GEOLOGICA CARPATHICA, 44, 2, BRATISLAVA, APRIL 1993
75 - 79

OBSERVATIONS OF ULTRASTRUCTURE OF THE UPPER JURASSIC AND LOWER CRETACEOUS CALPIONELLID TESTS

DANIELA REHÁKOVÁ and JOZEF MICHALÍK

Geological Institute, Slovak Academy of Sciences, Dúbravská 9, 842 26 Bratislava, Slovak Republic

(Manuscript received June 12, 1992; accepted in revised form December 16, 1992)

Abstract: SEM study of test ultrastructure of *Chitinoidella*, as well as *Crassicollaria* and the phylogenetically more progressive calpionellids indicates different calcification and diagenetic recrystallization, related to different original test structure. The walls of *Chitinoidella* loricas were thicker, composed of micritic substance with dispersed calcite rhombs. On the other hand, the lorica wall of other studied calpionellids was thinner, the calcite content in it was originally higher. In early diagenesis, the superficial calcite rhombohedrons grew, forming a continuous rim composed of scalenohedral crystals. This rim prevented further test destruction during later phases of diagenesis when the original organic substance had already been destroyed.

Key words: calpionellida, ultrastructure, SEM study, diagenesis, Late Jurassic, Early Cretaceous.

Introduction

Calpionellids formed an important component of Late Jurassic/Early Cretaceous plankton in the tropical belt between eastern Mexico and East India (Remane in Haq & Boersma 1978; Remane in Bolli, Saunders & Perch-Nielsen 1985). Their remains (along with the ammonites) support the Jurassic and Lower Cretaceous biostratigraphical division (Le Hegarat & Remane 1968; Remane et al. 1986; Allemann et al. 1971, 1980; Pop 1976, 1980; Trejo 1975 and others). Jurassic and Lower Cretaceous pelagic carbonates in the Western Carpathians are very poor in macrofaunal remnants (ammonite shells, belemnite rostra and rhyncholites). Their stratigraphic subdivision is therefore supported by the parastratigraphic scale based on the distribution of calpionellids, fibrosphaeras, stomiosphaerids and cadosinids (Borza 1984; Borza & Michalík 1986).

Methods of study

Fresh surfaces of limestone fragments and thin sections were etched by 10 % HCl during 5 - 10 sec. Etching by organic acids (EDTA) was unsuitable. Clay admixture (mainly in Lower Cretaceous limestones) was removed by HF. Etched samples were cleaned by an ultra-sonic generator. Microstructure of tintinnid tests was studied by SEM BS 600 (Geological Institute of SAS, Dr. I. Holický).

Discussion of calpionellid test construction

Pokorný (1954) characterized *Infusoria* of the suborder *Tintinnina* as protozoans forming the hard test (lorica) of organic substance (tectine), sometimes covered by agglutinated grains. Organic substance of the lorica of fossil *Infusoria* was supposedly substituted by calcite. Deflandre (1936) considered them as agglutinated forms. Colom (1948) found fine structures in the calpionellid lorica wall, on the basis of which he assumed rapid substitution of the original fine organic wall by calcite. Andrusov (1950), had a similar opinion, whereas Bonet (1956) thought that the loricae were primarily calcitic.

The lorica is usually spherical, bell-shaped, or cylindrical, depending on the life style (the lorica length of actively moving forms is supposed to be larger). The aboral pole is rounded, pointed or ended by a caudal appendage (sometimes there are several caudal appendages). The function of this element has not been yet discussed in the literature. We assume that it could help to stabilize the floating forms or improve the moving ability of swimming forms. The opened (oral) zone of lorica often passes into the collar. According to Brandt (in Pokorný 1954) widening the collar made the floating of tests of passively drifting forms easier. Some collars (*Remaniella, Calpionellopsis, Calpionellites*) are clearly separated from their loricas. It is unusual for tests secreted by surface of a unicellular microorganism. It is possible that these structures could have been mobile and they could play a role in hydrostatic navigation of the organism during the daily migration to the surface of the sea and into the depths.

The size of tests is variable. According to Pokorný (l.c.) the length (measured without the protuberance) attains 50 to 200 μm. Houša (1987) considered test size to be the reflection of specific niche within the planktonic association. Nagy (1986) used it as one of the taxonomical signs. Pokorný (l.c.) pointed out that the test size is an uncertain taxonomic mark, since it changes with the temperature of water (thermophile forms are smaller). It is possible that detailed morphometric studies of tests would indicate cold seasons or places of penetration of cold marine currents.

Microstructure study of chitinoidella tests

Chitinoidellas attained a dominant position in the plankton during the Middle Tithonian. According to earlier authors, their tests were composed of organic substance. Borza (1969) described the

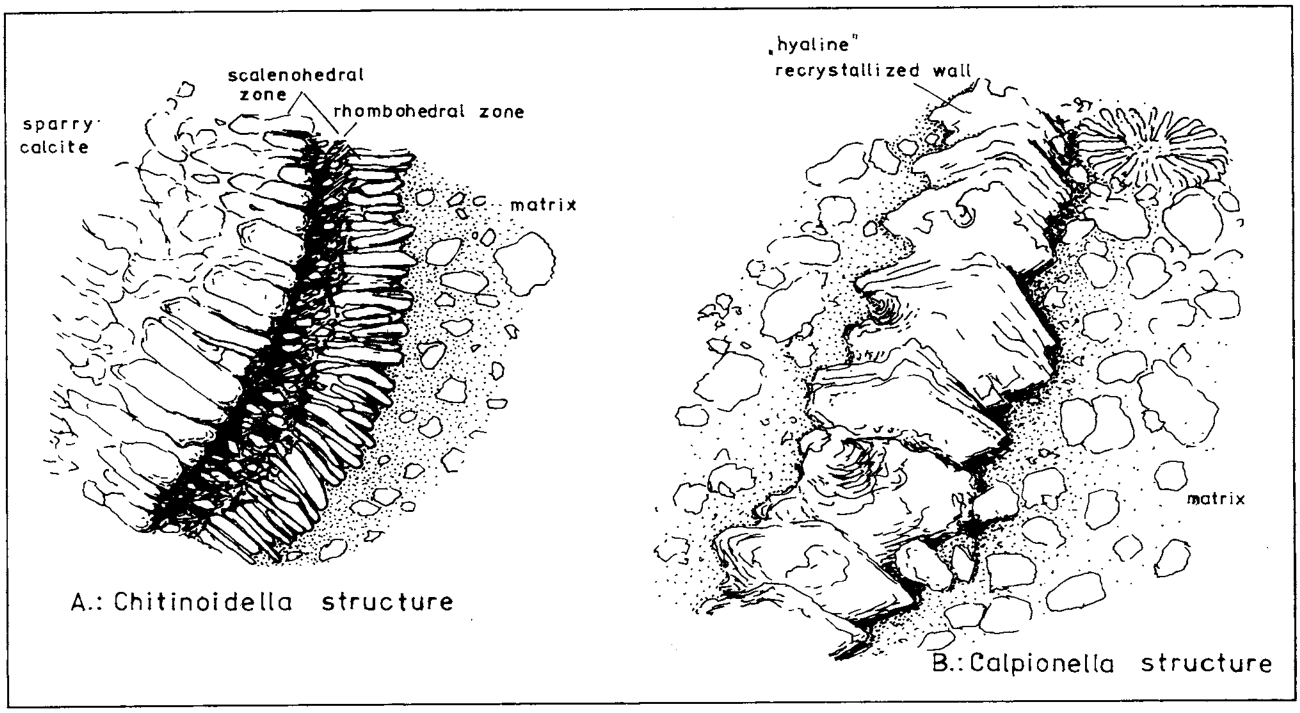


Fig. 1. A sketch of the pricipal differences between the chitinoidellid A - and calpionellid B - type of structure, based on SEM observations.

structure of his new species *Ch. slovenica* as composed of fine calcite grains with brownish organic cement. According to the same author, *Ch. boneti* Doben has a similar character.

SEM study of *Ch. dobeni* Borza and *Ch. boneti* Doben tests confirmed Borza's hypothesis. The test (1 - 2 μm thick) is composed of tiny (0.5 - 1 μm) rhombohedral transversaly oriented calcite crystallites (Pl. 1, Fig. 1A). They are mostly separated, sometimes they touch each other, or they can grow together. The dark colour of this layer in optic microscope is caused by fine-grained crystals and by remains of the original organic substance filling the spaces between them.

From both sides, the micrograhular layer is rimmed by scalenohedral calcite crystallites (4 - 6 μm), perpendicular to the wall of the test (Pl. 1, 5). This layer (the same case as the Domerian schizosphaeras in Noël & Busson 1990) represents a postmortal superstructure, formed by oriented growth of tiny rhombohedral crystals at the test surface. Tiny fragments of tests in the surrounding sediment, especially nannoplankton (Loeblich & Tappan 1968) served as the source of newly-formed calcite. The base of scalenohedrons forms a nearly straight surface which originally might have been limited by an organic lamina. The length of these crystallites depended on the rate of burial processes, lithification and permeability of the sediment. The scalenohedral layer did not originate in rapidly lithified micrites. After the organic substance had been destroyed, the test is difficult to recognize in the light microscope (Pl. 1, 10). This could be the reason of many problems with the identification of the Mid-Tithonian *Chitinoidella* Zone not only in the Western Carpathians, but also in the Alps and Mecsek Mts. (Reháková & Michalík 1992; Blau & Grün - oral information, Nagy 1986).

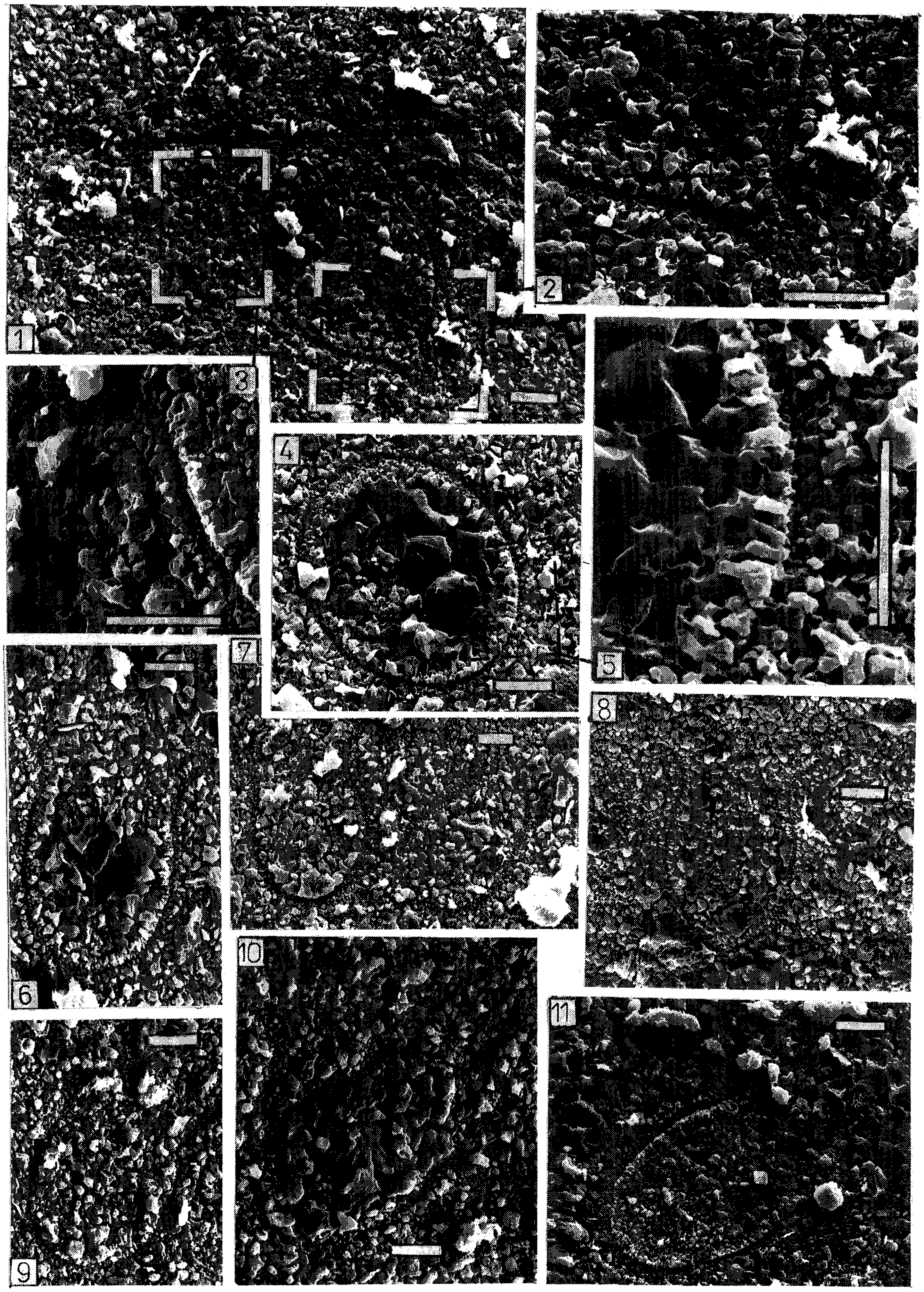
The test of *Praetintinnopsella* is composed of hyaline (inner) and microgranular (outer) layers (Borza 1969). Their microstructures were not studied in detail (by SEM) because of absence of suitable samples.

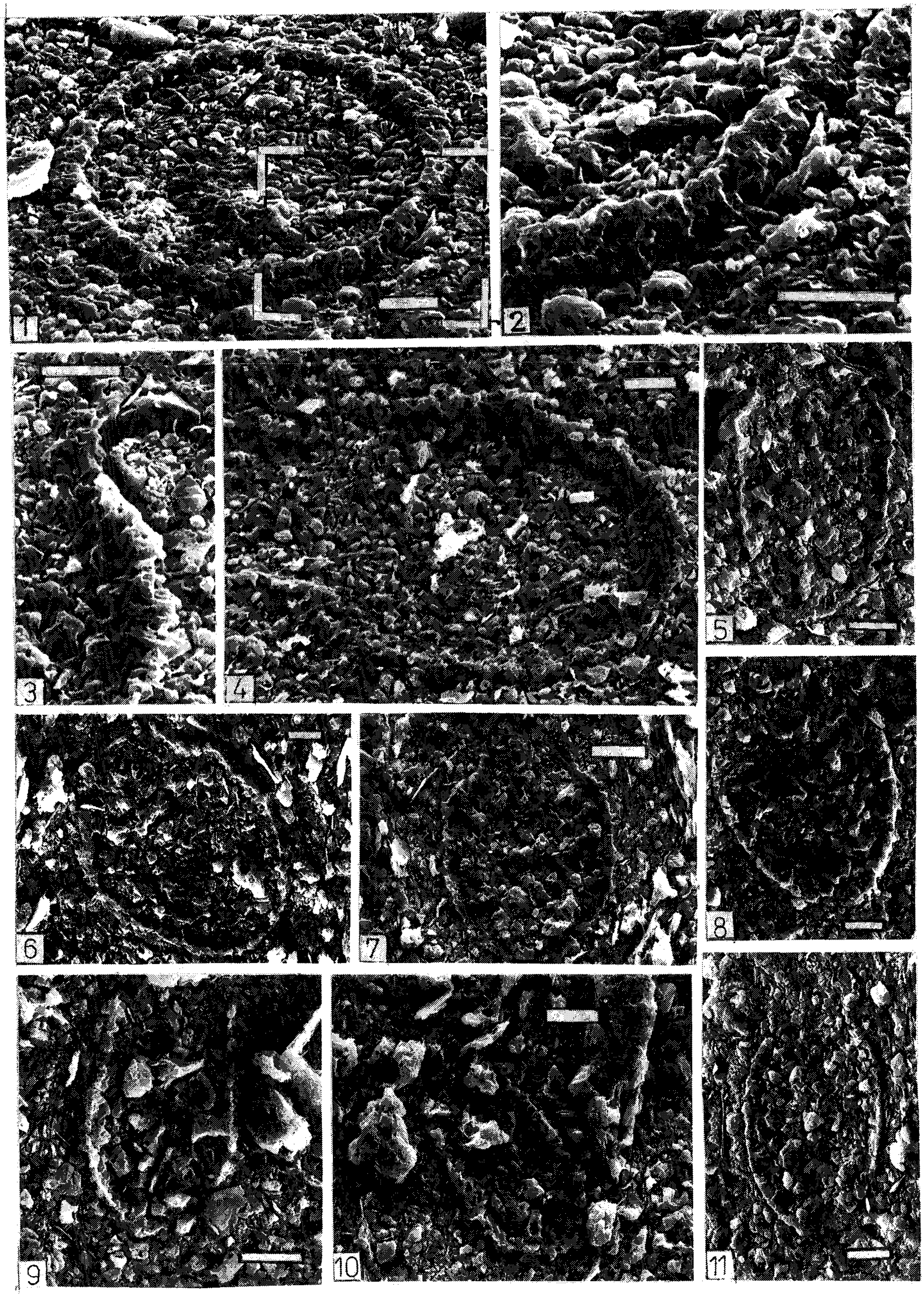
Comparision of Tithonian and Lower Cretaceous calpionellid test ultrastructure

According to Aubrey et al. (1975) the wall of calpionellid test consists of a single layer of small polyhedric, helicoidically arranged crystallites 0.3 - 5 μm in size. The symmetry of arrangement has been disturbed during the diagenetic growth of crystallites.

Loricas of Upper Tithonian and Lower Cretaceous calpionellids (we studied them in limestones with argillaceous admixture) is composed of hyaline compact substance (Fig. 1B, Pl. 2), consisting of radially oriented, large, irregularly restricted calcite crystals (4 - 7 μm). Their surface is corroded, sometimes covered by newly-formed calcite. In more marly beds, remains of thin organic membrane occur locally inside the wall of the test, rimmed from both sides by tiny (1.5 - 2 μm) calcite crystals (Fig. 1 B, Pl. 2, 9). It seems that loricas of *Crassicollaria* and Lower Cretaceous calpionellids were thinner and originally they contained more abundant calcite elements. They were more intensively affected by diagenesis, if compared with the *Chitinoidella* tests.

Plate 1: Fig. 1 - Structure of the lorica wall of chitinoidellas. SEM photo No. 3858; Fig. 2 - Detail (part of Fig. 4) of caudal appendage of *Ch. boneti* Doben, No. 3859; Fig. 3 - Detail (part of Fig. 4) structure of collar of *Chitinoidella boneti* Doben, No. 3860; Fig. 4 - Transversal section of Chitinoidella test, No. 3856; Fig. 5 - Detail of Fig 4. No. 3857; Fig. 6 - *Chitinoidella boneti* Doben, No. 3866; Fig. 7 - *Ch. dobeni* Borza, No. 3902; Fig. 8 - *Ch. boneti* Doben, No. 3891; Fig. 9 - *Ch. dobeni* Borza, No. 3898; Fig. 10 - Destruction of chitinoidellid test, No. 3899; Fig. 11 - *Ch. boneti* Doben, No. 3866. All the specimens were derived from the Hlboč section, beds No. 31 - 37. (The bar denotes distance of 10 μm).


1
2
3
4
5
6
7
8
9
10
11


1
2
3
4
5
6
7
8
9
10
11

Acknowledgments: The authors are indebted to Prof. Jürgen Remane (Neuchâtel) and to Dr. Jan Řehánek (Hodonín) for critical reading of the manuscript and for valuable comments improving it. We also acknowledge Prof. Milan Mišík, Dr. Ondrej Samuel (Bratislava), Dr. Václav Houša (Praha), and Dr. Ján Soták (Banská Bystrica) for inspiring discussions.

References

Allemann F., 1970: Berriasian calpionellids in Southern Spain. *Abstracts II.Plankt.Conference*, Roma.

Allemann F., Catalano R., Farés F. & Remane J., 1971: Standard calpionellid zonation (upper Tithonian Valanginian) of the western Mediterranean province. *Proceed.II. Plankt. Conference*, Roma, II, 1337 - 1340.

Aubrey M. P., Bignot G., Bismuth H. & Remane J., 1975: Premiers résultats de l'observation au M.E.B. de la lorica des calpionelles et de quelques microfossiles qui leur sont associés. *Revue Micropaleont.* (Paris), 18, 127 - 133.

Andrusov D., 1950: Mesozoic fossils of the Carpathians, I.: Plants and protozoans. *Práce št. geol. úst., Soš.* (Bratislava), 25, 165 (in Slovak).

Bonet F., 1956: Zonification microfaunistica de las calizas cretacicas del Este de Mexico. *XX^e Congr. Internat.* Mexico, *Assoc. Mexic. Geol. Petrol.*, 8, 389 - 488.

Borza K., 1969: Die Mikrofazies und Mikrofossilien des Oberjuras und der Unterkreide der Klippenzone der West Karpaten. *Vydav. Slov. Akad. Vied.*, Bratislava, 301.

Borza K., 1974: Die stratigraphische Verwendung von Calpionelliden in den Westkarpaten. *Sect. Geol. Palaeont., Proc. Xth Congr. CBGA* Bratislava, 31 - 35.

Borza K., 1984: The Upper Jurassic-Lower Cretaceous parabiostratigraphic scale on the basis of Tintinninae, Cadosinidae, Stomiosphaeridae, Calcisphaerulidae and other microfossils from the West Carpathians. *Geol. Zbor. Geol. carpath.* (Bratislava), 35, 5, 539 - 550.

Borza K. & Michalík J.,1986: Problems with delimitation of the Jurassic/Cretaceous boundary in the Western Carpathians. *Acta Geol. Hungar.* (Budapest), 29, 1 - 2, 133 - 149.

Catalano R. & Liguori V., 1971: Facies a Calpionelle della Sicilia occidentale. *Proce. II. Planktonic Conf.*, Roma I, 167 - 210.

Colom G., 1948: Fossil tintinnids: loricated Infusoria of the order of the Oligotricha. *J. Palaeont.* (London), 22, 233 - 263.

Deflandre G., 1936: Tintinnoidiens et Calpionelles. Comparaison entre les Tintintinnoidiens, Infusoires loriqués pélagiques des mers actuelles, et les Calpionelles, microfossiles de l'époque secondaire. *Bull. Soc. Franc. Microsc.* (Paris), 5, 112 - 122.

Dragastan O., Mutiu R. & Vinogradov C., 1973: Microfacies zones of the Jurassic-Cretaceous boundary in the Eastern Carpathians (Hagimas Mts.) and in Moesian Platform. *Stud. Cerc. geol. geogr., Geol.* (Bucureşti), 18, 509 - 533 (in Roumanian).

Furrazola Bermudez G. & Kreisel K., 1973: Los tintínidos fósiles de Cuba. *Rev. technol.* (Habana), 11, 27 - 45.

Houša V.,1990: Ecological aspects of the evolution of calpionellids (Calpionellidae, Protozoa inc.sed.). *Atti 3. Conv. Internat. „Fossili, Evoluzione "Ambiente"*, Pergola 1990, 357 - 363.

Loëblich A.R. & Tappan H., 1968: Annotated Index to Genera, Subgenera and Suprageneric Taxa of the Ciliate Order Tintinnida.- *Journ. Protozoology*, 15, 185 - 192.

Nagy I., 1986: Investigation of calpionellides from the Mecsek Mountains (S. Hungary). *Acta Geol. Hungarica* (Budapest), 29, 1 - 2, 45 - 64.

Noël D. & Busson G., 1990: L'importance des schizosphères, stomiosphères, Conusphaera et Nannoconus dans la genèse des calcaires fins pélagiques du Jurassique et du Crétacé inférieur. *Sci. Géol. Bull.* (Strassbourg), 43, 1, 63 - 93.

Pokorný V.,1954: Principles of zoological micropaleontology. *Naklad. Čs. Akademie Věd* Praha, 651 (in Czech).

Pop G.,1974: Les zones de calpionellides Tithonique - Valanginiennes du sillon de Resita (Carpathes Mériodionales). *Revue Rouman. Géol. Géophys. Géogr., Géologie* (Bucureşti), 18, 109 - 125.

Pop G. 1976: Tithonian - Valanginian calpionellid zones from Cuba. *Dări Seamă sedintelor* (Bucureşti), 62, 237 - 266.

Pop G., 1980: Zones, sous - zones et ensembles caractéristiques de Calpionellidae Tithonique - Néocomiennes. *Ann. Inst. Géol. Géoph.* (Bucureşti), 56, 195 - 203.

Reháková D. & Michalík J., 1992: Correlation of the Jurassic /Cretaceous boundary beds in West Carpathian profiles. *Földt. Közl.* (Budapest), 122/1, 51 - 66.

Remane J.,1964: Untersuchungen zur Systematik und Stratigraphie der Calpionellen in den Jura - Kreide - Grenzschichten des vokontischen Troges. *Palaeontographica* (Stuttgart), A 123., 1 - 57.

Remane J., 1968: Les faunes de calpionelles. In: Le Hégarat G. & Remane J.: Tithonique supérieur de la bordure cévenole. Corrélation des Ammonites et de Calpionelles. *Géobios* (Lyon) 1., 30 - 57.

Remane J., 1969: Les possibilités actuelles pour une utilisation stratigraphique des calpionelles (Protozoa, incertae sedis, Ciliata).- *Proc. I. Plankt. Conf. Microfossils*, Genéve (Leiden), 2, 559 - 573.

Remane J., 1971: Les Calpionelles, Protozoaires planctoniques des mers Mesogéennes de l'époque secondaire. *Ann. Guebhard*, Neuchâtel 47, 369-393.

Remane J., 1985: Calpionellids.- In: Bolli H. ., Sanders J. B. & Perch-Nielsen C. (Eds.): Plankton Stratigraphy. *Cambridge Univ. Press*, Cambridge - London - New York - Melbourne, 555 - 572.

Remane J., Bakalova-Ivanova D., Borza K., Knauer J., Nagy I., Pop G. & Tardi-Filácz E., 1986: Agreement on the subdivision of the standard calpionellid zones defined at the II^nd planktonic conference, Roma 1970. *Acta geol. Hungarica*, 29, 1 - 2, 5 - 14.

Trejo M. 1975: Los tintinidos mesozoicos de Mexico. *Mém. Bureau Rech. Géol. Min.* (Paris), 86, 95 - 104.

Plate 2: Fig. 1 - Transversal section of calpionellid test, No. 1009; Fig. 2 - Detail of Fig.3:1, No. 1010; Fig. 3 - Detail of calpionellid collar structure, No. 1004; Fig. 4 - *Calpionella elliptica* Cadisch, No. 899. Fig. 5 - *Crassicollaria intermedia* (Durand Delga), No. 4129; Figs. 6-7 - *Calpionella alpina* Lorenz, No. 895, 4121; Fig. 8 - *Calpionellites darderi* (Colom), No. 4094; Fig. 9 - *Calpionellopsis simplex* (Colom), No. 4097; Fig. 10 - *Calpionellopsis oblonga* (Cadish), No. 4092; Fig. 11 - *Tintinnopsella carpathica* (Murg. & Filip.), No. 4151; The first four specimens come from the Hlboč section, the others were derived from the Osnica section. Bar = 10 μm.