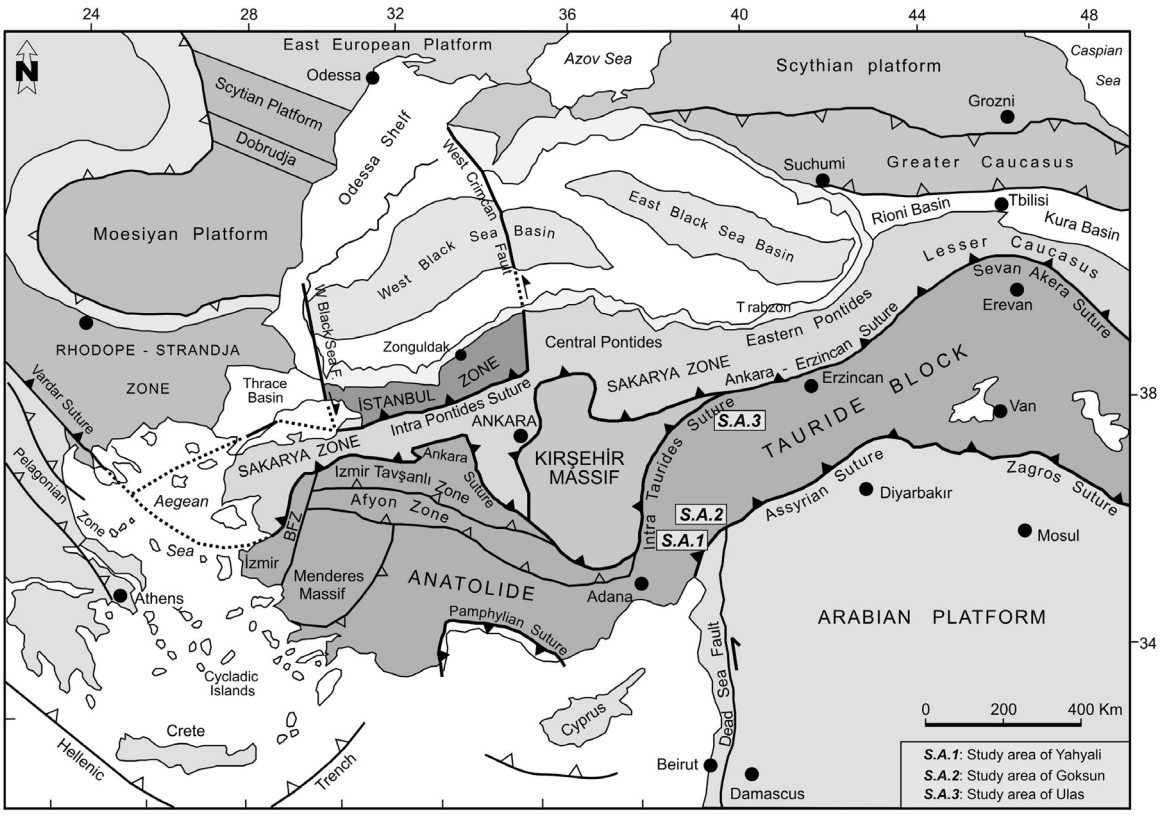

Fig. 1. Tectonic map of the north-eastern Mediterranean region showing the major sutures and continental blocks and the location of the studied areas (modified after Okay and Tüysüz, 1999).

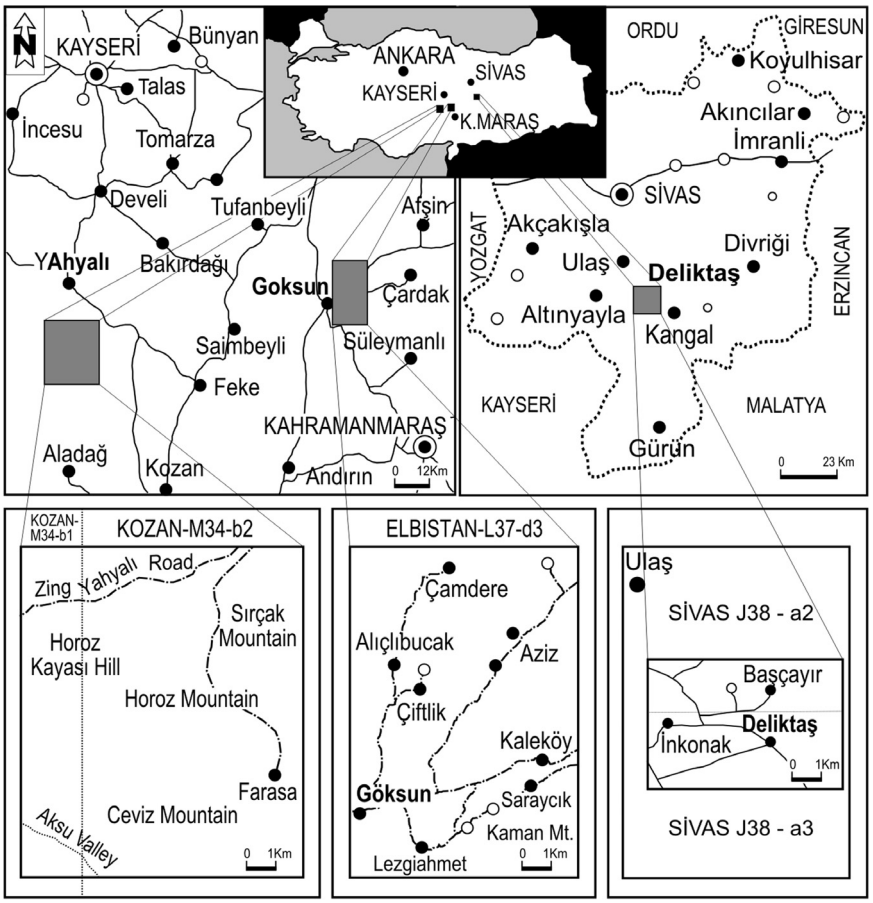

Fig. 2. Location maps of the Yahyalı, Göksun and Deliktaş areas.

- to present seven new stratigraphic sections, which have been measured and described in detail, in the Yahyalı area (Eastern Taurus) that was never investigated in detail before;
- to provide and illustrate the first precise account of the benthic foraminiferal assemblages from the Triassic successions over a large region in Eastern Taurus, covering the Yahyalı, Göksun and Deliktaş areas;
- to propose new stratigraphic partitions based on biostratigraphic correlations;
- to give palaeogeographic considerations about the Eastern Taurus carbonates.

2. Material and methods

The study material was collected in the Triassic, and subordinately Early Jurassic successions that crop out in the Yahyalı, Göksun and Deliktaş areas. However, singular emphasis was concentrated in the poorly known Yahyalı area. There, the most widespread lithotypes are the carbonates with chert levels of the newly proposed Aktepe Formation, the platform type carbonates of the Üçağaç Tepe Formation, the platform and lagoon carbonates of the Cevizdağı Formation, and the shelf carbonates of the Sırçak Limestone. Very similar lithologies are present both in the Göksun (shelf-type carbonates) and in the Deliktaş areas (platform-type carbonates).

We performed a microscopic analysis in transmitted light of about three hundred samples from nine stratigraphic successions. A large number of samples yielded well-preserved and determinable benthic Foraminifera. The field survey, including mapping, was done by Z.U. Yümün in collaboration with A.M. Kılıç and M. Tunç; the micropalaeontological determinations by R. Martini, and the complete iconography by J. Meztger.

3. Results

3.1. Yahyalı area

In the Yahyalı area, the several parautochthonous nappes that build up the Eastern Taurus are only represented by the Çataloturan Nappe at the base, and the Beyaz Aladağ Nappe on the top. From South to North, these two parautochthonous nappes are separated and overlain by the Tethyan nappes comprising:

- the Upper Cretaceous (Senonian) Aladağ Ophiolitic Mélange that overlies the upper Beyaz Aladağ Nappe;
- the Miocene Zebil Formation, consisting of conglomerates and sandstones, that generally buries the entire tectonic edifice in this region.

Plio-Quaternary glacial deposits and Quaternary alluvial cover also occur (Figs. 3 and 4). Özgül (1976), dividing the Taurus Zone into tectonic units, included the rock formations of the Aladağ region into the Aladağ Unit.

3.1.1. Çataloturan Nappe

This nappe consists of the Upper Permian Arkaçça Formation, concordantly overlain by the Lower Triassic (Olenekian-Lower Anisian) Küçüksu Formation, with the Middle Triassic (Upper Anisian) Horozkayası Dolomite on top. In the Yahyalı area, a Late Carboniferous-Early Permian hiatus interrupt the Early Carboniferous deepwater facies sedimentation, after which Late Permian shallow water carbonate sedimentation progressively starts. In the SW part, behind the Arkaçça Ridge, the Arkaçça Formation (Tekeli et al., 1983) (Pa; Figs. 3 and 4; Fig. S1(A), Appendix A) is represented by a ~500 m-thick dark grey to grey, medium to thick-bedded hard-textured limestone showing a regressive trend. Abundant Foraminifera, for example, *Paradagmarita monodi, Dagmarita chanackchiensis, Pachyphloia ovata* as well as representatives of the genera *Nankinella*, *Reichelina*, *Chusenella*, *Kahlerina*, *Globivalvulina*, *Hemigordius*, *Dagmarita, Geinitzina*, and Algae (*Mizzia* and *Pseudovermiporella*) confer an early Late Permian age to the Arkaçça Formation (Tekeli et al., 1981).

Northwest of the study area, concordantly overlying the Arkaçça Formation, the 815 m-thick Küçüksu Formation (Trk; Figs. 3 and 4; Fig. S1(A) and cross-section C–C') starts with a 1–1.5 m-thick level of grey-light yellow oolitic limestone. Further up, the formation is represented by yellowish, greenish grey to grey, and dark grey medium- to thin-thick bedded alternating marls, claystones and clayey limestone, ending with a 10 m-thick light yellow limestone with brownish-grey clay levels. The microfacies of alternating clastics and carbonates above the oolitic level vary from mudstone to sandstone and yield abundant ostracod and bivalve shell fragments. Ferruginous cracks may cross the rock. The overall environment shows evaporitic trend from platform to intertidal zone. The Foraminifera *Meandrospira pusilla* (Fig. S2) and *Hoyenella sinensis* (Fig. S2) give an Olenekian-early Anisian age to the formation.

In the same area, between Küçüksu Stream and Küçüksu Hill, the ~295 m-thick Küçüksu Dolomite (Trh; Figs. 3 and 4; Tekeli et al., 1983) overlies the Küçüksu Formation. It comprises medium to thick layers of white-grey, light yellow-grey dolomite and dolomitic limestones (Fig. S1(B) and cross-section C–C'). Tekeli et al. (1981) found the Foraminifera "*Trochammina*" *almtalensis* (Fig. S3), *Endotriada* sp. (Fig. S4), *Glomospira* sp., *Duostominidae* and some Involutinids, suggesting a Middle–Late Triassic age for the succession.

3.1.2. Beyaz Aladağ Nappe

In the Yahyalı area (Ceviz Mountains), the Beyaz Aladağ Nappe (Ayhan and Lengeranlı, 1986) is composed of a 4000 m-thick carbonate stack of Early Mesozoic formations forming the Beyaz Aladağ Group (emend. Blumenthal, 1952). This group is subdivided into four units (Tekeli et al., 1983, 1987): the Aktepe Formation (late Anisian–Carnian) at the base, followed by the Üçağaç Tepe Formation (mostly Norian), the Cevizdağı Formation (Rhaetian), and the Sırçak Limestone (Jurassic-Early Cretaceous) on top. It is worth noting that Yümün (2005) raised the Beyaz Aladağ Formation of Blumenthal (1952) to the rank of a group on the base of lithological, sedimentological, palaeontological and tectonic features, together with the important areal distribution of the Beyaz Aladağ Formation. This author also renamed the Beyaz Aladag Formation of Tekeli et al. (1983) as the Üçağaç Tepe Formation, after the homonym type locality in the Ceviz Mountains.

The type section of the here newly proposed Aktepe Formation (Tra; Figs. 3 and 4) is at Cinnikoyaklar, south of Aktepe, 20 km outer the southwest corner of the study area (Kozan sheet 1/25.000-M34-b1). Section L–L' (Figs. 3 and S5), crops out between 37° 57' 32" N/35° 22' 05" E and 37° 57' 12" N/35° 23' 44" E, striking N87°W, along the 2490 m-long northern slopes of the Emli Strait. The formation consists of carbonates with cherts, formerly called "Teknepınar Flysch" by Blumenthal (1952); it is lithologically different from the overlying Üçağaç Tepe Formation which represents the main body of the Beyaz Aladağ Group.

Two auxiliary sections of the Aktepe Formation are at Aktepe and at Çamyolu Hill (Fig. 3; cross-section C'–C"). The first (Aktepe; Kozan sheet 1/25.000-M34-b1), located between 37° 58' 05" N/35° 22' 40" E and 37° 58' 18"/35° 23' 45" E, striking N85°W, is 2315 m-long. (Fig. S6(A) and cross-section C'–C"). The second (Çamyolu Hill; Kozan sheet 1/25.000-M34-b1) is between 37° 57' 32" N/35°

20' 41'' E and 37° 57' 59'' N/35° 24' 20'' E, striking N85°W, and measure 4180 m (Fig. S6(B) and cross-section C'–C'').

The lower contact to both the Horozkayasi Dolomite (Trh; Fig. 3) and the Aladağ Ophiolitic Mélange (Kra; Fig. 3) is tectonic. The upper contact with the Üçağaç Tepe Formation is concordant and transitional. The Aktepe Formation has an average thickness of 1150 m. However, it can vary due to the tectonic nature of the exposures. It mostly consists of medium-thick beds of fairly fine and locally dolomitic limestone, with intercalated levels of cherts. The colour is light and dark beige, grey and yellow. The microtexture is clastic, consisting of extra- and intraclasts, together with peloids and skeletal fragments (e.g., Foraminifera, Ostracods, Bivalves, Echinoids, Algae) in a sparry calcite or neomorfic sparry calcite cement. In the uppermost beds of the formation the incertae sedis *Microcodium* occurs.

The lithologies alongside the microfacies indicate an evolution of the depositional environment from basin to platform, as confirmed by the presence of microcodiaceans (*Microcodium*), indicating a shallow marine setting (Nassichuk et al., 1986). Based on the presence of rich and diversified associations of Foraminifera (see Section 3.4.; Figs. S2–S4, S7, S8), a Middle-Late Triassic (Late Anisian-Carnian) age is assigned to the Aktepe Formation (Rettori et al., 1994; Broglio Loriga et al., 1999).

From a lithologic point of view, the Aktepe Formation can be compared to the Teknepınar Formation, which is exposed south-west of the study area, although its deposition took place in a shallower environment (i.e., on the coastal region of the shelf instead of in an open sea as for the Teknepınar Formation, formerly named "Teknepınar Flysh").

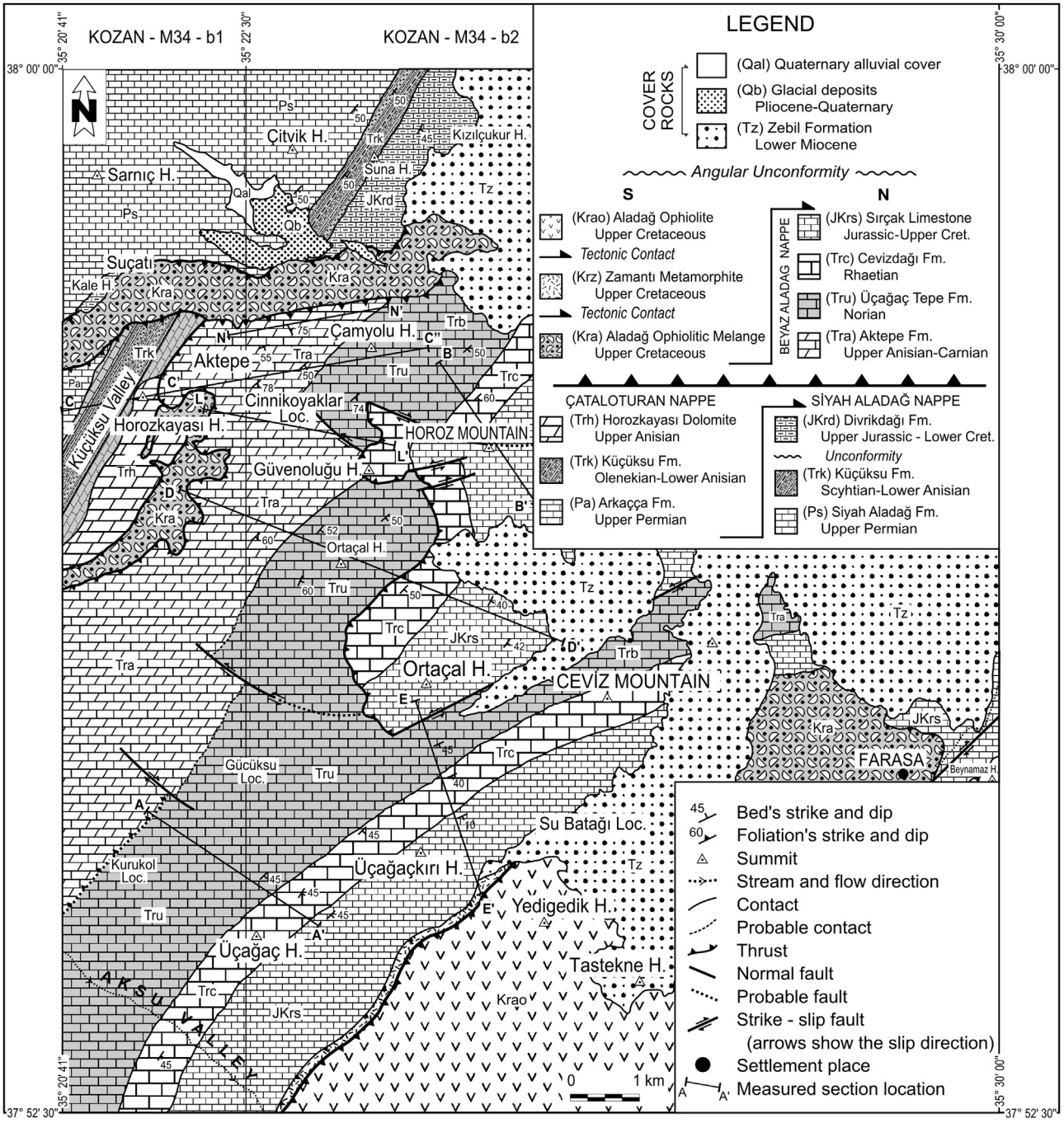

Fig. 3. Geological map of the Yahyalı area showing the location of the measured sections.

3.1.3. Beyaz Aladağ Nappe - Aladağ Tepe Formation

The Üçağaç Tepe Formation (Tru; Figs. 3 and 4) is the new name proposed here for the Beyaz Aladağ Formation of Tekeli et al. (1983), as this last is erected to the rank of group. This new formation is named after the homonym type locality in the Ceviz Mountains (Figs. S9(A) and cross-section B–B', S10(A) and cross-section A–A', S11(A) and cross-section E–E'). According to previous studies, the Üçağaç cagac Tepe Formation (= Beyaz Aladağ in Tekeli et al., 1983, 1987) consists of Late Triassic (Norian), greyish yellow to yellow-dark beige, medium-thick bedded platform-type carbonates containing the Algae *Griphoporella curvata* and *Thaumatoporella parvovesiculifera*. Textural differences occur in the lower and upper levels. The lower levels are characterised by increasingly neomorphic sparry calcite, and poorly-washed biosparite with few

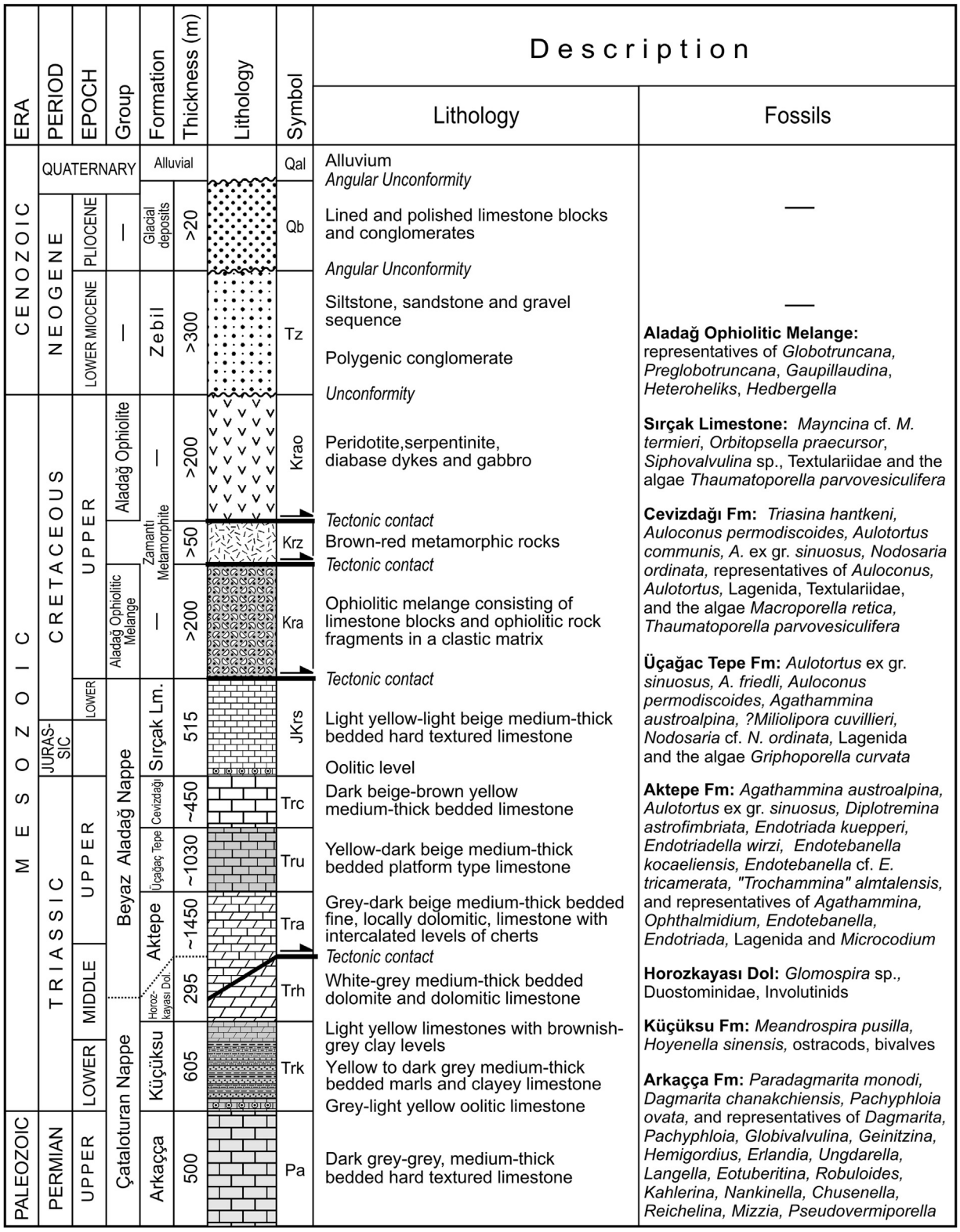

Fig. 4. Composite stratigraphic section of the Yahyalı area.

Foraminifera and Algae. The micrite generally contains pellets, which in upper levels turns to biomicrite with pellets. On the contrary, these levels contain relatively abundant Foraminifera and Algae (see Section 3.4.; Figs. S2–S4, S8, S12, S14). Based on the micropalaeontological content, the age interval of the Üçağaç Tepe Formation is Norian–Rhaetian.

3.1.4. Beyaz Aladağ Nappe - Cevizdağı Formation

Named after the Ceviz Mountain (Kozan sheet 1/25.000-M34-b2), this unit consists of uppermost Triassic (Rhaetian) platform and lagoon carbonates. The Cevizdağı Formation (Yümün, 2005) (Trc; Figs. 3 and 4) is well exposed in the upper slopes of the Ceviz range that stretches in SW–NE direction across the southwest of the study area and, further north, in the western part. It also builds up the north-eastern slopes of the Sırçak Mountain and the Güvenoluğu Hill (Kozan sheet 1/25.000-M34-b2), which is part of the Horoz Mountain (Fig. 3). The Cevizdağı Formation also crops out at the Kuskayasi Hill (Kozan sheet 1/25.000-M34-b1) in the west. A total area of 20 km^2 in the study area consists of this unit that spreads wider west, outside the study area.

The type section of the Cevizdağı Formation is located in the Üçağaç Hill (Kozan sheets 1/25.000-M34-b1 and M34-b2). The 2925 m-long stratigraphic cross-section (Figs. 3, S10(B) and cross-section A–A') was measured at Üçağaç Hill, between 37° 54' 40'' N/35° 21′ 30'' E and 37° 53' 20'' N/35° 23' 13'' E, in a N60°W direction.

Three auxiliary sections of the Cevizdağı Formation were measured at the Üçağaçkırı Hill, Horoz Mountain and Ortaçal Hill, respectively. The first one, 2737.5 m-long, is situated in the Ceviz Mountain (Kozan sheet 1/25.000-M34-b2), coordinates 37° 55' 23'' N/35° 24' 50'' E and 37° 54' 05''N/35° 24' 11'' E, striking N22°W (Figs. 3, S11(B) and cross-section E-E'). The second one, 2312.5 m-long, is from the Horoz Mountain (Kozan sheet 1/25.000-M34-b2) between 37° 57' 55'' N/35° 24' 29'' E and 37° 56' 53'' N/35° 25' 26'' E, striking N40°W (Figs. 3, S9(B) and cross-section B–B'). The last section, 5937.5 m-long, is south of the Ortaçal Hill (Kefenalan; Kozan sheet 1/25.000-M34-b2), between 37° 56' 57'' N/35° 21' 52'' E and 37° 55' 52'' N/35° 25' 43'' E, striking N70°W (Figs. 3, S13(A) and cross-section D–D').

The lower contact with the Üçağaç Tepe Formation is marked by a sudden change in lithology (Fig. S11) resulting in a steeper topography. The upper contact with the overlying Sırçak Limestone is concordant and transitional; it encompasses a colour change, which becomes much clearer, and an increase of the limestone hardness. The Cevizdağı Formation has an evaluate thickness from 386 and 550 m, according to the localities where it crops out. The succession is composed of medium–thick bedded (2–5 m) limestones; in the lower part they are dark beige-brown yellow, getting lighter upwards. Microtexture varies from mudstone-wackestone to boundstone in the lower part of the series, to bioclastic wackestone towards the upper part. The components mainly consist of bioclasts, especially Foraminifera and Microgastropods, together with the Algae *Macroporella retica* and *Thaumatoporella parvovesiculifera* (see Section 3.4.; Figs. 1–3). A small amount of intraclasts and pellets also occur. Megalodont bivalves occasionally also occur. The cement is of microcrystalline calcite due to a low metamorphism.

The microcomponents clearly reflect the standard properties of a shallow water environment (Wilson, 1975) that evolves, from the lower to the upper part of the formation, into a restricted platform or lagoon. Probably the sedimentation took place above the storm wave base. Oolitic limestone in the basal levels of the Sırçak Limestone, that concordantly overlie the Cevizdağı Formation, is a further important indicator for shallowing conditions towards the top of the Triassic. The foraminiferal associations indicate the uppermost Norian (Sevatian) to Rhaetian based on the presence of the foraminifer index *Triasina hantkeni* and the Algae *Macroporella retica*.

The Cevizdağı Formation is comparable to the lower Kurudere member of the Munzur Limestone, defined by Özgül (1983) in the Felfan Mountains, and with the middle part of the Andırın Limestone in the Kaman Mountains. These three series all consist of shallow water carbonates with Algae and megalodonts, passing upwards to the Lower Jurassic (Liassic) Sircak Limestone.

3.1.5. Beyaz Aladağ Nappe - Sırçak Limestone

Tekeli et al. (1983) named the shelf carbonates that form the uppermost part of the Beyaz Aladağ Nappe as the Sırçak Limestone (JKrs; Figs. 3 and 4). It crops out in the southern part of the Sırçak Mountain, East of the Aladağ range (Eastern Taurus) and in the southern slopes of the Ceviz Mountain (Fig. 3). We precise that this last outcrop was first included in the Beyaz Aladağ Formation (= Üçağaç Tepe Formation in this work) by Blumenthal (1952).

The Sırçak Limestone rests on the Upper Triassic (uppermost Norian to Rhaetian) Cevizdağı Formation concordantly and transitively. Towards south it is covered by the Upper Cretaceous Aladağ Ophiolitic Mélange, and to southeast and northeast it is overlain by the Miocene clastic rocks of the Zebil Formation with an angular discordance (Figs. 3 and 4).

The succession is composed of light yellow-light beige, medium-thick bedded hard-textured limestone. The microtexture of the biomicritic Sırçak Limestone is principally packstone, subordinately grainstone, with Foraminifera, Bivalves and the Algae *Thaumatoporella parvovesiculifera* (see Section 3.4.; Figs. S3 and S14); few pellets and intraclasts also occur. In the lower beds, oolites have been observed (Fig. S13(B) and cross-section D–D'). Upwards, recrystallization increases due to a low metamorphism.

The depositional environment matches to facies zone 7 of Wilson (1975), showing that initially sedimentation took place mainly below storm wave base, and then environment shallows towards the top. Moreover, the oolitic texture found at the base of the Sırçak Limestone clearly indicates the general shallowing-upward trend that affects the sequences in the whole study area at the end of the Triassic. Although in the previous studies a Jurassic–Early Cretaceous age assignment was proposed for the Sırçak Limestone, an early Liassic–Late Cretaceous age is proposed here according to the Foraminifera and Algae.

3.2. Göksun area

In the Göksun area (Fig. 5), the Göksun Ophiolite (Upper Cretaceous) represents the base of a stack of seven sedimentary units, each other separated by tectonic unconformities showing angular discordances. The four lower units are the Palaeozoic Yoncayolu Formation, the Upper Permian Çayderesi Formation, the Lower Triassic Alicli Formation, and the Upper Triassic Çamdere Formation. These units form the Keban-Malatya Group; it is discordantly followed by the Andırın Limestone (Upper Triassic to Lower Cretaceous), the Upper Miocene Salyan Formation, and by the Pliocene Nadir Formation (Yümün and Kılıç, 2002). The whole sequence of tectonically independent sedimentary units lies buried under Quaternary alluvium (Fig. 6). Lithologically, the Upper Triassic successions of the Keban-Malatya Group in the Göksun area, briefly described below, are closely comparable to those of the Beyaz Aladağ Group in the Yahyalı area.

3.2.1. Çamdere Formation (Keban-Malatya Group)

Outcropping in the northeast part of the Goksun district (Kahramanmaras), the Çamdere Formation (Trc) mainly consists of locally recrystallized limestones (Fig. S15 and cross-section A–A'). Bivalve shell fragments and Foraminifera (see Section 3.4.) have been mentioned in this succession together with the dasycladale

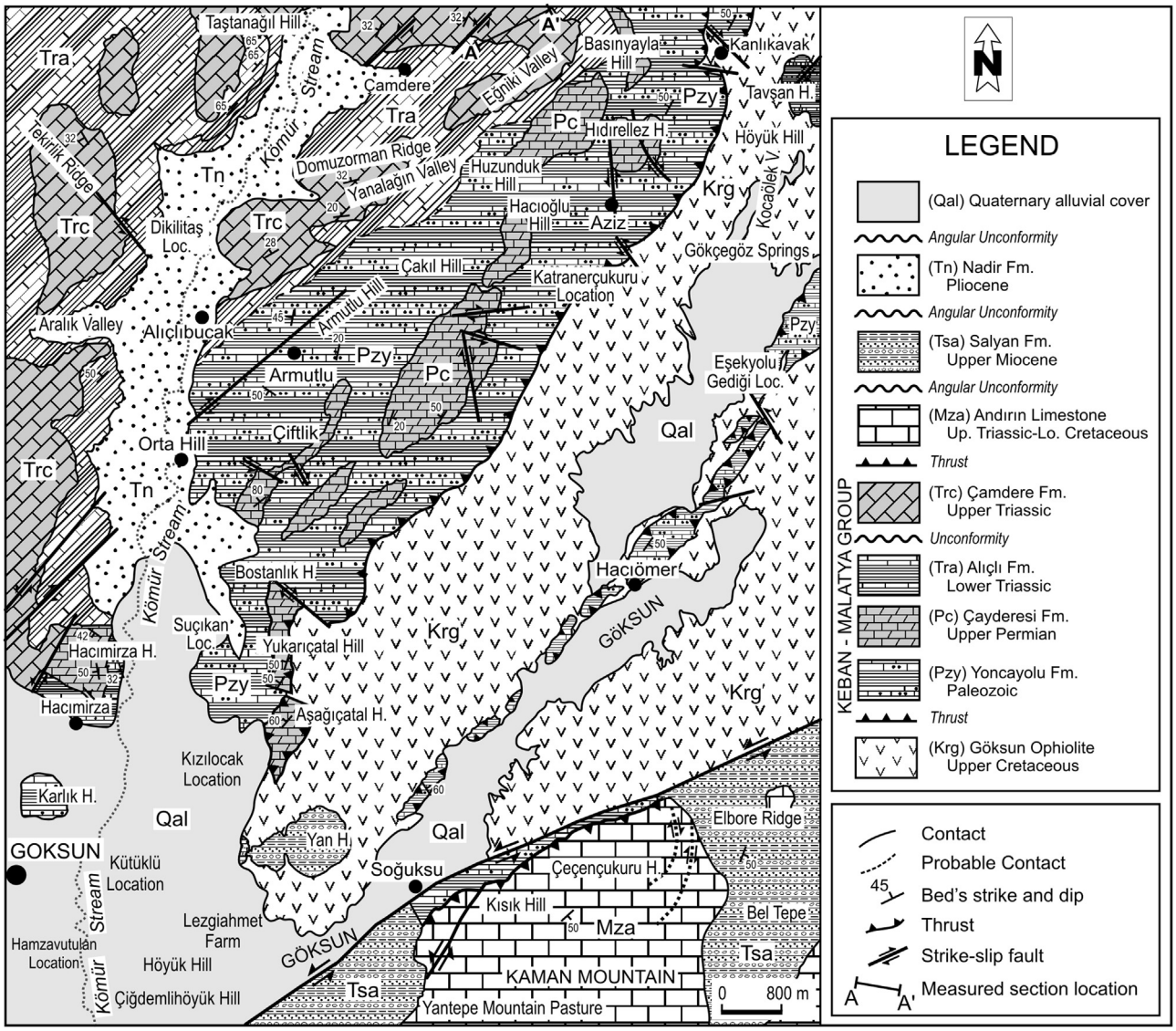

Fig. 5. Geological map of the Göksun area showing the location of the measured section (A-A') (modified after Yümün and Kılıç, 2002).

Clypeina besici (Yılmaz et al., 1993). According to the fossiliferous content, the age of the Çamdere Formation is Late Triassic. Therefore Upper Triassic levels are present in the Keban-Malatya Unit. It is worth noting that the Çamdere Formation was firstly named as Palaeozoic marble in the Malatya Metamophic. Later on, it was added to the Çayderesi Formation by Yılmaz et al. (1993) and more recently, it has been named as Çamdere Formation by Yümün and Kılıç (2002) from the Çamdere village of Göksun.

3.2.2. Andırın Limestone

The Upper Triassic–Jurassic shelf-type carbonates of the Andırın Limestone (Mza) crop out in the south and southeast of the Göksun district (Kahramanmaraş). In the lower-middle part of the succession, the thick layers of grey-beige limestones and cherts, locally recrystallized, contain a rich and diversified association of Foraminifera (see Section 3.4.), along with the Algae *Thaumatoporella parvovesiculifera* and rarer megalodont shells. Upwards, the limestone becomes light yellow and biomicritic with relatively abundant megalodont shells and few Foraminifera, suggesting a shallowing trend. Oolitic levels also occur, especially in the Jurassic upper part of the succession. According to Yümün and Kılıç (2006), the micropalaeontological association confers a Late Triassic to Jurassic age to the Andırın Limestone (Fig. 6).

Lithologically, this unit resembles the upper part of the Sırçak Limestone (Yahyalı area; Beyaz Aladağ Nappe) and the upper levels of the Munzur Limestone (Deliktaş area; Ulaş-Sivas region). The shallowing that occurs in each of the three series (Yahyalı, Göksun and Deliktaş) is interpreted as a feature related to the Upper Triassic-Lower Jurassic transition, suggesting the existence of a regional indicator of the carbonate sedimentation within a single large basin. It is worth noting that originally the Andırın Limestone was named Andırın Carbonates by Ayaşoğlu (1970), Pampal and Kurtman (1983) and Perinçek and Kozlu (1983) referring to the carbonate rocks present in the southwest part of the study area.

3.3. Deliktaş area

East of Deliktaş, southeast of Ulaş (Sivas), raise the Felfan Mountains, fashioned by a tectonic stack of several tectonic elements (Fig. 7). At the base, the pile starts with the Permian-Lower Cretaceous Munzur Limestone (Mzm), lying under the Upper Cretaceous Yeşiltaşyayla Mélange (Ky), a polymictic mélange in a clastic matrix. A north-plunging tectonic contact

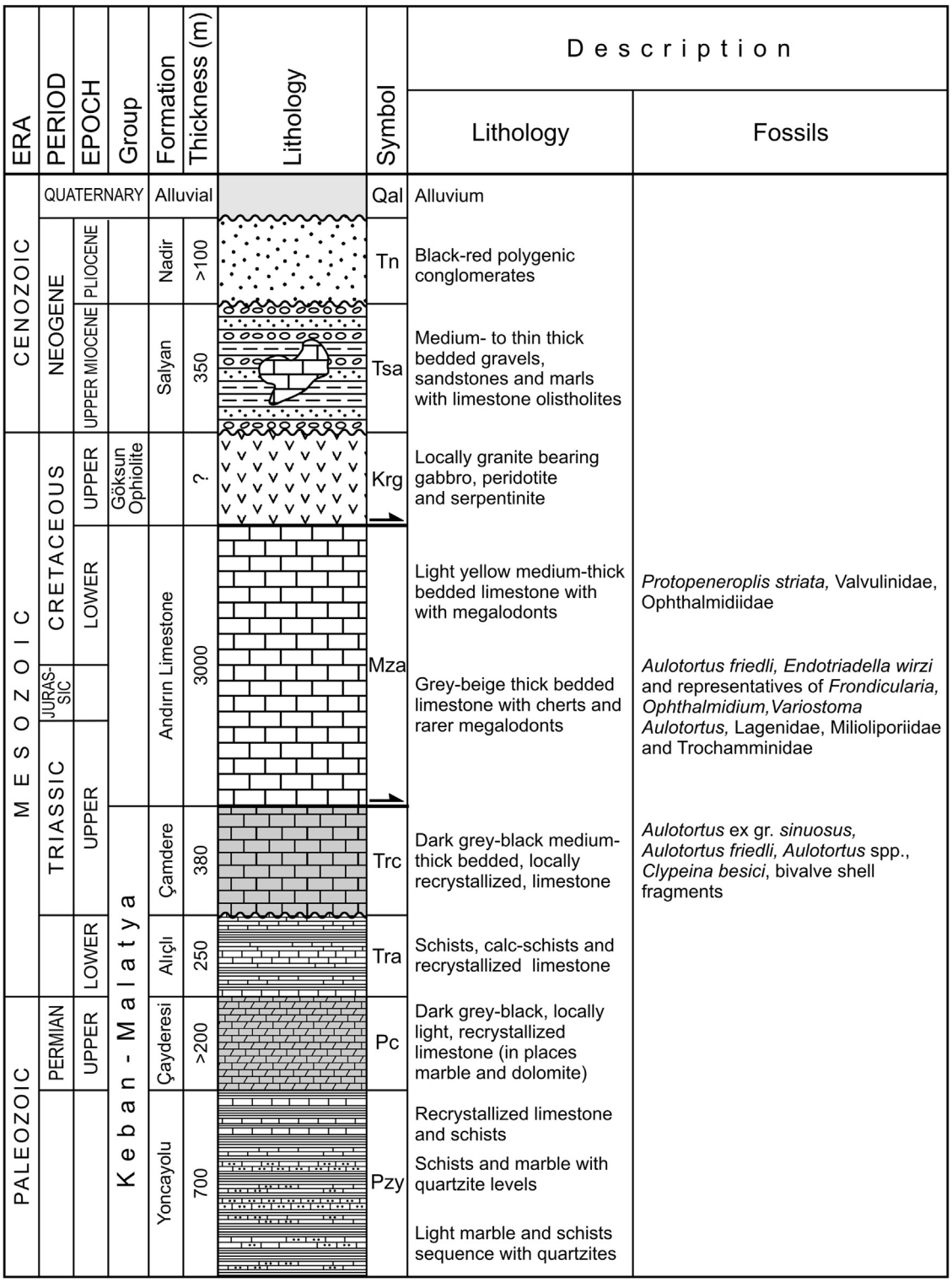

Fig. 6. Composite stratigraphic section of the Göksun area (modified after Yümün and Kılıç, 2002).

separates the Yeşiltaşyayla complex from the overlying serpentinite, peridotite, gabbro, pyroxenite, verlite and lherzolite of the Cretaceous Güneş Ophiolite (Kg). An angular unconformity divides the latter from the overlying Oligocene-Miocene sandstone, clayey limestone, marls, lacustrine limestone and fine-layered limestone of the Altınyayla (Ta) and Kulmaçdağı formations (Tk). Finally, an angular unconformity underlies the Upper Pliocene–Quaternary polygenic gravels and blocks of the Örenlice Formation, all buried under Quaternary alluvium (Fig. 8).

Exposed 20 km southeast of Ulaş (Sivas), Munzur Limestone consists of Permian–Lower Cretaceous platform-type carbonates. Named after the Munzur Mountains by Özgül et al. (1981), the Monzur Limestone was already observed by Aktimur et al. (1988, 1990) in the Sivas area. A junior synonym of the Munzur Limestone is Yılanlıdağ Formation (Gökten, 1993).

In this work we only consider the Norian–Rhaetian portion of the Munzur Limestone (Fig. S16). The succession starts with a pinkish to grey, thick-bedded or massive hard-textured, megalodont

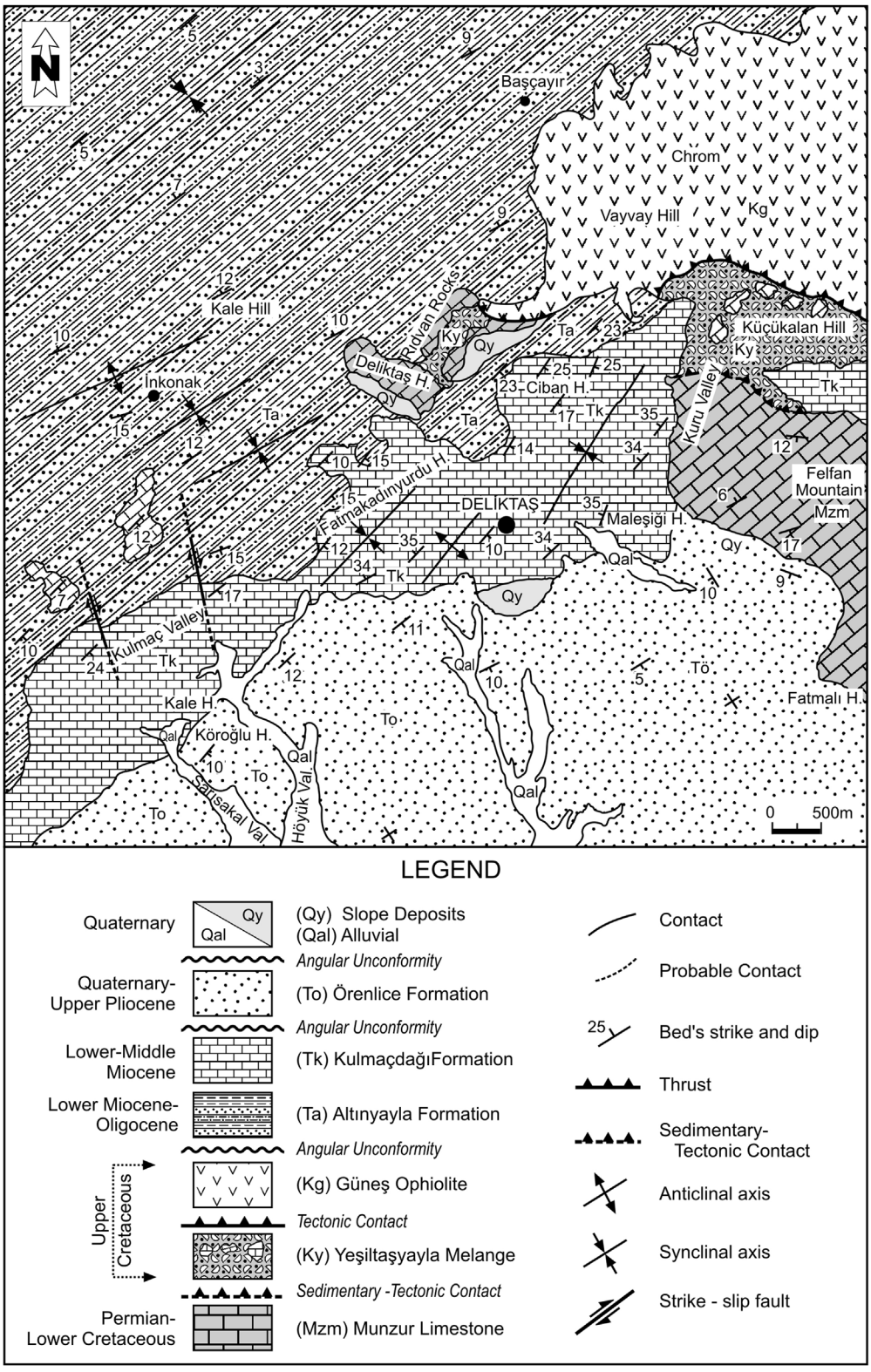

Fig. 7. Geological map of the Deliktaş area (modified after Yümün and Kılıç, 2006).

shell-bearing limestone, locally dolomitized. Levels rich in echinoderms and corals also occur. Recrystallized calcite infillings and calcite veins fill up karstic cavities at micro- and macro-scales. Frequent changes in colour typify this limestone. The middle part of the succession is fairly characterised by a very hard-textured dark grey limestone, having recrystallized karstic cavities and joints. In the upper part, a light grey, thick-bedded hard-textured limestone, slightly recrystallized, yield rare megalodonts.

Overall, the microfacies of the Munzur Limestone passes from micrite at the base to microsparite upwards. Granular components are mainly represented by various bioclasts and intraclasts as well as small amounts of pellets and lithoclasts. Foraminifera also occur;

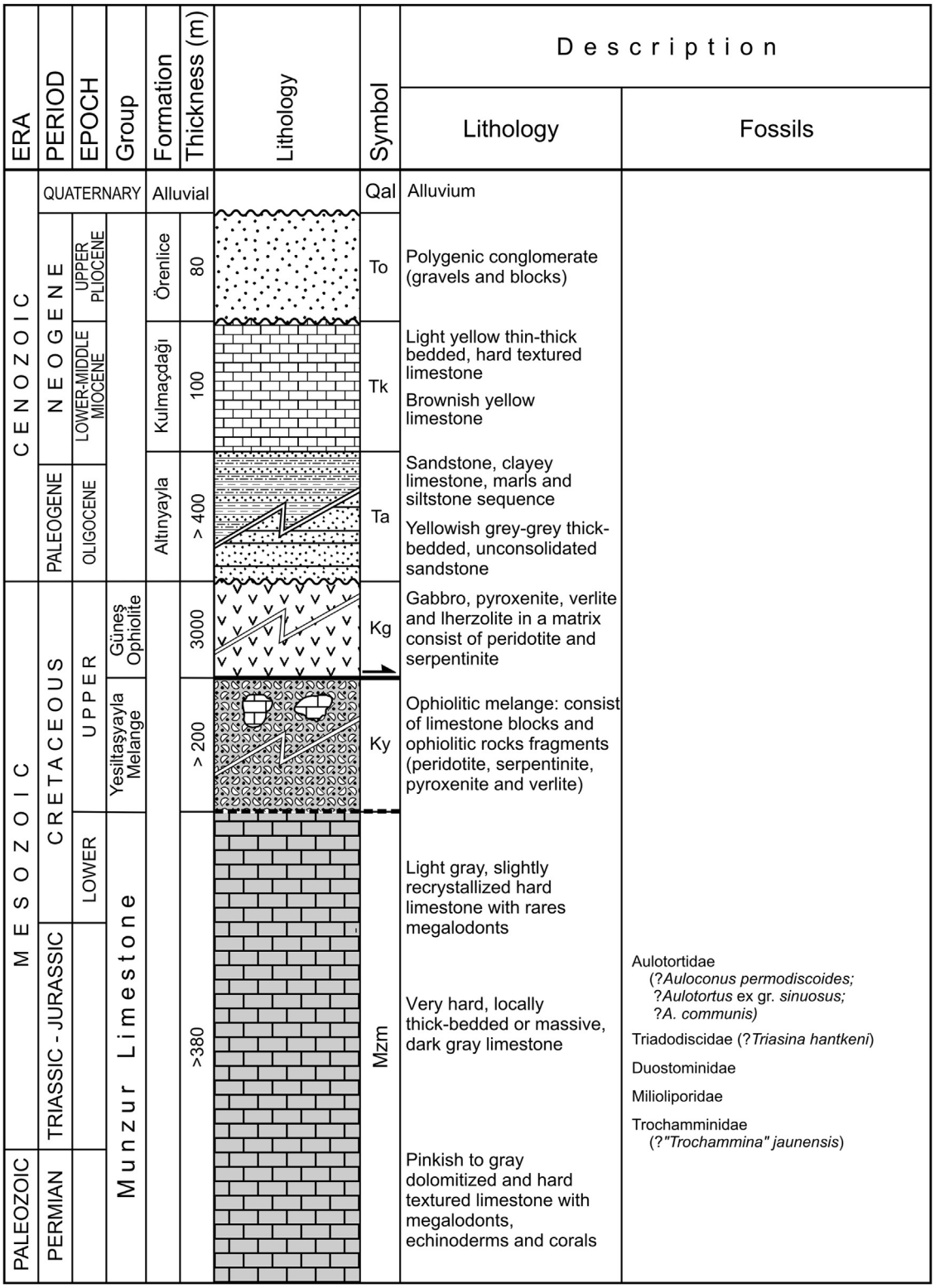

Fig. 8. Composite stratigraphic section of the Deliktaş area (modified after Yümün and Kılıç, 2006).

however, strong recrystallization prevents their accurate determination (see Section 3.4.). The deeper marine environment of the micrite seems to become shallower upwards, recalling similar features of the Andırın Limestone (Göksun area; Keban-Malatya Group) and the Cevizdağı Formation (Yahyalı area; Beyaz Aladağ Nappe), once more suggesting similar depositional conditions of the carbonates of the three study areas within the same basin.

3.4. Foraminifer associations

In the Triassic and Early Jurassic successions of the Beyaz Aladağ Nappe, in the Yahyalı area, a rich and well-preserved assemblage of benthic Foraminifera has been identified. Very similar foraminiferal associations have also been found in the coeval successions of the Keban-Malatya and Munzur nappes, in the Göksun and

Deliktaş areas, respectively. These associations are reported below, in stratigraphic order, for the three study areas.

3.4.1. Yahyalı area

The microfauna characterising the Aktepe Formation is mainly composed of: *Agathammina austroalpina* Kristan-Tollmann and Tollmann, 1964 (Fig. S4), *Aulotortus* ex gr. *sinuosus* (Weynschenk, 1956) (Figs. S2 and S7), *Diplotremina astrofimbriata* Kristan-Tollmann, 1960 (Fig. S4), *Diplotremina* cf. *D. astrofimbriata* Kristan-Tollmann, 1960, *Endotriada kuepperi* (Oberhauser, 1960) (Fig. S8), *Endotriadella wirzi* (Koehn-Zaninetti, 1968) (Fig. S8), *Endoteba* ex gr. *controversa* Vachard and Razgallah, 1988 (Fig. S8), *Endotebanella kocaeliensis* (Dager, 1978), *Endotebanella* cf. *E. tricamerata* (Salaj, 1967) (Fig. S8), "*Trochammina*" *almtalensis* Koehn-Zaninetti, 1969, *Agathammina* spp. (Fig. S4), *Ophthalmidium* spp. (Fig. S3), *Endotebanella* spp. (Fig. S8), *Endotriada* spp. (Figs. S4 and S8), Milioliporidae (Fig. S3), and Lagenida (Fig. S3), providing a Late Anisian to Carnian age.

The middle part of the Üçağaç Tepe Formation yields: *Auloconus permodiscoides* (Oberhauser, 1964) (Fig. S7), *Aulotortus* ex gr. *sinuosus* (Weynschenk, 1956) (Fig. S7), *Aulotortus friedli* (Kristan-Tollmann, 1962) (Fig. S2), *Agathammina austroalpina* Kristan-Tollmann and Tollmann, 1964, *Nodosaria* cf. *N. ordinata* Trifonova, 1965, ?*Miliolipora cuvillieri* Bronnimann and Zaninetti, 1971 (Fig. S12), *Endoteba* ex gr. *controversa* Vachard and Razgallah, 1988 (Fig. S8), *Auloconus* spp., *Aulotortus* spp., *Gandinella* sp. (Fig. S3), and *Glomospirella* spp., with representatives of Lagenida and Textularidae (Fig. S14). The Algae *Griphoporella curvata* (Gümbel, 1872) (Fig. S4) and *Thaumatoporella parvovesiculifera* (Raineri, 1922) (Fig. S4) are also present. The co-occurrence of *Auloconus permodiscoides*, *Aulotortus* ex gr. *sinuosus* and *Aulotortus friedli* as well as their relative abundance indicate a Norian-Rhaetian age. The presence within the lower part of the Üçağaç Tepe Formation of *Griphoporella curvata*, which is restricted to the Norian, characterises the "*Griphoporella curvata* Acme Zone" (Mancinelli et al., 2005).

The end of the Triassic succession is represented by the Cevizdağı Formation, bearing a well-preserved and diversified microfauna that includes the foraminifer index *Triasina hantkeni* Majzon, 1954 (Fig. S12) along with *Auloconus permodiscoides* (Oberhauser, 1964) (Figs. S7 and S12), *Aulotortus communis* (Kristan, 1957) (Fig. S2), *Aulotortus* ex gr. *sinuosus* (Weynschenk, 1956) (Fig. S7), *Nodosaria ordinata* Trifonova, 1965 (Fig. S3), *Auloconus* spp., *Aulotortus* spp., representatives of Lagenida and Textularidae, as well as the Algae *Macroporella retica* Zanin-Buri, 1965 and *Thaumatoporella parvovesiculifera* (Raineri, 1922). While *Auloconus permodiscoides* and *Aulotortus communis* have a Norian-Rhaetian range, *Triasina hantkeni* is confined to the uppermost Norian (Sevatian) to Rhaetian, and *Macroporella retica* is restricted to the Rhaetian. Thus, this association perfectly matches with the "*Triasina hantkeni* Range Zone" (Mancinelli et al., 2005).

The lower part of the Sırçak Limestone, which concordantly and transitively overlies the (uppermost Norian to Rhaetian) Cevizdağı Formation, contains: *Mayncina* cf. *M. termieri* Hottinger, 1967 (Fig. S14), *Orbitopsella praecursor* (Gümbel, 1872) (Fig. S14), *Siphovalvulina* spp. (Figs. S3 and S14), Textularidae (Fig. S14), together with *Thaumatoporella parvovesiculifera* (Raineri, 1922). This association points to an early–middle Liassic age. However, considering the presence of *Orbitopsella praecursor* in the Sırçak Limestone, as well as its stratigraphic distribution confined to the Pliensbachian (Septfontaine, 1984; Septfontaine et al., 1991), a younger age for this formation is not excluded.

3.4.2. Göksun area

The Foraminifera from the Late Triassic succession in Göksun (Keban-Malatya Nappe) are poor comparing to the coeval one in the Yahyalı area (Beyaz Aladağ Nappe). In the Çamdere Formation only Aulotortidae have been found, that is, *Aulotortus* ex gr. *sinuosus* Weynschenk, 1956, and *Aulotortus friedli* (Kristan-Tollmann, 1962). Therefore, the formation is attributed to an undifferentiated Upper Triassic.

Surprisingly, the overlying Andırın Limestone yields, in its lower and middle part, relatively abundant Foraminifera, for example, *Aulotortus friedli* (Kristan-Tollmann, 1962), *Endotriadella wirzi* (Koehn-Zaninetti, 1968), *Ophthalmidium* spp., *Variostoma* spp., *Aulotortus* spp., as well as representatives of the families Lagenida, Milioliporidae and Trochamminidae. *Protopeneroplis striata* Weynschenk, 1950, Ophthalmidiidae and Valvulinidae have been found in the upper part of the Andırın Limestone. According to Yümün and Kılıç (2006), this foraminiferal association confers a Late Triassic to Jurassic age.

3.4.3. Deliktaş area

In this area, the Upper Triassic–Jurassic portion of the Munzur Limestone contains relatively abundant Foraminifera. However, they are often strongly recrystallized and determinations at the specific level remain highly speculative. Based on the general morphologies and sizes, representatives of the families Aulotortidae, Triadodiscidae, Duostominidae, Milioliporidae and Trochamminidae have been confidently recognised.

4. Discussion and concluding remarks

4.1. Triassic environments and Triassic-Jurassic continuity

Sedimentological and biostratigraphic study of the Lower Mesozoic successions of the Beyaz Aladağ Group in the Yahyalı area (Eastern Taurus), and their comparison with coeval series in the Göksun (Keban-Malatya group) and Deliktaş (Munzur Limestone) areas, clearly indicate that the Middle–Late Triassic Aktepe Formation deposited in a single large basin including deep to platform environments. The upper part of the Aktepe Formation contains quite abundant Algae *Microcodium* suggesting that a shallow environment near water surface took place most probably close to the Carnian–Norian boundary. This datum is corroborated by the up to 500 m-thick Norian basal pebble unit of the Üçağaç Tepe Formation (Özgül, 1983). Higher, the succession evolves into platform-type carbonates with abundant and well-preserved Foraminifera, corresponding to the Norian "Aladağ fauna" in the literature, whilst shallow water to lagoonal carbonates with Foraminifera and Algae characterise the Rhaetian Cevizdağı Formation. Towards the upper part of the Cevizdağı Formation, the transition to the shelf carbonates of the Lower Jurassic Sırçak Limestone is smooth. These depositional conditions are then maintained all along the Lower Jurassic, except some local and short deepening.

Özgül (1983) compared the Middle to Upper Triassic–Lower Jurassic successions from this study to coeval sections in the Aladağ and Bolkar Mountain units. The Aladağ Nappe, starting with Lower Triassic stromatolitic and oolitic limestones, consists higher up of turbidites up to 1000 m in thickness, followed by Anisian carbonate series with plant fragments. Above these Anisian units discordantly follow Carnian–Norian conglomerates, while the Rhaetian–Liassic transition is concordant. However, in his generalised columnar section of the Aladağ unit, Özgül (1997) recognised no Ladinian–Carnian interval within the Triassic Gevne Formation (Özgül, 1976). The discovery of Ladinian and Carnian in the Aktepe Formation (this work) modifies our viewpoint of the general character of the Aladağ unit. Accordingly, the depositional environment of the carbonates in this unit deepens from west to east.

Together with field data and foraminiferal contents, all these observations clearly show that:

- the stratigraphic and palaeontological features of the Lower Mesozoic carbonate units of the Ceviz Mountains (Yahyalı area; Kayseri, east of Aladağ range) extend further east to the Göksun (Kahramanmaraş) and Deliktaş (Ulaş-Sivas) regions (Fig. 2);
- several synchronous transgressive–regressive events suggest continuity within the stratigraphy that covers a large zone of the Taurus chain;
- no interruption of sedimentation affected the carbonate platform. Indeed, the widely occurring oolitic levels and the relative abundance of Algae (e.g., *Thaumatoporella parvovesiculifera*) in the middle Liassic prove that a shallowing environment took place at that time but no apparent hiatus occurred.

4.2. Palaeogeographic considerations about the Eastern Taurus carbonates

Following the literature, Turkey consists of six major lithospheric fragments: the Rhodope-Strandja block, the Istanbul zone, the Sakarya zone, the Anatolide-Tauride block, the Kırşehir Massif, and the Arabian Platform (Fig. 1; Şengör and Yılmaz, 1981; Şengör et al., 1982; Okay et al., 1994; Okay and Tüysüz, 1999). The first three zones clearly show Laurasian affinities and are classically referred to as the Pontides. Boundaries are the Izmir–Ankara–Erzincan suture between the Kırşehir Massif and the Anatolide–Tauride block. This latter is in contact with the Arabian Platform along the Assyrian–Zagros suture. Although separated from it by this suture, the Anatolide–Tauride block shows a Palaeozoic stratigraphy similar to that of the Arabian Platform, and hence to the northern margin of Gondwana.

The Kırşehir Massif, which mainly consists of Cretaceous metamorphic and granitic rocks, is in contact along the controversial Intra-Taurides Suture (ITS) with the Anatolide–Tauride block, while the Intra-Pontides Suture (IPS) constitutes the former plate boundary between the Sakarya and the Istanbul zones (Okay and Tüysüz, 1999). For Şengör and Yılmaz (1981), Neotethyan ophiolites mark sutures that bound blocks, continents and platforms.

The study area lies in the Aladağ range, in the western part of the Eastern Taurus belt, where the following three stages developed:

- stable continental margin from Lower Triassic to Lower Cretaceous;
- dismantling of the continental margin and first emplacement of ophiolites (Upper Cretaceous);
- deformation of the continental margin and emplacement of the Peridotite Nappe in the Maastrichtian (Tekeli, 1980).

During the stable period, carbonate platform deposition started in the Eastern Taurus from the Upper Anisian and may have extended until the Lower Cretaceous. During this timespan, carbonate deposition encompasses three phases of platform evolution in the Aladağ range, spaced by two intervals of shallow water conditions (at the Carnian–Norian boundary and between the Rhaetian and the middle Liassic, respectively) to non-deposition (middle Liassic-Dogger).

In the Lower Triassic, a huge platform extended from the Arabian plate to the southern edge of the Paleotethys Ocean until the Upper Triassic closure of this latter. This platform included the carbonates of the Eastern Taurus of the northern side of Gondwana. Simultaneously the opening of the Neotethys caused the detachment of Gondwanian fragments, leaving however the sedimentation area of the Eastern Taurus within the Gondwana shelf, as witnessed by the Lower Jurassic microfacies with foraminifera like *Orbitopsella praecursor*, typical for the southern Tethyan shelf of Gondwana.

The first shallowing stage near the Carnian–Norian boundary may be in unison with a global eustatic cycle and, during the Norian, platform conditions prevailed. During the second shallowing stage at the Rhaetian–Liassic transition, the increasing of Foraminifera and the widespread distribution of the Algae *Macroporella retica* characterise the Rhaetian. In the Liassic, the *Thaumatoporella parvovesiculifera* peak and several oolitic limestone levels characterize the Eastern Taurus Lower Jurassic microfacies. Finally, the Late Cretaceous ophiolites and the Alakırçay serpentinite-gabbro Mélange became imbricate in the Eastern Taurus carbonate stacks during Palaeogene tectonic phases.

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Appendix A. Supplementary information

Supplementary information (Figs. S1–S16, including stratigraphic sections, measured cross-sections and foraminifer illustrations) associated with this article can be found, in the online version, at: http://dx.doi.org/10.1016/j.geobios.2013.05.002.

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