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VERSITA

Towards a standard Tithonian to Valanginian calpionellid zonation of the Tethyan Realm

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ABSTRACT:

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A calpionellid zonal scheme is proposed for the Tithonian through Valanginian pelagic carbonates of the Western Balkan Unit, based on the vertical ranges of 57 chitinoidellid and calpionellid species recognized. This zonal scheme consists of calpionellid zones that are widely accepted in the Mediterranean Realm, such as the zones of Chitinoidella, Praetintinnopsella, Crassicollaria, Calpionella, Calpionellopsis, Calpionellites and Tintinnopsella. Subzonal divisions are comparable to those in the Carpathians. Direct correlations between ammonite and calpionellid ranges suggest that the base of the Upper Tithonian corresponds to the FO of *Chitinoidella boneti*; that of the Upper Berriasian to the FO of the genus *Calpionellopsis*; and the base and top of the Lower Valanginian to the FO and LO of the genus *Calpionellites* respectively. Correlations of the calpionellid zonation in the study area with zonations in other areas are discussed.

Key words: Calpionellids; Tithonian; Berriasian; Valanginian; Western Balkan Unit; Mediterranean standard zonation.

INTRODUCTION

The pelagic carbonate sequences cropping out in the West Balkan Mountains, western Bulgaria (Text-fig. 1) provide an excellent calpionellid record through the Jurassic–Cretaceous boundary interval. The boundary succession, spanning the Tithonian, Berriasian and Valanginian, is represented lithostratigraphically by the Gintsi Formation (pink and grey nodular limestones), Glozhene Formation (hard grey micritic limestones) and the Salash Formation (alternation of micritic limestones, clayey limestones and marls).

The lithostratigraphy and ammonite biostratigraphy of the successions studied were documented earlier (Nikolov and Sapunov 1970, 1977; Nikolov and Tsankov 1971; Mandov 1971; Sapunov 1976). The Gintsi and Glozhene formations were introduced by Nikolov and Sapunov (1970), and the Salash Formation by Nikolov and Tsankov (1971). Mandov (1971) analysed the lithological sequences and ammonite faunas of the Lower Cretaceous parts of the successions.

The calpionellid biostratigraphy of the Tithonian to Valanginian of the Western Balkan Mts and the Western Fore-Balkan was established by Bakalova (1977), Lakova (1993, 1994), Lakova *et al.* (1999, 2007) and Ivanova *et al.* (2006). Bakalova (1977) recognized the zones of Chitinoidella through to Calpionellites, with two subzones (Alpina and Elliptica-Carpathica) distinguished in the Calpionella Zone. Bakalova-Ivanova (1986) divided the Calpionella Zone into the Alpina, Remaniella and Elliptica subzones.

Three main periods can be distinguished in the calpionellid biostratigraphic studies of the uppermost Jurassic and Lower Cretaceous. The first period, initiated by

Remane (1963, 1971), Allemann *et al*. (1971), Trejo (1980) and Borza (1984), ended with the establishment of the standard zonation for the Tethyan Realm. During the second period (1986–1999) the calpionellid zonation was refined, and the key bioevents and subzones were defined (Pop 1986c, 1989, 1994, 1997b; Bakalova-Ivanova 1986; Remane *et al*. 1986; Reháková 1995; Reháková and Michalík 1997a, b; Grün and Blau 1997; Lakova *et al*. 1999). The third period represents a renaissance of capionellid research, with new projects spanning wider geographic territories, refining the taxonomy and biostratigraphy of the group, and integrating calpionellid studies with other biostratigraphies, as well as with chemo- and magnetostratigraphy.

The present paper aims at presenting the results of a calpionellid zonation for the Western Balkan Mts, western Bulgaria, with discussion of the correlations with all of the important previous zonations in the Tethyan Realm. The widely accepted calpionellid bioevents and subzones, and selected unresolved problems are discussed.

The calpionellid biostratigraphy of the Gintsi 1 and Gintsi 2 sections studied herein was the subject of SP's unpublished Ph.D. thesis "Ammonite and calpionellid biostratigraphy of the Berriasian, Valanginian and Hauterivian in the Western Srednogorie and Western Balkan Mts", supervised by IL. The calpionellids from the Barlya section have been re-studied using material from Lakova *et al.* (1999), reflecting more recent taxonomic concepts and knowledge of calpionellid bioevents.

SECTIONS STUDIED AND MATERIAL

The study is based on three sections, Barlya, Gintsi 1 and Gintsi 2, located in the Western Balkan Mts, western Bulgaria (Text-fig. 1).

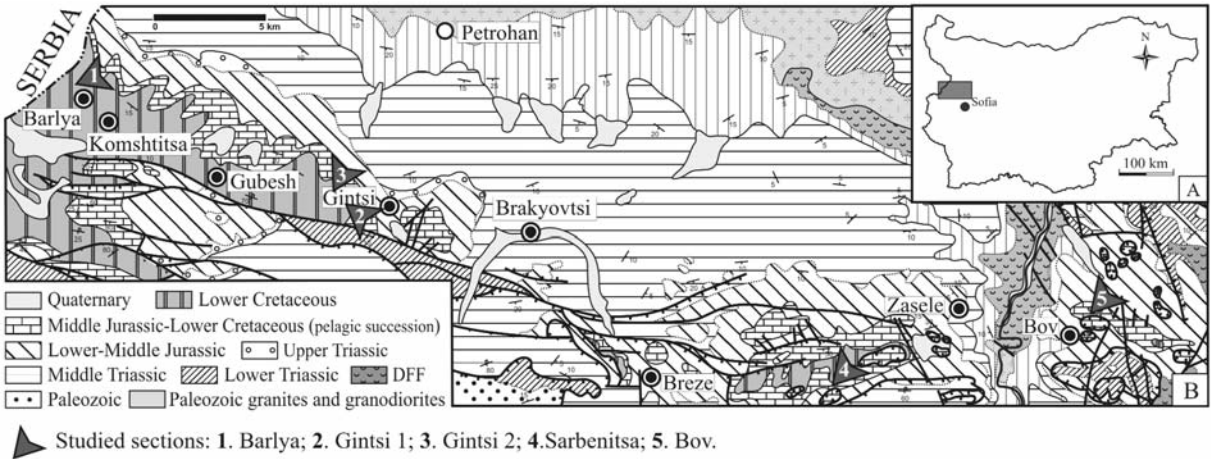
The Barlya section is located immediately north of the village of Barlya, Sofia District (Text-fig. 2). A total of 57 thin sections were examined from this locality, spanning the top of the Gintsi Formation (samples 0310–0308), the Glozhene Formation (samples 0307–329), and the lower part of the Salash Formation (330–346). The sampling interval was usually 1 m, and was 5 m in the Salash Formation.

The two Gintsi sections (Text-figs 3, 4) are located in the southern part of the village of Gintsi, Sofia District, on the right bank of the Nishava River (Text-fig. 1). 50 thin sections, with a sampling interval of 1 m, were examined from the Gintsi 1 section, spanning the upper part of the Gintsi Formation (10 m), the Glozhene Formation (37 m), and the lowermost part of the Salash Formation (3 m) (Text-fig. 3). 54 thin sections from the Gintsi 2 section came from various sources; we used the old sample set of Bakalova (in Nikolov and Sapunov 1977) for the upper part of the Gintsi Formation (13 m, samples 608–610) and the lower part of the Glozhene Formation (19 m, samples 611–618). New samples were taken from the highest 7 m of the Glozhene Formation (samples 1–18), and from the basal 31 m of the lower part of the Salash Formation (samples 19–39) (Text-fig. 4). The average sample interval in the Gintsi 2 section was between 1 and 2 m.

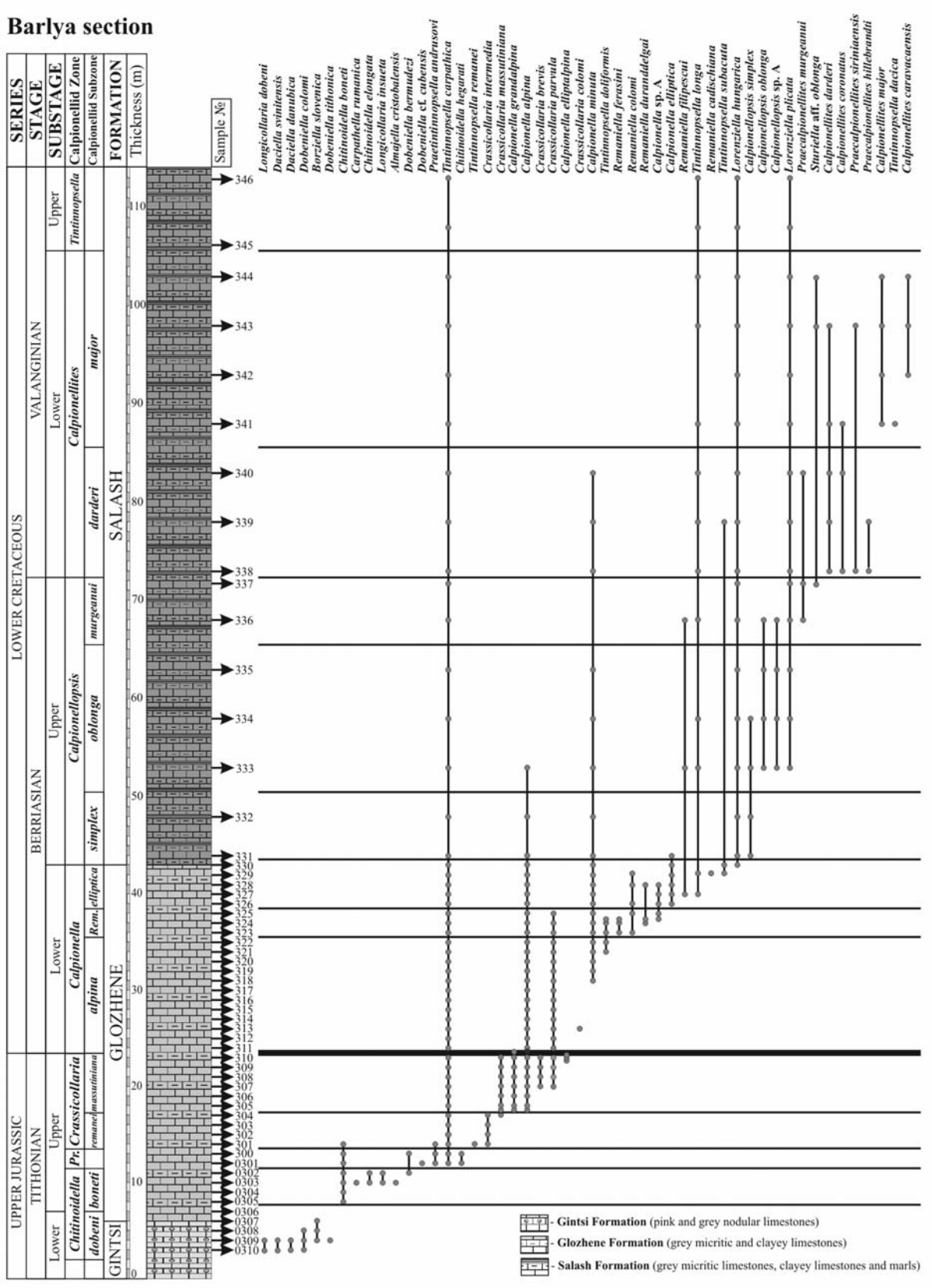
The Gintsi 2 section is the type section of the Gintsi Formation (Sapunov and Ziegler 1976), and it is the section presented during the International symposium on the Jurassic/Cretaceous boundary in Bulgaria (Nikolov and Sapunov 1977).

CALPIONELLID BIOZONATION OF THE WESTERN BALKAN MTS

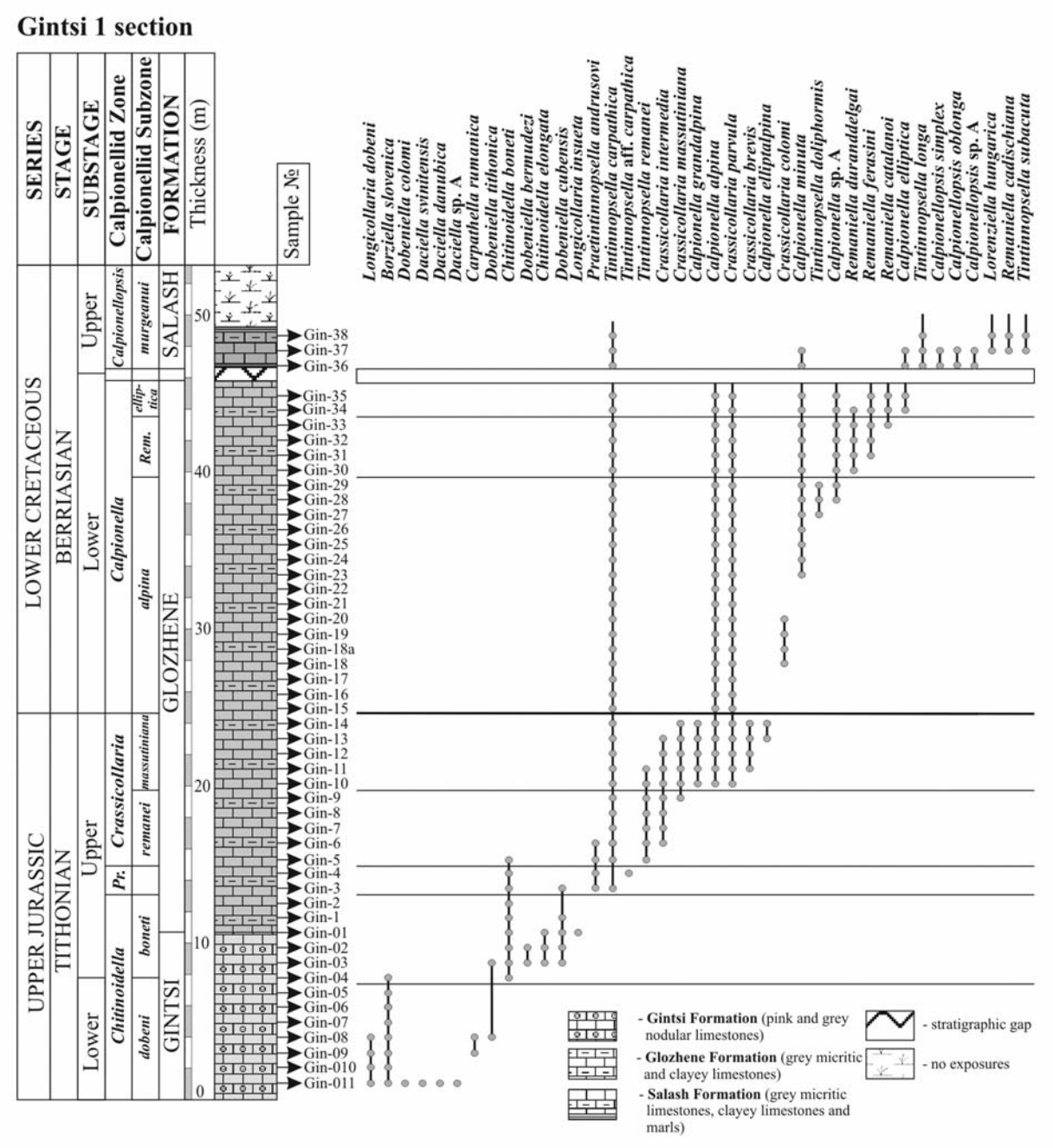
The microfossils of the succession studied are represented by calpionellids, calcareous nannofossils, cal-



Text-fig. 1. Location map of Bulgaria (courtesy of L. Metodiev) with position of the study area (A) and geological map (B) of the study area with positions of the sections studied



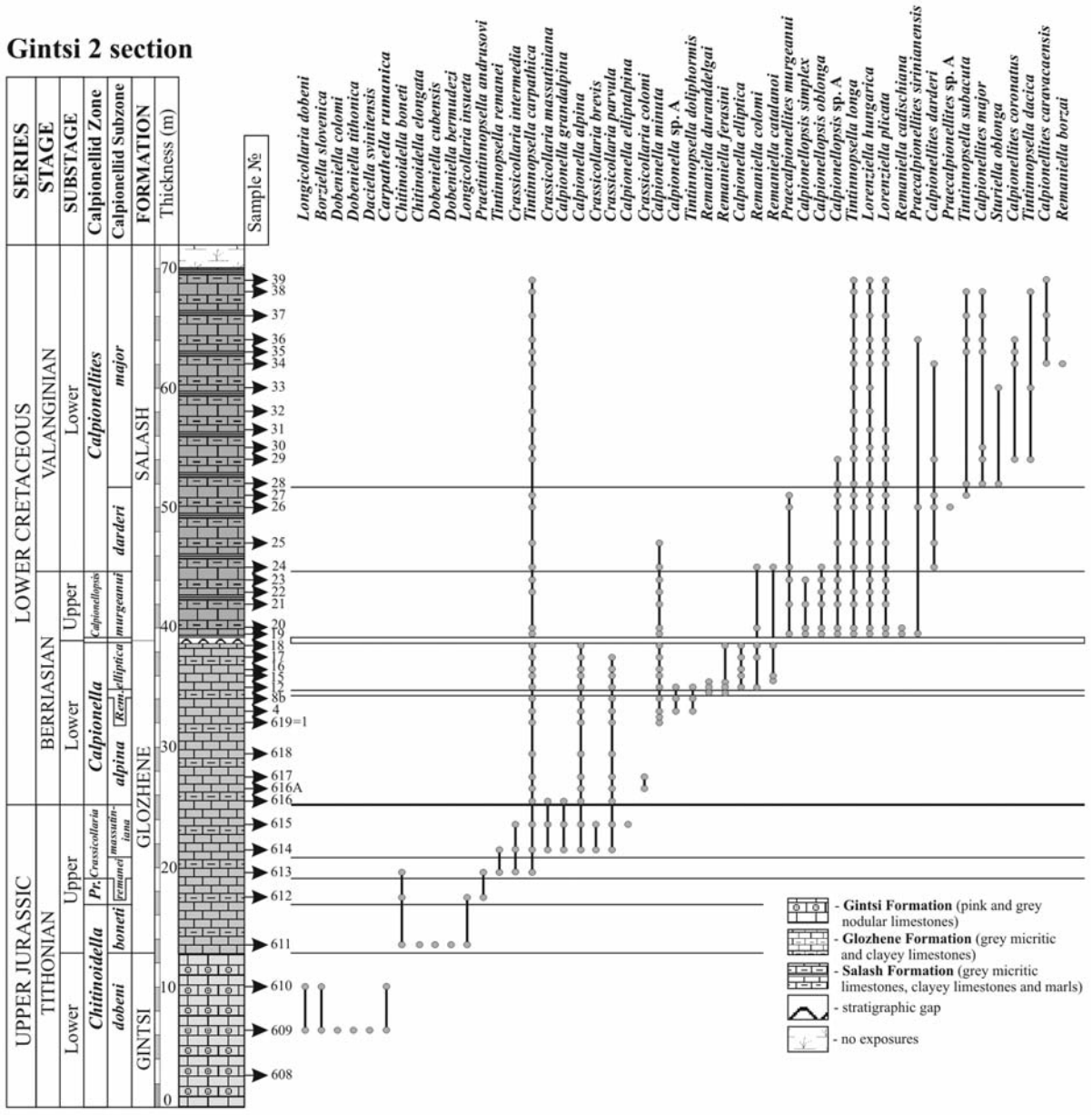
Text-fig. 2. Lithological log with calpionellid occurrences in the Barlya section



Text-fig. 3. Lithological log with calpionellid occurrences in the Gintsi 1 section

careous dinocysts, globochaetids, radiolarians and small benthic foraminifers. Macrofossils, such as bivalves, gastropods, ostracods, aptychi and juvenile ammonites, also occur. Spicules of siliceous sponges, crinoid and echinoid fragments derived from a neighbouring carbonate platform are less common. The fossil content identifies the sediments as hemipelagic to pelagic deposits. Koleva-Rekalova (in Lakova *et al.* 2007) classified the limestones as wackestones and mudstones and distinguished the following microfacies in stratigraphic order: Saccocoma, Globochaete, Calpionellid and Spicule microfacies.

The calpionellids are characterized by rapid evolution and vast geographic distribution, so they are ideal for biostratigraphic studies. They are essential for fine subdivision, precise dating and reliable long-distance correlation of pelagic carbonates of Tithonian to Valanginian age throughout the Mediterranean Realm.



Text-fig. 4. Lithological log with calpionellid occurrences in the Gintsi 2 section

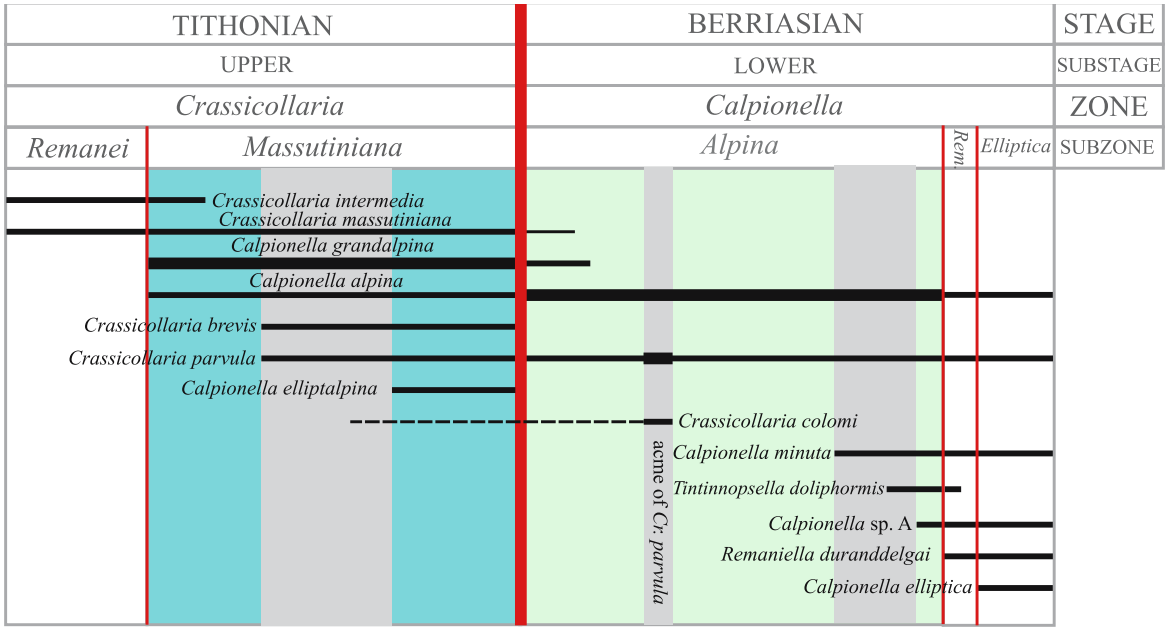
Numerous calpionellid zonal schemes exist. The zonal and subzonal scheme of Pop (1994, 1997b) and Reháková and Michalík (1997a, b), slighty modified by Lakova (1993) and Lakova *et al*. (1999, 2007), is used herein. Seven calpionellid zones and eleven interval subzones are recognized and characterized in the present report (Text-fig. 6).

This zonation is based on the vertical ranges of 57 species of chitinoidellids and calpionellids. Fourteen successive calpionellid bioevents, mainly first occurrences (FOs), serve as indicators of the lower zonal and subzonal boundaries (Text-fig. 6). Thus, the calpionellid zones and subzones are almost invariably interval zones.

Tithonian

Chitinoidella Zone (Lower and Upper Tithonian); Plates 1, 5

The Chitinoidella Zone was introduced by Enay and Geyssant (1975) and defined by Grandesso (1977).



Text-fig. 5. Calpionellid bioevents within the Crassicollaria and Calpionella zones

It is subdivided into the Dobeni and Boneti subzones, characterized by Grandesso (1977) and Borza (1984). The lower boundary of the zone is defined by the FO of microgranular-walled chitinoidellids.

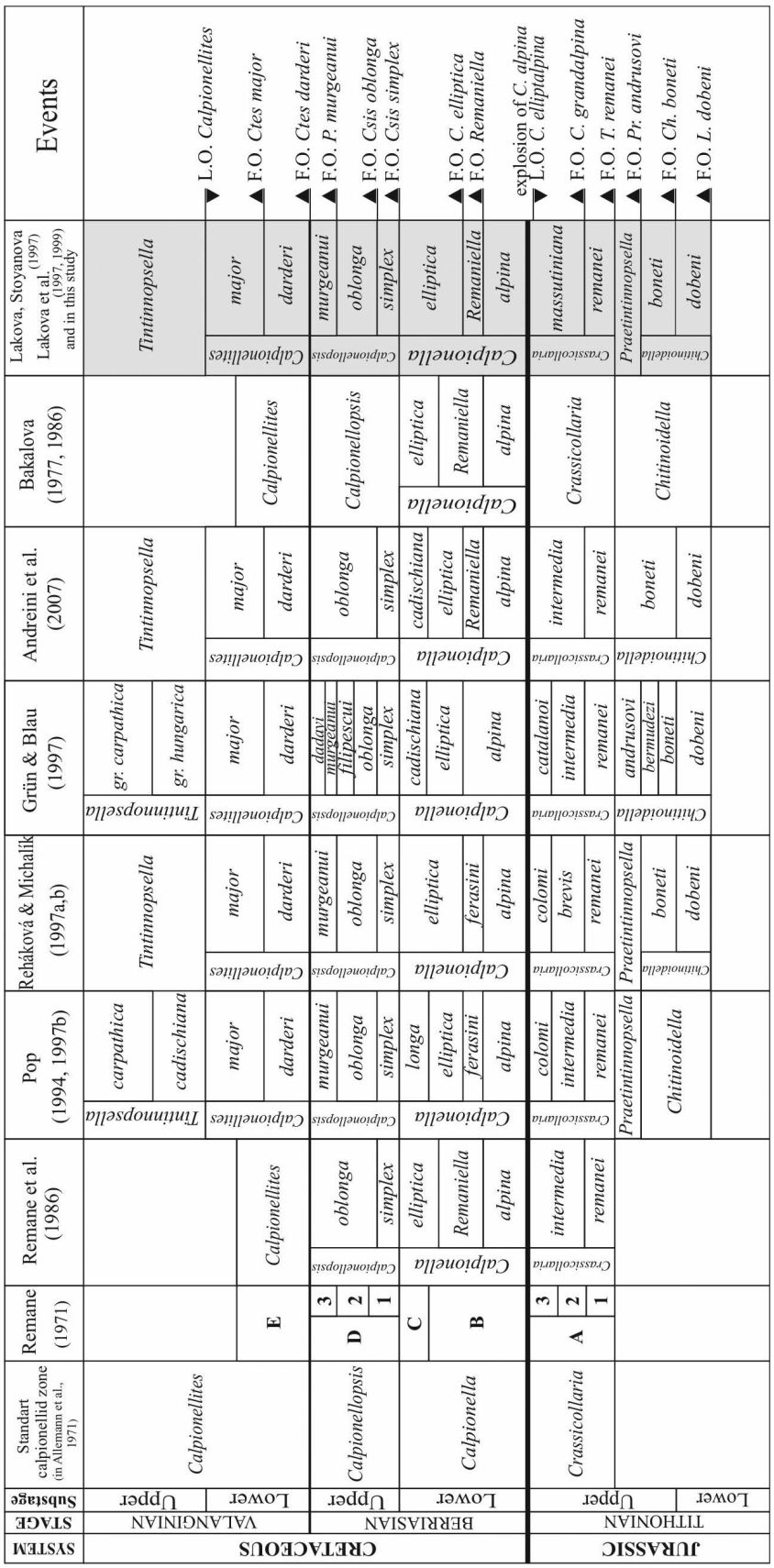
Correlations: The Chitinoidella Zone was recorded from Spain (Enay and Geyssant 1975, Pruner *et al.* 2010), Slovakia (Borza 1984; Borza and Michalík 1986; Reháková 1995; Reháková and Michalík 1997a, b; Houša *et al.* 1999a, b; Michalík *et al.* 2009; Grabowski *et al.* 2010b), Hungary (Grabowski *et al.* 2010a), Romania (Pop 1986b, 1994, 1997b, 1998b), Poland (Pszczółkowski 1996; Pszczółkowski and Myczyński 2004; Grabowski and Pszczółkowski 2006), Ukraine (Reháková *et al.* 2011), Italy (Grandesso 1977; Channell and Grandesso 1987; Grün and Blau 1997; Andreini *et al.* 2007; Houša *et al.* 2004), Austria (Reháková *et al.* 1996, 2009; Lukeneder *et al.* 2010), Turkey (Altiner and Özkan 1991), Tunisia (Boughdiri *et al.* 2006, 2009; Sallouhi *et al.* 2011), Morocco (Benzaggagh and Atrops 1995; Benzaggagh *et al.* 2010), Cuba (Pszczółkowski 1999; Pszczółkowski and Myczyński 2010). The presence of the genus *Chitinoidella* was also reported from Germany (Doben 1963). In Bulgaria, the Chitinoidella Zone was recognized in the Western Balkan Mts (Bakalova 1977; Lakova 1993; Lakova *et al.* 1999), in the Western Fore-Balkan (Lakova *et al.* 1999), in the Central Fore-Balkan (Ivanova 1997) and from the subsurface of the Moesian Platform of northeast Bulgaria (Ivanova *et al.* 2002).

Sallouhi *et al.* (2011) proposed a new, more detailed subdivision of the classic Chitinoidella Zone. They introduced the Longicollaria Zone, equivalent of the Dobeni Subzone, and restricted their Chitinoidella Zone to the interval of the widely used Boneti Subzone. Our study has not confirmed the presence of *Dobeniella bermudezi* below the FO of *Chitioidella boneti*. Further detailed studies outside North Africa may support Sallouhi's *et al.* (2011) chitinoidellid subzonal division.

Dobeni Subzone. Its lower boundary coincides with the zonal base, which is indicated by the FO of *Longicollaria dobeni*. The chitinoidellids are represented by *Borziella slovenica*, *Dobeniella colomi*, *Dobeniella tithonica*, *Daciella svinitensis*, and *Carpathella rumanica*. The subzone corresponds to the upper part of the Gintsi Formation. Its thickness is 5 to 8 m.

This subzone was previously reported from the Western Carpathians, Slovakia (Borza 1984; Borza and Michalík 1986; Reháková 1995, 2002; Reháková and Michalík 1997a, b; Houša *et al.* 1999a, b; Michalík *et al.* 2009; Grabowski *et al.* 2010b), Southern Carpathians, Romania (Pop 1994, 1997b, 1998b), Italy (Andreini *et al.* 2007), Spain (Pruner *et al.* 2010), Hungary (Grabowski *et al.* 2010a), Tunisia (Boughdiri *et al.* 2006, 2009), Morocco (Benzaggagh and Atrops 1995; Benzaggagh *et al.* 2010); Cuba (Pszczółkowski and Myczyński 2010); and Bulgaria (Western Balkan Mts and the Western Fore-Balkan; Lakova 1993; Lakova *et al.* 1999).

Boneti Subzone. The base of the subzone is defined by the FO of *Chitinoidella boneti*. The assemblage is dominated by *Chitinoidella boneti*; *Longicollaria insueta*,



Text-fig. 6. Correlation between calpionellid zonations proposed for the Lower Tithonian to Upper Valanginian in the Mediterranean Realm and calpionellid FO events for the Lower Tithonian to Upper Valanginian

Dobeniella cubensis, *Dobeniella bermudezi, Almajella cristobalensis* and *Daciella danubica* also occur. The subzone is 4.5 to 7 m thick and comprises the uppermost part of the Gintsi Formation and the base of the Glozhene Formation.

The Boneti Subzone was recorded from Slovakia (Borza 1984; Borza and Michalík 1986; Reháková 1995, 2002; Reháková and Michalík 1997a, b; Houša *et al*. 1999a, b; Michalík *et al.* 2009; Grabowski *et al.* 2010b), Poland (Grabowski and Pszczółkowski 2006), Romania (Pop 1997b, 1998b), Italy (Grün and Blau 1997; Andreini *et al.* 2007; Houša *et al.* 2004), Spain (Pruner *et al.* 2010), Hungary (Grabowski *et al.* 2010a), Austria (Reháková *et al.* 2009; Lukeneder *et al.* 2010), Tunisia (Boughdiri *et al.* 2006, 2009), Morocco (Benzaggagh and Atrops 1995; Benzaggagh *et al*. 2010); Cuba (Pszczółkowski and Myczyński 2010); and Bulgaria (Gintsi 2 section, Bakalova 1977; Western Balkan Mts., Lakova 1993; Central Fore-Balkan, Ivanova 1997; and Western Fore-Balkan, Lakova *et al.* 1999).

Praetintinnopsella Zone (Upper Tithonian); Plates 1, 5

The base of the zone is defined by the FO of *Praetintinnopsella andrusovi* and its top by the FO of representatives of the family Calpionellidae with hyaline calcite wall (Grandesso 1977). Its interval includes ca. 0.5 to 2.0 m of the lower part of the Glozhene Formation. *P. andrusovi* co-occurs with *Chitinoidella boneti, Chitinoidella hegarati*, and single atypical *Tintinnopsella carpathica.*

Correlations: The Praetintinnopsella Zone was recorded from Slovakia (Borza 1984; Borza and Michalík 1986; Reháková 1995; Reháková and Michalík 1997a; Michalík *et al*. 2009), Romania (Pop 1994, 1997b, 1998b), Poland (Pszczółkowski 1996; Grabowski and Pszczółkowski 2006), Hungary (Grabowski *et al.* 2010a), Ukraine (Reháková *et al.* 2011), Austria (Reháková *et al*. 2009; Lukeneder *et al.* 2010), and from Italy (Grandesso 1977; Andreini *et al.* 2007). It is also known as the "andrusovi subzone" of the Chitinoidella Zone in Italy (Grün and Blau 1997), Spain (Pruner *et al.* 2010), and Cuba (Pszczółkowski and Myczyński 2010). The genus *Praetintinnopsella* also occurs in the upper part of the Chitinoidella Zone in Turkey (Altiner and Özkan 1991), without defining a separate zone. In Bulgaria the Praetintinnopsella Zone was distinguished in the Barlya section in the Western Balkan Mts (Lakova 1993), in the Gintsi 1 and 2 sections (Lakova and Petrova 2009), in the Central Fore-Balkan (Ivanova 1997), and in the Western Fore-Balkan (Lakova *et al*. 1999).

Crassicollaria Zone (Upper Tithonian); Plates 1, 2, 5, 6

The zone was introduced as the "A Zone" by Remane (1963). The Crassicollaria Zone was defined by Allemann *et al.* (1971). Its lower boundary is defined by the FO of hyaline-walled calpionellids and its upper boundary by the "explosion" of the medium-sized spherical variety of *Calpionella alpina*. The zone is here divided into two subzones, Remanei and Massutiniana.

Correlations: The zone is widely known from the Tethyan Realm: in France (Remane 1963, 1971; Le Hégarat and Remane 1968; Cecca *et al.* 1989), Italy (Catalano and Liguori 1971; Channell and Grandesso 1987; Grün and Blau 1997; Andreini *et al.* 2007; Houša *et al.* 2004), Spain (Allemann *et al.* 1975; Pruner *et al.* 2010), Slovakia (Borza 1984; Borza and Michalík 1986; Reháková 1995; Reháková and Michalík 1997a, b; Houša *et al.* 1999a, b; Michalík *et al.* 2009; Grabowski *et al.* 2010b), Poland (Wierzbowski and Remane 1992; Pszczółkowski 1996; Pszczółkowski and Myczyński 2004; Grabowski and Pszczółkowski 2006), Romania (Pop 1974, 1986b, c, 1994, 1997b, 1998b; Barbu and Melinte-Dobrinescu 2008), Hungary (Grabowski *et al*. 2010a), Austria (Reháková *et al.* 1996, 2009; Lukeneder *et al.* 2010), Greece (Skourtsis-Coroneou and Solakius 1999), Turkey (Altiner and Özkan 1991), Iran (Azimi *et al.* 2008), Tunisia (Boughdiri *et al.* 2006, 2009). It is the same as the "A zone" of Remane (1963) in Tunisia (Ben Abdesselam-Mahdaoui *et al.* 2010), Morocco (Benzaggagh and Atrops 1995; Benzaggagh *et al.* 2010), Cuba (Pop 1976; Pszczółkowski *et al.* 2005; Pszczółkowski and Myczyński 2010) and Mexico (Trejo 1980; Adatte *et al.* 1994). In Bulgaria the Crassicollaria Zone was established in the Western Balkan Mts and the Western Fore-Balkan (Bakalova 1977; Lakova 1993; Lakova *et al.* 1999), in the Central Fore-Balkan (Ivanova 1997) and is known from the subsurface of the Moesian Platform in northeast Bulgaria (Ivanova *et al.* 2002). Lakova *et al.* (2009) reported the Crassicollaria Zone from eastern Serbia.

Remanei Subzone. The subzone was defined by Remane *et al.* (1986) as the lower subzone of the Crassicollaria Zone, equivalent to the A1 subzone of Remane (1963). Its lower boundary is marked by the almost simultaneous appearance of *Tintinnopsella remanei* and the typical small variety of *Tintinnopsella carpathica*. *Crassicollaria intermedia* first appears in this subzone. The subzone is 4 to 5 m thick in the Glozhene Formation in all three sections.

Correlations: The subzone is known from Romania (Pop 1986b, 1994), Slovakia (Reháková and Michalík

1997a, b; Houša *et al.* 1999a, b; Michalík *et al.* 2009; Grabowski *et al.* 2010b), Poland (Wierzbowski and Remane 1992; Pszczółkowski 1996; Grabowski and Pszczółkowski 2006), Italy (Grün and Blau 1997; Andreini *et al.* 2007; Houša *et al.* 2004), Hungary (Grabowski *et al.* 2010a), Austria (Reháková *et al.* 2009; Lukeneder *et al.* 2010), Spain (Pruner *et al.* 2010), Tunisia (Boughdiri *et al.* 2006, 2009; Sallouhi *et al.* 2011) and Cuba (Pszczółkowski and Myczyński 2010). In Bulgaria it is known from the Western Balkan Mts and Western Fore-Balkan (Lakova 1993; Lakova *et al.* 1999), as well as from the subsurface of the Moesian Platform (Ivanova *et al.* 2002). The Remanei Subzone was determined as the A1 Subzone in France (Remane 1963, 1971; Cecca *et al.* 1989), Turkey (Altiner and Özkan 1991) and Morocco (Benzaggagh and Atrops 1995; Benzaggagh *et al.* 2009). It is equivalent to the lower Crassicollaria intermedia Subzone sensu Pop (1974) in Romania, and sensu Skourtsis-Coroneou and Solakius (1999) in Greece.

Massutiniana Subzone. This subzone was introduced by Lakova (1993). It corresponds to the A2 + A3 subzones of Remane (1963) and to the Intermedia Subzone of Remane *et al.* (1986). The lower boundary of the Massutiniana Subzone is marked by the FOs of *Calpionella grandalpina* and *Calpionella alpina*. The subzone is characterized by high diversity of the genus *Crassicollaria* and a quantitative increase in calpionellids. *Crassicollaria massutiniana*, *C. brevis* and *C. parvula* first appear in this zone, and *Calpionella elliptalpina* is limited to the zone (Text-fig. 5). The subzone is 5 to 6 m thick in the Glozhene Formation.

The Massutiniana Subzone was previously recorded in Bulgaria (Lakova 1993; Lakova *et al.* 1999; Ivanova *et al.* 2002). It is equivalent to the Intermedia + Colomi Subzones in Romania (Pop 1994), to the Brevis + Colomi Subzones in Slovakia (Reháková and Michalík 1997a, b; Michalík *et al.* 2009), to the A2 + A3 Subzones in France (Remane 1963, 1971; Cecca *et al.* 1989), Poland (Wierzbowski and Remane 1992), Turkey (Altiner and Özkan 1991) and Morocco (Benzaggagh and Atrops 1995; Benzaggagh *et al.* 2010), to the Intermedia + Catalanoi Subzones in Italy (Grün and Blau 1997) and to the Intermedia Subzone in Italy (Andreini *et al.* 2007; Houša *et al*. 2004), Poland (Pszczółkowski 1996; Grabowski and Pszczółkowski 2006), Slovakia (Houša *et al.* 1999a, b; Grabowski *et al.* 2010b), Hungary (Grabowski *et al.* 2010a), Austria (Reháková *et al.* 2009; Lukeneder *et al.* 2010), Spain (Pruner *et al.* 2010), Romania (Barbu and Melinte-Dobrinescu 2008), Tunisia (Boughdiri *et al.* 2006, 2009) and Cuba (Pszczółkowski and Myczyński 2010); to the Brevis-Parvula Subzone in Romania (Pop 1974); and to the Intermedia + Brevis Subzones in Greece (Skourtsis-Coroneou and Solakius 1999).

Berriasian

Callpionella Zone (Lower Berriasian); Plates 2, 6

The Calpionella Zone was introduced and defined by Allemann *et al.* (1971). Its lower boundary is marked by the "explosion" of *Calpionella alpina*, i.e. the medium-sized spherical variety of this species. This boundary was recommended as the base of the Berriasian Stage at the Lyon-Neuchâtel Colloquium in 1973 and the 32nd International Geological Congress in Florence, 2004. The zone was divided into three subzones (Remane *et al.* 1986): Alpina, Remaniella and Elliptica.

Correlations: The zone is known from Slovakia (Borza 1984; Borza and Michalík 1986; Reháková 1995, 2000a; Reháková and Michalík 1997a, b; Houša *et al.* 1999a, b; Michalík *et al.* 2009; Grabowski *et al.* 2010b), Poland (Pszczółkowski 1996; Pszczółkowski and Myczyński 2004; Boorova *et al.* 2004; Grabowski and Pszczółkowski 2006), Romania (Pop 1974, 1986b, c, 1994, 1997b, 1998b; Barbu and Melinte-Dobrinescu 2008), eastern Serbia (Lakova *et al.* 2009), Greece (Skourtsis-Coroneou and Solakius 1999), Italy (Channell and Grandesso 1987; Grün and Blau 1997; Houša *et al.* 2004; Andreini *et al.* 2007), Austria (Vašíček *et al.* 1999; Lukeneder and Reháková 2004, 2007; Reháková *et al.* 1996, 2009; Lukeneder *et al.* 2010), Hungary (Grabowski *et al.* 2010b), Spain (Pruner *et al.* 2010), Iran (Azimi *et al.* 2008), Tunisia (Boughdiri *et al.* 2006, 2009), Morocco (Benzaggagh and Atrops 1995; Benzaggagh *et al.* 2009), Cuba (Pop 1976; Pszczółkowski *et al.* 2005; Pszczółkowski and Myczyński 2010), Mexico (Adatte *et al.* 1994) and Bulgaria (Bakalova 1977; Lakova 1993; Lakova *et al.* 1999; Ivanova 1997; Ivanova *et al.* 2002). It is known as the B + C zones in France (Remane 1963, 1971; Le Hégarat and Remane 1968; Cecca *et al.* 1989), and Turkey (Altiner and Özkan 1991), as the B + C zones (Calpionella alpina + Calpionella elliptica) in Italy (Catalano and Liguori 1971), Spain (Allemann *et al.* 1975) and Poland (Wierzbowski and Remane 1992); and as the Calpionella alpina + Calpionella elliptica Subzones, in Mexico (Trejo 1980). Ben Abdesselam-Mahdaoui *et al.* (2011) recognized five successive subzones in the Calpionella Zone, namely B1, B2, B3, C1 and C2. Of these, their B2+B3 subzones equate by definition with the Remaniella Subzone; and their C2 Subzone with the Elliptica Subzone.

Alpina Subzone. This subzone was introduced and defined by Pop (1974). Its base is defined by the "explosion" of *Calpionella alpina*, and its top by the FO of the genus *Remaniella*. *Calpionella alpina* is the dominant species in this subzone. Three other bioevents within the Alpina Subzone could be used for a further subdivision. These are the acme of *Crassicollaria parvula*, and the FOs of *Calpionella minuta* and *Tintinnopsella doliformis*. Additional studies may confirm the usefulness and geographic record of these minor bioevents, which have been so far documented in Spain (Pruner *et al.* 2010). *Crassicollaria colomi* has been recorded below and above the lower boundary of the Alpina Subzone (Textfig. 5) in this study, as well as in the Komshtitsa section earlier (Lakova 1993; Lakova *et al.* 2007). This record of *Cr. colomi* in the Alpina Subzone differs from data reported in the Western and Southern Carpathians and elsewhere in the Mediterranean Realm, where *Cr. colomi* was documented only in the highest part of the underlying Crassicollaria Zone and was even used to define the Colomi Subzone. The Alpina Subzone is normally 16 m thick (Glozhene Formation) in the sections studied.

Correlations: The subzone is known from Romania (Pop 1974, 1986b, c, 1994, 1997b, 1998b; Barbu and Melinte-Dobrinescu 2008), eastern Serbia (Lakova *et al.* 2009), Slovakia (Reháková 1995, 2000a; Reháková and Michalík 1997a, b; Houša *et al.* 1999a, b; Michalík *et al.* 2009; Grabowski *et al*. 2010b), Poland (Pszczółkowski 1996; Pszczółkowski and Myczyński 2004; Grabowski and Pszczółkowski 2006), Ukraine (Reháková *et al.* 2011), Italy (Grün and Blau 1997; Houša *et al.* 2004; Andreini *et al*. 2007), Hungary (Grabowski *et al.* 2010a), Austria (Vašíček *et al.* 1999; Reháková *et al.* 1996, 2009; Lukeneder *et al.* 2010), Tunisia (Boughdiri *et al.* 2006, 2009), Greece (Skourtsis-Coroneou and Solakius 1999), Iran (Azimi *et al.* 2008) and Cuba (Pop 1976; Pszczółkowski and Myczyński 2010). Its correlatives are: the lower Calpionella alpina Zone in Italy (Catalano and Liguori 1971; Allemann *et al.* 1975); the lower B Zone in France, Morocco, Turkey (Remane, 1963, 1971; Le Hégarat and Remane 1968; Cecca *et al.* 1989; Benzaggagh and Atrops 1995; Benzaggagh *et al.* 2010; Altiner and Özkan 1991), and the lower Calpionella Zone in Mexico (Trejo 1980). In Bulgaria it is known as the Calpionella alpina Subzone in the Western Balkan Mts, Western Fore-Balkan and from the subsurface of the Moesian Platform (Bakalova-Ivanova 1986; Lakova 1993; Lakova *et al.* 1999; Ivanova 1997; Ivanova *et al.* 2002).

Remaniella Subzone. This subzone was defined by Pop (1974), and its lower boundary was redefined by Remane *et al.* (1986). The base of the Remaniella Subzone is defined by the FO of *Remaniella ferasini* and/or *R. duranddelgai* and its upper boundary by the FO of *Calpionella elliptica*. It is characterized by *R. ferasini*, *R. duranddelgai*, *Calpionella alpina*, *C. minuta*, *Crassicollaria parvula* and *Tintinnopsella carpathica* (small form). The abundance of calpionellids decreases rapidly in this subzone. It is 3 m thick in the Gintsi 1 and Barlya sections, 0.5 m thick in the Gintsi 2 section; and is limited to the Glozhene Formation.

Correlations: The subzone is known from Romania (Pop 1974, 1986b, c), Serbia (Lakova *et al.* 2009), Poland (Pszczółkowski 1996), Italy (Houša *et al.* 2004; Andreini *et al.* 2007), Morocco (Boughdiri *et al*. 2006, 2009), Greece (Skourtsis-Coroneou and Solakius 1999) and Cuba (Pop 1976). It is known as the Ferasini Subzone in Romania (Pop 1994, 1997b, 1998b; Barbu and Melinte-Dobrinescu 2008), Slovakia (Reháková 1995; Reháková and Michalík 1997a, b; Grabowski *et al.* 2010b), Poland (Pszczółkowski and Myczyński 2004; Grabowski and Pszczółkowski 2006), Ukraine (Reháková *et al.* 2011), Austria (Vašíček *et al.* 1999; Lukeneder and Reháková 2004; Reháková *et al.* 1996, 2009; Lukeneder *et al.* 2010). Its equivalents are: the upper B Zone in France (Remane 1963, 1971; Le Hégarat and Remane 1968) and Turkey (Altiner and Özkan 1991); the upper Calpionella alpina Zone in Italy (Catalano and Liguori 1971) and Spain (Allemann *et al.* 1975), as well as the upper Calpionella alpina Zone sensu Grün and Blau (1997). In Bulgaria it was reported by Bakalova-Ivanova (1986); Lakova (1993); Lakova *et al.* (1999); Ivanova (1997); Ivanova *et al*. (2002).

Elliptica Subzone. Catalano and Liguori (1971) introduced the zone as the "Calpionella elliptica Zone". Pop (1974) redefined it, placing its base at the FO of *C. elliptica*, as the Calpionella elliptica Subzone, the latter being equivalent to Catalano and Liguori's zone. In the present study the Elliptica Subzone has been used in the sense of Pop (1974). It is 2 to 4.5 m thick in the upper parts of the Glozhene Formation.

Correlations: The subzone is known from Romania (Pop 1974, 1986b, c), Serbia (Lakova *et al.* 2009), Slovakia (Reháková 1995; Reháková and Michalík 1997a, b), Poland (Wierzbowski and Remane 1992; Pszczółkowski 1996), Austria (Vašíček *et al.* 1999; Lukeneder and Reháková 2004, 2007; Reháková *et al.* 1996, 2009; Lukeneder *et al.* 2010), Morocco (Boughdiri *et al.* 2006, 2009), Greece (Skourtsis-Coroneou and Solakius 1999), Iran (Azimi *et al.* 2008), Cuba (Pop 1976; Pszczółkowski and Myczyński 2010) and Mexico (Trejo 1980). It is also known as the Calpionella elliptica Zone in Italy (Cata-

lano and Liguori 1971) and Spain (Allemann *et al.* 1975). Its correlatives are: the C Zone in France (Remane 1963, 1971; Le Hégarat and Remane 1968) and Turkey (Altiner and Özkan 1991); the Elliptica + Longa subzones in Romania (Pop 1994, 1997b; Barbu and Melinte-Dobrinescu 2008), the Elliptica + Cadischiana subzones in Italy (Grün and Blau 1997; Andreini *et al.* 2007), Poland (Pszczółkowski and Myczyński 2004; Grabowski and Pszczółkowski 2006), Slovakia (Grabowski *et al.* 2010b) and Hungary (Fözy *et al.* 2010). In Bulgaria it was reported from the Western Balkan Mts and the Western Fore-Balkan by Bakalova-Ivanova (1986), Lakova (1993) Lakova *et al.* (1999) and Petrova (2010); from the Central Fore-Balkan by Ivanova (1997); and from the Moesian Platform by Ivanova *et al*. (2002).

Calpionellopsis Zone (Upper Berriasian); Plates 3, 4, 7

The zone was introduced as the "D Zone" by Remane (in Le Hégarat and Remane 1968) and defined subsequently as the Calpionellopsis Standard Zone by Allemann *et al*. (1971). It is defined by the FO of *Calpionellopsis simplex* (base) and the FO of *Calpionellites darderi* (top). It is divided into three subzones, Simplex, Oblonga and Murgeanui.

Correlations: The zone is known from France (Le Hégarat and Remane 1968; Blanc *et al.* 1994), Spain (Allemann *et al.* 1975; Aguado *et al.* 2000), Italy (Catalano and Liguori 1971; Channell and Grandesso 1987; Grün and Blau 1997; Andreini *et al.* 2007), Slovakia (Borza 1984; Borza and Michalík 1986; Reháková 1995, 2000a; Reháková and Michalík 1997a, b), Poland (Wierzbowski and Remane 1992; Pszczółkowski 1996; Pszczółkowski and Myczyński 2004; Grabowski and Pszczółkowski 2006), Romania (Pop 1974, 1986b, 1994, 1997b; Barbu and Melinte-Dobrinescu 2008), Greece (Skourtsis-Coroneou and Solakius 1999), Austria (Vašíček *et al.* 1999; Lukeneder and Reháková 2004, 2007; Reháková *et al.* 1996), Hungary (Fözy *et al.* 2010), Tunisia (Ben Abdesselam-Mahdaoui *et al*. 2010), Turkey (Altiner and Özkan 1991), Cuba (Pop 1976; Pszczółkowski *et al.* 2005; Pszczółkowski and Myczyński 2010) and Mexico (Adatte *et al.* 1994). It is equivalent to the Calpionellopsis simplex–Calpionellites darderi Zone of Azimi *et al.* (2008). In Bulgaria, the zone was reported by Bakalova-Ivanova (1986); Lakova (1993); Lakova *et al.* (1999); Ivanova (1997); Ivanova *et al*. (2002) and Petrova (2010).

Simplex Subzone. The lower boundary of the subzone is defined at the FO of *Calpionellopsis simplex* (Remane *et al.* 1986). It is equivalent to the D1 Subzone of Remane (1971).

Correlations: It is known as the Calpionellopsis simplex subzone in France (Le Hégarat and Remane 1968), Romania (Pop 1986b, c, 1994), Poland (Wierzbowski and Remane 1992; Pszczółkowski 1996; Pszczółkowski and Myczyński 2004; Grabowski and Pszczółkowski 2006), Slovakia (Reháková 1995, 2000a; Reháková and Michalík 1997a, b), Austria (Lukeneder and Reháková 2004, 2007), Italy (Grün and Blau 1997; Andreini *et al.* 2007), Greece (Skourtsis-Coroneou and Solakius 1999), Hungary (Fözy *et al.* 2010), Iran (Azimi *et al.* 2008), Cuba (Pop 1976; Pszczółkowski and Myczyński 2010) and Mexico (Adatte *et al.* 1994). Its correlatives are: the lower Calpionellopsis simplex–Calpionellopsis oblonga Zone in Sicily, Italy (Catalano and Liguori 1971) and the lower Calpionellopsis simplex Subzone in Spain (Allemann *et al.* 1975), the D1 Subzone in Tunisia (Ben Abdesselam-Mahdaoui *et al.* 2011). In Bulgaria, the Simplex Subzone was reported in the West Balkan Mts and West Fore-Balkan by Lakova (1993); Lakova *et al.* (1999); Petrova (2010).

Oblonga Subzone. This subzone corresponds to the D_2 + D_3 subzones of Remane (Le Hégarat and Remane 1968). Remane *et al.* (1986) introduced it as the Oblonga Subzone. Pop (1986b) restricted the subzone to the interval between the FO of *Calpionelliopsis oblonga* (base) and the FO of *Praecalpionellites murgeanui* (top), this restricted interval being used by the present authors herein. It is characterized by the highest diversity of calpionellid species throughout the entire time span of their existence. The FOs of *Calpionellopsis* sp. A*, Remaniella filipescui* and *R. cadischiana*, and the abundance of *Lorenziella hungarica* and *L. plicata,* are documented in this subzone. The Oblonga Subzone is 3 to 15 m thick in the lowermost part of the Salash Formation.

Correlations: The Calpionellopsis oblonga Subzone sensu Pop (1986b, c) is known from Romania (Pop 1986b, c, 1994; Barbu and Melinte-Dobrinescu 2008), Slovakia (Reháková 1995; Reháková and Michalík 1997a, b), Greece (Skourtsis-Coroneou and Solakius 1999), Austria (Vašíček *et al.* 1999; Lukeneder and Reháková 2004, 2007), Hungary (Fözy *et al.* 2010), Iran (Azimi *et al.* 2008) and Cuba (Pszczółkowski and Myczyński 2010). It is known as the lower Calpionellopsis oblonga Subzone sensu Remane *et al.* (1986) in Poland (Pszczółkowski 1996; Pszczółkowski and Myczyński 2004; Grabowski and Pszczółkowski 2006), and Italy (Andreini *et al.* 2007). Its correlatives are: the D2 in Tunisia (Ben Abdesselam-Mahdaoui *et al.* 2011), the D2 + lower D3 in France (Le Hégarat and Remane 1968; Remane 1971), Turkey (Altiner and Özkan 1991), and Poland (Wierzbowski and Remane 1992); the middle

Calpionellopsis simplex–Calpionellopsis oblonga Zone in Italy (Catalano and Liguori 1971) and Spain (Allemann *et al.* 1975); the Oblonga + Filipescui Subzones in Italy (Grün and Blau 1997), and the middle Calpionellopsis Zone in Cuba (Pop 1976). In Bulgaria, the Calpionellopsis Zone was recorded from the Western Balkan Mts and the Western Fore-Balkan by Lakova *et al*. (1999, 2007); Ivanova *et al.* (2002); Petrova (2010).

Murgeanui Subzone. It was introduced and defined by Pop (1986b). Its base is defined by the FO of *Pracalpionellites murgeanui*. This subzone is documented only in the Gintsi 2 and Barlya sections. It is about 3 to 7 m thick, in the basal part of the Salash Formation.

Correlations: The subzone is known from Romania (Pop 1986b, c, 1994), Slovakia (Reháková 1995; Reháková and Michalík 1997a, b), Austria (Vašíček *et al.* 1999), Greece (Skourtsis-Coroneou and Solakius 1999), Cuba (Pszczółkowski and Myczyński 2010), and Bulgaria (Lakova *et al.* 1999, 2007).

Lower Valanginian

Calpionellites Zone; Plates 4, 7

Allemann *et al.* (1971) designated the E zone of Remane (1971) as the Calpionellites Standard Zone. Later Pop (1974) restricted the top of the zone to the LO of the genus *Calpionellites*, and this concept is used herein. The lower boundary is placed at the FO of *Calpionellites darderi*. The latter is also a primary criterion recommended for the definition of the base of the Valanginian Stage at the 32nd International Geological Congress in Florence, 2004. Pop (1994) subdivided the Calpionellites Zone into the Darderi and Major subzones.

Correlations: The zone is known from Slovakia (Borza 1984; Reháková 1995; Reháková and Michalík 1997a, b), Poland (Pszczółkowski and Myczyński 2004), Romania (Pop 1994), Italy (Channell and Grandesso 1987; Grün and Blau 1997; Andreini *et al*. 2007), Spain (Aguado *et al*. 2000), Austria (Vašíček *et al.* 1999; Lukeneder and Reháková 2004, 2007; Reháková *et al.* 1996), Hungary (Fözy *et al.* 2010), Cuba (Pszczółkowski and Myczyński 2010) and Mexico (Adatte *et al.* 1994). It is known as the E Zone in Turkey (Altiner and Özkan 1991) and Tunisia (Ben Abdesselam-Mahdaoui *et al.* 2010, 2011), as the Calpionellites darderi Subzone in Romania sensu Pop (Pop 1989) and in Mexico sensu Trejo (Trejo 1980). In Bulgaria Bakalova (1977) and Lakova *et al*. (1999, 2007) reported the zone from the Western Balkan Mts and the Western Fore-Balkan, and Ivanova *et al.* (2002) from the subsurface of the Moesian Platform.

Darderi Subzone. The subzone was first mentioned by Trejo (1980), but formally introduced by Pop (1994). Its lower boundary is marked by the FO of *Calpionellites darderi* (Pop 1994). It is 6.5 to 13 m thick in the Salash Formation. *Calpionella minuta* and *Praecalpionellites murgeanui* disapper within this subzone.

Correlations: The subzone is known from Romania (Pop 1986a, 1994, 1997b), Slovakia (Reháková 1995; Reháková and Michalík 1997a, b), Poland (Pszczółkowski and Myczyński 2004), Italy (Grün and Blau 1997; Andreini *et al.* 2007), Spain (Aguado *et al*., 2000), Austria (Reháková *et al.* 1996; Vašíček *et al.* 1999; Lukeneder and Reháková 2004, 2007), Hungary (Fözy *et al*. 2010) and Cuba (Pszczółkowski and Myczyński 2010). In Bulgaria, Lakova *et al*. (1999, 2007) and Petrova *et al*. (2010) reported the subzone from the Western Balkan Mts and the Western Fore-Balkan, and Ivanova *et al*. (2000, 2002) from the Western Srednogorie and the Moesian Platform.

Major Subzone. The subzone was established by Pop (1994). The lower boundary is defined by the FO of *Calpionellites major* and its upper boundary by the LO of the genus *Calpionellites*. The interval of the Major Subzone is about 18 m thick, in the Salash Formation. The LOs of *Praecalpionellites* sp. A, *Calpionellites coronatus* and *Calpionellites caravacaensis* are noted from this subzone.

Correlations: The subzone is known from Romania (Pop 1994, 1997b), Slovakia (Reháková 1995; Reháková and Michalík 1997a, b), Poland (Vašíček *et al.* 1999; Pszczółkowski and Myczyński 2004), Italy (Grün and Blau 1997; Andreini *et al.* 2007), Austria (Lukeneder and Reháková 2004, 2007) and Cuba (Pszczółkowski and Myczyński 2010). In Bulgaria, Lakova *et al*. (1999, 2007) and Petrova *et al*. (2010) reported the subzone from the Western Balkan Mts and the Western Fore-Balkan, and Ivanova *et al*. (2000, 2002) from the Western Srednogorie and the Moesian Platform.

Upper Valanginian and Hauterivian

Tintinnopsella Zone

The *Tintinnopsella* Zone was introduced and defined by Borza (1984). Its base is defined by the LO of *Calpionellites* and its top by the LO of the family Cal-

pionellidae. The calpionellid association characterizing the zone is poor in species; *Tintinnopsella longa*, *Lorenziella hungarica*, *L. plicata* and *Remaniella cadischiana* occur in the lower part of the zone only, which is late Valanginian in age (Petrova *et al.* 2010). Upwards, only *T. carpathica* persisted in the Hauterivian part. Pop (1994) reported on the occurrence of *T. carpathica* in Hauterivian successions dated on ammonites and proposed to divide the Tintinnopsella Zone into the Cadischiana and Carpathica subzones.

Correlations: The zone is known from Romania (Pop 1989, 1994), Slovakia (Borza 1984; Reháková 1995; Reháková and Michalík 1997a,b), Poland (Pszczółkowski and Myczyński 2004), Italy (Grün and Blau 1997; Andreini *et al.* 2007), Spain (Granier *et al*. 1995), Austria (Reháková *et al.* 1996, Vašíček *et al.* 1999; Lukeneder and Reháková 2004, 2007; Reháková *et al*. 2006), Hungary (Fözy *et al.* 2010), Turkey (Altiner and Özkan 1991), and as the Tintinnopsella carpathica Zone in Mexico (Trejo 1980). In Bulgaria, Lakova *et al*. (1999, 2007) and Petrova *et al*. (2010) reported the subzone from the Western Balkan Mts and the Western Fore-Balkan, and Ivanova *et al*. (2000, 2002) from the Western Srednogorie and the Moesian Platform.

DISCUSSION

Most of the calpionellid bioevents applied herein are widely used in calpionellid biostratigraphy (Remane 1971, 1986; Remane *et al.* 1986; Pop 1974, 1997b; Reháková 1995; Reháková and Michalík 1997a, b; Lakova *et al.* (1999); Andreini *et al.* 2007). The following calpionellid bioevents (mainly FOs), in ascending stratigraphic order, which are used for definition of the bases of calpionellid zones and subzones, are documented in the West Balkan Mts. (Text-fig. 6):

The FO of chitinoidellids (*Longicollaria dobeni* and related species)
FO of *Chitinoidella boneti*
FO of *Praetintinnopsella andrusovi*
FO of hyaline-walled calpionellids (*Tintinnopsella carpathica* and *T. remanei*)
FO of *Calpionella grandalpina* and *Calpionella alpina*
The almost coeval explosion of *Calpionella alpina*, decline of the genus *Crassicollaria* and LO of *Calpionella elliptalpina*
FO of the genus *Remaniella* (*R. ferasini* and *R. duranddelgai)*
FO of *Calpionella elliptica* and almost coeval FO of large variety of *T. carpathica*
FO of *Calpionellopsis simplex*
FO of *Calpionellopsis oblonga*
FO of *Praecalpionellites murgeanui*
FO of *Calpionellites darderi*
FO of *Calpionellites major*
LO of the genus *Calpionellites*

Recent publications emphasize the need for detailed studies of calpionellid stratigraphical distribution and the relationships of calpionellids to other microfossils, such as calcareous nannoplankton, radiolarians and calcareous dinocysts. Research into the calpionellid biostratigraphy of the Upper Tithonian and Berriasian currently focuses on integrated bio- and magnetostratigraphy and the proposal of reliable criteria to define the base of the Berriasian (Channell and Grandesso 1987; Houša *et al.* 1999a, b, 2004; Michalík *et al.* 2009; Pruner *et al.* 2009; Grabowski and Pszczółkowski 2006; Grabowski *et al.* 2010a, b; Lukeneder *et al.* 2010; Fözy *et al.* 2010; Grabowski 2011; Wimbledon *et al.* 2011, Michalík and Reháková 2011).

There is a general agreement on the subzonal divisions of the Chitinoidella*,* Calpionella*,* Calpionellopsis and Calpionellites zones. Further study is needed of the calpionellid distribution in the Upper Tithonian in order to to work out generally acceptable subzones of the Crassicollaria Zone (Text-fig. 5).

As long as the stage and substage boundaries of the Tithonian to Hauterivian in the Mediterranean Realm are based mainly on ammonites, the correlation between ammonite and calpionellid ranges is crucial in determining the chronostratigraphic value of the latter. A great amount of work has already been done (Le Hégarat and Remane 1968; Enay and Geyssant 1975; Cecca *et al.* 1989; Wierzbowski and Remane 1992; Pop 1994; Tavera *et al.* 1994; Benzaggagh and Atrops 1995; Granier *et al.* 1995; Vašíček *et al.* 1999; Aguado *et al.* 2000; Skupien *et al.* 2003; Lukeneder and Reháková 2004, 2007; Boughdiri *et al*. 2006, 2009; Pruner *et al.* 2009; Benzaggagh *et al*. 2009; Petrova 2009, Petrova *et al.* 2011); however, a number of questions remain to be answered.

Chronostratigraphic importance of the FO of chitinoidellids

The available data on the timing of the first appearances of chitinoidellids (earliest *Longicollaria dobeni* and related species) are rather scarce. Pruner *et al.* (2009) reported what they claim to be the first chitinoidellids from the upper Admirandum/Biruncinatum ammonite Zone; and Benzaggagh *et al.* (2010) from the upper part of the coeval Burkhardticeras Zone.

The Gintsi Formation in the Gintsi 2 section spans an

interval from the middle Kimmeridgian (Crusoliceras divisum ammonite Zone) to the upper Lower Tithonian (Sapunov in Nikolov and Sapunov 1977). We noted the first appearance of chitinoidellids in sample 609 of the Gintsi Formation, which is 8 m above the top of the Virgatosimoceras rothpletzi ammonite Zone (Sapunov in Nikolov and Sapunov 1977). Olóriz and Tavera (1989) correlated the upper part of the V. rothpletzi Zone with the Richteri and Admirandum/Biruncinatum ammonite zones in Spain. The latter two ammonite zones are regarded as of late Early Tithonian age (Gradstein *et al.* 2004). The appearance of the first chitinoidellids from the base of the Admirandum/Biruncinatum ammonite Zone (upper Ponti Zone in North Africa) was also reported by Reháková and Michalík (1997) and Grün and Blau (1997).

Base of the Upper Tithonian

Recent studies from Spain and Tunisia have demonstrated that the FO of *Chitinoidella boneti* coincides with the base of the Simplisphintes ammonite Subzone of the Microcanthum ammonite Zone (Pruner *et al.* 2009; Benzaggagh *et al.* 2010), the level which is regarded as the base of the Upper Tithonian (Gradstein *et al.* 2004). Similar dating of this calpionellid event was formerly reported from Morocco (Boughdiri *et al.* 2006). This dating is also confirmed by magnetostratigraphy (magnetochron M20n) and calcareous dinocysts (*Colomisphaera fortis*). The coincidence of parts of these events was demonstrated in the Gresten Klippenbelt in Austria (Reháková *et al.* 2009), the Western Balkan Mts in Bulgaria (Lakova *et al.* 1999), the Puerto Escaño section in Spain (Pruner *et al.* 2009), the Western Carpathians in Slovakia (Michalík *et al.* 2009) and in Morocco (Benzaggagh *et al.* 2010).

The Crassicollaria Zone and its subzones

Based on the FO of *Crassicollaria colomi*, in the uppermost part of the Crassicollaria Zone, Pop (1994) and Reháková and Michalík (1997) proposed the Colomi Subzone in the topmost part of the zone. In the Western Balkanides sections (Lakova, 1993; Lakova *et al*. 1999), *Crassicollaria colomi* was documented in the lower part of the *Calpionella* Zone (Alpina Subzone). These contradictory data could be due to particular facies features and/or a specific local longer range of *Cr. colomi* in the West Balkan Mts. area. The almost coeval FOs of *Calpionella grandalpina* and/or *Calpionella alpina* mark an important calpionellid bioevent in the Upper Tithonian that is used to define the base of the Massutiniana Subzone (Lakova 1993), which coincides with the Intermedia (= A2 + A3) Subzone of Remane (1986). Also appearing at that level are the nannofossil *Microstaurus chiastius* and the calcareous dinocyst *Stomiosphaera proxima* (Lakova *et al.* 1999; Reháková 2000b). Importantly, the level coincides with the base of the M19r magnetic polarity chron (Houša *et al*. 1999a, b; Pruner *et al*. 2009). These biological and physical events should be considered in the context of multidisciplinary high-resolution stratigraphy of the Jurassic/Cretaceous boundary interval as possible criteria for the definition of the base of Berriasian.

The Tithonian-Beriasian boundary

The base of the Berriasian and, by definition, the base of the Cretaceous System, coincides in calpionellid terms with the base of the Calpionella Zone. The base of this zone is very close to the base of the *Berriasella jacobi* ammonite Zone/Subzone, which was provisionally recommended by the Second Cretaceous Symposium in Brussels in 1996 (Zakharov *et al.* 1996) and widely accepted by the Lower Cretaceous Ammonite Working Group (Reboulet and Klein 2009), as the base of the Cretaceous System. The combined ammonite and calpionellid biostratigraphy in the Tethyan Realm indicated that the explosion of the small variety of *Calpionella alpina* occurs at or just below the base of the *B. jacobi* Zone (Cecca *et al.* 1989; Aguado *et al.* 1994; Boughdiri *et al*. 2006; Benzaggagh *et al*. 2010). In terms of magnetostratigraphy, the base of the Berriasian is within the M19n chron (Grabowski 2011 and references therein).

Regional stratigraphic hiatus across the Early-Late Berriasian boundary

In the study area, a stratigraphic hiatus between the Glozhene and Salash Formations has been documented. It covers a time interval from the latest Early Berriasian to the early Late Berriasian. The presence of a stratigraphic hiatus between the Glozhene and Salash Formations was first recognised by Mandov (1971). That author accepted it as a boundary between the Jurassic and Cretaceous without palaeontological data. The calpionellid biostratigraphy suggests that the stratigraphic gap corresponds to the upper Elliptica Subzone, the whole Simplex Subzone and the lower Oblonga Subzone.

Base of the Valanginian

The Berriasian/Valanginian boundary is placed at the base of the Calpionellites Zone. Direct co-occurrence of calpionellids and calcareous dinocysts was reported from the Tithonian to Valanginian in Slovakia, Poland, Ukraine, Austria and Bulgaria (Reháková 2000a, b; Michalík *et al.*

2009; Reháková and Wierzbowski 2005; Reháková *et al.* 2009, 2011; Lakova *et al.* 1999, 2007; Ivanova *et al.* 2006). The base of the Valanginian was defined at the FOs of the ammonite *Thurmanniceras pertransiens* and the calpionellid *Calpionellites darderi* (Aguado *et al.* 2000), a level which coincides with the FO of the calcareous dinocyst *Colomisphaera conferta* (Ivanova in Lakova *et al*. 2007; Ivanova in Petrova *et al.* 2011).

Unsolved problems in applying certain calpionellid bioevents to zonation include:

1. Tripartite or bipartite subdivision of the Crassicollaria Zone?
2. Problems with recognition of the Murgeanui Subzone, the latter being no longer important for definition of the base of the Valanginian.
3. Avoiding the use of species with controversial occurrences, such as *Dobeniella bermudezi*, *Crassicollaria colomi, Tintinnopsella longa, Lorenziella hungarica, Remaniella filipescui* and *Remaniella cadischiana*, as indicators of subzonal bases.
4. Future direct correlations of the following calpionellid bioevents in the Upper Tithonian with ammonite, calcareous dinocysts, calcareous nannofossil bioevents and magnetic polarity chrons: the FO of *Chitinoidella boneti*; the FO of *Tintinnopsella carpathica* and *Tintinnopsella remanei*; the FO of *Calpionella grandalpina*; the "explosion" of *Calpionella alpina*; and the FOs of *Calpionella minuta* and the genus *Remaniella*.

CONCLUSIONS

- 57 species belonging to 17 genera were recognized in the Tithonian–Valanginian succession of the three sections studied, Barlya, Gintsi 1 and Gintsi 2, located in the Western Balkan Mts, western Bulgaria. The family Chitinoidellidae is represented by 17 species and 8 genera, and the family Calpionellidae by 41 species and 9 genera.
- Application of the updated taxonomy of the Chitinoidellidae proposed by Pop (1997a, 1998a), Reháková (2002) and Sallouhi *et al.* (2011) resulted in the identification of the Tithonian genera *Almajella, Longicollaria*, *Borziella*, *Dobeniella*, *Daciella* and *Carpathella* for the first time in Bulgaria, as well as the species *Chitinoidella hegarati*, known so far exclusively from Tunisia.
- 7 zones and 11 subzones (from upper Lower Tithonian to Upper Valanginian–Hauterivian) are defined, and their correlation to other areas is discussed. The chronostratigraphic position of the selected zones/subzones is discussed and corrected; the Boneti Subzone and the Praetintinnopsella Zone are included in the Upper Tithonian.
- Two stage boundaries have been fixed in the Gintsi 1, Gintsi 2 and Barlya sections (Text-figs 2–4) – the Tithonian-Berriasian and Berriasian-Valanginian boundaries. The Tithonian-Berriasian boundary is drawn at the base of the *Calpionella* Zone at the "explosion" of *Calpionella alpina* and the LO of *Calpionella elliptalpina*; and the base of the Valanginian at the FO of *Calpionellites darderi.* In two of the sections (Gintsi 1 and 2), a stratigraphic gap between the Elliptica Subzone and the Oblonga Subzone (upper part) has been established.
- This review of the calpionellid zonations in numerous regions from Central America, northern Africa, Europe and the Middle East revealed the progress in detailed biostratigraphy and the necessity of a general consensus on a standard calpionellid bioevent/subzonal scale for the Tithonian to Valanginian time interval in the Tethyan Realm.

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APPENDIX
List of chitinoidellid and calpionellid species

Almajella cristobalensis (Furrazola-Bermúdez, 1965)
Borziella slovenica (Borza, 1969)
Carpathella rumanica Pop, 1998
Chitinoidella boneti Doben, 1963
Chitinoidella elongata Pop, 1997
Chitinoidella hegarati Sallouhi, Boughdiri and Cordey, 2011
Daciella danubica Pop, 1998
Daciella svinitensis Pop, 1998
Daciella sp. A
Dobeniella bermudezi (Furrazola-Bermúdez, 1965)
Dobeniella colomi (Borza, 1966)
Dobeniella cubensis (Furrazola-Bermúdez, 1965)
Dobeniella cf. *cubensis* (Furrazola-Bermúdez, 1965)
Dobeniella tithonica (Borza, 1969)
Longicollaria dobeni (Borza, 1966)
Longicollaria insueta (Řehánek, 1986)
Praetintinnopsella andrusovi Borza, 1969
Calpionella alpina Lorenz, 1902
Calpionella elliptalpina Nagy, 1986
Calpionella elliptica Cadisch, 1932
Calpionella grandalpina Nagy, 1986
Calpionella minuta Houša, 1990
Calpionella sp. A
Calpionellites caravacaensis Allemann, 1975
Calpionellites coronatus Trejo, 1975
Calpionellites darderi (Colom, 1934)
Calpionellites major (Colom, 1948)
Calpionellopsis oblonga (Cadisch, 1932)
Calpionellopsis simplex (Colom, 1939)
Calpionellopsis sp. A
Crassicollaria brevis Remane, 1962
Crassicollaria colomi Doben, 1963
Crassicollaria intermedia (Durand-Delga, 1957)
Crassicollaria massutiniana (Colom, 1948)
Crassicollaria parvula Remane, 1962
Lorenziella hungarica Knauer and Nagy, 1964
Lorenziella plicata Remane, 1968
Praecalpionellites hillebrandti Grün and Blau, 1999
Praecalpionellites murgeanui (Pop, 1974)
Praecalpionellites siriniaensis Pop, 1986
Praecalpionellites sp. A
Remaniella borzai Pop, 1994
Remaniella cadischiana (Colom, 1948)
Remaniella catalanoi Pop, 1996
Remaniella colomi Pop, 1996
Remaniella duranddelgai Pop, 1996
Remaniella ferasini (Catalano, 1965)
Remaniella filipescui Pop, 1994
Sturiella oblonga Borza, 1981
Sturiella aff. *oblonga* Borza, 1981
Tintinnopsella carpathica (Murgeanu and Filipescu, 1933)
Tintinnopsella aff. *carpathica* (Murgeanu and Filipescu, 1933)
Tintinnopsella dacica Filipescu and Dragastan, 1970
Tintinnopsella doliphormis (Colom, 1939)
Tintinnopsella longa (Colom, 1939)
Tintinnopsella remanei Borza, 1969
Tintinnopsella subacuta (Colom, 1948)

PLATE 1

Calpionellids of the Barlya section, Western Balkan Mts.

1-5 – *Daciella danubica* Pop, Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, sample 0310. **6-8** – *Daciella svinitensis* Pop, Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, **6** – sample 0310, **7-8** – sample 0309. **9-10** – *Borziella slovenica* (Borza), Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, sample 0309. **11-12** – *Longicollaria dobeni* (Borza), Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, sample 0309. **13-16** – *Dobeniella colomi* (Borza), Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, **13** – sample 0310, **14-16** – sample 0309. **17-18** – *Chitinoidella boneti* Doben, Upper Tithonian, Chitinoidella Zone, Boneti Subzone, sample 0303. **19** – *Chitinoidella hegarati* Sallouhi, Boughdiri and Cordey, Upper Tithonian, Praetintinnopsella Zone, sample 0301. **20-21** – *Chitinoidella elongata* Pop, Upper Tithonian, Chitinoidella Zone, Boneti Subzone, **20** – sample 0302, **21** – sample 0303. **22**. *Almajella cristobalensis* (Furrazola-Bermúdez), Upper Tithonian, Chitinoidella Zone, Boneti Subzone, sample 0303. **23-24** – *Dobeniella* cf. *cubensis* (Furrazola-Bermúdez), Upper Tithonian, Chitinoidella Zone, Boneti Subzone, sample 0301. **25-26** – *Dobeniella bermudezi* (Furrazola-Bermúdez), Upper Tithonian, Chitinoidella Zone, Boneti Subzone, **25** – sample 0302; Praetintinnopsella Zone, **26** – sample 300. **27-31** – *Praetintinnopsella andrusovi* Borza, Upper Tithonian, Praetintinnopsella Zone, **27-29**, **31** – sample 0301, **30** – sample 300. **32-33** – *Crassicollaria intermedia* (Durand-Delga), Upper Tithonian, Crassicollaria Zone, Remanei Subzone, **32** – sample 301, **33** – sample 302. **34** – *Tintinnopsella remanei* Borza, Upper Tithonian, Crassicollaria Zone, Remanei Subzone, sample 301. **35-36** – *Tintinnopsella carpathica* (Murgeanu & Filipescu), Upper Tithonian, Praetintinnopsella Zone, sample 300.

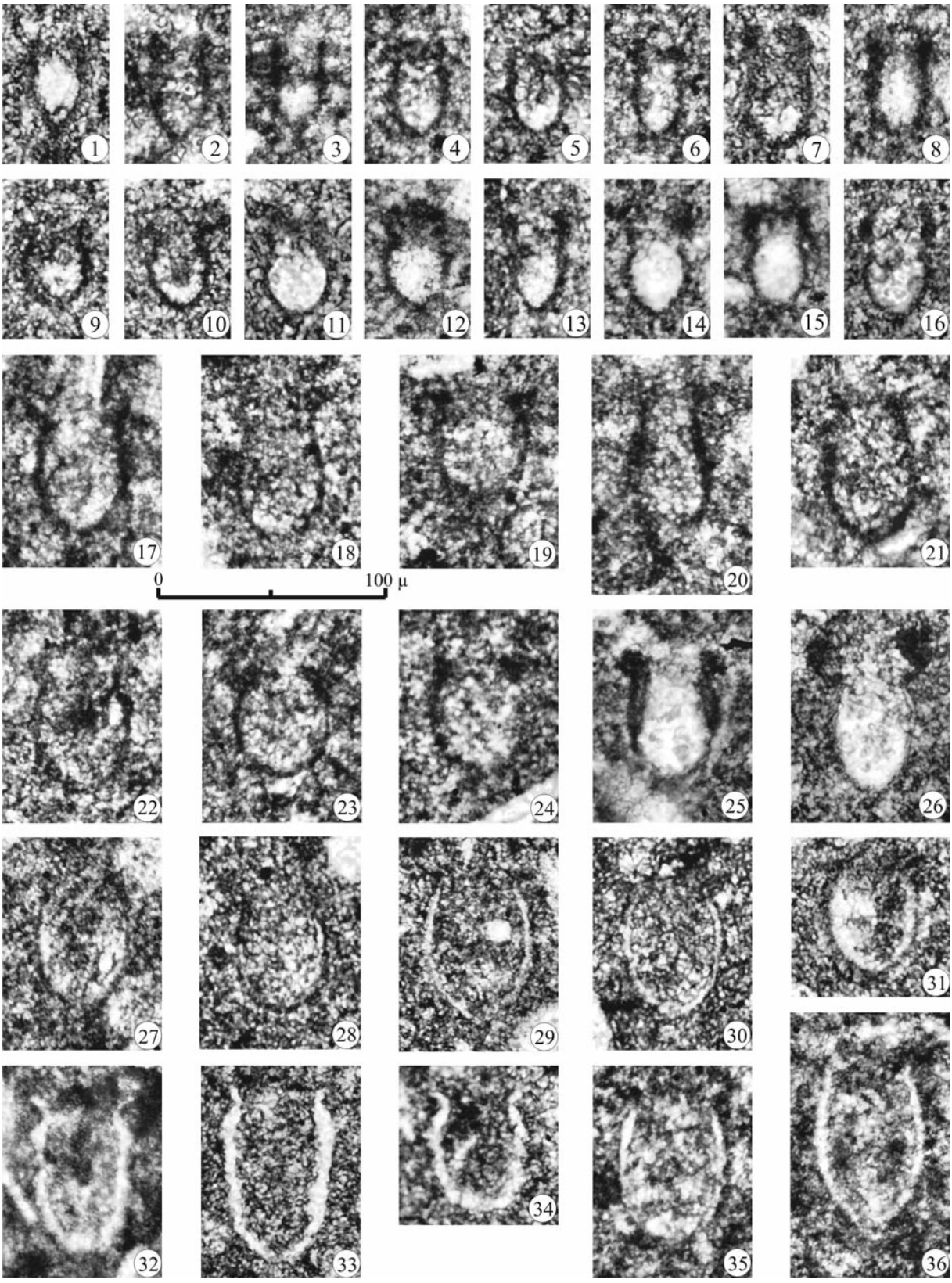

PLATE 2

Calpionellids of the Barlya section, Western Balkan Mts.

1 – *Crassicollaria massutiniana* (Colom), Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, sample 304-4. **2-3** – *Crassicollaria brevis* Remane, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, sample 307. **4-5** – *Crassicollaria parvula* Remane, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, **4** – sample 307, **5** – sample 310. **6-7** – *Crassicollaria colomi* Doben, Lower Berriasian, Calpionella Zone, Alpina Subzone, sample 313. **8-9** – *Calpionella grandalpina* Nagy, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, **8** – sample 304-6, **9** – sample 307. **10-11** – *Calpionella elliptalpina* Nagy, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, sample 310. **12-16** – *Calpionella alpina* Lorenz, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, **12-13** – sample 307; Lower Berriasian, Calpionella Zone, Alpina Subzone, **14** – sample 313, **15** – sample 318, **16** – sample 321. **17-20** – *Calpionella minuta* Houša, Lower Berriasian, Calpionella Zone, Alpina Subzone, **17-18** – sample 318, **19-20** – sample 321. **21-22** – *Tintinnopsella doliphormis* (Colom), Lower Berriasian, Calpionella Zone, Alpina Subzone, **21** – sample 321, **22** – sample 322. **23-25** – *Remaniella ferasini* (Catalano), Lower Berriasian, Calpionella Zone, Remaniella Subzone, **23-24** – sample 323, **25** – sample 324. **26-28** – *Remaniella duranddelgai* Pop, Lower Berriasian, Calpionella Zone, Remaniella Subzone, **26-27** – sample 324, **28** – sample 325. **29-32**. *Remaniella colomi* Pop, Lower Berriasian, Calpionella Zone, Remaniella Subzone, **29** – sample 323, **31** – sample 325; Elliptica Subzone, **30**, **32** – sample 326. **33** – *Remaniella filipescui* Pop, Lower Berriasian, Calpionella Zone, Elliptica Subzone, sample 327. **34** – *Tintinnopsella carpathica* (Murgeanu & Filipescu), Lower Berriasian, Calpionella Zone, Elliptica Subzone, sample 327. **35** – *Tintinnopsella longa* (Colom), Lower Berriasian, Calpionella Zone, Elliptica Subzone, sample 327. **36-37** – *Calpionella elliptica* Cadisch, Lower Berriasian, Calpionella Zone, Elliptica Subzone, **36** – sample 327, **37** – sample 328.

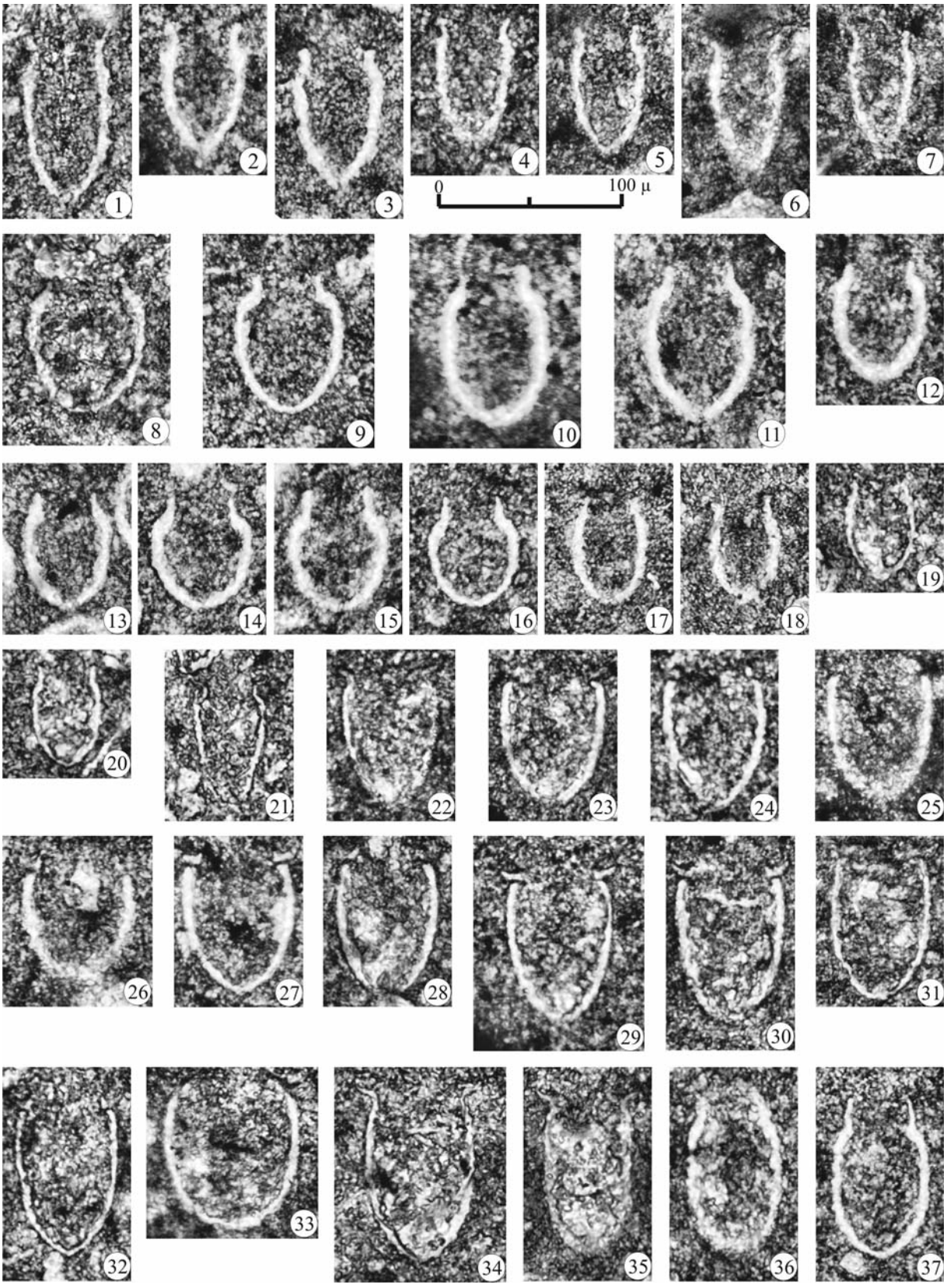

PLATE 3

Calpionellids of the Barlya section, Western Balkan Mts.

1-2 – *Calpionella elliptica* Cadisch, Lower Berriasian, Calpionella Zone, Elliptica Subzone, **1** – sample 328, **2** – sample 329. **3** – *Calpionella* sp.A, Lower Berriasian, Calpionella Zone, Elliptica Subzone, sample 328. **4** – *Calpionella minuta* Houša, Lower Berriasian, Calpionella Zone, Elliptica Subzone, sample 328. **5-8** – *Lorenziella hungarica* Knauer and Nagy, Lower Berriasian, Calpionella Zone, Elliptica Subzone, **5** – sample 330; Upper Berriasian, Calpionellopsis Zone, Simplex Subzone, **6** – sample 331, **7** – sample 332; Oblonga Subzone, **8** – sample 333. **9-11** – *Lorenziella plicata* Remane, Upper Berriasian, Calpionellopsis Zone, Oblonga Subzone, **9** – sample 333, **10-11** – sample 334. **12** – *Remaniella durand-delgai* Pop, Lower Berriasian, Calpionella Zone, Elliptica Subzone, sample 328. **13-16** – *Remaniella colomi* Pop, Lower Berriasian, Calpionella Zone, Elliptica Subzone, **13-14** – sample 328, **15-16** – sample 329-3. **17** – *Remaniella filipescui* Pop, Upper Berriasian, Calpionellopsis Zone, Oblonga Subzone, sample 333. **18** – *Remaniella cadischiana* (Colom), Lower Berriasian, Calpionella Zone, Elliptica Subzone, sample 329-3. **19-26** – *Calpionellopsis simplex* (Colom), Upper Berriasian, Calpionellopsis Zone, Simplex Subzone, **19** – sample 331, **20-22** – sample 332; Oblonga Subzone, **23-24** – sample 333, **25-26** – sample 334. **27-33** – *Calpionellopsis oblonga* (Cadisch), Upper Berriasian, Calpionellopsis Zone, Oblonga Subzone, **27-29** – sample 333, **30** – sample 334, **31-33** – sample 335. **34-35** – *Calpionellopsis* sp.A, Upper Berriasian, Calpionellopsis Zone, Oblonga Subzone, **34** – sample 333, **35** – sample 334. **36-37** – *Tintinnopsella subacuta* (Colom), Lower Berriasian, Calpionella Zone, Elliptica Subzone, **36** – sample 329-3, **37** – sample 330. **38-40** – *Tintinnopsella longa* (Colom), Upper Berriasian, Calpionellopsis Zone, Oblonga Subzone, **38** – sample 333, **39-40** – sample 334. **41-44** – *Tintinnopsella carpathica* (Murgeanu and Filipescu), Lower Berriasian, Calpionella Zone, Elliptica Subzone, **41** – sample 328, **42** – sample 329; Upper Berriasian, Calpionellopsis Zone, Simplex Subzone, **43** – sample 332; Oblonga Subzone, **44** – sample 334.

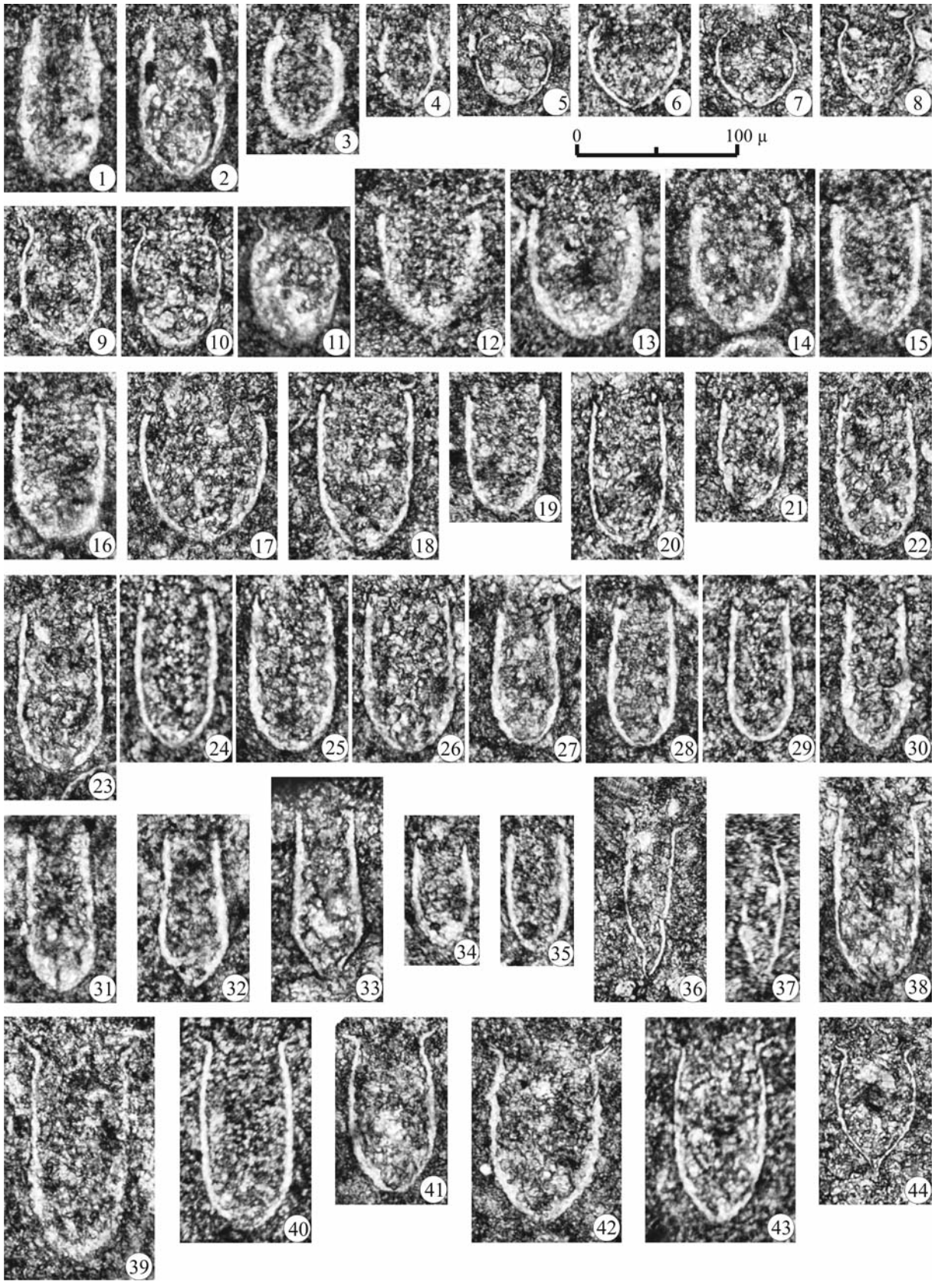

PLATE 4

Calpionellids of the Barlya section, Western Balkan Mts.

1-3 – *Calpionellopsis oblonga* (Cadisch), Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, sample 336. **4-7** – *Calpionellopsis* sp.A, Upper Berriasian, Calpionellopsis Zone, Oblonga Subzone, **4-5** – sample 335; Murgeanui Subzone, **6-7** – sample 336. **8-9** – *Lorenziella plicata* Remane, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **8** – sample 336; Lower Valanginian, Calpionellites Zone, Major Subzone, **9** – sample 341. **10** – *Remaniella filipescui* Pop, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, sample 336. **11** – *Tintinnopsella subacuta* (Colom), Lower Valanginian, Calpionellites Zone, Darderi Subzone, sample 339. **12-15** – *Praecalpionellites murgeanui* (Pop), Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **12** – sample 336, **13-14** – sample 337; Lower Valanginian, Calpionellites Zone, Darderi Subzone, **15** – sample 340. **16-17** – *Praecalpionellites siriniaensis* Pop, Lower Valanginian, Calpionellites Zone, Darderi Subzone, **16** – sample 338; Major Subzone, **17** – sample 343. **18-19** – *Praecalpionellites hillebrandti* Grün & Blau, Lower Valanginian, Calpionellites Zone, Darderi Subzone, **18** – sample 339, **19** – sample 338. **20-24** – *Calpionellites darderi* (Colom), Lower Valanginian, Calpionellites Zone, Darderi Subzone, **20-21** – sample 338, **22-23** – sample 340; Major Subzone, **24** – sample 343. **25-36** – *Calpionellites major* (Colom), Lower Valanginian, Calpionellites Zone, Major Subzone, **25** – sample 341, **26-27** – sample 342, **28-30** – sample 343, **31-36** – sample 344. **37-38** – *Calpionellites coronatus* Trejo, Lower Valanginian, Calpionellites Zone, Darderi Subzone, sample 338. **39-44** – *Calpionellites caravacaensis* Allemann, Lower Valanginian, Calpionellites Zone, Major Subzone, **40** – sample 342, **41-42** – sample 343, **39**, **43-44** – sample 344. **45-46** – *Sturiella* aff. *oblonga* Borza, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **45** – sample 337; Lower Valanginian, Calpionellites Zone, Major Subzone, **46** – sample 344. **47-49** – *Tintinnopsella carpathica* (Murgeanu & Filipescu), Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **47-48** – sample 336; Lower Valanginian, Calpionellites Zone, Darderi Subzone, **49** – sample 340. **50-53** – *Tintinnopsella longa* (Colom), Lower Valanginian, Calpionellites Zone, Darderi Subzone, **50-51** – sample 338, **52** – sample 339; Major Subzone, **53** – sample 341. **54** – *Tintinnopsella dacica* Filipescu & Dragastan, Lower Valanginian, Calpionellites Zone, Major Subzone, sample 341.

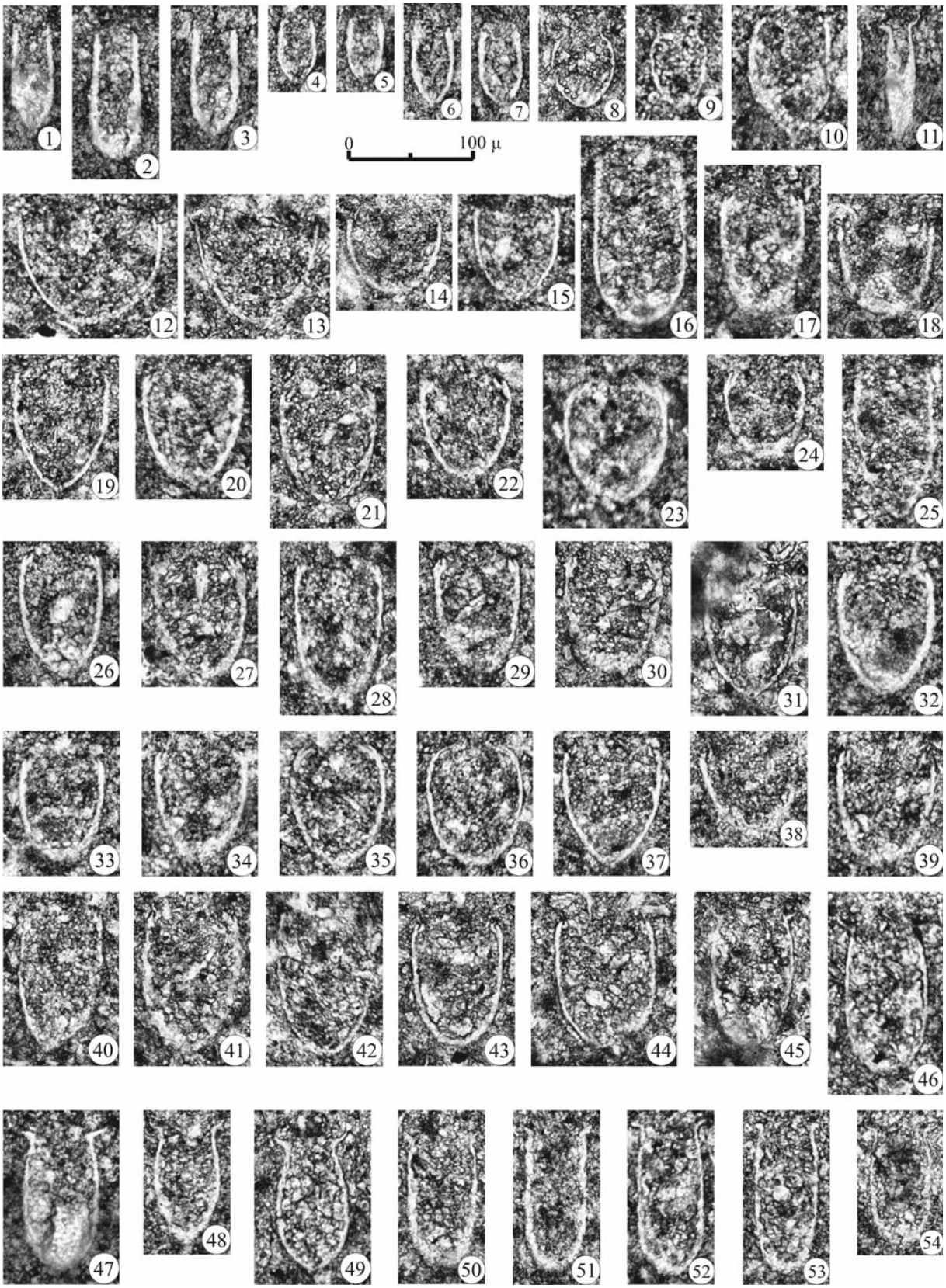

PLATE 5

Calpionellids of the Gintsi 1 and Gintsi 2 sections, Western Balkan Mts.

1-5 – *Daciella svinitensis* Pop, Gintsi 1 section, Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, sample Gin-011. **6-7** – *Borziella slovenica* (Borza), Gintsi 1 section, Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, **6** – sample Gin-011; Gintsi 2 section, **7** – sample 610. **8** – *Carpathella rumanica* Pop, Gintsi 2 section, Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, sample 610. **9-13** – *Daciella danubica* Pop, Gintsi 1 section, Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, sample Gin-011. **14-15** – *Dobeniella colomi* (Borza), Gintsi 1 section, Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, sample Gin-011. **16** – *Daciella* sp. A, Gintsi 1 section, Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, sample Gin-011. **17-20** – *Longicollaria dobeni* (Borza), Gintsi 1 section, Lower Tithonian, Chitinoidella Zone, Dobeni Subzone, **17** – sample Gin-08, **18-19** – sample Gin-011, **20** – sample Gin-09. **21-23** – *Chitinoidella boneti* Doben, Gintsi 1 section, Upper Tithonian, Chitinoidella Zone, Boneti Subzone, **21** – sample Gin-03, **22** – sample Gin-02, **23** – sample Gin-01. **24-25** – *Chitinoidella elongata* Pop, Gintsi 2 section, Upper Tithonian, Chitinoidella Zone, Boneti Subzone, **24** – sample 611; Gintsi 1 section, **25** – sample Gin-02. **26** – *Longicollaria insueta* (Řehánek), Gintsi 1 section, Upper Tithonian, Chitinoidella Zone, Boneti Subzone, sample Gin-01. **27-28** – *Dobeniella bermudezi* (Furrazola-Bermúdez), Gintsi 1 section, Upper Tithonian, Chitinoidella Zone, Boneti Subzone, **27** – sample Gin-03, **28** – sample Gin-02. **29-32** – *Dobeniella cubensis* (Furrazola-Bermúdez), Gintsi 2 section, Upper Tithonian, Chitinoidella Zone, Boneti Subzone, **29** – sample 611; Gintsi 1 section, **30** – sample Gin-02, **31-32** – sample Gin-1. **33-35** – *Praetintinnopsella andrusovi* Borza, Gintsi 1 section, Upper Tithonian, Praetintinnopsella Zone, sample Gin-3. **36-37** – *Tintinnopsella* aff. *carpathica* (Murgeanu & Filipescu), Gintsi 1 section, Upper Tithonian, Praetintinnopsella Zone, sample Gin-4. **38-41** – *Tintinnopsella carpathica* (Murgeanu & Filipescu), Gintsi 1 section, Upper Tithonian, Praetintinnopsella Zone, **38** – sample Gin-3; Crassicollaria Zone, Remanei Subzone, **39-40** – sample Gin-7, **41** – sample Gin-5. **42-43** – *Tintinnopsella remanei* Borza, Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Remanei Subzone, sample Gin-5. **44-46** – *Crassicollaria intermedia* (Durand-Delga), Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Remanei Subzone, **44-45** – sample Gin-7, **46** – sample Gin-9. **47-48** – *Crassicollaria massutiniana* (Colom), Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, **47** – sample Gin-10, **48** – sample Gin-11. **49** – *Crassicollaria parvula* Remane, Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, sample Gin-10. **50-51**, **53-54** – *Calpionella grandalpina* Nagy, Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, **50-51** – sample Gin-10, **53-54** – sample Gin-11. **52** – *Calpionella alpina* Lorenz, Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, sample Gin-10.

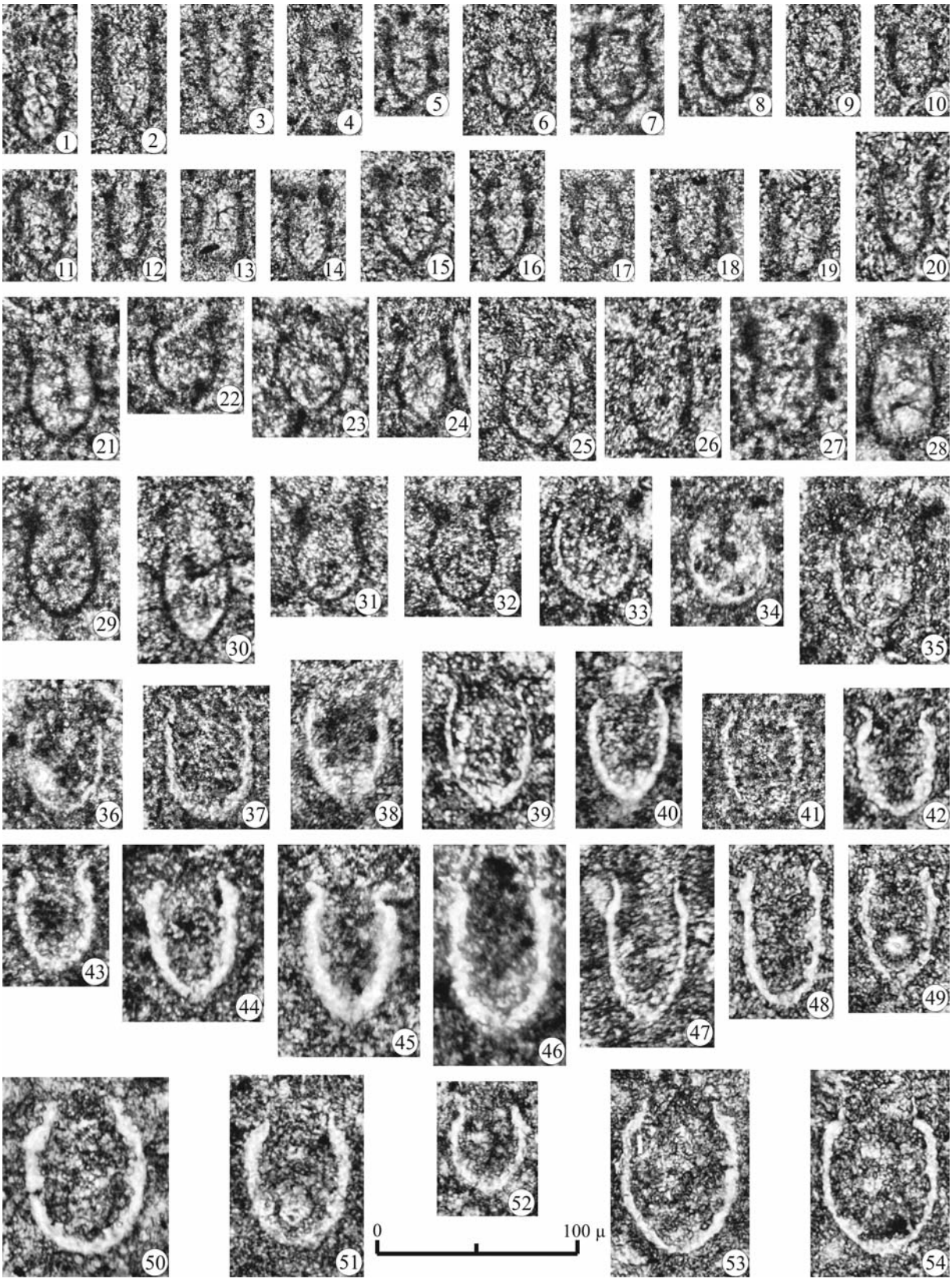

PLATE 6

Calpionellids of the Gintsi 1 and Gintsi 2 sections, Western Balkan Mts.

1 – *Calpionella grandalpina* Nagy, Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, sample Gin-11. **2** – *Calpionella elliptalpina* Nagy, Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, sample Gin-14. **3-7** – *Calpionella alpina* Lorenz, Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, **3** – sample Gin-11; Lower Berriasian, Calpionella Zone, Alpina Subzone, **4-6** – sample Gin-19; Remaniella Subzone, **7** – sample Gin-30. **8-9** – *Calpionella minuta* Houša, Gintsi 1 section, Lower Berriasian, Calpionella Zone, Remaniella Subzone, **8** – sample Gin-30, **9** – sample Gin-31. **10-13** – *Calpionella* sp.A, Gintsi 1 section, Lower Berriasian, Calpionella Zone, Remaniella Subzone, **10-11** – sample Gin-30, **12** – sample Gin-31; Elliptica Subzone, **13** – sample Gin-35. **14** – *Calpionella elliptica* Cadisch, Gintsi 2 section, Lower Berriasian, Calpionella Zone, Elliptica Subzone, sample 11. **15-17** – *Crassicollaria massutiniana* (Colom), Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, sample Gin-11. **18-19** – *Crassicollaria brevis* Remane, Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, sample Gin-14. **20-29** – *Crassicollaria parvula* Remane, Gintsi 1 section, Upper Tithonian, Crassicollaria Zone, Massutiniana Subzone, **20-22** – sample Gin-11, **23-24** – sample Gin-12; Lower Berriasian, Calpionella Zone, Alpina Subzone, **25-28** – sample Gin-19; Remaniella Subzone, **29** – sample Gin-30. **30-31** – *Crassicollaria colomi* Doben, Gintsi 1 section, Lower Berriasian, Calpionella Zone, Alpina Subzone, sample Gin-19. **32** – *Tintinnopsella carpathica* (Murgeanu & Filipescu), Gintsi 1 section, Lower Berriasian, Calpionella Zone, Alpina Subzone, sample Gin-19. **33-35** – *Tintinnopsella doliphormis* (Colom), Gintsi 1 section, Lower Berriasian, Calpionella Zone, Remaniella Subzone, **33** – sample Gin-30; Gintsi 2 section, Lower Berriasian, Calpionella Zone, Alpina Subzone, **34** – sample 8b; Elliptica Subzone, **35** – sample 12. **36-41** – *Remaniella ferasini* (Catalano), Gintsi 1 section, Lower Berriasian, Calpionella Zone, Remaniella Subzone, **37** – sample Gin-31, **38** – sample Gin-32, **39-41** – sample Gin-33; Gintsi 2 section, Lower Berriasian, Calpionella Zone, Remaniella Subzone, **36** – sample 10. **42-49** – *Remaniella duranddelgai* Pop, Gintsi 1 section, Lower Berriasian, Calpionella Zone, Remaniella Subzone, **42-44** – sample Gin-30, **45** – sample Gin-31, **46-47** – sample Gin-32, **48-49** – sample Gin-33. **50-51** – *Remaniella colomi* Pop, Gintsi 2 section, Lower Berriasian, Calpionella Zone, Elliptica Subzone, **50** – sample 11, **51** – sample 18. **52-55** – *Remaniella catalanoi* Pop, Gintsi 1 section, Lower Berriasian, Calpionella Zone, Remaniella Subzone, **52** – sample Gin-33; Elliptica Subzone, **53-55** – sample Gin-34.

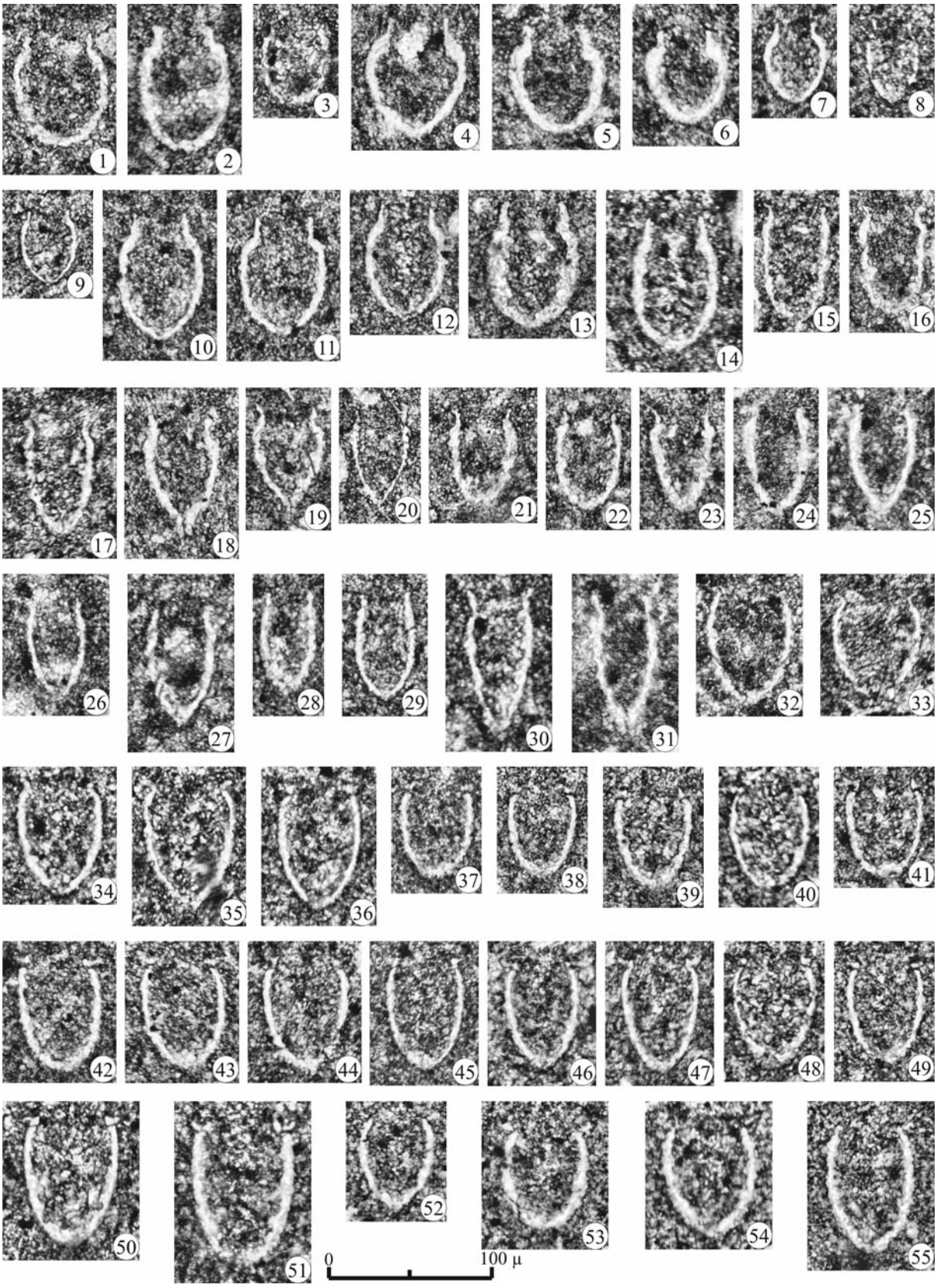

PLATE 7

Calpionellids of the Gintsi 1 and Gintsi 2 sections, Western Balkan Mts.

1-2 – *Calpionellopsis simplex* (Colom), Gintsi 1 section, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **1** – sample Gin-36; Gintsi 2 section, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **2** – sample 21. **3-6** – *Calpionellopsis oblonga* (Cadisch), Gintsi 2 section, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **3-4** – sample 19, **5-6** – sample 20. **7-8** – *Calpionellopsis* sp.A, Gintsi 2 section, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **7** – sample 19, **8** – sample 21. **9-12** – *Lorenziella hungarica* Knauer & Nagy, Gintsi 2 section, Lower Valanginian, Calpionellites Zone, Major Subzone, **9** – sample 28, **10** – sample 30, **11** – sample 35, **12** – sample 38. **13-14** – *Lorenziella plicata* Remane, Gintsi 2 section, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **13** – sample 20; Lower Valanginian, Calpionellites Zone, Major Subzone, **14** – sample 35. **15-17** – *Praecalpionellites murgeanui* (Pop), Gintsi 2 section, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **15** – sample 21; Lower Valanginian, Calpionellites Zone, Darderi Subzone, **16-17** – sample 27. **18-20** – *Praecalpionellites siriniaensis* Pop, Gintsi 2 section, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **18** – sample 19; Lower Valanginian, Calpionellites Zone, Darderi Subzone, **19** – sample 26; Major Subzone, **20** – sample 36. **21** – *Praecalpionellites* sp. A, Gintsi 2 section, Lower Valanginian, Calpionellites Zone, Darderi Subzone, sample 26. **22** – *Remaniella borzai* Pop, Gintsi 2 section, Lower Valanginian, Calpionellites Zone, Major Subzone, sample 34. **23-24** – *Remaniella cadischiana* (Colom), Gintsi 2 section, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **23** – sample 19, **24** – sample 20. **25-26** – *Calpionellites darderi* (Colom), Gintsi 2 section, Lower Valanginian, Calpionellites Zone, Darderi Subzone, **25** – sample 27; Major Subzone, **26** – sample 32. **27-29** – *Calpionellites coronatus* Trejo, Gintsi 2 section, Lower Valanginian, Calpionellites Zone, Major Subzone, sample 36. **30-32** – *Calpionellites major* (Colom), Gintsi 2 section, Lower Valanginian, Calpionellites Zone, Major Subzone, **30** – sample 28, **31** – sample 29, **32** – sample 30. **33-35** – *Calpionellites caravacaensis* Allemann, Gintsi 2 section, Lower Valanginian, Calpionellites Zone, Major Subzone, **33-34** – sample 34, **35** – sample 37. **36-41** – *Tintinnopsella carpathica* (Murgeanu & Filipescu), Gintsi 2 section, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **36-37** – sample 20; Lower Valanginian, Calpionellites Zone, Major Subzone, **38** – sample 33, **39-40** – sample 36, **41** – sample 37. **42-44** – *Tintinnopsella subacuta* (Colom), Gintsi 2 section, Lower Valanginian, Calpionellites Zone, Darderi Subzone, **42** – sample 27; Major Subzone, **43** – sample 35, **44** – sample 36. **45-48** – *Tintinnopsella longa* (Colom), Gintsi 2 section, Upper Berriasian, Calpionellopsis Zone, Murgeanui Subzone, **45** – sample 19; Lower Valanginian, Calpionellites Zone, Major Subzone, **46** – sample 35, **47** – sample 38, **48** – sample 39. **49-50** – *Sturiella oblonga* Borza, Gintsi 2 section, Lower Valanginian, Calpionellites Zone, Major Subzone, **49** – sample 28, **50** – sample 33. **51-53** – *Tintinnopsella dacica* Filipescu & Dragastan, Gintsi 2 section, Lower Valanginian, Calpionellites Zone, Major Subzone, **51-52** – sample 29, **53** – sample 33.