Preliminary radiolarian biostratigraphy across the Jurassic-Cretaceous boundary from northwestern Turkey

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ABSTRACT

This is the first study from Turkey where radiolarians from calcareous sequences of the Sakarya Continent are tested in the delineation of the Jurassic-Cretaceous boundary. The Sakarya Continent, which comprises the southern part of northwest Turkey, was a Jurassic-Early Cretaceous carbonate platform micro-continent distant from terrestrial sediment influx. It was a site of pelagic carbonate deposition with abundant calcareous and siliceous microfossil input. Among 44 measured stratigraphic sections of the Jurassic-Lower Cretaceous deposits of the Sakarya Continent, four continuous sections (MK, KEL, AÇ, ÇD) which encompass the Tithonian-Berriasian boundary were selected for study. However, due to poor preservation and calcification of radiolarian faunas, only section KEL produced rich and well-preserved radiolarians. This section is 600 meters in thickness and spans the upper Tithonian-lower Berriasian interval. In addition to radiolarians, sec-

KEY WORDS
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Jurassic-Cretaceous boundary,
northwest Turkey,
calpionellids,
calcareous nannofossils.

tion KEL contains abundant calpionellids, calcareous nannofossils, benthic foraminifera and calcareous algae. The upper part of this stratigraphic section is made up of the Soġukçam Limestone which lithologically resembles the Biancone and Maiolica formations in the Umbria-Marche Region of Italy. The best preservation and richest radiolarian faunas were observed from the Soġukçam Limestone in section KEL. This is significant because many radiolarian studies as well as studies on magnetostratigraphy, calcareous nannofossils and calpionellid biostratigraphy in the Tethyan realm have been carried out on the Biancone and Maiolica formations. The rapid sedimentation rate, pelagic microfacies and well preserved non-calcified radiolarian faunas make section KEL ideal for the investigation of the Jurassic-Cretaceous boundary with radiolarians. The correlation between radiolarian faunas and co-occurring calpionellids and calcareous nannofossils in section KEL can be compared with similar biostratigraphic studies from the Biancone and Maiolica formations in Italy. The calcareous nannofossils in section KEL sometimes attain rock forming abundance, and the first appearance of nannoconids as well as their first abundance peak are recognized in this section. Throughout the present study, the boundary between Calpionellid standard zones A and B is considered as the Tithonian-Berriasian boundary. The close sampling interval, 15-20 meters, provides excellent resolution in documenting the first occurrences of numerous Cretaceous radiolarian species. These first occurrence datum points for radiolarian taxa are not concurrent. Due to the refined resolution of dating, a stepwise appearance of Cretaceous radiolarian faunas in section KEL is clearly observed; however, radiolarians do not delineate the Jurassic-Cretaceous boundary because a marked synchronous faunal turnover does not exist.

RÉSUMÉ

Étude biostratigraphique préliminaire des radiolaires à travers la limite jurassique-crétacé du nord-ouest de la Turquie.

Cette étude est la première de Turquie où les radiolaires ont été analysés pour décrire la limite jurassique-crétacé dans des séquences calcaires du continent de Sakarya localisé dans la partie sud de la Turquie nord-occidentale. Le continent de Sakarya a été une plate-forme isolée dans le Jurassique et Crétacé inférieur et un lieu de dépôt des carbonates pélagiques contenant des microfossiles calcaires et siliceux abondants. Parmi les 44 coupes stratigraphiques qui ont été mesurées dans les dépôts jurassiques et crétacés du continent de Sakarya, quatre coupes (MK, KEL, AÇ, ÇD) traversant la limite tithonique-berriasien ont été choisies pour cette étude. Néanmoins, à cause de la mauvaise préservation et de la calcification de la faune de radiolaires, seule la coupe KEL a produit des radiolaires bien préservés et abondants. L'épaisseur de cette coupe est de 600 mètres pour l'intervalle du Tithonien supérieur-Berriasien inférieur. En plus des radiolaires, la coupe KEL contient en abondance des calpionelles, des nannofossiles calcaires, des foraminifères benthiques et des algues calcaires. La partie supérieure de cette coupe est représentée par le Calcaire de Soġukçam qui ressemble par sa lithologie aux formations de Biancone et Maiolica dans la région d'Ombrie-Marche, en Italie. La faune de radiolaires la plus riche et la mieux préservée a été retrouvée dans le Calcaire de Soġukçam de la coupe KEL. Cette observation est importante parce que plusieurs études sur les radiolaires comme sur la magnétostratigraphie et la biostratigraphie des nannofossiles calcaires et calpionelles, dans le domaine de la Téthys, ont été effectuées sur les formations de Biancone et Maiolica. Le taux de sédimentation élevé, le microfaciès pélagique et la faune de radiolaires non-calcifiée et bien préservée rendent la coupe de KEL idéale pour décrire la limite jurassique-crétacé avec les radiolaires. La corrélation entre la faune de radiolaires et la présence conjointe de calpionelles et de nannofossiles calcaires dans le même matériel en Turquie peut être comparée avec les études biostratigraphiques similaires des formations de Biancone et Maiolica. Les nannofossiles calcaires dans la coupe deviennent parfois le constituant majeur de la roche et la première apparition des nannoconides ainsi que leur première acme y ont été reconnues. La limite entre les zones standards des calpionelles A et B est considérée comme la limite du Tithonien et Bérriasien dans cette étude. L'échantillonnage serré de 15-20 mètres a fourni une résolution parfaite pour documenter la première apparition de plusieurs espèces de radiolaires. Ces premières apparitions ne sont pas simultanées. Grâce à la résolution fine des datations par échantillonnage serré, l'apparition graduelle de la faune des radiolaires crétacés a été nettement observée dans la coupe KEL ; néanmoins, les radiolaires ne décrivent pas la limite jurassique-crétacé puisqu'un changement synchronisé important n'existe pas dans la faune de radiolaires.

MOTS CLÉS
Radiolaires,
limite jurassique-crétacé,
Turquie du nord-ouest,
calpionelles,
nannofossiles calcaires.

INTRODUCTION

Radiolarians are diverse and abundant in Upper Jurassic-Lower Cretaceous sequences across the world. They have been studied intensively in the past thirty years from North America (Pessagno & Blome 1982, 1990; Pessagno *et al.* 1984; Yang & Pessagno 1989; Hull 1995, 1997), Europe and the Middle East (Baumgartner & Bernoulli 1976; Baumgartner 1980, 1984, 1987; Steiger 1992; Jud 1994; O'Dogherty 1994; Baumgartner *et al.* 1995a; Kiessling 1995, 1996; Dumitrica *et al.* 1997), Japan (Nakaseko & Nishimura 1981; Aita & Okada 1986; Matsuoka & Yao 1986; Aita 1987; Matsuoka 1995a, b, c; Yang & Matsuoka 1997) and southern high latitudes (Baumgartner 1992, 1993; Kiessling & Scasso 1996).

The main purpose of this study is to compare radiolarian biostratigraphy with biozonations of calpionellids, calcareous nannofossils and other calcareous microfossils (e.g. algae and benthic foraminifera) across the Jurassic-Cretaceous boundary on samples from northwest Turkey, near Ankara. Our objectives are: (1) reporting the radiolarian assemblage from this boundary for the first time from Turkey; (2) investigating the chronostratigraphic ranges of our radiolarian faunas; (3) correlating our radiolarian biostratigraphy with that of co-occurring calcareous microfossils.

The study area is located in the southern part of northwest Turkey near the towns of Kozluca, Kabalar and Aktaş (Fig. 1) which lie northwest of Turkey's capital, Ankara. Altiner *et al.* (1991) studied the stratigraphy and paleogeographic evolution of this region where the Upper Jurassic-Lower Cretaceous successions occupy approximately 120.000 square kilometers. Altiner *et al.* (1991) measured 44 stratigraphic sections from these successions in which four sections were reported to contain radiolarians. These four sections are AÇ (by Aktaş), KEL (by Kozluca), MK (by Kabalar) and ÇD (by The Ismet Paşa railway station) (Fig. 1). Among these four sections, only section KEL produced well

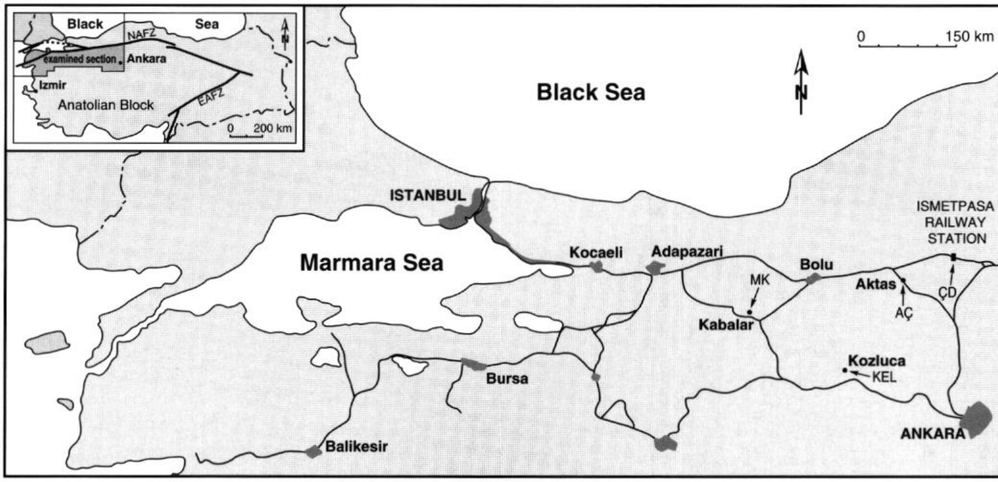

FIG. 1. — Geographic map of study area (modified after Altiner *et al.* 1991) illustrating locations of radiolarian bearing stratigraphic sections (AÇ, ÇD, KEL, MEK).

preserved radiolarians. It is also the thickest of these four sections (600 m for the upper Tithonian and Berriasian interval) and provides superior resolution for marking the Jurassic-Cretaceous boundary due to its high to very high sedimentation rate.

Within a tectono-stratigraphic framework, the southern part of northwestern Turkey contains the deposits of a Mesozoic micro-continent, the Sakarya Continent (Fig. 2). The Sakarya Continent was a Jurassic-Cretaceous carbonate platform micro-continent amidst the branches of the Neo-Tethys (Şengör & Yilmaz 1981). During the Tithonian-Berriasian interval, the Sakarya Continent was distant from terrestrial sediment influx and hence a site of carbonate deposition. This micro-continent rifted away from Gondwanaland in the Jurassic and moved northward to eventually collide with Eurasia (Rhodope-Pontide Fragment in Fig. 2) by the end of the Late Cretaceous (Şengör & Yilmaz 1981). Today, the Sakarya Continent is a part of Turkey and bound to the Rhodope-Pontide Fragment in the north by the Intra-Pontide Suture and to the Tauride and Kirşehir Blocks in the south by the Izmir-Ankara Suture (Fig. 2). These sutures are ophiolite belts remaining from the closure of the branches of Neo-Tethys.

LITHOLOGY

Section KEL (600 meters in thickness) contains the Tithonian-Berriasian pelagic limestone deposits of the Sakarya Continent. The thickness of the section, its pelagic microfacies and rich microfossil content of radiolarians, calpionellids, calcareous nannofossils, benthic foraminifera and calcareous algae, make it ideal for the examination of the Jurassic-Cretaceous boundary. Calcareous nannofossils in this section occasionally attain rock-forming abundance. Located at Kozluca, northwest of Beypazari, section KEL consists of the Yosunlukbayiri Formation in its lower portion (samples 24-36) and the Soǵukçam Limestone in its upper part (samples 2-23) (Altiner *et al.* 1991) (Fig. 3).

The Yosunlukbayiri Formation is a thick calciturbiditic sequence. The upper part of this formation, outcropping in section KEL, is composed of fine detritic limestones containing six distinct olistostrome levels. The uppermost detritic limestone beds contain *Zoophycus* as well as abundant calpionellids and calcareous nannofossils (Altiner *et al.* 1991; Özkan 1993a, b).

The Yosunlukbayiri Formation is gradually overlain by the porcelaneous micrites of the Soǵukçam Limestone in the area. The lower part of the

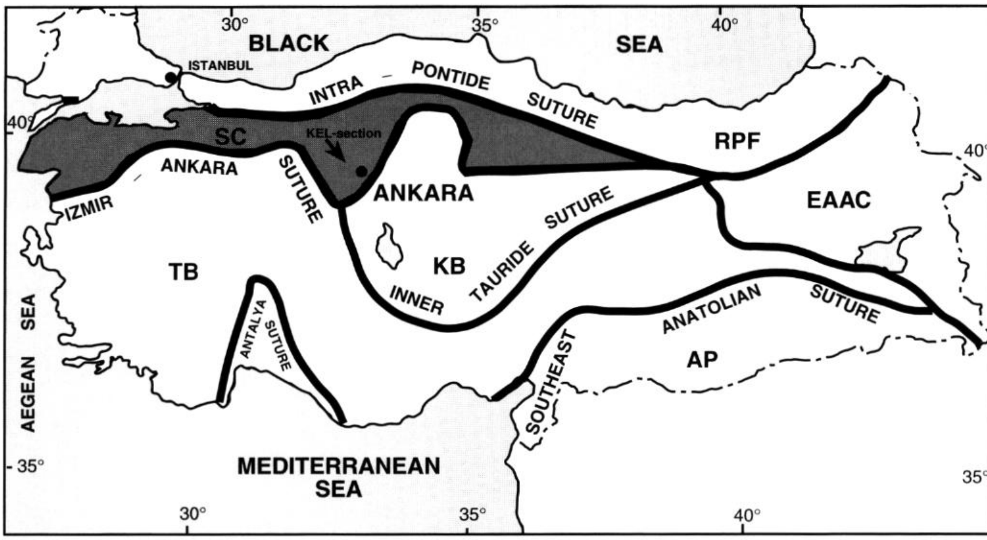

FIG. 2. — Map of Turkey illustrating tectono-stratigraphic units (modified after Şengör 1984). **SC**, Sakarya Continent; **RPF**, Rhodope-Pontide Fragment; **TB**, Tauride Block; **KB**, Kirşehir Block; **EAAC**, East Anatolian Accretionary Complex; **AP**, Arabian Plate.

Soǵukçam Limestone (KEL 2-24) is characterized by thin, medium or thickly bedded, sometimes silicified, white to cream micritic limestones bearing chert nodules and intercalated with fine turbidite layers (Altiner *et al.* 1991). The Soǵukçam Limestone lithologically resembles the Biancone and Maiolica formations in the Umbria-Marche Region in Italy (Farinacci *et al.* 1981a, b; Altiner *et al.* 1991). The Biancone and Maiolica formations have been extensively studied for calpionellids, calcareous nannofossils and magnetostratigraphy (e.g. Lowrie & Channell 1983; Erba & Quadria 1987; Channell *et al.* 1987, 1993) as well as for radiolarians (e.g. Baumgartner 1984; Jud 1994; O'Dogherty 1994). The strong lithologic similarity between the Soǵukçam Limestone and the Maiolica and Biancone formations is due to their deposition in the same ocean, during the same time interval, and under similar conditions as submerged carbonate platforms distant from terrestrial sediment influx (see Altiner *et al.* 1991). For this reason the radiolarian biostratigraphy we present here and its correlation to calpionellid and calcareous nannofossil biozonations previously established for the same section (KEL) is significant as a correlative example from Turkey to the previous studies in Italy.

THE JURASSIC-CRETACEOUS BOUNDARY

The Jurassic-Cretaceous boundary is one of the most problematic system boundaries because the Tithonian does not have a stratotype, the lower parts of the Berriasian tend to lack fossils in many parts of Western Europe, and the boundary does not correspond to any major faunal or floral turnover (Hoedemaeker 1987; Oloriz & Tavera 1989; Remane 1991; Pessagno *et al.* 1997). Ammonites (Kemper *et al.* 1981; Hoedemaeker 1991), *Buchia* (Zakhanov 1987; Pessagno *et al.* 1987a, b; Hoedemaeker 1991; Pessagno *et al.* 1993), calpionellids (Le Hegarat & Remane 1968; Allemann *et al.* 1971; Remane 1964, 1985, 1986; Remane *et al.* 1986; Cecca *et al.* 1989) and calcareous nannofossils (Thierstein 1975; Cooper 1985; Bralower 1990; Bown & Özkan 1992; Özkan 1993a, b) have been utilized in biostratigraphically marking this boundary. Ammonites, which are traditionally considered the basis of standard and high resolution biostratigraphy, become strongly provincialized during the Tithonian-Berriasian interval. This provincialism creates problems in correlation between the Tethyan and Boreal realms

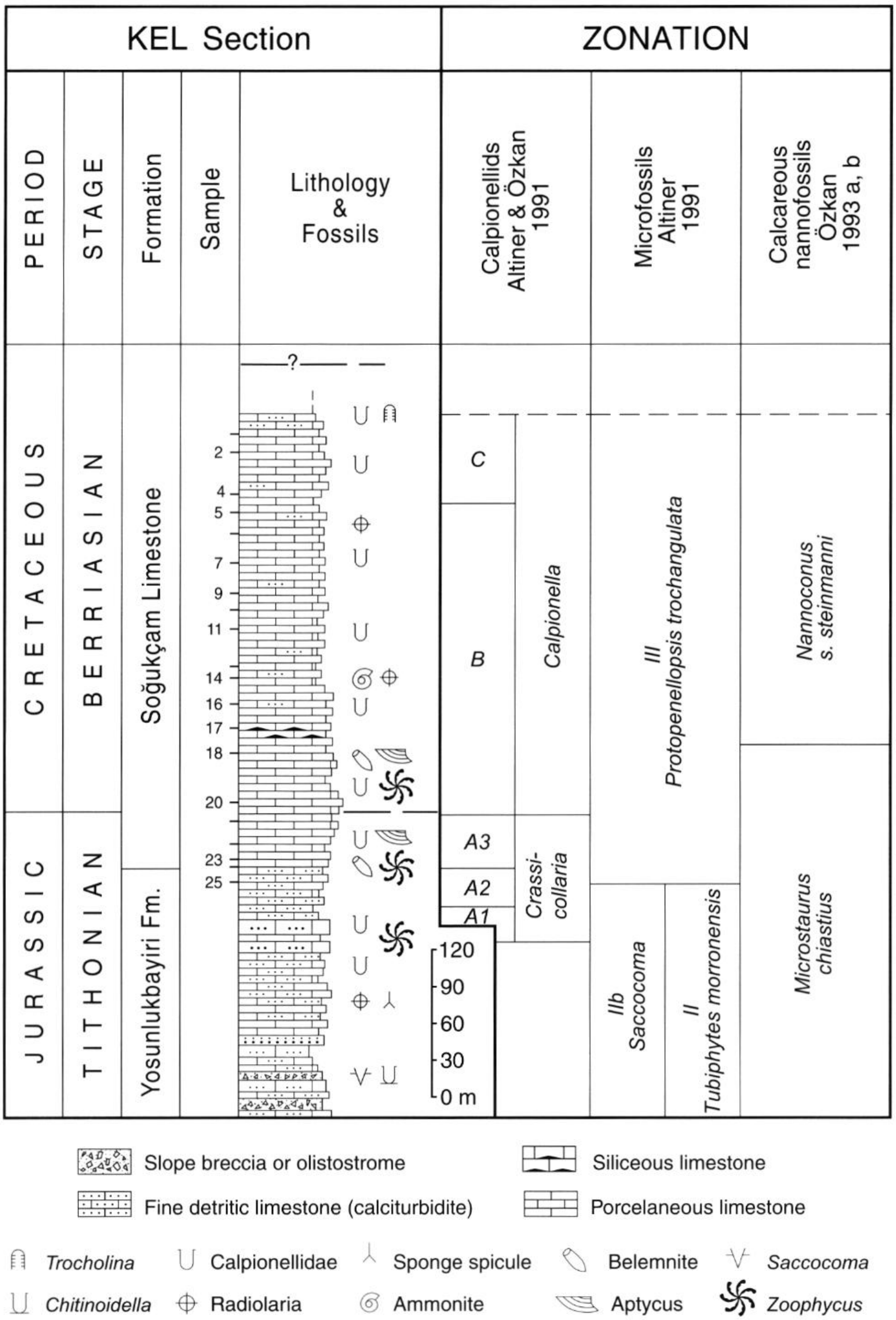

FIG. 3. — Calpionellid, calcareous nannofossil, and benthic foraminifera and algae biozonations on stratigraphic section KEL. Rich radiolarian assemblages were recovered from the numbered samples in the figure.

(Jeletsky 1984; Zeiss 1984, 1986; Remane 1991; Pessagno *et al.* 1997). According to Pessagno *et al.* (1997) calpionellids are diachronous with longer ranging zones in North America than in Europe. However, since Turkey is located in Eurasia, and since calpionellid biozones are well established in Europe (Allemann *et al.* 1971; Trejo 1980; Remane *et al.* 1986; Altiner & Özkan 1991; Pop 1994a,b; 1996; Grün & Blau 1997), calpionellid zones are used to mark the boundary in this study.

Le Hegarat & Remane (1968) placed the Jurassic-Cretaceous boundary within Calpionellid standard zone B in the stratotype of the Berriasian. For this reason, Altiner & Özkan (1991) also placed the boundary in zone B in section KEL. However, since the boundary between Calpionellid standard zones A and B also corresponds to the boundary between the *Durangites* and *Euxinus* ammonite zones, the Jurassic-Cretaceous boundary was accepted as the limit between Calpionellid standard zones A and B at the Colloque (Anonymous 1975), and by Cecca *et al.* (1989). Other researchers (Jeletsky 1984; Channell & Grandesso 1987; Özkan 1993b; Grün & Blau 1997) consider the limit between Calpionellid standard zones A and B as the Jurassic-Cretaceous boundary as well. On the other hand, Tavera *et al.* (1994) stated that the boundary between *Durangites* and *Jacobi* ammonite zones does not correspond to the limit between Calpionellid standard zones A and B in the Vocontian Region (see also Oloriz & Tavera 1989) but rather to a level within Calpionellid standard zone A. We also consider the Jurassic-Cretaceous boundary to correspond to the limit between Calpionellid standard zones A and B in section KEL based on the consensus reached at the Colloque (1975) and many subsequent publications accepting this limit as the Jurassic-Cretaceous boundary. Therefore, the limit between Calpionellid standard zones A and B in section KEL falls between samples 20 and 21 (Fig. 3).

The development of a magnetic polarity time scale for the Jurassic-Cretaceous boundary (Ogg & Lowrie 1986; Ogg *et al.* 1991) and the correlation of this time scale with biozonations of calcareous nannofossils (Bralower *et al.* 1989), calpionellids (Channel & Grandesso 1987) and radiolarians (Jud 1994) are important advances in the multidisciplinary delineation of this boundary. According to Ogg (1992) the boundary is defined as the base of the reverse polarity chron M 18R and Bralower *et al.* (1989) correlate the base of M 18R with the boundary between Calpionellid standard zones A and B.

The following is a brief discussion on comparison of radiolarian biozonations across the Jurassic-Cretaceous boundary from North America (Pessagno 1977a; Pessagno *et al.* 1987a; Pessagno & Blome 1990; Pessagno *et al.* 1993; Hull 1997), Europe (Baumgartner 1980, 1984, 1987; Steiger 1992; Jud 1994; Baumgartner *et al.* 1995b; Dumitrica *et al.* 1997) and Japan (Matsuoka & Yao 1986; Aita 1987; Matsuoka 1995a, b, d; Yang & Matsuoka 1997) which illustrates problems of provincialism and diachroneity among radiolarians:

North America. Originally the top of zone 4 was defined as the Jurassic-Cretaceous boundary (Pessagno 1977a; Pessagno *et al.* 1984, 1987b, 1993; Pessagno & Mizutani 1992). Recently the uppermost part of subzone 4a has been revised and is considered to belong to the Lower Cretaceous (Berriasian). This boundary within subzone 4a coincides with the tops of the *Durangites* (ammonite) and the *Buchia piochii* zones (bivalve) (Pessagno *et al.* 1997). It should be noted here that originally Pessagno (1977a) and subsequently Pessagno *et al.* (1984, 1987b, 1993) considered the last occurrences of *Ristola altissima* and *Ristola procera* (primary marker taxa) for defining the top of zone 4 (and subzone 4a). *Parvicingula colemani* becomes extinct slightly below this level. The datum where *Parvicingula colemani* becomes extinct falls within the *Pseudodictyomitra carpatica* zone of Japan (Yang & Matsuoka 1997).

Europe. Baumgartner *et al.* (1995b) utilize unitary associations among radiolarian taxa to construct radiolarian biozones (UAZ 95). Each biozone is defined by a group of radiolarian taxa that only co-occur in that zone. When UAZ 95 is compared with North American zones (Pessagno *et al.* 1993), diachronism between the zones is evident. Discrepancies between first appearance data of some taxa between Europe

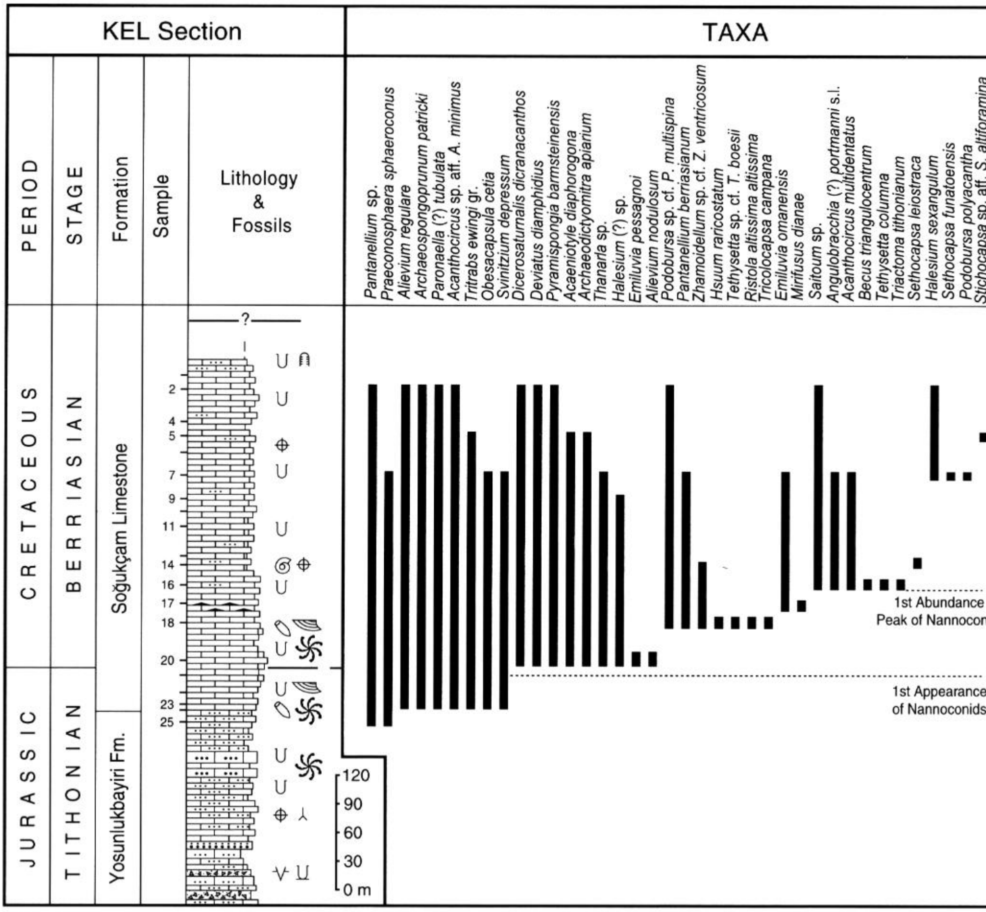

FIG. 4. — Chronostratigraphic distribution of radiolarian fauna in section KEL. Symbols on stratigraphic section are the same as in Fig. 3.

and North America as well as radiolarian provincialism during the Late Jurassic-Early Cretaceous interval hamper the correlation of radiolarian biozones between North America and Europe; however, in some recent studies this correlation is becoming increasingly closer (Hull 1997).

Japan. The evolutionary first appearance of *Pseudodictyomitra carpatica* from *Loopus primitivus* (= *Pseudodictyomitra primitivus*) defines the boundary between the *Loopus primitivus* and *Pseudodictyomitra carpatica* zones. This boundary is in the latest Tithonian and it is approximately one million year older than the Jurassic-Cretaceous boundary in both Japanese Island sections and in the western Pacific deep ocean basin (Matsuoka 1995a, b; Yang & Matsuoka 1997).

RESULTS AND DISCUSSION

Section KEL was previously studied for its calpionellids (Altiner & Özkan 1991), calcareous nannofossils (Özkan 1993a, b) and benthic foraminifera and calcareous algae (Altiner 1991). In the present study, we compare these previously established zonations for the same section with our radiolarian biostratigraphy. Section KEL was reported to contain abundant radiolarians in 28 of 40 samples from thin section examinations

(Özkan 1993a). However, well-preserved and rich radiolarian faunas could only be obtained from the upper part of the section that corresponds to the Soǵukçam Limestone in section KEL. In the lower part of the section radiolarian preservation is poor and hence recovery is very low. Radiolarians are recovered from samples in section KEL assigned to Calpionellid standard zones A2 (KEL 25-26), A3 (KEL 20-24), B (KEL 19-5) and C (above KEL 4) (Altiner & Özkan 1991) (Fig. 3). Altiner & Özkan (1991) also report the presence of *Duvalia tithonica* (belemnite) in subzone A2 whose range is known to be from late Tithonian to early Berriasian (*Euxinus* zone). We will first discuss calcareous microfossil biostratigraphy for section KEL.

Biostratigraphy of co-occurring calcareous microfossils

The Jurassic-Cretaceous boundary is considered as the boundary between Calpionellid standard zones A and B which corresponds to the location between samples 20 and 21 in section KEL (Fig. 3). This boundary falls within the upper part of the *Microstaurus chiastius* calcareous nannofossil zone in section KEL and it is impossible to delineate with Altiner's (1991) foraminiferal and algal zonation where his *Protopeneroplis trochangulata* zone (zone III) transgresses the boundary (Fig. 3).

Radiolarian biostratigraphy

Due to the poor preservation of radiolarians in the fine detritic limestones of the Yosunlukbayiri Formation, the initial occurrences of the majority of Cretaceous radiolarians in section KEL begin near the base of the Soǵukçam Limestone. In section KEL, the first appearance of nannoconids as a group is observed in sample KEL 21 (Fig. 4) from which well-preserved radiolarians could not be extracted. The Jurassic-Cretaceous boundary corresponds to the first occurrences of *Dicerosaturnalis dicranacanthos*, *Deviatus diamphidius*, *Pyramispongia barmsteinensis*, *Acaeniotyle diaphorogona*, *Archaeodictyomitra apiarium*, *Thanarla* sp., *Halesium* (?) sp., *Emiluvia pessagnoi* and *Alievium nodulosum* in this section. Also, the first occurrences of *Saitoum* sp., *Angulobracchia portmanni* s.l., *Acanthocircus multidentatus*, *Becus triangulocentrum*, *Triactoma tithonianum* and *Tethysetta columna* correspond to the first peak in nannoconid abundance as defined by Özkan (1993a, b) (Fig. 4) in section KEL. As a general pattern, the initial occurrences of Cretaceous radiolarians throughout the section are not abrupt, but stepwise, emphasizing that a major radiolarian faunal turnover does not exist across the Jurassic-Cretaceous boundary in northwest Turkey.

The chronostratigraphic distribution of radiolarian taxa within section KEL (Fig. 3) does not comply with any of the established radiolarian zonations in North America or Japan. This is due to the lack of biostratigraphically index species such as *Pseudodictyomitra carpatica*, *Ristola procera* or *Parvicingula colemani* in our samples. The taxa we describe herein (e.g. *Alievium regulare*, *Dicerosaturnalis dicranacanthos*, *Mirifusus dianae*, *Tethysetta boesii*, *Deviatus diamphidius*, *Pantanellium berriasianum*, *Hsuum raricostatum*) enables us to correlate section KEL with Jud's (1994) biozone D2 and UAZ 95 zones 13 and 14 (Baumgartner *et al.* 1995a).

SYSTEMATIC MICROPALEONTOLOGY

The supra-generic classification for radiolarians is based on, for the most part, Dumitrica's (1995) classification. The synonymy lists contain only a few representative studies.

Subclass RADIOLARIA Muller, 1858
Order POLYCYSTINA Ehrenberg, 1838
emend. Riedel, 1967
Suborder NASSELLARIA Ehrenberg, 1875
Family ARCHAEODICTYOMITRIDAE
Pessagno, 1976
Genus *Archaeodictyomitra* Pessagno, 1976

Archaeodictyomitra apiarium (Rüst, 1885)
(Fig. 5B)

Lithocampe apiarium Rüst, 1885 (*fide* Jud, 1994): 314, pl. 39 (14), fig. 8.

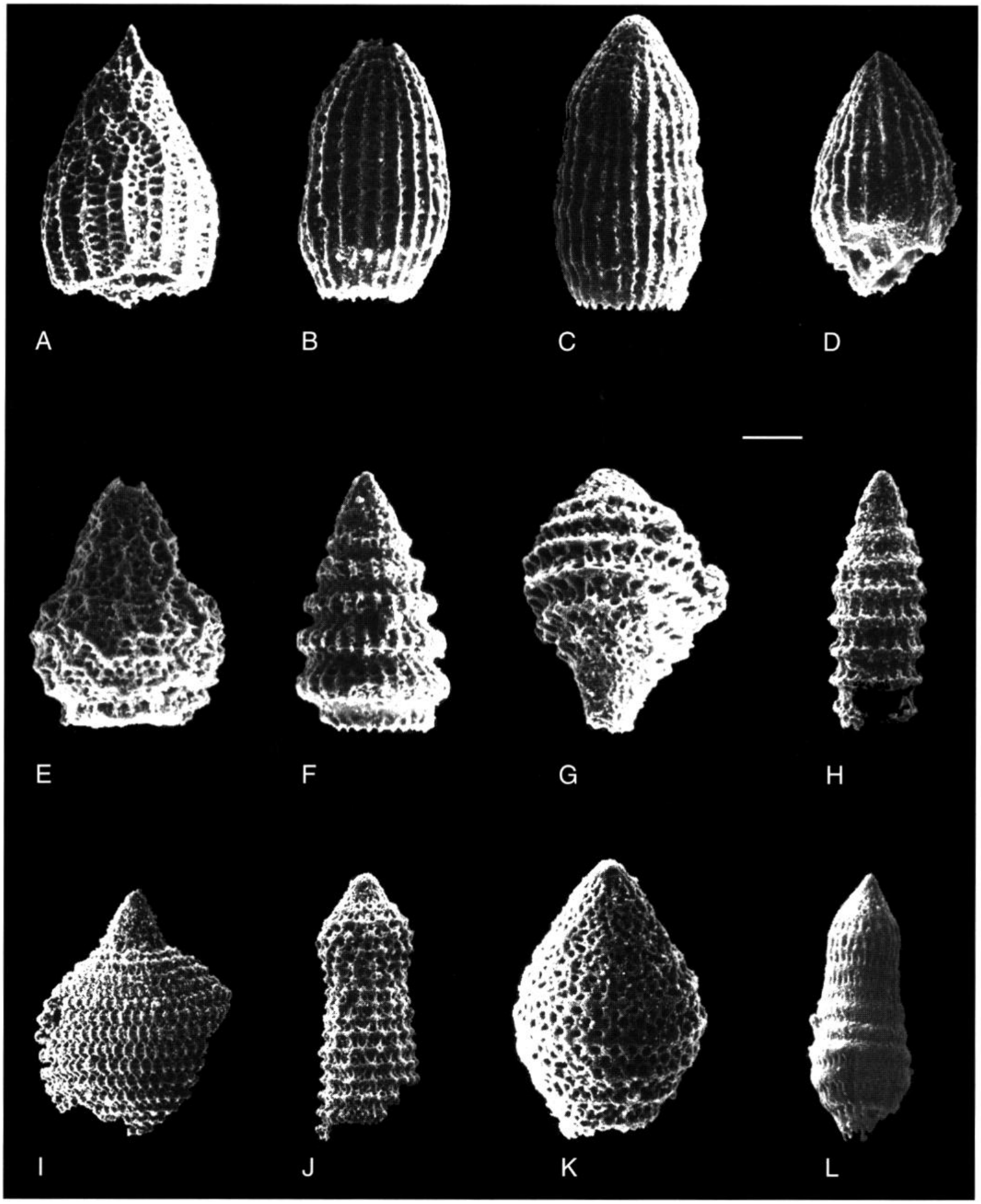

FIG. 5. — **A**, *Hsuum raricostatum* Jud (KEL 18); **B**, *Archaeodictyomitra apiarium* Kocher (KEL 7); **C**, *Archaeodictyomitra* sp. cf. *A. minoensis* (Mizutani) (KEL 7); **D**, *Thanarla* sp. (KEL 16); **E**, *Stichocapsa* sp. aff. *S. altiforamina* Tumanda (KEL 4); **F**, *Svinitzium depressum* (Baumgartner) (KEL 20); **G**, *Tethysetta* sp. cf. *T. boesii* (Parona) (KEL 18); **H**, *Tethysetta columna* (Rüst) (KEL 16); **I**, *Mirifusus dianae* (Karrer) (KEL 17); **J**, *Ristola altissima altissima* (Rüst) (KEL 18); **K**, *Tethysetta ovoidala* Dumitrica (KEL 11); **L**, *Loopus yangi* Dumitrica (KEL 25). Scale bar: A, 55 µm; B, E, K, 45 µm; C, H, 65 µm; D, G, 40 µm; F, 50 µm; I, 120 µm; J, 75 µm; L, 70 µm.

Archaeodictyomitra apiara – Pessagno 1977a: 41, pl. 6, figs 6, 14. – Baumgartner 1984: 758, pl. 2 figs 5-6.
Archaeodictyomitra apiarium – Kocher 1981 (*fide* Jud, 1994): 56, pl. 12, fig. 13. – Jud 1994: 62, pl. 3, figs 10, 11. – Baumgartner *et al.* 1995a: 98, pl. 3263, figs 1-7(H). – Dumitrica *et al.*, 1997: 38, pl. 7, fig. 7.

OCCURRENCE. — Samples KEL 5-20; from Jurassic-Cretaceous boundary to boundary between Calpionellid standard zones B and C.

Archaeodictyomitra sp.
cf. ***A. minoensis*** (Mizutani, 1981)
(Fig. 5C)

OCCURRENCE. — Samples KEL 5-7; from upper portion of Calpionellid standard zone B to boundary between zones B and C.

Genus *Thanarla* Pessagno, 1977b

Thanarla sp.
(Fig. 5D)

OCCURRENCE. — Samples KEL 7-20; from Jurassic-Cretaceous boundary to upper part of Calpionellid standard zone B.

Family HSUUIDAE Pessagno & Whalen, 1982
Genus *Hsuum* Pessagno, 1977a
emend. Takemura, 1986

Hsuum raricostatum Jud, 1994
(Fig. 5A)

Hsuum raricostatum Jud, 1994: 81, pl. 12, figs 3-5. – Baumgartner *et al.* 1995a: 286, pl. 3591, figs 1-3. – Dumitrica *et al.* 1997: 46, pl. 10, fig. 1.

OCCURRENCE. — Sample KEL 18; in Calpionellid standard zone B.

Family PARVICINGULIDAE Pessagno, 1977a
Genus *Mirifusus* Pessagno, 1977a

Mirifusus dianae (Karrer, 1867)
(Fig. 5I)

Lagena dianae Karrer, 1867 (*fide* Jud, 1994): 365, pl. 5, figs 8a, b.
Mirifusus dianae – Dumitrica & De Wever 1991: 553-557, figs 1, 2a, b. – Dumitrica *et al.* 1997: 52, pl. 11, fig. 8.

Mirifusus dianae minor – Baumgartner 1984: 772, pl. 5, figs 11, 14. – Jud 1994: 84, pl. 13, fig. 2. – Baumgartner *et al.* 1995a: 314, pl. 3286, figs 1-5.

OCCURRENCE. — Sample KEL 17: in Calpionellid standard zone B.

Genus *Ristola* Pessagno & Whalen, 1982
emend. Baumgartner, 1984

Ristola altissima altissima
(Rüst, 1885)
(Fig. 5J)

Lithocampe altissima Rüst, 1885 (*fide* Pessagno, 1977a): 315 (45), pl. 40, fig. 2.
Parvicingula altissima – *emend.* Pessagno 1977a: 85, pl. 8, figs 9-10.
Ristola altissima (Rüst) – Baumgartner 1984: 783, pl. 8, fig. 3, *non* figs 4, 9. – Dumitrica *et al.* 1997: 52, pl. 11, fig. 5, ?7.
Ristola altissima altissima – Jud 1994: 101, pl. 19, fig. 1. – Baumgartner *et al.* 1995a: 472, pl. 3241, figs 1-5(H).

OCCURRENCE. — Sample KEL 18; in Calpionellid standard zone B.

Genus *Svinitzium* Dumitrica, 1997

Svinitzium depressum
(Baumgartner, 1984)
(Fig. 5F)

Pseudodictyomitra depressum Baumgartner, 1984: 782, pl. 8, figs 2, 7, 8, 11.
Wrangellium depressum – Baumgartner *et al.* 1995a: 632, pl. 3284, figs 1-5.
Svinitzium depressum – Dumitrica *et al.* 1997: 53, pl. 11, figs 11, 17.

OCCURRENCE. — Samples KEL 7-23; from Calpionellid standard zone A subzone 3 to zone B.

Genus *Tethysetta* Dumitrica, 1997

Tethysetta sp. cf. ***T. boesii***
(Parona, 1890)
(Fig. 5G)

OCCURRENCE. — Sample KEL 18; in Calpionellid standard zone B.

REMARKS
The broken nature of the specimen makes a positive assignment of the present species to *T. boesii* difficult.

Tethysetta columna (Rüst, 1898)
(Fig. 5H)

Lithocampe columna Rüst, 1898: 63, pl. 18, fig. 5.
Parvicingula columna – Jud 1994: 116, pl. 23, fig. 17.
Tethysetta columna – Dumitrica *et al.* 1997: 49, pl. 11, figs 13-15.

OCCURRENCE. — Sample KEL 16, in Calpionellid standard zone B.

REMARKS
This species differs from *Wrangellium columnarium* Jud, 1994 by having three rows of pores per chamber.

Tethysetta ovoidala Dumitrica, 1997
(Fig. 5K)

Tethysetta ovoidala – Dumitrica *et al.* 1997: 50, pl. 50, figs 21, 22.

OCCURRENCE. — Sample KEL 11; in Calpionellid standard zone B.

Family PSEUDODICTYOMITRIDAE
Pessagno, 1977b
Genus *Loopus* Yang, 1993

Loopus yangi Dumitrica, 1997
(Fig. 5L)

Loopus yangi – Dumitrica *et al.* 1997: 31, pl. 5, figs 8, 9.

OCCURRENCE. — Sample KEL 25, Calpionellid standard zone A subzone 2.

Family THEOPERIDAE Haeckel, 1881
emend. Riedel, 1967 *emend.* Takemura, 1986
Genus *Stichocapsa* Haeckel, 1881

Stichocapsa sp. cf. ***S. altiforamina***
Tumanda, 1989
(Fig. 5E)

OCCURRENCE. — Sample KEL 4; just below the boundary between calpionellid zones B and C.

Family SETHOCAPSIDAE Haeckel, 1881
Genus *Gongylothorax* Foreman, 1968
emend. Dumitrica, 1970

Gongylothorax sp.
(Fig. 6E)

OCCURRENCE. — Sample KEL 25; in Calpionellid standard zone A subzone 2.

Genus *Sethocapsa* Haeckel, 1881

Sethocapsa funatoensis Aita, 1987
(Fig. 6A)

Sethocapsa funatoensis Aita, 1987: 73, pl. 2, figs 6a-7b; pl. 9, figs 14-15. – Baumgartner *et al.* 1995: 494, pl. 3070, figs 1-5(H).
Zhamoidellum funatoensis – Hull 1997: 132, pl. 38, figs 13, 15.

OCCURRENCE. — Sample KEL 7; in the upper part of Calpionellid standard zone B

Sethocapsa leiostraca Foreman, 1973
(Fig. 6D)

Sethocapsa leiostraca Foreman, 1973: 268, pl. 12, figs 5-6. – Jud 1994: 105, pl. 20, fig. 5. – Baumgartner *et al.* 1995a: 498, pl. 3062, figs 1-5(H).

OCCURRENCE. — Sample KEL 14; in Calpionellid standard zone B

Family SPONGOCAPSULIDAE
Pessagno, 1977a
Genus *Obesacapsula* Pessagno, 1977a

Obesacapsula cetia (Foreman, 1973)
(Fig. 6B)

Sethocapsa cetia Foreman, 1973: 267, pl. 12, fig. 1; pl. 16, fig. 19.
Obesacapsula cetia – Baumgartner 1992 : 325, pl. 12, fig. 1. – Jud 1994: 87, pl. 13, fig. 11. – Baumgartner *et al.* 1995a: 342, pl. 3203, figs 1-4(H).

OCCURRENCE. — Samples KEL 7-23; from Calpionellid standard zone A subzone 3 to upper part of zone B.

Family WILLIRIEDELLIDAE Dumitrica, 1970
Genus *Cryptamphorella* Dumitrica, 1970

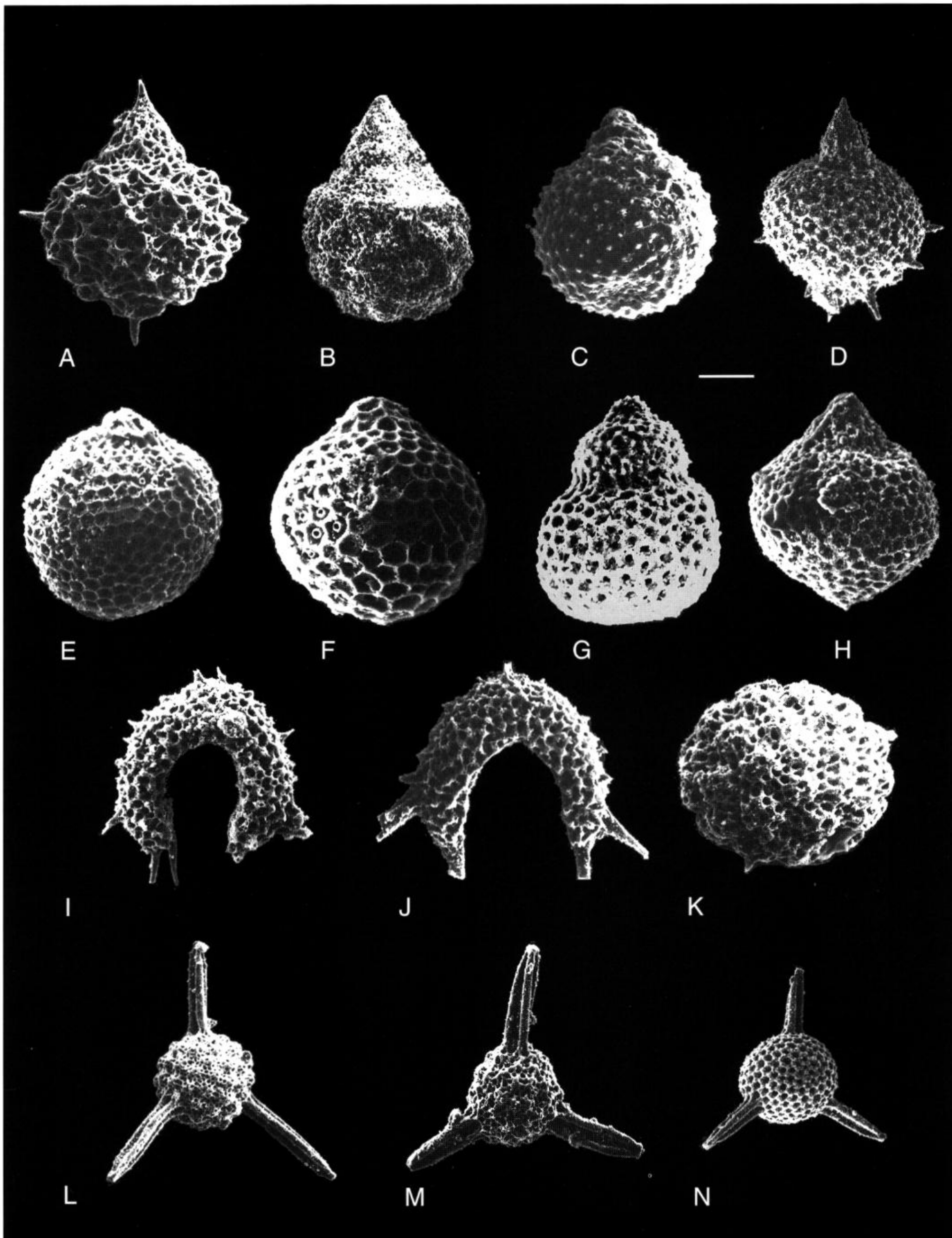

FIG. 6. — **A**, *Sethocapsa funatoensis* Aita (KEL 7); **B**, *Obesacapsula cetia* (Foreman) (KEL 23); **C**, *Tricolocapsa* sp. (KEL 25); **D**, *Sethocapsa leiostraca* Foreman (KEL 14); **E**, *Gongylothorax* sp. (KEL 25); **F**, *Cryptamphorella* sp. (KEL 25); **G**, *Tricolocapsa campana* Kiessling (KEL 18); **H**, *Zhamoidellum* sp. cf. *Z. ventricosum* Dumitrica (KEL 18); **I**, *Deviatus diamphidius* (Foreman) (KEL 20); **J**, *Deviatus diamphidius* (Foreman) (KEL 16); **K**, *Praeconosphaera sphaeroconus* (Rüst) (KEL 18); **L**, *Acaeniotyle diaphorogona* Foreman (KEL 16); **M**, *Acaeniotyle diaphorogona* Foreman (KEL 16); **N**, *Triactoma tithonianum* Rüst (KEL 16). Scale bar: A, D, 65 µm; B, L, 100 µm; C, E, F, G, 35 µm; H, 40 µm; I, K, 60 µm; J, 75 µm; M, 80 µm; N, 105 µm.

Cryptamphorella sp.
(Fig. 6F)

OCCURRENCE. — Sample KEL 25; in Calpionellid standard zone A subzone 2.

Genus *Tricolocapsa* Haeckel, 1881

Tricolocapsa campana Kiessling, 1995
(Fig. 6G)

Tricolocapsa campana Kiessling, 1995: 338, figs 7/1-4

OCCURRENCE. — Sample KEL 18; in Calpionellid standard zone B.

Tricolocapsa sp.
(Fig. 6C)

OCCURRENCE. — Sample KEL 25; Calpionellid standard zone A subzone 2.

Genus *Zhamoidellum* Dumitrica, 1970

Zhamoidellum sp. cf. **_Z. ventricosum_**
Dumitrica, 1970
(Fig. 6H)

OCCURRENCE. — Samples KEL 14-18; in Calpionellid standard zone B.

Family POULPIDAE De Wever, 1981
Genus *Saitoum* Pessagno, 1977b

Saitoum sp.
(Fig. 7K)

OCCURRENCE. — Sample KEL 16-2; from middle of Calpionellid standard zone B to zone C.

Family AMPHIPYNDACIDAE Riedel, 1967
Subamily SYRINGOCAPSINAE
Foreman, 1973
Genus *Podobursa* Wisniowski, 1888

Podobursa sp.
cf. **_P. multispina_** Jud, 1994
(Fig. 7L)

OCCURRENCE. — Samples KEL 2-18; from Calpionellid standard zone B to zone C.

REMARKS
Poor preservation prevents the positive identification of this form as *Podobursa multispina*.

Podobursa polyacantha (Fischli, 1916)
(Fig. 7H)

Theosyringium acanthophorum Rüst var. *polyacanthus* Fischli, 1916 (*fide* Baumgartner *et al.*, 1995a): 47, fig. 41.
Podobursa polyacantha – Baumgartner *et al.* 1995a: 424, pl. 3174, figs 1-4(H).

OCCURRENCE. — Sample KEL 7; in upper part of Calpionellid standard zone B.

Suborder SPUMELLARIA Ehrenberg, 1875
Superfamily ACTINOMMACEA Haeckel, 1862
Family LEUGONIDAE Yang & Wang, 1990
emend. Dumitrica, 1995
Genus *Acaeniotyle* Foreman, 1973

Acaeniotyle diaphorogona
Foreman, 1973
(Fig. 6L, M)

Acaeniotyle diaphorogona Foreman, 1973: 258, pl. 2, figs 2-5. – Thurow 1988: 396, pl. 9, fig. 8. – Baumgartner *et al.* 1995a: 50, pl. 3090, figs 1-6.

OCCURRENCE. — Samples KEL 5-20; from the Jurassic-Cretaceous boundary to upper part of Calpionellid standard zone B.

Genus *Praeconosphaera* Yang, 1993

Praeconosphaera sphaeroconus
(Rüst, 1898)
(Fig. 6K)

Conosphaera sphaeroconus Rüst, 1898: 13, pl. 4, fig. 8.
Praeconosphaera sphaeroconus – Yang 1993: 105, pl. 17, figs 2, 6, 12, 16, 23. – Dumitrica *et al.* 1997: 21, pl. 3, fig. 3.

OCCURRENCE. — Samples KEL 7-23; from Calpionellid standard zone A subzone 3 to upper part of zone B.

Family PANTANELLIIDAE Pessagno, 1977a
emend. Pessagno & Blome, 1980

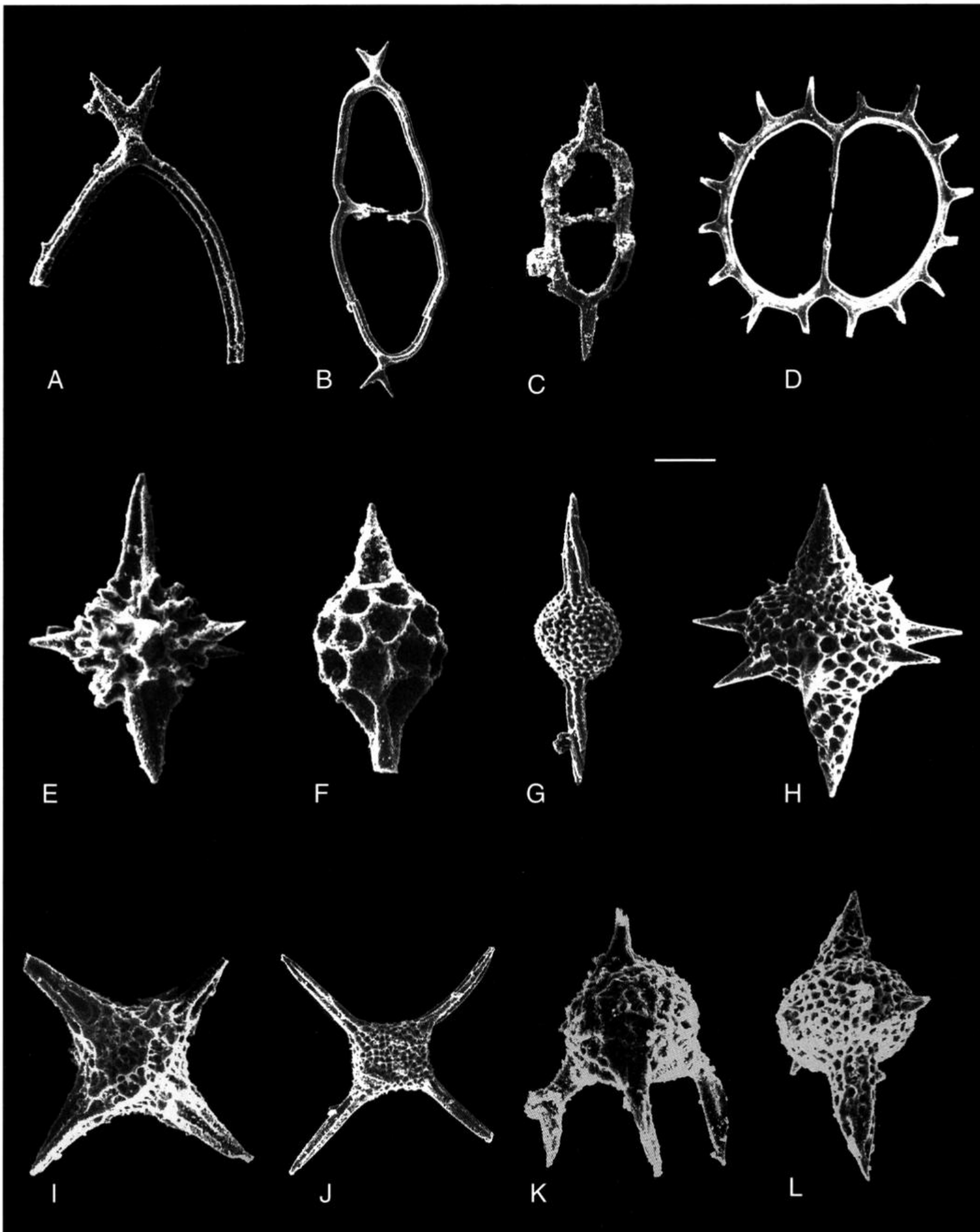

FIG. 7. — **A**, *Dicerosaturnalis dicranacanthos* (Squinabol) (KEL 16); **B**, *Dicerosaturnalis dicranacanthos* (Squinabol) (KEL 7); **C**, *Acanthocircus* sp. aff. *A. minimus* (Squinabol) (KEL 2); **D**, *Acanthocircus multidentatus* (Squinabol) (KEL 7); **E**, *Pantanellium berriasianum* Baumgartner (KEL 16); **F**, *Pantanellium* sp. (KEL 18); **G**, *Archaeospongoprunum patricki* Jud (KEL 20); **H**, *Podobursa polyacantha* (Fischli) (KEL 7); **I**, *Emiluvia omanensis* Kiessling (KEL 16); **J**, *Emiluvia pessagnoi* Foreman (KEL 20); **K**, *Saitoum* sp. (KEL 5); **L**, *Podobursa* sp. cf. *P. multispina* Jud (KEL 18). Scale bar: A, 70 µm; B, 160 µm; C, 105 µm; D, 95 µm; E, 50 µm; F, H, 60 µm; G, 90 µm; I, L, 80 µm; J, 155 µm; K, 35 µm.

Subfamily PANTANELLIINAE
Pessagno, 1977a
emend. Pessagno & Blome, 1980
Genus *Pantanellium* Pessagno, 1977a
emend. Pessagno & Blome, 1980

Pantanellium berriasianum
Baumgartner, 1984
(Fig. 7E)

Pantanellium (?) *berriasianum* Baumgartner, 1984: 776-777, pl. 6, figs 14-15.
Pantanellium berriasianum – Jud 1994: 89, pl. 15, figs 5-6. – Baumgartner *et al.* 1995a: 368, pl. 3280, figs 1(H)-2.

OCCURRENCE. — Samples KEL 7-17; from lower to upper part of Calpionellid standard zone B.

Pantanellium sp.
(Fig. 7F)

OCCURRENCE. — Samples KEL 2-25; from Calpionellid standard zone A subzone 2 to zone C.

REMARKS
Poor preservation hinders further identification of this specimen.

Family XIPHOSTYLIDAE Haeckel, 1881
emend. Pessagno & Yang,
in Pessagno *et al.*, 1989
Genus *Triactoma* Rüst, 1885

Triactoma tithonianum Rüst, 1885
(Fig. 6N)

Triactoma tithonianum Rüst, 1885 (*fide* Baumgartner *et al.*, 1995a): 289, pl. 28, fig. 5. – Jud 1994: 115, pl. 23, figs 10-11. – Baumgartner *et al.* 1995a: 52, pl. 3097, figs 1-3 (H).

OCCURRENCE. — Sample KEL 16; in Calpionellid standard zone B.

Superfamily PYLONIACEA Haeckel, 1881
emend. Dumitrica, 1989
Family ORBICULIFORMIDAE Pessagno, 1973
emend. Dumitrica, 1995
Subfamily EMILUVIINAE Dumitrica, 1995
Genus *Emiluvia* Foreman, 1973

Emiluvia omanensis Kiessling, 1995
(Fig. 7I)

Emiluvia omanensis Kiessling, 1995: 330, figs 6/5-8. – Dumitrica *et al.* 1997: 27, pl. 4, figs 2, 4.

OCCURRENCE. — Samples KEL 7-16; in Calpionellid standard zone B.

Emiluvia pessagnoi Foreman, 1973
(Fig. 7J)

Emiluvia pessagnoi Foreman, 1973: 262, pl. 8, fig. 6.
Emiluvia pessagnoi s.l. – Jud 1994: 77, pl. 10, figs 1, 2. – Baumgartner *et al.* 1995a: 206, pl. 3066, figs 1, 2.

OCCURRENCE. — Samples KEL 20-21; on Jurassic-Cretaceous boundary.

Family TRITRABIDAE Baumgartner, 1980
Genus *Deviatus* Li, 1986

Deviatus diamphidius (Foreman, 1973)
(Fig. 6I, J)

Paronaella (?) *diamphidia* Foreman, 1973: 262, pl. 8, figs 3,4.
Foremanella diamphidia – Baumgartner 1984: 765, pl. 6, fig. 18.
Deviatus diamphidius – O'Dogherty 1994: 345, pl. 64, fig. 14. – Dumitrica *et al.* 1997: 28, pl. 4, fig. 3.
Deviatus diamphidius diamphidius – Baumgartner *et al.* 1995a: 172, pl. 3112, figs 1-6(H).

OCCURRENCE. — Samples KEL 2-20; from lower part of Calpionellid standard zone B to zone C.

Genus *Tritrabs* Baumgartner, 1980

Tritrabs ewingi gr. (Pessagno, 1971)
(Fig. 8B)

Paronaella (?) *ewingi* Pessagno, 1971: 47, pl. 19, figs 2-5.
Tritrabs ewingi s.l. – Baumgartner *et al.* 1995a: 606, pl. 3113, figs 1-8(H).
Tritrabs ewingi gr. – Jud 1994: 116, pl. 23, figs 12-13.
Tritrabs ewingi – Dumitrica *et al.* 1997: 27, pl. 4, fig. 1. – Hull 1997: 4, pl. 19, fig. 9, 12.

OCCURRENCE. — Samples 2-7; from upper part of Calpionellid standard zone B to zone C.

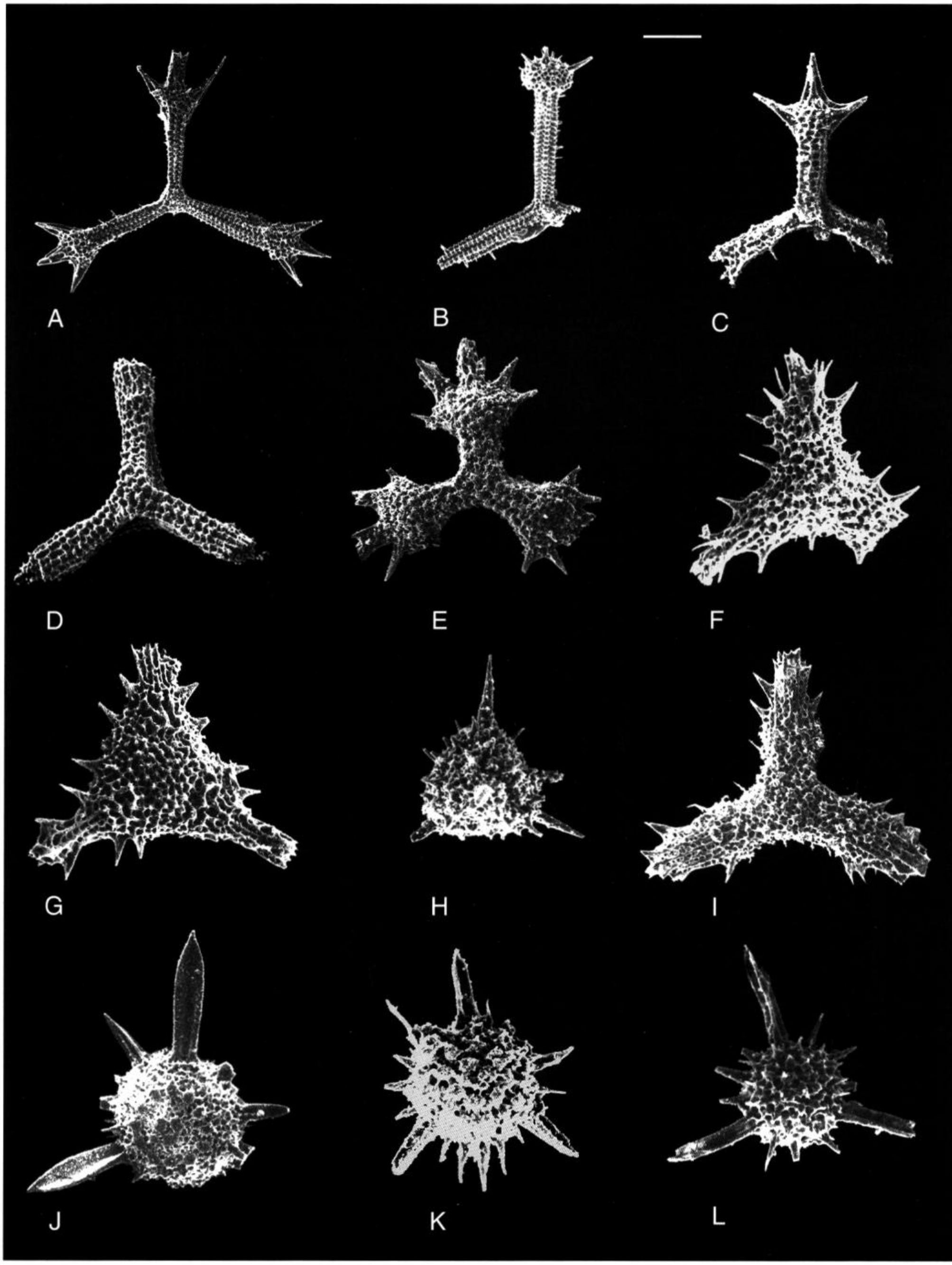

FIG. 8. — **A**, *Halesium sexangulum* Pessagno *sensu* Steiger (KEL 7); **B**, *Tritrabs ewingi* gr. (Pessagno) (KEL 18); **C**, *Halesium irregularis* Steiger (KEL 16); **D**, *Angulobracchia* (?) *portmanni* s.l. Baumgartner (KEL 16); **E**, *Halesium* (?) sp. (KEL 20); **F**, *Paronaella* (?) sp. cf. *P. tubulata* Steiger (KEL 7); **G**, *Paronaella* (?) sp. cf. *P. tubulata* Steiger (KEL 7); **H**, *Pyramispongia barmsteinensis* (Steiger) (KEL 20); **I**, *Paronaella* (?) *tubulata* Steiger (KEL 7); **J**, *Becus triangulocentrum* Dumitrica (KEL 16); **K**, *Alievium nodulosum* Dumitrica (KEL 20); **L**, *Alievium regulare* (Wu & Li) (KEL 18). Scale bar: A, 120 µm; B, 155 µm; C, 85 µm; D, 145 µm; E, 110 µm; F, 90 µm; G, J, 75 µm; H, I, K, L, 65 µm; K, 105 µm.

Superfamily SATURNALIACEA
Deflandre, 1953
Family SATURNALIDAE Deflandre, 1953
Subfamily SATURNALINAE Deflandre, 1953
Genus *Acanthocircus* Squinabol, 1903

Acanthocircus multidentatus
(Squinabol, 1914)
(Fig. 7D)

Saturnalis multidentatus Squinabol, 1914: 298, pl. 23 [4], figs 11, 12.
Acanthocircus multidentatus – Pessagno 1977b: 32, pl. 2, figs 15, 20. – O'Dogherty 1994: 255, pl. 44, figs 7-10.

OCCURRENCE. — Samples KEL 7-16; from lower to upper part of Calpionellid standard zone B.

Acanthocircus sp.
aff. ***A. minimus*** (Squinabol, 1914)
(Fig. 7C)

OCCURRENCE. — Samples KEL 2-23; from Calpionellid standard zone A subzone 3 to zone C.

REMARKS
Our specimen differs from *A. ellipticus* (Squinabol, 1903) and *A. bispinus* (Yao, 1972) by its smaller size and narrower ring. It more closely resembles *A. minimus* (Squinabol, 1914) although it has a more rectangular outline and flatter ring.

Genus *Dicerosaturnalis*
Dumitrica & Jud, 1997

Dicerosaturnalis dicranacanthos
(Squinabol, 1914)
(Fig. 7A, B)

Saturnalis dicranacanthos Squinabol, 1914: 289, pl. 22, figs 4-7; pl. 23, fig. 8.
Acanthocircus dicranacanthos – Foreman 1975: 610, pl. 2D, figs 5-6. – Hull 1997: 29, pl. 9, fig. 3, 4.
Acanthocircus trizonalis dicranacanthos – Baumgartner *et al.* 1995a: 72, pl. 3087, figs 1-8(H).
Dicerosaturnalis dicranacanthos – Dumitrica *et al.* 1997: 18, pl. 1, fig. 15.

OCCURRENCE. — Sample KEL 2-21; from Jurassic-Cretaceous boundary to Calpionellid standard zone C.

Superfamily SPONGODISCACEA
Haeckel, 1862
Family CAVASPONGIDAE Pessagno, 1973
Genus *Pyramispongia* Pessagno, 1973

Pyramispongia barmsteinensis
(Steiger, 1992)
(Fig. 8H)

Nodotetraedra barmsteinensis Steiger, 1992: 33, pl. 4, figs 9-14.
Pyramispongia barmsteinensis – Baumgartner *et al.* 1995a: 464, pl. 6109, figs 1-4. – Dumitrica *et al.* 1997: 26, pl. 4, fig. 12.

OCCURRENCE. — Samples KEL 2-20; from Jurassic-Cretaceous boundary to Calpionellid standard zone C.

Family PATULIBRACCHIDAE Pessagno, 1971
emend. Baumgartner, 1980
Genus *Angulobracchia* Baumgartner, 1980

Angulobracchia (?) ***portmanni*** s.l.
Baumgartner, 1984
(Fig. 8D)

Angulobracchia (?) *portmanni* Baumgartner, 1984: 757, pl. 2, fig. 3.
Angulobracchia (?) *portmanni* s.l. – Baumgartner *et al.* 1995a: 88, pl. 6121, figs 1-4.
Angulobracchia (?) *portmanni* – Dumitrica *et al.* 1997: 30, pl. 4, fig. 16.

OCCURRENCE. — Samples KEL 7-16; from lower to upper part of Calpionellid standard zone B.

Genus *Halesium* Pessagno, 1971
emend. Baumgartner, 1984

Halesium sexangulum
Pessagno, 1971 *sensu* Steiger, 1992
(Fig. 8A)

Halesium sexangulum Pessagno, 1971: 25, pl. 1, figs 5-6; pl. 2, figs 1-6. – Steiger 1992: 47, pl. 11 figs 1, 2.

OCCURRENCE. — Samples KEL 2-7; from upper part of Calpionellid standard zone B to zone C.

Halesium irregularis
Steiger, 1992
(Fig. 8C)

Halesium irregularis Steiger, 1992: 47, pl. 11, figs 3-5.

OCCURRENCE. — Sample KEL 16; in Calpionellid standard zone B.

Halesium (?) sp.
(Fig. 8E)

OCCURRENCE. — Samples KEL 9-20; from Jurassic-Cretaceous boundary to upper part of Calpionellid standard zone B.

Genus *Paronaella* Pessagno, 1971
emend. Baumgartner, 1980

Paronaella (?) **_tubulata_**
Steiger, 1992
(Fig. 8I)

Paronaella (?) *tubulata* Steiger, 1992: 45, pl. 10, fig. 10. – Jud 1994: 91, pl. 15, figs 18-19. – Baumgartner *et al.* 1995a: 400, pl. 5183, figs 1-5 (H).

OCCURRENCE. — Samples KEL 2-7; from upper part of Calpionellid standard zone B to zone C.

Paronaella sp.
cf. ***P.*** (?) ***tubulata*** Steiger, 1992
(Fig. 8F, G)

OCCURRENCE. — Samples KEL 2-7; from upper part of Calpionellid standard zone B to zone C.

Family PSEUDOAULOPHACIDAE Riedel, 1967
emend. Dumitrica, 1997
Genus *Alievium* Pessagno, 1972

Alievium nodulosum Dumitrica, 1997
(Fig. 8K)

Alievium nodulosum Dumitrica, 1997: 224, pl. 3, fig. 9.

OCCURRENCE. — Sample KEL 20; on Jurassic-Cretaceous boundary.

Alievium regulare (Wu & Li, 1982)
(Fig. 8L)

Praeconocaryomma regulare Wu & Li, 1982 : 65, pl. 1, figs 1,3.
Alievium helenae – Schaaf 1981: 431, pl. 7, fig. 9; (*non*) pl. 10, fig. 2a-b. – Baumgartner *et al.* 1995a: 80, pl. 3228, figs 1,3,4, non 2,5.
Alievium regulare – Dumitrica 1997: 221, pl. 2, figs 12-14; pl. 3 figs 1-3, 5.

OCCURRENCE. — Samples KEL 2-23; from Calpionellid standard zone A subzone 3 to zone C.

Genus *Becus* Wu, 1986
Becus triangulocentrum
Dumitrica, 1997
(Fig. 8J)

Becus triangulocentrum Dumitrica, 1997: 216, pl. 1, figs 8-9; pl. 2, figs 1, 2, 4, ?3, ?5, ?6.
Alievium helenae – Baumgartner *et al.* 1995a: 80, pl. 3228 (*pars*), fig. 2, *non* 1-4 = *Alievium regulare*, 5 = *Becus helenae*.

OCCURRENCE. — Samples KEL 16; in Calpionellid standard zone B.

REMARKS
Our specimen differs from *Becus helenae* (Schaaf, 1981) by having three nodes at the center of the circle of nodes on each side. It differs from *B. gemmatus* Wu, 1986 by having twelve nodes composing a circle rather than nine. It more closely resembles *B. triangulocentrum* Dumitrica, 1997 by having twelve nodes making up a circle on each face and by having three nodes in the central area inside the circle.

Family SPONGURIDAE Haeckel, 1862
Genus *Archaeospongoprunum* Pessagno, 1973

Archaeospongoprunum patricki
Jud, 1994
(Fig. 7G)

Archaeospongoprunum patricki Jud, 1994: 63, pl. 4, figs 2-4. – Baumgartner *et. al.* 1995a: 110, pl. 5042, figs 1(H)-4. – Dumitrica *et al.* 1997: 21, pl. 2, fig. 3.

OCCURRENCE. — Samples KEL 2-23; from Calpionellid standard zone A subzone 3 to C.

CONCLUSIONS

The resolution of radiolarian bioevents increases with the fine sampling interval in section KEL (15-20 meters) and the stepwise initial occurrence of Cretaceous radiolarian taxa is accentuated. This gradual appearance of the taxa is probably an artifact of selective preservation because taxa such as *Alievium regulare*, *Dicerosaturnalis dicranachanthos*, *Deviatus diamphidius*, *Acaeniotyle diaphorogona*, *Archaeodictyomitra apiarium*, *Emiluvia pessagnoi*, *Pantanellium berriasianum*, and *Hsuum raricostatum*, among others, appear at chronostratigraphically lower levels in other European sections (see Baumgartner *et* al. 1995a) than they do in section KEL (Fig. 4). Selective preservation, the lack of a sudden change/turnover in radiolarian fauna at the Jurassic-Cretaceous boundary and only two samples from the latest Tithonian make the delineation of the Jurassic-Cretaceous boundary impossible in section KEL at this time. Despite preservational problems, a typical Tethyan radiolarian fauna consisting of 33 genera and 36 species are illustrated from Turkey for the first time.

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REFERENCES

Aita Y. 1987. — Middle Jurassic to Lower Cretaceous radiolarian biostratigraphy of Shikoku with reference to selected sections in Lombardy Basin and Sicily. *Science Reports of the Tohoku University, Series 2: Geology* 58 (1): 1-91.

Aita Y. & Okada H. 1986. — Radiolarians and nannofossils from the uppermost Jurassic and Lower Cretaceous strata of Japan and Tethyan regions. *Micropaleontology* 32 (2): 97-128.

Alleman F., Catalano R., Fares F. & Remane J. 1971. — Standard calpionellid zonation of the western Mediterranean Province. *Proceedings of the Second Planktonic Conference, Rome 1970*, 2: 1337-1340.

Altiner D. 1991. — Microfossil biostratigraphy (mainly foraminifers) of the Jurassic-Lower Cretaceous carbonate successions in northwestern Anatolia (Turkey). *Geologica Romana* 27: 167-213.

Altiner D. & Özkan S. 1991. — Calpionellid zonation in northwestern Anatolia (Turkey) and calibration of the stratigraphic ranges of some benthic foraminifera at the Jurassic-Cretaceous boundary. *Geologica Romana* 27: 215-235.

Altiner D., Kocyigit A., Farinacci A., Nicosia U. & Conti M. A. 1991. — Jurassic-Lower Cretaceous of the southern part of northwestern Anatolia (Turkey). *Geologica Romana* 27: 13-80.

Baumgartner P. O. 1980. — Late Jurassic Hagiastridae and Patulibracchidae (Radiolaria) from the Argolis Peninsula (Peleponnesus, Greece). *Micropaleontology* 26 (3): 274-322.

— 1984. — A Middle Jurassic-Early Cretaceous low latitude radiolarian zonation based on unitary associations and age of Tethyan radiolarites. *Eclogae geologicae Helvetiae* 77 (3): 729-841.

— 1987. — Age and genesis of Tethyan Jurassic radiolarites. *Eclogae geologicae Helvetiae* 80 (3): 831-879.

— 1992. — Lower Cretaceous radiolarian biostratigraphy off Northern Australia (ODP sites 765 and 766 and DSDP site 261) Argo Abyssal Plain and Lower Exmouth Plateau, *in* Gradstein F. M., Ludden J. L. (eds), *Proceedings of the Ocean Drilling Program, Scientific Results*, College Station, Texas 123: 299-342.

— 1993. — Early Cretaceous radiolarians of the Northeast Indian Ocean (Leg 123: Sites 765, 766 and DSDP Site 261): The Antarctic-Tethys connection, *in* Lazarus D. & De Wever P. (eds), InterRad VI, *Marine Micropaleontology* 21: 329-352.

Baumgartner P. O., Bartolini A., Carter E. S., Conti M., Cortese G., Danelian T., De Wever P., Dumitrica P., Dumitrica-Jud R., Gorican S., Guex J., Hull D. M., Kito N., Marcucci M., Matsuoka A., Murchey B., O'Dogherty l., Savary J., Vishnevskaya V., Widz D. & Yao A. 1995b. — Middle Jurassic to Early Cretaceous radiolarian biochronology of Tethys based on unitary associations, *in* Baumgartner P. O., O'Dogherty L., Gorican S., Urquhart E., Pillevuit A. & De Wever P. (eds), Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology, *Mémoires de Géologie*, Lausanne 23 : 1013-1048.

Baumgartner P. O. & Bernoulli D. 1976. — Stratigraphy and radiolarian fauna in a Late

Jurassic-Early Cretaceous section near Achladi (Evvora, Eastern Greece). *Eclogae geologicae Helvetiae* 69 (3): 601-626.

Baumgartner P. O., O'Dogherty L., Gorican S., Dumitrica-Jud R., Dumitrica P., Pillevuit A., Urquhart E., Matsuoka A., Danelian T., Bartolini A., Carter E. S., De Wever P., Kito N., Marcucci M. & Steiger T. 1995a. — Radiolarian catalogue and systematics of Middle Jurassic to Early Cretaceous Tethyan genera and species, *in* Baumgartner P. O., O'Dogherty L., Gorican S., Urquhart E., Pillevuit A. & De Wever P. (eds), Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology, *Mémoires de Géologie*, Lausanne 23 : 37-685.

Bown P. R. & Özkan S. 1992. — Calcareous nannofossil biostratigraphy and correlation across the Jurassic-Cretaceous boundary. *Memori di Scienze Geologische* 43: 77-87.

Bralower T. J. 1990. — Lower Cretaceous nannofossil stratigraphy of the Great Valley Sequence, Sacramento Valley, California, *Cretaceous Research* 11: 101-123.

Bralower T. J. , Monechi S. & Thierstein H. R. 1989. — Calcareous nannofossil stratigraphy and correlation with the upper M-sequence magnetic anomalies. *Marine Micropaleontology* 14: 153-235.

Cecca F., Enay R. & Le Hagarat G. 1989. — L'Ardescien (Tithonique supérieur) de la région stratotypique : séries de référence et faunes (ammonites, calpionelles) de la bordure Ardéchoise. *Documents des Sciences de Lyon* 107 : 1-116.

Channel J. E. T., Bralower T. J. & Grandesso P. 1987. — Biostratigraphic correlation of M-sequence polarity chrons M1 to M22 at Capriolo and Xausa (Southern Alps, Italy). *Earth and Planetary Science Letters* 85: 203-221.

Channell J. E. T., Erba E. & Lini A. 1993. — Magnetostratigraphic calibration of the Late Valanginian carbon isotope event in pelagic limestones from Northern Italy and Switzerland. *Earth and Planetary Science Letters* 118: 145-166.

Channel J. E. T. & Grandesso P. 1987. — A revised correlation of magnetozones and calpionellid zones based on data from Italian pelagic limestone sections. *Earth and Planetary Science Letters* 85: 222-230.

Colloque 1975. — Colloque sur la limite Jurassique-Crétacé Lyon/Neuchâtel (1973). *Mémoires du Bureau des Recherches Géologiques et Minières* 86, 394 p.

Cooper M. K. E. 1985. — Nannofossils across the Jurassic-Cretaceous boundary in the Tethyan realm, *in* Michelson O. & Zeiss E. (eds), *Proceedings on the International Symposium on Jurassic Stratigraphy*, Copenhagen 2: 429-443.

Dumitrica P. 1995. — Systematic framework of Jurassic and Cretaceous Radiolaria, *in* Baumgartner P. O., O'Dogherty L., Gorican S., Urquhart E., Pillevuit A. & De Wever P. (eds), Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology, *Mémoires de Géologie*, Lausanne 23 : 19-35.

Dumitrica P. 1997. — On the status of the Lower Cretaceous radiolarian species *Alievium helenae* Schaaf and of other related species. *Revue de Micropaleontologie* 40 (3) : 211-226.

Dumitrica P. & De Wever P. 1991. — Assignation to Radiolaria of two Upper Jurassic species previously described as Foraminifera: systematic consequences. *Comptes Rendus de L'Académie des Sciences*, Paris, Serie II, 312 : 553-558.

Dumitrica P., Immenhauser A. & Dumitrica-Jud R. 1997. — Mesozoic radiolarian biostratigraphy from Masirah Ophiolite, Sultanate of Oman. Part I: Middle Triassic, Uppermost Jurassic and Lower Cretaceous spumellarians and multi-segmented nasselarians. *Bulletin of the National Museum of Natural Science* 9: 1-106.

Erba E. & Quadrio B. 1987. — Biostratigrafia a Nannofossili calcarei, Calpionellidi e Foraminiferi planctonici della Maiolica (Titoniano superiore-Aptiano) nelle Prealpi Bresciani (Italia settentrionale). *Rivista Italiana di Paleontologia e Stratigrafia* 93: 3-108.

Farinacci A., Malantrucco G., Mariotti N. & Nicosia U. 1981a. — Ammonitico Rosso facies in the framework of the Martanni Mountains: Paleoenvironmental evolution during Jurassic: 311-332, *in* Farinacci A. & Elmi S. (eds), *Proceedings of the Rosso Ammonitico Symposium.*

Farinacci A., Mariotti N., Nicosia U., Pallini G. & Schiavinotto F. 1981b. — Jurassic sediments in the Umbria-Marchean Apennines: an alternative model: 333-398, *in* Farinacci A. & Elmi S. (eds), *Proceedings of the Rosso Ammonitico Symposium.*

Foreman H. 1973. — Radiolaria from the DSDP Leg 20: 249-305, *in* Heezen B. C., MacGregor J. D. *et al.* (eds), *Initial Reports of the Deep Sea Drilling Project.* U.S. Government Printing House, Washington D.C.

Foreman H. P. 1975. — Radiolaria from the North Pacific, Deep Sea Drilling Project Leg 32: 579-676, *in* Larson R. L., Moberly. R. *et al.* (eds), *Initial Reports of the Deep Sea Drilling Project.* US Government Printing House, Washington D.C.

Grün B. & Blau J. 1997. — New aspects of calpionellid biochronology: proposal for the revised calpionellid zonal and subzonal division. *Revue de Paléobiologie* 16 (1) : 197-214.

Hoedemaeker Ph. J. 1987. — Correlation possibilities around the Jurassic/Cretaceous boundary. *Scripta Geologica* 84: 1-55.

— 1991. — Tethyan-Boreal correlations and the Jurassic-Cretaceous boundary. *Newsletter of Stratigraphy* 25 (1): 37-60.

Hull D. M. 1995. — Paleogeographic significance and morphological diversity of the Family

Parvicingulidae (Radiolaria). *Micropaleontology* 41 (1): 1-48.
Hull D. M. 1997. — Upper Jurassic Tethyan and southern Boreal radiolarians from western North America. *Micropaleontology* 43 (2): 1-202.
Jeletsky J. A. 1984. — Jurassic-Cretaceous boundary beds of Western and Arctic Canada and the problem of the Tithonian-Berriasian stages in the Boreal realm, *in* Westermann G. E. G. (ed.), Jurassic-Cretaceous biochronology and biogeography of North America, *Geological Society of Canada*, Special Paper 27: 175-255.
Jud R. 1994. — Biochronology and Systematics of Early Cretaceous radiolarians of the Western Tethys. *Mémoires de Géologie*, Lausanne 19, 147 p.
Kemper E., Rawson P. F. & Thieloy J.-P. 1981. — Ammonites of Tethyan ancestry in the early Lower Cretaceous of northwest Europe. *Paleontology* 24: 251-311.
Kiessling W. 1995. — New radiolarians from the earliest Cretaceous of the Sultanate of Oman (Wahrah Formation, Jebel Buwaydah). *Paläontologische Zeitschrift* 63 (3/4): 321-342.
— 1996. — Facies characterization of mid-Mesozoic deep water sediments by quantitative analysis of siliceous microfaunas. *Facies* 35: 237-274.
Kiessling W. & Scasso R. 1996. — Ecological perspectives of Late Jurassic radiolarian faunas from the Antarctic Peninsula. *Georesearch Forum* 1-2: 317-326.
Le Hegarat G. & Remane J. 1968. — Tithonique supérieur et Berriasien de la bordure cévenole. Corrélations des ammonites et des calpionelles. *Geobios* 1: 7-70.
Lowrie W. & Channell J. E. T. 1983. — Magnetostratigraphy of the Jurassic-Cretaceous boundary in the Maiolica limestone (Umbria, Italy). *Geology* 12: 44-47.
Matsuoka A. 1995a. — Radiolaria-based Jurassic/Cretaceous boundary in Japan. *Proceedings of the 15th International Symposium at Kyungpook National University*: 219-232.
— 1995b. — Jurassic and Lower Cretaceous radiolarian zonation in Japan and in the western Pacific. *The Island Arc* 4: 140-153.
— 1995c. — Late Jurassic tropical Radiolaria: *Vallupus* and its related forms. *Paleogeography, Paleoclimatology, Paleoecology* 119: 359-369.
— 1995d. — Middle Jurassic-Lower Cretaceous radiolarian zonation in Japan and the Western Pacific, and age assignments based on the unitary associations method, *in* Baumgartner P. O., O'Dogherty L., Gorican S., Urquhart E., Pillevuit A. & De Wever P. (eds), Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology, *Mémoires de Géologie*, Lausanne 23 : 1049-1057.
Matsuoka A. & Yao A. 1986. — A newly proposed radiolarian zonation for the Jurassic of Japan. *Marine Micropaleontology* 11 (1-3): 91-106.
Nakaseko K. & Nishimura A. 1981. — Upper Jurassic and Cretaceous Radiolaria from the Shimanto Group in Southwest Japan. *Science Reports, College of General Education Osaka University* 30 (2): 133-203.
O'Dogherty L. 1994. — Biochronology and paleontology of Mid-Cretaceous radiolarians from Northern Appenines (Italy) and Betic Cordillera (Spain). *Mémoires de Géologie*, Lausanne 21, 413 p.
Ogg J. G. 1992. — Jurassic magnetic polarity timescale: 12-13, *in* Westermann G. E. G. (ed.), *The Jurassic of the Circum-Pacific*. Cambridge University Press, Cambridge.
Ogg J. G. & Lowrie W. 1986. — Magnetostratigraphy of the Jurassic-Cretaceous boundary. *Geology* 14: 547-550.
Ogg J. G., Hasenyager R. W., Wimbledon W. A., Chanel J. E. T. & Bralower T. J. 1991. — Magnetostratigraphy of the Jurassic-Cretaceous boundary interval, Tethyan and English faunal realms. *Cretaceous Research* 12: 455-482.
Olóriz F. & Tavera J. M. 1989. — The significance of Mediterranean ammonites with regard to the traditional Jurassic-Cretaceous boundary. *Cretaceous Research* 10: 221-237.
Özkan S. 1993a. — *Calcareous nannofossil and Calpionellid biostratigraphy of the Upper Jurassic-Lower Cretaceous in northwest Anatolia, Turkey*. PhD Thesis (unpublished), University College, London, 279 p.
— 1993b. — Calcareous nannofossils from the Late Jurassic-Early Cretaceous of Northwest Anatolia, Turkey. *Geological Journal* 28: 295-307.
Pessagno E. A. 1971. — Jurassic and Cretaceous Hagiastridae from the Blake-Bahama Basin (Site 5A, JOIDES Leg 1) and the Great Valley Sequence, California Coast Ranges. *Bulletins of American Paleontology* 60 (264): 5-83.
— 1977a. — Upper Jurassic Radiolaria and radiolarian biostratigraphy of the California Coast Ranges. *Micropaleontology* 23 (1): 56-113.
— 1977b. — Lower Cretaceous radiolarian biostratigraphy of the Great Valley Sequence and Franciscan Complex, California Coast Ranges. *Contributions to the Cushman Foundation of Foraminiferal Research*, Special Publication 15: 1-87.
Pessagno E. A. & Blome C. D. 1982. — Bizarre Nassellariina (Radiolaria) from the Middle and Upper Jurassic of North America. *Micropaleontology* 28 (3): 289-318.
— 1990. — Implications of new Jurassic stratigraphic, geochronometric and paleolatitudinal data from the Western Klamath terrane (Smith River and Rogue Valley subterranes). *Geology* 18: 665-668.
Pessagno E. A. Jr., Blome C. D., Hull D. M. & Six W. M. 1993. — Jurassic Radiolaria from the

Josephine ophiolite and overlying strata, Smith River subterrane (Klamath Mountains), northwestern California and southwestern Oregon. *Micropaleontology* 39 (2): 93-166.

Pessagno E. A., Blome C. D.& Longoria J. F. 1984. — A revised radiolarian zonation for the Upper Jurassic of western North America. *Bulletins of American Paleontology* 87 (320): 5-51.

Pessagno E. A. Jr., Blome C. D., Crater E. S., Macleod N., Whalen P. A. & Yeh K. Y. 1987a. — Part II. Preliminary radiolarian zonation for the Jurassic of North America. *Cushman Foundation for Foraminiferal Research*, Special Publication 23 (II), 28 p.

Pessagno E. A. Jr., Cantu-Chapa A., Hull D. M. & Meng X. 1997. — *New data from North America on the placement of the Jurassic-Cretaceous boundary*: 108 [Abstracts]. InterRad VIII, Paris.

Pessagno E. A. Jr., Longoria J. F., Macleod N. & Six W. M. 1987b. — Studies of North American Jurassic Radiolaria. Part I, Upper Jurassic (Kimmeridgian-upper Tithonian) Pantanelliidae from the Taman Formation, east-central Mexico: tectonostratigraphic, chronostratigraphic and phylogenetic implications. *Cushman Foundation for Foraminiferal Research*, Special Publication 23 (I): 1-51.

Pessagno E. A. Jr. & Mizutani S. 1992. — Radiolarian biozones of North America and Japan: 293-295, *in* Westermann G. E. G. (ed.), *The Jurassic of the Circum-Pacific*. Cambridge University Press, Cambridge, England.

Pop G. 1994a. — Systematic revision and biochronology of some Berriasian-Valanginian Calpionellids (Genus *Remaniella*). *Geologica Carpathica* 45 (6): 323-331.

— 1994b. — Calpionellid evolutive events and their use in biostratigraphy. *Romanian Journal of Stratigraphy* 76: 7-24.

— 1996. — Trois nouvelles espèces de genre Remaniella (Calpionellidae Bonet 1956). *Comptes Rendus de l'Académie des Sciences*, Paris, Série II, 322 : 317-323.

Remane J. 1964. — Untersuchungen zur Systematik und Stratigraphie der Calpionellen in den Jura-Kreide Grenzschichten des Vocontischen Troges. *Paleontographica Abteilung A* 123: 1-57.

— 1985. — Calpionellids: 555-572, *in* Bolli H. M., Saunders J. B. & Perch-Nielson K. (eds), *Plankton Stratigraphy*. Cambridge University Press, Cambridge.

— 1986. — Calpionellids and the Jurassic-Cretaceous boundary. *Acta Geologica Hungarica* 29: 15-26.

— 1991. — The Jurassic-Cretaceous boundary: problems of definition and procedure. *Cretaceous Research* 12: 447-453.

Remane J., Bakalova-Nanova D., Borza K., Knauer J., Nagy I., Pop G. & Tardi-Filacz E. 1986. — Agreement on the subdivision of the standard calpionellid zones defined at the IInd Planktonic Conference, Roma 1970. *Acta Geologica Hungarica* 29: 5-14.

Rüst D. 1898. — Neue Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen des Jura und der Kreide. *Paleontographica* 45: 1-67.

Schaaf A. 1981. — Late Early Cretaceous Radiolaria from Deep Sea Drilling Project Leg 62: 419-470, *in* Thiede J., Vallier T. L. *et al.* (eds), *Initial Reports of the Deep Sea Drilling Project*. U.S. Government Printing Office, Washington D.C.

Şengör A. M. C. 1984. — Structural classification of the tectonic history of Turkey. *Turkish Geological Society, Ketin Symposium*: 37-62.

Şengör A. M. C. & Yilmaz Y. 1981. — Tethyan evolution of Turkey: a plate tectonic approach. *Tectonophysics* 75: 181-241.

Squinabol S. 1914. — Contributo alla conoscenza dei Radiolarii fossili del Veneto. Appendice – Di un genera di radiolari caratteristico del Secondario. *Memorie dell'Instituto Geologico della Reale Universita di Padova* 2: 249-306.

Steiger T. 1992. — Systematik, Stratigraphie und Paleokölogie der Radiolarien des Oberjura-Unterkreiden-Grenzbereiches im Osterhorn-Tiroloikum (nordliche Kalkalpen, Salzburg und Bayern). *Zitteliana* 19: 3-188.

Tavera J. M., Aguado R., Company M. & Olóriz F. 1994. — Integrated biostratigraphy of the Durangites and Jacobi Zones (J/K Boundary) at the Puerto Españo section in southern Spain (Province of Cordoba). *Geobios* 17 : 469-476.

Thierstein H. R. 1975. — Calcareous nannofossils biostratigraphy at the Jurassic-Cretaceous boundary, *in* Colloque sur la limite Jurassique-Crétacé, Lyon, Neuchâtel, *Mémoires du Bureau de Recherches Géologiques et Minières* 86: 84-94.

Thurow J. 1988. — Cretaceous radiolarians of the North Atlantic Ocean: ODP Leg 103 (Sites 638, 640 and 641) and DSDP Legs 93 (Site 603) and 47B (Site 398), *in* Boillot G., Winterer E. L. *et al.* (eds), *Proceedings of the Ocean Drilling Program, Scientific Results*, College Station 103: 379-418.

Trejo M. 1980. — Distribucion estratigrafica de los Tintinidos mesozoicos mexicanos. *Revista del Instituto Mexicano del Petroleo* 12 (4): 4-13

Wu H. R. & Li H. S. 1982. — Radiolaria from the olitostrome of the Zongzhuo Formation, Gyangze Southern Xizang (Tibet). *Acta Micropaleontologica Sinica*, Beijing 21 (1): 64-72.

Yang Q. 1993. — Taxonomic studies of Upper Jurassic (Tithonian) Radiolaria from the Taman Formation, East-Central Mexico. *Paleoworld*, Special Issue 3: 1-164.

Yang Q. & Matsuoka A. 1997. — A comparative study on Upper Jurassic radiolarian biostratigraphy of the Taman Formation, East Central Mexico and the ODP site 801B section, west Pacific. *Science Reports of Niigata University* 12: 29-49.

Yang Q. & Pessagno E. A. 1989. — Upper Tithonian Vallupinae (Radiolaria) from the Taman Formation, East Central Mexico. *Micropaleontology* 35 (2): 114-134.

Zakharov V. A. 1987. — The bivalve *Buchia* and the Jurassic-Cretaceous boundary in the Boreal province. *Cretaceous Research* 8: 141-153.

Zeiss A. 1984. — Comments on the paper by Jeletsky J. A., *in* Westermann G. E. G. (ed.), *Jurassic-Cretaceous Biochronology of North America*, *Geological Society of Canada*, Special Paper 27: 250-253.

— 1986. — Comments on a tentative correlation chart for the most important marine provinces at the Jurassic/Cretaceous boundary. *Acta Geologica Hungarica* 29: 27-30.

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