INTEGRATED BIOSTRATIGRAPHY OF THE LOWER AND MIDDLE CONICIAC IN ROMANIA

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Abstract: A first model, for the Coniacian of Romania, with the integrated biostratigraphy based on ammonites, inoceramids, Didymotis, planktonic foraminifera, dinoflagellates, pollen and calcareous nannoplankton has been elaborated. In the present study the authors of this model present the primary, proxy and auxiliary intercorrelated bioevents that define in Romania the boundary and the content of the Lower and Middle Coniacian substages.

Keywords: Romania, Coniacian, intercorrelated biostratigraphy, ammonites, bivalves, planktonic foraminifera, dinoflagellates, pollen, nannoplankton.

INTRODUCTION

A first model, for the Coniacian of Romania, with the integrated biostratigraphy based on the ammonites, inoceramids and Didymotis bivalves (L.S.), planktonic foraminifera (J.I.), dinoflagellates and pollen (E.A.), calcareous nannoplankton (M.C.H.) has been elaborated by us (Ion et al., 1997, 1998). For this only few data have been published so far. The present study reveals the primary, proxy and auxiliary intercorrelated bioevents that define in Romania the boundary and the content of the Lower and Middle Coniacian substages.

It is worth emphasizing that in the Coniacian biostratigraphic key sections in Romania all six fossil groups studied by us co-occur, a situation rarely recorded, especially concerning macrofaunas; the ammonites and inoceramids are represented by taxa already used for making the biostratigraphic scales in Europe or in other areas of the world; except for the upper part of the Lower Coniacian, ammonite content of which has been newly separated in Romania [as Yabeiceras / Forresteria (Harleites) nicklesi Zone], the Coniacian ammonite biostratigraphy recognized for this area is the same as in the standard west European scales proposed by Kennedy (1984, 1985, 1986). In this context, in order to establish/modify the primary, proxy and auxiliary bioevents of the Coniacian stage in Romania, and especially of the Lower and Middle Coniacian, a high resolution was possible and all the biostratigraphic conclusions were documented with indubitable data. The bioevents emphasized for the Coniacian in Romania were previously classified (Ion et al., 1997, 1998) in three categories/values according to their practical reproduction (with regard to their chronological significance and correlation potential toward other parts of the Tethys): (i) the general/global bioevents, that have an extent covering very large areas sometimes including the whole Tethys; (ii) the regional ones, supposed to be valid for some parts of the Tethys; (iii) the local ones, known only in Romania, sometimes synchronous or complementary/proxy to some bioevents in the first two categories. Detailed data on the main taxa and bioevents and their categories which define the Coniacian stage in Romania are presented in Figure 1; the intercorrelated biostratigraphic subdivisions and their primary, proxy and auxiliary marker bioevents are consigned in Figure 2.

It is to note that the integrated biostratigraphic data here presented are the result of our studies in the sedimentary successions of the East and South Carpathians (especially of the Median Decides as a major tectonic unit) and of North Dobrogea (in the Babadag Basin). The biostratigraphic key sections in the Carpathians are located in the basinial sequences visible in the Peșâni Mountains (the Cârbunelui Valley, the Satului Valley-Ormeniș, the Ormeniș natural reserve quay and the Racior Valley sections), the Țara Bărești Basin (the Bârsă Valley and the Ghimbavului Valley sections), the Cheia Basin (the Codric Valley-Cheia Valley section) and the Breziol Basin (the Lotru Valley left river side section). In North Dobrogea (the Babadag Basin respectively), the biostratigraphic key sections are located in the Cacaguia - Baia - Ceamurile de Jos area (the sections: Bai Bair Hill at Cacaguia, Cobarul Mic, South Bai Bair Hill and North Baia quarries, between Baia and Ceamurile de Jos quarry); there are additional sections south of Văleni.

In the Carpathians the integrated biostratigraphic studies have been carried out on all fossil groups mentioned, while in North Dobrogea only on the macrofauna and planktonic foraminifera.

Some general data concerning the Lower and Middle Coniacian integrated biostratigraphy on these seven fossil groups, and for the entire Coniacian stage respectively, have been published by Ion et al., 1997, Ion et al., 1998 (regarding the categories of the bioevents) and Ion et al., in press (with the new biostratigraphic units defined by the authors). Part of the detailed data used concerning the integrated ammonite, inoceramid and planktonic foraminiferal biostratigraphy are given in Szasz & Ion (1984, 1988), Ion & Szasz (1994), Ion (1993). Data on the integrated macrofauna, planktonic foraminifera and microflora biostratigraphy are given in Ion et al. (1987, unpublished), plus the nannoplankton in Szasz et al. (1993, unpublished) and Ion et al. (1998, unpublished). Additional papers concerning palaeontology and biostratigraphy are (as more recently): by Szasz (e.g., 1981, 1985, 1986 b, 1986 c) and Walaszczyk & Szasz (1997) for the bivalves and ammonites; by Ion (e.g., Ion, 1983, 1993) for the planktonic foraminifera; by Melinte (1997, unpublished) for the nannoplankton; by Antonescu (in press) for microflora.

LOWER CONICIACIAN

The continuous successions across the Turonian-Coniacian boundary were observed only in the Babadag Basin and the Peșâni Mountains.

In the Babadag Basin, North Dobrogea respectively, the base of the Coniacian is marked by the first presence (FP) of Forresteria (Harleites) petrocreniosis (COQUAND) (as primary marker, of global value). ?Barroliceras haberfellneri (HAUER). Inoceramus (Cremnoceras) brongnarti MANTELLI, Didymotis genus and Marginotruncana tarfayensis (LEHMANN) (all

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these as the main proxy markers of regional value), as well as the FP of Mytiloides incertus (JIMBO) and Hedbergella flandrina (PORTHAULT) (as auxiliary proxy markers, the first of local value, the second of regional one). It is to note that the uppermost part of the Upper Turonian being deprived of macrofaunas, a detailed biostratigraphic study across the Turonian-Coniacian boundary only on planktonic foraminifera has been possible. *M. tarfayensis* always has the first occurrence (FO) 3.5 m above the last stratum with Upper Turonian ammonites and inoceramids (in Visterna and Cogarul Mic sections) and 1-2 m below the first presence of the Lower Coniacian ammonites and inoceramids as well as of the *Didymotissa* (in the Bal Bair Hill-Caucagia section).

For the North Dobrogea, a composite succession of the biostratigraphic data/events across the Upper Turonian-basal Coniacian is the following: (i) The approximate lower part of the Upper Turonian is represented by a pile of strata (5-10 m thick, Visterna by Cogarul Mic sections) characterized (at Visterna) by the presence of *Inoceramus* (*I.*) falcatus HEINZ, *I.* (*I.*) costellatus WOODS, *I.* (*I.*) longealatus TRÖGER, *I.* (*I.*) parvus TRÖGER, *I.* (*I.*) tenuisistratus NAGAO & MATSUMOTO, *Mytiloides lusitiae* (ANDERT) (= the assemblage of the *I.* (*I.*) falcatus and *I.* (*I.*) teshioensis Assemblage Zone) and *Tongoboryceras rhodanicum* (ROMAN & MAZERAN), all having the FP at the base of this pile of strata, or (in Cogarul Mic section) by the presence of *Romaniceras* sp. and *I.* ex gr. *fragilis-perplexus* in the basal segment and of *Pachydesmoceras linderi GROSSOUVRE, Parapuplosia moben GROSSOUVRE and *Mytiloides carpaticus* (SIMIONESCU) in the upper one. Associated with these macrofaunas there is the characteristic planktonic foraminiferal assemblage [including *gr. Sigalotruncana Margutrinucrana undulata undulata* (LEHMAN) and *Margutrinucrana paraconcaeva* PORTHAULT that have the FO at the base of the Upper Turonian] of the Upper Turonian segment of the *Margutrinucrana corona* Zone. (ii) The upper or the uppermost part of the Upper Turonian is represented by a pile of strata (of 3.5 m, in Visterna and Cogarul Mic) deprived of macrofaunas and including the same planktonic foraminifera as for subjacent strata. (iii) Follows the FO of *Margutrinucrana tarfayensis* (= the beginning of the *M. tarfayensis* Zone) succeeded at 1-2 m (in the Bal Bair Hill-at Caucagia section) by the simultaneous FP of *F. (H.) petrocoriensis* (= the beginning of the *F. (H.) petrocoriensis* Zone), *B. haberfellneri haberfellneri* (HAUER), *B. haberfellneri hemitissotiformis* PLOCHINGER, *Inoceramus (Cremnoceras) bronniari* (= the beginning of the *I. (C.) bronniari* Zone), *My. incertus* and of the *Didymoceras* genus (by Di. sp. and Di. aff. variabilis GERHARDT). The planktonic foraminifera species *Margutrinucrana angusticarinata* (GANDOLFI) (a later FO comparatively with those from the Carpathians), *M. sigali* (with 2 carenas), *M. schneegansii* (SIGNAL) (with 2 carenas) and another new taxa (*I. on, 1983, 1993, I. on in ION & SZASZ 1994) have the FO together with the FO of *M. tarfayensis*. 
According to the data from the Perşani Mountain key area (Cârbuneleului Valley at Racogul de Sus section) the succession of biostratigraphic data across the Upper Turonian-basal Coniacian is the following: (i) The first Upper Turonian sequence (approximate 5 m thick) contains the Subprionocyclos neptuni ammonite Zone [represented by the assemblage with S. neptuni (GEINITZ), S. branneri (ANDERSON), S. cf. normalis (ANDERSON), Damasites sugata (FCRBES) and Lewesiceras sp.], the Inoceramus (L.) falcatus - L. (L.) teshioensis Assemblage Zone [with the nominate species and L. (L.) costellatus, L. (L.) parvus, L. (L.) gatziæ FLEGEL, L. (L.) longeanus, L. (L.) inequivalvis SCHLÜTER, Inoceramus (Cremnoceramus) globosus SIMIONESCU, My. lusitaniae], the planktonic foraminiferal characteristic assemblage [including gr. S.-M. undulata undulata, M. paraconcaeva and some new morphotypes as Marginotruncana aff. M. angusticarinata (GANDOLFI) – with very involute chambers on the spiral side, M. aff.(1) M. pseudolinneiana PESSAGNO – with the spiral side in Globotruncana obliqua HERM type form, M. aff.(2) M. pseudolinneiana – with angular lobate outline] of the middle and upper segments of the M. coronata Zone, and the nannoplankton of the Kampnagius magnificus Zone and of the lowermost segment of the Marnhastites furcatus Zone (of the Lucianorhabdus maleformis Subzone respectively). (ii) The following Upper Turonian sequence (10–15 m) is deprived of macrofaunas and contains the same planktonic foraminiferal assemblage as in immediately subjacent strata. (iii) Follows the simultaneous FO of My. incertus (= Inoceramus fiegei TRÖGER in Szasz, 1986 a), M. tarfayensis, H. flandrinii (= the beginning of the M. tarfayensis Zone and of the F. loeblichiae Subzone), M. "sigali" (as possible morphotype of Dicarinella primitiva DALBEZ) and M. schneegansi. (iv) At 10 m above follows a new level with My. incertus succeeded at 5 m by (v) a pile of strata (of approximate 5 m) with Mytiloides carpathicus (SIMIONESCU) and My. herbichii (ATABAKIAN) (= Inoceramus szadetzki SIMIONESCU in Szasz, 1986 a). In the (iv) and (v) segments the planktonic foraminiferal assemblage is the same as in subjacent strata and the nannoplankton is of the M. furcatus Zone and probably into this interval Lilasterites angularis STRADNER & STEINMETZ (= the beginning of the Li. angularis Subzone) and then Lithastrinus moratus STOVER appear. In the Perşani Mountains are also present the specimens of B. haberfellneri which are preserved in several collections (e.g. Patruliu's collection, Geological Institute of Romania) but it is not known where the fossiliferous point is exactly situated in the Coniacian succession.
Figure 2 - The integrated biozonation for the Coniacian from Romania and tentative correlation with other ones from the Tethyan realm. Legend of signs: 1 - not investigated biostratigraphically; 2 - first occurrence; 3 - last occurrence, as boundary bioevents for the zones and subzones; 4 - first occurrence; 5 - last occurrence as auxiliary bioevents. Key to fossils: Macrofauna: Clad, Cladidicerasum; S, Selenceramus. Planktonic foraminifers: Ct, Contusotruncana; f, Ct. fornicata; D, Dicarinella; as, D. asymmetrica; cv, D. concavata; F, Falsotruncana; Fl, F. loeblichsae; G, Globotruncana; bu, G. bullioideis; ro, G. rosetta; H, Hedbergella; fl, H. flandrina; H, Helvetoglobotruncana; he, H. helvetica; M, Marginotruncana; sp, M. spinosa; tf, M. tarflyensis. Dinoflagellate: Ch, Chatangiella; Dy, Dinogymnium; I, Isabelidinium. Foraminfera: K, Krutschiopollis; M, Megatricopollis; Ms, M. santonius; Mg, M. glabrums; S, Suemeghipollis; St, S. triangularis; Sem, Semioconipollis mediaus; Tr, Trudopolis cf. nonperfectus; V, Verrucocipollis. Calcareous nanoflagellate: K, Kampnoweris; ang, Lillasterites angularis; Lit, Lithastromis; q, Lit. grillii; s, Lit. septimanus; m, Lucianochabius maleformis; f, Martasterites furcatus; M, Micula; d, M. decussata; c, M. concava; R, Reinhardtites; an, R. anthrophorus.
On the base of the above listed data from Persi Mountains and from other Carpathian areas, as well as by correlation with those from North Dobrogea, we admit that in the Carpathian domain the base of the Lower Coniacian is marked by the simultaneous FO of *My. incertus*, *M. tarfayensis* and *H. flandrii*. Concerning the nannoflora, there is no criteria for establishing this boundary; it should have been situated into the lowermost segment of the *M. furcatus* Zone (into the Lucianothubolbidae maleformis Subzone respectively). There are no microfloristic data across this boundary. In the Carpathians, as well as in North Dobrogea, the approximate upper part of the Upper Turonian is devoid of macrofaunas, the base of the Lower Coniacian being situated at 10-15 m above the last levels with Subprorionycys nepuni ammonite Zone and the Inoceramus (I.) falcatus and I. (I.) teshiosinis Assemblage Zone.

The Lower Coniacian stage in Romania, from the point of view of the ammonites, inquoridams and planktonic foraminifera, is represented by two parts, the second one being separated/defined (Szasz in Szasz & Ion, 1988 for ammonites; Szasz in Ion et al.1997, 1998, for inoceramids; Ion, in this paper, for planktonic foraminifera) in this area.

The lower part of the Lower Coniacian

In summary, this time interval is represented in macrofaunistic terms by the Forrestaria (Harlellia) petrocoriensis ammonite Zone in co-occurrence with the inoceramus (Cremnoceramus) bronngarti Zone and in the base with the first specimen of *Didymotis* genus (the first *Didymotis* event known only in North Dobrogea). Associated with these there is a lower Lower Coniacian characteristic planktonic foraminiferal assemblage of the lowermost segment of the Marginotruncans tarfayensis Zone (of the Faislortuncana loeblichiae Subzone respectively). It contains the nominal species and other ones that appear at the Turonian-Coniacian boundary (listed at point "I"), the Faislortuncana genus, Helvetoglobotruncana helveticus (BOLL), and it is deprived of Globotruncana rosseta (CARSEY) and G. mariei (BANNER & BLOW). The nanofossil floras zonal assemblage is of the *M. furcatus* Zone (of the Lucianothubolbidae maleformis Subzone and Liliasterites angularis Subzone respectively) (see Figure 2). The microflora of this interval has not been sufficiently investigated.

The detailed succession of biostratigraphic data/events across the basal/lowermost Lower Coniacian has been presented in the Turonian - Coniacian boundary chapter.

With regard to the detailed biostratigraphic data across the lower part of the Lower Coniacian, it is to note that in North Dobrogea (in Bal Bair Hill at Caucaiga section, along a pile of strata 6-8 m thick), all macro- and microfaunistic characteristics briefly listed above are clearly outlined. The *F. (H.) petrocoriensis* ammonite Zone and the I. (Cr.) bronngarti Zone concomitantly contain, from base, the *F. (H.) petrocoriensis*, B. habefelleri haberfellneri, B. h. heminitisotiformis as well as I. (Cr.) bronngarti and My. incertus respectively; the first specimens of *Didymotis* (Di. aff. variabilis GERHARDT, Di. spp.) are in the base of these two co-occurring macrofaunistic zones; approximately in the middle part of these zones there are specimens of *Micraster cortestudinarium* GOLD. The planktonic foraminiferal assemblage of the *M. tarfayensis* Zone (and of the F. loeblichiae Subzone), that starts from 1-2 m below the beginning of these macrofaunistic zones and co-occurs with them, is characterized by: the presence, from base, of *M. tarfayensis*, *H. flandrii*, M. "sigallii", M. naceaegani, M. angusticarinata, the persistence of *Faislortuncana* and *H. helvetica*, the absence of *G. rosetta* and G. mariei.

In the Carpathian domain, as macrofauna for the lower part of the Lower Coniacian (in the Cârbenului Valley section from the Persi Mountains) only an inoceramus assemblage is known [assigned to the I. (Cr.) bronngarti Zone], including *My. incertus, My. carpathicus* and *My. herbichii*. It is associated with the planktonic foraminiferal of the *M. tarfayensis* Zone (and of the F. loeblichiae Subzone) and the nanoplankton of the *M. furcatus* Zone (and of the L. maleformis and L. angularis Subzones respectively). The planktonic foraminiferal assemblage from the Carpathians differs from that in North Dobrogea by the presence of some morphotypes noted as *M. aff. M. angusticarinata*; *M. aff. (1) M. pseudolinneiana, M. aff. (2) M. pseudolinneiana, M. aff. Sigillotuncana marianoi* (DOUGLAS, M. n.sp.1, M. n.sp.2 and others (Ion, 1983, 1993; Ion in Ion & Szasz, 1994). Except M. n.sp.2 that has the first occurrence in the base of the Coniacian, all the cited taxa start from the base of the Upper Turonian.

The upper part of the Lower Coniacian

In macrofaunistic terms this time interval is represented in summary by the Yabeiceras/Forrestaria (Harlellia) nicklesi ammonite Zone and Inoceramus (Cremnoceramus) crassus Zone; a level with *Didymotis* bivalve (the first level being in the Carpathians, the second one in North Dobrogea) is present in the basal/lowest segment of these macrofaunistic zones.

The most important intercorrelated biostratigraphic data/events across the upper Lower Coniacian strata with these ammonite and inoceramid zones are the following in the Carpathians and North Dobrogea. (i) The base of this interval is marked by concomitant events: in ammonite terms, the FP of Yabeiceras genus (Y. orien tale (TOGUNAGA & SHIMUSU), Y. spp. in North Dobrogea (in the Bal Bair Hill at Caucaiga section) or of F. (H.) nicklesi GROSSOUVE in the Carpathians (in Cheia Valley section) [= the beginning of the Yabeiceras/F. (H.) nicklesi Zone respectively], as well as the FP of Neocricoceras (Schlueterella) kossmati (SIMIONESCU), Scaphites kieslingswaldensis LANGENHAN & GRUNDE and Gaudrycerae mite (HALEVA) in both domains, Peroniceras (Zuluiceras) isamberti (FALLOT) in the Carpathians (Cheia Valley), Nowakites macovei SZASZ and Kosmoceratinae sp. in North Dobrogea (Bal Bair Hill section at Caucaiga); in inoceramid terms, the FP of I. (Cr.) sp. of PETRASCHK [= the beginning of the I. (Cr.) crassus Zone] as well as of I. (Cr.) deformis MEEK, I. (Cr.) rotundatus sensu TRÖGER non FIEGE, I. (Cr.) pseudolinneiana SZASZ, I. (Cr.) incurvatus FIEGE in both domains, and other species in North Dobrogea such as I. (Cr.) woodsii FIEGE, I. (Cr.) naumannii YOKOYAMA and new species separated by Szasz (Szasz in Szasz & Ion, 1988). In both domains, in this boundary level there is a planktonic foraminiferal assemblage of the *M. tarfayensis* Zone (and of the F. loeblichiae Subzone respectively) with the same characteristics as in the lower part of the Lower Coniacian, as well as a nanoplankton assemblage of the *M. furcatus* Zone (of the L. angularis Subzone respectively) as in immediately subjacent lower Lower Coniacian strata. (ii) Very closely above (at 1 m in Cheia...
of the Yabeiceras/F. (H.) nicklesi Zone and I. (Cr.) cassus Zone (and of the upper part of the Lower Coniacian respectively) there is the LO of Helvetoglobotruncana genus (of H. helvetica respectively). (ix) into the upper segment, the planktonic foraminifera Marginotruncana spinea (KIKOINE) has the FO (= the beginning of the M. spinea Subzone) and (x) little higher, in the facies "with concavates", there is the FO of Dicarinella concava (BROTZEN) (= the beginning of the D. concava Zone). The events listed at the points (vii), (ix) and (x) are present in both the Carpathian and North Dobrogea domains. (x) In the terminal segment, in the Carpathians (Satulai Valley-Ormenis) there is present the ammonite Scaphites geinitzi (d'ORBNIGY) associated with the FO of the dinoflagellate Odontochitina criouflodis and followed by the presence of the ammonite Tissotidiospis haplophyllus (REDTEBACHER).

This succession of biostratigraphic data/events supports the following conclusions concerning the intercorrelated biostratigraphy of the upper part of the Lower Coniacian.

(a) The criteria for the base of this time interval are: the FP of the Yabeiceras genus in North Dobrogea, or of F. (H.) nicklesi in the Carpathians, as primary boundary markers (of local value); for both domains, the FP of I. (Cr.) cassus, G. rosetta and G. mariet as proxy marker (the first of regional value, the last two of local value) and of other numerous auxiliary bioevents noted at point (i). The nanoplankton criteria for this boundary level do not exist and it falls into the M. furcatus nanoplankton Zone (in the Li. angularis Subzone respectively). Concerning the microflora, it has not been yet established that the FO of the Didogymnium, Chatangytiella and Megapatria genera, as well as of other taxa listed at point (iv), is at the base of the Lower Coniacian or higher characterizing the upper part of the Lower Coniacian.

(b) The ammonite fauna of this interval, separated as Yabeiceras/F. (H.) nicklesi Zone, is characterized by the absence of B. habordelleri, F. (H.) petrococeriensis and of the specimen of Peroniceras sensu striato; the presence from base of the Yabeiceras genus in North Dobrogea and of F. (H.) nicklesi in the Carpathians; Neocricoceras (Sch.) kosmaiti, Scaphites kieslingswaldensis [in the Carpathians cited by Szasz, 1981, as Sc. aff. compressus (d'ORB.)] and Gaudryceras mite in both domains are characteristically occurring from its base too. In the Carpathians the characteristic assemblage for entire this ammonite zone includes also, from its base, Peroniceras (Zolocerac. torimarii) sikserti (= Samoyerceras aff. moromi MTSUMOTO in Szasz, 1981); only in the upper segment and Nowakites tallagnesi, N. karezi, Pseudokosmatisceras sp. (= P. aff. brandti (REDTEBACHER) in Szasz, 1981), Eupachydiscus sayani, Saghinalites n.sp. (= Tetragonites aff. epigonum KOSMATT, in Szasz, 1981) that concomitantly appear approximately in the middle of the zone; in its uppermost segment Lewesiceras simionescui PAULIU, Scaphites geinitzi, and in the terminal one Tissotidiospis haplophyllus are present as well. In North Dobrogea, Nowakites macoveiei and Pachydesmoceras sp. add in the base of this zone as characteristic species, and the assemblage contains also Tongoboryceras canalii, Gaudryceras varagurense KOSSMAINT, G. densepetecatum (JIMBO), Parapuziosia (Austinerac. mberigi.

(c) The nanoplankton fauna, separated as the I. (Cr.) cassus Zone, is characterized by: the absence of Inoceramus (Piatyceras) mantelli; the occurrence,
only in this zone and coming from its base, of the I. (Cr.) crassus-I. (Cr.) deformis group; the occurrence, from base, of I. (Cr.) rotundatus sensu TRÖGER non FIEGE. The characteristic species in both the Carpathian and North Dobrogea domains are: (Cr.) crassus, I. (Cr.) rotundatus sensu TRÖGER non FIEGE, I. (Cr.) pseudoinconstans, I. (Cr.) incuvatissimus. To these species add the numerous inoceramids, cited at point (vi), that are present from the middle of the I. (Cr.) crassus Zone (in the same level in which in the Carpathians several ammonites appear) characterizing its upper segment.

It is obvious that the upper segment of the upper Lower Coniacian ammonite and inoceramid zones has common characteristics with those of its lower segment but also some of its. In the Carpathians and North Dobrogea, in the upper segment there is present Micraster gracilis - costei - costeiunderianum too.

(d) The level with specimens of Didymotos (as the first Didyotis level known in the Carpathians, the second one in North Dobrogea) is present in the basal/lowermost segment of the upper Lower Coniacian because: (i) in North Dobrogea it is located very closely above the beginning of the Yabieceras/ F. (H.) nicklesi Zone, I. (Cr.) crassus Zone and G. rosetta Subzone; (ii) in the Carpathians this bivalve co-occurs with the inoceramid assemblage of the I. (Cr.) crassus Zone (in the natural reserve Ormeniș quarry) and the planktonic foraminifer assemblage of the G. rosetta Subzone (at Ormeniș quarry and in the Racior Valley) that is calibrated as being characteristic of the lowest segment of the upper Lower Coniacian.

(e) Associated with the macrofaunas of the Yabieceras / F. (H.) nicklesi and I. (Cr.) crassus Zones there are the planktonic foraminifera and the noninoceramid of the several zones and subzones as well as the microflora of some zones, represented in Figure 2. Theirs boundary bioevents and auxiliary ones [listed at (i)-(x) points] are accurately calibrated on ammonite and inoceramid faunas.

The new G. rosetta Interval Subzone, new defined (by ION in this paper) in Romania, represents the interval from the FO of the nominal species to the LO of Falsotruncana loeblichiae. By the separation of this subzone the FO of the loeblichiae Subzone has the definition (ion in lon et al., 1999) and emended by lon in present paper): the interval from the FO of Marginotruncana tarfayensis to the FO of G. rosetta.

It should be noted that beginning from the uppermost Lower Coniacian (as well as for the Middle and Upper Coniacian) in planktonic foraminifera terms there is a biofacies "with concavates" (in North Dobrogea and in some areas in the Carpathians) and other "without concavates" (in same areas in the Carpathians). But from a biostratigraphic point of view they have in common the first occurrence of the Marginotruncana spinea that is situated near to the FO of D. concavata.

On the ground of the planktonic foraminifera events, the following characteristic assemblages are recorded during this time interval from the Carpathians and North Dobrogea: (i) for the lowermost segment (= G. rosetta Subzone), an assemblage with G. rosetta, G. mariei, M. tarfayensis, H. flandini, Falsotruncana, Helvetoglobotruncana (H. helvetica); for the approximately median segment (= H. flandini Subzone), (ii) an assemblage without Falsotruncana genus and with M. tarfayensis, H. flandini, G. rosetta, G. mariei, Helvetoglobotruncana, followed by (iii) an assemblage without Helvetoglobotruncana (H. helvetica); (iv) for the approximately upper segment (= D. concavata Zone) and a part of the M. spinea Subzone respectively, the assemblage with M. spinea, M. tarfayensis, G. rosetta, G. mariei, H. flandini and with or without (in facies without "concavates") D. concavata.

As characteristic nanoplancton assemblages for the upper part of the Lower Coniacian there are: (i) for the lowermost segment (= uppermost segment of the Li. angularis Subzone), an assemblage with M. furcatus and Li. angularis; (ii) beginning from the median segment, the assemblage with Li. septentrionalis, M. furcatus and Li. angularis (= Li. septentrionalis Subzone).

The microflora belongs to the approximately lower segment of the synchronous Dinogymnium spp. dinoflagellate Zone and Megatriplorhizus santonius pollen Zone as well as (only in open sea facies) to the Turonian-Lower Maastrichtian Xenasus ceratoids dinoflagellate Zone. Except for some events, such as the FO of Oculopollis sp. ex gr. O. serratus - O. breviculus in the median segment of the upper Lower Coniacian (into the H. flandini planktonic foraminifera Subzone) and of Odontochitina cibropoda in the uppermost one (into the M. spinea Subzone), the microflora of this time interval is unitary. It is characterized by the presence of the numerous taxa that do not occur in the Turonian, such as: Megatriplorhizus (M. santonius and M. glabrum), Trudopolis, Interporopollinates, Semioculopollis, Hofkeripollinates (H. hemimechicus) and Emsheripollinates pollen gena, as well as Oculopollis orbicularis, O. seminivirus and O. sp. ex gr. serratus - breviculus pollen species; Chatangiella and Dinogymnium dinoflagellate gena, Odontochitina cibropoda dinoflagellate species. Several taxa persist from the Cenomanian, Turonian, etc.

**MIDDLE CONACIAN**

The base of the Middle Coniacian in Romania would be marked by the following concomitant bioevents: in ammonite terms, by the FO of the genus Peroniceras s.str. represented by P. tridorsatum (SCHLÜTER) as primary marker (of global value) and P. (Zuluiceras) bajuvaricum (REDTENBACHER) as proxy marker (of regional value); in inoceramid terms, by the FO of Inoceramus (Platyceramus) mantelli MERCERY as primary marker (of regional value), I. (Volviceramus) koeneni MULLER as proxy marker (of general value) and of I. (V.) involutus SOWBERY as proxy marker, the absence of the specimens from the I. (Cr.) crassus - I. (Cr.) deformis group; in planktonic foraminifera terms, by the FO of Dicarinella asymetrica (SIGAL) (in facies without "concavates") as primary marker (of regional value) and/or (in facies without "concavates") by the FO of Compositotrunca spicornicata (PLUMMER) that may be a proxy marker (of regional value) for the basal/lowermost segment of this substage being located no longer above the first occurrence of asymetrica. No microflora and noninoceramid criteria are known for the base of the Middle Coniacian.

It is to note that for an ammonite and inoceramid biostratigraphic study concerning the Lower-Middle Coniacian boundary, we do not have a pile of strata with macrofaunas across this contact. In North Dobrogea (North Baia-near the oil station quarry) and in some areas from the South Carpathians (Lotru Valley section from Brezoii Basin) where the Middle Coniacian ammonite and inoceramid zones are the best
represented, this contact does not outcrop. But the first outcropping Middle Coniacian levels are with *P. tridorsatum* and/or *I. (Pl.) mantelli*, as well as with *D. concavata* (in North Dobrogea, in facies with "concavenes"). In two sections from the Carpathians, from the Cheia Basin (Cheia Valley section) and in the Perșani Mountains (Satul lui Ormeniag respectively, across this boundary an outcropping succession exists but having some ammonites and incoceramids only around it (respective above or below a pile of rocks without macrofauna and in which this limit would have lied). The succession of the planktonic foraminifera events and the characteristics across the uppermost Lower Coniacian-middle Coniacian have been well documented in the Târa Bărsăi Basin (in Bârsa Valley section) but in sediments deprived of macrofauna.

In summary, in macrofaunistic terms the Middle Coniacian in Romania is represented by co-occurrence of the *Peroniceras tridorsatum* ammonite Zone and the *Inoceramus* (Platiceramus) *mantelli* Zone. Associated with these macrofaunas there are: as planktonic foraminifera, the approximate lower segment of the *Dicarinella asymetrica* Zone (in facies with "concavenes") and of the *Cotusoturunclana formicata* Subzone (in facies with or without "concavenes") as well as the terminal segment of the Marginoturunclana spinea Subzone (in both facies too); for the nannoplankton, the terminal segment of the *Marchantines furculus* Zone and of the *Lithastinix septenarius* Subzone, as well as the great part of the *Micula decussata* Zone; for the microfora, a part from the *Dinogymnium* spp. and *Xenacera ceratioides* dinoflagellate Zones and of the *Megatrichopolis santonius* pollen Zone.

The Middle Coniacian ammonite zonal assemblage in North Dobrogea (North Baia-near the oil station quary, near the Ceamură de Jos quarry) includes: *P. tridorsatum*, *P. (Z.) cozemigli* (REDELBACHER), *Nowakites karezi*, *Euchadysidiscus saynii*. In the South Carpathians (Lotru Valley) it contains: *Peroniceras*, *P. (Z.) baujaricum*, *?Anapachycis arriaaleoens* (STOLICKA), *Nowakites saynii*, *Gaudercyis glaeneggensi* (REDELBACHER), *Sc. kieslingswaldensis*, *Baculites sp.* In the East Carpathians, the Middle Coniacian macrofauna is represented only by *Peroniceras aff. dravidicum* (in Satul lui Valley from Perșani Mountains) from Patru Saluri collection.

The Middle Coniacian inercamid amonite zonal assemblage is characterized by the absence, in both the Carpathian and North Dobrogea domains, of *I. (Cr.) crassus* and *I. (Cr.) deformis*; in North Dobrogea it contains *I. (Pl.) mantelli* associated with *I. (Cr.) inconstans* and *I. (Cr.) waltersdorffensis*; in South Carpathians, it comprises *I. (Pl.) mantelli*, *I. (Pl.) szaszi*, *I. (V.) koeni*, *I. (V.) involuitus*, *I. supercostatus* and other species.

In both domains, excepting the marker bioevents listed for the base of the Middle Coniacian, the followiing buevents/data are also known across the strata with *P. tridorsatum* and *I. (Pl.) mantelli* Zones: (i) into the basal segment, the microflora is the same as in the Lower Coniacian but the *Oculeopolis* is very abundant, the planktonic foraminifera *Cotusoturunclana formicata* has the FO (= the beginning of the *Ct. formicata* Subzone); (ii) higher, into the lowermost segment, the nannoplankton *Micula decussata* has the FO (of local value event; = the beginning of the *M. decussata* Zone); (iii) higher, the *Atlaptipolis* pollen genus has the LO (of local value event) as well as *Complexipolpis funiculis* TACHUDY and other microfora.

The above presented conclusions regarding the biostratigraphy of the Middle Coniacian from Romania, are the best documented by the following detailed data recorded in several key sections.

For the terminal Lower Coniacian-basal/lowestest Middle Coniacian the data supplied by the Cheia Valley section are the following. Above the last levels with faunas of the *Yabeiceras F.*, *H. (H.) nicklesi* and *I. (Cr.) crassus* Zones follows: (i) 0.25 m thick rocks without macrofauna but including, as in the subjacent levels, the planktonic foraminiferal assemblage (of the *M. spinea* Subzone) with *M. spinea*, *G. rosetta*, *G. mariel*, *M. tarfaeyensis*, the nannoplankton assemblage (of *Lit. septenarius* Subzone/M. *furcatus* Zone) with *Lit. septenarius* and *M. furcatus*, the microfiora with *Megatrichopolis santonius*, *Dinogymnium* spp. and Chattangiella, etc. (of the *Megatrichopolis santonius* pollen Zone and the *Dinogymnium* spp. dinoflagellate Zone); (ii) follows 2.75 m thick rocks also deprived of macrofauna, the planktonic foraminifera content not known, but including the same microfiora as in subjacent levels; (iii) immediately above follow the first indubitable Middle Coniacian levels including *I. (V.) koeneni* and the planktonic foraminiferal assemblage (of the *Ct. formicata* Subzone) with *Ct. formicata*, *M. tarfaeyensis*, *M. spinea*, etc., while the microfiora and nannofiora are the same as in subjacent levels.

For the same time interval, the Satul lui Valley-Ormeniag section reveals the following biostratigraphic data from the bottom to the top: (i) a terminal Lower Coniacian pile of strata (of approximately 10 m thick) including *I. (Cr.) crassus* and *Lewesiceras simonciclus* followed by *Sc. groeniti*; (ii) a 5-6 m Lower Coniacian strata also deprived of macrofauna but including the planktonic foraminiferal assemblage with *M. spinea*, *G. mariel*, *M. tarfaeyensis*, etc. (of the *M. spinea* Subzone) and the microfiora with *Dinogymnium*, Chattangiella and the first *Odontochitina chirobopoda* (of the *Dinogymnium* spp. dinoflagellate Zone) as well as with *Megatrichopolis glabrum* and other pollen taxa (of the *M. santonius* pollen Zone); (iii) immediately above, there is *T. haplophyllos*; (iv) 5 m pile of strata without macrofauna and microfiora data, but including the same planktonic foraminiferal assemblage as at (i) point; (v) at 1 m above, the FO of *Ct. formicata* (the beginning of the *Ct. formicata* Subzone) that would indicate the basal/lowestest segment of the Middle Coniacian.

For the Carpathians domain, the biostratigraphic section showing the greatest part of the Middle Coniacian to the boundary with the Upper Coniacian, lies on the left side of the Lotru Valley (Brezoiu Basin). Here, across the Middle Coniacian pile of strata (50 m) with faunas of *P. tridorsatum* ammonite Zone and *Inoceramus* (Pl.) *mantelli* Zone the following integrated biostratigraphic data from bottom to the top are known: (i) a sequence of strata (10 m) including *I. (Pl.) mantelli* and *Anapachycis arriaaleoens* macrofauna associated with the nannoplankton assemblage with *Micula decussata* (of the lowermost part of *M. decussata* Zone); (ii) a sequence (2 m) with the same nannofiora and macrofaunas as in subjacent strata but plus *P. (Z.) baujaricum* and *Peroniceras* sp.; (iii) at 2-3 m above, some levels including *G. glaeneggensi*, *Sc. kieslingswaldensis*, *Anap. arriaaleoens*, *I. (Pl.) mantelli*, *Inoceramus* sp., an important planktonic foraminiferal assemblage, a microfiora with *Dinogymnium*, Chattangiella, *Megatrichopolis* and *Atlaptipolis* as in the upper part of the Lower Coniacian but having more frequently the *Oculeopolis* genus (O. orbiculareis
GOCZAN, O. semimaximus KRUTZSCH, O. suturalis), a nanoplancton assemblage of the M. decussata Zone as in the underlying strata; (v) a sequence of strata (15 m) with I. (P.) mantelli and the same planktonic foraminifera, microfossil and nanofossil as in subjacent strata; (v) the last sequence (10 m), with I. (P.) mantelli, G. planeggense, the planktonic foraminifer assemblage (of the Ct. fomite subzone) with Ct. fomite and the same nanofossil as in underlying strata. In this section the Middle Coniacian planktonic foraminifer assemblage is without "concavetes".

In North Dobrogea the Middle Coniacian is represented by several segments of strata outcropping in the quarries from the area between North Baia - Ceaumuria - the point "Two cantones". (i) The uppermost Lower Coniacian is represented (in the North Baia quarry) by a segment of strata (2 m) including N. (Schl.) kossmati, I. sabzakensis, I. (Cr) waltersdorffensis (= I. stummi ANDERT in Szaasz & Ion, 1988) and the planktonic foraminifer assemblage (of D. concavata Zone) with D. concavata, M. pseudolitiniaria, M. "renzi" (plan-convex), etc. (ii) The first outcropping (in North Baia quarry, near the oil station) Middle Coniacian segment of strata (6-8 m) includes the zonal assemblages of the P. tridorsatum ammonite Zone, the I.(P.) mantelli Zone and of the Dicarinella asymetrica planktonic foraminifera Zone. The ammonite zonal assemblage comprises P. tridorsatum, P. (L) coemnigii, N. karrei, Eup. saynii. The inoceramid zonal assemblage is with I. (P.) mantelli beynenburgi, I. (Cr) waltersdorffensis, I. (Cr) inconstans, My. incertus. The planktonic foraminifer assemblage is with D. asymetrica, D. concavata, M. paraconcavata, M. "renzi", M. renzi (biconvex), M. pseudolitiniaria. (iii) The next outcropping segment of strata (5-6 m, North Baia quarry) follows after a not outcropping part and bears Eup. saynii and a level with Cardiaster as macrofauna, as well as the planktonic foraminifer assemblage (of D. asymetrica Zone) with D. asymetrica, D. concavata, M. paraconcavata and into its base the Ct. fomite species has the FO. The Middle Coniacian segment of strata outcropping in the Ceaumuria de Jos quarry is equivalent of the (iii) segment from North Baia quarry. It bears Peroniceras sp., I. (P.) mantelli mantelli, I. (P.) mantelli beynenburgi, Puzosia sp., Micraster sp., and other macrofaunas, as well as the planktonic foraminifer assemblage (of the D. asymetrica Zone) with D. asymetrica, Ct. fomite, M. paraconcavata.

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