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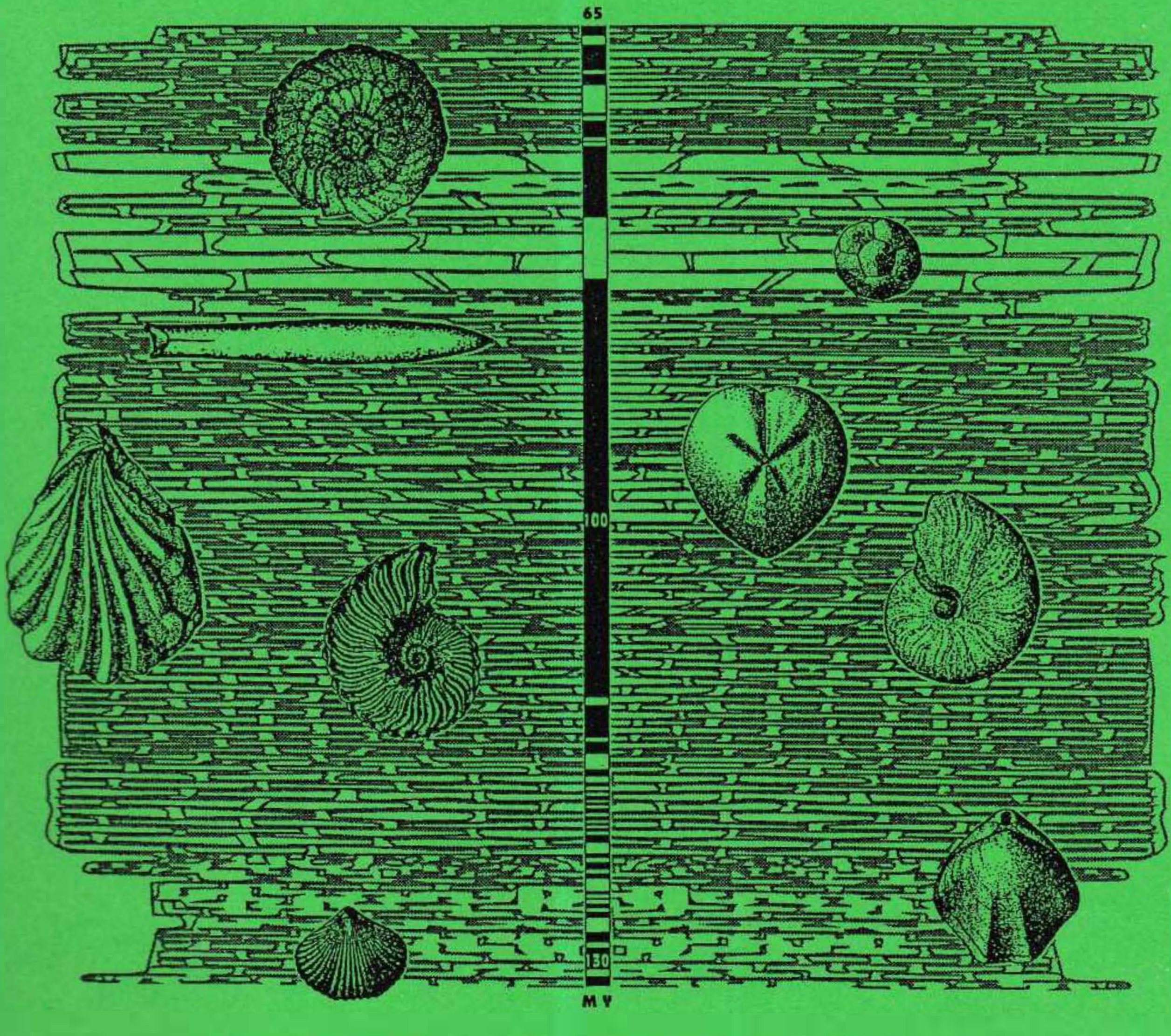
ABSTRACT VOLUME



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FOREWORD

The abstract volume of the Second International Symposium on Cretaceous Stages Boundaries contains reports of the Stage working group chairmen (or to be correct one chairwoman and 11 chairmen) and abstracts of papers (77) and posters (75), representing the Cretaceous under most aspects and from almost everywhere on earth.
All reports, papers and posters, shall be presented and discussed during the four days of the symposium at the Institut royal des Sciences Naturelles/ Koninklijk Belgisch Instituut voor Natuurwetenschappen in Brussels. We hope that many precise proposals on stage and substage boundaries shall result from these discussions.

The organisation of the meeting has only been made possible by generous assistance from the Services Federaux des Affaires Scientifiques, Techniques et Culturelles (Service des Etablissements scientifiques fédéraux)/ Federate Diensten voor Wetenschappelijke, Technische en Culturele Aangelegenheden (Dienst van de federate wetenschappelijke instellingen) (Brussels), the Nationaal Fonds voor Wetenschappelijk Onderzoek (Brussels), Exekutive der Deutschsprachige Gemeinschaft (Eupen), Société Générate de Banque (Brussels) and, last but not least, from D. Cahen, Director of the IRScNB/KBIN and colleagues from many departments and services at the Institute.

The preparation of the abstract volume has only been possible because of the hard work and good advice of many in the IRScNB/KBIN. We would like to express our deepest gratitude to everybody in the Palaeontology Department, and to many who helped us in the Library, in the Educational Services, in the Printing Office. Our sincere thanks go especially to Dirk ANNE, Jean-Jacques BLAIRVACQ, Claire BODSON, Anne-Marie BORREMANS, Jan CLAERBOUT, Mia CLAUS, Suzanne CLINET, René CREMERS, Walter DE CONINCK, Hugo DE POTTER, Eric DERMIENCE,Anouk DUBOIS, Paul FREROTTE, Marcella HAEMELINCK, Arthur NYS, Mia VAN LOMMEL.

Brussels, August 24, 1995

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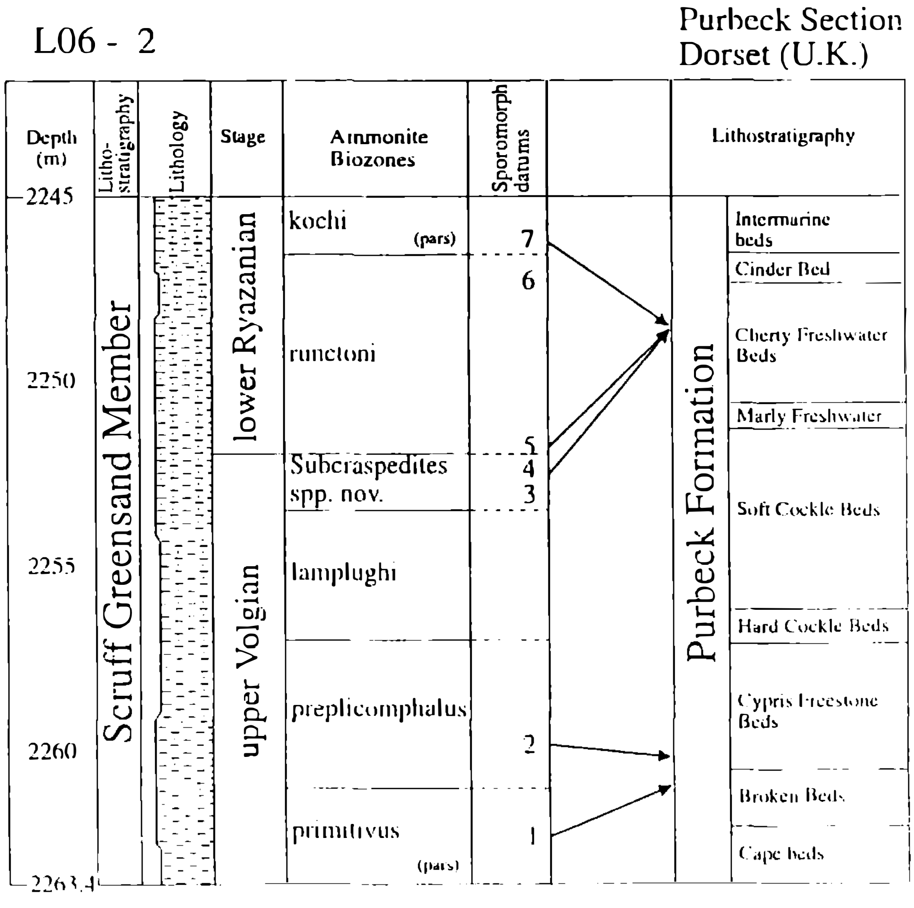
High resolution correlation of the Boreal Jurassic - Cretaceous boundary interval with the Purbeck Beds (Dorset, U.K.) and other terrestrial to marginal marine sequences in NW Europe

Acored interval of NAM Well L06-2 from the Offshore The Netherlands has been investigated macropalaeontologically and palynologically. Ammonites recovered from 32 core samples of Well L06-2 are correlative with the */amp/ugh/, preplicomphalus* and *primitivus* ammonite zones (upper Volgian) and the *runctoni and kochi* ammonite zones (lower Ryazanian), respectively. The Boreal ammonite stratigraphy in Northwest Europe of the Jurassic - Cretaceous boundary interval is hitherto based on fragmentary and incomplete successions. Therefore, the findings from this core section are thought to be of considerable general importance (see Abbink *et al.*, poster presentation, this meeting).

All ammonite-bearing samples have been analyzed for their palynomorph content. The palynological assemblages yield abundant and well preserved dinoflagellate cysts and poorly preserved but relatively diverse sporomorph associations. The sporomorph record allows the establishment of a newly defined, high resolution sporomorph stratigraphy permitting detailed ammonite calibrated age-assessment of terrestrial and shallow marine sections from adjacent areas. Accordingly, the investigated interval of Well L06-2 is correlated in detail with the Purbeck Formation (Dorset, U.K.), based on the sporomorph datums. These correlations suggest that (1) the base of the *preplicomphalus* ammonite zone approximately corresponds with the base of the Cypris Freestone Beds, (2) the Jurassic - Cretaceous boundary occurs within the Cherty Freshwater Beds, and (3) strata equivalent to the *runctoni* ammonite zone are lacking due to a hiatus present at the suggested Jurassic - Cretaceous boundary level (Figure 1).

Furthermore, based on the sporomorph stratigraphy correlations between the investigated interval of Well L06-2 and terrestrial to marginal marine sequences from The Netherlands and Germany have been established.



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Palynology and ammonite stratigraphy of a Late Volgian - Early Ryazanian interval of two wells from the Terschelling Basin, The Netherlands

Ammonites recovered from 32 samples from the core of Well L06-2 from Offshore The Netherlands are correlative with the *lamplughi*, *preplicomphalus* and *primitivus* ammonite zones (upper Volgian) and the *runctoni* and *kochi* ammonite zones (lower Ryazanian), respectively. In 9 samples from the core of Well L06-3 from Offshore The Netherlands ammonites are recovered which allow a correlation with the *lamplughi* and *preplicomphalus* ammonite zones (upper Volgian). The Boreal ammonite stratigraphy in Northwest Europe of the Jurassic-Cretaceous boundary interval is hitherto based on fragmentary and incomplete successions. Therefore, the two core sections are considered to best represent the Jurassic - Cretaceous boundary interval characterized by ammonites in this area found thus far.
All ammonite-bearing samples have been analyzed for their palynomorph content. Both wells yielded abundant and well preserved dinoflagellate cysts enabling a detailed comparison with known stratigraphical ranges and existing zonal schemes. The apparent completeness of the two intervals makes them ideal reference sections for the Volgian - Ryazanian boundary. Furthermore, all samples produced poorly preserved but relatively diverse sporomorph associations which can be applied stratigraphically. A newly defined, high resolution sporomorph stratigraphy permits detailed ammonite calibrated age-assessment of terrestrial to marginal marine sections from The Netherlands, England and Germany.

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The Cenomanian-Turonian boundary in the Gafsa-Chotts area (southern part of central Tunisia): biostratigraphy, palaeoenvironments.

In the Gafsa-Chotts area the Cenomanian-Turonian boundary is characterised by a transgression in an anoxic environment. Three outcrops situated in the neritic area of the northern range of the Chotts or in the subsident trough of Gafsa-Metlaoui, show the following succession:

1. White micritic limestone with dwarf oysters and Upper Cenomanian ammonites: *Neolobites vibrayeanus brancai* ECH and *Pseudocalycoceras* sp.

2. Rich organic matter (OM) facies of the Bahloul Fm. and its limestone equivalent: The lower part of this formation contains Upper Cenomanian ammonites such as: *Calycoceras (Proeucalycoceras)* sp., *Vascoceras (Paravascoceras)* aff. *durandi* (THOMAS & PÉRON), *V. (P.)* aff. *obessum* FREUND & RAAB. The upper part exhibits Lower Turonian ammonites such as *Neoptychites* gr. *cephalotus* (COURTILLER), *Choffaticeras* aff *massipianum* (PERVINQUIERE), *Neoptychites (Betiokyites)* gr. *pioti* (PERON & FOURTAU).

3. Gattar dolomite Fm. and its equivalents: The Gattar dolomite replaced rudist reef bodies and bioclastic sediments. Despite dolomitisation, the lowest part reveals Turonian *Hoplitoides* or *Choffaticeras.* The middle part consists of rudist reef bodies and their fabrics. On top of this appear many hippuritic sections in dolomicritic facies. In the neighbouring Jebel Bou Jarra, situated on the south side of the Gafsa trough, the equivalent of the Gattar Fm is under micritic and bioclastic limestones. This facies reveals a rich ammonite fauna: *Neoptychites* gr. *cephalotus, Thomasites rollandi* (PERON), etc.; from the top *Choffaticeras luciae* (PERViNQUIERE) was collected and indicates the upper part of the Lower Turonian. Further north, at Wadi Berda, the equivalent of Gattar of the latest facies, is under rich OM deposits. This section displays: *T.* cf. *rollandi, N.* gr. *cephalotus, Hoplitoides* aff. *ingens*, etc. and from the top levels *Spathites (Jeanrogiceras)* aff. *reveliereanus* COURTILLER and *C. luciae.*

The three studied sections characterise different sedimentary environments. Uppermost Cenomanian and lowermost Turonian deposits indicate a widespread anoxic environment. Lower Turonian deposits characterise three settings: a. infratidal oxic sedimentation on the shallower areas (rudist reef bodies), followed by a tidal flat environment; b. further north, Jebel Bou Jarra exhibits infratidal oxic and bioclastic sedimentation; c. the Wadi Berda, situated near the deepest sector of the Gafsa trough, is characterised by an anoxic environment with nectonic and planktonic organisms. In this section the anoxia is spread in the uppermost Cenomanian- Lower Turonian, while it occurs in uppermost Cenomanian-lowermost Turonian in the shallower areas.

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Age and nature of the near K-T deposits in Mexico, implications for the proposed Chicxulub impact on Yucatan

Since the discovery of the supposed K/T impact structure in Yucatan (Mexico), a lot of attention has been focused on nearby outcrops like those of central and NE Mexico. The last one presenting a clastic deposit quickly interpreted as a tsunami deposit by SMIT *et al.* (1992), related to the supposed impact. We interpret this clastic deposit as a series of gravity flows or turbidite currents related to the latest Maastrichtian sea-level lowstand and tectonic activity (uplift of the Sierra Madre).

Seven K-T boundary sections with clastic deposits have been examined in NE Mexico spanning a distance of over 300 km. The thickness of the clastic deposits ranges from 10 cm to 7 m; the thickest deposits contain three lithologically and mineralogically distinct and correlatable units which thin laterally. This spatial distribution suggests channelized sedimentation that does not blanket the region. Such mineralogically and lithologically distinct units, correlatable over 300 km and representing variable detrital influx alternating with normal hemipelagic sedimentation, are incompatible with a proposed Chicxulub impact-generated tsunami deposit. The age of the clastic deposits is latest Maastrichtian *A. mayaroensis* Zone and *Micula prinsii* Zone as indicated by the presence of these microfossils in a marl layer above the clastic deposit and below the K/T boundary. Moreover, grain size, clay mineral analyses and bioturbation, as well as the stratigraphic age of the clastic deposit do not support deposition within a few hours or days by an impact generated tsunami wave, related to the supposed K-T impact on Yucatan.

We interpret the channelized clastic beds of NE Mexico as fan deposits which accumulated during the major eustatic sea-level lowstand near the end of the Maastrichtian. The top of the clastic member marks the end of this regressive cycle followed by a transgression which began a few thousand years prior the K/T boundary as indicated by the deposition of the thin marl layer of Late Maastrichtian age present in four of the seven studied sections. In NE Mexico, as elsewhere, the trans-K/T interval is marked by a sea-level rise, sediment starvation and a short hiatus.

Published stratigraphies and resistivity well logs of the Yucatan cores integrated with our own investigations provide stratigraphic and palaeontological correlations that may place constraints on the current impact scenario and provide a database for possible alternative scenarios. Our results call for a reevaluation of the Chicxulub structure as a K/T boundary age bolide impact crater. Major inconsistencies include an upper Maastrichtian age for 170 m of stratified marls and shales overlying the andesitic breccia that are supposed to have formed by the K/T boundary impact, and interbedded anhydrite and limestones with the supposed impact melt rock. These data do not support a K-T boundary bolide in the Chicxulub area, and if a bolide impact occurred, it must have pre-dated the K-T boundary.

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Considerations about the Berriasian-Valanginian boundary in SE Spain.

The Berriasian-Valanginian boundary has been subject to controversy in the last years. Two appreciably different solutions have been proposed in our region:
- in the Cehegín area, Company & Tavera (1982) placed it at the base of the Otopeta Zone, in accordance with the definition proposed by Busnardo & Thieuloy (1979) in SE France and currently accepted (Birkelund *et al.*, 1984).
- in the Río Argos section, Hoedemaeker (1982, 1983, 1984) placed the Berriasian-Valanginian boundary at a lower level, at the base of the Alpillensis Subzone. Furthermore, he regarded the Otopeta Zone as an equivalent of the lower part of the Pertransiens Zone.

In order to clarify this disagreement, we undertook a bed-by-bed sampling of the Río Argos section. The stratigraphic distribution of ammonite, calpionellid, and calcareous nannoplankton species has been analyzed and the results have been compared with data from Cehegín sections. In both cases we have found a similar faunal succession which allows us to recognise three distinct biostratigraphic units:
- the Alpillensis Subzone is characterised by typical "Berriasian" genera such as *Berriasella, Fauriella, Tirnovella* and *Jabronella*, and the first specimens of the genus *Kilianella*. *Percivalia fenestrata* and some other nannofossil species have their first occurrence in the middle part of this subzone.
- the ammonite association of the overlying Otopeta Subzone is mainly composed by species inherited from the Alpillensis Subzone. Beside them, some new "Valanginian" forms (*Thurmanniceras otopeta, Kilianella lucensis* and *Olcostephanus drumensis*) appear.
- at the base of the Pertransiens Zone, an almost complete faunal renewal takes place. "Berriasian" faunas disappear and they are substituted by *Th. pertransiens* and the first specimens of the genera *Neocomites* and *Sarasinella*. This event correlates with the first occurrence of *Calpionellites darderi* and is followed by the appearance of the nannofossil species *Calcicalathina oblongata* in somewhat higher levels.

These results lead us to consider, in accordance with Bulot *et al.* (1993), the base of the Pertransiens Zone -where the broadest faunal turnover is located- as the best candidate for the Berriasian-Valanginian boundary. This proposal implies the inclusion of the *Th. otopeta* beds as a distinct subzone at the top of the Berriasian. This solution practically coincides with the classical interpretation of the Berriasian-Valanginian boundary as it was expressed by Mazenot (1939) who included the "Horizon supérieur à *K.* aff. *pexiptycha* et *Th.* aff. *pertransiens*" (= *Th. otopeta* beds) in the Berriasian.

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Biostratigraphic events around the Barremian-Aptian boundary in the Betic Cordillera (Southern Spain).

The Barremian-Aptian boundary is currently defined by the first appearance of the ammonite genus *Deshayesites*, coinciding with the base of the Tuarkyricus Zone. Alternately, first occurrences of the nannofossil species *Hayesites irregularis* and *Chiastozygus litterarius* have been proposed to place this boundary. Notwithstanding, the characterisation of this boundary rises still many uncertainties derived both from the scarcity of biostratigraphically significant ammonites, specially in the pelagic domain of the Mediterranean region, and from the variability observed in the nannobiostratigraphic datum planes.

In order to solve some of these problems we have analyzed the stratigraphic distribution of ammonites and calcareous nannoplankton species in several sections covering the uppermost Barremian (Giraudi and Sarasini Zones)-lowermost Aptian (Tuarkyricus and Weissi Zones) interval. All these sections are located in the External Zones (Prebetic and Subbetic Domains) of the Betic Cordillera (southern Spain) and are made up of marl-limestone rhytmites, a suitable lithology for this study.

As already mentioned, significant ammonites are extremely scarce. This is the case of *Deshayesites*. A single specimen of this genus, out of more than 1000 ammonites, has been collected from beds assigned to the Tuarkyricus Zone. Fortunately, it becomes more frequent in the Weissi Zone.

Other ammonites which have been occasionally employed to characterise the Barremian-Aptian boundary are *Pseudohaploceras matheroni* and *Procheloniceras*. However, our data allow us to confirm that *P. matheroni* (or closely allied forms) is already present in the Giraudi Zone. Species of the group of *Procheloniceras albrechtiaustriae-pachystephanum* have their acme in the Tuarkyricus Zone, but some specimens have been collected from the top of the Barremian. Furthermore, other species traditionally assigned to this genus (*"Procheloniceras"* gr. *amadei-trachyomphalum*) are characteristic of the Feraudianus, Giraudi and Sarasini Zones. A similar distribution is shown by the genus *Kutatissites*, which appears in the upper part of the Sarasini Zone (just above the last record of heteroceratids) and reaches its greatest development in the Tuarkyricus Zone.

As for the calcareous nannoplankton, our data show that the first occurrence of *Hayesites irregularis* is placed in the upper part of the Sarasini Zone (nearly coinciding with the first record of *Kutatissites*). *Chiastozygus litterarius* does not seem to be a suitable species to characterise the boundary in our region, due to a scarce and discontinuous distribution. In any case, its first occurrence predates that of *H. irregularis* and is located near the base of the Sarasini Zone. *Flabellites oblongus*, a species whose first occurrence has been placed in the Lower Aptian, actually appears in the lower part of the Sarasini Zone clearly predating the first occurrence of *H. irregularis*.

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Micropaleontological Campanian-Maastrichtian boundary in South-Western Crimea

In Late Cretaceous the Crimean Peninsula was covered by waters of a relatively shallow marine basin of the northern margin of the Tethys, but the faunal appearance supports the idea that Crimea was to the south of the European paleobiogeographicprovince. Coexistence of some southern elements (planktonic foraminifera) and boreal elements (especially belemnites) is favorable for correlation of a wide spectrum of events near to the Campanian-Maastrichtian boundary. Uppermost Campanian-Maastrichtian on the northern slope of SW Crimea is shallowing up middle and inner shelf sequence of chalky limestones, marls, siltic marls and siltic limestones. Two section (Beshkosh and Chakhmakhly) were studied micropaleontologically (foraminifera, calcareous nannofossils) in Bakhchisaray District between the Kacha and Bodrak rivers. Macrofossil findings also were fixed, mainly belemnites and ammonites. The litostratigraphic subdivision used, was described by A. S. Alekseev (1989). The interval of interest includes units XIX-XXIII. Unit XX (65 m) subdivided into three subunits (XXa - siliceous marls, XXb- sandy marls and XXc - sandy marls with spotted silification). Total thickness of studied interval is 175 m in Beshkosh section and 130 m in Chakhmakhly section. Planktonic/benthic ratio is high enough in the uppermost Campanian unit XIX (15-43%) and remains at about the same level in the Lower Maastrichtian except its uppermost part (unit XXc) where planktonic species represent only about 10% in fraction above 50 m, but growth up to 20-30%
in middle part of the basal Upper Maastrichtian unit XXI.
Among planktonic foraminifera heterohelicids are predominant; however, at several levels globotruncanids are not rare.
Globotruncanid planktonic zonation is difficult to use because the low diversity of the assemblages, but first appearance of *Globotruncanita stuarti* coincides with base of unit XXa and first *Hoploscaphites gr. constrictus*. Relatively to benthic foraminiferal zonation for eastern European palaeobiogeographicprovince (Naidin *et al.*, 1984) this level is within the *Angulogavelinella gracilis* Zone. The upper part of unit XXb, unit XXc and basal strata of the unit XXI belong to beds with *Globotruncana gagnebini*, above which the interval with *Pseudotextularia elegans* is traced. Upper Maastrichtian units XXII and XXXIII are very shallow-water and index form *Abathomphalus mayaroensis* was not found. Upper part of unit XXa and units XXb and XXc are included in *Brotzenella complanata* Zone. According to the data on the Chakhmakhly section the for Crimea very impressive level with *Belemnitella conica* is in the Maastrichtian *Brotzenella complanata* Zone.

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Albian Substage boundaries: presentation, discussion and proposals.

The Albian stage and substage boundaries are discussed.
As base of the Albian stage the 1983 Copenhagen Symposium (BIRKELUND et al. 1984) recommended the base of the *Leymeriella schrammeni* Zone. At the present state of our knowledge this proposition is the most satisfactory, despite that the species is restricted to the North-European province of the boreal realm.
The lower Albian-middle Albian boundary recommended in Copenhagen is at the base of the *Lyelliceras lyelli* Subzone; this is an unfortunate definition because the base of this subzone does not coincide with the appearance of the species. Two propositions are formulated:
- (1) The appearance of *L. lyelli* would define the lower -middle Albian boundary.
- (2) The level of flooding of *Lyelliceras* would define the lower-middle Albian boundary; this represents a major event in both boreal and tethyan realms. Furthermore it is the event implicitly retained in Copenhagen.

The middle-upper Albian boundary recommended by the Copenhagen Symposium is at the base of the *Diploceras cristatum* Subzone andis satisfactory. The existence of a second level of flooding of cosmopolitan ammonites (comparable to that of *Lyelliceras*) recognisable across several faunal provinces above the *D. cristatum* Subzone leads us to formulate another proposal which would be at the base of the *Mortoniceras (M.) pricei* Zone.

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On the age of the *Nostoceras hyatti* Zone.

It is well known that the Nostoceras hyatti Zone is very widespread and that it is traced in different parts of the world. According to our data it is found also in the North Caucasus, in Kopetdag and other regions of the former USSR. It is also known that in different parts of the world the age of the *N. hyatti* Zone has so far been determined by different methods, even in the same sections depending on the author's approach. It is difficult to decide on which of these zonal ages are better-grounded - the Late Campanian or the Early Maastrichtian. But when it became possible to determine the *N. hyatti* Zone in Poland (Kennedy, Cobban, Scott, 1992) where it contains *Belemnitella langei* besides distinctive ammonite species and is directly overlain by the *Belemnella lanceolata* Zone, its Late Campanian age was admitted by all scientists. Researchers everywhere (with only a few exceptions (Sugarman *et al.*, 1995)) began to draw the Campanian-Maastrichtian boundary on the top of this Zone as the most valid variant of drawing the boundary between these stages.

On the basis of the analysis of materials from the West Kopetdag, the North Caucasus, Mangyshlak and from other regions of the European part of Russia, the author came to the conclusion that the age of the *N. hyatti* Zone is early Maastrichtian, and thus confirms the first point of view of W.J.Kennedy (1986). This conclusion makes it possible to draw the lowest boundary of the Maastrichtian stage at the base of the above-mentioned zone.

The example of the age determination of the *N.hyatti* Zone is very important from the methodical point of view. The first appearance of *B. lanceolata* as the universally acknowledged criterion for defining the Campanian-Maastrichtian boundary was taken for granted by the previous authors for the whole of the European palaeobiogeographical province. Few specialists paid attention to D.P.Naidin's remark (1973, p.57) that *Belemnella kazimiroviensis* in the European successions is represented by its Teilzone and in the Eastern part of the European palaeobiogeographic province by its Biozone, which is equal to the Upper Maastrichtian substage. According to this author's opinion, a similar picture is observed with respect to the *B. lanceolata* species.

A number of circumstances have been central to making this conclusion. The most important of them is the grounding of Early Maastrichtian age of the *Hauericeras sulcatum* Zone in Kopetdag (presence of *Pachydiscus neubergicus, P. ootacodensis, Diplomoceras cylindraceum* and other species); grounding of its synchronicity with the *H. sulcatum* Zone in the North Caucasus (particularly Daghestan). The above mentioned conclusion has been made possible by the detection in the *H. sulcatum* Zone of a number of species characteristic of the *N. hyatti* Zone *(N. hyatti, N. excelsus, N. mendryki, Didymoceras navarroense, Pseudokossmaticeras tercense, P. galicianum, Baculites leopoliensis* and others) as well as *Micraster grimmensis*. This last taxon is found on Mangyshlak slightly higher than the first appearance of *B. lanceolata* and *B. licharewi* (Naidin *et al.*, 1984, p. 16) and in the Saratov-Volga region in conjunction with *B. licharewi*. This proves that the three zones are of the same age. *M. grimmensis* is typical of the Lower Maastrichtian substage not only in the regions mentioned but in the Mali Caucasus as well. It probably also has the same age in West Germany (Atabekian, 1979, p. 516).

Thus, the age of the *N. hyatti* Zone, falls within the stratigraphic volume of the Maastrichtian stage as first suggested by Arkhangelsky in 1926. He drew the Campanian-Maastrichtian boundary between the *Belemnitella mucronata* and *B. lanceolata* Zones which he himself proposed earlier (1912). The *Belemnella licharewi* species is generally found in the lowest beds of the *B. lanceolata* Zone *sensu* Archangelsky (Mozgovoi, 1969, p.140-141). *Micraster grimmensis* also occurs in these lowest beds.

The lower boundary of the Maastrichtian stage is stratigraphically lower in the eastern part of the European palaeobiogeographical province than in its western part. This lower position of the boundary has priority.

1. The age of the *Nostoceras hyatti* Zone is Early Maastrichtian.
2. The *N. hyatti* Zone corresponds to the lowest part of the transitional beds, which, on historical grounds, were previously not included neither in the Campanian stage nor in the Maastrichtian stage.
3. Archangelsky was the first to refer these transitional beds to the Maastrichtian stage. This fact has priority in terms of the determining of the lower boundary of the Maastrichtian stage.

poster

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The middle-upper Cenomanian Substage boundary.

Among the boundaries of stages and substages of the Upper Cretaceous the most stable are those which are determined by using the principle of priority - in stratotypes of the relevant stages. Unfortunately, in distinguishing his stages d'Orbigny, although he indicated the type localities for each of them, not always followed the methodical approach worked out by himself, when he made up the list of the species for every stage. He gave his methodical approach in detail in both volumes of his monograph: "Cours élémentaire de Paléontologie et de Géologie Stratigraphiques". According to the modern concept this is the most bright display of several events - biological, physico-chemical and eustatic - which are mutually related.

Through the attentive study of the display of these events at boundaries of the stages it is possible to arrive at a correct interpretation of the boundaries of the stages and substages primarily defined by their authors.

By observance of these principles it would be better to choose the lower boundary of the Upper Cenomanian at the base of the "Sables du Perche" and its upper boundary at the top of the "Marnes à Ostrea biauriculata" in the stratotypical region of this stage. This has been discussed by the author in: "Zonalnie podrazdelenia senomana Evrazii", Zonalnie podrazdelenia I mezhregionalnaya korraliatzia paleozoiskich I mezozoiskich otlozhenii Rossii I sopredelnich territorii, kn.2. Mezozoi, St.-Petersburg, 1994, pp.126-150.

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Boreal immigrants into the Valanginian successions of the Rumanian Carpathians

The completed and revised inventories of the ammonite, foraminifers and nannofossil assemblages of the Carpathian Valanginian successions pointed out the presence there of some boreal immigrants and/or some taxa descending from boreal ancestors. These data were recognised in the Central Carpathians (= Transylvanian and Median Dacides, sensu Sandulescu, 1984) as well as in the Outer Carpathian (= Outer and Marginal Dacides) structural units. They lead to the conclusion that a more important than was hitherto considered Boreal-Tethyan connection existed during the Late Valanginian, which is felt in the nectonic, benthic and planktonic fossil assemblage.

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Role of acanthoceratid ammonoids in defining stage boundaries - Indian example.

The commonly decorated acanthoceratid ammonoids are frequent in the Uttatur Group (Late Albian to Early Turonian), Trichinopoly Group (Middle Turonian to Coniacian) and in the Ariyalur Group (Campanian to Maastrichtian) of the southern Indian Cretaceous. The members of the Superfamily Acanthocerataceae are also found in the northern Himalayan ranges of Sikkim and in Spiti and are represented by species found in Albian and Cenomanian of southern India. The other Indian Cretaceous basins are devoid of acanthoceratids, though an unusual reference to *Acanthoceras rhotomagense* in Meghalaya is available (Bora & Gosh, 1987).

Ten well marked ammonoid zones are recognised in the highly fossiliferous southern Indian Cretaceous and they are *Mortoniceras inflatum* Zone, *Mantelliceras vicinale* Zone, *Calycoceras newboldi* Zone, *Eucalycoceras pentagonum* Zone, *Mammites conciliatum* Zone, *Romaniceras (Yubariceras) ornatissimum* Zone, *R. deverianum, Peroniceras dravidicum* Zone, *Texanites roemeri* Zone and *Sphenodiscus siva* Zone. The associated acanthoceratid species are many and total to nearly fifty species. Their stratigraphic range is very restricted and well marked which make this group useful in identifying various boundary levels. Albian-Cenomanian boundary is marked by the presence of *Mortoniceras inflatum* (Sowerby) overlain by *Mantelliceras vicinale* (Stoliczka). Cenomanian-Turonian is marked by the change in fauna from *Eucalycoceras pentagonum* (Jukes-Browne & Hill) to *Mammites conciliatum* (Stoliczka) (Ayyasami & Banerji, 1984). The top part of Turonian is absent in southern Indian outcrops (Ayyasami & Rao, 1984; Chidambaram, 1985). Santonian is again absent here (Ayyasami & Rao, 1980). *Texanites roemeri* (Yabe & Shimizu) from the basal bed of Ariyalur Group suggests that the boundary of Santonian is very near this level as all the species of the genus *Texanites* are known from the Santonian of Europe and probably elsewhere. *Sphenodiscus siva* (Forbes) from Pondicherry may well mark the top of Maastrichtian or near that level as Pondicherry fossils are mainly Upper Maastrichtian in age (Kennedy & Henderson, 1992). The common species such as *Mantelliceras discoidale* (Kossmat) and *Calycoceras newboldi* (Kossmat) and the species of *Stoliczkaia* in southern India and the Himalayan region make correlation of strata in the two areas possible.

Thus, the paper presents the distribution acanthoceratids in India with reference to the geological sections showing the different stage boundaries from southern Indian formations where the Cretaceous rocks are largely well developed and discusses their usefulness in correlating with the European stages. This study also brings out the breaks in sedimentary succession in southern Indian Cretaceous based on acanthoceratid fauna.

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Cretaceous invertebrate fossils distribution in time and space - south Asian example.

The Cretaceous sediments, both marine and continental, are variously distributed in the south Asian region and are known from India (including Sikkim), Pakistan, Afghanistan and Burma. Fossils from these rocks are preserved in the museum of the Geological Survey of India, and a few selected fossil groups, namely ammonites, gastropods, echinoids and bivalves were studied for their distribution in time and space. Fossils ranging in age from Aptian to Maastrichtian are known from these areas and many of them are comparable to European forms. Based on this museum study, the presence of various Cretaceous stages in each basin is assessed. Further inferences are also drawn on the Cretaceous palaeogeography of the region.

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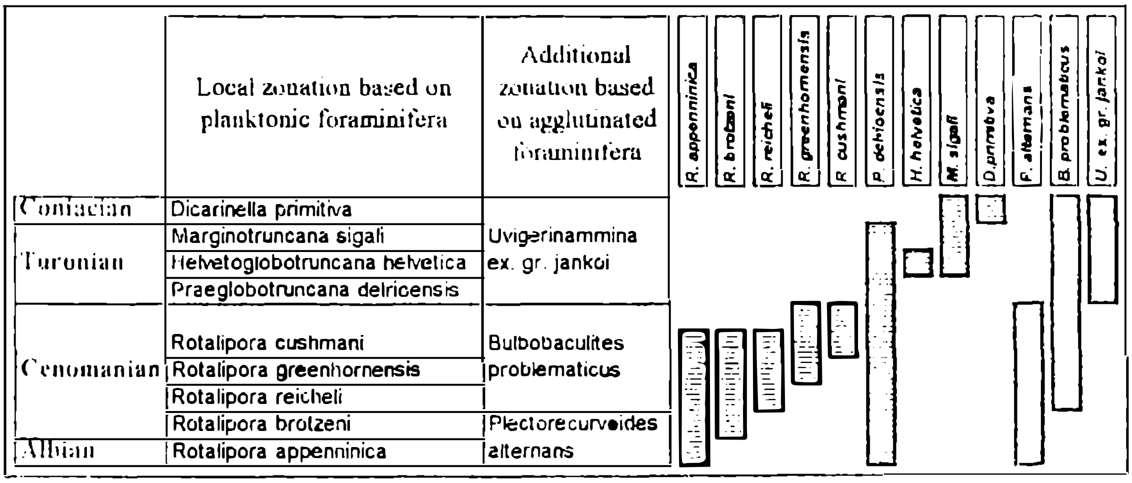
Cenomanian to Turonian foraminiferal biostratigraphy in the Polish part of the Pieniny Klippen Belt (Carpathians)

Foraminiferal assemblages have been studied in the Cenomanian and Turonian deposits in the Polish part of the Pieniny Klippen Belt with respect to their biozonation. The deposits comprise pelagic and shaly turbidite facies. The palaeontological data were taken from 13 sections representing deposits from shallow (shelf) to deep-water environments of the Pieniny Klippen basin. A local biostratigraphical zonation is proposed on the basis of index planktonic foraminifera. Four zones have been distinguished in the Cenomanian deposits: *Rotalipora brotzeni* Zone (Interval zone), *R. reicheli* Zone (Interval zone), *R. greenhornensis* Zone (Interval zone), *R. cushmani* Zone (Total range zone) and three - in the Turonian deposits: *Praeglobotruncana delrioensis* Zone (Partial range zone), *Helvetoglobotruncana helvetica* Zone (Total range zone), *Marginotruncana sigali* Zone (Partial range zone).

Additional zonation is based on agglutinated foraminifera. It consists of the *Plectorecurvoides alternans* Zone (Interval zone), *Bulbobaculites problematicus* Zone (Interval zone) corresponding to the Cenomanian and *Uvigerinammina* ex. gr. *jankoi* Zone (Interval zone) representing the Turonian through Santonian stages. The Albian / Cenomanian stage boundary is accepted here on the basis of the first occurrence of *Rotalipora brotzeni*. The Cenomanian / Turonian stage boundary is noted as the last occurrence of *R. cushmani* and a change in the benthic assemblages (appearance of *Uvigerinammina* ex gr. *jankoi* Majzon, *Trochammina umiatensis* Tappan, *Gerochammina conversa* (Grzybowski), *G. lenis* (Grzybowski), *Recurvoides godulensis* Hanzlikova, *R. primus* Mjatliuk, *Haplophragmoides* cf. *bulloides* (Beissel), *H. kirki* (Wickenden), *H.* cf. *walteri* (Grzybowski) and last occurrence of *H. concavus* (Chapman), *H. gigas minor* Nauss, *Dorothia gradata* (Berthelin) and *Lenticulina gaultina* (Berthelin)). The Turonian / Coniacian stage boundary is accepted as the first occurrence of *Dicarinella primitiva*



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Radiolarian biostratigraphy in Albian to Turonian deposits in the Pieniny Klippen Belt, Polish Carpathians.

The deposits from the Albian to Turonian interval in the Polish part of the Pieniny Klippen Belt, Carpathians (Branisko, Niedzica and Czorsztyn successions) are relatively rich in radiolarian fauna as well as in planktonic foraminifera. This fact allows to present updated modifications of the previous radiolarian biozonations of Sanfilippo & Riedel (1985), Schaaf (1985) and Thurow (1988).
The top of each zone is defined by the base of the overlying zone, which coincides with the first occurrence of each named species.

Foraminiferal zones according to K.Bak (1994)
Proposed radiolarian biozonation

		Foraminiferal zones according to K.Bąk (1994)	**Proposed radiolarian biozonation**
TURONIAN	LATE	*M. sigali*	***Praeconocaryomma universa***
	EARLY	*H. helvetica*	***Hemicryptocapsa prepolyhedra***
CENOMANIAN		*R. cushmani*	
		R. reicheli - R. greenhornensis	
		R. reicheli	***Obesacapsula somphedia***
		R. brotzeni	
ALBIAN	VRAC.	*R. appenninica*	***Thanarla veneta***
		P. buxtorfi - R. appenninica	
		R. ticinensis - P. buxtorfi	***Pseudodictyomitra pseudomacrocephala***
	LATE	*R. subticinensis - R. ticinensis*	***Novixitus weyli***
		B. breggiensis	***Squinabollum fossilis***
	MIDDLE	*T. primula*	***Holocryptocanium barbui***
	EARLY	*T. roberti*	

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On the Hauterivian/Barremian boundary in Central Crimea.

Hauterivian and Barremian deposits are well-known in the central part of Mountainous Crimea. Most of the previous biostratigraphical schemes for the region based on ammonites show a stratigraphical gap at the Lower/ Upper Hauterivian boundary and the presence of only one Upper Hauterivian zone - *Pseudothurmannia angulicostata* (Druzchiz, Kudrjavcev, 1959; Kakabadze, 1981).

The Hauterivian-Barremian transition was considered uninterrupted. Recently those strata were re-investigated (1990-1993). It is established that all Upper Hauterivian-Lower Barremian sections in the region are highly condensed, rhythmically built limestones with many complex hardgrounds and very sharp stratification. In fact, every limestone bed (0.3-0.1 m) presents a single ammonite zone. The strongest condensation occurred in the *Simbirskites deheni* zone (0.3-0.25 m), where *Speetoniceras inversum*, *Balearites* spp. and *Crioceratites* spp. are found in rewashed condition and numerous *Anahamulina* spp., *Barremites* spp., *Raspailiceras* spp., *Valdedorsella* spp., *Phyllopachyceras* spp., *Euphylloceras* spp., are partially rewashed. Findings of typically Barremian ammonites such as *Nicklesia pulchella*, *Macroscaphites yavni* and *Paraspiticeras* spp. in this horizon are of special interest.

The *Pseudothurmannia angulicostata* zone (0.2 m) is determined by representatives a.o. of *Pseudothurmannia* accompanied by *Crioceratites* sp., *Barremites* spp., *Phyllopachyceras* spp.. A characteristic feature of the zone is the presence of large *Pseudosonneratia* (0.2-0.3 m) in the top, eroded by hardground surface.

The *Spitidiscus hugii* zone (0.1 m) that should start the Barremian (sensu Busnardo, 1984) contains zonal index in assemblage with *Barremites* ex gr. *stettostoma, Hamulina* spp. and numerous *Phyllopachyceras.* The top of the zone is strongly eroded reflecting a very important basin event. The next zone - *Holcodiscus caillaudianus* is characterised by *Holcodiscus* spp., *Spitidiscus* spp., rare *Pulchellia* sp., *Barremites* spp. and heteromorphs. The base of the zone is marked by a red limestone conglomerate (0.2 - 0.3 m), and the upper part is slightly condensed (in comparison with the Upper Hauterivian). It seems that the Hauterivian /Barremian boundary is more natural at the base of the *Holcodiscus caillaudianus* zone, but not at the base of *Pseudothurmannia angulicostata* zone as it is usually considered. The position of the *Spitidiscus hugii* zone can be discussed because the main changes in the ammonite fauna take place below or above it.

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Albian ammonite zonation and magnetostratigraphy of the Northern Caucasus.

An Albian biostratigraphical scheme based on ammonites, for the Northern Caucasus was presented by many previous authors (such as Rengarten, A.E.Glazunova, Luppov, Mordvilko, Druzchiz, Kudrjavcev, Michailova). Most recent is that of Michailova (Michailova & Saveliev 1989), but it is not as detailed as in western Europe or Mangyshlak. Badly exposed clayey Albian sections, usually covered by landslides and poorly preserved fossils are the real difficulty when studying these strata. New data were obtained during field campaigns of the Caucasus expedition of Moscow State University in 1986-1992. This fieldwork was done in the Karachaevo-Cerkessy region, Russia, in Kabardino - Balkary, Northern Osetia, in Checheno-Inguschetia and in Daghestan. The most complete Albian section in the Northern Caucasus is the Akusha village section in Daghestan. This section was investigated by biostratigraphical and by palaeomagnetic methods. A palaeomagnetic stratigraphical chart was prepared by A.J.Guzhikov, V.N.Erjomin and E.A.Molostovsky from the Palaeomagnetic laboratory of Saratov State University. The new chart (fig.) is more detailed than those previously published and it contains several intervals with magnetic reversals in Lower and Upper Albian and continuous intervals of normal polarity.

Substage boundaries coincide more or less with reversal intervals. Shallow water (100-150 m deep) marine clayey Albian sections of the Northern Caucasus contain diverse ammonite assemblages close to western European Albian assemblages. Therefore the western European biostratigraphical scheme can be used for this region. In the new scheme herein (fig.) zones *Cleoniceras floridum, Protohoplites puzosianus, Pseudosonneratia (Isohoplites) eodentata, Lyelliceras lyelli, Hoplites spathi, Oxytropidoceras roissyanum, Anahoplites intermedius, Dipoloceras cristatum, Hysteroceras varicosum* and subzones *Mortoniceras rostratum* and *Durnovarites perinflatum* are established for the first time in the Northern Caucasus.

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The Cenomanian/Turonian Boundary in Northeastern Brazil: a progress report.

The Cenomanian/Turonian transition is recorded in most of the South Atlantic basins of Brazil but the rocks are well exposed only in the Sergipe Basin in the northeastern part of the country (Bengtson , 1983). Ammonites and foraminifera are the main fossil groups utilized in the Cretaceous biostratigraphy of Sergipe; an integrated zonation for these groups has recently been published (Koutsoukos & Bengtson, 1993). This zonal scheme can be further refined; in particular, the position of the Cenomanian/Turonian boundary in terms of the so-called standard stratigraphic scale remains unclear. Using one of the currently most widely accepted boundary markers the first appearance of the ammonite *Watinoceras devonense* (e.g., Robaszynski & Gale, 1993) the boundary probably falls within or at the base of the *Vascoceras harttii/ Pseudaspidoceras footeanum* Zone and its corresponding foraminiferal zones. A recently initiated integrated study of the Cenomanian/ Turonian boundary interval in Sergipe aims at solving this key problem of correlation and at contributing palaeontological and palaeoenvironmental data in order to improve the understanding of the "Cenomanian/Turonian event". Three major outcrop areas have been selected for study: the Japaratuba area in the northern part of the Cenomanian/ Turonian outcrop belt, the Laranjeiras area in the central part and the Itaporanga area in the south. The study involves detailed mapping of the boundary sequences, litho- and biostratigraphic profiling, bed-by-bed collecting of macrofossils, and sampling for microfossils, microfacies analysis and chemo-stratigraphical analyses (stable isotopes, trace elements, clay minerals). The initial field season focused on the Japaratuba area, where shallow-water bioclastic carbonates dominate the sequence. The rocks are partly dolomitic and deeply weathered and therefore less suitable for micro- and nannofossil extraction, so microfossil work in this area is restricted to thin section analysis (cf. Berthou & Bengtson, 1988). Ammonites and inoceramids are the stratigraphically most useful macrofossils and occur locally abundant. The *Euomphaloceras septemseriatum* Zone can be subdivided on the basis of the first appearance of *Vascoceras (V. gamai)* and/or the more or less coeval appearance of *Thomasites gongilensis.* The main inoceramid occurrences ("floods") are found in the *Vascoceras harttii Pseudaspidoceras footeanum* Zone and may indicate proximity to the Cenomanian/Turonian boundary, *sensu* Hancock (1991).

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The Aptian-Albian boundary in northern Tunisia

The Aptian-Albian boundary in northern Tunisia has not been studied previously. In Solignac (1927), Dubourdieu (1950), Jauzein (1967) the stratigraphic attributions of lithofacies to Aptian, Albian and Cenomanian were often erroneous, principally because the ammonite zones were not well defined.

The lithostratigraphic column of Jebel Oust in the east, and the cross-section of Jebel Hameïma-Gara in the NW of Tunisia, both considered as type-localities were studied for their macro- and microfaunal content, in order to specify the Aptian-Albian boundary.

The Upper Albian contains the following lithofacies:

- green marls with meter scale limestone beds with a variable siliciclastic input.
- green marls poor in thin bedded limestone intercalations.
- massive limestone grading upwards into marls.

These Aptian lithofacies are overlain by compacted Albian sediments. The latter include black marls at the base, and an upper unit dominated by limestone beds often referred to the "Allam limestones".

Abundant late Aptian ammonites indicate the following zones:

- *Parahoplites melchioris*
- *Diadochoceras nodosocostatum.*

In the basal Albian no ammonites were identified; however, ammonite species of the *Douvilleiceras mammillatum* Zone were easily recognised.

The microfaunal content shows at the Albian-Aptian boundary a considerable drop in quantity and diversity of the plankton species, especially among the coarse sized forms of the Late Aptian *(Ticinella bejaouaensis)*, and to a lesser degree among the benthic taxa. In contrast to the basal Albian, the diversity and density of the Foraminifera increases in the *Hedbergella planispira-H. rischi* Zone. This suggests palaeoenvironmental conditions which were favourable for microfaunal extension during Early Albian times, near or just above the Aptian-Albian boundary.

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Boundaries of the Upper Cretaceous Stages on the East part of the European region, on foraminifera.

26 foraminiferal zones were established in the Upper Cretaceous of the eastern part of the European paleobiogeographic region (Volga river region, Precaspian basin, Mangyshlak).

Their zonal assemblages include species, representing the branches of important stratigraphical generic phylogenetic evolution: *Stensioeina, Gavelinella, Brotzenella, Cibicidoides, Bolivinoides,* and some others. The foraminiferal zonal scale is closely correlated with the zonal scale based on mollusca (NAIDIN et al., 1984). Several zonal and leading species appearances and disappearances determine the important stratigraphical levels of stages and substages value.

The common occurrences of *Gavelinella cenomanica, Rotalipora appeninnica* are referred to the Lower Cenomanian, and the appearance of *Lingulogavelinella globosa* is related to the Upper Cenomanian. The Lower Turonian interval of foraminiferal evolution is marked by the presence of large hedbergells, while the Upper Turonian interval is determined by *Marginotruncana, Gavelinella moniliformis*, and a different *Marssonella* appearance. The abundance of *Marginotruncana* or "large rosalins" increases in the Turonian-Coniacian boundary deposits. Their T/C boundary is determined by the appearance of *Gavelinella praeinfrasantonica, G.* aff. *vombensis, Reussella kelleri* and also small stensioenas. Mass amount of typical *Stensioena granulata granulata, Gavelinella thalmanni, G. vombensis, Osangularia whitei whitei* appearances are fixed in Upper Coniacian. Mass distribution of *Stensioena exculpta exculpta* is typical for the terminal Coniacian. St/Cp boundary is considered to be settled within the *Bolivinoides strigillatus* Zone. The appearance and mass occurrences of *Stensioena pommerana, Gavelinella clementiana clementiana, Bolivinoides decoratus* is connected with Lower Campanian, those of *Brotzenella monterelensis* with the Middle-Upper Campanian. The Upper Campanian is determined by the *Cibicidoides voltzianus* appearance followed by *Bolivinoides draco miliaris, Bolivina kalinini = B.incrassata* (narrow specimens), upsection by *Brotzenella taylorensis* and in the most terminal part by *Angulogavelinella gracilis.* Cp/M boundary is determined on the basis of *Neoflabellina reticulata, Bolivinoides decurrens* appearance and of abundant *Angulogavelinella gracilis.* The middle part of the Lower Maastrichtian is distinguished by *Brotzenella complanata* and the upper part by *Bolivinoides draco draco, Anomalinoides subcarinatus.* The Upper Maastrichtian is characterised by *Brotzenella praeacuta, Anomalinoides pinguis* appearance and its terminal part by *Hanzawia ekblomi, Pseudotextularia elegans* occurrences.

Reference: Naidin et al. Vestnik MGU., 1984. Ser. 4. Geology.
5: 3 - 15

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The problem of stage boundaries within the Lower and Middle Cretaceous turbiditic sequences of the Gerecse Mts. (Transdanubian Range, Hungary).

The clastic sequence of the Gerecse Mts. was classified as Neocomian (Berriasian to Barremian) on the basis of the ammonite fauna (FÜLÖP, 1958). Recently, micropalaeontological and nannoplancton investigations have shown that the siliciclastic, turbiditic formations (Bersek Marl, Làbatlan Sandstone, Neszmely Sandstone) are of Berriasian to Albian/Cenomanian age (see Bodrogi, 1994 for complete references). The oldest formation is an allodapic limestone (Felsövadacs Breccia = F.B.) which underlies the Bersek Marl and Neszmély Sandstone fms. It is Berriasian because of the occurrence of *Fauriella boissieri* (see FÜLÖP, 1958, FÖZY, 1993). Ammonites, calpionellids, nannoplancton, foraminifers, calcareous algae confirm the Late Berriasian to Valanginian age of the F.B. Fm. (VIGH, 1984; BODROGI *et al.*, 1990; BODROGI, 1994).
The Bersek Marl Fm. develops continuously from the F.B. in Bersek-hegy, Labatlan. Previously it was considered as Valanginian-Hauterivian (a.o. FÜLÖP, 1958). This opinion has to be revised because:

1. The entire sequence was considered by these authors to be Upper Valanginian-Hauterivian. The 66 m thick lower part of the Bersek Marl Fm. was uncovered by borehole B1, and continuously overlies F.B. Member. The upper part of the marl (65 m) is substantially younger: Aptian-Albian (FELEGYHAZY & NAGYMAROSY, 1991, 1992).
2. Slumping and hardgrounds were described at the basis of the Labatlan Sandstone (Barremian ?) by FOGARASI (1992). Repeated collections in this interval uncovered 4 new ammonite genera and Pulchellidae - some of them are only known from the Albian: *Phylloceras (Hypophylloceras) velledae, Anisoceras* sp., *Hamites (Stomohamites)* sp., *Hypohoplites* sp. These data were neglected when FÖZY (1993, 1995) drew his conclusions only based on older publications.

In the Urgonian olistholites of the Köszörükö-banya Conglomerate Mbr. *Conicorbitolina conica, C. corborica* were identified thus proving their Upper Albian - Cenomanian age. Pebbles with *Orbitolina (M.) texana* are derived from the lower part of the Albian-Cenomanian carbonate platform (SCHLAGINTWEIT, 1992; BODROGI, 1992; GÖRÖG, 1992, 1994).
In the stratotype of the Neszmély Sandstone Fm. *Costidiscus reticostatus* and *Barremites* gr. *difficilis* indicate the Upper Barremian, and, *Costidiscus* gr. *microcostatus, Pseudohaploceras* gr. *matheronites* and *Phylloceras albrechtiaustriae* indicate the Lower Aptian (HORVATH, 1978). The lower boundary of the Aptian is characterised by *Praeorbitolina cormyi*, the upper one by *Globigerinelloides algerianus, G. ferroelensis, Hedbergella trochoidea, H.* cf. *labocaensis, Ticinella* cf. *bejauensis* (BODROGI, 1990, 1993).
The following stratigraphic units are represented in the Vértesomlo Siltstone stratotype section (borehole Agt 2):

- Aptian/Albian boundary (**T. bejauensis Zone**)
- older Lower Albian strata (**Hedbergella planispira Zone**)
- middle Albian strata (**Ticinella primula Zone**) (a.o. BODROGI, 1994).

Near Tata the lower part of the formation was placed in the **Leymeriella tardefurcata Zone**. In the stratotype of the Tata Limestone Fm. (Kalvaria-hegy, Tata) the Upper Aptian *Globigerinelloides algerianus* and the *"ticinella"* zones were separated by SIDO (1975).

poster

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The Santonian/ Campanian boundary in the "Senonian" of the Bakony Mts. (Transdanubian Range)

The "Senonian" of the Bakony Mts. is subdivided into five formations, and three of them are of marine origin. Formation four, the Ajka Coal Fm., contains marine interbeddings only in its upper part, formation five, the Csehbanya Fm., of terrestrial origin is the oldest one.

The Santonian/Campanian boundary has been dated by the local "standard palyno-zonation" used for the Bakony Mts., to the middle Ajka Coal Fm. (at the boundary of the *Oculopollis - Trilobosporites* and *Zankliskaia globosus* zones - see SIEGL-FARKAS, 1993 for further references).

The Santonian/Campanian boundary was placed in the lower Csingervölgy Member of the second Jako Marl Fm. by SIDO (1982, 1984 for further references) following a.o. PREMOLI-SILVA & BOLLI,, 1972, VAN HINTE, 1972). FELEGYHAZY (1983, 1985) confirmed this and placed the boundary at the *Bronsonia parca* event. BODROGI (1992, 1993) from the wells Süt. 22, Mp. 42, Cr.2, Ug. 262 could support SIDO and FELEGYHAZY. These foramniferal and nannoplancton results were confirmed by palaeomagnetic measurements in well Bj. 528 of LANTOS (1992).

These palaeomagnetic measurements contradict the results of SIEGL-FARKAS (1992) in which two zones *(Zankliskaia globosus* and *Hungaropollis krutschi)* previously dated as Campanian, are placed under the Santonian/Campanian boundary.

The marine formations (Ugod Limestone, Jako Marl, Polany Marl) are heterotopic and heterochronous: the speed of the transgressions and the subsidence history of the individual subbasins differs. In such formations with different evolution, the identification of stratigraphic boundaries by mere mechanical reference to palaeomagnetic measurements cannot be recommended. Further investigations are necessary.

The Santonian/Campanian boundary is characterised by the following planktonic foraminiferal events:

1. *Globotruncanita stuartiformis* and later *G. elevata* appear in the Upper Santonian;
2. *Globotruncana arca* appears by the end of the Upper Santonian, immediately below the S/Ca boundary;
3. There is no planktonic foraminiferal event at the S/Ca boundary, but it is marked by the first appearance of *Bronsonia parca*.
4. *Dicarinella concavata* and *D. asymetrica* disappear above this boundary.

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The Barremian/Aptian Boundary in the Transcaspian area (ammonites, bivalves, brachiopods, echinoids).

1. The Lower Aptian substage, yielding abundant fossils, occurs in southern Tuarkyr Anticline, in the Transcaspian area. This section represents two closely situated easily accessible and reliably correlated exposures. One of them occurs on the northeastern slope of the Keldzhe mount, the other, at the base of the Tekedzhik Range. The proposed section forms a continuous succession of beds from the top of Beds with *Imerites* and *Colchidites* (Barremian) to the *Epicheloniceras subnodosocostatum* Zone (Middle Aptian). All zones contain typical assemblages of ammonites and other fossils groups, which display a succession in practically monofacies deposits. The boundary of stages is reliably drawn at both exposures: the lower and middle substages, at the Tekedzhik outcrop. The palaeontological ground for drawing the boundary of substages is provided by the Bijneu exposure, west of the above mentioned section.

2. According to N.P.Luppov, S.Z.Tovbina and the authors of the abstract, the Barremian is crowned by the *Turkmeniceras turkmenicum* Zone. The Lower Aptian deposits comprise 4 ammonite zones: *Deshayesites tuarkyricus, D.weissi, D.deshayesi* and *Dufrenoya furcata*. The Middle Aptian starts with the *Epicheloniceras subnodosocostatum* Zone. Simultaneously, zones based on brachiopods have been distinguished: *Belbekella renngarteni* (Upper Barremian), *Cyclothyris hythensis* (Lower Aptian), *Sellithyris upwarensis* (within the range of the subnodosocostatum Zone), and echinoids: *Epiaster toxasteroides* (Upper Barremian - Lower Aptian). Such a succession of biostrata is traced over the Transcaspian area (Tuarkyr, Kubadag, Greater and Lesser Balkhan, Kopetdag). Ammonite zones are correlated with the corresponding units of the Lower Aptian and the boundary beds in Georgia, Germany, U.K. etc.

3. The Barremian/Aptian boundary is drawn between *T. turkmenicum* and *D. tuarkyricus* Zones. This viewpoint is based on one of the principles for drawing palaeontological (biostratigraphic) boundaries, i.e. the principle of priority. However, there are also other viewpoints concerning the position of this boundary, i.e. at the base of the *T. turkmenicum* Zone. This viewpoint is based on a different principle - the first occurrence of new forms. The genus *Turkmeniceras* is considered by many palaeontologists as an early link of the family Deshayesitidae. The consideration of different approaches to drawing boundaries of biostrata rarely results in an unambiguous solution. Therefore, in our particular case, it would be more correct to take the solution recommended by D.L.Stepanov and M.S.Mesezhnikov (1979, p. 326), to draw this boundary "by agreement among geologists of different countries".

4. Type sections of the Aptian substages in Southeastern France up to now remain unrevised. Data on these sections should, doubtless, be taken into account, when the Aptian scale for the Mediterranean Region is developed. As is known from the earlier published papers, the type section of the Bedoulian, in case of their most accurate study, cannot, unfortunately, offer good prospects as regards the number and preservation of the contained ammonite remains for solving the problem of zonal subdivision of the Lower Aptian, and the zonal index species. In this connection, apparently, a problem can be raised of choosing parastratotypes of Aptian substages. For this purpose, sections of the Transcaspian area and the Caucasus, which are stratigraphically complete and richly characterised by diverse fauna, can be used.

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Microbiostratigraphy and palaeobathymetry of Berriasian and Valanginian pelagic deposits (Western Carpathians, southern France, northern Tunisia)

Results of a microbiostratigraphic study based on Foraminifera from Berriasian and Valanginian pelagic deposits from the Western Carpathians ("Neocomian facies"), from the Vocontian trough (profile at Angles, S.E. France) and from Djebel Oust (N. Tunisia) are presented. The connecting link between the areas is their pelagic character and presence of calpionellids, but they differ in composition and preservation of the foraminiferal association.

The "Neocomian facies" of the Western Carpathians represents a hemipelagic marine basin, poorly oxygenated. The bottom was above the CCD, but definitely below the ACD level. Foraminiferal association: rare tests of *Ammodiscus, Lenticulina* and *Nodosaria*.

The Berriasian-Valanginian sediments of the Vocontian trough also originated in deep water conditions: scarce thin-walled agglutinated Foraminifera and an association redeposited by turbidity wash-outs, from the external platform towards the basin. A taphonomic analysis of these associations documents that the material is damaged by mechanical transport and selected according to size. The scarcity of Epistomins, not previously mentioned at the hypostratotype at Angles, is due to the dissolution of their aragonitic tests resulting from greater depth. In most cases only pyritized or limonitized cores are found.

The Lower Cretaceous deposits at Djebel Oust, northern Tunisia are better preserved and more suited for parabiostratigraphic studies based on Formanifera. Berriasian sequences contain many benthonic foraminifers mainly belonging to the Nodosaridae. The Valanginian sediments are biostratigraphically divided by the presence of *Lenticulina* and *Epistomina.* The latter often have preserved aragonitic tests, indicating sedimentation above the ACD level. Through a detailed analysis of microfacies and the ratio planktonic/benthonic foraminifera Maamouri *et al.* have shown that the Lower Cretaceous sediments of Djebel Oust were deposited at a depth of 200 - 500 m (maximally 700 m).

Reference:

Maamouri, A. L., Salaj, J., Maamouri, M., Matmati, F., & Zargouni, F., 1994. Lower Cretaceous of the Djebel Oust (North-east Tunisia), microbiostratigraphy, biozonation, sedimentology. *Zemny plyn a Nafta, Hodonin* 39, 1: 73-105.

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Micropalaeontology and biostratigraphy of Barremian, Aptian and Albian of Essaouira Basin (Moroccan High Atlas).

Barremian, Aptian and Albian formations of Essaouira basin (Moroccan High Atlas) show facies and thickness changes from West to East. Barremian and Aptian strata are mainly constituted of clays and sands. Planktonic foraminifera are rare in the basal part, but towards the top the strata also contain limestones and marls with an important microfaunal (Foraminifera and Ostracods) content.

Albian marls which contain planktonic and benthic foraminifers are homogeneous throughout the basin except in the East (Amizmiz section) where they are partly dolomitized.

In general, thickness decreases from West to East. A micropalaeontologic study, based essentially on foraminiferal associations, has allowed to establish a detailed biozonation of the Barremian, Aptian and Albian formations of the Essaouira basin. The Barremian interval is composed of three biozones:

+ *Hedbergella sigali* biozone indicates the Lower Barremian,
+ *H. similis* biozone and *Globigerinelloides gottisi/ G. duboisi* biozone indicate the Upper Barremian.

The Bedoulian is characterised by the *Schackoina cabri* biozone.

The Gargasian interval age is identified by:

+ *Globigerinelloides ferreolensis* biozone,
+ *G. algerianus* biozone.

Both biozones characterise the Lower Gargasian.

+ *Hedbergella gorbachikae* biozone,
+ *H. trochoidea* biozone

These two biozones indicate the Upper Gargasian.

The Clansayesian is recognised by the *Ticinella bejaouaensis* biozone and the base of the *Hedbergella planispira* biozone.

The Albian is subdivided as follows:

+ *Hedbergella planispira - H. rischi* biozone - Lower Albian
+ *Ticinella primula* biozone - Middle Albian
+ *Biticinella breggiensis* - Upper Albian.

When planktonic foraminifers are missing, the presence of the benthic foraminifer *Pleurstomella* gr. *subnodosa* indicates the Lower Albian; the *Planomalina buxtorfi* biozone indicates the lower part of the Vraconian.

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Correlation of Lower Cretaceous Stage Boundaries using calcareous nannofossils.

The correlation of Lower Cretaceous stages between their type areas in SE France and the more northerly, Boreal areas, has proved problematical due to the existence of ammonite provincialism. Limited mixing of ammonite faunas, through certain intervals, has allowed limited calibration of the regional zonations, however, the correlation of stages and particularly stage boundaries remains difficult. The power of integrated biostratigraphies using a variety of complimentary fossil groups is beyond question. Calcareous nannofossils, while not yet able to provide as refined a biostratigraphy as ammonites, have many features which make them a powerful tool for correlation, most importantly, their largely pandemic distribution and excellent record from subsurface studies, including ocean basins. The initial development of Lower Cretaceous nannofossil biostratigraphy was largely undertaken in the circum-Mediterranean area, and relied mainly on species considered to be "Tethyan". More recently, work has centred around the circum-North Sea area and has provided a series of increasingly refined zonations, often utilising newly described "Boreal" species but also including cosmopolitan taxa. It is becoming apparent that many species, initially thought to have been endemic, are in fact widely distributed but have been overlooked because of rarity or simply because of taxonomic progress.

We will primarily address the correlation and placement of the Valanginian-Hauterivian and Hauterivian-Barremian boundaries, based upon a major new review of Boreal sections and new, published data from Tethyan sections. A preliminary nannofossil-based correlation of the Valanginian-Hauterivian of Boreal and Tethyan regions is presented in Figure 1. The agreement between nannofossil- and ammonite-based correlations is remarkably good. With variable degrees of confidence we can confirm the current position of the Lower/Upper Valanginian, Valanginian/Hauterivian and Lower/Upper Hauterivian boundaries in Boreal sections. The position of the Hauterivian/Barremian boundary at Speeton has recently been questioned by Bralower (1991) based on nannofossil evidence. We disagree with his interpretations but suggest that the boundary is placed slightly too low in the Speeton section, and should be raised to the top of the *variabilis* Zone. This younger placement agrees with Rawson's (1971) original definition, and with the positioning of the boundary in Germany (top *discofalcatus* Zone).

While some of the most easily utilised nannofossil marker species have restricted distributions or are impracticably rare, the improved documentation of nannofossils in Tethyan and the Boreal area have revealed great potential for direct inter-regional correlation.

References

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Rawson, P. 1971. The Hauterivian (Lower Cretaceous) biostratigraphy of the Speeton Clay of Yorkshire, England. *Newsletters in Stratigraphy*, **1:** 61-75.

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Integrated Nannofossil/Macrofossil biostratigraphy at Upper Cretaceous Stage Boundaries.

An integrated study of primarily nannofossil and macrofossil biostratigraphies (with some planktonic foraminifera biostratigraphy, chemostratigraphy and magnetostratigraphy) around potential Upper Cretaceous stage boundaries, from a variety of geographical locations, was undertaken. This project was devised in response to the discussions held at the original symposium on Cretaceous Stage Boundaries, held in Copenhagen in 1983 by the Subcommission on Cretaceous Stratigraphy, and a subsequent "call for help" by Dr. K. (von Salis) Perch-Nielsen (1986), in which potential boundary stratotypes were identified. The work was carried out in collaboration with J.M. Hancock (ex-ICL), W.J. Kennedy (Oxford) and A.S. Gale (NHM/ICL), and others.

Traditionally, it has been accepted that macrofossil events will be used to define the stage boundaries. However, macrofossils cannot be used to *directly* date the majority of boreholes, nor any of the cores drilled by the Ocean Drilling Program. In the oceans, nannofossils and planktonic microfossils are extensively used for dating and correlation due to their small size, high abundance and wide geographical coverage. Complications arise when it comes to providing precisely correlatable dates (i.e. stage ages) for sediments from the ocean basins. Unfortunately, it is already the case that we have a system of stage boundaries defined on macrofossils for onshore sequences, and ones based on nannofossils and microfossils for the oceans. Thus, in order to precisely define a stage boundary, and, importantly, to be able to correlate it, it is imperative that the stratigraphies of all of these fossil groups are precisely *integrated.*

This study integrated the biostratigraphies of nannofossils and macrofossils across potential boundary stratotypes (Albian/Cenomanian to Maastrichtian/Palaeocene) around the world (*see below). The chosen sequences incorporated all palaeobiogeographical regions. Thus, the inconsistency between macrofossil and nannofossil approximations for stage boundaries has been largely overcome. The results are presented here in summary.

*(**Palaeocene/Maastrichtian**: Denmark, Poland, Spain, France, The Netherlands, Belgium, South Africa; **Campanian/Maastrichtian**: France, Spain, Germany, England, Poland, Russia, South Africa; **Santonian/Campanian**: Germany, England, Poland, Russia, South Africa; **Coniacian/Santonian**: Texas, England, Germany; **Turonian/ Coniacian**: Germany, Czech Republic, England; **Cenomanian/Turonian**: Spain, South Africa, England; **Albian/Cenomanian**: France, England, Germany, South Africa.)

Reference

Perch-Nielsen, K. 1986.Call for help. INA Newsletter, 8(2): 64-65.

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The Albian to Coniacian stage boundaries and subdivisions in the N.E. Atlantic (Goban Spur and Galicia Bank) as defined by planktonic Foraminiferida, with emphasis on the Albian-Cenomanian stage boundary.

Deep Sea Drilling Project (DSDP) sites 550B, Goban Spur and 398D, Galicia Bank have been analysed to evaluate the application of planktonic Foraminiferida to the chronostratigraphy of the N.E. Atlantic. The importance of these successions comes from the proximity of the rich planktonic assemblages to the 'stratotypes' many of which are in shallow water facies. The assemblages also contain benthonic foraminiferal assemblages used in the shelf successions of N.W. Europe.

Site 550B, was drilled on the Porcupine Abyssal Plain, 10 km south-west of the seaward edge of the Goban Spur. The Upper Cretaceous succession can be subdivided into a unit of Coniacian/Santonian age with impoverished agglutinated fauna and high diversity planktonic assemblages, a lower to middle Cenomanian interval indicating well defined restricted benthonic and planktonic fauna and a thin layer of upper Albian age with many stratigraphically significant planktonics. In this study species with well known stratigraphic ranges were used; although the upper Albian and lower Cenomanian do not provide diagnostic planktonic Foraminiferida. At site 550B the planktonic foraminiferal datum for the stage boundary is represented at a core depth of 674.1 m by the first occurrence of *Rotalipora brotzeni* and *Schakoina cenomana* and the last occurrence of *Planomalina buxtorfi* at a core depth of 681.55 m although both datums are slightly below the base of the Mantelliceras mantelli Zone.

These results can be correlated across to the site 398D on the southern edge of the Vigo Seamount, 160 km off the western coast of the Iberian Peninsula. A zonal stratigraphy can be applied to the site 398D from the base of the Albian were conditions were favourable for the establishment of diverse planktonic and benthonic assemblages. Although the Cenomanian succession is incomplete there are many planktonic Foraminiferida of stratigraphic significance to mark the Albian-Cenomanian boundary. The last appearance of *P. buxtorfi* and *Rotalipora ticinensis* at core depth 974.7 m denote the late Albian whilst the first appearance of *R. brotzeni* and *R. globotruncanoides* at core depth 966.3 are also recognised as a datum which is also below the acknowledged Albian-Cenomanian boundary. As with the stratotype sections defining the upper Albian and lower Cenomanian there are no well defined marker species.

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Ammonite biostratigraphy in the Lower Cretaceous Maiolica Limestone in Umbria-Marche Apennines and Lombardy basin (Italy): correlation with magnetic chrons and calcareous nannofossil events.

Recent ammonite finds in Italian Maiolica limestone, particularly in Umbria-Marche Apennines and Lombardy Basin (Southern Alps), allow direct correlation of Upper Valanginian-Lower Aptian ammonite zones to polarity chrons and calcareous nannofossil events. In the Maiolica limestones there are no continuous faunal successions because the ammonites are scattered in some levels which can be relatively reached. These ammonitiferous levels allow us to recognise most of the ammonite biozones defined for the Mediterranean Domain. The most important results are:

1. At Monte Acuto (Umbria-Marche) ammonites spanning the Valanginian/ Hauterivian transition and the last appearance of the nannofossil *T. verenae* occur close to the CM11/ CM 11n. The Valanginian/ Hauterivian stage boundary has generally been placed between the first appearance of *L. bolli* and the last appearance of *T. verenae*, or between CM10 and CM11.
2. The correlation of the Hauterivian/ Barremian boundary to CM4, recently realised in the Gorgo a Cerbara section has also been confirmed in the Bosso section (Umbria-Marche).
3. A *Prodeshayesites*, showing affinities with *P. bodei* and *P. fissicostatus*, indicating the lowermost Aptian *D. tuarkyricus* zone, has been found in Gorgo a Cerbara in the upper part of CM0.
4. At Laghetto (Lombardy), Late Barremian ammonites of the *H. sartousi* and *H. feraudi-I. giraudi* zones occur in CM1n.
5. At Alpetto (Lombardy) two major ammonite levels have been found: the first, characterised by a very particular fauna, correlates with the middle of CM0. The second occurs just above CM0 and below the nannoconid crisis which pre-dates the Selli-Level; it is ascribed to the *D. weissi* zone and is characterised by *Procheloniceras* gr. *albrechtiaustriae* (Uhlig in Kilian), *Ptychoceras emerici, Silesites seranonis* and *Deshayesites* sp.

Points 4 and 5 are consistent with the Barremian/Aptian boundary being close to the base of CM0.

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A chemostratigraphical correlation of Turonian sediments in the Bohemian Cretaceous Basin.

Nearshore siliciclastic sediments and offshore pelitic facies characterise two main facies development of the Turonian sequences in marginal marine condition of the Bohemian Cretaceous Basin. The Turonian sequences consist of several upward shoaling cycles interrupted by periods of erosion and non-deposition caused by the activity of submarine currents, at the middle-upper Turonian. The correlation between nearshore prograding sand bodies and shallow shelf biomicritic limestone and marlstone facies is based on characteristic curve of maxima and minima of calciumcarbonate, quartz, clay minerals and trace elements in the sequence. The chemostratigraphical events are biostratigraphically controlled by macrofauna, foraminifera and calcareous nannoplankton. Detailed palaeoecological analysis of macrofauna, foraminiferal assemblages (e.g. benthonic and planktonic diversity, ratio plankton/benthos, abundance) and calcareous nannoplankton enabled to distinguish variation in environmental deposition, sea level changes, water temperature etc.

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The Upper Campanian and Lower Maastrichtian *Belemnitella* succession of Norfolk.

The standard Upper Campanian *Belemnitella* zonation includes, in ascending order, the *B. mucronata* Zone (lower part of the Upper Campanian), and the *B. minor* and *B. langei* Zones (upper part of the Upper Campanian). This zonation was introduced by Jeletzky (1951) and has been used subsequently by numerous workers. The standard zonation of the Lower Maastrichtian includes two *Belemnella* zones, the *B. lanceolata* Zone below and the *B. occidentalis* Zone above. Schulz (1978) subdivided the Lower Maastrichtian into six *Belemnella* zones on the basis of species of the stout *Belemnella (Pachybelemnella)* and the slender *Belemnella (Belemnella)*.

The concepts of *B. minor* Jeletzky, 1951 and *B. langei* Jeletzky, 1948 have been open to question since they were established, and the concepts of these taxa differ from one author to another. *B. minor* has been placed in synonymy with either *B. langei* or *B. mucronata*. Christensen *et al.* (1975) split the holotype of *B. minor* and showed that the internal characters do not agree with the diagnosis. They questioned the legitimacy of *B. minor*. Others consider *B. minor* as a subspecies of *B. langei*. Christensen (1995) interpreted *B. minor* with respect to its holotype, which came from the Norwich Chalk in contrast to earlier authors, who interpreted it on the basis of the diagnosis. These concepts are rather different. He recognised three subspecies, *B. minor* I from the lower Upper Campanian, *B. minor* II from the upper Upper Campanian, and *B. minor* III from the lower Lower Maastrichtian. *B. langei* is understood only in the sense of the holotype and paratype, and the variation is not known, because statistically evaluated samples of the species from the type locality in Ukraine is not available. *B. langei sensu* Birkelund is not conspecific with *B. langei* Jeletzky, and *B. langei sensu* Schulz is neither conspecific with *B. langei* Jeletzky nor with *B. langei sensu* Birkelund. Christensen (1995) suggested, therefore, that the traditional *B. minor* and *B. langei* Zones should not be maintained.

Christensen (1995) subdivided the Upper Campanian of Norfolk into four informal *Belemnitella* zones, in ascending order, the *B. mucronata* zone (lower part of lower Upper Campanian), the *B. woodi* zone (upper part of lower Upper Campanian), the *B. minor* I zone (lower part of upper Upper Campanian), and the *B. minor* II zone (upper part of upper Upper Campanian). The *B. minor* I zone is subdivided into three subzones, and the *B. minor* II zone into two subzones. The *B. minor* III zone may equate with the traditional *Belemnella lanceolata* Zone (lower Lower Maastrichtian).

Christensen, W.K. 1995. *Belemnitella* from the Upper Campanian and Lower Maastrichtian Chalk of Norfolk, England. *Special Papers in Palaeontology 51*, 84 pp. References to the papers mentioned in the abstract are listed herein.

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Molluscan faunas of the Coniacian-Santonian stage boundary interval of Alberta, Western Canada.

Of the three best documented Upper Cretaceous stage boundaries within marine strata of the Western Interior Basin of North America (Cenomanian-Turonian, Turonian-Coniacian, and Coniacian-Santonian), the latter has received relatively little paleontological attention. Although the fauna defining the base of the Santonian were first found in Western Canada (FAD of *Clioscaphites saxitonianus*), the stratigraphic sequence(s) in which these key marker taxa occur are often sparsely fossiliferous (e.g. the Wapiabi Formation of the Rocky Mountain Foothills) or in remote locations which are not easily accessible.
However, recent work has uncovered a unique and extraordinary interval encompassing the Coniacian-Santonian boundary, within the Bad Heart Sandstone of west-central Alberta. This prolifically fossiliferous fine-grained oolitic sandstone has yielded a well-preserved and taxonomically diverse molluscan fauna. In addition to abundant scaphite/ pteroscaphite and baculite ammonites (incl. rarer placenticerids), the bivalves are well represented by: biostratigraphically-important epifaunal inoceramids such as *Cremnoceramus, Cordiceramus* and *Sphenoceramus*, infaunal *Pholadomya, Goniomya,* and *Panopea* (among many others), encrusting oysters such as *Pseudoperna*, wood-boring *Teredo,* and large *Pinna* and *Camptonectes* (otherwise uncommon elements within the Western Interior seaway). A surprising variety of gastropods (incl. limpets), cephalopods (e.g. *Eutrephoceras*), arthropods (*Linuparus* and *Hoploparia*), stalkless crinoids (*Uintacrinus*), a diverse microbiota (foraminifera, dinoflagellates and other palynomorphs), large teleost fish (e.g. *Xiphactinus*), sharks (*Cretoxyrhina*) and mosasaurids were additional components of this robust mixed assemblage.
Comparable coeval micro- and macrofaunas are known from the Kanguk Formation of the Sverdrup Basin in the Canadian Arctic, suggesting that this vast region of Canada was dominated by boreal and cool-temperate organisms during the Coniacian-Santonian transition approximately 84.0 million years ago. Higher latitude faunas may indeed be more biostratigraphically-important and widespread at this time than more restricted and possibly endemic Tethyan faunas (particularly planispiral ammonites). For this reason Mesozoic paleontologists are recognising the pitfalls of utilising low-paleolatitude, carbonate-dominated shallow-water sequences for defining significant chronostratigraphic boundaries. The presence of key factors outlined herein, such as presence of cosmopolitan and biostratigraphically-important taxa, unprecedented diversity of well-preserved marine biota, relatively easy access to fossiliferous exposures, absence of major hiatuses or unconformities within the stratigraphic sequence, and tectonically-undisturbed nature of the Bad Heart Sandstone outcrops along the Smoky River of Alberta combine to make it a potential candidate for a Global Stratotype Section and Point (GSSP). Inasmuch as this world-class locality meets all the necessary IUGS requirements, it is recommended for consideration as a candidate for the Coniacian-Santonian stratotype.

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Inoceramid bivalve and ammonite biostratigraphy of the Turonian-Coniacian transition, Western Interior region of the United States.

The Upper Cretaceous (Cenomanian - Maastrichtian) mid-basinal sequences within the Western Interior Seaway are characterised by uncommonly complete and fossiliferous fine-grained pelagic/hemipelagic strata. However, in the region of Colorado and New Mexico these cyclically-bedded sequences contain a rather restricted fauna, particularly with respect to molluscs. The Upper Turonian and Lower Coniacian substages, for example, yield little else than inoceramid bivalves, small oysters (epifaunal and encrusting), and ammonites (planispiral and heteromorph forms). Fortunately, these faunas are the most important elements for defining and correlating biozones and stage/substage boundaries within this interval. Precise recognition of the Turonian-Coniacian (Tur-Con) stage boundary in the U.S. has been established by the First Appearance Datum (FAD) of the cosmopolitan inoceramid *Cremnoceramus rotundatus* (Fiege). Work since 1989 within the Raton Basin of southeastern Colorado and northeastern New Mexico has led to placement of the Tur-Con stage boundary within the **fifth** limestone bed above the base of the Fort Hays Member, Niobrara Formation. This precisely-defined level is marked at nearly all studied exposures by an unusual an unique *Pycnodonte* oyster biostrome. Biostratigraphic correlation of this horizon westward into the more shoreface-dominated clastic sequences of the San Juan Basin correspond exactly with a surface of extensive marine and subaerial erosion into the underlying regressive strata (i.e. Gallup Sandstone). This regional unconformity, and correlative conformity in the mid-basin, is overlain by transgressive marine deposits (Tocito Sandstone) which contain Coniacian guide fossils. The controversial Tur-Con stage boundary thus coincides with the exact stratigraphic level of a major eustatic regression, a relation which has been reported from coeval sections on several continents, including the type locality of the Coniacian in the Aquitaine Basin of southern France. The first appearance of *C. rotundatus* has become widely used as an indicator of the basal Coniacian, inasmuch as biostratigraphically-useful co-occurring ammonites (e.g. forresteriids) are quite rare at this level in most carbonate-dominated regions, and virtually non-extant in fine-grained clastic deposits of the higher latitudes. The FAD of cremnoceramids within the fossil record is **not** synchronous with the FAD of the key ammonite taxon *Forresteria*, which likely appears within the uppermost Turonian (e.g. *F. peruana* Brüggen). Thus, the appearance of basal Coniacian index *F. petrocoriensis* (Coquand), most notably in Western Europe, should **not** be considered the origin of the genus. In terms of coeval and co-occurring foraminifera, the base of the *Dicarinella primitiva* Zone also pre-dates the Tur-Con boundary (as defined by cremnoceramids); these planktic forms have often been reported in association with faunas of the *Mytiloides incertus / Prionocyclus germari* Zone, unequivocally of Late Turonian age.

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Barremian/Aptian boundary in platform carbonates and Aptian/Albian boundary in hemipelagic formation.

Attempts are made to draw Barremian/Aptian and Aptian/Albian stage boundaries within different tectonic units and different sedimentary environments in Hungary. The first is developed in carbonate platform of Urgonian facies and situated in the Villany zone of the Tisza Unit separated from the European platform in the Jurassic and shifted southwards; the latter is studied in the hemipelagic sequence of the Transdanubian Range of the Pelso Unite derived from the Apulian plate.

The Lower Cretaceous sequence of the Villany zone consists of supratidal freshwater limestone, brackish water limestone of varied salinity and fully marine limestone. Its deposition started after the Late Jurassic emergence and formation of bauxite. Foraminiferal, rudistid and Dasycladacean algae-bearing facies of lagoonal environment are alternating in the sequence from the Barremian upwards. The best opportunity to draw the Barremian/Aptian boundary presents itself in the Nagyharsany quarry mainly on grounds of large foraminifers (*Orbitolinopsis cuvillieri*, *Falsurgonia pileola*, *Palorbitolina lenticularis*, *Praeorbitolina cormyi-wienandsi*) and to a certain extent Dasycladacean algae (GÖRÖG, 1994).

The Aptian and Albian formations are deposited transgressively on an erosional surface ranging from the Upper Triassic to the Lower Cretaceous. The succession of siliciclastic bathyal sediments of the Gerecse Mts. developed continuously from the Jurassic is now replaced by crinoidal limestone (Tata Limestone - Tl. F.) on the flanks. It turns upwards into silty marl (Vértessomlo Siltstone - VSL). Basically the study is focused on cores from a borehole (Vértessomlo Vst. 8 - fig. 1): its basic fossils are: planktonic forams, nannoplankton, dinocysts and palynomorphs. The late (and middle) Aptian age of TLF elsewhere is proven by ammonites (*Acanthohoplites nolani*, etc. FÜLÖP, 1975) and with foramzones (*Globigerinelloides algeriana*, *Ticinella bejaouaensis*). The *Ticinella primula* Zone (BODROGI, 1994) and the CC7 (*Chiastozygus litterarius* nannoplankton Zone) represent the lower part of VSF. Dinocysts also show the Albian age, but a few species (*Cyclonephelum intensum*, *Florentinia khaldunii*) indicate the closeness of the Aptian age. In addition to the lack of angiosperms the frequent occurrence of bisaccate gymnosperms and smooth-walled fern spores indicate an older age than Albian. The Albian age is proven by *Leymeriella* taxa in other boreholes (FÜLÖP, 1975). Consequently the Aptian/Albian boundary is situated within the TLF.

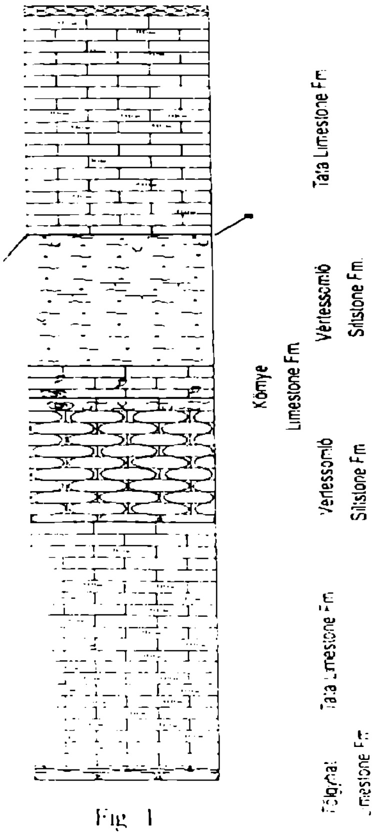

Fig. 1

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Inter-regional dinoflagellate cyst stratigraphy across the Cenomanian-Turonian boundary

Dinoflagellate cysts have been studied from the late Cenomanian to early Turonian deposits of six separate depositional basins. The most distinctive inter-regional event close to the boundary is the acme of *Lithosphaeridium siphonophorum* (its acme is defined here as the stratigraphical interval throughout which it generally comprises 0.1-10% of marine palynomorph assemblages - late Albian to late Cenomanian). the top of the acme occurs in the same position, relative to the stratigraphies based on planktonic foraminifera (a few beds higher than the range top of *R. cushmani*), ammonites (mid *M. geslinianum/ S. gracile* Zone) and geochemistry (immediately below maximum 1^3 C values) at Pueblo, Colorado (Western Interior Seaway), Lulworth and Eastbourne, S. England (Wessex-Paris Basin) and Misburg, Germany (Lower Saxony Basin). Above its acme, *L. siphonophorum* occurs at an abundance of approximately 11 per 10000 in the upper part of the *M. geslinianum* Zone, and specimens are only recovered sporadically from Turonian sediments. *Microdinium setosum*, *Gonyaulacysta cassidata*, *Adnatosphaeridium tutulosum* and *Carpodinium obliquicostatum* have *M. geslinianum* Zone or *N. juddii* Zone range tops.

Otherwise, the diversity of cosmopolitan dinoflagellate cysts does not seem to have been affected during the Cenomanian-Turonian transition, even in regions where "OAE 2" organic-rich sediments were deposited, though diversity in such sediments is often masked by a dominance of peridiniineaen cysts, sphaeromorph acritarchs and/or terrestrially-derived bisaccate pollen grains (such dominance is secondarily enhanced by laboratory oxidation techniques).

The extrapolation of this compatible dinoflagellate cyst stratigraphy in regions were calcareous fossils are poorly preserved, such as the "black band" deposits of eastern England and the Crimea (below and above which palynological recovery is itself very poor), facilitates their dating. Of the above-mentioned dinoflagellate cysts, only *A. tutulosum* and *C.obliquicostatum* (and two specimens of *G. cassidata* at Flixton) have been recorded as being present in the eastern England "black band" while all five, including *L. siphonophorum* at acme abundance, are found in the Aksu-Dere "black band" in the Crimea; thus the deposition of organic-rich strata in the Crimea (*M. geslinianum* Zone or older) would seem to have terminated before that in eastern England (*N. juddii* Zone) commenced.

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Preliminary results from an almost continuous and well-exposed Cretaceous-Tertiary (K-T) boundary section in the Kalaat-Senan area (Central Tunisia)*).

The newly discovered K-T boundary section is located in the Kalaat-Senan area, about 90 km south of the well known El Kef section.

The yellowish K-T boundary clay has been identified within a 5 cm thick heterogeneous succession, overlying a blue-grey marl (carbonate content : 30 % to 45 %). This boundary succession consists of 5 beds (in ascending order) : (1) a basal 2 cm thick bioturbated dark clay, deeply burrowed into the blue-grey marls, (2) the yellowish boundary clay, rich in jarosite and iron oxides, forming small dome-shaped to saucer-shaped lenses, (3) a thin brownish clay, (4) a discontinuous layer of pale grey carbonate-rich (40 %) silt and (5) a heterogeneous brown clay forming small elevations (ripples ?). It is covered by a 0.6 m thick uniform jarosite-rich dark clay (carbonate content : 5 % to 20 %). Mineralogical and geochemical studies, which are still in progress, are expected to provide detailed palaeoenvironmental information, especially on detrital supply and climate (clay mineralogy) and the redox conditions (study of behaviour of trace metals).

The study of the planktonic foraminiferids indicates a major faunal break (disappearance of 46 species) between the top of the Late Maastrichtian blue-grey marl and the base of the jarosite-rich dark clay, about 8 cm higher up in the section. Data on the foraminifera from the boundary succession are not yet available. No major extinction event has been observed in the dinoflagellate assemblages. However, specimens of *Danea californica*, which first occurrence is believed to mark the base of the Danian, have been found in bed 1, clearly below the yellowish boundary clay. The calcareous nannoplankton associations from the topmost 40 cm of the blue-grey marl are rich (> 25 specimens/field of view), diverse, and are quite similar throughout the interval. They are characterised by *Micula prinsii*, *Lithraphidites quadratus* and *Ceratolithoides kamptneri*, indicating the upper part of Zone CC 26, and the top of the Late Maastrichtian. The associations from the basal 10 cm of the jarosite-rich dark clay are very poor (1 specimen/field of view). They contain *Neobiscutum romeinii*, *Cyclagelosphaera reinhardtii*, *Thoracosphaera* spp. (up to 25 %) and large numbers of Cretaceous coccoliths (up to 75 %), indicating the base of Zone NP 1, and the earliest Paleocene. The assemblages of the boundary succession are uniquely made up of Cretaceous coccoliths (no or very few *Thoracosphaera* and *Braarudosphaera*). There seems to be a substantial and abrupt decrease in number of nannofossils just above the boundary clay (from ca 25 to ca 10 specimens/ field of view).

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Calcareous nannofossils and foraminiferal biostratigraphy of Al Hilal Shale Formation, North East Libya.

Al Hilal Shale Formation exposed in two surface outcrops in Ras Al Hilal (sea-cliff and mouth of wadi Al Qalah), were analysed for calcareous nannofossils and foraminiferal content. Fifty species of well preserved calcareous nannofossils are described and illustrated for the first time which permit the revision of the previously established age based on foraminiferal biostratigraphy.

Previously, Al Hilal Shale was assigned to different ages within the Late Cretaceous, Coniacian (Barr, 1972), Albian-Coniacian (Bannerjee, 1980), and Coniacian-Santonian (El-Mehdawi and Duronio et al., 1991).

In the present study two calcareous nannofossil zones *Reinhardtites anthophorus* and *Lucianorhandus cayeuxii* (Perch-Nielsen, 1979, 1985) are recognised for the first time. Similarly two foraminiferal zones reported previously *Dicarinella concavata* Sigal (1955) and *D. asymetrica* of Postuma (1971), are also recognised.

Based on the presence of the *R. anthophorus* and *L. cayeuxii* zones, the Al Hilal Shale can now be restricted to the Santonian. Accordingly, *D. concavata* foraminifera zone recognised in this section is of Santonian age.

The dominance of the keeled planktic foraminifera as well as the deep benthic foraminifera indicate a deep open marine environment of normal marine conditions.

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Cretaceous chronostratigraphy of the third millennium: ammonite-based or something else-based?

During the past decade, Early Cretaceous stratigraphy has been revised to improve the correlation between chronostratigraphy and bio-magnetostratigraphy, using data from sections located at high and low latitudes from different basins and oceans. Traditionally, ammonites zones provide the base for chronostratigraphy, but several sections are barren of ammonites or yield only sparse specimens. In order to bypass this problem, efforts have been made to establish a sequence of events based on various stratigraphic tools, such as biostratigraphy, magnetostratigraphy, chemostratigraphy, sequence stratigraphy and cyclostratigraphy.

Because the record of calcareous plankton (nannofossils and planktonic foraminifers) in pelagic/hemipelagic sequences is usually continuous, nannofossils and planktonic foraminifers have been systematically investigated and routinely used for short- and long-distance correlations. Additional biostratigraphic data derive from calpionellids, radiolarians and dinoflagellates.

Magnetostratigraphy, sequence stratigraphy and stable isotope stratigraphy (δ 13C) are now available for the entire Lower Cretaceous, while cyclostratigraphy has been established for selected intervals. Because GPTS (Geomagnetic Polarity Time Scale) is the preferred means of correlation and interpolation among diverse chronostratigraphic elements, magnetostratigraphy is central for Mesozoic time scales. Lower Cretaceous sections with ammonite control have been used to recalibrate stage boundaries (current definitions based on ammonites) with respect to magnetic polarity chronozones and/or calcareous plankton events as follows:

Albian/Cenomanian boundary = just above the FAD of *Rotalipora brotzeni* ; Aptian/Albian boundary = just above the FAD of *Prediscosphaera columnata* ; Barremian/Aptian boundary = base of CMO; Hauterivian/Barremian boundary = upper part of CM4, close to the LAD of *Lithraphidites bollii* ; Valanginian/Hauterivian boundary = base of CM11n, close to the LAD of *Tubodiscus verenae* ; Berriasian/Valanginian boundary = within CM15n; and Tithonian/Berriasian boundary = base of CM18.

Geologists are looking for isochronous horizons that can be detected in wide areas and traced across different basins. Thus, they are prone to substitute biostratigraphy with other stratigraphic tools, if available. In particular, since the Lower Cretaceous M-sequence is well established, correlations are frequently based on magnetostratigraphy, with additional data derived from chemostratigraphy and sequence stratigraphy. The stratigraphers of the third millennium might determine stage and substage boundaries at events other than ammonite and other fossil horizons. Are palaeontologists ready for such a change?

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Radiolarian biostratigraphy and stable isotope successions from the Late Albian to Early Cenomanian of the western Tethys and North Atlantic

Several DSDP/ODP-cores and onshore sections from the North Atlantic and westem Tethys have been investigated in order to establish and correlate an 'event-stratigraphy' of mid-Cretaceous radiolaria. We focus on the evolution of Late Albian to Early Cenomanian radiolaria and try to introduce radiolaria as a useful group to define biostratigraphic zones and boundaries in this time interval.

Late Albian to Early Cenomanian (*T. praeticinensis* to *R. brotzeni* foraminiferal-zone) pelagic sediments from the western Tethys and North Atlantic are characterized by several levels, exceptionally rich in well preserved and highly divers radiolarian faunas.
The more or less continuous radiation of radiolaria, following an extinction/radiation event in the lowermost Albian is interrupted by a significant extinction/radiation event in the middle part of the Vraconian (*P. buxtorfi* foraminiferal-zone). In the sections investigated in central Italy this event causes the extinction of 15 radiolarian taxa (28% of the fauna). During and immediately after this event 12 new taxa appear (23% of the fauna). Similar patterns seem to be evident for sections from the North Atlantic. This event is paralleled by a positive excursion of the δ13C carb values as well as black paper shales and therefore shows similar patterns like other important extinction/radiation events of the mid-Cretaceous OAE 1a, 1b and 2 (Erbacher, 1994). We therefore termed this event as OAE 1d (Erbacher & Thurow, submitted).
No radiolarian events and positive ä13C-excursions have been observed around the Albian/ Cenomanian-Boundary.

Erbacher, J. (1994). Entwicklung und Paläoozeanographie mittelkretazischer Radiolarien der westlichen Tethys (Italien) und des Nordatlantiks. *Tübinger Mikropaläontologische Mitteilungen*, **12**, 120.
Erbacher, J., & Thurow, J. (submitted). Influence of Oceanic Anoxic Events on the evolution of mid-Cretaceous radiolaria in the North Atlantic and westem Tethys. *Marine Micropalaeontology*.

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Charophyte biostratigraphy of the Purbeck and Wealden of Southern England and the problem of the Jurassic-Cretaceous boundary.

The distribution of charophyte assemblages in the Purbeck and Wealden sequence of southern England has been established from borehole samples from the Weald and from outcrop material collected in Dorset and in the Isle of Wight. In the context of the phylogeny of the Family Clavatoraceae, *G. rectispirale* represents the Jurassic ancestor of the *Globator* lineage and a separate origin is suggested for both *Flabellochara* and *Clypeator*. The correlations established with the Tethyan realm locate the Jurassic - Cretaceous boundary within the Lulworth Formation of the Purbeck Limestone Group; in this context, the whole 'Purbeck' sequence of Swindon (Wiltshire) is attributed to the Upper Tithonian. The distribution of Clavatoraceae indirectly confirms the contemporaneity of the Boreal *Titanites anguiformis* and the Tethyan *'Durangites'* ammonite Zones. For the Wealden Supergroup, the charophyte data affirm the Hauterivian - Barremian boundary at the base of the upper division of the Weald Clay and the Upper Barremian is identified at the base of the Vectis Formation of the Isle of Wight.

[After FEIST, M., LAKE, R.D. and WOOD, C. J., *Palaeontology* (in press)]

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Biosedimentary events around the Cenomanian-Turonian boundary, from the Basque Basin to the Castilian ramp (Northern Spain)

Sedimentologic, biostratigraphic and geochemical analyses of the latest Cenomanian - earliest Turonian series of the Basque basin and of the Navarro-Cantabrian distal ramp and Castilian proximal ramp, reveal the following main facts:

1) A major biosedimentary unconformity occurred during the latest Cenomanian (Archaeocretacea Zone or Juddii Zone).
2) Thin layers of organic matter-bearing laminated black shales in the Basque basin correlate with glauconitic-pyritic bioturbated hardgrounds on the Navarro-Cantabrian and Castilian ramps. They underline the unconformity and indicate anoxia in the basin and hypoxia on the ramps.
3) A main bioevent (extinction of *Rotalipora* in the basin, and of benthic foraminifera and rudists on the proximal ramp) is linked to the unconformity and to the anoxia and hypoxia.
4) A weak sedimentation rate characterised the latest Cenomanian-earliest Turonian interval in the whole area and particularly in the Basque basin (starved basin).
5) Hardgrounds on the distal and proximal ramps display high values of $\delta^{13}C$ and peak values of Mn and Fe.
6) Large variations in the $\delta^{13}C$, $\delta^{8}O$ and Mn values are recorded in the basin deposits. The overall high Mn values may have been related to submarine volcanic emissions that occurred then in this setting.

Such biosedimentary events are regarded as results of a net marine deepening. The laminated black shales and the hardgrounds are believed to correspond to a main transgressive surface at the scale of the transgressive-regressive Late Cretaceous depositional megacycle.

These events correspond to the biosedimentary events widely known near the C/T boundary but are accurately dated here from the latest Cenomanian only. They are recognised for the first time on the whole Basque-Cantabrian and Castilian marine areas.

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The use of stable isotopes in the definition and correlation of Cretaceous Stage boundaries.

Over the last 20 years, secular variance in stable isotopes has been shown to be of great value in stratigraphic correlation. For example, in the deep sea Neogene record δ 180 underpins a Milanovitch timescale (20-100 ka) which can be applied almost globally. The value of strontium isotopes (Sr 86/87) in the correlation of Cenozoic marine sediments has been well established, and is now extended back as far as the early Jurassic.

In the Late Cretaceous (Santonian-Maastrichtian), variance in Sr 86/87 allows correlation of marine sediments with a time resolution of about 1 my. However, higher resolution correlation is achieved using stable carbon isotopes. Variance in δ 13C through the Late Cretaceous was characterised by its peakiness, with ornate positive excursions at the Albian-Cenomanian and Cenomanian-Turonian boundaries, and minor peaks in the Mid-Cenomanian, Turonian, Coniacian and latest Santonian. Peaks and troughs of δ 13C values enable high resolution correlation because global turnover in the carbon cycle takes less than 10ky. The δ 13C curve reflects globally recognisable shifts in the carbon cycle which should register both in marine and continental facies.

The specific value of carbon isotope stratigraphy in the study of Upper Cretaceous sediments is that it provides an isochronous correlation framework independent of biostratigraphy, against which the ranges of different fossil groups can be compared. For this purpose reference are required which yield both high quality isotope data and material of key fossil groups (ideally, ammonites, planktic foraminifera, nannofossils, inoceramids) and form the basis of an integrated stratigraphy. This is illustrated with reference to the Albian-Cenomanian, Cenomanian-Turonian, Coniacian-Santonian and Santonian-Campanian boundaries.

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Cretaceous macrofaunas from SE Spain

Cretaceous fossil sites, corresponding to the southeastern end of the Iberian Range and to the northeastern part of the Betic Range (southeast Spain), have been surveyed; their macrofaunal content has been identified and interpreted both biostratigraphically and biogeographically.

In the Iberian Range, tectonic structures are oriented NW-SE, while they are ENE-WSW in the Betic Range. In the External Zones of the latter, several tectostratigraphical units, deposited in the southern margin of the Iberian plate during the Alpine cycle and differently affected by tectonic translations and deformations, are currently distinguished: the Prebetic Zone is a domain with shallow marine sedimentation, where an External and an Internal Prebetic are recognised, and the Subbetic Zone is a domain with pelagic facies; the Intermediate Units, which correspond to the sediments deposited between the Prebetic Zone and the Subbetic Zone, overthrust the former and are overthrusted by the latter. In the studied area, Cretaceous facies in the Iberian Range are very similar to those of the External Prebetic.

In the Iberian domain, studied macrofauna is mainly composed of late Campanian and early Maastrichtian rudists; echinoid, inoceramid and brachiopod records are uncommon. Concerning the Betic Range, in the External Prebetic, a late Campanian macrofauna with rudists, echinoids, inoceramids and brachiopods, and a late Maastrichtian one with rudists and echinoids have been identified.

In the Internal Prebetic, ammonites, echinoids, inoceramids and rudists occur in the upper Albian, and ammonites, echinoids and brachiopods, in the lower Cenomanian. Rich inoceramid, echinoid and ammonite associations characterise the upper Campanian and the Maastrichtian.

In the Intermediate Units, Maastrichtian echinoids, inoceramids and scarce brachiopods and rudist fragments occur.

Considering the whole studied area, Albian and Cenomanian faunas are cosmopolitan, while Campanian and Maastrichtian ones are clearly Tethyan with some Boreal forms.

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Brachiopod events in Aptian to Turonian interval in Northwestern Europe - discussion for a zonation.

Though well represented in the Cretaceous in three faunal provinces (Boreal, Jura, and Tethys) brachiopods are not generally considered as competitors of ammonites and foraminifers for establishing a standard zonation. Brachiopods as benthic organisms are environmentally controlled and highly variable (this aspect is not always well understood) and therefore were considered as unimportant stratigraphically.

It is of course difficult to correlate brachiopod occurrences with ammonite zones - indeed impossible according to Middlemiss (1981). Nevertheless, brachiopods (only those of the Boreal realm are considered here) are sometimes frequent in thin beds where major groups are absent or poorly represented, and brachiopods can be useful in correlation (local, regional, provincial use). Such is the case for *Moutonithyris dutempleanus** (d'Orbigny), while characteristic of the Tethyan fauna is widely represented during the Upper Albian. *Orbirhynchia mantelliana** (Sowerby) can also be considered as a stratigraphic marker (occurrence at the upper limit of the T. costatus subzone, A. rhotomagense zone in England, France, Germany, Poland (Jeans, 1968; Panow in Biernat & Popiel-Barczyk, 1969; Robaszynski et al., 1980; Owen, 1988). The *O. wiesti* (Quenstedt) - *cuvieri* (d'Orb.)* group (N. juddii Zone - basal Turonian) is also in strategic position. The author agrees with Owen (1988) that *O. cuvieri*, *O. wiesti* and probably *O. multicostata* Pettitt are conspecific, and considers *O. boussensis* (Owen, 1988) as also belonging to the same taxon. *Gemmarcula carantonensis* (d'Orb.)* (though more regional, upper Upper Cenomanian), and *Terebratulina gracilis lata* Etheridge* (Mid Turonian - generally known as *T. lata*) are also important.

Also the distribution of important groups and genera: *Loriolithyris*, *Musculina* (end of evolution in the Aptian), *Rhombothyris*, *Cyrtothyris*, and *Sulcirhynchia* (rhynchonellid with end of evolution during the Aptian), *Cyclothyris*, *Orbirhynchia*, *Grasirhynchia*; - *Capillithyris* and *Rectithyris* (more endemic); *Boubeithyris*, *Moutonithyris* (end of evolution: basal Cenomaian), *Concinnithyris* (not confirmed as a transformation from *Moutonithyris*, Middlemiss 1984), *Gibbithyris*, *Praelongithyris* (end of evolution: Lower Cenomanian); *Sellithyris* and *Phaseolina* (end of evolution of Sellithyridinae: Upper Cenomanian); *Kingena*; *Gemmarcula*; *Terebratulina*) ... prominent species such as those previously quoted (*) can be highlighted in a first approach for a zonation in correlation with other invertebrate groups in the Boreal Cretaceous.

The distribution of the taxa and their migration routes were dependant on and controlled by the environment: shallow water (best environment), high energy conditions (could form a barrier), argillaceous or muddy environment (bad conditions, few taxa survive: *Moutonithyris* f. ex.) or arenaceous (*Cyclothyris*), duration of free swimming larval period...

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Subdivision of Lower Cretaceous deposits of the South Framework of the Russian Platform (Crimea, Caucasus) on planktonic foraminifera.

The south of the former USSR is the north framework of the Tethyan realm. Planktonic Foraminifera (PF) have been found in Lower Cretaceous deposits in Crimea, Caucasus, Turkmenia and Eastern Carpathians. It is possible to select some zones and layers with Foraminifera on the basis of the analysis of this group development (Gorbachik & Poroschina).

The oldest Cretaceous PF - *Conoglobigerina gulekhensis* - appeared at the basis of the Lower Berriasian in Azerbaijan, in the ammonite Zone *ponticus-euxinus*.

In Valanginian and Hauterivian PF are rare, only *C. gulekhensis* and *Globuligerina hoterivica* (Subbotina). The Hauterivian/Barremian boundary is characterised by the appearance of *Praehedbergella tuschepsensis* (Antonova) and *P. sigali* (Moullade) and the beginning of the Aptian time by the appearance of typical *Blefuscuiana aptica* (Agalarova) [= *B. infracretacea* (Glaessner)]. *Blowiella blowi* (Bolli) and *Clavihedbergella bollii* (Longoria) are typical for upper part of the Lower Aptian. On the lower/middle Aptian boundary in the Crimea appeared *Leupoldina cabri* (Sigal).

During middle Aptian in Crimea it is possible to see the following zone succession: *Lp. cabri*, *Globigerinelloides ferreolensis*, *Gl. algerianus*, *Hedbergella trocoidea*, *Planomalina cheniourensis*. On the middle/upper Aptian boundary in Crimea appeared *Ticinella roberti* (Gandolfi).

Near boundary between Aptian and Albian in Crimea, Caucasus and Turkmenia *Blefuscuiana planispira* (Tappan) appeared and between middle and upper Albian *Ticinella breggiensis* (Sigal) appeared in Eastern Carpathians. *Thalmanninella ticinensis* (Gandolfi) is rarely present in the Upper Albian in Crimea.

Late Jurassic and Early Cretaceous is the time of planktonic mode of life formation for Foraminifera. Practically at the middle of the Early Cretaceous (Barremian-Aptian) all morphological PF features had formed. Different combinations of these features we can see in the further evolution of PF and in the appearing of new taxa.

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Upper Cretaceous Stratigraphy in the Basco-Cantabrian Basin (N. Spain).

The Basco-Cantabrian Basin (BCB) is situated at the southern passive margin of the Bay of Biscay in a transitional zone between the Boreal and the Tethyan Realm. In the last decades, a detailed biostratigraphic framework founded on the regional zonal successions of ammonites, inoceramids, planktic foraminifers, and benthic foraminifers was obtained for the Upper Cretaceous through the combined effort of several working groups. Furthermore, the stratigraphic resolution was considerably improved by adding a basinwide sequence stratigraphic framework that is based on the analysis of outcrop sections, borehole sections, and seismic profiles. This allowed the recognition of stratigraphic events, time-gaps, and unconformities in the investigated sedimentary series. Also, the intra-basinal correlation between more basinward sections and the shallow-marine to neritic realm was enhanced. Generally, the BCB can be divided in two well-defined parts, a shallow-marine ramp or neritic domain and a basinal deep-marine (outer neritic to bathyal) realm. Both areas were separated by a continental slope of varying gradient. The stratigraphic succession on the shallow ramp is interrupted by several unconformities and time-gaps near the Upper Cretaceous stage boundaries (Cenomanian -Turonian, Turonian-Coniacian, Santonian-Campanian, and various gaps in the Campanian and Maastrichtian). Between the unconformities, the succession of ammonites and foraminifers allows in some time-slices a very detailed zonation (e.g., in the Middle and Upper Coniacian as well as in the Lower and Middle Turonian). In the whole Upper Cretaceous, 34 ammonite biozones are recognised in the BCB. In the basinward areas, the sedimentary series is composed of conformably stratified sediments that exhibit well-diversified and rich planktic foraminiferal assemblages. The foraminiferal associations there allow the definition of 15 Upper Cretaceous planktic foraminiferal interval and total range zones. The Upper Cretaceous sedimentary series in the BCB was divided into 5 megasequences, each of these bounded at its base by type-1 sequence boundaries superimposed by thick lowstand wedges. These type-1 sequence boundaries were recognised in the Mantelli Zone, at the top of the Geslinianum Zone, near the base of the Petrocoriense Zone, in the Syrtale Zone, and in the Hyatti Zone. Furthermore, the Upper Cretaceous of the BCB was divided into 20 third-order depositional sequences. In summary, the composed Upper Cretaceous biostratigraphic and sequence stratigraphic framework of the BCB allows a good intra-basinal correlation between the numerous sections as well as the correlation with the proposed chronostratigraphic scale for the Late Cretaceous of W-Europe and the Western Tethys domain.

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The Dicarinella primitiva Zone (Lower Coniacian) diachronous?

Recent field investigations in the western Vocontian basin have been realised to precise the Turonian-Coniacian biostratigraphy based on planktonic foraminifera. The three following foraminiferal associations were recognised in three sections located near Nyons (Drôme, SE France), at Venterol (Groshény & Malartre, 1994).
[1]: *Heterohelix* sp., *Globigerinelloides* sp., *Hedbergella delrioensis* (CARSEY), *Whiteinella archaeocretacea* (PESSAGNO), *W. brittonensis* (LOEBLICH & TAPPAN), *W. paradubia* (SIGAL);
[2]: *Heterohelix* sp., *Globigerinelloides* sp., *Hedbergella delrioensis* (CARSEY), *H. flandrini* PORTHAULT, *Whiteinella archaeocretacea* (PESSAGNO), *W. brittonensis* (LOEBLICH & TAPPAN), *W. paradubia* (SIGAL), *Marginotruncana renzi* (GANDOLFI), *M. schneegansi* (SIGAL), *M. pseudolinneiana* (PESSAGNO), *M. coronata* (BOLLI), *M. marginata* (REUSS), *M. paraconcavata* PORTHAULT, *Sigalitruncana sigali* (REICHEL), *Dicarinella hagni* (SCHEIBNEROVA), *D. imbricata* (MORNOD), *D. canaliculata* (REUSS), *Archaeoglobigerina cretacea* (d'ORBIGNY);
[3]: *Dicarinella primitiva* (DALBIEZ), *Archaeoglobigerina blowi* PESSAGNO, *A. cretacea* (d'ORBIGNY), *Marginotruncana tarfayaensis* (LEHMANN), *M. sinuosa* PORTHAULT, *M. schneegansi* (SIGAL), *M. pseudolinneiana* (PESSAGNO), *M. coronata* (BOLLI), *M. marginata* (REUSS), *M. paraconcavata* PORTHAULT, *Heterohelix* sp., *Globigerinelloides* sp., *Hedbergella delrioensis* (CARSEY), *H. flandrini* PORTHAULT, *Whiteinella archaeocretacea* (PESSAGNO), *W. brittonensis* (LOEBLICH & TAPPAN), *W. paradubia* (SIGAL), and *Sigalitruncana sigali* (REICHEL).
Following the classical accepted data (Caron, 1985; Robaszynski & Caron, 1979), *Dicarinella primitiva* is usually used to mark the base of the Coniacian. So [1] and [2] are Turonian, and [3] Coniacian. Nevertheless, as underlined by Robaszynski *et al.* (1990) in the Kalaat Senan area (central Tunisia), species of planktonic foraminifera belonging to the genera *Whiteinella*, *Dicarinella*, *Marginotruncana* and *Sigalitruncana* appear with the onset of the Turonian and many individuals possess morphological characters intermediary between these genera. Of special interest here is the appearance of *Dicarinella primitiva* in the uppermost part of the middle Turonian (*Coilopoceras* interval) even though it is often cited as a lower Coniacian taxon.
What we want to point out is the significance of such a paradoxl The recent study of central Tunisia (Robaszynski *et al.*, 1990) is in contrary with the admitted planktonic foraminifera biozonation, because of the discovery of associated Turonian ammonites. All of this leads to two possible interpretations.
- 1. the classical biozonation based on foraminifera is invalidated for the Turonian-Coniacian boundary (and maybe for the whole two stages or others as evidenced by Caron *et al.*, 1993) and *Dicarinella primitiva* appears actually all over the world at the uppermost middle Turonian as suggested previously. - 2. the *Dicarinella primitiva* zone is diachronous. It appears sooner on the southern part of the Tethys realm (middle Turonian) and later in the northern part of the Tethys realm (lower Coniacian).
These interpretations lead to the conclusion that other sections in the Vocontian area as far as in the North African province must be studied in detail.

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Scalar magnetic characteristics of sedimentary rocks as sea-level indicators (Hauterivian-Albian from the Northern Caucasus and Santonian-Maastrichtian from the Low Volga Region).

Scalar magnetic characteristics of sedimentary rocks (magnetic susceptibility - k, remanent saturation magnetization - Jrs, etc) are functionally related with palaeogeographic and geochemical settings of sedimentogenesis (Guzhikov, Molostovsky, 1995).Under certain circumstances, rock magnetic properties may be used to reconstruct sea-level fluctuations. Magnetic susceptibility analyses based on the Hauterivian-Albian sections from the Northern Caucasus, allow to recognise three petromagnetic complexes recording three principal stages in the Early Cretaceous sedimentation: the Hauterivian-Barremian, Aptian and Albian ones. Allothigenic magnetite is the main magnetization-carrier in the deposits considered here. That is why the k-curve variations are interpreted as indicators of irregular inputs of terrigenous ferromagnetic material to the palaeobasin. Concentration increases of clastic magnetite particles are caused by the sourceland proximity. Reduction of highly-magnetic material input, on the contrary, is associated with sedimentation site remoteness from the coastline. The Hauterivian-Barremian time is characterised by frequent tectonic vibration and the related repeated rising and lowering of erosion basis recorded by alternations of highly- (k(av.)=0.00040 SI units) and weakly-magnetized (k(av.) =0.00008 SI units) layers. The palaeobasin water-area was expanding during the Aptian age. Stabilisation of tectonic setting within the sourceland has pre-determined a drastic reduction in ferromagnetic fraction drift to the Cis-Caucasus territory, which resulted in substantial reduction of bottom-sediment magnetic susceptibility (k(av.) =0.00008 SI units). The Albian time is noted for maximum development of the Early Cretaceous transgression which has led to creation of a weakly-magnetized (k(av.) =0.00003 SI units). bedding complex. The Santonian-Maastrichtian deposits from the Low Volga region are characterised by extremely low magnetization and practically do not differ in k (k=0.00001-0.000010 SI units). Sample remanent magnetization, however, sharply increases on exposure to artificial magnetic field and displays significant variations along the sections (from 0.03 to 0.3 A/m). The zones of increased Jrs values, associated with the Upper Santonian and Lower Maastrichtian sequences, result from more intensive material input to the areas of sedimentation, which was caused by their proximity to the sourceland. This inference is confirmed by Bondarenko (1990) who stated that palaeobasin regressions took place in the Late Santonian and Early Maastrichtian. Petromagnetic material correlations with palaeogeographic maps (Bondarenko, 1990) show that the Late Santonian deposits formed within the littoral zone, are characterised by higher remanent saturation magnetization than their analogues, formed under sublittoral conditions. Thus, an opportunity arises to estimate a palaeobasin depth by Jrs values.

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Parallelisation of the Berriasian-Valanginian biostratigraphic scales for Mangyshlak, the northern Caucasus and western Europe on chronostratigraphic levels.

Palaeomagnetic units, are unlike palaeontologic ones, stable on global scale. In certain cases they may be used as a measuring rule for parallelisations of stratigraphic scales from distant regions.

Magnetostratigraphic studies of the Berriasian stage were carried out in the North Caucasus, on the Assa and Urukh rivers. Both are reference sections for the North Caucasian region and they contain all four Berriasian biozones. Each biozone, except the Pseudosubplanites ponticus Zone, are further subdivided into two subzones (Sakharov,1976). Three reverse -(R) and two normal-polarity zones are recognised within the palaeomagnetic section through the North Caucasus. Galbrun (1985) has revealed a similar magnetozone succession in the stratotype section of the Berriasian. Magnetostratigraphic correlation of the Berriasian deposits from the Caucasus and the stratotype region has made it possible to reveal the interrelations between the ammonite scales from the two regions, and furthermore, to establish the approximate locations of calpionellid-zone boundaries in the sections on the Assa and Urukh rivers. The P. ponticus Zone in the Caucasus turned out to be analogous to the stratotype P. grandis Zone and the Tirnovella subalpina Subzone, and the T. occitanica unit corresponds only to the upper two subzones of the identically named one from France. The Caucasian E. euthymi Zone is parallel to the lower two subzones of the F. boissieri Zone from the stratotype, and R. rjasanensis - to the B. callisto subzone. The boundaries between the B and C, C and D calpionellid zones correlate with the P. ponticus/T. occitanica zone boundary from the Caucasus and with the lowermost of the Tirnovella berriassensis Zone, respectively.

The Valanginian deposits in Mangyshlak were studied from Tyuesu Mt. section, divided into the lower and upper substages according to microfaunal complexes including those of ammonites (Valanginian of Mangyshlak,1983). Correlations of magnetostratigraphic sections from Mangyshlak, the Northern Mediterranean (Cirilli et al.,1984; Bralower,1987) and the English hypostratotype (Besse et al.,1986) made it possible to consider the interrelations between the ammonite and calpionellid scales of the Valanginian.

Alternating polarity is recorded in the South Alpine sections, were the substages were distinguished on the basis of microfaunal data. Within the hypostratotype and Mangyshlak sections, subdivided according to ammonites, the normal polarity corresponds chiefly to the upper substage, while the alternating polarity corresponds to the lower one. Thus it may be supposed, that the deposits from the Calpionellites zone and from the uppermost Calpionelliopsis from Umbria correspond to the Lower Valanginian substage of the general stratigraphic scale.

This inference conforms to Kent & Gradstein (1985) on the correlation of the Valanginian calpionellid and ammonite zones.

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Magnetostratigraphy of Santonian to Maastrichtian strata from NW Germany and Poland

An integrated magnetostratigraphic and biostratigraphic study has been carried out on Santonian to Maastrichtian strata from NW Germany and Poland. A coal mine shaft (Radbod 6, Münsterland basin), four borehole sections (Pulawy IG2 (middle Vistula River valley), Metelen 1001, Oberdarfeld 1, Longinusturm 1 (Münsterland basin)) and an outcrop section (Piotrawin, middle Vistula River valley) were sampled between 1988 and 1993.

Since the pioneering work of ALVAREZ et al. (1977) the correlation of the geomagnetic polarity time scale (GPTS) with the biozonations of Upper Cretaceous sequences are under discussion. The recent Mesozoic Time Scale published by GRADSTEIN et al. (1994) shifts the Campanian/Maastrichtian boundary from the upper part of magnetochron 33N to the top of magnetochron 32 (about 4 Ma) using a direct correlation of ammonite and magnetic polarity stratigraphy derived from investigations in the Western Interior Basin, U.S.A. (HICKS 1993). The rarity of planktonic index species (e.g. foraminifera, calcareous nannoplankton, cephalopods) in the boreal Upper Cretaceous of NW Germany and Poland poses the main problem to correlate the strata with the global biochronozones.

A characteristic sequence of normal and reversed magnetic polarity has been established in all investigated sections. The Santonian/Campanian boundary, based on benthonic and planktonic foraminifera, was found in the Radbod, Metelen and Pulawy sections near to the boundary of magnetochrons 34N and 33R which is in agreement with all time scales. Benthonic foraminifera and calcareous nannoplankton fix the upper part of the Oberdarfeld and the Longinusturm sections and the entire Piotrawin section near to or around the Campanian/Maastrichtian boundary. The upper parts of all three sections have reversed polarity. Their correlation with the magnetochron 32N2N and 32N1R is very probable. The stratigraphic position of the lower part of the Oberdarfeld and the Longinusturm boreholes and the uppermost part of the Metelen and the upper half of the Pulawy section is still under discussion.

The reversed polarity in the top few meters of the Metelen and in the bottom few meters of the Longinusturm boreholes may correlate to magnetochron 32R. For the Oberdarfeld section and the uppermost Campanian to Maastrichtian part of the Pulawy section alternative solutions will be discussed.

Problems with both inter-sectional and section to GPTS correlation are presumably caused

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How does the Commission fix boundaries?

The Commission on Stratigraphy makes the decisions on stage boundaries by a postal vote of its members, most of whom are the Chairmen of the individual system subcommissions. In each subcommission there are some 15-20 Voting Members - the Cretaceous Subcommission has 17 Voting Members. The Subcommission itself reaches decisions by postal vote so that it is not necessary for all the members to assemble, nor is any Voting Member denied a vote because he or she cannot get to a particular meeting. To reach a decision which can be forwarded to the Commission, at least 60% of the Voting Members must agree, but history suggests that decisions reached by small majorities have a limited change of being adopted by custom; as in a jury, consensus should be aimed for. For example, it was widely agreed by 1979 that the Danian stage should be spewed out of the Cretaceous System, but it was not until the National Committee of the USSR had agreed in 1984 to make the Maastrichtian the top stage of the Cretaceous, that it was practical to get a satisfactory international agreement on the K/T boundary.

For each stage boundary there has to be: (1) a definition of the boundary level of the base of the higher stage; (2) a boundary-stratotype where this boundary level can be recognised at a particular point in the section. The Commission on Stratigraphy will not accept proposals which do not include the Subcommission's agreement on both these criteria.

Our work at this symposium ('a convivial meeting for drinking, conversation, and intellectual entertainment' *Oxford English Dictionary*) is to try to reach a consensus on the definition of each stage boundary and a choice of locality for its boundary-stratotype. We have the model of the good humoured meeting in Copenhagen in 1983 under the masterly chairmanship of Tove Birkelund. Following that meeting, Tove (with help of seven other geologists) put together a survey of Cretaceous stage boundaries. For each stage she quoted papers which describe the original stratotype; surveyed briefly possible boundary levels, firstly based on ammonites, then on other groups of fossils; a provisional conclusion on both boundary level and boundary-stratotype.

We are not bound by any of those recommendations, but they provide a guide for initial discussion which individual working groups have been using. In making recommendations it is essential that we have a firm knowledge of the criteria we are proposing for each boundary, and the detailed succession at the proposed boundary-stratotype.

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Stage boundaries, palaeogeography, and climate simulations.

Climate simulations require, as a boundary condition, palaeogeographic reconstructions that include not only correct placement of the continental blocks and terranes, but a shoreline and topography of the land areas. If circulation of the ocean is included, the boundary conditions must include bathymetry. The GENESIS (Global ENvironmental and Ecological Simulation of Interactive Systems) climate model, developed by the Interdisciplinary Climate Systems section of the Climate and Global Dynamics Division at NCAR (National Center for Atmospheric Research, Boulder CO. USA) also requires information on soil texture, vegetation, and ocean heat flux. It currently uses a 2 X 2 degree grid for calculation of surface processes, equivalent to 220 km resolution at the equator, becoming finer toward the poles.

Distribution of continental blocks and terranes is based on plate tectonic models that rely mostly on palaeomagnetic data and to a much lesser extent on the distribution of fossils. Outside the Atlantic, there are few sea floor magnetic lineations to guide the reconstruction, and palaeomagnetic data are derived from land sections. The palaeomagnetic data are related to a numerical time scale, but rarely are there direct ties to type localities of stages or stage boundaries. Fossil data are commonly tied to stages but not to the palaeomagnetic scale.

Shoreline information is almost always expressed in terms of stages, but whether the shoreline represents a sealevel highstand, lowstand, or intermediate level is rarely stated. For the simulation of Campanian climate shown in our poster, we used shorelines from the global palaeolithologic compilation of Ronov, Khain, & Balukhovsky (1989) and reconstructed topography from their qualitative elevations of Late Cretaceous orogenic areas, intermontane basins, and erosional and depositional land surfaces. Topography/bathymetry of oceanic plateaux and volcanic islands were determined from DSDP-ODP data using subsidence histories based on crustal age. Soil textures were estimated from a simple based on the lithology of parent material, elevation and tectonic stability of the land surface, and a general estimate of the local climate from a prior simulation. The global distribution of vegetation was simulated by an Equilibrium Vegetation Ecology (EVE) model, altered to predict the distribution of Late Cretaceous plants.

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Cretaceous palynofloral provinces with particular emphasis on palynostratigraphy of the equatorial regions.

Major categories of Cretaceous palynofloral provinces are:

Northern hemisphere

- The Early Cretaceous *Cerebropollenites* P. which is characterised by a predominance of spores, bisaccate pollen, and the polysaccate eponymous taxon;
- The mid Cenomanian-Maastrichtian *Normapolles* P. and the Turonian-Maastrichtian *Aquilapollenites* P.;
- The newly established Aptian-Senonian *Schizaeoisporites* P. occupies major parts of southern Asia and reflects increasing aridity from west to east.

Equatorial belt

The Neocomian-Aptian *Dicheoropollis etruscus/Afropollis*, the Albian-Cenomanian Elaterate, and the Senonian Palmae Provinces. Turonian assemblages have several features in common with those characterising the Senonian.

Austral region

- The Early Cretaceous-Cenomanian *Microcachryidites* P. which is characterised by trisaccate pollen;
- The Turonian-Senonian *Proteaacidites/Nothofagidites* P.

Through comparison of paleo- and actuopalynological characteristics a climatic interpretation is presented for each of these paleoprovinces. The main microfloral boundaries are latitudinal, this suggests that paleoclimatic conditions played a major role in the geographical extension of land plants and the sporomorphs derived from them. The circumpolar boundary between the *Auqilapollenites* and *Normapolles* Provinces rectifies previous ideas of a meridional disposition held by many authors. Paleogeographic factors such as epicontinental seas may determine second order boundaries.

In the last decade some compilations of Cretaceous (-Tertiary) sporomorph ranges have been published for Africa and South America. For the present study a selection of the most reliable taxa will be presented. Emphasis will be placed on palynomorph events during the Cretaceous.

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Sequence of events around the Berriasian-Valanginian boundary.

Started from the non-disturbed complete sections near Los Miravetes (Caravaca, SE Spain) we will try to make a detailed correlation with Angles, Berrias and other sections in France.

The big faunal turn-over at the base of the Alpillensis Subzone will be shown (disappearance of the bulk of *Berriasella* and *Subthurmannia* etc. followed by the appearance of *Thurmanniceras*, *Sarasinella*, *Olcostephanus*, *Neocomites*) and the inferred reason of this turnover, viz. a rapid high-amplitude fall of the sea level directly above the level of the turn-over. Because of this sea-level fall the lowstand systems tract on top of this unconformity is commonly missing; only where deposition was continuous it is preserved (I know only two localities in SE France where it is preserved). The exact stratigraphic position of this turn-over in relation to sequence stratigraphy and first and last occurrences of ammonites and calpionellids will be shown. Also the stratigraphic position of the Otopeta zone in relation to sequence stratigraphic surfaces and first and last appearances of ammonites and calpionellids will be discussed. The level of the first appearance of *T. pertransiens* in relation to sequence stratigraphy and calpionellid stratigraphy is shown.

The sequence of events is the following:

15. Appearance of *E. darderi* (= base of Zone E).
14. Type 1 Sequence boundary V1.
13. Maximum flooding surface (= discontinuity Di2).
12. Boundary within calpionellid Subzone D3 between parts with and without *C. oblonga*.
11. Base of T. pertransiens Zone (= first *T. pertransiens*).
10. Base of former T. otopeta zone.
9. Transgressive surface.
8. Type 1 Sequence boundary Be7 (= 'Late Cimmerian').
7. Base of T. alpillensis Subzone (= first *Thurmanniceras*).
6. Maximum flooding surface (= discontinuity Di1')
5. Base of former *B. callisto* Subzone.
4. Appearance of *L. hungarica* (= base of subzone D3).
3. Type 2 Sequence boundary Be6.
2. Maximum flooding surface (= discontinuity Di1).
1. Base of the B. picteti Subzone (first *E. paquieri*).

The base of the Alpillensis Subchron was proposed to be the base of the Valanginian Stage.

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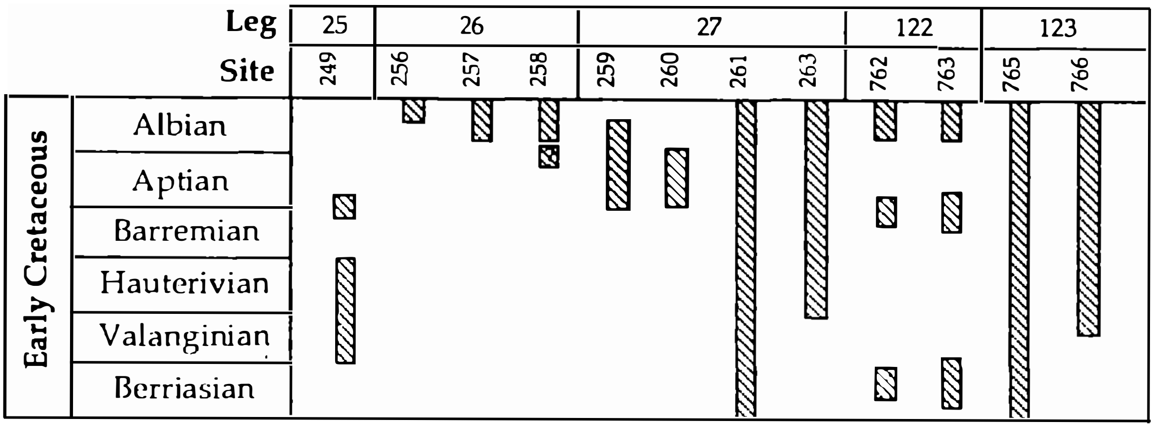
Benthic Foraminiferal Biostratigraphy of Indian Ocean DSDP and ODP Sites: a Lower Cretaceous Synthesis.

Although benthic foraminifera represent one of the few microfossil groups to possess a relatively complete stratigraphic record in the Lower Cretaceous of the Indian Ocean, their use in biostratigraphy has previously been greatly limited by the lack of coherent taxonomy. We have conducted new taxonomic and biostratigraphic investigations of benthic foraminiferal assemblages from Indian Ocean DSDP and ODP holes, which have led to the introduction of a standardised nomenclature and to a biostratigraphic reappraisal of Lower Cretaceous sedimentary sequences.

The original chronostratigraphy of the Indian Ocean DSDP sites was poorly defined, owing to the paucity of nannofossil and planktonic foraminiferal index taxa recovered from the cores. Our study provides new determinations with improved biostratigraphic resolution to core sections DSDP Sites 256, 257, 258, 259, 260 and 263, which were previously dated as undifferentiated Aptian or Albian. Correlations are also established between all DSDP and ODP sites, which recovered Lower Cretaceous sediments. This biostratigraphic synthesis provides crucial time constraints for interpreting the evolution of the nascent ocean.

Despite the cosmopolitan distribution of many tax during the Early Cretaceous, a comparison of biostratigraphically important species from Indian Ocean DSDP and ODP sites with those from the published boreal and Tethyan zonations reveals the absence of important zonal markers (in particular, the *Epistomina*, *Falsogaudryinella* and *Marssonella* lineages). Some significant discrepancies are also noted in the stratigraphical ranges of some species. Tethyan and boreal benthic foraminiferal zonations are not applicable in the high southern latitudes, supporting the existence of a distinct Austral Bioprovince. A new zonal scheme is proposed for the Lower Cretaceous of the Indian Ocean.



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The Santonian-Campanian Stage Boundary in Israel

Extensive, partly well exposed Santonian-Lower Campanian pelagic sediments occur in Israel. This mainly chalky sequence (Menuha Fm. in the south) is divided by a marly unit (Kabri Mbr. at the lower part of the En Zetim Fm. in northwestern Israel) with a varying phosphate content into a Lower (1st) Chalk Mbr. (Har Zefat Fm. in the north), and an Upper (2nd) Chalk Mbr. (part of En Zetim Fm. in the north). Microfossils in the marl indicate the transition between the Santonian and Campanian stages. A detailed study of foraminifera, calcareous nannofossils and ostracodes confirm the close position of the presently accepted datums for the stage boundary as correlated elsewhere to the standard ammonite zonation. The first occurrence (FO) of *Globotruncanita elevata* (BROTZEN) [frequently associated with the latest *Dicarinella asymetrica* (SIGAL)] almost coincides, or is a little below the FO of *Calculites obscurus* (DEFLANDRE) (base of CC 17 nannofossil Zone). These two datum levels are close to the base of the local ostracode S-3b Subzone. The FO *Aspidolithus parcus parcus* (STRADNER), marking base CC18 nannofossil Zone, occurs in the lower part of the *D. asymetrica* - *G. elevata* Concurrent Range Zone (CRZ) in northern Israel. The top of this relative short CRZ (last occurrence *D. asymetrica*) is characterised by the FO *Globotruncana arca* (CUSHMAN). The transition between the two local ostracode assemblage zones S-3b to S-4 occurs in northern Israel in the lower part of the *D. asymetrica* - *G. elevata* CRZ, and at its top in the south. *Spinaptychus spinosus* (COX) (assumed operculum of a texanitid ammonite) ranges from the Upper Santonian throughout this latter CRZ.

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Foraminifera from the Cenomanian/Turonian boundary sediments in the Bohemian Cretaceous basin.

The Cenomanian/Turonian boundary is one of the most important stratigraphic boundary-lines in the Bohemian Cretaceous Basin. It is characterised by major changes in biostratigraphic, lithologic and geochemical records in marine deposits.

The Cenomanian/ Turonian boundary in the Bohemian Cretaceous Basin is located at, or in some areas below, a boundary between the Peruc-Korycany Formation (Upper Cenomanian) and overlying Bila Hora Formation (Lower-Middle Turonian). The boundary between the Peruc-Korycany and Bila Hora Fm. is diachronous. The upper part of the Peruc-Korycany Fm. is characterised by shallow marine sandstones and siltstones to calcareous siltstones ("siltstone facies") in deeper parts of the basin (the Korycany Member). The lower part of the Bila Hora Fm. is developed as an omission surface overlain by a glauconite horizon. The formation is represented mostly by marlstones to calcareous claystones.

Mostly, no foraminifers were preserved in the sandstones underlying the siltstone facies. The lower part of the siltstone facies was inhabited by a relatively diverse assemblage of agglutinated foraminifers (lituolids, trochamminids, textulariids and tritaxiids). The base of the upper part of the siltstone facies of the Korycany Member is marked by the appearance of calcareous foraminifers dominated by gavelinellids [*Gavelinella cenomanica* Brotzen, *G. polessica* (Akimetz)] and the overall abundance of foraminifers is increased. However, benthonic species diversity is low probably because of oxygen depletion of the environment. The species diversity shows an increase about 1-2 m below the base of the Bila Hora Fm. Some new species, such as *G. berthelini* (Keller), *Lingulogavelinella globosa* (Brotzen) and *L. pazdroae* Gawor-Biedowa appear. In this interval planktonic species mainly belong to the hedbergellids.

Significant changes in foraminiferal assemblages occur at the base of the Bila Hora Fm. Planktonic diversity and the planktonic/benthonic ratio shows a strong increase. The rise in species diversity is related to the appearance of Lower Turonian species, e.g. *Cassidella tegulata* (Reuss), *Gaudryina angustata* Akimetz, as well as to the proliferation of dicarenellids and praeglobotruncanids. These changes were caused by a significant increase of water depth and by return to normal (oxygenated) bottom conditions.

Generally, the association of Foraminifera from boundary sediments has a boreal character. The benthonic foraminifera dominate, especially agglutinated species. Planktonic species are scarce or practically absent or very rare in keeled forms.

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The stratigraphic distribution of Late Cretaceous Cephalopods and inoceramid bivalves in the Maastrichtian type area.

The stratigraphic ranges of early Campanian to latest Maastrichtian ammonoid and coleoid cephalopods and inoceramid bivalves in the extended type area of the Maastrichtian Stage are illustrated. Although the museum-based revision (KENNEDY, 1987) of Campanian and especially Maastrichtian ammonoid faunas from the area has greatly improved our knowledge of these biota, stratigraphic ranges of many species are still poorly known. Quite a number of ammonoid species, including zonal index taxa as recognised elsewhere in Europe, have been collected from the late Campanian and early Maastrichtian during recent fieldwork.

The most noteworthy addition to the ammonoid faunas from the type Maastrichtian is the record of the key index pachydiscid *Menuites terminus*, a short-ranging species which in the Bay of Biscay sections (France, Spain) characterises the latest Maastrichtian *terminus* Zone (WARD & KENNEDY, 1993). Specimens from Blom and ENCI NV quarries allow the upper half of the Meerssen Member (Maastricht Formation) to be correlated with the *terminus* Zone, which has also been recently documented in the latest Maastrichtian white chalk of Denmark (BIRKELUND, 1993).

Of the coleoids, the range of the *Belemnella (Neobelemnella) casimirovensis* group, is now comparatively well known, first appearing in the middle of the Meerssen Member, thus matching the FAD of *Menuites terminus*. Studies of late Campanian and early Maastrichtian coleoid faunas have enabled recognition of various biozones as employed in the standard white chalk section in northern Germany.

Amongst inoceramid bivalves, the 'true' representatives appear to range higher into the late Maastrichtian than they do at the Bay of Biscay sections (MACLEOD, 1994). Of the 'tegulated' species (DHONDT, 1992), the equivalve *Spyridoceramus tegulatus* seems to range to the top of the Nekum Member (Maastricht Formation), with the inequivalve *Tenuipteria argentea* apparently restricted to the overlying Meerssen Member, and ranging to the K/T boundary.

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The working group Beutenaken/Vijlen Members: a status report

It is widely known that the refined lithostratigraphical subdivision (W.M. Felder, 1975) of Upper Cretaceous-Lower Palaeocene strata in the type area of the Maastrichtian Stage is not matched by a comparably detailed biozonation. This holds especially true for the late(st) Campanian and early Maastrichtian portions of the sequence exposed in the extended type area (southern Limburg, Limburg/Liège and Aachen area). Recent studies of calcareous nannofossils, coleoid cephalopods and dinoflagellates have greatly improved our knowledge of the biostratigraphy of the Beutenaken and Vijlen members of the Gulpen Formation, but many questions remain. Combining the results of analyses of bioclast and of benthic foraminifer/ostracod assemblages, P.J. Felder & Bless (1994) have recently proposed a re-interpretation of the Vijlen Member in its type area, correlating it with the Aachen sections studied by Keutgen & van der Tuuk (1990).

In an effort to restudy the biozonation of the (upper part of the) Zeven Wegen, Beutenaken and Vijlen members, a group of local palaeontologists/geologists, the so-called 'Vijlen Groep' selected in the spring of 1992 a number of key sections between Maastricht, Liège and Aachen. Whenever possible, attempts have been made to log sections anew, collect age-diagnostic macrofossils and take samples for nannofossil and palynological analyses. Fieldwork started at the Altembroeck section: the first results recently published (Jagt *et al.*, 1995) are promising. It is planned to have similar field sessions of the 'Vijlen Groep' at the other key localities, and to present interim reports during the coming years. The final report will then provide detailed discussions of local stratigraphy, interregional correlations (preferably with the NW German white chalk standard section) and of all fossil groups used for biozonation.

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New biostratigraphical data on the Cenomanian-Turonian boundary of the South Provence Basin (S.E. France) : the Cassis section.

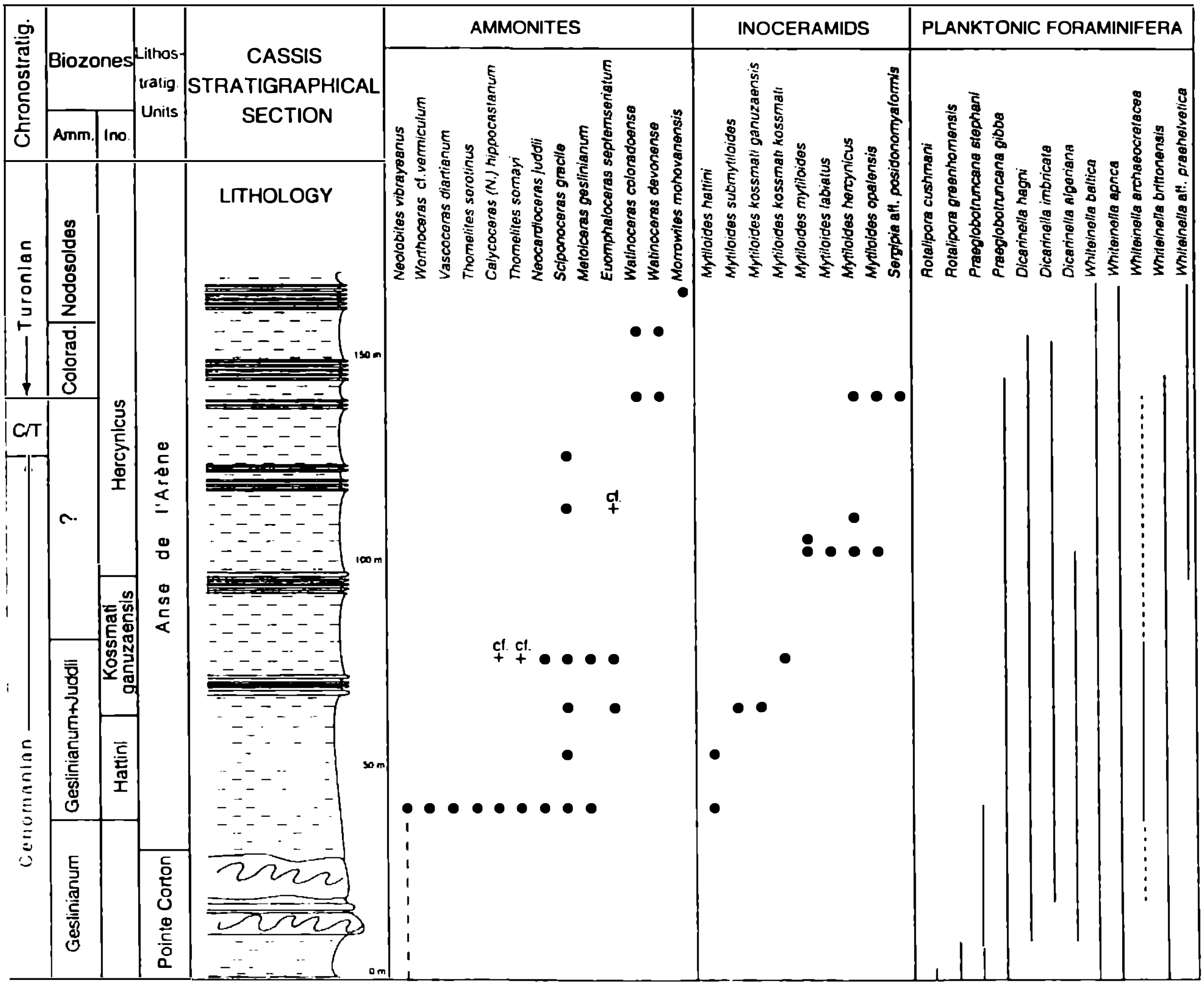
The discovery of a new ammonite fauna in the Upper Cenomanian-Lower Turonian beds of Cassis (S.E. France) allows to date the Cenomanian-Turonian boundary in Provence more precisely.

For the first time the *Geslinianum, Juddii* and *Coloradoense* zones are characterised from this region.

Three inoceramid zones are defined : *Hattini, Kossmati ganuzaensis* and *Hercynicus* zones.

Conclusions

- In the Cassis section, the Cenomanian-Turonian boundary is located 120 m higher than previously admitted.
- A rich and diversified fauna (ammonites, inoceramids, planktonic and benthic foraminifera, ostracods) allows this area to be considered as one of the most important sections for the definition of the Cenomanian/Turonian boundary.
- Note the co-occurrence of *Metoiococeras geslinianum* and *Neocardioceras juddii* in the same bed.
- Hence, the correlation scheme between ammonite and inoceramid zones, commonly accepted in a world-wide consensus for Cenomanian and Turonian times, is questioned.



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Problems of Tethyan/Boreal Cretaceous Correlation: Principles and Methodology.

The emphasis is on the need for a more constructive use of all existing stratigraphical methods, especially - the need to integrate the various biostratigraphical and palaeobiogeographical data with the cyclic property of the marine depositional sequences. The fossil content of the Cretaceous stages (substages, zones) of the Tethyan and Boreal realms differ in many cases considerably from each other, and the degree of difference increases with increasing distance in the palaeomeridional direction. In addition, the time-ranges of the characteristic zonal species and genera of typical Tethyan regions do not coincide with the time-ranges of the taxa that characterise contemporaneous rocks in the typical Boreal regions. Therefore, mostly there exists a different zonation of one and the same stage in Tethyan and Boreal regions and their boundaries are not isochronous. Hence, in order to provide successful interrealm zonal correlation of each stratigraphical stage it is necessary to select an additional section - substratotype outside the stratotype realm. Unlike other secondary stratotypes (e.g. hypostratotype, etc.), which should be or which may be situated within the stratotype realm, the suggested additional sections (substratotypes) are to be chosen outside the realm of the stratotype. Each of the non stratotype realms should have only one such secondary stratotype (e.g., as the Barremian stratotype is in the Tethyan realm, for this stage two such secondary stratotypes should be selected: one in the Boreal Realm and the other in the Austral Realm).

Tethyan/boreal zonal correlation should start with correlation of the stage boundaries of the stratotype and its substratotype regions. The successful solution of this question depends considerably on phylogenetic data of the index-fossils, as well as on bio- and lithostratigraphical analyses of the correlative levels in the Tethyan/Boreal transitional area. Different restricted distribution patterns of species, the incompleteness of the fossil record, as well as phenomena of various kinds of synergism cause considerable difficulties in interrealm zonal correlation. In such cases, the results of other stratigraphic methods (magnetostratigraphy, isotopic stratigraphy, lithostratigraphy, etc.) based on global (rarely-regional) abiotic events, can as a rule be used successfully. In many cases such data are also insufficient.

With respect to the biotic event, it is important to reveal the phylogenetic lineages of the index-fossils and the sudden-extinction levels of the various fossil groups, as well as the migration peculiarities of the palaeobiogeographical realm boundaries and, and connected herewith, replacement (or reversal) features of certain fossil groups.

All data have to be analyzed against a background of cyclic features of the depositional sequences. Such an analytical approach will in many cases provide good time markers, i.e. a reliable basis for precise interrealm zonal correlation.

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Cenomanian/Turonian boundary in Egypt, based on ammonites.

Cenomanian-Turonian strata are widely distributed and well exposed in Egypt, including beds extremely rich in macrofauna. Ammonites are the most common among the various marine invertebrate builders of these Cenomanian-Turonian sediments. In spite of such enrichment in ammonites and the extensive literature dealing with stratigraphy and palaeontology of the Egyptian Cenomanian-Turonian successions, a precise definition of the Cenomanian/Turonian boundary is generally lacking and the boundary is still debatable. The aim of the present paper is to use the well-dated ammonite taxa, of indisputable occurrence, to provide a precise definition for the Cenomanian/Turonian boundary in Egypt. This study is based on the ammonites collected from the strata bounding the Cenomanian/Turonian boundary in the northeastern Desert and southwestern Sinai.

It has been concluded that, the Cenomanian/Turonian boundary is located within the Galala Formation in the Eastern Desert, coinciding with the contact between the basal Turonian *Pseudaspidoceras flexuosum* and the Upper Cenomanian *Vascoceras cauvini* Zone. In southwestern Sinai, the boundary is marked by the first appearance of the globose ammonites of the Lower Turonian *Vascoceras proporium* Zone within the Abu Qada Formation. The index species *Vascoceras proporium* (REYMENT) and *Pseudaspidoceras flexuosum* POWELL are co-existing in most of the studied sections. Highly involute, globose vascoceratid ammonites of the *Vascoceras proporium* Zone are very useful in tracing the Cenomanian/Turonian boundary in the field. Absence of certain Upper Cenomanian ammonite zones as well as occurrence of erosive surfaces document prevalence of several discontinuity episodes during deposition of the Upper Cenomanian and Lower Turonian sediments in Egypt. Inter-regional correlation of the Cenomanian/Turonian boundary and the ammonites identified from its bounded strata are also discussed.

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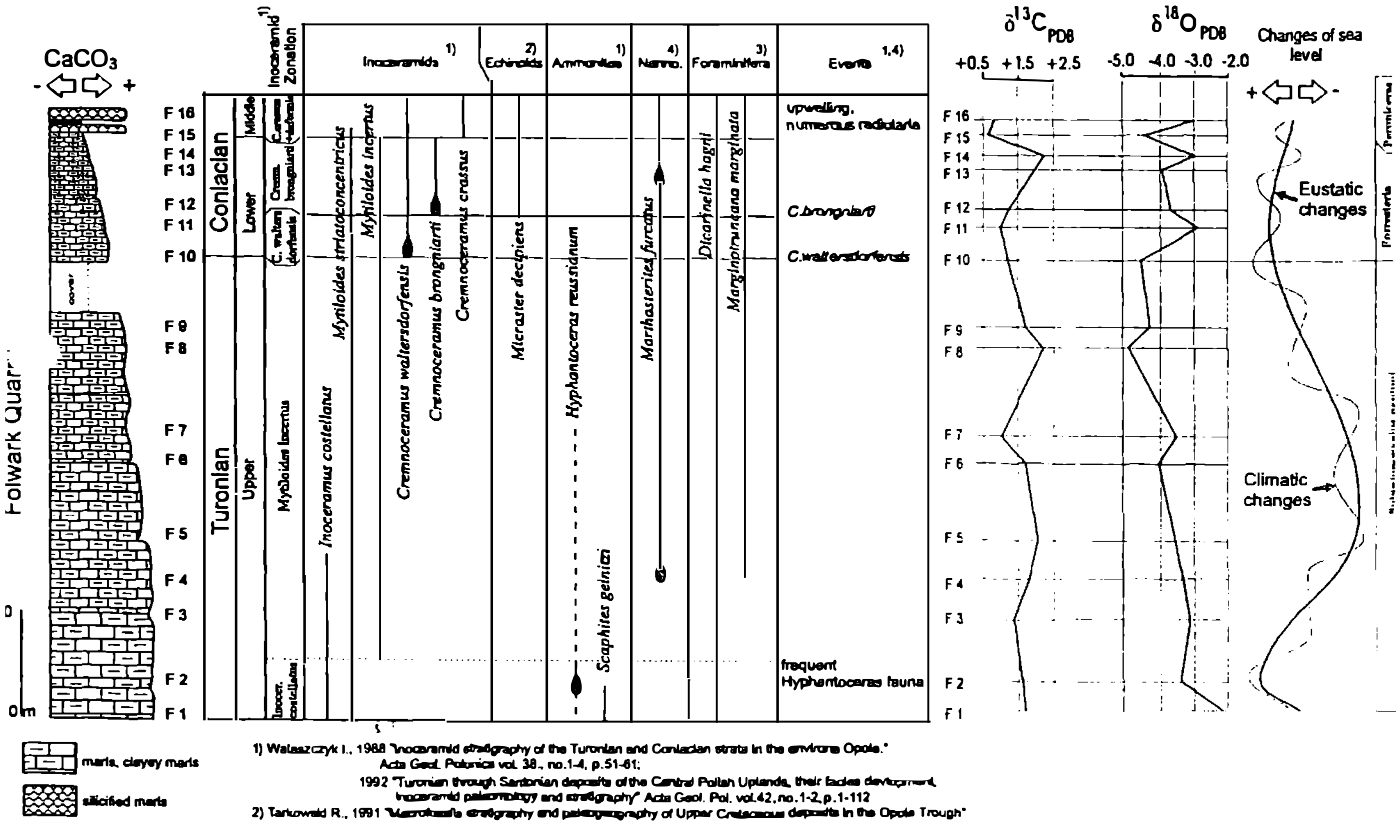
High-Resolution stratigraphy of the Turonian/Coniacian boundary in SW Poland.

The deposits of the middle Turonian through middle Coniacian are exposed in SW Poland, near Opole at the Forwark Quarry. They consist of interbedded marls and clayey marls. These sediments are very rich in fossils. Herein we have used biostratigraphic divisions based on macrofossils (Walaszczyk, 1988, 1992; Tarkowski, 1991), foraminifera (Kozdra, 1993), calcareous nannofossils (Kedzierski, 1994). The curve showing change of isotope ratio δ 18 O and δ 13 C and interpretation of sedimentological environments have been added. The scheme of inoceramid biozonation of the investigated strata, placing the Turonian/Coniacian boundary at the first occurrence of *Cremnoceramus waltersdorfensis* is taken from Walaszczyk, 1992. This inoceramid zonation has been correlated with the stratigraphic ranges of other fossils. Some bioevents and increase of surface current circulation (caused by upwelling?) have been recognised. They allow to correlate the Opole Cretaceous with sections from Germany and from the Czech Republic.



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Ammonite definitions of Late Cretaceous stage boundaries: progress since 1984.

There has been considerable progress on clarifying the classic ammonite-based definitions of Upper Cretaceous stage boundaries, and identifying putative boundary stratotypes for at least some.

The ammonite faunas of all of the Upper Cretaceous stratotypes/ type areas have been revised, and can be related to boundary levels. For the Cenomanian, the base of the classic *Mantelliceras mantelli* Zone is now clearly defined in expanded, continuous sections in SE France, with mixed Boreal and Tethyan faunas and a range of secondary markers. For the Turonian, the sequence at Pueblo, Colorado has great potential; a boundary at the base of a *Watinoceras devonense* Zone can be related to a series of isotopic and biostratigraphic secondary markers. For the Coniacian, the base of the *Forresteria (Harleites) petrocoriensis* Zone - the *"haberfellneri"* Zone of de Grossouvre and others, remains the classic datum, but is defined by an unconformity in the type area of the Coniacian, and is poorly represented elsewhere. It may be better to define the boundary on some other, e.g. inoceramid datum that approximates to the base of the *petrocoriensis* zone in a section where both can be recognised. For the Santonian, the appearance of *Texanites gallicus* (the *Texanites texanus* of de Grossouvre and others) is the classic ammonite definition, but the detailed ammonite succession across the boundary remains inadequately documented, as do the relative ranges of *Texanites*, *Cladoceramus undulatoplicatus*, and the *Inoceramus pachti-cardissoides* group. For the Campanian, we now know that the appearance of *Submortoniceras*, proposed as a potential boundary marker in Copenhagen, is below the extinction point of the crinoid *Marsupites*, widely used as a boundary marker. Perhaps we should use the first appearance of *Marsupites* as a boundary marker proxy for *Submortoniceras* that can also be linked to the widely occurring *Scaphites leei* - *S. hippocrepis* lineage. For the Maastrichtian, the classic ammonite marker is *Hoploscaphites constrictus*, now known to extend into Tethyan regions of SW France and adjacent parts of Spain, where its first occurrence corresponds to that of *Pachydiscus neubergicus*, which may serve as a proxy. The Kronsmoor section remains the best documented, but its boreal aspects presents problems. The Biscay coastal sections (Zumaya-Hendaye-Bidart) and those around Kef, Tunisia, are totally unsuitable as boundary stratotypes if a macrofossil datum is to be used to mark the base of the stage.

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The Santonian/Campanian boundary in South Africa

The Santonian/Campanian boundary in Zululand and Pondoland in South South Africa is defined locally between the last occurrence of *Texanites* and *Reginaites*, and the first occurrence of *Submortoniceras*. *"Heteroceras" amapodense* Van Hoepen spans the Santonian/Campanian boundary.

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Facies control of Upper Cretaceous mollusc distribution: U.S. Atlantic and Gulf Coastal Plain.

Walther's law of facies implies that a vertical sequence of facies will be the product of a series of depositional environments which lay laterally adjacent to each other. It follows that animals and plants, whose distribution in space is controlled by facies, will have their temporal distribution similarly controlled. Thus biostratigraphers must be wary that the reported first and last occurrence of a taxon may be controlled by facies rather than evolution and that occurrences earlier and later are likely to be reported when the taxon's preferred facies is sampled. The facies preference of taxa within a time slice for which effects of evolution are minimal, will be helpful if measured, documented and used to evaluate the confidence that we may place on reported first and last occurrences.

Such data exist for a time slice in the mid-Maastrichtian of the U.S. Gulf and Atlantic Coastal Plain. Examination of 660 collections, mostly bulk, by the author and the late Norman F. Sohl of the U.S.G.S. from 1978 to 1988 resulted in 110,000 specimens being assigned to 790, mostly molluscan, taxa. Eighty four of the molluscan taxa are significantly represented in terms of specimen abundance. The occurrence frequency of these was determined for collections from carbonates, fine clastics and coarse clastics respectively. About ten species were distributed approximately evenly in the three sediment categories and four were restricted to a single sediment category. Of the other 70 species, 38 had a relatively high occurrence in the coarse clastics, 9 in the fine clastics, and 23 in the carbonates. High occurrence in one sediment category means that a taxon has low occurrence in one or both of the other sediment categories.

This information can answer a number of important questions. Such as: "What types of mollusc are most insensitive to facies?", "What genera of molluscs are consistent in their sediment preference and what genera contain species with varying sediment preference?", and "What mollusc groups have such a predictable difference in response to facies that they are usable as biostratigraphic indicators when confidence limits are calculated?". Publication of specific sediment response of all taxa will provide for selection of those taxa best suited to define biostratigraphic units.

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Santonian-Campanian boundary on the Russian Platform and adjacent areas.

The Santonian-Campanian boundary is a very important problem of Cretaceous stratigraphy for the Russian Platform and its framework.

We have studied Santonian-Campanian (st-cp) sedimentary sequences of three structures of Russian Craton, Crimea and Mangyshlak.

Lithology. The first sequence (centre of Russian Craton) made up of light grey, almost white chalky marls and chalk. Carbonate facies are replaced laterally by shallow marine siliciclastics. They are not continuous between st and cp, but are located higher in the Lower Campanian.

The second structure (Povoljie region) consists of only shallow marine siliceous sediments. Underwater erosion surface is present at the base of the Campanian, with reworked pebbles from underlying sediments. The st/cp hiatus is important, because the Upper Santonian is absent.

Peri-Caspian syneclise consists only of pelagic carbonate facies in st-cp sequence. Sediments of these stages are made up of chalk and chalky marls which are almost devoid of siliciclastic input.

The disconformity at the base of the Campanian has angular character in the eastern part of this structure. The hiatus is less important than in the Povoljie region, because only the highest part of the Santonian is lacking. There are pelagic marls with green clay spots in the Crimea basin in the st-cp sedimentary sequence. There is no hiatus between st and cp, but st section is not complete in its lower part. There are st/ cp volcanic "boundary clays" in some sections of the Crimea mountains. Mangyshlak sections consist of chalk and chalky marls and have no conform nor hardgrounds, but some condensation is present.

Biostratigraphy. The st/cp boundary is connected with the problem of *Pteria*-beds on the Russian Platform and with "*Marsupites*-layers" in its southern framework. There are *Oxytoma tenuicostata* remains and many belemnite rostra inside the "*Pteria*-Beds" interval. This association of belemnite faunas indicates this sequence as being of Early Campanian age. The *Oxytoma tenuicostata* Biozone varies in scale in different basins. It is largest in sequences with siliceous or terrigenous facies: from Early Santonian till middle Campanian, and only Early Campanian in sequences with carbonate facies.

Marsupites-layers are connected with Late Santonian belemnite assemblages in Western Europe and in southern adjacent areas of Russian Craton (Crimea, North Caucasus, Mangyshlak). This level never contains remains of *Oxytoma*. Assemblages of Foraminifera are a very good instrument for correlation of *Marsupites*-layers and *Pteria*-beds. *Marsupites*-layers coincide with *Gavelinella stelligera/Bolivinoides strigillatus* Zone (benthic forms) and *Dicarinella asymetrica/Rosita fornicata* Zone (planktic forms) and are of Late Santonian age. *Pteria*-beds coincide with Early Campanian forams-level - *Gavelinella clementiana/ Stensioeina pommerana* Zone (benthic forms) and *Globotruncana arca* Zone (planktic forms). The first *Globotruncanita elevata* could be in Upper Santonian, as the first *Gavelinella clementiana*, but *Bolivinoides decoratus* and *Globotruncana arca* are only Campanian species. The complicated boundary situation can be explained by tectonics and sea level changes.

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Turonian/Coniacian boundary on the Russian Platform

The Turonian/Coniacian boundary was traditionally based on the *Inoceramus (Cremnoceramus) deformis* Zone in Russian stratigraphical schemes. The position of this boundary was described by V.P. Renngarten for all areas of the Russian Platform and its southern framework. There were three inoceramids-zones in the Lower and Upper Turonian: *In. labiatus - Lower Turonian*, *In. lamarcki* and *In. woodsi* (= *costellatus*) - Upper Turonian.

More recently the inoceramid zonation applied in Western Europe differs mainly at the Turonian/Coniacian boundary.

The *In. costellatus* Zone comprises the lower part of *In. costellatus* (= *woodsi*) Zone in Russian traditional usage, while its upper part may be subdivided into the *Cremnoceramus waltersdorfensis* and *C. rotundatus* Zones. These two zones, distinguished in many areas of central Europe, as well as in Spain, are also traceable in the Northern Caucasus (Daghestan), in W. Kazakhstan and in regions of Russian Craton. The correlation of these inoceramid zones with a standard ammonite subdivisions is far from a final acceptance. The middle/upper Turonian boundary is placed at the entrance level of *In.* gr. *costellatus* which has an almost simultaneous entrance level with the Upper Turonian index ammonite species *Subprionocyclus neptuni*. The most diversified inoceramid assemblage is found in the *Cremnoceramus waltersdorfensis* Zone, the lower boundary of which coincides with the appearance of *Forresteria petrocoriensis* (ammonite) and the Turonian/Coniacian boundary interval in western and central Europe, W. Kazakhstan and the Russian Platform. At this level the fauna is relatively diversified. The foraminiferal assemblages consist mainly of benthic forms in the Turonian part of the sections. There are *Globorotalites hangensis/Gavelinella moniliformis* Zones in the Turonian and *Ataxophragmium nautiloides/Gavelinella praeinfrasantonica (= vombensis)* Zones in the Lower Coniacian.

It is interesting, that the trend in changing abundance of inoceramids at the Turonian/Coniacian boundary is similar in many regions of Europe. This level coincides with a high percent of planktic forams inside foraminiferal assemblages everywhere in Boreal Europe (Zone "à Grandes Rosalines" of J.Sigal, 1967). Most probably these events are basin-limited phenomena and are confined to central and eastern Europe. Beginning at the Coniacian forams change their type of evolution - punctualistic to gradualistic.

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On Albian Stage and Substage boundaries in Georgia.

For perfect characterisation of boundaries between stages it is necessary to take into account the regions and their schemes which differ from traditional subdivision in certain features. Such is Georgia where in the Albian : 1. general depauperisation of the fauna is observed when compared with the Barremian and Aptian; 2. there are no hoplitids.
The first feature is common to the Caucasus, the second - to the Transcaucasus.
Ammonites remain an orthostratigraphic group, but their areal is reduced; the role of belemnites and bivalves is increasing - clearly characterising sediments on the substage level and being of considerable help in drawing boundaries between them.
The lower boundary of the Albian Stage is drawn according to the extinction of the Clansayesian genera: *Acanthohoplites*, *Nodosohoplites*, *Hypacanthoplites* (except *H. milletianus*) and the appearance of the Lower Albian genus *Leymeriella*. The actual drawing of the boundary depends on the facies - ammonites are distributed in the terrigenous deposits. The complex of *Aucellina*, common with the Clansayesian (*A. caucasica, A. aptiensis*) occurs in the calcareous-marly sediments. Here *Neohibolites minor* appears. The boundary of the first type is spread locally - on the central part of the Georgian block (peripheries of the Dzirula mass and southern Okriba); the second is widespread.
The boundary between the Lower and Middle Aptian is established by appearance of widespread layers with *Liostrea delettrei*. Appearance of concentric-ribbed inoceramids (*I. concentricus*, *I. salomoni* etc.), *Neohibolites minimus*, *Plicatula gurgitis* is characteristic of Middle Albian. The rare representatives of the genus *Hoplites* appear higher. In the upper part of the substage the genera *Kossmatella* and *Oxytropidoceras* appear.
The boundary between the Middle and Upper Albian is clearly drawn according to the appearance of radial-ribbed inoceramids (*Actinoceramus sulcatus*, *A. subsulcatus*, *A. sulcatoides*) and the disappearance of the genus *Oxytropidoceras*.
Consequently, precise correlation of Albian stage and substage boundaries of Georgia with those of other Mediterranean provinces is for the present hardly possible.

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Foraminifers and ammonites across the Aptian-Albian boundary in Sergipe, Brazil. (*)

(*) Contribution to IGCP Project 381, "South Atlantic Mesozoic Correlations".

A systematic survey has been carried out across the Aptian-Albian boundary on surface and subsurface samples from the Sergipe Basin in northeastern Brazil. Foraminifera and ammonites are abundant and form the basis for an integrated biostratigraphy, which can be applied both in the field and to subsurface sections. The Aptian-Albian boundary occurs in Sergipe within the lowermost part of the marine sequence, represented by the carbonate-siliciclastic Riachuelo Formation. The upper Aptian is subdivided with planktonic foraminifera into two zones, the *Globigerinelloides barri - Hedbergella (H.) gorbachikae* and *Gl. ex gr. maridalensis - H. (H.) similis* zones (Koutsoukos & Bengtson, 1993, *Docum. Lab. Géol. Lyon*, 125: 241-262); the latter zone contains the first appearance of *Ticinella* spp. The upper zonal boundary is defined by the last appearance of diagnostic species such as *Globigerinelloides aptiense, G. barri, G. ferreolensis, G.* ex gr. *maridalensis, Hedbergella (H.) labocaensis, H. (H.) maslakovae* and *H. (H.) semielongata*, at or near the Aptian-Albian boundary. The evidence from Sergipe therefore suggests a higher (younger) extinction level for these species at low latitudes than is known elsewhere in the northern hemisphere (e.g., Longoria, 1974, *Rev. Esp. Micropaleont.*, *Num. Extr.*, pp. 1-107; Sliter, 1989, *Jour. Foram. Res.*, 19, 1: 1 - 19). The zone correlates with the lower part of the *Globigerinelloides ferreolensis-Ticinella bejaouensis* Zone of van Hinte (1976, *A.A.P.G. Bull.*, 60, 4: 498-516). The lowermost marine beds have yielded ammonites of the early douvilleiceratid lineage *Cheloniceras-Eodouvilleiceras*, such as *Epicheloniceras* sp., *Diadochoceras* sp., *Eodouvilleiceras* sp., *E. horridum* and "*Dufrenoyia*" cf. *justinae*, which point to a broadly late Aptian age. The Upper Aptian *Hypacanthoplites jacobi* and the Lower Albian *Leymeriella tardefurcata* zones of north-west Europe (Hancock, 1991, *Cret. Res.*, 12, 3: 259-291) are not recognisable in Sergipe.

The overlying lowermostAlbian *Globigerinelloides cushmani-Ticinella bejaouaensis* Zone is characterised by a marked increase in the abundance of specimens of *T. bejaouaensis* ("2nd abundance peak"), together with the first appearance of rare specimens of *G. cushmani*. In the absence of the *Leymeriella tardefurcata* Zone, the first appearance of *Douvilleiceras sp.* is taken to define the base of the Albian. This species is followed by *Douvilleiceras inaequinodum* and *D.* ex gr. *mammillatum,* which can be correlated with the upper lower Albian *Douvilleiceras mammillatum* Zone of north-west Europe.

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Campanian Ammonite Zonation and Stage and Substage Boundaries in Northern Spain

The following nine assemblage zones are recognised in Navarra: an unnamed barren ammonite interval, the *Scaphites hippocrepis* Zone, *Hoplitoplacenticeras marroti* Z., *Trachyscaphites spiniger* Z, *Pseudoxybeloceras phaleratum* Z., *Nostoceras* (*Bostrychoceras*) *polyplocum* Z, *N.* (*B.*) *polyplocum secoense* Z., *N.* (*Didymoceras*) *archiacianum* Z. and *N.* (*Nostoceras*) *hyatti* Z. This zonation refines and completes existing subdivisions considerably. It can be compared with the French subdivisions and directly with the upper part of the Polish zonation.

In northern Spain, the **Santonian/Campanian transition** generally exhibits a hiatus (expression of the Wernigerode tectonic phase) that comprises the uppermost Santonian and the lowermost Campanian. Locally, younger events overprint the hiatus and therefore its extension varies considerably. Usually, terminal Early Campanian *hippocrepis* Zone strata age rests on Santonian strata. Consequently, all the macrofossil bioevents proposed by Birkelund *et al.* (1984) for defining the base of the Campanian, cannot be applied in Spain and the stage boundary has traditionally been recognised by litho- or sequence stratigraphic events.

In the Barranca (Navarra), the hiatus in the boundary interval is of comparably short duration. The uppermost ammonite assemblage (*Jouaniceras, Glyptoxoceras* and *Scalarites* spp.) of Santonian age is the *Jouaniceras* aff. *sicardi* Zone fauna. It lies in the higher part of the planktonic foraminifera Zone of *Dicarinella asymetrica*. It also corresponds to a zone with *Inoceramus muelleri* that may be an equivalent of the *Sphenoceramus pinniformis* Zone as used by Tröger (1989). It is therefore of earliest Late Santonian age.

The oldest Campanian deposits correlate with the higher part of the *Placenticeras bidorsatum* Zone, which in Navarra is substituted by an assemblage zone of irregular echinoids (Zone of *Offaster pomeli/ Micraster (Isomicraster)* sp., Küchler & Kutz 1989). This zone is well correlatable with the middle Early Campanian Zone of *O. pilula* of NW Germany and southern England. However, it is doubtful that it correlates with the Zone of *Bevahites subquadratus* sensu Wiedmann (comp. Gischler et al. 1994).

The first appearance of the ammonite genus *Hoplitoplacenticeras* as the **Early/Late Campanian boundary** marker is accepted. It is fixed in Spanish sections within an integrated bio- and event stratigraphical framework. The first appearance of *H. marroti* in Navarra lies eventstratigraphically well dated somewhat below a flood occurrence of *O. pilula* that obviously can be traced to S. England. The first appearance of the planktonic foraminifer *Globotruncana ventricosa* lies some metres above that level. *T. spiniger* enters well above the *marroti* zonal assemblage and after an eustatic pulse.

The *Nostoceras hyatti* Zone is regarded as the uppermost Campanian zone in Spain (comp. Küchler & Kutz 1989). The Maastrichtian is marked by the *Pachydiscus neubergicus/P. epiplectus* Zone, which correlates well with the *epiplectus* Zone of Ward & Kennedy (1993) in Guipuzcoa.

The **Campanian /Maastrichtian transitional succession** shows a typical sequence of events: *N. hyatti* enters below *P. neubergicus* and underneath a transgressive impulse. The entrance date of *P. neubergicus* coincides more or less with that of *P. epiplectus. Hoploscaphites constrictus* occurs 13 m above that level together with *Nostoceras helicinum* in a mass occurrence of *N. helicinum* and *P. neubergicus.*

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Fossil occurrences in the Upper Cenomanian-Lower Turonian at Ganuza (N. Spain): an approach to the C/T boundary *)

Samples were taken southward of Ganuza village (Upper Cenomanian and Lower Turonian). The fossil assemblage consists of ammonoids, inoceramids and microfossils, namely foraminifera and calcareous nannofossils, which characterise two planktonic foraminifer biozones: the *Rotalipora cushmani* Zone and the *Whiteinella archaeocretacea* Zone. The nannofossils characterise the *Eiffellithus turriseiffelii* Zone and the *Quadrum gartneri* Zone. The macrofauna occurrences are somewhat scarce and characterise the *Mammites nodosoides* Zone and several inoceramid assemblages.

In the *Rotalipora cushmani* Zone from bottom to top the following taxa are recorded: a. Last occurrence (L.O.) of ***Rotalipora greenhornensis***; b. L.O. of *Axopodorhabdus albianus*; c: *Euomphaloceras euomphalus*; *Forbesiceras* sp.; *Calycoceras* sp.; d. L.O. of *Lithraphidites acutus*; e. L.O. of ***Rotalipora cushmani***.

In the *Whiteinella archaeocretacea* Zone are recorded: f. *Protacanthoceras?* sp.; *Thomelites* sp. aff. *T. hancocki*; g. ***Calycoceras naviculare***; h. L.O. of *Microstaurus chiastius*; i. *Kamerunoceras* sp.; j. ***K. calvertense***; k. *Spathites (J.)* sp.; l. first occurrences (F.O.) of ***Quadrum gartneri*** and *Helvetoglobotruncana praehelvetica*; m. ***Mammites nodosoides***; *Spathites* cf. *obliquus*; n. *Watinoceras* sp.; *Mytiloides goppelnensis ganuzaensis*; ***M. mytiloides***; *M. labiatus*; *M. transiens*; o. *Fagesia* aff. *rudra*; *F.* cf. *pachydiscoides*; *Kamerunoceras puebloense*; p. *F.* cf. *pachydiscoides*; *Mammites* ? sp.; *Kamerunoceras puebloense*; *Pachydesmoceras linderi*; *Lecointriceras fleuriausianum*; q. *Choffaticeras pavillieri*; *Fagesia pachydiscoides*; r. *F.* aff. *rudra*; *Choffaticeras pavillieri*. The top of this zone is marked by the F.O. of ***Helvetoglobotruncana helvetica***.

We have marked in bold the most interesting taxa, related to the Cenomanian-Turonian transition according to Birkelund *et al.* (1984). A possible Cenomanian-Turonian (C/T) boundary could be defined by the F.O. of *Q. gartneri*, which is recorded below *Mammites nodosoides* and *Mytiloides* occurrences, but above *Kamerunoceras calvertense*, which was recorded from the *P. flexuosum* Zone in west Texas (Calvert Canyon, Quitman Mountains) and in north Chihuahua (Kennedy, Wright & Hancock, 1987). Thus, we find some differences in event sequences between our locality and N. American ones, as *Q. gartneri* (F.O.) occurs in the *Watinoceras devonense* Zone in the Pueblo section, underlying the *P. flexuosum* Zone. Alternatively, since *Q. gartneri* earliest records are very rare (<1%), it would be possible that its actual first occurrence was overlooked. In this case, the underlying strata with *Kamerunoceras* sp. and *K. calvertense* would be of Early Turonian age. Indeed, below the *Kamerunoceras* spp. assemblages the L.O. of *Microstaurus chiastius* (latest Cenomanian), *Calycoceras naviculare* (Late Cenomanian, *Metoiococeras geslinianum* Zone, and the L.O. of *Rotalipora cushmani*, of *Axopodorhabdus albianus*, of *R. greenhornensis* are recorded.

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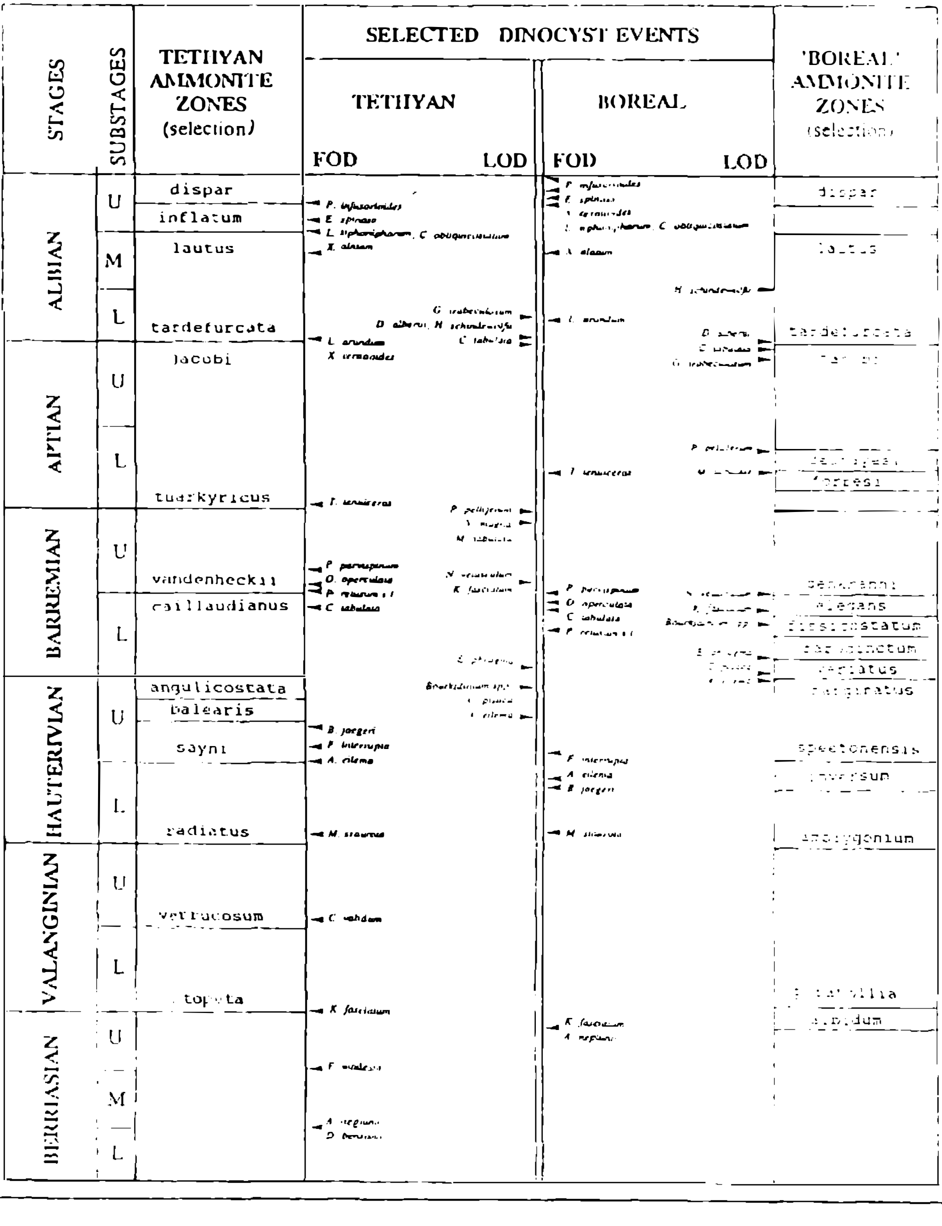
The recognition of Lower Cretaceous stage and substage boundaries in the Boreal and Tethyan compositional developments in dinocyst assemblages.

Most of the Lower Cretaceous Stage and Substage boundaries in the Boreal and Tethyan Realm can be characterised by means of dinoflagellate cyst (dinocyst) information. Here first occurrence data (FOD) and last occurrence data (LOD) of dinocyst taxa are summarised which are more or less contemporaneous in both realms (see table); the selection of dinocyst events is based on biostratigraphically controlled records.

No coeval events in the compositional developments of dinocyst assemblages in both Realms occur around the Berriasian Stage and Substage boundaries, nor at the Valanginian and Aptian Substage boundaries and the Lower-Middle Albian boundary. However, within the realms all Stage and Substage boundaries can be recognised well on the basis of qualitative dinocyst data.



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The ammonite *Hoploscaphites constrictus* (J. Sowerby, 1817) in the Upper Maastrichtlan of central Poland.

The ammonite *Hoploscaphites constrictus* (J. Sowerby, 1817) occurs frequently in the sequence of siliceous chalk, called the Kazimierz Opoka, which crops out along the Vistula river near Kazimierz Dolny, Central Poland. The lower part of the Kazimierz Opoka is exposed mainly in the Town Quarry at Kazimierz Dolny, whereas the upper one - in the Nasilów quarry. The whole sequence is assigned to the upper Upper Maastrichtian *Belemnella kazimiroviensis* Zone in the standard West-European scheme, based on the occurrence of its index taxon (Abdel-Gawad 1986).

The studied material is divided into two samples, A and B, corresponding to the lower and the upper part of the Kazimierz Opoka, respectively. All collected specimens fall within the variability range of *H. constrictus*, as defined by Kennedy (1986). The shell diameter of mature macroconchs ranges from 34 to 63 mm in sample A (mean: 48 mm) and from 37 to 71 mm in sample B (mean: 56 mm). The shell diameter of mature microconchs ranges from 23 to 39 mm in sample A and from 27 to 39 mm in sample B. The mean value of the shell inflation index (maximum thickness: diameter) of macroconchs is 0.20 in sample A and 0.24 in sample B. The fat, coarsely ribbed macroconchs of the "variety" *H. c. crassus* (£opuski, 1911) are very rare in sample A and more frequent in sample B.

The number of ribs on the last centimetre of the body chamber in macroconchs decreases upwards in the sequence, ranging from 9 to 25 in sample A (mean: 15) and from 6 to 21 in sample B (mean: 12). The same trend was observed by Birkelund (1993), who compared two successive samples from the lower and upper part of the *B. kazimiroviensis* Zone of Denmark, respectively. The number of ribs in sample A from the Kazimierz Opoka exceeds significantly those noted for both Danish samples, whereas sample B fits well to the lower sample from Denmark. If the changes in ribbing were synchronous in both regions, then the Kazimierz Opoka is older than previously accepted. Its upper part would be a time equivalent of the lower part of the *B. kazimiroviensis* Zone in Denmark, whereas the lower part equivalent of the lower Upper Maastrichtian *Belemnitella junior* Zone in Denmark. The presence of the ammonite *Acanthoscaphites varians* (£opuski, 1911) also supports this supposition. Outside Poland this ammonite is known only from *B. occidentalis* and *B. junior* Zones (in Denmark, Germany and Belgium).

In fact, the conflict between ammonite and belemnite data may not exist at all, taking into account the much earlier appearance of *B. kazimiroviensis* within the Upper Maastrichtian succession of the eastern part of the Russian Platform, than in its western part (Naidin 1973). It is thus probable that this belemnite appeared earlier in Poland than in Denmark.

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Upper Albian/Cenomanian dinoflagellate cysts from Algerian outcrops.

Combined with an interpretation of ammonite and foraminiferal data, the palynological analysis of samples from two sections (EMP and DMP) located in the SE Constantinois (Tebessa area, Algeria) allowed us to recognise 27 genera and 22 species of dinoflagellate cysts.

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Santonian-Campanian and Campanian-Maastrichtian stage boundaries, Eastern Gulf Coastal Plain, U.S.A.

The Upper Cretaceous (Santonian-Maastrichtian) stratigraphic succession of the eastern Gulf Coastal consists of 250 to 300 m of nonmarine, strandline, and marine siliciclastic and carbonate sediments. This section comprises the Eutaw Formation (Tombigbee Sand Member), Mooreville Chalk (Arcola Limestone Member), and Coffee Sand of the Santonian-Campanian UZAGC 3.1 depositional sequence and the Demopolis Chalk (Bluffport Marl Member) and Ripley Formation of the Campanian-Maastrichtian UZAGC4.1 depositional sequence. The Prairie Bluff Chalk and Owl Creek Formation constitute the Maastrichtian UZAGC-5.1 depositional sequence.

Strata of the UZAGC-3.1 and UZAGC-4.1 sequences are assigned to the following planktonic Foraminifera zones as defined by Caron (1985): *Dicarinella asymetrica* Total Range Zone, *Globotruncanita elevata* Partial Range Zone, *Globotruncana ventricosa* Interval Zone, *Globotruncanita calcarata* Total Range Zone, *Globotruncanella havanensis* Partial Range Zone, *Globotruncana aegyptiaca* Interval Zone, and *Gansserina gansseri* Interval Zone. Utilising the ranges of planktonic Foraminifera to define the Upper Cretaceous stage boundaries, the Santonian-Campanian boundary is in the Mooreville Chalk and the Campanian-Maastrichtian boundary is in the Demopolis Chalk. The Santonian-Campanian boundary is recognised by the last (highest) occurrence of *Dicarinella asymetrica* SIGAL. *Globotruncanita elevata* occurs concurrently with *D. asymetrica* in the Tombigbee and lower Mooreville. The Campanian-Maastrichtian boundary is recognised by the last (highest) occurrence of *Globotruncanita calcarata* (CUSHMAN).

Planktonic Foraminifera are the preferred organism to define these stage boundaries in that they demonstrate lithofacies independence in the strata of the eastern Gulf Coastal Plain. The Santonian-Campanian boundary occurs in the transgressive systems tract deposits of the UZAGC-3.1 sequence and as such appears time transgressive because the Tombigbee and Mooreville are lithofacies equivalents. In south-central Alabama, the boundary is some 30 m above the Tombigbee-Mooreville contact, while in east-central Mississippi the boundary is at the Tombigbee-Mooreville contact. The Campanian-Maastrichtian boundary occurs in the highstand systems tract deposits of the UZAGC-4.1 sequence and is independent of lithofacies changes. In south-centralAlabama, the boundary is in massive chalk of the Demopolis, while in east-central Mississippi the boundary is in the siliciclastic marls of the Bluffport Marl Member of the Demopolis.

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Mangyshlak mid-Cretaceous: chronostratigraphic boundaries at the marginal part of the North European Province

The studied sedimentary sequence, ranging from the Upper Albian to the Coniacian, and exposed along the limbs of the Central Mangyshlak Anticlinorium, western Kazakhstan, begins with deposits developed during the Late Albian acceleration of the mid-Cretaceous transgression, the maximum of which was emplaced at the Late Turonian, and was expressed by a cease of clastic supplies and a burst of carbonate deposition. Within this interval appear numerous and variably thick phosphatic horizons, the five major of which are traceable in all sections studied, along a distance of about 250 km. The phosphatic horizons correspond to regressive pulses (shallowing, slow, or stop of sedimentation, phosphatization, redeposition), although the condensation span-time is variable in particular sections (e.g. Lower Cenomanian through Middle Turonian at Besakty section) as resulted from local synsedimentary block-faulting of the substrate (cf. *also* Naidin *et al.* 1984). An appreciable number of fossils (ammonites, belemnites, inoceramids, echinoids) allow a correlation of the studied sections, and a recognition of local *versus* panregional events. The panregional regressive pulses are well correlatable with those from England (cf. Hancock, 1990) and they point to the boundary of the *inflatum/dispar* Zone (IIIrd phosphatic horizon), the middle of the mid-Cenomanian (IVth phosphatic horizon = Mid-Cenomanian Non Sequence), the high part of the *woollgari* Zone and lower part of the *neptuni* Zone (Vth phosphatic horizon). The remaining two regressive pulses (Ist and IInd phosphatic horizon, respectively) appear in the middle of the *inflatum* Zone, and are of a local significance. The hiatus concretions of the hardground provenance, present in some phosphatic horizons, are thought to be reverse points at the turn of the trans- and regressive pulses, similarly as the hardground surfaces in the Chalk facies (cf. Hancock 1990, Fig. 2). The section exposed at Mt. Aksyrtau displays the Cenomanian/ Turonian boundary beds with an almost complete faunistic key record: *Actinocamax plenus/ Neocardioceras juddii?/Inoceramus pictus/ Watinoceras amudariense/ ?I. pictus W. amudariense /Mytiloides hattini/M. kossmati/M.* ex gr. *labiatus M. kossmati/M.* ex gr. *labiatus*. The cephalopod succession of Mangyshlak is thus identical to that of north-west Europe (cf. Kennedy, 1984), and the associated inoceramids allow a further correlation with the Western Interior of the United States (cf. Walaszczyk 1992). Moreover, if the presence of black shales at the base Turonian of the Aksyrtau section is taken into account as an evidence of the Cenomanian/Turonian anoxic event, it is apparent that this very section bears a paramount potential to designate the Cenomanian/Turonian boundary on the global scale.

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Early Cretaceous rudist biostratigraphy from the south of France, a reference for Mesogean correlations.

In the south of France (northern subalpine regions, Provence-Languedoc and the Aquitaine-Pyrénées domain) shallow water carbonates with rudists are known throughout the Berriasian-Albian interval. The corresponding fauna was subject to detailed palaeontological investigations already at the end of last century. During the last decades, improvements in the micropalaeontologic biozonations of carbonate platform series (based on benthic foraminifera and dasyclad algal distributions referred to ammonite standard biozones) give the opportunity to reappraise the Early Cretaceous rudist biostratigraphy in a precise, well documented, biochronologic framework.

Following a systematic overview and discussion, the biostratigraphy of about 60 rudist species corresponding to 22 genera is therefore provided at stage, substage or even ammonite zone level. This distribution is compared to those known from adjacent countries (Spain, Switzerland) belonging to the northern margin of the Mediterranean Mesogée (i.e. European Province). That proposed biozonation is considered as a valuable reference for biostratigraphic interpretations and correlations for the Mesogean domain where cosmopolitan taxa are dominant.

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Recognition of the Cenomanian and Turonian Stages in Japan.

Based on the ammonite and inoceramid zones that are correlated with those of NW Europe and N. America, the above entitled two stages are recognised in Japan. The reference sections for them are taken in well-investigated areas of central and northwestern Hokkaido, as is explained by MATSUMOTO et al. (1991, 1993). The important species are enumerated below for the subdivisions, which are here abbreviated as follows: A= Albian, C= Cenomanian, T= Turonian; L, M, U = Lower, Middle, Upper "Substage".

(1) The basal C (i.e. lower LC) in Japan is defined by the assemblage of *Graysonites adkinsi*, *Utaturiceras* n.sp., *Sounnaites alaskaensis*, *Parajaubertella kawakitana*, *Mariella lewesiensis*, *Inoceramus* aff. *reachensis* etc. This zone overlies the upper UA unit which contains *In. comancheanus*, *Zelandites odiensis*, *Mortoniceras (Cantabrigites)* aff. *subsimplex* etc. (2) The main part of LC is recognised by *Mantelliceras japonicum*, *M. cantianum*, *Sharpeiceras kongo*, *Sh.* sp., *Acompsoceras renevieri*, *Hypoturrilites gravesianus*, *Zelandites inflatus*, *In.* aff. *reachensis* etc. (3) MC: *Cunningtoniceras takahashii*, *Calycoceras (Newboldiceras) asiaticum*, *Turrilites acutus*, *Birostrina tamurai* etc. (4) UC: *Eucalycoceras pentagonum*, *Euomphaloceras septemseriatum*, *Pseucalycoceras angolaense*, *In. pictus minus*, *In. nodai* etc. (5) The C/T boundary is best exposed on a cliff of the Shirakin River of Oyubari, central Hokkaido and is marked by black mudstone which indicates OAE (HASEGAWA, 1995). *In.* n. sp. aff. *In. saxonicus* appears above that rock and ranges throughout LT, but *Watinoceras devonense* has yet to be searched for in the lower LT. The boundary is within *Whiteinella archaeocretacea* Zone, but other faunas show a marked change here. (6) LT: *Pseudaspidoceras flexuosum*-*Mytiloides columbianus*, *Mammites* sp.-*My.mytiloides*, and *Fagesia* spp.-*My. subhercynicus* successively. (7) MT: *Yubariceras yubarense*-*In. costatus* (lower part); *Romaniceras deverianum*-*In. hobetsensis* (upper part). *Kamerunoceras turoniense* may occur in the former and *Collignoniceras woollgari* in the latter. (8): UT: *Subprionocyclus neptuni*-*In. teshioensis*. It can be subdivided by *S. bravaisianus* (lower), and *S. minimus* (upper). *Lymaniceras planulatum*, *In. tenuistriatus*, *My. incertus* etc. are associated.

It should be noted that some of the world-wide guide species show dissimilar vertical ranges between Japan and NW Europe. For instance, in Japan *Turrilites costatus* ranges from mid-LC to mid-MC, whereas *Neostlingoceras carcitanense* is not found in the lower LC but occurs in the middle and even upper LC. Several long-ranging species of the Desmocerataceae are useful to distinguish the two Substages.

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Possible impact on the Cretaceous/Tertiary boundary of studies on pollen and spores.

Terrestrial palynological diagrams (pollen and spores) from the C/T transition at Brazos, USA and Seymour Island, Antarctica are presented. The most obvious fact they show, already demonstrated earlier (e.g. Jerzykiewicz & Sweet 1986, Frederiksen *et al.* 1988), is a change with substitution of forms, in place of the classic Tschudy *et al*'s disruption of the terrestrial plant ecosystem (1984); i.e. an extinction event with complete different floras on both sides of the proposed C/T limit. Then the variations of percentages observed in these diagrams, may be related to a succession of events of different origin: climate, sea-level change, and/or volcanic activity. But among this succession, the major variation used to trace the C/T boundary, normally results from a paleogeographic change, short but of possible minor importance. On the contrary, the climate-driven change in percentages of larger extension, would actually appear as a part of a long term process.

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Upper Cenomanian and Lower Turonian biostratigraphical framework in Niger - Nigeria and tentative correlations with Tunisia.

If the Late Cretaceous ammonite biostratigraphical framework in the Iullemmeden Basin (Niger) and the Benue Trough (Nigeria) is still incomplete, it is nevertheless possible to propose correlations for the Upper Cenomanian and Lower Turonian faunas in spite of differences in taxonomic conceptions between authors.
There are now indexes for the link between Tethys and South Atlantic areas through the Benue Trough. But the correlations are also incomplete and difficult with the North, especially with Tunisia which is placed in the northern part of the sea that crosses the Western African Craton. It is largely because of the scarcity of detailed studied outcrops and of the faunal originality between Tunisia and Niger - Nigeria. Acute correlations are possible with the *Vibrayeanus* horizon and the *Flexuosum* horizon, less evidently with the *Pseudonodosoides* horizon. The *Vascoceras (Paravascoceras)* ssp. event, the *Thomasites* and the *Choffaticeras/Hoplitoides* events must be clarified.

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Microfacies and environmental development of the Upper Cretaceous Formations, Southern Galala, Gulf of Suez, Egypt.

This study is concerned with the general lithostratigraphy, microfacies and palaeoenvironments of the Upper Cretaceous rocks exposed in Wadi El Dakhl, Gabal El Jeir and Wadi El Deir.

These rocks were referred to the Galala, Wata and Matulla Formations and Sudr Chalk. The 16 recognised microfacies associations can be categorised as siliciclastic group and carbonate group.

In addition to the oscillating nature of the Cretaceous sea prevailing through the deposition of the investigated shallow marine sediments , there are representatives of two deep marine transgressive phases. The alternating beds of the Galala Formation and their indigenous faunal content indicate deposition in a warm shallow marine environment of normal salinity. While the pelagic macrofauna represented by highly diversified Turonian ammonoid assemblages as well as the lithology suggest that deposition of the Wata Formation took place in an open shelf of slightly deep water and low energy. Another remarkable shallowing in the sea level accompanied by the increase of land terrigenous influx characterised the deposition of the clastics of the Matulla Formation. Finally, the scarcity of the macrofauna and richness of the planktonic Foraminifera as well as the lithologic aspect of the Sudr Chalk reflect deep water of open marine environment.

These sequences of environmental changes reflect a great conjunction of the studied area with the global sea level changes during the Upper Cretaceous. Little exceptions were detected and attributed to some local synsedimentary structural movements.

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Microplankton development at the Tithonian - Berriasian boundary in the western Carpathians.

Late Tithonian origin of hyaline calpionellids (Praetintinnopsella Zone) and their successive diversification in the Intermedia Subzone was followed by their first diversity and abundance maximum. Calpionellid association was dominated by *Crassicollaria (Cr. brevis, Cr. massutiniana, Cr. parvula)* accompanied by abundant elongate and spherical *Calpionella alpina* and less frequent small *Tintinnopsella carpathica.* Calpionellid diversity gradually decreased during the latest Tithonian and lowermost Berriasian, when the small spherical form of *C. alpina* accompanied by rarer *T. carpathica* and *Cr. parvula* dominated in the calpionellid association. Sudden increase in abundance of both the nannoplankton and monoassociation of *C. alpina* happened contemporaneously with the minimum of calpionellid diversity. According to the Second Colloque in Lyon-Neuchatel, 1973, the J/K Boundary was situated at the beginning of this bioevent (Remane *et al.*, 1986).

The second diversity maximum occurred during middle Berriasian (transition of the Elliptica and Simplex Subzones), when the calpionellid association consisted of *Calpionella (C. alpina, C. elliptica)*; *Tintinnopsella (T. carpathica, T. longa)*; *Remaniella (R. ferasini, R. cadischiana, R. filipescui, R. borzai)* and of the first *Calpionellopsis* represented by *C. simplex*. While the size of *C. alpina* decreased gradually *(C. minuta)*, the calpionellids of the Elliptica Subzone and younger *(Calpionellopsis, Calpionellites, Tintinnopsella)* zones are characterised by the size increase of loricas.

Late Tithonian radiolarians (UA 10) are represented by *Acanthocircus dicranacanthos*, *Sethocapsa cetia*, *Triactoma echiodes*, *Mirifusus mediodilatatus* persisting until Early Cretaceous. During the topmost Tithonian, the UA 11 association composed of *Parvicingula cosmoconica*, *Pseudodictyomitra depressa*, *Xitus spicularius*, *Pantanellium berriasianum* and *Obesacapsula rusconensis* (Ondrejíçková *et al.*, 1993) appeared. Tithonian nannoplankton associations were characterised by long-lived genera *Ellipsogelosphaera*, *Cyclagelosphaera*, *Watznaueria* and *Zeugrhabdotus*. New association CC1 represented by zonal species *Nannoconus steinmannii* appeared at the end of Tithonian.

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Towards a world-wide applicable biostratigraphy of Early Cretaceous nannofloras.

The nannofossil assemblages of the Early Cretaceous show a distinctive palaeobiogeographic distribution pattern for the intervals Berriasian-Barremian on one hand and for the Aptian-Albian on the other. The Berriasian-Barremian period is characterised by provinciality on the generic level. It is possible to differentiate in between a Boreal Realm and a Tethyan Realm. These different palaeobiogeographic distribution patterns of calcareous nannofloras are caused by the interaction of various autecological factors including sea-level changes, temperature and nutrients. Long term fluctuations (3rd and 2nd order cycles), which are controlled by sea-level changes, are clearly reflected by calcareous nannofossils. Regressive periods favoured the evolution of boreal and endemic species under restricted conditions. These regressive periods are: the latest Berriasian, the late early Hauterivian, the mid late Hauterivian and the Barremian. Moderate sea-level highstands, on the other hand, allowed tethyan nannofloras to spread into NW Europe and boreal species to migrate southwards. High stands can be postulated for: the early late Valanginian, the early Hauterivian, the mid Hauterivian, the late Hauterivian and the late Early Barremian. Different and independent biostratigraphic schemes were developed for the two areas using tethyan and boreal markers respectively. In the Tethyan Realm nannofossil events are calibrated to magnetostratigraphy, whereas in the Boreal Realm calibration to ammonite biostratigraphy is available. Assemblages from the Indo-Pacific area show cosmopolitan elements and weak influences of tethyan floras. Therefore the Tethyan Realm is subdivided into a Mediterranean Province (Tethyan Realm *sensu stricto*) and an Indo-Pacific Province. A major shift towards a more open oceanic regime caused changes of the constituency of calcareous nannofloras on a global scale. Due to the early Aptian transgression endemic species disappeared and calcareous nannofloras became homogenised and cosmopolitan. The differences in between the Boreal Realm and the Tethyan Realm vanished, as well as the differences in between the two provinces within the Tethyan Realm. For this interval a new biozonation based on calcareous nannofossils is discussed and one scheme is proposed for world-wide correlation.

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On the Turonian/Coniacian boundary in Germany.

Calcareous nannoplankton analysis were carried out on outcrop samples from the quarries of Salder, Sölde (Lower Saxony) and Hoppenstedt (Sachsen-Anhalt). Core samples from the borehole Werne 8 (Westphalia) have also been investigated.

Rich nannoplankton assemblages were recovered. The following nannoplankton zones have been recognised: *Lucianorhabdus maleoformis*, *Lithastrinus septenarius*, *Marthasterites furcatus*.

The first appearance of *M. furcatus*, which represents for most nannofossil specialists, the base of the Coniacian lies at the base of the marl layer (ME) within the Lower Limestone Unit. According to the inoceramid stratigraphers the marl layer (ME) is of Late Turonian age.

The biostratigraphic results of the nannoplankton analysis and the known important macrofossil assemblages have been discussed with reference to the proposals of Copenhagen.

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Palynological and Rock-Eval/TOC Pyrolysis indicators of the Cenomanian/Turonian Boundary in the Canadian Arctic.

The Upper Cretaceous Kanguk Formation is well exposed in the Sverdrup Basin, Canadian Arctic Archipelago. Dark grey mudstones and rare to abundant bentonite interbeds constitute the main lithology of this formation. Due to a significant underlying unconformity the age of the base of this formation varies from late Cenomanian in central Sverdrup Basin to Turonian in other areas of the Canadian Arctic. At Glacier Fiord, southern Axel Heiberg Island, the palynological assemblage indicates that the Kanguk Formation is latest Cenomanian at the base and Campanian at the top. However, no obvious internal stratigraphic boundaries can be recognised in the field on the basis of lithological variations, colour changes, or sequence stratigraphy. Therefore, palaeontology is the only basis to assess and establish the stratigraphy of this otherwise rather uniform formation. Moreover, palynomorphs are the best microfossils for the study of the Kanguk Formation since the high acidity of the mudstones and their fine grain prevent good preservation of other fossils.

The lower Kanguk palynological assemblages are composed mainly of dinocysts although other palynomorphs such as acritarchs, pollen, and spores are also present. The latest Cenomanian contains a diverse dinocyst assemblage followed by the biological crisis of the Cenomanian/Turonian (C/T) boundary which is characterised by an interval of very low diversity. The boundary is followed by a reflourishing of the assemblages. The dinocyst extinction, temporal disappearance, and introduction events occur stepwise. At Glacier Fiord the Cenomanian is characterised by the presence of *Luxadinium primulum*, *Limbicysta* sp., *Rugubivesiculites multisaccus*, and *Stephodinium* spp. whereas the Turonian is represented by the first appearance of *Isabelidinium ? globosum*.

Comparison of Rock-Eval/TOC data from the Kanguk Formation with data from the Cretaceous Western Interior Sea of North America further supports the occurrence of a significant event at the C/T boundary. At Glacier Fiord two significant peaks, one for Total Organic Carbon (TOC) and one for Hydrogen Index (HI), occur at this boundary and are followed by a rapid decrease in their values. The TOC peak reaches 7.37 wt. % whereas the HI peak gets to 379 mg HC/g TOC. The low TOC and low HI interval above the boundary coincides with the low palynological assemblage.

In the Canadian Arctic, both the palynological assemblages and Rock-Eval/TOC pyrolysis data indicate warm, favourable climatic conditions with high planktic productivity up to the latest Cenomanian followed by abrupt paleoenvironmental changes and oceanic anoxic conditions in the earliest Turonian. No massive dinocyst extinction event occurs at the C/T boundary but rather a stepwise extinction and disappearance of taxa followed by stepwise reappearance of some species and introduction of new forms.

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A review of modern data bearing on a time scale for the early Cretaceous.

Although several time scales have been published in the past few years (Harland *et al.*, 1989; Obradovich, 1993; and Gradstein *et al.*, 1994) there are still significant differences between these due primarily to the data bases employed and also the biostratigraphic criteria used to define stage boundaries. Unfortunately most of the currently available isotopic ages are up to three decades old, often imprecise by modern standards and include chronometers of questionable value. Any future time scale of the early Cretaceous must take into consideration the moderate number of ages (both ^{40}Ar-^{39}Ar and U-Pb) that are not only precise but make use of high temperature stable mineral phases and have adequate biostratigraphic control.

The following ages are considered to make up this core group:

(1) ^{40}Ar-^{39}Ar ages of 97.2 +/- 0.7 Ma and 98.5 +/-7 Ma on sanidine from bentonites which bracket the *Neogastroplites* lineage of the Western Interior. Most, if not all, *Neogastroplites* are placed in the Cenomanian.

(2) ^{40}Ar-^{39}Ar ages of 104.4 +/- 0.4 Ma on sanidine from a bentonite marking the incursion of the Skull Creek sea way and the entry of the *Inoceramus comancheanus* and *I. bellvuensis* faunas. This transgression could possibly match the rapid transgressive sea level rise occurring in the *Hysteroceras orbignyi* and *H. varicosum* subzones (Hancock, 1994).

(3) ^{40}Ar-^{39}Ar ages of 107.1 +/- 0.9 Ma on sanidine from a bentonite in the *Pseudopulchellia pattoni* Zone equated by Jeletzky (1987) to the *Euhoplites loricatus* Zone of mid-mid Albian age.

(4) ^{40}Ar-^{39}Ar ages of 114.0 +/- 1.3 Ma on sanidine from a bentonite in the upper part of the *Parahoplites nutfieldensis* Zone of late Aptian age which is correlative with the upper part of the *Nannoconus truittii* acme.

(5) ^{40}Ar-^{39}Ar ages averaging 122.3 +/- 1.0 Ma on basalts from ODP site 807 on the Ontong Java Plateau. Basalts and overlying limestones have normal polarity. Interbedded and overlying sediments contain earliest Aptian fossils. Results place a minimum age on the Barremian/Aptian boundary.

(6) U-Pg age of 122.0 +/- 0.3 Ma on zircons from a bentonite in the Great Valley sequence of northern California. Bentonite is within the lower part of the *Chiastozygus litterarius* Zone of early Aptian age and places a minimum age on the Barremian/Aptian boundary.

(7) ^{40}Ar-^{39}Ar age of 123.5 +/-1.0 Ma on basalt at the top of polarity zone M1r in the MIT Guyot seamount (Pringle, 1994).

(8) ^{40}Ar-^{39}Ar ages averaging 126.0 +/- 2.3 Ma from a series of plutons in the Monteregian Hills, Quebec, canada. All plutons are of reversed polarity and were probably emplaced during reversed chron M3 of early Barremian age.

(9) U-Pb ages of 137.1 +/-1.6 Ma and 136.9 +/- Ma on zircons from two different bentonites in sediments of the Great Valley Sequence of northern California. These bentonites lie in the *Cretarhabdus angustiforatus* Zone of late middle Berriasian and within polarity chron M16.

These ages will be discussed and how they constrain the ages of the early Cretaceous stage boundaries and how the durations of stages so derived agree or disagree with those based on Milankovitch based periodicities.

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The Tercis outcrop: a reference section for the Campanian-Maastrichtian stage boundary.

The Tercis outcrop is located between the Champagne charentaise (stratotype of the Campanian Stage, SW France) and the well documented Biscay area [Zumaya (Spain) Hendaye, Bidart (France)]. The outcrop can serve as a connection between the Boreal (chalk facies) and the Tethyan (pelagic facies). Many factors including the essential biostratigraphic record are comparable with both areas.

The outcrop is on private land and shall soon be proposed as a geological reserve. It can be reached easily (4 hours train from Paris), provided that permission has been granted by the owners, and the scientist responsible for the research has been informed. Several sections are present - they have been measured and since 1992 beds are marked. The total series has a thickness of 260 m. The facies is generally homogeneous all along the sedimentary limy (more or less argillaceous) series. A description has been published (Odin & Odin, 1994).

Chemostratigraphy and magnetostratigraphy have been undertaken.

The biostratigraphic potential is high and this has long been known; a number of groups and taxa have also been newly found at the quarry. More than 500 macrofossils are available for study from the present author. Other collectors have also been involved. The most commonly occurring fossils are: Echinoids (+ Asteroids and Crinoids), Bivalves (numerous inoceramids), Ammonites (regular and unwhorled forms with evolutive series for both), Brachiopods (including macro- and micro forms). Also sponges, bryozoans, corals and very many fish remains are present. Among microfossils benthic and pelagic foraminifera, coccoliths, dinoflagellates occur frequently; ostracods are not rare; pollen is present.

All groups which are potentially useful for correlation are under study by one to three experts so as to recognise the potential of the quarry and insure the "reproducibility" of the characters and knowledge - an essential factor for any section to be used for correlative purpose all over the world. More than 30 persons are involved.

In 1993 (Hancock *et al.*, Ward *et al.)* located the basal portion of the main section as middle Campanian, late Campanian is reached soon. The Campanian-Maastrichtian transition has been located in the unit "Calcaire à silex gris" (between levels 100 and 131).

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A biochronological scale based on Radiolarians for the Late Jurassic-Mid Cretaceous of the western Tethys.

Highly diverse radiolarian faunas of Late Jurassic-middle Cretaceous age have been recovered from pelagic and hemipelagic sequences recording the Tithonian-Turonian interval in Mediterranean Regions. Several lithologies (limestones, cherty limestones, radiolarites, marls and siliceous shales) were thoroughly examined for radiolarian occurrences in continuous successions of deep-water facies. The study includes localities, in the Prealpine Nappes, in the Carpathians, in the Southern Alps and the Umbria-Marche Apennines (Apulian Block), and on the External Zones of the Betic Cordillera (Southern Iberian Paleomargin).
The taxonomy and biochronology of the Late Jurassic to middle Cretaceous Radiolarians has been studied in order to construct a precise radiolarian zonation in the western Mediterranean, on the basis of their vertical distribution. The biochronological correlation was made by means of BioGraph (Savary & Guex, 1991) based on the Unitary Association Method (Guex 1977, 1991). The U.A.'s method generates discrete biochronological scales which will detect maximal intersections of the existence intervals for the co-occurring species. The radiolarian inventory consists of a database recording the occurrence of 405 species in 270 superposed horizons selected from more than one thousand samples of 21 sections.
The biochronological analysis has allowed the definition of 45 U.A.'s for this time interval. The resulting U.A.'s differ from each other by containing mutually exclusive species. Individual Unitary Association, identified in separate sections, can differ in faunal content due to ecological, taphonomic or documentary factors. These usually have no chronological significance. For this reason some of them must be merged to construct chronologically meaningful units, each of which is labelled either as a zone or a subzone. Zonal boundaries are chosen to ensure the optimum of lateral reproducibility and of superpositional control of zones in as many sections as possible. Such units will be characterised by a wide lateral traceability and a good mutual superpositional control. These biochronological units are tied to chronostratigraphy by means of ammonites, calpionellids, calcareous nannofossils and planktonic foraminifers previously studied by other authors at the same localities. The radiolarian biochronology also is calibrated and correlated to the magnetic polarity chrons, which has been previously established in five of our investigated localities.
Finally, the detailed radiolarian biochronology was used as a basis for tracing evolutionary lineage and to revise partly generic and suprageneric classification.

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Westward migration of the Echinoid species *Micraster rogalae* NOWAK in the North European Province during the Coniacian and Santonian.

The species *Micraster rogalae* was erected by NOWAK (1909) on the material from the Upper Cretaceous (Upper Coniacian according to the subsequent authors) from Halicz, western Ukraine. This species is documented only in a few places within the Late Cretaceous North European Province. Outside western Ukraine it is known from the Upper Coniacian and Lower Santonian from Mangyshlak (western Kazakhstan), from the upper part of the Lower Santonian to the lower part of the Upper Santonian of Lägerdorf (northern Germany), from the middle(?) Santonian of Ulina Wielka (southern Poland), and from the Santonian of Frameries (Belgium).

The species reveals a marked diachronism within the North European Province: it first appeared in the Late Coniacian in the east and reached the area of the central and western Europe in the late Early Santonian. In some places the species occurs abundantly, but horizons with its mass occurrence observed in particular regions are apparently not synchronous. In Mangyshlak *Micraster rogalae* is abundant within the upper part of the Upper Coniacian, whereas at Lägerdorf, Germany, its acme falls into the middle Santonian (ERNST & SCHULZ, 1974).

The eastern origin of the species and its subsequent migration towards the west explains the difficulties in placing *Micraster rogalae* in the evolutionary tree (see ERNST, 1972) of the genus *Micraster*. The intermediate forms between *M. rogalae* and the earlier species *M. cortestudinarium* (GOLDFUSS) occur only in the Coniacian of Mangyshlak.

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The Campanian/Maastrichtian boundary in the Piotrawin quarry (central Poland): the benthic foraminiferal evidence.

A 35-m thick sequence composed of monotonous siliceous white chalk is exposed in a large quarry at Piotrawin. Benthic and planktonic foraminifera from 35 samples have been studied from this section.

A very low P/B ratio (0-15%) and an almost complete lack of keeled forms within planktonic foraminiferal assemblages indicate an inner shelf environment for the site.

Planktonic foraminiferal assemblages are not very diverse and devoid of index species, while benthic foraminiferal assemblages are well diversified and comprise species which are useful for determining the stratigraphic position of the exposed chalk.

The presence of *Bolivina incrassata, Globorotalites hiltermanni, Angulogavelinella bettenstedti, Heterostomella foveolata, H. gracilis, Bolivina decurrens, Neoflabellina reticulata, Reussella szainochae, Bolivinoides decoratus* and *B. paleocenicus* indicate the uppermost Campanian and lowermost Maastrichtian in the Piotrawin quarry, the *peterssoni/hiltermanni* Concurrent Range Zone and *decurrens* Interval Zone of Schönfeld (1990).

The first appearances of *Bolivina decurrens* and *Neoflabellina reticulata* 17.5 and 21.5 m above the bottom of the quarry, respectively, indicate that the Campanian-Maastrichtian boundary should be placed somewhere within this interval, i.e. in the middle part of the quarry.

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Zonal stratigraphy of Upper Cretaceous deposits in western Siberia, on foraminifera.

In western Siberia the Upper Cretaceous strata are the cover, and partially the reservoir, of gas fields, iron ore and other useful minerals. This fact explains the importance of preparing a detailed stratigraphic framework, mainly based on microfaunal analysis.

Late Cenomanian age of the upper strata of the Pokursky and Uvatsky horizons in the northern plain areas and in Zauralia is faunistically well characterised. Here two zones are distinguished: a lower one with *Verneuilinoides kansasensis*, and upper one with *Trochammina wetteri, T. subbotinae*, both related to the Upper Cenomanian (Podobina, 1989). In the Kuznezovsky horizon (Turonian) two zones were established: a lower one with *Gaudryinopsis filiformis angusta* and an upper one with *Pseudoclavulina hastata.*

The Berezovsky horizon (Senonian) contains diverse foraminiferal complexes (Podobina, 1966; 1975). The lower part of this horizon (lower Berezovsky, Sedelnikovsky, the larger part of the Ipatovsky suites) is divided into layers containing foraminiferal complexes with *Haplophragmium chapmani, Ammoscalaria antis* in the lower one, and with *Dentalina basiplanata, D. tineaformis* and *Nonionellina ixtensa* in the upper one,; they are of Early and Late Coniacian age respectively.

In Zauralia (t. Berezovo, borehole 23) a complex with *Cibicides sandidgei, Gavelinella costulata* indicates Upper Coniacian. It is comparable with Coniacian complexes from the Russian platform and western Europe. Th lower part of the Discorbis Zone, established by Dain (1961) in southern Zauralia (st. Shumicha) is also Coniacian.The upper Berezovsky subhorizon (upper Berezovsky subsuite, Slavgorodsky suite) can be divided into two zones (except for the uppermost levels): *Ammobaculites dignus, Pseudoclavulina hastata admota* (Lower Santonian) and *Cribrostomoides cretaceus exploratus, Ammomarginulina crispa* (Upper Santonian). Strata underlying the Slavgorodsky suite are also attributed to the Lower Santonian, on the base of the foram complex *Recurvoidella sewellensis parvus, Recurvoides optivus.* Molluscs are rare and poorly preserved in outcrops of the Berezovsky and Slavgorodsky suites, but the foraminiferal assemblages are highly specific, especially the agglutinated forms.The Santonian age attributed to these assemblages is based on microfaunal analysis and comparison with similar assemblages known in W. Europe, Canada and N. Alaska.

Campanian strata (upper levels of Berovsky horizon, lower levels of Gankinsky horizon) are not fully developed. The upper levels of the Bererovsky horizon contain *Bathysiphon vitta* and *Recurvoides magnificus* indicating the Lower Campanian, the lower levels of the Gankinsky horizon contain *Cibicidoides eriksdalensis, Bolivinoides decoratus* indicating the Upper Campanian. On the Russian platform these correspond to part of the quadrata Zone, to the mucronata Zone and to the upper *Brotzenella insignis* Zone and the complete *B. monterelensis* Zone.

Through comparison of the foraminiferal assemblages from Western Siberia with those of the Russian platform the Gankinsky horizon could be dated as Late Maastrichtian, with a lower assemblage with *Spiroplectammina variabilis, Gaudryina rugosa spinulosa*, and an upper assemblage with *Spiroplectammina kasanzavi* and *Bulimina rosenkrantzi.*

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Micropalaeontological base of the Maastrichtian/Danian boundary in western Siberia.

Foraminifera are the only group of organisms which are widely distributed in the Gankinsky horizon and in the lower part of the Talizky horizon.

The middle levels of the Gankinsky horizon form the late Maastrichtian *Spiroplectammina kasanzevi, Bulimina rosenkrantzi* zone with the foraminiferal assemblage of the same name (Podobina 1975, 1979; Podobina & Kseneva, 1994). These strata are formed of grey calcareous aleurolites and clays, 6 to 47 m thick. The most complete sections contain a.o. *Heterostomella foveolata* and *Cibicides danicus* in the top of the zone; the uppermost subzone is distinguished by them. The Upper Maastrichtian complex is characterised by numerous and diverse foraminifera: 60 genera with 120 species. Most numerous are the representatives of *Nodosaria, Dentalina, Guttulina, Valvulineria, Gyroidinoides, Eponides, Anomalinoides, Cibicides, Bulimina, Reussella* and *Bolivina*. Forms with secretory carbonate wall predominate (85 %). A few shells (15 %) have agglutinated and secretory-agglutinated wall: a.o. *Glomospira, Ammodiscus, Labrospira, Haplophragmoides, Adercotyma, Cribrostomoides, Spiroplectammina* and *Dorothia*. The continuous abundance and diversity of foraminifera in the sections of this area indicate stable conditions in a relatively shallow basin in the Upper Maastrichtian (Podobina & Kseneva, 1994).

Danian strata are preserved as wash out in fall down parts of western Siberia; they are found in the upper part of the Gankinsky horizon as well as in transitional strata attributed to the base of the Talizky. The latter consist of dark grey opaka and compact clays. Specific foram assemblages are confined to this part of the section.

S.-E. Danian complex (Omsk depression) with *Brotzenella praeacuta* consists of 38 genera and 57 species, largely the same taxa found in the underlying Late Maastrichtian complex predominate in its composition. Strata containing the specific Danian complex are restricted to the foram zone of the same name. A Danian complex with *Bathysiphon nodosarieformis, Glomospira charoides*, of different systematic composition was found towards the east (Ust-Tim depression). Secretory-agglutinated, agglutinated, mainly quartz-siliceous forams of the genera *Bathysiphon, Ammodiscus, Glomospira, Trochamminoides, Haplophragmoides, Cribrostomoides, Adercotruma, Spiroplectammina* predominate here. Important is the presence of the Paleocene taxon *Trochamminoides* aff. *proteus* and of the Maastrichtian *Spiroplectammina* aff. *kasanzevi*. Such a complex is found in strata overlaying the Upper Maastrichtian foraminiferal zone. This complex corresponds to the Danian *Brotzenella praeacuta* zone. Comparison of this complex, with analogous one from the Russian platform, and the planktonic forams indicate a Danian age.

The investigated complex is very similar with the assemblage from the Alburgansky horizon (Northern Caucasus, Subbotina 1950) also found in rocks overlying Maastrichtian strata. Assemblages combining relict Cretaceous and new Paleocene taxa are typical for many regions including western Siberia.

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Cretaceous planktonic foraminiferal evolutionary events and correlations to other stratigraphies: the state of the art.

In the last years, Cretaceous planktonic foraminifera recovered from sedimentary successions worldwide in different geological settings, from deep sea to near shore open marine sequences, have been studied by several scientists. The remarkable depositional continuity in some of these successions allowed the refinement of the biozonal scheme implemented by new bioevents based on planktonic taxonomic groups other than those related to globotruncanids. Frequently the study of planktonic foraminifera was parallelled by a companion study on calcareous nannofossils, and thus the stratigraphic resolution increased considerably. A further effort was made to find firm tie-points between calcareous plankton bioevents and the ammonite scale, as well as in calibrating physical parameters such as magnetic polarity chronozones and prominent events in geochemical isotopic curves. The result of these efforts, although far from completed, is a stratigraphic framework which can be exported outside the tropical areas and to shallow-water sequences at least in some intervals of the Cretaceous. It should be noted that only rarely macrofaunal and calcareous plankton contents were exhaustively investigated from the same section, because studies of different taxonomic groups mainly progressed independently or because sediments rich in macrofossils yielded poor or non age-diagnostic calcareous plankton.

The numerous events based on calcareous plankton, chemo- and physical stratigraphies are subsidiary to ammonite or other macrofossil stratigraphic schemes and are useful tools to better approximate stage boundaries and, f.i., correctly date sequences in the absence of ammonites and other markers. Following the revised stratigraphy, (1) the Cenomanian/ Turonian boundary falls within the *Whiteinella archaeocretacea* Zone as does the Livello Bonarelli and the prominent δ 13C shift; (2) the *Helvetoglotruncana helvetica* Zone begins in the lowermost Turonian and extends to the upper half of the middle Turonian; (3) the *Marginotruncana sigali* Zone is confined to the middle Turonian; (4) the base of the *Dicarinella concavata* Zone correlates to the base of the upper Turonian and the zone extends from the upper Turonian through the Coniacian and possibly straddles the Coniacian/Santonian boundary; (5) the base of the *Dicarinella asymetrica* Zone falls very close to the base of the Santonian with the first occurrence of *Sigalia* and ventilabrellids almost coincident or slightly above the FO of *D. asymetrica*; (6) the Santonian/ Campanian boundary falls close to the top of the Cretaceous Normal Polarity Superchron (34N) and is best approximated by the FO of *Aspidolithus parcus parcus*; (7) the LO of the *Dicarinella asymetrica* is early Campanian in age and is equated to the termination of the Cretaceous Normal Polarity Superchron; (8) chron 33R spans the *Globotruncanita elevata* Zone and extends into the basal part of the *Globotruncana ventricosa* Zone; (9) the Campanian/Maastrichtian boundary is equated to the 32N/31R chron boundary, which falls within the *Gansserina gansseri* Zone; and, finally, (10) the 31N/31R chron correlates with the base of the *Abathomphalus mayaroensis* Zone.

These new correlations imply that the *Radotruncana calcarata* zone does no longer represent the uppermost zone of the Campanian as previously considered, and, moreover, also the *Globotruncanella havanensis* and *Globotruncana aegyptiaca* Zones, and apparently the lower half of the *Gansserina gansseri* Zone are all late Campanian in age.

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The Santonian-Campanian boundary in eastern and northern Tunisia, based on planktonic Foraminifera.

In northern and central-eastern Tunisia, Upper Cretaceous strata contain abundant and well preserved foraminifera. The Santonian/Campanian boundary is characterised by the extinction of *Dicarinella asymetrica* SIGAL and the persistence of *Globotruncanita elevata* BROTZEN. The uppermost Santonian contains the first *Globotruncana arca* CUSHMAN specimens. Furthermore, *Pseudoplanoglobulina austinana* CUSMAN extends into the Campanian.

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Hauterivian-Barremian boundary in the Western Carpathians marked by marine microplankton changes.

Hauterivian plankton association consisted predominantly of nannoflora (*Ellipsogelosphaera, Parhabdolithus, Cyclagelosphaera* and *Nannoconus).* Planktonic foraminifers *Globuligerina,* calpionellids (*Tintinnopsella carpathica*) and dinoflagellates were sporadic (Borza, 1984). The last calpionellids occur in nannocone wackestones of the lower part of the Pseudothurmannia Beds together with *Globuligerina hoterivica,* dinoflagellate cysts *Colomisphaera vogleri, C. heliosphaera, Cadosina fusca fusca, Stomiosphaera echinata, St. wanneri* and radiolarians (*Cecrops septemporatus, Triactoma echiodes, Podobursa triacantha, Alievium helenae, Acanthocircus dicranacanthus, Acaeniotyle umbilicata, Archaeodictyomitra rigida, Pantanellium lanceola*, etc.) (Vasíçek *et al.*, 1992).

Important qualitative change in plankton composition happened during latest Hauterivian (Vasíçek *et al.,* 1994). During the Hoterivica Subzone, calpionellids were gradually retreated by planktonic foraminifers (*Globuligerina hoterivica, Hedbergella subcretacea).* Besides them, nannocone mudstones of the upper Pseudothurmannia Beds (Angulicostata Zone) contain less frequent radiolarians and calcareous dinoflagellate cysts. Rich nannoplankton is represented by *Cretarhabdus crenulatus, Cr. conicus, Zygolithus compactus, Braarudosphaera bigelowi,* more sporadically by *Cyclagelosphaera margereli, Manivitella pemmatoides, Parhabdolithus* sp. and *Ellipsagelosphaera* sp. (Borza *et al.*, 1984).

Composition of the microplankton association did not change substantionally during the Hauterivian/Barremian transition. *H. tuschepsensis* (syn. *Hedbergella sigali)* indicating Early Barremian appeared in the planktic foraminifer association with common *H. subcretacea.* Nannoplankton association of this time was represented by thick-walled *Parhabdolithus* and similar forms.

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Microfossil and palaeoenvironmental data on the Cenomanian/ Turonian boundary in South Moravia (Czech Republic).

In south Moravia the Cenomanian\ Turonian boundary lies within the autochthonous Klement Formation deposited on the SE slopes of the Bohemian Massif in epicontinental sea depositional environment as a result of the global Upper Cretaceous transgression. In the underlier of the West Carpathian Flysch Belt the Klement Formation comprises the Upper Cenomanian-Lower Campanian stratigraphic interval whereas Turonian - Coniacian beds have only been determined at outcrops in the Zdanice Flysch Unit.

In deep borehole profiles the Cenomanian\Turonian boundary exhibits marked changes in lithology, facies development and microfossil assemblage composition due to sea level rise in the lowermost part of the Turonian stage. Consequently, this boundary has been evidenced by the core material at the transition beds situated here between sponge claystones and *Pithonella* marlstones facies. In contrary to the Upper Cenomanian beds the basal horizons of the Turonian deposits represent a striking increase in diversity\abundance of microfossil occurrences in particular referring to the calcareous dinoflagellate (Pithonelloidae KEUPP, 1987) and planktonic foraminifera assemblages.

Regarding calcareous dinoflagellate findings, the Cenomanian\Turonian boundary is characterised by *Bonetocardiella conoidea* (BONET), *B.* cf *betica* (AZEMA), *Pithonella trejoi* BONET species extinction and on the opposite, by the first *P. innominata lata* (ADAMS, KHALILI & SAID) and *P. biedai* (NOWAK) appearances.

Among Foraminifera, the assemblage with *Thalmaniella* cf. *appenninica* (RENZ) and *Whiteinella archaeocretacea* (PESSAGNO) is symptomatic for Upper Cenomanian deposits, whereas the Turonian borehole intervals studied are dominated by *Hedbergella* cf. *delrionensis* CARSEY, *H. planispira* (TAPPAN), *Helvetoglobotruncana helvetica* (BOLLI) and *Praeglobotruncana imbricata* MORNOD, representatives.

Contrasts established at the Cenomanian/Turonian boundary, in south Moravia corresponding both to facies development changes and microfossil diversity/abundance increase, arose by deposition area deepening (inner shelf-outer shelf environmental transitions) and by an extensive Mediterranean/ Tethyan microplanktonic influx into the margins of the Bohemian Massif.

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Unconformity-bounded stratigraphic unit in the Upper Cretaceous of Murge (Apulia, southern Italy).

In this study we propose the statement of an **unconformity bounded stratigraphic unit** in the Upper Cretaceous succession of Murge: the "Sinthem of south-east Murge limestones".
This Sinthem is bounded by two regional unconformities referred respectively to the Turonian and to the Paleocene-Miocene age. It includes the well-known units of "Calcare di Altamura", "Calcare di Ostuni", "Calcare di Caranna", as well as the recently defined unit "Dolomie di Monte S. Elia".

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Draft of the revised "Guidelines for the Establishment of Global Chronostratigraphic Standards by ICS".

The original Guidelines, regulating the procedure of defining chronostratigraphic standards, were issued by the Bureau of the International Commission on Stratigraphy (ICS), Cowie *et al.*, 1986. There are two main reasons for a revision:

(1) The principle of boundary-stratotypes (Global chronostratigraphic Standard Section and Points, GSSPs) has proved to be inapplicable to Precambrian strata in the absence of fossils; Proterozoic system boundaries have therefore been defined through absolute ages.

(2) Progress has been made in the field of non-biostratigraphic correlation methods. Members of the ICS Bureau have therefore prepared a new version of the Guidelines, which is actually being circulated in all subcommissions of ICS.

The most important statements of the revised Guidelines (many of them taken from the original ones) are:

(1) Chronostratigraphic units are defined by their lower boundary only, which becomes automatically the upper boundary of the underlying unit;

(2) All Phanerozoic chronostratigraphic boundaries down to stage level must be defined by a GSSP;

(3) Correlation precedes definition, the practical value of the envisaged boundary has to be tested first;

(4) There is no formal priority regulation in stratigraphy, the redefinition may change the position of a chronostratigraphic boundary, if necessary;

(5) Chronostratigraphic boundaries are conventional boundaries and can be decided upon by a majority vote.

The rest concerns the more technical aspects of the prerequisites to be fulfilled by a chronostratigraphic type-section:

(6) The type-section has to provide a sufficient unbiased and complete sedimentary record of the interval around the boundary (normal succession of strata exposed over an adequate thickness, continuous sedimentation, freedom from metamorphism and strong diagenetic alteration);

(7) The type-section should give access to as many methods of correlation as possible (rich, preferably marine fauna, radiometric dating, magnetostratigraphy, and chemostratigraphy).

All GSSPs have to be voted upon by the Full Commission of the ICS before being submitted to IUGS for ratification. So far only 20 of more than 100 stage boundaries have been defined. Due to this slow progress, stratigraphy has lost a good deal of its credit in the geological community. Future discussions about boundary definitions will not only have to bear in mind the prerequisites of the ideal type-section, but also to examine how far we can depart from this ideal and still respect the necessity of a workable definition.

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The Lower Cretaceous Gavelinellids (Foraminifera).

Gavelinellids are the oldest known representatives of the Rotalina and hence of considerable interest for evolutionary studies of Foraminifera. The earliest known representatives have been recovered from Hauterivian deposits. Gavelinellids radiated quite quickly and form an important part of the diversity in the Cretaceous. Confusion and other difficulties with their systematics has hampered the full use of this group for palaeontological and stratigraphical purposes.

The generic revision of, amongst others, gavelinellids has yielded a more clearly defined taxonomic framework. As a result, the concepts of the genera *Gavelinella, Berthelina* and *Lingulagavelinella* are now better constrained, allowing more consistent generic assignations to be made.

A closer study of Lower Cretaceous deposits in Australia, including core material from ODP Site 766 (Exmouth Plateau - Gascoyne Abyssal Plain) led to a substantial increase of species recognised.

The initial comparison between Lower Cretaceous Gavelinellids recovered from different geographic locations (Alaska - N. Canada; NW Europe; Australia) provides a strong indication of pronounced endemism. Taxonomic analysis shows that taxa like *G. sigmoicosta, B. intermedia* or *L. barremiana* are not as widespread as is often assumed in the literature. These preliminary findings raise questions as to the use of these taxa for biostratigraphic correlations on a world-wide scale.

The majority of Lower Cretaceous deposits represent shelf to upper bathyal environments. ODP Site 766 for the first time provides material from abyssal depths. The recovery of two new *Gavelinella* species of Late Hauterivian age not only consolidates the presence of *Gavelinella* as early as the Hauterivian, it also questions the classical model of radiation of Foraminifera. The hypothesis is put forward that *Gavelinella* originated in very deep water and subsequently colonised shallower environments. If corroborated, this hypothesis will force a reappraisal of the palaeobathymetric models based on Foraminifera used in the Lower Cretaceous.

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Preliminary data for the Campanian-Maastrichtian boundary in Central Tunisia (Tethyan Realm).

In the last decades, the position of the Campanian-Maastrichtian boundary in Central Tunisia - especially in the El Kef area - was placed successively:

- at the base of the *Bostrychoceras polyplocum* ammonite zone (in the upper part of the "lower Abiod" white limestones; Burollet, 1956, p.126);
- at the top of the "niveau à *Globotruncana calcarata*", planktonic foraminifera level (in the "marly alternation" between lower Abiod and upper Abiod; Dalbiez, 1956; Burollet & Sainfeld, 1956);
- at the disappearance of "*Archaeoglobitruncana kefiana*" (within the upper Abiod; Salaj,1969);
- at the appearance of "*Globotruncana falsostuarti*" (at the top of the upper Abiod; Salaj & Maamouri,1983);
- above the level containing the ammonite *Pseudokossmaticeras brandti* (in the uppermost part of the marly alternation; Salaj & Wiedmann,1989).

Recent investigations* in the Kalaat Senan area, about 50 km south of El Kef, show a lithological succession with almost the same characteristics as for El Kef. It is as follows, from the top to the bottom:

- El Haria Fm: basal marls with *Globotruncanita falsotuarti*
- upper Abiod: white limestones
  - *scaphitids at the top,
  - *in the lower third part: *Nostoceras alternatum* (Maastrichtian) and *Scaphites pumilus* (Hyatti Zone, Upper Campanian?)**
- marly alternation
  - *upper part with *Gansserina gansseri*
  - *lower middle part with *Globotruncanita calcarata*
  - *lower part with *B. polyplocum*
- lower Abiod: white limestones, the top with some *B. polyplocum.*

As *Pseudokossmaticeras brandti* is now considered as Upper Campanian, *sensu* Hancock & Kennedy 1993 (with a Maastrichtian beginning with the appearance of *Belemnella lanceolata*), the Campanian-Maastrichtian boundary in Central Tunisia seems to lie within the upper Abiod white limestones at the transition of *S.pumilus* and *N.alternatum.*

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* Litho -and biostratigraphical work in progress with F. Amédro, J.-M. Gonzalez Donoso, D. Linares, M. Caron, C. Dupuis, S. Gartner and A.V. Dhondt.

** Identifications by W.A. Cobban and F. Amédro are gratefully acknowledged.

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The Bahloul Formation and the Cenomanian-Turonian Boundary in Central Tunisia: New data and re-interpretation (biostratigraphy, geochemistry, microfacies)

In the Kalaat Senan area, several outcrops of the Bahloul Formation are well exposed and were described in regional studies the Cenomanian-Turonian (Robaszynski *et al.*, 1990, 1993, 1994). The oued Smara section (SM) was re-visited and new data are now available which support a re-interpretation of the Cenomanian-Turonian boundary position.

Lithology: from SM 108 m to SM 140 m, the succession can be divided in five parts, from the top to the bottom:

- above SM 137: Annaba Member (calcareous marls);
- SM 137-129: "post-Bahloul", mainly black marly limestones with some thin laminated Bahloul facies recurrences);
- SM 129-118: Bahloul Formation *s.s.* (millimetre thin laminated black limestones, with very few organic remains);
- SM 118-114.2: "pre-Bahloul" (one thick and several small calcisphere beds with some laminated beds);
- below SM 114.2: Fahdene Formation (marls and limestone beds with rich organic remains).

Microfacies: new observations of previous and recent thin sections show:

- calcispheres (frequent in open marine environments) abundant in the Fahdene and "pre-Bahloul" units,
- heterohelicids (frequent in stratified marine waters) beginning in "pre-Bahloul" and abundant above, especially in the thinly black laminated Bahloul *s.s.*,
- radiolarians : well represented in the Bahloul *s.s.*,
- filaments (micro-bivalves), whiteinellids and hedbergellids becoming frequent from SM 128 and higher.
- The last *Rotalipora cushmani* was found at SM 114,7 and
- the first *Whiteinella praehelvetica* at SM 131.

This indicates a Bahloul facies *s.s.* restricted to SM 118-128 with:
absence (or rare) of calcispheres,
absence (or rare) of filaments and whiteinellids,
absence (or rare) of ammonites,
presence of radiolarians and heterohelicids (*r*-speciation).

Ammonites. New records were made at SM 121 and between SM 128 and 132 and specimens previously collected were re-examined. All specimens were identified following recent publications and figurations, and some of them were submitted to W. A. Cobban who is greatly thanked.

The **biostratigraphical interpretation** is based on the Pueblo ammonite-zones succession where *Watinoceras devonense* Zone is considered as the base of the Turonian (Chancellor *et al.*, 1994).

- The last uppermost Cenomanian ammonite collected is *Pseudaspidoceras pseudonodosoides* at SM 121 (equivalent to the *N. juddii* zone).
- The first ammonites which are very probably Turonian are quite abundant imprints of *Watinoceras* sp. and *Fagesia* sp. from SM 128 to SM 132 and the presence at SM 130 of a badly preserved specimen of cf. *Pseudaspidoceras flexuosum.*

The Cenomanian-Turonian boundary lies between the two levels SM 121 and SM 128, within the mm thin laminated, black and anoxic part of the Bahloul Formation *s.s.*, where ammonites are very rare, small, smooth and flattened.

Geochemistry.

Total Organic Carbon : 2-4 % in the Bahloul *s.s.* (the most anoxic part of the Bahloul Fm *s.s.*), 0.2 - 1.5 % in "pre"-and "post-Bahloul".

Carbon Isotopes: δ13C :a positive excursion begins at the end of the Fahdene Formation then followed by two peaks, the first one at SM 117, the second at SM 121.5. On the basis of biostratigraphical data (ammonites, micro-and nannofossils), the δ13C evolution is compared with the carbon isotopic curves from Pueblo (Pratt, 1985), Dover (Lamolda *et al.*, 1994) and Menoyo (Paul *et al.*, 1994).

If the δ13C positive excursion records a global oceanic geochemical event, the Cenomanian-Turonian boundary can be placed after the last peak referring to the Pueblo section.

In the Smara section, this suggests a position of the boundary on isotopic carbon evidence between SM 121.5 and SM 128 or even SM 123.

Conclusion. Taking into account new data from fossil collecting and from geochemistry analysis and the new interpretation for the base of the Turonian at the first appearance of *Watinoceras devonense*, the Cenomanian-Turonian boundary in the Kalaat Senan area of central Tunisia is placed within middle to upper part of the Bahloul Formation *s.s.*

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Type-Locality proposal for the Albian-Cenomanian boundary in the Tethyan Realm: the Kef-el-Azreg section in Tunisia.

In Central Tunisia, the Kalaat Senan-Jerissa area exposes more than 600 m of Albian and 655 m of Cenomanian sediments deposited in a distal environment. The Upper Albian represents more than 400 m and the Lower Cenomanian about 300 m. The palaeogeographical position of the area is transitional between the platform and the deep basin favouring the development of continuous and dilated successions of marls and marly limestones and the presence of benthic to planktonic biota (ammonites, echinids, bivalves, planktonic and benthic foraminifera, nannoplankton etc).

The Albian-Cenomanian boundary is particularly well exposed at Kef-el-Azreg where the KZ section outcrops in tributaries of the Azreg wadi with a gentle 5-10° dipping on a large surface. At several levels, a channelling marks the sedimentation, especially in the Upper Albian, and is accompanied with phosphatisation of the fossil content. Moreover, transgressive flooding surfaces from the uppermost Albian to the Lower Cenomanian facilitate phosphatisation. The result is the presence, per hundred square metres, of hundreds of phosphatised fossils, especially ammonites, well and fully preserved or in fragments, not crushed, and with fine details in the ornamentation.

The succession of the most important biological events can be summarized as follows, from oldest to youngest:

- the last occurrence of *Planomalina buxtorfi* (planktonic foraminifera).
- the last occurrence of *Mortoniceras* (*Durnovarites*) (ammonite).
- the first occurrence of *Corollithion kennedyi* (nannoplankton).
- the first occurrence of *Rotalipora globotruncanoides* (pl.foram.).
- the first occurrence of *Lithraphidites pseudoquadratus* (nannopl.).
- the last occurrence of typically Albian ammonites: *Stoliczkaia* and *Mariella bergeri.*
- the first occurrence of typically Cenomanian ammonites: *Mantelliceras lymense, M. azregense, Sciponoceras roto* and *Hypoturrilites gravesianus.*
- the first occurrence of *Mantelliceras* aff. *saxbii, Sharpeiceras schlueteri* (amm.).
- the first occurrence of *Mantelliceras cobbani, Neostlingoceras carcitanense* and *Hypoturrilites schneegansi* (amm.).
- the first occurrence of *Mantelliceras mantelli* (amm.).
- the first occurrence of *Lithraphidites acutus*(nannopl.).
- the first occurrence of *Euhystrichoceras nicaisei* and *Algericeras.*
- etc.

As expressed by Odin (1992,following Cowic *et al*,1986), a GSSP ("Global Stratotype Section or Point") has to satisfy a number of criteria. In short, the Kef-el-Azreg section

1/ is easily accessible, in slightly hilly area, all along the year;
2/ a permanent artificial marker should be fixed in the outcrop;
3/ is in a distal marine semi-pelagic environment;
4/ the deposition is practically continuous, even phosphatisation affects several layers due to transgressive conditions;
5/ there are no structural complications;
6/ and no strong facies changes;
7/ a very good macro-and micropalaeontological record (more than 800 ammonites in a surface of thousand square metres);
8 & 9/ magneto-and chemostratigraphy can be applied. Moreover, a sequence interpretation was made for the complete Upper Albian-Cenomanian succession.

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paper

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The position of the Santonian-Campanian boundary in the Chartres area (Paris Basin, France).

To the North of Chartres, in and around the Eure Valley, several natural outcrops, pits and small quarries contained macrofaunas in a chalk-with-flint succession. More precisely, the chalk is a biocalcarenite with an abundant bryozoan fragments content which confers a strong porosity. Flint layers half-metre to two metres spaced are numerous and formed of decimetric flints, space or nearly coalescent on half-decimetre to three decimetres thickness.

Through an about 35 m succession, a macrofaunal sequence was found as follows, from the base to the top: *Echinocorys scutata*, *Uintacrinus* sp., *Conulus albogalerus*, *Marsupites* gr. *testudinarius*, *Micraster* sp. cf. *schroederi*, *Actinocamax verus*, *Offaster pilula*, *Gonioteuthis quadrata*. Benthic foraminifera associations can be calibrated on the vertical distribution of these macrofaunas.

The Santonian-Campanian boundary can be placed at the last appearance of *Marsupites* (following for example Mortimore,1986; Milsom *et al.*,1994) or at the first appearance of *Offaster* or of *Goniotenthis granulataquadrata* (the latter taxon appearing just before *G.quadrata*, following Bailey *et al.*,1983; Christensen *et al.*,1993).

This succession of the Chartres area seems to be more accessible and more fossiliferous than the recently described section at Cap d'Ailly (Bignot *et al.*,1993).

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The Albian-Cenomanian boundary in Northern California, U.S.A.

The potential stratotypes for the base of the Cenomanian Stage listed by the 3rd International Symposium on the Cretaceous System held in Copenhagen in 1983 (BIRKELUND *et al.*, 1984, Table 2) still have not produced the data to qualify them for the GSSP, and the Albian-Cenomanian boundary remains undefined. Nevertheless, there appears to be consensus that faunas with *Stoliczkaia*, *Beudanticeras*, and *Mortoniceras* are Albian, and mantelliceratine ammonites are Cenomanian. These conclusions are supported by the KZ section in Tunisia, and recent work there promises an Albian-Cenomanian definition based on lineages within these taxa (ROBASZYNSKI *et al.*, 1993). However, a main unresolved taxonomic problem that affects correlation is how to identify juveniles in the transition from *Stoliczkaia* to Mantelliceratinae. A solution to this problem is necessary before adequate correlation within the Albian-Cenomanian boundary interval can be accomplished.

The Albian-Cenomanian boundary in northern Californian is in a thick sequence of pelagic siltstones and fine-grained sandstones interbedded with pebbly mudstones and polymictic conglomerates that crop out on the west side of the northern Sacramento Valley. The sediments are interpreted as having accumulated as part of a deep-sea fan. The coarse-grained deposits reflect accelerated uplift in the source area to the east and northeast from the region presently occupied by the Sierra Nevada Range. These large, rapid uplifts of the source area, however, produced no significant biostratigraphic gap in the Albian-Cenomanian boundary interval of the Dry Creek section in Tehama County. This section provides an important confirmation of the Albian-Cenomanian boundary sequence in other regions of the Tethyan province, and it also provides an important link connecting Europe and North Africa to regions around the Pacific Rim.

The ammonite-based Albian-Cenomanian boundary in northern California is between the last occurrence of the typically Albian genera *Mortoniceras* and *Stoliczkaia*, and the entry of mantelliceratine juveniles, identified as *Graysonites*, associated with *Mariella*. *Pseudouhligella japonicum*, heretofore regarded as a Cenomanian indicator in Japan, Alaska, and California, occurs in northern California in the Upper Albian with *Mortoniceras* and *Stoliczkaia*, and in the Lower Cenomanian with *Graysonites*, *Sciponoceras* and *Mariella*.

The revision of the range of *Pseudouhligella japonicum* together with collation of the ammonite and foraminiferal studies in the Dry Creek section and review of the foraminiferal literature show that all previous localities in the Chickabally Member of the Budden Canyon Formation previously assigned a Cenomanian age are Late Albian (MARIANOS & ZINGULA, 1966; DAILEY, 1973).

Studies of Radiolarians from the Dry Creek section lack detailed sampling through the boundary interval and we are not yet able to evaluate the potential of this group. However, it is clear from the ammonite data that locality NSF 934 of PESSAGNO (1977) is in the Upper Albian, not in the Lower Cenomanian.

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Calcareous nannoplankton and the position of the K/T boundary in the Geulhemmerberg section (Maastrichtian type area, The Netherlands)

In the type area of the Maastrichtian the K/T boundary has always been equated with the Vroenhoven horizon, a hardground separating the Maastricht Formation from the overlying Houthem Formation. The recent discovery of a 1.8 m thick sequence with fining-up calcarenites and thickening-up clay layers in man-made caves near Geulhem drastically changed the existing stratigraphic framework. The sequence occurs below the Vroenhoven horizon and it seems to drape and fill a Late Cretaceous paleorelief.
Calcareous nannoplankton analyses of the sequence gave ambiguous results:
- Light microscopy indicated the presence of the Early Danian and the latest Maastrichtian separated by a hiatus encompassing the earliest Danian; the latter could explain the absence of an iridium anomaly,
- SEM analyses, however, revealed that the whole section, including the top part of the Maastricht Formation, is of Early Danian age. This is in line with earlier reports on the presence of Early Tertiary nannoplankton taxa in the Maastricht Formation, occurring as low as the Mb.

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Non-marine Cretaceous correlation using seismic stratigraphy

The Wealden "facies" refers to the development of non-marine Lower Cretaceous strata age that are found at outcrop in the type localities of the Wessex Basin, southern England (and adjacent subsurface) and in extensive and thick successions filling the North Celtic Sea Basin.

Elucidating the climatic, tectonic and sea-level controls on Wealden facies sedimentary processes and stratigraphy has long proven difficult through lack of common or high-resolution biostratigraphy.

Analysis of seismic data, through seismic facies and sequence stratigraphic analysis, allows direct comparison of the Wealden in these basins, and new interpretations to be made of the tectonic and depositional influences. In the north-eastern end of the North Celtic Sea Basin, tectonic controls on seismic facies can be demonstrated and are related to coarse-grained fan-delta horizons documented in core. In the south-western North Celtic Sea Basin, adjacent to the Cretaceous proto-Atlantic, tectonic controls are less apparent, and changes in relative sea level were probably more important in controlling the preservation of stratigraphic sequences. Where the non-marine Lower Cretaceous succession is imaged clearly, the stratigraphic similarity between parts of the North Celtic Sea and the Weald and Channel Basins suggests a wider control by relative sea-level fluctuations. However, important variations in seismic facies within the basins indicate localised, dominant tectonic control.

The recognition of a very distinctive "lower" Wealden seismic facies, observed as undulatory (?channelised), domal (?lowstand fans) and downlapping reflections, is contrasted with the parallel/synsedimentary fault-dominated "upper" Wealden facies. These seismic characteristics reflect the previously recognised climatic/tectonic change from Hastings to Weald Clay Group environments: namely, a rift-dominated, humid and high run-off early Wealden to a post-rift, seasonally dry later Wealden facies. The debate on tectonics vs. eustacy is further complicated: palaeoclimate appears a third process responsible for stratigraphic variation. The implications of this third controlling factor have yet to be fully realised.

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Cretaceous stage boundaries in Tunisia, based on Foraminifera.

The IGCP 262 meeting in Urbino (Monechi-Trevers, TCC News 4, 1989) recommended 4 Cretaceous standard profiles for the Tethyan Realm.

We selected two: the profile in the area of Dj. Oust (for Berriasian-Albian stratigraphy - Maamouri et al., 1994) and the profile of El Kef (Cenomanian - Maastrichtian - Salaj, 1980; Salaj & Maamouri, 1987; Salaj & Wiedmann, 1989).

These profiles were also dated by macrofauna (Castany, 1951; Burollet, 1956; Busnardo & Memmi, 1972 a.o. Moreover at El Kef, Dalbiez (1955) described the first zonal division in the world based on planktic foraminifers. Equally at these profiles several stratotype boundaries have been proposed (Birkelund *et al.*, 1984; Salaj, 1984; CP/-Washington, 1989) including the proposal of the El Haria Formation as the marine stratotype for the Paleocene (Salaj, Pozaryska & Szczechura, 1976). On basis of Foraminifera (F.A.) we propose the following stratotype boundaries (base): for the Hauterivian: *Globuligerina hoterivica*, for the Barremian: *Hedbergella tuschepsensis* (syn. *sigali*), for the Aptian: *Leupoldina cabri*, for the Albian: *Hedbergella globigerinellinoides*, *Haplophragmoides nonioninoides*, *Biticinella* n.sp.; for the Cenomanian: *Thalmanninella brotzeni*, *Th. ticinensis* - conical form; for the Turonian: *Dicarinella imbricata*, for the Coniacian: *D. concavata*, for the Santonian: *Sigalia carpathica*; for the Campanian: *Globotruncana arca*, *Neoflabellina rugosa* and for the Maastrichtian: *Archaeoglobitruncana kefiana* Salaj & Wiedmann, 1989.

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Calcareous nannofossils and Campanian stage boundaries on the Brazilian continental margin: review and state of the art.*

(*) This is a contribution to IGCP Project 381, "South Atlantic Mesozoic Correlations".

The first appearance (FA) of *Aspidolithus parcus* has been considered in the literature either to coincide with the Santonian-Campanian (S/C) boundary or lie immediately above it. The extinctions of *Lithastrinus grillii* and *Marthasterites furcatus* are believed to have occurred in the oldest part of the Campanian. Moreover, the Campanian-Maastrichtian (C/M) boundary has been placed between the first appearance and extinction levels of *Quadrum trifidum*. However, a more precise characterisation of the C/M boundary involves other species, some of which, apparently, display geographically diachronous extinctions. For instance, a number of authors hold that the species *Eiffellithus eximius* and *Reinhardtites anthophorus* became extinct at the end of the Campanian. Others believe that these bio-events may have taken place either at the end of the Campanian or that beginning of the Maastrichtian, depending solely on the area studied. There have been several steps in the identification and delimitation of the Campanian in the Brazilian continental margin. The first research studies identified the S/C boundary at the last appearance (LA) of *L. grillii* and *Petrobrasiella venata*. *P. venata* was later abandoned as an index species and the extinction of *M. furcatus* became the new datum, considered to be more important than the LA of *L. grillii*. Thus, the dating of these biohorizons diverged from that found in the literature. These extinctions, rather than having occurred within the Campanian, were considered to mark the end of the Santonian, as suggested by correlations with other microfossil groups (foraminifera and palynomorphs). To explain this diachronism the existence of a condensed zone was postulated in most of the Brazilian marginal basins, where the uppermost Santonian deposits are apparently indistinct from those of the lowermost Campanian. At present, in line with concepts stated in the literature on nannofossils and with new information obtained from core and side wall samples of the Campos Basin, in southeastern Brazil, it is believed that the extinction of these species took place in the earliest Campanian.

The C/M boundary was initially characterised by the LA of *A. parcus*, later identified by the LA of *E. eximius*. However, that boundary has always been marked within the range of *Q. trifidum*. Recent works on the Santos and Campos basins have provided more data on the *Reinhardtites levis* and *A. parcus* extinction levels, which seem to be in the early Maastrichtian. The LA's of *R. anthophorus* and *E. eximius* were placed immediately below the C/M boundary. Further studies are required to integrate the nannoplankton, foraminiferal and palynological data.

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Age of the Albian/Cenomanian boundary: a graphic correlation solution.

Recently, the absolute age of the Albian/Cenomanian boundary has been revised downward to 98.5 +/-0.5 Ma by Obradovich (1993). Analysis by graphic correlation of European and North American key sections, however, suggest that this revision should be reconsidered. The biostratigraphic definition of this boundary in the type region in France and in neighbouring areas of the U.K. by ammonites is well known and generally accepted. The uppermost zone in the Albian is the *Stolickzkaia dispar* Zone, and the basal Cenomanian zone is the *Neostlingoceras carcitanse* Subzone of the *Mantelliceras mantelli* Zone (Birkland *et al.*, 1990; Hancock *et al.*, 1993). Unfortunately, radiometric dates from these reference areas have been unsatisfactory. The most reliable and precise date near the Albian/Cenomanian boundary is from the Clay Spur Bentonite in the Western Interior of North America, which is 97.17 +/- 0.69 Ma (Obradovich, 1993). However, the ammonites in this basin are endemic and cannot be readily correlated with the European zones (Cobban & Kennedy, 1989). Furthermore, palaeoenvironmental conditions precluded planktic foraminifers and nannofossils from the basin. But, dinoflagellates, spores and pollen do occur with these ammonites and they are also present in the northern European sections, so they provide a common succession for correlation.

Six key taxa have LADs in the Late Albian: *Appendicisporites unicus*, *Classopollis echinatus*, *Janusporites spiniferus*, *Litosphaeridium conispinum*, *Oligosphaeridium totum minor*, and *Trilobosporites apiverrucatus.* Seven taxa have FADs in the Late Albian: *Apteodinium grande*, *Florentinia verdieri*, *Odontochitina singhii*, *Ovoidinium verrucosum*, *Palaeohystrichophora infusorioides*, *Rugubivesiculites rugosus*, and *Subtilisphaera cheit.* The Early Cenomanian is indicated by the LADs of *Afropollis jardinus*, *Apteodinium grande*, *Ginginodinium evitti*, *Luxadinium propatulum*, *Muderongia asymmetrica*, *Neoraistrickia robusta*, *Ovoidinium verrucosum*, *Pilosisporites trichopappilosus*, *Pseudocertium expolitum*, and *Stellatopollis barghoornii.*

The ranges of these and other palynomorph taxa are related to the ranges of ammonites in the composite section in the Sarthe area of France, in the Boulonnais coastal section of northwest France, in the Folkestone and Isle of Wight sections in England by the quantitative stratigraphic technique of graphic correlation.

The Albian/Cenomanian boundary as defined in France and recorded in the composite standard data base correlates with the base of the *Graysonites adkinsi* Zone in north Texas. This is consistent with planktic foraminiferal data. In the southern part of the Western Interior the Albian/Cenomanian boundary in the composite standard correlates with an erosional sequence boundary within the mainly non-marine Dakota Formation. In Wyoming the Albian/Cenomanian boundary correlates with the Caly Spur Bentonite at the top of the Mowry Formation and the top of the *Neogastroplites maclearni* Zone of Cobban. This analysis suggests that the age of this boundary is about 97 Ma.

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Turonian Inoceramid evolution and its use for stage and zonal boundary definition.

In the northern hemisphere, the Boreal Realm as well as temperate parts of the Tethyan Realm of the Cretaceous seas yield lots of *Inoceramus* species with high individual numbers. Especially throughout the Turonian, the low-oxygen tolerant inoceramids are much more common and widespread than the ammonites. Thousands of specimens studied in the past twenty years show that flood occurrences are coeval with evolutionary peaks (Events in Fig.I). Within these events, the appearance of inherited characters is common as well as the evolution of new ones, both sometimes combined in iterative recapitulation. So, biostratigraphic work is more precise, especially in deeper Turonian strata, using morphovariants of the diverse events than distinct species that represent only spots of a greater morphological variation. According to this concept, manyTuronian inoceramid species, especially from levels of the four *Mytiloides* Events are morphovariants of a few diagnostic species. Only the better known "morphovariant-species" are listed below to give an idea of the concept. The Cenomanian-Turonian Stage boundary is characterised by a severe reduction in inoceramid evolution. The base of the Turonian can be defined by the extinction point of *I. pictus pictus* and the entry of *I. pictus sackensis* as an offshoot of *I. pictus bohemicus*. The 1st mytiloides Event show morphovariants from *pictus*-like (pictid forms, left side of Fig.I) to nearly *mytiloides*-like forms (middle part of Fig.I), and contains *I.(M.) hattini* as transitional species between *I.pictus sackensis* and *I.(M.) wiedmanni* (= *I. (M.) submytiloides* and *I.(M.) opalensis auctorum*). The Lower Turonian can be divided by means of three mytiloides Events, each of which contains a distinct morphological variation: 1st ME (see above); 2nd ME of *I.(M.) mytiloides* (pictid early forms of *I.(M.) labiatus*; *I.(M.) transiens*; *I. columbianus auctorum*, which is a morphovariant of the Barremian-Aptian *plicatus* d'ORBIGNY-group), and 3rd ME of *I.(M.) labiatus* (pictid narrow forms leading to *I. apicalis*; *I.(M.) goppelnensis*: *I.(M.) opalensis* s.s.; *I.(M.) subhercynicus*; *I. plicatus* auctorum). The Lower/Middle Turonian boundary shows a further reduction and new evolutionary steps. It can be defined by the extinction point of *I.(M.) mytiloides* s.l. and the appearance of *I. apicalis* together with the beginning of the 4th ME of *I.(M.) hercynicus*. This ME includes the last acme of *I.(M.) labiatus*, leading to *I. cuvierii* via intermediate forms represented by the *I. hobetsensis*-group. Another peak of the ME lies in the *Mytiloides*-Main Lineage with mytiloid forms like *I.(M.) duplicostatus* on one side and subcircular ones like *I.(M.) hercynicus* on the other, both characterised by a distinct double-ring morphology. The Middle Turonian itself can be divided by several subspecies of the *I. lamarcki/flaccidus*-group as offshoots of *I. apicalis*, ranging into the Upper Turonian, often being ecologic substitutes of the *I. cuvierii/latus*-group. The Middle/Upper Turonian boundary represents the next cut in frequency and evolution. It can be defined by the extinction points of *I. propinquiformis*, *I. cuvierii*, and *I. latus* as well as the appearance of *I. costellatus*. The Upper Turonian is characterised by another rapid evolution with numerous still mytiloid or even pictid forms (*I.(M.) lusatiae*, *I.(M.) labiatoidiformis*, *I.(M.) incertus*, etc.), and subcircular to circular forms as *I.(M.) striatoconcentricus*, most of them ranging up into the Lower Coniacian. The Turonian-Coniacian Stage boundary is marked by the development of the *Cremnoceramus* group, starting polyphyletically with the more mytiloid-subcircular *I. (Cr.) waltersdorfensis* leading to *I. (Cr.) deformis erectus* and the more subcircular *I. (Cr.) stillei* (= senior synonyrn of *I.(Cr.) rotundatus*) leading to *I. (Cr.) deformis deformis*.

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Berriasian and "Ryazanian" stages in Russia and J/K boundary in the boreal realm.

Of great significance for drawing the J/K boundary in the Boreal Realm is the correlation of Berriasian and "Ryazanian" stages. Such a correlation can be conducted on the basis of a Berriasian section in the Northern Caucasus, including together with typical Tethyan ammonites specific *Riasanites* and *Euthymiceras* fauna. The authors participated in study of the section along Urukh River in the Northern Caucasus. As a result of the study of ammonites from this section a detailed stratigraphic chart was developed, which is correlated with the stratotype (Table). The basic markers for correlation are *Dalmasiceras* and *Euthymiceras*. It is ascertained, that the *Riasanites* fauna is not older, than the Late Berriasian (above the *Dalmasiceras* level) and the Ryazanian is of Late Berriasian age. Distinguishing of two *Riasanites* levels, separated by *Euthymiceras* level in the Urukh section indicates, that the *Riasanites rjasanensis* s.l. Zone of the Russian Platform corresponds to the *Paramimounum* Subzone of the European scale. The upper *Riasanites* level most likely corresponds to the *Picteti* Subzone and has no equivalents in the Ryazanian. Here, the *Surites tzikwinianus* Zone possibly corresponds to the rest of the Upper Berriasian. With the Lower Berriasian we correlate the Upper Volgian substage. In the authors' opinion this can be based on the following items: 1. Similarity between the Upper Volgian and lowermost Ryazanian ammonite faunas; 2. Zeiss's and Kutek's data on correlation of the Tithonian and Volgian; 3. Association of the Upper Volgian *Buchia* and Lower Berriasian ammonites in the Far East of Russia, California and British Columbia. However, the problem of isochroneity of the Berriasian and Upper Volgian bases remains unsolved.

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Dinoflagellate stratigraphy of the Upper Cretaceous formations in Hungary.

Upper Cretaceous formations can be found in four Hungarian regions. The most complete sequence is developed in the Transdanubian Central Range (TCR). Here marine formations (Jako Marl, Ugod Limestone, and the younger Polany Marl Formation) are continuously developed on top of fluvial lacustrine sediments.

Stratigraphy based on palynology, malacology, and foraminifera has allowed to place the formations from the TCR in different periods of the "Senonian". Study of dinoflagellates was introduced recently. Dinoflagellates occur frequently in the marl formations and allowed a division in two zones each divided in two provisory subzones: *Odontochitina* Zone with *Apteodinium* and *Spinidinium* Subzones; *Pyxidinopsis bakonyensis* Zone with *Dinogymnium euclanis*, *Pterodinium cingulatum - Isabelidinium bakeri* Subzones.

The dinoflagellate zones are correlated with nannofossil zones based on the determinations of Wagreich (Siegl-Farkas 1995; Siegl-Farkas & Wagreich, 1994). The formations in TCR belong to nannofossil zones CC16-CC22c.

Based on correlation of magneto- and biostratigraphy the Santonian-Campanian boundary is at the top of the lower third of the Jako Marl, from where Summesberger (in Partenyi, 1986) identified *Placenticeras polyopsis*; this is in the upper part of the *Hungaropollis* Dominance-Zone, at the basis of the *Odontochitina* Zone and within the CC17b nannofossil Zone.

The boundary between the *Odontochitina* and the *Pyxidinopsis bakonyensis* Zones coincides with the transition of the CC21 to CC22 Nanno-zones. It is certainly a good datum for further correlations.

The CC22c Zone indicates the Campanian-Maastrichtian boundary at the top of the Polany Marl. A new palynozone, the *Plicapollis-Subtriporopollenites* Assemblage Zone was introduced here. Dinoflagellates were rare.

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Lower/Upper Maastrichtian boundary: a palaeaooceanographic and palaeoclimatic study from the North Sea Basin.

At the last substage boundary in the Cretaceous, the lower/upper Maastrichtian, there are major climatic changes on a global scale. A high resolution study of stable carbon and oxygen isotopes in monospecific foraminiferal samples from sections in Denmark and Germany, has permitted a modelling of the climatic development in the North Sea Basin during the last epoch of the Cretaceous. The lower Maastrichtian at these sites is marked by a regression trend that reaches a climax just before the boundary. The base of the upper Maastrichtian is defined at the FAD of the coccolithophorid *Nephrolithus frequens*. This is an alternative to the FAD of the planktonic foraminifer *Abathomphalus mayaroensis* that is the most commonly accepted marker for the upper Maastrichtian. This species, however, is not occurring in northern European sections. The boundary is marked with a trend towards colder climates and a deepening of the basin. The sea level is on a global scale oscillating at the mid Maastrichtian and the observed changes in the studied sites are well reflecting the proposed changes at the very boundary. The productivity in this part of the North Sea Basin was slowly decreasing towards and somewhat across the boundary. A clear positive trend in the carbon isotopes is observed synchronously with the transgression in the lower Upper Maastrichtian. A major dissolution event that was previously regarded as the Lower/Upper Maastrichtian boundary, occurs in the upper Lower Maastrichtian. This event is probably of a regional character and occurs as the result of an interaction between the regression and the incoming of North Atlantic water into the North Sea Basin which is otherwise dominated by a Tethys influx. The material was also carefully examined in the SEM for any diagenetic effects. It was shown that recrystallisation has occurred in the foraminifera tests. However, this is not thought to be of any major importance for the isotopic signals which most likely have registered the composition of the ambient waters during the test formation.
There is thus a change in climate in the mid-Maastrichtian. This is the last of climatic events that take place in the Cretaceous preceding the major mass extinctions at the Meso-Cenozoic boundary some five million years later.

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Pollen response to short term climatic changes in the Late Maastrichtian at ENCI, South Limburg, The Netherlands.

The study is based on a quantitative palynological analysis (Normand, 1993) of a very detailed sampling of a 2 m 50 sequence of chalk taken below the Horizon of Nivelle, in the upper part of the Gulpen Formation, late Maastrichtian, at the ENCI Quarry Maastricht, South Limburg, The Netherlands. This chalk is very rich in dinoflagellates (several thousands per gram) but rather poor in pollen and spores (a few tens per gram). Despite the scarcity of the pollen content a very clear quantitative response is shown to short term climatic changes deduced from an isotopic analysis (18 O/16 O) made on the samples. A progressive and cyclic cooling of the sea water upwards in that sequence (based on the isotopic analysis of sediment where planktonic elements - coccoliths - are very dominant) is matched by greater amount of pollen of the types *Normapolles* and *Triporates* received from the continent. They are supposed to represent temperate forest elements of a vegetation also containing subtropical elements such as palms. A trend for the pollen to anticipate the more progressive cooling of the water is noted. A correlation between these and Milankovitch cycles is attempted.

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Cretaceous stratigraphy of the Cauvery basin, S.E. India.

Until the late Jurassic-early Cretaceous, India was joined with Australia and Antarctica. The Precambrian crystalline basement first began rifting in the latest Jurassic and a number of half-grabens were developed. In these half-grabens plant-bearing clay-rich sediments deposited in lacustrine environments. Rifting of the Cauvery Basin continued in the early-middle Cretaceous and, probably in the late Aptian, marine sedimentation was initiated. The mid-upper Cretaceous succession is well established using foraminifera (and ammonites) and the pattern of sedimentation closely follows the global sea-level curve. Further rifting and basin subsidence continued adjacent to the present coastline, but the on-shore part of the Cauvery Basin appears to have stabilised by this time.The late Turonian regressive event is particularly well marked, with the development of near-shore or even estuarine facies. These sediments are characterised by the presence of mono-specific molluscan shell banks and an abundance of tree fragments (many of which have been intensely bored by bivalves). The remainder of the Cretaceous succession is very thin, with major sequence boundaries representing considerable periods of non-deposition. The sediments in the on-shore part of the basin (Ariyalur-Pondicherry Depression) are clastic-dominated and characterised by an abundant macro fauna and significant numbers of larger foraminifera (Orbitoides sp. and Siderolites sp.). The stratigraphy of the basin was first described by Blanford in the 1860's but it is only relatively recently that integrated micropalaeontological and sedimentological studies have been undertaken. This new interpretation of the succession and a revised stratigraphy will be presented.

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The Late Albian in borehole Kirchrode I from the Lower Saxony Basin - results from benthic microfossils.

A 245 m long continuously cored profile at Kirchrode near Hannover (F.R.G.) through the early and middle Late Albian into the late Late Albian was studied for benthic organisms, such as foraminifera, ostracods, echinoderms, as well as for remains of inoceramids and aucellinids.
The core has recovered sediments from an epicontinental basin that was not reached by coarse terrigenous input, but where hemipelagic sedimentation occurred.
Information from benthic organisms is used to:
1. detect phases of increased bottom water flow,
2. explain the cyclic changes in calcium carbonate content of the sediment.

It seems that the main factor that changed between the alternating marls and clayey marls was palaeoproductivity.
We interpret the cyclic abundance changes in benthic foraminifera as 100 000 cycles, thus getting a means for time control on the duration of the Late Albian.

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Coniacian to Maastrichtian stratigraphy in Japan.

Integration of ammonite-, inoceramid-, foraminiferal-, radiolarian-, calcareous nannofossil- and magneto-stratigraphy of the Upper Cretaceous System in Japan has been tentatively carried out through recent biostratigraphical researches (Toshimitsu *et al.*, 1995).

The Coniacian Stage is divided into three zones by means of collignoniceratids and inoceramids. *Inoceramus rotundatus* is a good marker of the lowest Coniacian. Recently, Noda (1995) has reported the occurrences of the following five inoceramid species: *In. (In.) lusatiae*, *In. (Cremnoceramus) deformis*, *In. (Cr.) emsti*, *In. (Cr.) lueckendorfensis* and *In. (Volviceramus) koeneni*, which are useful for the interregional correlation with the European Coniacian Stage. The *Dicarinella canaliculata - Marginotruncana marginata* Acme-Zone (upperTuronian to Coniacian), including the *D. primitiva*Zone (lower Coniacian) is perceived, on planktonic foraminifers.

The Santonian stage of Japan is characterised by *In. amakusensis*, *Texanites collignoni* and *Te. quinquenodosus* occur in the lower part, and *Plesiotexanites kawasakii* and *Pl. pacificus* in the upper part. Moreover, the Santonian is subdivided by two planktonic foraminiferal zones: the *D. concavata* Acme-Zone (below) and the *Rosita fornicata - M. pseudolinneiana* Concurrent range-Zone (above).

The so-called Campanian stage in Japan may be divided into five zones by collignoniceratid and nostoceratid ammonites, and be divided into four inoceramid zones. *Menabites mazenoti*, *Submortoniceras* cf. *condamyi* and *In. (Platyceramus) japonicus* define the basal zone. The *Globotruncana arca* Assemblage-Zone of planktonic foraminifera is recognised in this stage. Calcareous nannofossil zone CC18 is located in the upper part of the *In. (P.) japonicus* Zone, that is, in the lower (not lowest) part of the Campanian. Marine reverse magnetic chron 33r is situated in the lower part of the *Sphenoceramus schmidti* Zone (middle part of the Lower Campanian) in northern Hokkaido, which agrees with the proposal by Lillegraven (1991).

The Maastrichtian Stage may be divided into at least three zones by means of pachydiscids and inoceramids. As to planktonic foraminifera, the *Rugoglobigerina* Assemblage-Zone is recognised in the Maastrichtian of Japan. Regrettably, *Marsupites*, belemnoids, *Placenticeras* and *Sphenodiscus* are so far absent in the above sequence.

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Problems of Cenomanian stage in eastern Germany.

There are two main profile types concerning to the development of the Albian/Cenomanian stage boundary, to hiatuses in the Cenomanian profile and to its facial development.

A **northern profile type** is situated in Mecklenburg-Vorpommern, in northern Brandenburg, in the region of Altmark and the western part of the Subhercynian Basin. A transition between Late Albian marls and Early Cenomanian marls and clayey limestones was observed in wells in this profile type. Outcrops do not exist excluding the western part of the Subhercynian Basin. The Late Albian yields rare belemnites - *Neohibolites minimus* (MILLER) -, rare brachiopods, common *Aucellina gryphaeoides* (SOWERBY) and rare *Inoceramus anglicus* WOODS. The Albian/ Cenomanian boundary is fixed by inoceramid fragments which may belong to *Inoceramus anglicus* WOODS and by *Inoceramus cripsii cripsii* MANTELL.

Specimens of *Aucellina gryphaeoides* (SOWERBY) and *Neohibolites ultimus* (d'ORBIGNY) were observed especially in the nearshore regions (*Aucellina/ultimus* - event *sensu* G.ERNST). A similar lithological transition with intercalated glauconite lenses and phosphorite pebbles marking small hiatuses characterises the western part of the Subhercynian Cretaceous Basin (region Kleiner Fallstein, Salzgitterer Höhenzüge). By means of ammonites it is possible to differ the following Cenomanian zones in the last mentioned region: **Early Cenomanian** - *Mantelliceras mantelli, Mantelliceras saxbii, Mantelliceras dixoni*. **Middle Cenomanian** - *Turrilites costatus, Turrilites acutus, Acanthoceras jukesbrownei*; **Late Cenomanian** - ammonites are absent. The base of the Early Turonian is fixed by the first appearance of *Mytiloides (M. hattini* ELDER).

Late Albian is completely missing in the **southern profile type** (Southern Brandenburg, eastern part of the Subhercynian Cretaceous Basin, Eichsfeld graben and Cretaceous of Saxony). The Eichsfeld graben system yields a nearly complete Early Cenomanian profile near Holungen. Two Early Cenomanian sequences are developed comparably to the basal sequences described by ROBASZYNSKI et al. (in press) from the Anglo-Paris basin. The basal sequence resting upon Triassic (Mittlerer Muschelkalk) with a small disconformity consists of conglomerates, greensand and calciferous siltstones. The sequence 2 in the hanging wall comparable with the basal sequence in the eastern part of the Subhercynian Cretaceous Basin consists of basal conglomerates, greensand, sandy limestone and limestones. The basal conglomerates and the greensand yield reworked phosphorite pebbles with Early Cenomanian fauna including sponges, lamellibranchs, brachiopods and rare ammonites.

In the Eichsfeld region and the eastern part of the Subhercynian Cretaceous Basin uppermost Early Cenomanian and lowermost Middle Cenomanian are missing.

The *schoendorfi*- and *atlanticus* - Middle Cenomanian inoceramid zones especially are developed in the eastern part of the Subhercynian Cretaceous Basin.

Cretaceous of Saxony: Early Cenomanian conglomerates and greensands resting upon Hercynian monzogranites are present in the region of Meissen (sequence 2 of Eichsfeld). Marine Middle Cenomanian sediments are missing. The fluviatile-limnic Niederschöna formation mostly of Middle Cenomanian age is influenced by ingressions in its uppermost parts. The main transgression took place in the lower part of the Late Cenomanian. Late Cenomanian is shown by *Calycoceras naviculare* (MANTELL), *Metoicoceras geslinianum* (D'ORBIGNY), *Euomphaloceras septemseriatum* (CRAGIN) and by *Actinocamax plenus* (BLAINVILLE). The Cenomanian/Turonian boundary is fixed by a sharp sequence boundary (base of the Lohmgrund marl). Some meters in the hanging wall of this boundary *Mytiloides hattini* ELDER was observed in wells in Dresden.

All profiles in eastern Germany are not useable for establishing an Albian/Cenomanian od Cenomanian/Turonian boundary stratotype.

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Hauterivian/Barremian boundary in the Western Carpathians.

The West Carpathian reference section of the Hauterivian/Barremian boundary is exposed in the Polomec hill quarries near Lietavská Lúçka (Krízna Nappe of the Strázov Mts, cf. Borza *et al.*, 1984). In accordance with the results of the Copenhagen (1983) and Mula (1993) meetings (Hoedemaeker *et al.*, 1993), we put this boundary between the ammonite Angulicostata- and Hugii Zone. Recently, the ammonite biostratigraphy of the section was supplemented by the microplankton study.

Ammonite association of the Ptychoceras Beds (marly nannoconid wackestone / mudstone) contains *Euptychoceras borzai* along with other less frequent species accompanied by microfauna of *Tintinnopsella carpathica, Globuligerina* sp., dinoflagellate cysts of *Colomisphaera vogleri, C. heliosphaera, Cadosina fusca fusca, Stomiosphaera echinata, St. wanneri,* radiolarians, sponge spicules, foraminifers, ostracods, aptychi and uniserial bryozoans.

Ammonite association of the Angulicostata Zone dominated by *Pseudothurmannia* and *Crioceratites* occur in nannoconid wackestone of the Pseudothurmannia Beds. *Crioceratites binelli* and the last pseudothurmannias (*P. mortilleti*) along with the last lamellaptychi survived until the Hauterivian/Barremian passage (Vasíçek *et al.*, 1994). Hedbergellid and globigerinelloid foraminifers (*G. hoterivica, H. subcretacea*), which substituted the calpionellid microplankton occur together with fragments of aptychi, brachiopods, bivalves, ostracods; radiolarians and calcareous dinoflagellate cysts are infrequent.

Veveysiceras escheri, Hamulina lorioli, sporadically also *Spitidiscus* ex. gr. *hugii* indicating the Hugii Zone appeared as the first representatives of the ammonite association of the overlying marly limestone complex (Vasíçek & Michalík 1988). Hedbergellid foraminifers (*H. sigali, H. subcretacea)* accompanied by abundant nannoplankton dominate in microfossil association of the Sigali Zone.

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Cretaceous calcareous nannofossil stratigraphy - what progress since 1983 ?

The symposium on "Cretaceous Stage Boundaries" in Copenhagen (1983) was organised "to fulfil the Subcommission's primary responsibility: the defining of the stage boundaries" (Birkelund & Surlyk *in* Birkelund *et al.*, 1984: 1). Considerable progress has since been made in calcareous nannofossil stratigraphy both in the austral, boreal and in the tethyan realm and in their correlation. On the other hand, looking back over the past 12 years, we have to admit with great regret, that no stage boundary has been defined in the Cretaceous.

As a specialist of calcareous nannofossils I had noticed for the first time during the 1983 symposium, a certain willingness to use other than ammonite events for the definition of a GSSP, a geological stratotype and point, for the subdivision of the Cretaceous. Although Birkelund *et al.* (1984) in their "Cretaceous stage boundaries - Proposals", still first discussed ammonites as "possible boundary levels" for each stage, they did discuss the relevant calcareous nannofossil events too. In fact, in their conclusions, calcareous nannofossil events were discussed as possible marker events for the

Albian: first occurrence of *Prediscosphaera columnata*
Turonian: first occurrence of *Quadrum gartneri*
Campanian: first occurrence of *Aspidolithus parcus*

Birkelund *et al.* (1984) pointed out the need for further investigations into the correlations of ammonite events and the first and last occurrences of "other groups" including, of course, calcareous nannofossils.

With satisfaction we can conclude in 1995, that many calcareous nannofossil studies have been performed correlating not only coccolith-events with ammonite events but also with planktic foraminifera, belemnite and other events and, in some cases, also with palaeomagnetics. Detailed studies of the coccolith-distribution in sequence stratigraphic units are, however, yet to be evaluated. The amount of published data is considerable and I assume that much was done that has not (yet) been published.

So why, the impatient observer asks, have all these activities in one of the important groups of fossils not lead to the definition of at least some GSSP's? My guess is that those of us working in scientific institutions are more interested now in the evolution of one or several lineages in our group and/or in the discovery, description and analysis of the geological processes that were reigning during the Cretaceous and that were so different from what we see now. Those working for the oil-industry have either lost their job, were set to perform other jobs or are just asked to provide a dating-service within the accepted stratigraphical scheme of the given company.

Who cares about stages? DSDP and ODP have shown clearly, that one can very well do without them in the Caenozoic. The fact that we have not yet succeeded in redefining the Cretaceous stage-boundaries in modern terms would suggest that we can well do without them also in the Cretaceous. Do not worry. A major effort of correlation in European Basins by Jan Hardenbol and others still also gives the stages beside the palaeomagnetic, sequence chronostratigraphy, ammonites, belemnites, planktic and benthic foraminifera, calcareous nannofossils, dinoflagellates and ostracodes.

The reports and recommendations given by the boundary-working groups in this Abstract-Volume and during the present symposium will show how much calcareous nannofossils may eventually contribute to the definition of Cretaceous GSSP's. They will certainly contribute to the global correlation of the stage boundaries.

I strongly urge the community of specialists of Cretaceous stratigraphy to grab the opportunity given with this symposium in Brussels "to get their act together" and PREPARE DECISIONS.

Birkelund, T. *et al.*, 1984: Cretaceous Stage Boundaries - Proposals. *Bull. geol. Soc. Denmark*, 33: 3 - 20.

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Calcareous nannofossil - palynostratigraphical correlations in the Late Cretaceous, Austria - Hungary.

Integrated stratigraphic investigations including calcareous nannofossils and palynostratigraphy were undertaken in Late Cretaceous sections of the Northern Calcareous Alps of Austria and the Transdanubian Central Range of Hungary. In Austria, shallow-marine sections of the Gosau Group allow the integration of the results into the standard Tethyan ammonite/inoceramid and planktonic foraminifera zonations.
In the marine Gams section the lower boundary of the Coniacian, defined by the occurrence of the bivalve *Didymotis*, lies within the *Marthasterites furcatus* nannofossil zone (CC13). *M. furcatus* appears already in the Late Turonian. *Quadrum gartneri* becomes significantly rare above the Coniacian boundary. Palynostratigraphic samples from the Late Turonian of Gams contained *Subtrudopollis*, *Complexiopollis* and early Angiospermae-type pollen. The first scarce occurrence of *Oculopollis* and *Krutzschipollis* together with abundant *Complexiopollis* is typical for middle Coniacian to Early Santonian samples at or above the first occurrence of the nannofossil marker *Micula decussata* (CC14/15).

From the basal lacustrine Late Cretaceous sediments of the Transdanubian Central Range in Hungary a similar *Normapolles* association was determined as from the Santonian (CC16) of the Gams section. Core sections from the Transdanubian Central Range yield new information about the Late Santonian-Early Campanian. New palaeomagnetic data (LANTOS et al., in prep.) confirm the base of the reversed chron C33R in nannofossil zone CC17, below the first occurrence of *Broinsonia (Aspidolithus) parca* and above the first occurrence of curved *Lucianorhabdus cayeuxii*. This falls into the *Hungaropollis* dominance zone of the Hungarian palynostratigraphic zonation.

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Campanian-Maastrichtian biostratigraphy from the Pacific Coast of North America.

The macrofossil biostratigraphic framework for Campanian-Maastrichtian shelfal sediments of the Pacific Coast was put on a modern footing through the work of Matsumoto (1959). Significant revisions and modifications were later made by Jeletzky ((in Muller & Jeletzky, 1970), Ward (1978a, b), Ward & Haggart (1981), Haggart & Ward (1984), Haggart (1989) and Saul (1988). Because of the endemic nature of the fauna, however, correlation between the Pacific coast and the European stratotype areas has been problematical at best. Until recently, the sequence of ammonites in the European type regions during the Campanian and Maastrichtian has been poorly known. A third problem has been that there have been virtually no areas along western North America where long, uninterrupted stratal records of marine sedimentation are exposed.

Field investigations at the La Jolla Cove, Punta San Jose, Rosario beach, and Santa Catarina Landing localities of the Rosario Formation, California and Mexico, have yielded a rich ammonite fauna bearing on these problems. Collections from Punta San Jose revealed the presence, in a single continuous stratigraphic section, of *Baculites inornatus, B. regina, B. occidentalis,* and *B. rex.* This is the first known locality on the American Pacific Coast or from Japan where all four of these species have been recovered from a single, continuous marine section. The top of this section contained *Nostoceras mexicanum* (Anderson), as well as unidentified baculitids. Near the town of Rosario, Baja California, the same ammonite sequence was observed in the field. At this locality, specimens of the European and Gulf Coast zonal index *Nostoceras hyatti* were also found in float. Finally, the thick, extensive sections found at Santa Catarina landing, Baja California, were also briefly investigated. A thick succession of ammonite-rich strata were observed there as well. Examination of large ammonite collections from this locality housed at the Los Angeles County Museum revealed the presence of numerous *Nostoceras hyatti* (from localities LACM 2962). The recognition of this zone from the Pacific Coast of North America is a major advance in regional and interregional biostratigraphy; its placement within the magnetic time scale will also be a major contribution for world-wide biostratigraphic correlation of the Upper Cretaceous.

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Turonian Substage Boundaries in Northern Spain

While some workers take the entry of *Collignoniceras woollgari* as diagnostic for the Lower/ Middle Turonian boundary, others use *Kamerunoceras turoniense.*
The entry of *Subprionocyclus neptuni* is used in the Boreal Realm to reçognize the Middle/Upper Turonian boundary, while *Romaniceras deverianum* is preferred in the transitional and Tethyan realms.
New data on sedimentology, sequences, integrated bio- and event stratigraphy from the Estella area and the Barranca (Navarra) and the Santander area (Cantabria) are presented. The entry, ranges and overlaps of these index ammonites are discussed, with special emphasis on major interbasinal events.
Lower/Middle Turonian Boundary: The entry of *C. woollgari* and *K. turoniense* in both condensed and expanded sections in Navarra is discussed. The boundary interval is delimited by two interbasinal (Spain, France, Germany) events, the *Spathites revelierianus* Event below and the *Kamerunoceras turoniense/Mytiloides hercynicus* Event above.
The *reveliereanus* Event, a peak occurrence of *S. reveliereanus*, coincides in northern Spain and France with the first occurrence of *K. turoniense*, the latter showing an overlap with *Mammites nodosoides* at this level. The *turoniense/hercynicus* Event represents a mass occurrence of a diverse ammonite fauna and marks the youngest peak occurrence of *Mytiloides hercynicus.* This level correlates in Germany and France with the entry of *C. woollgari*, which in Spain first occurs higher, together with *R. kallesi* and *R. ornatissimum.* In Germany, this event marks the almost contemporaneous entry of *Inoceramus apicalis* and *I. cuvierii.*
It therefore appears that the second event - the *turoniense/hercynicus* Event - is a better potential boundary marker for interbasinal correlation.
Middle/Upper Turonian Boundary: The entry of *R. deverianum* lies in the *Helvetoglobotruncana helvetica* Zone. The first *S. neptuni* occurs a few metres above the LAD of *H. helvetica.* In the Santander area, *R. deverianum* shows an overlap with *S. neptuni* and ranges up into the higher *neptuni* Zone. In Navarra, *R. deverianum* ranges higher and occurs together with *Prionocyclus* cf. *germari*, the latter indicating the equivalent of the *S. normalis* Zone.
In the Santander area, a sequence boundary (SB1) in the transitional interval marks the LAD of *H. helvetica* and is overlain by a flood occurrence of *R. deverianum. S. neptuni* enters 3 m higher. The *deverianum* event can be inferred to correlate with the *costellatus/ plana* Event of Germany, which is likewise marked by the entry of *S. neptuni.* The entry of *S. neptuni* marks the beginning of a turnover of the ammonite fauna and an increasing boreal influence in the Spanish sections. We therefore prefer *S. neptuni* to *R. deverianum* as an indicator for the base of the Upper Turonian. The transgressive pulse of the next sequence is marked by an acme of *M. incertus* and small „*Micraster*" *leskei*, which may well correlate with the *M. incertus* Event of NW Germany (higher *neptuni* Zone). The entry of *I.* aff. *frechi* together with *Prionocyclus* cf. *germari* a few metres higher indicates the *normalis* Zone and supports the former interpretation. SB2 is inferred to correlate with the base of the *Hyphantoceras* Event of Germany (higher *neptuni* Z.).
The data from Spain show that event correlation is a useful tool for recognizing Turonian substage boundaries.

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Planktonic Foraminifera and the Campanian/Maastrichtian boundary.

The Campanian/Maastrichtian boundary has been defined both within the Tethyan and Boreal realms using separate, non-cosmopolitan, fossil taxa, thus inhibiting correlations between the two palaeogeographic provinces. In the Tethyan realm, the boundary is often defined using planktonic foraminifera - the extinction of *Globotruncanita calcarata*. Several recent papers have suggested that this event is not synchronous with the boundary as defined in a Boreal sense. Examination of a geographically "intermediate" boundary sections at Tercis, south-west France suggests that this debate should be reopened. This is supported by a re-evaluation of DSDP data from the North Atlantic. Evidence from North America however, does point to a discrepancy in the position of the boundary in a Boreal versus Tethyan sense. To reconcile this dichotomy, it is necessary to carefully reappraise the taxonomy of certain planktonic foraminifera (e.g. *Globotruncanita elevata*) and to assess the impact and causes of relative sea-level changes on Campanian/Maastrichtian boundary sections. To further clarify the problem it is recommended that the Boreal hypostratotype of the Campanian/Maastrichtian boundary at Kronsmoor, northern Germany be calibrated globally by the use of Sr isotope analysis.

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C. A. Wright's Cretaceous planktonic foraminiferal zonation for the Northwest Shelf, Australia.

In 1973, C. A. Wright compiled a Cretaceous foraminiferal zonation for the Northwest Shelf for the petroleum exploration wells being drilled by his employer, Burmah Oil Company of Australia Ltd. This poster presents a brief account of the main features of that zonation, together with comments and modifications. Wright returned to the U.K. in the mid-1970s. Apthorpe is responsible for compiling the poster from Wright's original report and for the comments. The work draws on unpublished but open file data from Wright, Apthorpe and R. S. Heath. The species concepts are illustrated from specimens picked by the first two palaeontologists.

Thirteen zones were defined, based on local species ranges established mainly from sidewall cores. Emphasis was placed on extinction horizons (or local disappearance horizons) so that the zonation can be used with ditch cutting samples whilst drilling wells, in spite of the effect of downhole contamination. Twentyfive wells were used in the initial compilation; at least double that number of wells now support the zonation.

Definitions for eight of the zones have been published previously (Wright & Apthorpe, 1976; Morgan, 1980). Some of the zones are identical or similar to those found elsewhere. Others are distinctly different, reflecting much longer time ranges in the eastern Indian Ocean faunas. The long ranges of "Index" species such as *Globotruncana elevata* and *G. ventricosa*, commented on by Wonders (1991), were the reason why a local zonation was felt to be a necessity in 1973.

Zonal definitions

Approximate age	Zone	Original definition	Remarks
Late Maastrichtian	C13	TR *Abath. mayaroensis*	unchanged
~ Middle Maastr.	C12	Presence *G. contusa* below *A. mayaroensis*	some problems
Early Maastrichtian	C11	highest *G. linneiana*	longer range in northern areas
Late Campanian	C10	highest *G. ventricosa* + *G. stephensoni*	as above; new top indicator
Early Campanian	C9	highest *Gt. marginata* and *Archaeoglo. cretacea*	highest *Gt. elevata* also
~ Late Santonian	C8	highest *"Gt. concavata carinata"* = *Gt. asymetrica*	Nannoplankton top: basal Campanian*
~ Early Santonian	C7	highest *Gt. renzi* + *Gt. pseudolinneiana*	also: *Gt. concavata concavata*
~ Coniacian	C6	highest *Gt. imbricata*	see poster
Late Turonian	C5	highest *Gt. helvetica*	new definition
Early Turonian	C4	highest *Praegt. stephani*	acme zone - modified
Cenomanian	C3	highest *Rotalipora* spp. with 3 possible subzones	only two subzones used
uppermost Albian	C2	TR *Planomalina buxtorfi*	two subzones
Albian	C1	*Hedbergella* spp. below lowest *P. buxtorfi*	

* pers. comm. John Rexilius

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Santonian and Campanian ammonites from a remanié, western central Alabama, U.S.A.

In west-centralAlabama, primarily Hale, Dallas, Greene, and Montgomery Counties, there is a remanié in the Tombigbee Sand Member of the Eutaw Formation. The ammonites from this remanié are almost black, phosphatic steinkerns that have been sorted so that smaller forms have been winnowed down-current and presumably larger specimens have lagged up-current. These ammonites represent both latest Santonian and Lower Campanian species.

Latest Santonian species include: *Boehmoceras arculum* (MORTON, 1834), *Pseudoschloenbachia (P.) mexicana* (RENZ, 1836), *P. (P.)* cf. *umbulazi* (BAILY, 1855), *P. (P.)* cf. *coarctata* COLLIGNON, 1966, *Reginaites zulu* KLINGER & KENNEDY, 1980, *R. exilis* KENNEDY & COBBAN, 1991, and *Bevahites bevahensis* COLLIGNON, 1948.

Lower Campanian species include *Baculites asperoanceps* LASSWITZ, 1904, *B. asper* MORTON, 1834, *Glyptoxoceras* cf. *coarctatum* COLLIGNON, 1969, *G. ellisoni* YOUNG, 1963, *Exiteloceras* cf. *tricostatum* (WHITFIELD, 1877) and *Menabites (Delawarella) vanuxemi* (MORTON, 1834).

Among these species *Pseudoschloenbachia (P.)* cf. *umbulazi*, *P. (P.)* cf. *coarctata* , *Reginaites zulu*, *Bevahites bevahensis*, *Glyptoxoceras* cf. *coarctatum*, *G. ellisoni*, and *Baculites asper* are either also known from Madagascar and/or South Africa or have very closely related species there.

The remanié has been interpreted as a high-stand of sealevel by geologists of the Alabama Geological Survey. A number of specimens of *Boehmoceras arculum* and *Glyptoxoceras ellisoni* contain the excavations of acrothoracic barnacles on the steinkerns. I think it is significant that South African and Madagascaran species occurred in Alabama during such a high-stand.

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The boundaries of the boreal Berriasian.

(1) The boreal Berriasian (BB) is characterised by the following ammonite genera: *Praetollia, Hectoroceras, Surites, Borealites, Tollia, ? Lynnia, Peregrinoceras.* The BB deposits cover a huge territory upwards from 50° northern latitude.

(2) The stratigraphical range of the BB has been changed throughout the last century. The boundaries of the modern BB do not correspond to the Ryazanian *sensu* Bogoslovskii (1895) and Susonov (1951).

(3) The lower boundary of the BB is defined at the base of ammonite zones that are characterised by the first appearance of species of the genus *Praetollia.* These are: the *P. maincy* Zone in North Siberia, Subpolar Ural, Pechora River Basin, East Greenland, (?) Svalbard and Arctic Canada; the *P. runctoni* Zone in England. The *P. maincy* Zone base is placed in the middle of the *Buchia unchensis* of the BB's hypostratotype in North Siberia (see Zakharov's poster abstract below).

(4) There is no common opinion about the Boreal-Tethyan correlation of the Jurassic/ Cretaceous boundary zones. Two approaches are dominant.. Most "boreal" palaeontologists assume that the boreal *Praetollia* genozone base coincides with the Mediterranean *Berriasella grandis* one. But some "tethyan" palaeontologists believe that the bottom of the BB should coincide with the *Fauriella boissieri* Zone base.

(5) The upper boundary of the BB is placed at the base of the boreal Valanginian. The position of the upper BB boundary is less well defined than the lower one. The BB well terminates with the *Bojarkia* spp. Zones in North Siberia, Subpolar Ural and Canada; with the *Peregrinoceras* spp. Zones in England, on the Russian plain and East Greenland. There is a reliable Boreal-Tethyan correlative level at the base of the Boreal Valanginian owing to the finds of *Platylenticeras* and *Propolyptychites* together in the lowermost Lower Valanginian in northern Germany (Lower Saxony Basin). The *Propolyptychites quadrifidus* Zone of Northern Siberia correlates with the *Thurmanniceras pertransiens* standard Zone. The basal Boreal Valanginian *Neotollia klimovskiensis* Zone is correlated with the *Thurmanniceras otopeta* standard Zone by stratigraphical position.

(6) The BB hypostratotype's *Buchia*-Zones directly correlate with the *Buchia* zonation of a northern California Berriasian section (Grindstone Creek, Paskenta area, Glenn district). The best correlative level is the base of the *Buchia okensis* Zone in the lowermost part of Berriasian and BB stages.

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The rank and zonation of the boreal Berriasian.

1. As demonstrated by Sachs and Shulgina (1964, 1972) the range of the "Ryazanian stage" does not coincide with that of the Boreal Berriasian (BB). There are no continuous sections of the Ryazanian on the Russian plain. Everywhere, including the Oka River Basin, the Ryazanian horizon rests on underlying rocks with a stratigraphical and sedimentological break. A sedimentological hiatus occurs also at the top of "Ryazanian stage". A stratigraphical hiatus is very likely to be present within the Ryazanian horizon (sensu Bogoslovskii, 1895). There are no BB sections in Europe which meet the requirements of a stratotype standard.
2. The BB ammonites are as specific as Volgian ones. It is practically impossible to correlate directly the Berriasian and BB ammonite sequences. It is necessary to have a standard for the BB as the instrument of effective Panboreal correlation. The only continuous BB section occurs along the Laptev sea beach, on Nordvik Peninsula, Urdyuk-Khaya Cape. Upper Volgian substage, BB and Boreal Lower Valanginian are composed of offshore black shale facies. The lower and upper BB boundaries are recognized within clays and enriched by organic argillites in a monotonous succession. The complete successions of the ammonite, *Buchia*, forams, and dinocyst zones have been established. This section is proposed as the standard of the BB.
3. The following ammonite zones occur in the Upper Volgian substage: *Craspedites okensis* (thickness 4.7 m), *C. taimyrensis* (4.2 m), *Chetiates chetae* (1.2 m). The BB includes the following zones: *Praetollia maincy* (0.5 m), *Chetaites sibiricus* (3.5 m), *Hectoroceras kochi* (8.7 m), *Surites analogus* (4.7 m), *Bojarkia mesezhnikowi* (18.5 m). The Boreal Lower Valanginian includes: *Neotollia klimovskiensis* (14.1 m), *Propolyptychites quadrifidus* (37.8 m) (Zakharov *et al.* 1983; Bogomolov, 1989). The *Hectoroceras kochi* and *Surites analogus* Zones in the Kheta River section have been subdivided into 3 and 2 subzones respectively (Alekseev, 1984). The ammonite zones are widespread in North Eurasia from the Anabar River Basin in North Siberia to Greenland in the western hemisphere (Zakharov, 1981; Surlyk & Zakharov, 1982).
4. A complete *Buchia*-Zone succession is established in the same section as for the ammonite one: *Buchia unschensis* (Jurassic-Cretaceous boundary beds), *B. okensis*, *B. jasikovi*, *B. tolmatschowi*, *B. inflata* (BB/Boreal Valanginian transitional beds). The same or almost the same succession of *Buchia*- Zones is defined within the Boreal realm and in some Peri-Tethyan regions (for example in Northern California, USA). There is a good chance to correlate directly Boreal and Tethyan sections.

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Cretaceous Ammonoid Succession in Far East (South Sakhalin, Russia) and the basic factors of Syngenesis.

A more than 4000 m thick, late Early Cretaceous to Danian sequence is well exposed along the Naiba River, near Dolinsk (South Sakhalin). It is subdivided in four formations (suites): Ai (Albian), Naiba (Albian-Cenomanian), Bykov (Turonian-Santonian), and Krasnoyarka (Campanian-Danian). In the Albian-Maastrichtian ammonoid succession three phases have been distinguished, reflecting diverse marine biota. **Phase 1** [Ai and lower Naiba formations, Albian]: shallowing marine basin and periodical fresh water influence in latest Early Cretaceous; marine community contains the following number of taxa: 30 foraminifers, 14 radiolarians, one crinoid, one echinoid, 12 bivalves (including fresh water taxa), two gastropods and 6 ammonoids. **Phase 2** [upper Naiba, Bykov and lower Krasnoyarka formations, Cenomanian-Campanian]: abundant and diverse fauna with the following number of taxa: 38 foraminifers, more than 100 radiolarians, one crinoid, one crustacean, more than 100 bivalves (including inoceramids), five scaphopods, 25 gastropods, 177 ammonoids, 7 nautiloids and one belemnitoid. Within the ammonoids changes in the faunal dominance are: (1) *Desmophyllites (Pseudouhligella) japonicum (Turrilites costatus* beds and *Marshallites - Acanthoceras sanctorium* beds, Cenomanian); (2) *Tetragonites epigonus (Jimboiceras planulatiforme* beds, Turonian); (3) *Gaudryceras tenuiliratum (Jimboiceras mihoense* beds, A*napachydiscus naumanni* beds and lower *Canadoceras kossmati* beds, Coniacian - Early Campanian); (4) *Baculites zhuravlevi* (upper *Canadoceras kossmati* beds), Late Campanian). A sharp reduction in the ammonoid taxonomic diversity in the latest Santonian and at the Campanian-Maastrichtian transition seems connected with drops in temperature. The lowest palaeotemperature (about 5.8° - 11.1° at the bottom of the basin) is from the earliest Campanian on Sakhalin Island. **Phase 3** (middle Krasnoyarka formation, Maastrichtian): decrease in abundance and diversity for all groups; number of taxa: 12 foraminifers, 43 bivalves, two scaphopods, 14 gastropods, 43 ammonoids. *Zelandites japonicus* group, in the *Z. japonicus* beds, form the dominating group in the Early Maastrichtian. The fauna of the Late Maastrichtian strata (*Pachydiscus subcompressus* beds) comprises 20 taxa belonging to the genera *Neophylloceras, Anagaudryceras, Gaudryceras, Zelandites, Tetragonites, Sakhalinites, Baculites, Diplomoceras, Neancyloceras, Pseudoxybeloceras, Canadoceras, Neodesmoceras* and *Pachydiscus.*

The Maastrichtian-Danian boundary, at the base of the Sinegorsk horizon (Upper Krasnoyarka formation), is connected with radical faunal changes. **Phase 4**: Early Danian (*Pseudaphrodina extrema beds*) do not contain ammonoids and inoceramids. The following number of taxa are present: 32 foraminifers, 16 bivalves, two gastropods. Radiolarians have not been recorded. Middle Sinegorsk horizon (*Thyasira uncinata* beds) contain 38 bivalve taxa, in association with foraminifers, corals, scaphopods, gastropods and shark remains, but no radiolarians in this basin. A low index of δ13C was found Santonian-Maastrichtian and Danian invertebrate shells of Sakhalin Island (exception: Campanian: δ13C = 3D + 1.0 %.). The change in biota at the K/T boundary maybe mainly related to a climatic change.

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Boundary of Santonian/Campanian in the Peri-Tethys on pelagic sharks.

The Santonian/Campanian boundary was studied in the Aktiubinsk region and on the Mangyshlak Peninsula (Kazakhstan).

In the Aktiubinsk region the Santonian-Campanian boundary is found in the sandy-phosphoritic Koldenentemir Fm. The Lower Santonian deposits consist of quartz-glauconite sands with clays and phosphorites. Thickness: 5 m. Fauna: *Actinocamax verus fragilis* (Arkh.), *Goniocamax lundgreni uilicus* (Koltypin), *Squalicorax santonicus* Glückman & Zhelezko, *S. papulovi* Zhelezko, *Eostriatolamia aktobensis* Zhelezko.

The Upper Santonian deposits consist of quartz sands with lenses of phosphatic concretions. Thickness: 14 m. Fauna: *Actinocamax verus fragilis*, *Belemnitella praecursor praepraecursor* Naidin, *B. pr. media* (Jeletzky), *Squalicorax kaupi* (Agassiz), *Eostriatolamia venusta* (Leriche), *E. segedini* Glückman & Zhelezko. In the upper part of these sands *Oxytoma tenuicostata* (Roemer) and *Inoceramus* ex gr. *patootensis* have been found.

On top of these strata, without sedimentological hiatus, the Campanian beds are found - first a phosphorite bed (2 m thick) and on top of this an aleurite (7 m thick). Fauna: *Belemnitella praecursor media*, *Paractinocamax grossouvrei pseudoalfridi* Naidin, *Squalicorax lindstromi* (Davis), *Eostriatolamia lerichei* Glückman & Zhelezko, *Oxytoma tenuicostata.*

Foraminiferal distribution: Lower Santonian - with *Gavelinella infrasantonica*; Upper Santonian - with *G. stelligera*; Campanian - with *Cibicidoides temirensis.*

In Mangyshlak sediments of Santonian-Campanian age are well represented in the Dzalgan, Kusch, Aksyirtau and Sulukapy key sections.

Santonian sediments are divided in three parts (from lower to upper):

1. marls (2 m) with *Inoceramus undulatoplicatus* Roemer, *Stensioeina exculpta exculpta* - *S. granulata* foram zones.
2. Chalk (6-9 m) with *Uintacrinus, Marsupites, Squalicorax kaupi* and *Osangularia-Gavelinella stelligera* foram zones.
3. Chalk (6 m) with *Offaster pilula* Roemer, *Squalicorax kaupi, Gavelinella clementiana clementiana* foram zone.

Campanian:

4. alternation of white and green chalk (7 - 11 m) with *Micraster schroederi* Stolley, *Offaster pilula, Squalicorax lindstromi*, *Bolivinoides decoratus* and *Cibicidoides temirensis* zones.

Sections of the Aktiubinsk and Mangyshlak areas are situated in different biogeographic provinces. Therefore results form these sequences are not easy to correlate. The associations of foraminifera, mollusks and echinoids, f. i., are different. On the other hand the Santonian/Campanian pelagic shark associations from both regions are identical. We recommend to place the Santonian/Campanian boundary in the bottom of the beds with *Carcharocles lindstromi* and *Eostriatolamia lerichei.*

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Evolution of Cretaceous pelagic sharks and the Cretaceous stage boundaries.

The only remains of sharks, their teeth, have a very wide distribution in the Cretaceous sediments of the world. Our collection includes 150,000 separate upper Cretaceous shark teeth. This is an important palaeontological material, but generally the taxonomy of Cretaceous sharks have not been well studied.

Recently, the phylogenetic lines *Eoanacorax-Paleoanacorax-Squalicorax, Acrolamna, Protolamna* and *Striatolamia* have been studied by L. Glückman and the author; they have composed a shark zones scale for the Upper Cretaceous. The joint finding of shark teeth and other fossils make it possible to solve questions concerning stage boundaries. So far theAlbian/Cenomanian, Cenomanian/Turonian and Santonian/Campanian boundaries have been documented in this way. The Albian/Cenomanian boundary is situated at the base of the beds with *Acrolamna sulukapjenica*; the Cenomanian/Turonian boundary is located at the base of the beds with *Acrolamna gaja*; the Santonian/Campanian boundary is located at the base of the beds with *Squalicorax lindstromi.*

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Turonian/Coniacian boundary in Eastern Russia.

The boundary between the Upper Turonian and Lower Coniacian deposits which, due to endemicity of fauna, can be only presumed, were emplaced in the course of about two million years. During this time, sediments accumulated in the region under consideration, their thickness ranging from 190-900 m. Sections comprising the most complete time interval and yielding abundant fossils, are developed in northern spurs of Kamchatka (Pontonei Mounts, northeastern coast of the Penzhina Bay) and in Sakhalin Island. Structurally, the territory of Kamchatka comprises the PenzhinaTrough and Sakhalin, and forms the so-called Main Cretaceous Field. These structures are traced over many kilometers and have a composite tectonic structure. The Pontonei Mounts and the Northeastern coast of Penzhina Bay are two independent structural-facies zones. Each zone is characterised by its own biostratigraphic evolution, slightly differing from that of the zone next to it, which is partly due to changes in ecology and other environmental factors. Such a pattern is also recorded in Sakhalin Island, where the southern part of the island slightly differs in its geological evolution from the central and northern parts. Despite complex folding, and in certain cases, poor exposures, the selected sections are rather well characterized by abundant faunal remains of good preservation. These are, primarily, inoceramids, dominating remains of other faunal groups and enabling to establish the biostratigraphic succession (see Table). Ammonoids have a subsidiary significance in terms of their numbers in the considered regions, but they have not lost their significance as the basis for biostratigraphic subdivision even here. Some ammonoid species, recorded in associations of the distinguished zones, made it possible to date the deposits and trace boundaries in contiguous regions. A certain difficulty was also associated with the circumstance, that numerous ammonoid assemblages of an extensive vertical range (representatives of the genera *Gaudryceras, Tetragonites, Epigoniceras, Neophylloceras etc.* are confined to boundary beds of both stages); the same also concerns the transient inoceramids species (*Inoceramus concentricus costatus, I. mametensis, I. praeinconstans etc.*), which made the distinguishing of stratigraphic units and, as a result, drawing of the boundary proper, extremely difficult. Determination of inoceramid succession and occurrences of guide ammonoid species, associated with inoceramids, enabled to outline the following biostratigraphic chart. The resulting succession of biostratigraphic units correlates well with a similar zonal chart, developed for the Turonian-Coniacian of Japan (Matsumoto,1984).

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Santonian/Campanian Boundary in Sakhalin based on ammonoids and inoceramids.

In Sakhalin, drawing of boundaries of the Late Cretaceous and their correlation with the standard is complicated by faunal endemicity, typical of the Pacific area. The presence of a few representatives of cosmopolitan or widespread taxa, as well as a morphological similarity between some European and Pacific taxa of ammonoids and inoceramids, enables to outline the levels of interregional correlation. The deposits in the Pacific area which approximately correspond to the Santonian and Campanian are most fully represented in three sections in Sakhalin in the Naiba River Basin, in the south of the island; along the Bolshaya Orlovka River in the central part and in the north in the area of Cape Zhonkier (Kovalevs Creek Valley).

Despite the endemism, there is a certain similarity in the evolutionary trend of different groups of organisms in the Pacific, European and Tethyan realms. Appearance of the first representatives of the genus *Texanites* in Europe is confined to the base of Santonian. The first representatives of *Texanites* in Sakhalin occur in deposits, which we, in view of this fact, consider as the base of Santonian. However, *Texanites (Plesiotexanites) kawasakii*, which is a Pacific endemic, is used as the zonal index of Early Tithonian in Sakhalin and North-East Russia. Among inoceramids, *Inoceramus amakusensis* was selected for Sakhalin; its first occurrence is a good criterion for drawing this boundary in Northern Pacific. Besides, one of the sections in Sakhalin yielded other inoceramid remains, defined as *Inoceramus* sp. aff *I. undulatoplicatus* (which is an indicator of Santonian in Europe). Unfortunately, there is as yet only a single occurrence. In Pacific regions *I. japonicus*, which is a possible vicariant of *I. undulatoplicatus*, occurs, but its stratigraphic range requires a more precise determination. Possibly, this taxon will rather serve as a criterion for determination of the Upper Santonian substage. At present, there is no final solution concerning the Lower/Upper Santonian boundary. The most acceptable option for drawing this boundary in Eastern Russia is the first occurrence of *Eupachydiscus haradai*. In Sakhalin, as well as in North-East Russia and Japan, the base of Campanian is placed in the *Anapachydiscus (Neopachydiscus) naumanni* Zone. First appearance of this taxon is a good criterion for drawing the boundary in N. Pacific area. There is a certain similarity between *A. (N.) naumanni* and the European *Eupachydiscus levyi*, characteristic of the Lower Campanian deposits. We presume, that it would be more reasonable to draw the Santonian/Campanian boundary in the Pacific area from appearance of the first representatives of *Inoceramus nagaoi*, occurring with *A. (N.) naumanni*. Both species are recorded in mass numbers in sections of Sakhalin. In morphology *I. nagaoi* is very similar to *I. azerbaidjanensis*, which is widespread in the Lower Campanian of European and Tethys realms.

For drawing the Lower/Upper Campanian boundary in Eastern Russia and Japan, the first occurrence of the radially-ribbed inoceramids (*Schmidticeramus schmidti* Zone) is used, and the "acme" of the ammonite *Canadoceras*, confined to the *Pachydiscus (P.) egertoni* Zone. This ammonite was first recorded in India. The conducted research demonstrated the possibility of approaching a global interregional correlation.

WORKING GROUPS REPORTS

THE BERRIASIAN WORKING GROUP
Tithonian/ Berriasian = J/K boundary + substage boundaries.

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1. It is proposed to consider the ammonite zonation of the Mediterranean region - prepared within the IGCP 262 and coordinated by Lower Cretaceous cephalopod team in Digne - as the basis for discussion of the J/K boundary and substage boundaries (Hoedemaeker & Bulot, 1990).

2. It is necessary to discuss the potentialities of this scale for correlation of Tethyan Berriasian deposits of the Caribbean Basin in America with the east Tethyan deposits of Asia. When discussing Pantethyan correlation it is necessary to analyse not only ammonite scale, but also parallel scales based on calpionellida, nannofossils,foraminifera, dinocysts, and the date on palaeomagnetostratigraphy, geochronology, isotope stratigraphy, chemo- and sequence stratigraphy.

3. The main insoluble problem is the infrazonal Boreal-Tethyan correlation of the Berriasian stage and Boreal Berriasian (BB). Fourteen Zones and Subzones are distinguished in BB by ammonites (see drawing). Among these zones not one is valid for the Boreal ánd the Tethyan Realm. We have not one single level which allows us to correlate Tethyan and Boreal deposits using the ammonite zonation (*Riasanites* and *Euthymiceras* are not effective at the infrazonal level).

4. Only *Buchia* allows direct correlation of Boreal and Subtethyan deposits. The only continuous Berriasian sequence, without stratigraphical and sedimentological hiatus, which contains Tethyan ammonites of Latinoamerican habit, nannofossils and full sequence of Boreal *Buchia* Zones, is in northern California (Grindstone, Paskenta village). Based on *Buchia*, this section is readily correlated with the fullest section of BB of northern Siberia. Renewed detailed research is needed of this section.

5. It is possible that the roof of the Upper Tithonian is isochronous to that of the middle Volgian substage. This does not mean that the base of the Berriasian and the Upper Volgian substage are also isochronous. Should we accept the level of the J/K boundary at the base of the *Jacobi* Zone in the Mediterranean sections before we receive direct evidence of the place of this level in Boreal sections?

Non-approved zonal correlation of the Berriasian, Boreal Berriasian and Upper Volgian on ammonites

Stages	Substages	Mediterranean region		Zone's No.		Northern Siberia		Zone's No.	Substages	Stages
Berriasian	Upper	Fauriella boissieri	? ?			Tollia tolli		14	Upper	Boreal Berriasian
			Berriasella picteti	7		Bojarkia mesezhnikowi		13		
			Malbosiceras paramimounum	6		Surites analogus	Surites analogus	12		
							Surites subquadratus	11		
	Middle	Tirnovella occitanica	Dalmasiceras dalmasi	5	?	Hectoroceras kochi	Surites praeanalogus	10	Lower	
							Borealites constans	9		
			Berriasella privasensis	4			Hectoroceras kochi	8		
						Chetaites sibiricus	Chetaites sibiricus	7		
			Tirnovella subalpina	3			Praetollia mainci	6		
	Lower	Berrisella Jacobi	Pseudosubplanites grandis (?)	2	?	Chetaites chetae		5	Upper	Volgian
						Craspedites taimyrensis		4		
			Berriasella jacobi	1		Craspedites okensis	C. originalis	3		
							C. okensis	2		
							C. exoticus	1		
Tithon.	Upper		Durangites spp.		?	Epivirgatites variabilis			Mld.	

... THE VALANGINIAN WORKING GROUP

THE HAUTERIVIAN WORKING GROUP

compiled by **Jörg MUTTERLOSE** (Chairman)

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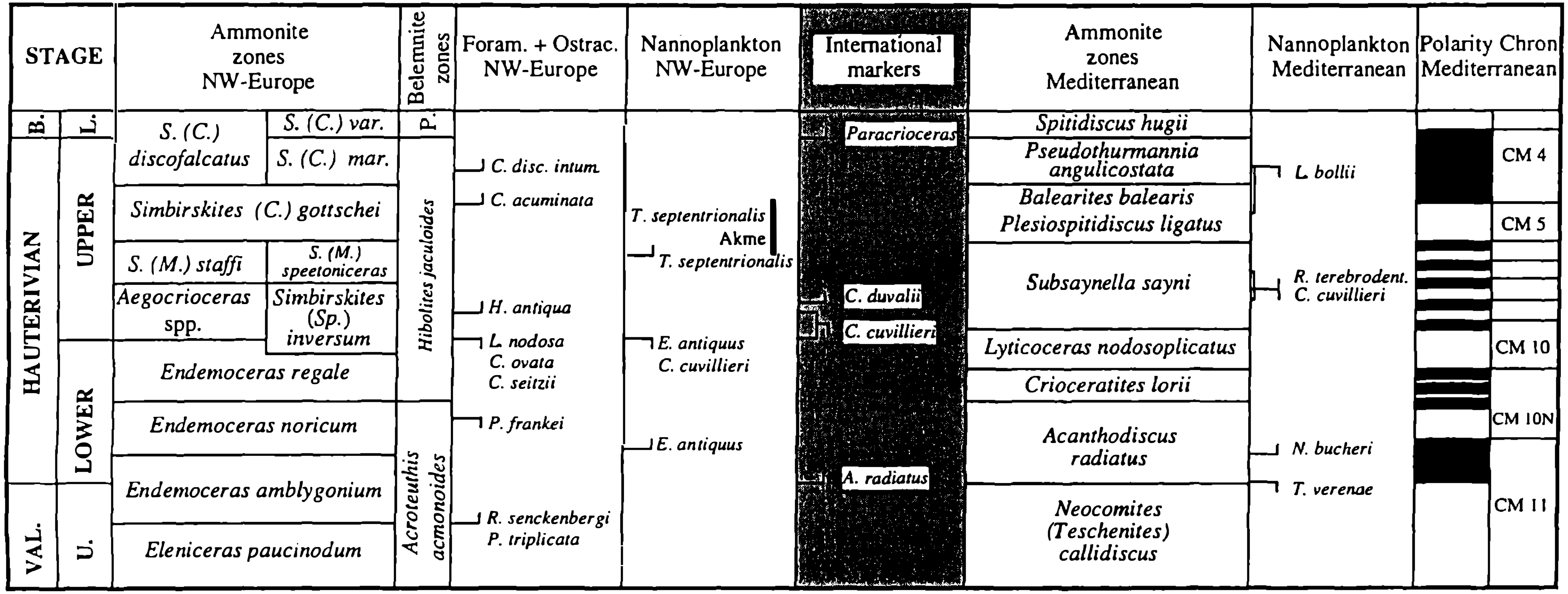
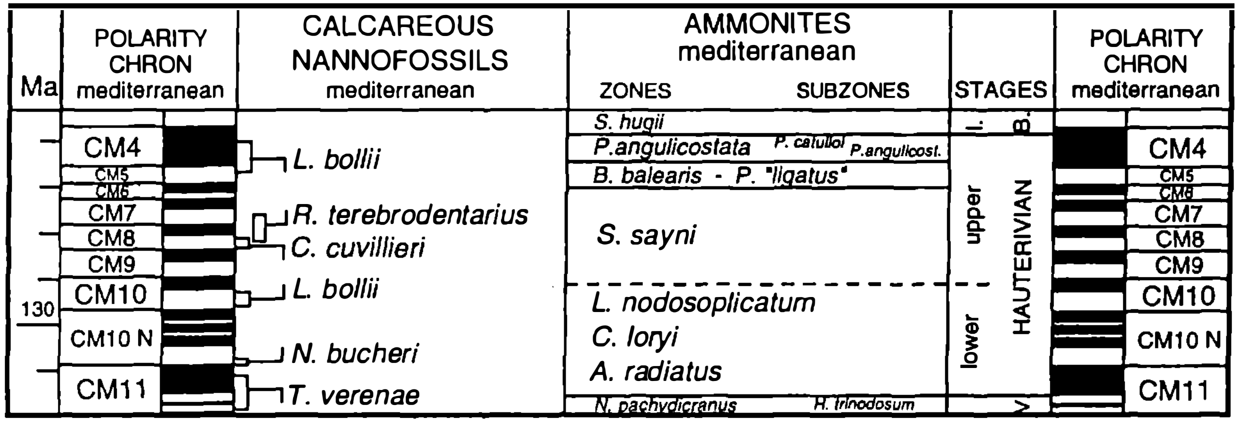
The Hauterivian stage is marked by a pronounced exchange of marine floras and faunas between Tethyan and Boreal Realms, while the Berriasian, Valanginian and Barremian stages are characterised by more endemic taxa. Thus, within Europe, some markers are present both in the Tethys and in the Boreal Realm, allowing an inter-regional correlation. Most members of the working group agreed on the traditional definition of the Valanginian/ Hauterivian boundary. Currently the base of the Hauterivian is defined by the first appearance of the ammonite *Acanthodiscus radiatus* and allied species. The value of *Acanthodiscus* lies in its presence in shallow water facies both in the Tethyan and Boreal Realm. A disadvantage of using this genus as a zonal index is its rarity in the deep-water facies of both the Tethys and the Boreal Realm. In the Boreal Realm the first *Acanthodiscus* appears above the first *Endemoceras amblygonium*, which historically has been taken as a proxy for the Valanginian/Hauterivian boundary. This would give the basal *E. amblygonium* Zone a latest Valanginian age.

Other groups (benthic foraminifera, ostracods) can only be used on a regional scale. Even planktonic organisms (calcareous nannofossils, dinoflagellates) are of limited use for inter-regional correlation. The dinoflagellate *Muderongia staurota* may be a candidate for defining the boundary. A detailed magnetostratigraphy is available for parts of the Mediterranean (Italy), but no comparable data are available currently for the Boreal Realm. Hoedemaker has proposed that the base of the Hauterivian be drawn at the base of the *Karakaschiceras pronecostatum* Horizon, i.e. the 2nd horizon within the *Saynoceras verrucosum* Zone. This level is marked by a faunal turnover of the ammonites and correlates with a change of the dinoflagellate assemblages. It approximately correlates with the level in which true *Dichotomites* and *Juddiceras* appear in NW Germany. This would alter the Hauterivian/Valanginian boundary radically and most of what presently is part of the Upper Valanginian would be included in the Hauterivian. Another problem is the correlation with the boreal succession. Both *Saynoceras verrucosum* and rare *Karakaschiceras* are known from the lowermost Upper Valanginian of NW-Germany, where they co-occur. There has been general agreement to place the Lower/Upper Hauterivian boundary in the Mediterranean at the base of the *Subsaynella sayni* Zone (= base of the *Cruasiceras cruasense* Horizon). Typical *nodosiplicatus* and *sayni* Zone ammonites in the Speeton Clay (eastern England) succession show that this boundary occurs in the middle *inversum* Zone. This species which co-occurs with *S. sayni* in the Mediterranean invaded the Boreal realm in the *Simbirskites (Speetoniceras) inversum* Zone. More suitable, however, may be the calcareous nannofossil species *Crucielliepsis cuvillieri*, which has its last occurrence close to the Lower/Upper Hauterivan boundary.


STAGE
Ammonite zones NW-Europe
Belemnite zones
Foram. + Ostrac. NW-Europe
Nannoplankton NW-Europe
International markers
Ammonite zones Mediterranean
Nannoplankton Mediterranean
Polarity Chron Mediterranean
B.
L.
HAUTERIVIAN
UPPER
LOWER
VAL.
U.
S. (C.) discofalcatus
S. (C.) var.
S. (C.) mar.
Simbirskites (C.) gottschei
S. (M.) staffi
S. (M.) speetoniceras
Aegocrioceras spp.
Simbirskites (Sp.) inversum
Endemoceras regale
Endemoceras noricum
Endemoceras amblygonium
Eleniceras paucinodum
P.
Hibolites jaculoides
Acroteuthis acmonoides
C. disc. intum.
C. acuminata
H. antiqua
L. nodosa
C. ovata
C. seitzii
P. frankei
R. senckenbergi
P. triplicata
T. septentrionalis
Akme
T. septentrionalis
E. antiquus
C. cuvillieri
E. antiquus
Paracrioceras
C. duvalii
C. cuvillieri
A. radiatus
Spitidiscus hugii
Pseudothurmannia angulicostata
Balearites balearis
Plesiospitidiscus ligatus
Subsaynella sayni
Lyticoceras nodosoplicatus
Crioceratites lorii
Acanthodiscus radiatus
Neocomites (Teschenites) callidiscus
L. bollii
R. terebrodent.
C. cuvillieri
N. bucheri
T. verenae
CM 4
CM 5
CM 10
CM 10N
CM 11


Ma
130
POLARITY CHRON mediterranean
CM4
CM5
CM6
CM7
CM8
CM9
CM10
CM10 N
CM11
CALCAREOUS NANNOFOSSILS mediterranean
L. bollii
R. terebrodentarius
C. cuvillieri
L. bollii
N. bucheri
T. verenae
AMMONITES mediterranean
ZONES
SUBZONES
S. hugii
P.angulicostata
P. catulloi
P.angulicost.
B. balearis - P. "ligatus"
S. sayni
L. nodosoplicatum
C. loryi
A. radiatus
N. pachydicranus
H. trinodosum
STAGES
l.
B.
upper
lower
HAUTERIVIAN
V
POLARITY CHRON mediterranean
CM4
CM5
CM6
CM7
CM8
CM9
CM10
CM10 N
CM11

THE BARREMIAN WORKING GROUP

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note: This abstract summarises the initial views offered by members of the Working Group. It has not been checked by the Group and must be regarded simply as an interim statement intended to stimulate fuller discussion at the Brussels meeting.

The objectives of the Barremian Working Group are

- *to nominate an internationally acceptable boundary for the base of the Barremian stage and for the base of the Upper Barremian substage.*
- *to propose candidate stratotype sections*

Our guiding principle was that we should select boundaries that could be recognisable over as wide an area as possible and ideally in both Tethyan and Boreal Realms. We also agreed that the stratigraphic level of the recommended boundaries should conform as closely as feasible with current practice. The preliminary proposal for the base of the Barremian made at the Subcommission's 1983 Copenhagen conference would be a necessary starting point (Birkelund *et al.* 1984).

The choice of the boundary stratotype sections will depend primarily on the chosen boundary. Although historical precedence should be considered it should not over-ride the importance of choosing a widely-correlatable boundary in the most appropriate section, in whatever part of the world that may be.

At Copenhagen, discussion on the base of the Barremian centred mainly on the ammonite sequence and little information was offered on possible microfossil or non-biological markers (Birkelund *et al.* 1984, pp. 7-8). The meeting recommended that the Hauterivian/ Barremian boundary should be placed either below or above the *Pseudothurmannia* beds and that a boundary **within** them should be avoided. The Lower/Upper Barremian boundary was not considered. It was also recommended that sections in southeast France, southeast Spain, the Carpathians, the Crimea and the Caucasus should be considered as candidates for the Hauterivian/Barremian boundary stratotype.

Since the Copenhagen meeting much new information has been published, especially on various European sequences. Some important palaeomagnetic data are now available and sequence stratigraphy has given new insights. However, this new information has highlighted the difficulty of correlating the better-known West Tethyan (Spain to the Caucasus) sequences with Barremian successions elsewhere. Even within Europe, the increasing endemicity of many fossil taxa by the beginning of the Barremian makes it difficult to correlate the West Tethyan faunas/floras with those of the NW European "Boreal" area. Conversely, the stratigraphy of some of the rich ammonite faunas of the Americas is poorly known.

We are therefore taking the pragmatic view that as a truly global correlation of Barremian rocks is still an unachieved ideal which may never be fully satisfied, it is better not to delay making our recommendations. Although there are differences of opinion and emphasis within our working group, which will be elaborated upon in our final report, the concensus so far is that the boundaries should be defined in the Western Tethys and based on the ammonite sequence there. The ranges of other fossil groups will also be incorporated in our final report.

Our provisional recommendations follow those of the Lower Cretaceous Cephalopod Team of IGCP Project **262** (now transferred to Project **362**) (Hoedemaeker & Bulot 1990; Hoedemaeker *et al.* 1993). These are:

BASE OF THE BARREMIAN

Base of the *Spitidiscus hugii* Zone, immediately **above** the *Pseudothurmannia* beds

Possible candidate boundary stratotype sections occur in SE Spain, SE France (Angles, the Barremian stratotype section) and Romania (Svinita and Dambovicioara in the Southern Carpathians).

THE LOWER/UPPER BARREMIAN BOUNDARY

Base of the *Ancyloceras vandenheckei* Zone.

Possible boundary sections include section X.KV of the Subbetic Zone (SE Spain) and the Romanian Carpathian localities mentioned above (the boundary beds are not exposed but could be excavated).

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THE APTIAN WORKING GROUP

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Barremian/Aptian boundary = base of the Aptian

Revision of the Aptian stage, including the Barremian/Aptian (B/A) boundary interval, has been carried out in the past three years. The stratotype section and other sequences from both low and high latitudes have been investigated to establish a sequence of events based on palaeontology, sedimentology, palaeomagnetics, geochemistry, sequence stratigraphy and orbitally-driven cycles.

The IUGS Subcommission on Cretaceous Stratigraphy (Birkelund et al., 1984) recommended to place the Barremian/Aptian boundary at the chronostratigraphic level coinciding with the appearance of the subgenus *Deshayesites (Prodeshayesites).* No alternative boundaries have been proposed since then. Busnardo (1965) placed the base of the Aptian at the base of bed 197 of the Route d'Angles section, because he found the first *Pseudohaploceras matheroni* in that bed. This species is now known to appear already earlier in the latest Barremian. Nevertheless, this conventional Barremian/Aptian boundary in the Route d'Angles section, which is a transgressive surface, has been retained as the base of the Aptian. This is not in conflict with the hitherto lowest find of *Deshayesites (Prodeshayesites)* in bed 200, only 2 m above the conventional boundary. (Delanoy, 1991). *Deshayesites (Prodeshayesites)* is extremely rare in France as well an in other Mediterranean sections.

In the Rio Argos section (Caravaca, Murcia, Spain) the first Aptian ammonites (*Procheloniceras* and *Deshayesites*) occur just above a global transgressive surface, whereas *Colchidites* disappears just below it. It is possible that a hiatus marks the Barremian/ Aptian boundary.

By accepting the *Deshayesites tuarkyricus* Zone as the basal zone of the Aptian at the Workshop in Digne (Hoedemaeker & Bulot, 1990), a problem was created because *Prodeshayesites* has not been reported from this zone in Turkmenia. It cannot be confirmed yet that the base of the *D. tuarkyricus* Zone coincides with the appearance of *Prodeshayesites* elsewhere.

Most ammonite palaeontologists of the Aptian WG prefer to maintain the Barremian/Aptian boundary at the first occurrence of *Prodeshayesites*, and potential stratotype sections have been identified in France, Spain, Turkmenia and Rumania. However, virtually no ammonite-dated sections represent a CONTINUOUS and COMPLETE Barremian/Aptian boundary. Thus the WG considers the possibility of placing the Barremian/ Aptian boundary (= base of the Aptian) at other events. Due to absence or uneven distribution of ammonite faunas in several Aptian sequences from continents or drilled in the oceans, chronostratigraphy is routinely derived from calcareous nannofossil and planktonic foraminiferal biostratigraphy. Calcareous plankton (nannofossils and planktonic foraminifers) were exhaustively studied in several sections, but no events were detected at the actual Barremian/Aptian boundary. Moreover, although a number of first and last appearances occurs across the boundary, none is regarded as suitable for interregional correlations.

Suggestions have been forwarded by members of the working group to equate the Barremian/ Aptian boundary, and therefore the base of the Aptian, at the base of magnetic chron MO, which has been identified in several low-latitude sections from the Tethys, Atlantic, Pacific and Indian oceans. If this proposition will be accepted, then the Gorgo a Cerbara section (Umbria-Marche Basin, central Italy), with an excellent exposure of Barremian to Aptian pelagic carbonate sequence, is proposed as stratotype section for the Barremian/Aptian boundary. In fact, the section has magnetostratigraphy, calcareous nannofossil and planktonic foraminiferal biostratigraphy, radiolarian biostratigraphy, dinoflagellate biostratigraphy. The record of ammonites is not continuous; hoverer, a few diagnostic layers have been detected. Cyclostratigraphy was completed across the Barremian/Aptian boundary and provides a resolution of 10k years. An alternative stratotype section for the Barremian/Aptian boundary is the Alpetto section located in the Lombardy Basin (Northern Italy). Magento- and biostratigraphy (ammonites, calcareous nannofossils, foraminifers) are available along with sequence stratigraphy.

It must be noticed that time scales of the past decade (Harland *et al.*, 1982; Kent & Gradstein, 1985; Harland *et al.*, 1990; Gradstein *et al.*, 1994; Channell *et al.*, 1995) used for Early Cretaceous chronostratigraphy magnetostratigraphy integrated with calcareous plankton stratigraphy. Ammonite control of magnetic chron is available only for a few polarity chrons. In recent time scales, the base of the Aptian is placed at the base of magnetic chron MO.

In the Boreal Realm magnetostratigraphy of Lower Cretaceous sequences has failed so far and the first occurrence of *Deshayesites* is still considered the best event to determine the Barremian/ Aptian boundary.

Aptian substage boundaries

Recent revisions of Cretaceous ammonite zonations (Hancock, 1991; Hoedemaeker, Company *et al.*, 1993; Rawson, 1993) point out that two different ammonite zonations are used for the Boreal and Tethyan Realms (see figure enclosed). While a two-fold subdivision (Lower/Upper) is adopted for the Boreal Aptian, a three-fold subdivision (Lower, Middle, Upper) is often proposed for the Tethyan aptian following the French division into Bedoulian, Gargasian and Clansayesian. Rawson (1983) discussed at length the Aptian substage divisions. The matter was discussed during the Lower Cretaceous Cephalopod meeting held in Piobicco (Italy) in 1994, but no final decision was taken.

The Aptian WG will discuss propositions during the symposium and forward candidates to the Commission.

THE ALBIAN WORKING GROUP

compiled by **Malcolm B. HART** (Chairman)

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The Albian Stage

The Stage was proposed by d'Orbigny (1842) for the interval between the Aptian and what is now called the Cenomanian. The name was originally derived from the Roman name for the Aube (Alba). The localities initially cited by d'Orbigny include Wissant (Pas-de-Calais), Côtes-Noires (Haute-Marne), Gaty, Maurepaire, Dienville, Ervy (Aube), Saint-Florentin (Yonne), Perte-du-Rhône (Ain), Machéromenil (Ardennes) and Varennes (Meuse) in France and Folkestone (Kent) in England.

Following the work of Breistroffer (1947) the Albian Stage was generally accepted as beginning with the *Leymeriella tardefurcata* Zone. At the meeting in Copenhagen in 1983 it was agreed that the base of the Stage would be better drawn at the base of the *L. schrammeni* Zone (Birkelund *et al.*, 1984). Unfortunately this nominate species is restricted to the north-west European faunal province ("Boreal") and is not known from the classic areas of the Paris Basin.

The internal subdivisions of the Albian Stage are equally problematical (Amédro, *manuscript*), with the base of the Middle Albian and the base of the Upper Albian yet to be agreed. At the present time *Lyelliceras lyelli* can be used to define the base of the Upper Albian.

Stratigraphic terms such as Selbornian (Jukes-Browne & Hill, 1900) and Vraconian (Renevier, 1867) have gained little acceptance, although the latter is often used in French literature.

Traditionally the Albian Stage has been subdivided on ammonites and there is established a well-known zonal and subzonal scheme. More recently a number of workers have described the foraminifera, ostracoda, dinoflagellates and calcareous nannofossils (s.l.). In the areas described as being typical of the Stage the lithology is predominantly a dark blue-grey clay, deposited in mid-palaeolatitudes. This rather restricts the faunas and floras and has somewhat limited the international correlation of the Stage.

The Albian Stage occupies a part of the mid-Cretaceous "magnetic quiet zone" and the majority of workers have few data for magnetostratigraphy. Recently Baraboschkin (*pers. comm.)* has indicated that a magnetic zonation is possible but this has yet to be tested. While there have been isolated attempts to use stable isotopes there is not yet a generally accepted isotopic curve for the Albian Stage that could be used for stratigraphical purposes (unlike some higher parts of the succession).

Working Group Data

In the period since the announcement of the Sub-Commission meeting a number of individuals have provided data on various fossil groups and various Cretaceous locations

around the world. These are as follows:
F. Amédro (Calais, France), E. Avram (Bucharest, Romania), E. Baraboschkin (Moscow, Russia), M. B. Hart (Plymouth, U.K.), W.J. Kennedy (Oxford, U.K.), E. Koutsoukos (Rio de Janeiro, Brazil), H. Leereveld (Utrecht, The Netherlands), J. Mutterlose (Bochum, Germany), A. Tewari (Lukcnow, India, currently in Plymouth, U.K.), R. Venkatachalapathy (Madras, India).

Tabled Data

Tables can be used to provide a basis for discussion at the meeting and represent some of the data freely sent by the contributors and other stratigraphic information that must be integrated with the proposed stratigraphy.

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THE CENOMANIAN WORKING GROUP

compiled by **Karl-Armin TRÖGER** (Chairman)

(Geologisches Institut, Bergakademie Freiberg (TU), B.-v.-Cotta-Str. 2, D - 09596 Freiberg/ Sa., Germany)

The working group consists of 38 members from Belgium (1), Czech Republic (1), Denmark (1), France (1), Germany (5), Georgian Republic (2), Hungary (1), Italy (3), Japan (1), Morocco (1), The Netherlands (1), Rumania (3), Russia (1), Spain (5), Sweden (1), Switzerland (1), United Kingdom (7), USA (2).
We deeply mourn the disappearance of our friend and colleague Jost Wiedmann in 1993. Jost was an active member of the Cenomanian Working Group.

Discussions concerning the Albian/Cenomanian took mainly place with A.S. Gale, W.J. Kennedy, J. A. Burnett, M. Caron, J. D. Marshall, K. v. Salis, J. Ion, T. Matsumoto.

In a paper submitted for publication by Gale, Kennedy, Burnett, Caron and Marshall [Mont Risou near Rosans (Drôme, S E France): a potential Albian-Cenomanian boundary stratotype] the Albian/Cenomanian boundary as mentioned in Copenhagen (1983-1984) are discussed:

1. base of the *Hypoturrilites schneegansi* Zone (Algeria and Tunisia):

2. base of the *Graysonites adkinsi* Zone (Tethyan and Pacific areas);

3. base of the *Neostlingoceras carcitanense* Zone (northern Europe);

4. base of the *Mariella (Wintonia) brazoensis* Zone (U.S.A.);

The authors propose a potential Albian/Cenomanian stratotype in the "Marnes Bleues" Fm. (Upper Albian/ Lower Cenomanian) at Mont Risou near Rosans (Drôme).
The reasons for this proposal are:

1. The sequence (Marnes Bleues Fm.) is highly expanded.

2. The base of the Lower Cenomanian is defined by the first occurrence of *Mantelliceras mantelli*.

3. The sequence allows a detailed study of ammonites, inoceramid bivalves, nannofossils and planktonic foraminifera.

4. δ^{13}C PDB curves are described and compared with curves of sections at Speeton (England) and Gubbio (Italy).

5. The sequence represents a continuous sedimentation without gaps and remarkable vertical facial changes.

Substage boundaries based on vertical ranges of ammonites have newly been discussed by W. J. Kennedy with the following proposals:

- Base of the Middle Cenomanian: first occurrence of *Cunningtoniceras inerme* or *C. cunningtoni*.
- Base of the Late Cenomanian: top of the vertical range of *Acanthoceras jukesbrownei*.

These proposals and those given in the second circular should be considered.
All members of the working group were informed in four circulars over the discussions.

THE TURONIAN WORKING GROUP

compiled by **Richard A. REYMENT** (Chairman)

(Institute of Earth Sciences, Uppsala University, Uppsala, Sweden)

Correspondence on the Turonian Stage leading up to the meeting of the Subcommission in September has been almost exclusively concerned with the stratigraphical location of the boundary between the Cenomanian and the Turonian. Little attention at all has been given to questions of zonation. The impression one gains from the contributions of the admittedly few active members of the Working Group is that the zonation by ammonites is still accepted as the most useful biostratigraphical basis for the Cenomanian and Turonian. The notes provided here are based on information furnished by members of the working group and disseminated in the circulars sent out to members (six circulars so far) and are in no wise meant to be construed as a proposal for a final solution. It was Pierre-Yves Berthou who, working in Portugal, first cast doubt on the widely adopted definition of the boundary between the Cenomanian and Turonian, an heretical act that took much time and persuasion to achieve general acceptance.

The recommended procedure is first to establish a correlation, and then to advance to the definition of a boundary, recognizable over as wide a geographical extent as possible, and in both the Tethyan and Boreal Realms. Such information has accrued so far for two areas.

The Pueblo Sequence: W. A. Cobban, A. S. Gale and W. J. Kennedy have prepared a working paper, entitled **Pueblo, Colorado: a candidate boundary stratotype for the base of the Turonian Stage,** the salient details of which are as follows. The Cenomanian-Turonian boundary is today recognized as an interval during which a major anoxic episode took place and a phase of mass-extinction is claimed by some to have occurred. The study of the ammonite associations of the U. S. Western Interior has resulted in a great refinement of the ammonite zonation across the interval. Biostratigraphical, isotopic, geochemical and radiometric analyses made on the sequence at Pueblo, Colorado advance persuasive support for proposing this section as a stratotype for the Cenomanian-Turonian transition.

An ideal section for the Cenomanian-Turonian boundary would have to encompass all of the biostratigraphical marker-levels and should be permanent and readily accessible. The Pueblo sequence fulfils many of the essential criteria for an ideal reference. There are good data available for ammonites, inoceramids, planktic foraminifers, calcareous nannofossils, stable isotopes, iridium anomalies, numerical dating of correlative sections, etc. The section shows no obvious signs of condensation or non-sequence and is composed of diagenetically modified limestone-mail Milankovich cycles, limestone and marl beds, of which many can be correlated across tens of thousands of square kilometres. Excellent exposures can be accessed in the Pueblo Reservoir Recreation area and in newly made railroad cuttings on the Denver-Rio Grande Western Railroad. Moreover, there are bentonites that are amenable to direct radioactive dating. The interval between the base of the Cenomanian *Metoicoceras geslinianum* ammonite Zone and the base of the Turonian *Mammites nodosoides* Zone includes a series of biostratigraphical datum-levels that fall into the same position relative to a complex $\delta^{13}C$ stable isotope that is identical on both sides of the Atlantic. The total time interval represented is constrained by radiometric dates obtained from bentonites intercalated in the Western Interior sequence and is, on present evidence, unlikely to embrace more than 1 Ma. The preferred definition of the base of the Turonian proposed by Cobban, Gale and Kennedy falls within the *Oceanic Anoxic Event* that encompassed perhaps 0.6 Ma, with a boundary age of 93.3± 0.2 Ma.

The ammonite zones recognized at Pueblo are assemblage zones which makes them unfit for defining the base of the Turonian. The first showing of *Watinoceras devonense* at the base of Bed 86 (Pueblo sequence) is being proposed as an indicator of the base. Records from the Pueblo sequence indicate that the first appearance of abundant *Mytiloides hattini* in the shale below bed 86 and the first appearance of *Praeglobotruncana helvetica* 5 m above the base of the Bridge Creek Limestone could be utilized to denote the base of the Turonian in the absence of ammonites. The working paper provides details of the ammonite sequence and ammonite zonation, integrated biostratigraphy for ammonites, inoceramids, planktic foraminifers and nannoplankton, and the correlation of the ammonite zones of Pueblo and southern England with the positions of common datum-levels indicated. There are also analyses of previous work and opinions and contrasts with the points brought forward by the present proposal. The points raised are mainly directed towards clarifications of the document arising from the meeting of the Subcommission in Copenhagen in 1983.

Paul Dodsworth has taken up the palynology of the Pueblo section, Colorado, USA, thereby providing further support for the selection of that sequence as a boundary stratotype. Dinoflagellate cysts have been studied from the upper Cenomanian to lower Turonian deposits of six separate depositional basins. The most distinctive inter-regional event near to the C-T-boundary is the top of the acme of *Litospshaeridium siphonophorum*. The summit of the acme occurs in the same position as indicated by planktic foraminifers (a few beds higher than the range-top of *R. cushmani*, ammonites (the middle of the *M.geslinianum/S. gracile*- Zone) and geochemistry (immediately below maximum ä^{13}*C* values) at Pueblo (Co), Lulworth and Eastbourne in the Wessex-Paris basin (U.K.), and Misburg in the Lower Saxon Basin, Germany. Four other species have been shown to have range-tops in the Zones of *M.geslinianum* or *N. juddii*. Otherwise, the diversity of cosmopolitan dinoflagellate cysts does not seem to have been affected during the Cenomanian-Turonian transition, even in regions were "Oceanic Anoxic Event 2" organic-rich sediments were deposited.

The Oyubari Sequence. Dr. Hasegawa has put a good case for the Oyubari sequence of Hokkaido as a boundary stratotype. Some of the main points he makes are:

(a) The Japanese Cenomanian-Turonian-boundary is drawn just above the upper of the twin positive carbon isotope excursion peaks which is taken to be the equivalent of the first appearance of *Watinoceras devonense* in the Pueblo section (see above). The correlation between Pueblo and Oyubari strengthens the claims for both of them for recognition as boundry stratotypes.

(b) The lithofacies across the Cenomanian-Turonian-boundary indicate that dysaerobic conditions (= mondial Oceanic Anoxic Event) also existed in the Pacific realm.

(c) The Oyubari section contains enough stratigraphical indicators to allow exact correlations with Cenomanian-Turonian sections around the world.

Other areas of possible interest. In addition to the two areas referred to above, there are others that could well be given consideration, but which have not been taken up so far by members of the Turonian working group.

There are analyses of the Cretaceous-Turonian boundary in central Tunisia available which incite interest from the standpoint of an integrated stratigraphy and a recognition of mondially recognizable events, such as the Cenomanian-Turonian anoxic episode. The Spanish Cenomanian-Turonian is covered in several recent publications treating sedimentology, tectonics, biostratigraphical resolution and regional characteristics, including a detailed account of the situation in the Pyrenees.

One of the challenging aspects of the Cretaceous Period is the ample evidence for tectonoeustatic, or Suessian, transgressions, many of which achieved great palaeogeographical significance. The classical event is that of the trans-Saharan Cenomano-Turonian transgression, the one upon which E. Suess based his concept. There have been recent claims for a Cenomanian-Turonian extinction event, a rather surprising concept for me and, I opine, others. It remains to discover how mondially general it is. Can mass-extinction not be confused with episodes of mass-mortality? The Saharan Cenomanian-Turonian houses impressive evidence of episodes of mass-mortality of ammonites due to their stranding at falls of sealevel or to deluges that quickly lowered salinity to a lethal level - just as can be seen today in the Waddenmeer where thousands of dead squids line the shore after heavy rain.

THE CONIACIAN WORKING GROUP

compiled by **Erle G. KAUFFMAN** (Chairman)

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Introduction

The Coniacian working group currently consists of 33 scientists from 14 nations. The work of the committee has been directed primarily at definition of the criteria for determining the T-C boundary worldwide, including first and/or last appearance datums (FAD's, LAD's respectively) of various molluscan and microfossil groups and potential event-chronostratigraphic surfaces, as well as a suitable boundary stratotype. In addition, we have addressed the philosophy of defining the T-C boundary: should it be only biostratigraphically defined, and if so by the entrance level of a single taxon or by assemblage zonation? Or should the T-C boundary be defined on a combination of event chronostratigraphic surfaces and biostratigraphy, where possible. Opinions on these matters vary widely among participants.

Historical perspective

At the type locality of the Coniacian (Richemont Seminary, near Cognac, Charente, France) a prominent regional disconformity separates Turonian from Coniacian strata, and biostratigraphically important groups like the Inoceramidae are poorly represented. Birkelund *et al.* (1984) thus proposed other possible candidates for the T-C boundary stratotype, including: (a) the "Priesener Schichten" in the Czech Republic, which have a diverse ammonite and inoceramid fauna, as well as facies suitable for microbiotic analyses; (b) the El Kef section (Tunisia) with its high potential for micro- and nannofossil recovery. Neither one of these sections has been subsequently proposed by members of this committee as the best stratotype, although both remain valid candidates. A third stratotype candidate, in the Fort Hays Limestone Member, Niobrara Formation, near Wagon Mound, New Mexico, USA was proposed by E.G. Kauffman, during preliminary communications (see below). W. A. Cobban has suggested that the Fort Hays Limestone section at Pueblo, might also make a good Turonian-Coniacian stratotype (see below).
Criteria suggested previously for the definition of the T-C boundary are as follows (Birkelund *et al.*, 1984) (remarks in [...] are added by the committee).

(a) The FAD of *Forresteria (Harleites) petrocoriensis* (Coquand) (= *Barroisiceras haberfellneri* recorded from the Charente by de Grossouvre, 1894, to Séronie-Vivien, 1972). This definition received the greatest support at the Copenhagen meeting. [The approximately equivalent FAD in North America would be *Forresteria peruana* and, slightly higher *F. blancoi*; however, *Cremnoceramus rotundatus*, another candidate for defining the T-C boundary, occurs slightly lower than the first recorded *Forresteria* in this region.

(b) The FAD of *Cremnoceramus deformis* (Meek) and *Cr. schloenbachi* (Böhm) (proposed by Tröger (1981) and Bailey *et al.* (1984). In the Western Interior the first appearance of *Cr. deformis* sensu Meek, lies above the FAD of *F. peruana, F. blancoi, Cr. erectus* and *Cr. rotundatus*, all regarded as Early Coniacian taxa. *Cr. schloenbachi* first appears above the *Cr. deformis* Zone in this area (Kauffman *et al.*, 1993).

(c) The flood occurrence (epibiole; acmezone) of *Cremnoceramus? waltersdorfensis hannovrensis* together with abundant *Didymotis* (e.g. *D. costatus*) in the "upper *Didymotis* event" (Bailey *et al.,* 1984; Wood *et al.,* 1984). The FAD of *Didymotis* is associated with basal Coniacian ammonites like *Forresteria*. [*Cr. waltersdorfensis hannovrensis* ranges into the latest Turonian (e.g. Kauffman *et al.*, 1993) and its epibole could be environmentally regulated at different times in different places, and thus is not a bioevent s.s.].

(d) The FAD's of the echinoids *Micraster decipiens* (Bayle) and/or *M. normanniae* at the base of the western European *M. cortestudinarium* Zone. The localised occurrences of these taxa, and the probability of strong ecological and preservational control on their occurrence, led Birkelund *et al.* (1984) and Bailey *et al.* (1984) to not recommend use of these criteria in defining the T-C boundary.

(e) The FAD of *Marthasterites furcatus* (Deflandre) is used by nannofossil specialists as the base of the Coniacian. But this FAD lies well within the range of Late Turonian ammonites such as *Subprionocyclus neptuni* (Geinitz).

(f) In the Western Interior (summarised in Kauffman *et al.*, 1993), the T-C boundary has recently been placed at the FAD of *Cremnoceramus rotundatus*, and at or just below the FAD's of *Forresteria peruana,* and subsequently *F. blancoi* (base of *Forresteria blancoi-Scaphites impendicostatus* assemblage biozone), associated with rare *Didymotis*. The regional LAD's of several species of latest Turonian *Mytiloides* (*M. incertus, M. dresdensis labiatoidiformis, M. problematicus*) occur at this boundary. This seems to fit the favoured European boundary criteria well.

New boundary stratotype proposals

(1) Only a single new proposal for the Turonian-Coniacian boundary stratotype has been formally received, namely that for the Wagon Mound (New Mexico, USA) locality of the Fort Hays Limestone Member, Niobrara Fm., from Erle Kauffman. Data from this locality have been made available through the work of A.P. Laferriere (Indiana University) and of C. J. Collom (Calgary University, Alberta, Canada) (publications: Laferriere, 1987a, b, Laferriere and Hattin, 1989) and subsequent fieldwork by E. G. Kauffman and C.C. Johnson (1995) (details in the presentation of Kauffman at this meeting).
This sections seems to meet all the requirements of an acceptable boundary stratotype:

(a), easily and continuously accessible along US Interstate Highway 25, 800 m north of Wagon Mound, Mora County, New Mexico.

(b), The Fort Hays Limestone Member is 7.3 m thick and records essentially continuous deposition of fossiliferous hemipelagic carbonates across the Turonian-Coniacian (T-C) boundary.

(c), The contact between the limestone and underlying Late Turonian shale is conformable.

(d). 14 planktic and 34 benthic foraminifer species and sparse nannofossils were identified; no major microbiotic change occurs at the T-C boundary.

(e). Macrofaunal diversity shows a major decline across the boundary, marking a regional extinction event. The LAD's of several latest Turonian *Mytiloides*, and the FAD of *Cremnoceramus rotundatus* occurs in the same limestone unit just above the boundary. Ammonites are rare, but by using event correlation from nearby Fort Hays sections can be supplemented.

(2) W. A. Cobban has suggested that the Fort Hays Limestone section at Pueblo, might also make a good Turonian-Coniacian stratotype because *Forresteria* are more abundant in the Early Coniacian limestones than at Wagon Mound, New Mexico, and they may occur closer to the T-C boundary. A rich and diverse inoceramid bivalve fauna also spans the boundary there, but is not as well preserved as to the south.

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THE SANTONIAN WORKING GROUP

compiled by **Marcos A. LAMOLDA** (Chairman)

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The Santonian Stage
Derivatio nominis: after the city of Saintes (Charente-Maritime, France).
Author: Coquand (1857).
Type-area: Javrezac (Charente) and Saintes (France).
(see Séronie-Vivien, 1972, 1980; van Hinte, 1979; Birkelund *et al.*, 1984; Kennedy, 1984; Hancock, 1991, for further details).

The Coniacian-Santonian boundary (C-S)
At the Copenhagen Symposium (Birkelund *et al.*, 1984 several proposals were considered:

1. First occurrence (F.O.) of the subgenus *Texanites (Texanites).*
-Usually a good index for this boundary, with a worldwide distribution, except in classic localities of NW Europe. *Texanites gallicus* is a common species in Europe, where it occurs with *Placenticeras polyopsis* from the lowermost Santonian, although the latter occurs throughout the Santonian stage: e.g. with *Marsupites* (top Santonian levels near Recklinghausen (Germany), and with *Placenticeras paraplanum* in Austria (after Hancock, 1991, p. 278).
-Toshimitsu (1988), in his monograph on the Santonian of NW Hokkaido, cited the occurrence of *Texanites* cf. *collignoni* and *T.* cf. *quinquenodosus*, associated with *Inoceramus amakusensis*; first occurrences of both species of *Texanites* should draw the Coniacian-Santonian boundary, or should be very close to it, since they overlie an Upper Coniacian fossil assemblage (Toshimitsu, *op. cit.*). Furthermore, the occurrence of *T. collignoni* is well known in basal Santonian beds in South Africa, Madagascar and Tunisia (= *T. oliveti* auct.).
- The first occurrence of *T. quinquenodosus* was cited by Tröger & Summesberger (1994) as a marker for the C-S boundary in Gosau (Austria). It is close to *Sphenoceramus cardissoides* and *Cladoceramus undulatoplicatus* entries, the latter being a common index for the C-S boundary (see below).

2. The appearance of *Inoceramus (Cladoceramus) undulatoplicatus*
This taxon was proposed as another main index for the C-S boundary, because of its common occurrence in broad regions of the Northern Hemisphere. In northern Germany it appears later than the *Sphenoceramus pachti-cardissoides* group, and in the Gosau (Austria) it occurs later than *S. cardissoides* and *T. quinquenodosus*. But in other cases, it is coincident with the appearance of *T. quinquenodosus*, such as in Tirol (Tröger & Summesberger, 1994, p. 184), N. Spain (Ernst, pers. comm.). Nevertheless in the Western Interior *I. (C.) undulatoplicatus* co-occurs with the Upper Coniacian species *Protexanites bourgeoisi* (Cobban, *fide* Hancock, 1991, p. 277).

3. The appearance of *Inoceramus siccensis.*
Up till now, only known from north Africa associated to rare *Texanites.*

Other possible indices

4. F.O. of *Sigalia carpathica*
Sigal (1977) cited this event as a good marker of the C-S boundary in the Mediterranean region. In northern Spain (Losa Valley) its F.O. is just above *Texanites* spp. (Lamolda *et al.*, 1991; Martinez *et al.*, in press), and *Inoceramus (C.) undulatoplicatus* (Olazagutia Quarry, Navarra), where *S. carpathica* occurs also with *Ventilabrella decoratissima. S. carpathica* is a good potential index which should be checked in other regions, mainly middle and low latitudes localities.

5. F.O. of *Sigalia deflaensis.*
Cited by Wagreich (1988, 1992) from Austria as a marker of the C-S boundary. In some localities (such as in the Gosau area) such records cannot be its first appearance since it is coincident with F.O. of *D. asymetrica* and *D. concavata*, underlying by detrital facies. In southern palaeolatitudes such as the Mediterranean regions, the F.O. of *S. deflaensis* is located in Coniacian materials (Sigal, 1977). This is also the case in N. Spain (pers. comm.).

6. F.O. of *Dicarinella asymetrica.*
This bio-event postdates the F.O. of *Texanites* and *I. (C.) undulatoplicatus*; hence it is well above the C-S boundary defined according to both macrofaunal indices. However, transitional specimens between *D. concavata* and *D. asymetrica* occur with the F.O. of *Texanites* and *S. carpathica.*

7. The C-S boundary lies in the *Micula staurophora* Zone (CC14 of Sissingh, 1977). However, the first occurrence of *Reinhardtites anthophorus* in unreliable due to the difficulties often experienced in its identification. Hence, there is room for improvement (Burnett, pers. comm., 1994).
- Other nannofossil events, such as the L.O. of *Eprolithus floralis* and F.O. of *Micula concava* and *Lithrastrinus grillii* occur later or earlier than the F.O. of *Texanites* and *I. (C.) undulatoplicatus.* However, abundances of *M. concava* and *L. grillii* are higher in Santonian than in Coniacian levels (Flores *et al.*, 1987). Therefore, their occurrences are useful to characterise the Coniacian-Santonian transition, but none coincide with macrofaunal events.

8. F.O. of *Placenticeras polyopsis*
Often used to indicate the proximity of the FO of *Texanites.* In actual fact, in many localities its total range characterises the Santonian (f.i. in the type are of the stage, Kennedy, 1983; in northern Spain (Martinez *et al.,* in press).

9. F.O. of *Sphenoceramus cardissoides.*
A good marker of the C-S boundary, associated with *Texanites* and *I. (C.) undulatoplicatus*, but unfortunately it does not occur in the Tethyan Realm (Lopez *et al.*, 1992). The entry of the *Sph. pachti* group was suggested by Seitz (1965) as a marker for the C-S boundary (*fide* Tröger, 1989).

Possible C-S boundary stratotypes

Sections in Austria, N. Germany, N. Spain, S. England, S. France (Corbières) and Tunisia should be considered. In the Far East, sections in Saghalin and Hokkaido should be considered for the Boreal-Pacific region.

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THE CAMPANIAN WORKING GROUP

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The Campanian Stage
Derivatio nominis: after the Champagne region, France (Campanian, Latin).
Author: Coquand (1857).
Type-area: Aubeterre (Charente), Grande et Petite Champagne (France).
(see Séronie-Vivien, 1972; van Hinte, 1979; Neumann, 1980; Birkelund *et al.*, 1984; Hancock, 1991, for further details).

The Santonian-Campanian boundary (S-C)
At the Copenhagen Symposium (Birkelund *et al.*, 1984 several proposals were considered:

1. First occurrence (F.O.) of *Placenticeras bidorsatum* (Roemer).
Commonly used in Central and W. Europe, but the species is rare.

2. F.O. of *Submortoniceras spathi* (in the lineage from *Texanites* to *Submortoniceras).*
Has a cosmopolitan distribution, but is unknown from the type-region in France. F.O. of *S. spathi* Collignon was proposed as marker of the S-C boundary, but some references are doubtful. Other F.O. of *Submortoniceras* spp. should be checked before taking them as marker of the S-C boundary.

3. The Santonian-Campanian *Scaphites hippocrepis* lineage. *Sc. aquisgranensis* (Schlüter) /= *Sc. hippocrepis* III, after Cobban, 1969/ occurs together with *Placenticeras bidorsatum.* According to Hancock (1991, p. 279): "The Texan evidence is important because it shows that the European standards for the base of the Campanian are very close to, and may even be coincident with, the transition from *Texanites* to *Submortoniceras*".

4. F.O. of *Gonioteuthis granulatoquadrata* of the *G. granulata-quadrata* lineage. This is a good marker in the Boreal Province. Its F.O. coincides with the last occurrence (L.O.) of *Marsupites testudinarius* in northern Germany. Some problems remain with species identification in this lineage.

5. L.O. of *Marsupites testudinarius.*
This is a favourite marker for the S-C boundary because of its coincidence with F.O. of two major indices: *P. bidorsatum* (point 1), and *G. granulatoquadrata* (point 4). Almost a cosmopolitan taxon; no records from deep-sea deposits.

6. F.O. of *Broinsonia parca (= Aspidolithus parcus)*
A well known index for nannofossil workers. The F.O. of *B. parca* postdates F.O. of *Offaster pilula* (Bailey *et al.*, 1984; Gale *et al.*, in press) and *Globotruncana arca* in Austria (Wagreich, 1992), and the L.O. of *M. testudinarius* in N. Germany (Burnett, 1990).

7. F.O. of *Bolivinoides strigillatus.*
Restricted to western Europe, where it is a diachronous species (Birkelund *et al.*, 1984).

8. F.O. of *Globotruncana arca,* which coincides in Tunisia with F.O. of *Stensioina labyrinthica, Neoflabellina rugosa* and *Broinsonia parca.* Usual index in Tethyan Realm. Its F.O. is discussed in relation with other planktonic foraminifers , e.g. *Globotruncanita elevata* and *Dicarinella asymetrica.* According to Ion & Szasz (1994) *G. arca* occurs below the F.O. of *G. elevata* in most Carpathian sections.

9. L.O. of *Dicarinella asymetrica.*
Coincides with the L.O. of *D. concavata*, and both taxa are well known in the Tethyan Realm. This bio-event postdated F.O. of *G. elevata* and *G. arca*.

Other possible indices

10. *Globotruncanita elevata.* Its F.O. is dated Late Santonian or S-C boundary. A good index with a wide distribution, which probably coincides with the F.O. of *G. stuartiformis*, or closely predates it. In Gosau (Austria), this bio-event coincides with the F.O. of *P. bidorsatum*, and overlies an Upper Santonian ammonite assemblage (Wagreich, 1992) On the Gulf Coast (Austin Chalk Group) Gale *et al.* (in press) wrote: "Bryan records the first occurrence of *Globotruncana elevata* from the "upper Dessau" which must thus either partly coincide with the range of *M. testudinarius* or enter just above it". In northern Spain (Losa Valley), the F.O. of *G. elevata,* in clay-marlstone, occurs above limestone with *Submortoniceras tenuicostulatum* and *Behavites subquadratus* of earliest Campanian age (Gischler *et al.*, 1994).

11. The F.O. of *Orastrum campanensis.* burnett (1990) proposed it as an index to the S-C boundary in the Boreal Province. The actual boundary is marked between F.O. of *Calculites obscurus* and *O. campanensis*, close to the latter, in N. Germany and E. England.

12. The F.O. of *Inoceramus balticus.* It may coincide with the S-C boundary in NW Germany (Schulz *et al.*, 1984); other references suggested other situations (*fide* Hancock, 1991, p. 279).

Far-Eastern Russia and Japan

Yazykova (pers. comm. 1995): " The appearance of *Anapachydiscus (Neopachydiscus) neumanni* (Yokoyama) and of *Inoceramus nagaoi* Matsumoto & Ueda are the best two boundary criteria for Saghalin".

In Japan F.O. of *Submortoniceras* cf. *condamyi, Menabites mazenoti* and *Globotruncana arca*, are the most appropriate to place the Santonian-Campanian boundary, which overlies occurrences of *Plesiotexanites kawasaki*, *P. pacificus* and *Inoceramus amakusensis* from top Santonian levels (S. Toshimitsu, pers. comm., 1995).

Magnetostratigraphy

The base of Chron 33R is quite variable according to its biostratigraphical dating. The close entry of *G. elevata* to the base of the reversal at Gubbio is not certain, since an interval 24 m thick is missing in the studies log (*fide* Jenkyns *et al.,* 1994). Lillegraven (1991) suggested that reversal should be younger than the S-C boundary, since "magnetochron 33R may eventually be shown to occur near the top (or even wholly above) the stratigraphic limit for the *P. bidorsatum* Zone". Also, Toshimitsu *et al.* (in press) think that reverse magnetic chron 33R is located in the Lower Campanian, well above the F.O.

of *G. arca*. On the contrary, Pechersky *et al.* (1983) and Gale *et al.* (in press) suggested a late Santonian age, according to occurrences of *M. testudinarius* in Turkmenia, and *Uintacrinus socialis* in the Isle of Wight and Seaford (Sussex, England) respectively.

Other physical evidences

A commonly occurring ä^{13}C positive shift at the top of *M. testudinarius* Zone has been cited (Gale *et al.* (in press).

Possible S-C boundary stratotypes

Sections in N. France, N. Germany, N. Spain, S. England, Texas and Tunisia should be considered.

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THE MAASTRICHTIAN WORKING GROUP

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Toward a GSSP for the Campanian-Maastrichtian boundary

The Working Group Maastrichtian (later on the WGM) is supposed to reach internationally agreed conventions related to the Maastrichtian time. The main problem to be solved is the proposal for a precise boundary between the Campanian and Maastrichtian Stages (later on the Ca-Maa By).

The concept of GSSP is currently accepted in order to give to historical definition (historical stratotype sections of Stages) a better precision and unique location, and sometimes, to reconcile inconsistencies. Because a GSSP is a supplementary information for definition of precise limits between a priori defined Stages, the knowledge of historical stratotype sections (Campanian of Charentes and Maastrichtian of Limburg for the WGM) is a necessary prerequisite for locating consistently the point within the section to be selected. Therefore, the presentation of new data for documentation of a potential GSSP will need to consider its correlation potential versus the historical stratotypes (as far as it is possible).

The role of a GSSP is to provide a concrete section easily correlatable on widest portion of the Earth. Therefore, consideration of data available from other areas (and as far from Europe as possible -Europe is mentioned here strictly because historical stratotypes are there) is strongly encouraged provided that correlation means common to Europe are present and have been documented from these areas.

If the GSSP, must be correlated to historical stratotype and correlatable to far areas, it must also be a unique point according to International Commission on Stratigraphy rules.

An appropriate section must have an easy access, it must be available for long (permanently available and protected), the record must be simple (no tectonic/depositional complexity), complete (continuous deposition), preserved since deposition (no strong diagenetic effect), and homogeneous (no facies change). If this is considered, the major task of the WGM is not to discuss the theoretical possible location of the level where to put the GSSP versus such or such fossil zonation, or eustatic sequence boundary, or palaeomagnetic chart; it is to work on sediments and accumulate knowledge using diversified approaches on previously selected sections.

The correlation potential depends on the Stage limit considered; it includes the environment of deposition and the correlation tools available; this partly depends on the palaeogeographic situation. For the Ca-Maa By, the key section needs to be in the marine domain. During late Cretaceous, the palaeogeography is such that a key section will have to be located in an area for which comparison will be possible with both the Boreal and the Tethyan domains.

The correlation tools which are appropriate for the Ca-Maa By are diversified and we are lucky enough to be able to undertake a real integrated stratigraphic approach; the latter is implied by the concept of GSSP. This means a combination of unequivocal tools (mostly biostratigraphy and, if possible, geochronology) and equivocal tools (litho-, with sequence analysis, chemo- and magneto-stratigraphy). If this multiple approach is preferred, then it will be necessary to consider a set of sections for application of most stratigraphic tools even if a single is formally proposed for definition.

As far as physico-chemical stratigraphy is concerned, two particular points may be emphasised. There are known variations of the Earth's magnetic field during the last portion of the Cretaceous; this fact has to be investigated in the sections considered (this record gives "high resolution" stakes). The other point is the known rapid variation of the Sr isotopic composition of the sea water during the same interval of time; this Sr record will allow relative location of a sediment and, like the previous one, it is of fully worldwide application.

Biostratigraphy, remains a key tool. For the particular Ca-Maa By a combination of fossil groups useful for correlation is necessary. Key fossils : macrofossils: Ammonites (*Nostoceras hyatti*, *Pachydiscus neubergicus, Hoploscaphites constrictus,*; Belemnites (*B. langei, Belemnella lanceolata*; Inoceramids (chronologic distribution apparently still to be improved), Echinoids (genera *Micraster* and *Echinocorys* are promising), Brachiopods (microforms).
Amongst micro- and nanno fossils: planktonic foraminifers (globotruncanids: *Globotruncanita calcarata, G. stuarti, Gansserina gansseri)*; benthic foraminifers (*Bolivinoides*); calcareous nannofossils (*Quadrum trifidum, Eiffelithus eximius, Broinsonia parca*...); Dinokysts.
Evaluating the respective interest of the groups may give preference to fossils - with large distribution, - with low potential of diachronism (low life duration).

The sections available, (i.e. well known and potentially useful) are essentially located three areas:

+ Northern Germany (Kronsmoor,. .)
+ Biscay Coast (from Zumaya, Spain to Bidart,France...)
+ Tunisia (El Kef)

The first is clearly boreal, the last is Tethyan; the sections in the Basque are still Tethyan but are of interest versus an old section recently revisited and presented during this meeting: Tercis. Comments or new results on these three areas will be welcome for discussion of the validity and reproducibility of correlation.

An appropriate level has to be selected. This is the last step of the research: there is no need for a GSSP to coincide with a particular signal especially a biostratigraphic one. The conventional character of the point would be even more clear If one could avoid such coincidence. This would not diminish the correlation potential but increase it by the use of several nearby signals. This would also avoid the endless discussion on what is the best fossil or correlation tool. The GSSP needs only to be **traced** using preferably, a moment in a continuous control.

The selection of a GSSP must not depend on a single criterion considered as the most "important". If this view is accepted, the GSSP will depend on a pool of criteria present in a section and on their potential domain of application. It may be emphasised that the historical type areas are known to be unsuitable, and that designation and study of a single section in a domain of restricted palaeogeographic extension will not solve the present situation.

ABSTRACTS OF POSTERS AND PAPERS

Latest arrivals...

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The Valanginian-Hauterivian boundary in the Neuquen Basin, Argentina.

The Agrio Formation of the Neuquen Basin (west-central Argentina) contains an abundant ammonite fauna of Valanginian to Barremian age. However, at most horizons taxonomic diversity is small, individual assemblages generally being monogeneric or even monospecific. The sequence consists of a mixture of globally distributed taxa (e.g. *Olcostephanus*, *Spitidiscus*, *Crioceratites*) and more geographically restricted genera. The latter group includes forms found also in the Indo-Malagasian Province and Andean genera.

Brief invasions of genera found also in the standard west European sections provide important inter-regional markers. Thus the sudden appearance of *Olcostephanus* of the *O. atherstoni* group, followed by a brief incursion of *Karakaschiceras-Neohoploceras* spp. provides a clear correlation with the European mid-Valanginian. An equally important correlation is indicated higher in the sequence by the appearance of *Spitidiscus* closely followed by *Crioceratites,* both comparable with European mid-Hauterivian forms.

Between these levels are several important fauna horizons whose age is more uncertain. They belong to the *"Lyticoceras" pseudoregale* and *Holcoptychites neuquensis* Zones of the current zonation. In the absence of ammonites characteristic of the basal Hauterivian of the west Mediterranean area the position of the Valanginian/Hauterivian boundary within this sequence remains uncertain. Both zones have traditionally been placed in the Hauterivian, but Aguirre Urreta and Rawson (*in press*) have now assigned the *pseudoregale* Zone to the Valanginian as the characteristic neocomitids of this zone appear close to *Besaireiceras* of the Indo-Malagasian Province. This is supported by the discovery of two poorly preserved fragments of *Oosterella*, one in the upper part of the *pseudoregale* Zone and the other in the basal part of the overlying *Holcoptychites* beds. *Oosterella* is a predominantly late Valanginian ammonite that just extended into the earliest Hauterivian. At present we place the base of the Hauterivian at the base of the *H. neuquensis* Zone but the possible relationship between *Holcoptychites* and the late Valanginian *Jeanthieuloyites* requires investigation.

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Dinocysts and pollens of the Campanian-Maastrichtian series at Tercis (SW France) - First results.

A preliminary study (25 samples, each 10 g)has been undertaken to check the correlation potential of the Tercis series (SW France) for dinocysts and pollen.
The **content** of the samples: 75 % of the samples contain useful material, 25 % contain more than 10 dinocyst taxa. Many specimens are not yet identified and cannot be shown in this report.
The **palynofacies** is homogeneous in all samples studied. Dinocysts are much more common than pollen; they are well preserved and clear. A few dinocysts are more darkly coloured because of transport. Some carbonized elements are present; this is equally so in macro remains which have been identified by F. Baudin as ferns, after a forest fire. The depositional environment is supposed to be open marine, in agreement with the known palaeogeography.
"**Events**" are not rare: 8 have been found, with 5 LO and 3 FO observed in the section. These changes appear to be mostly evolutionary and have good correlation potential. Three LO are grouped at the base of the main section and two FO are also grouped at 2:3 of the "Calcaire à silex gris" (Limestone with grey flints) unit.
It is interesting to note that a similar group of 2 LO and 2 FO are also grouped at about 2/3 of the "Calcaire à silex gris" unit when data available from ammonites are considered. This is not an artificial cut, since diverse levels are concerned within the same portion of the unit which is typically homogeneous and continuously deposited, as far as can be judged from a series formed with individual limestone beds.
In short the sediments of the series have a favourable and interesting correlation potential as far as dinocysts are concerned.
Other similar studies on other fossil groups are being undertaken for the same way. The dinocyst stratigraphic tool will thus be of special interest for increasing the quality of the Tercis series as a reference for the Campanian-Maastrichtian boundary. This is also emphasised by the fact that the same tool has been studied from the stratotype areas in Limburg (unpublished theses by Wilson and by Slimani) and from the Champagne charentaise (unpublished by E. Masure). Thus, the wide extension of these fossils will allow a correlation of the Tercis section in a really global manner.

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Distribution of planktonic foraminifera around the Cenomanian-Turonian boundary in some key-sections and the meaning of the "*Archeocretacea*" Zone"

In terms of foram biozonation, the C/T boundary appears located in the so-called "*Archeocretacea* zone" (interval range zone), defined between the L.O. of rotaliporas and the F.O. of *Helvetoglobotruncana helvetica*. To try to estimate the duration and synchronism of the corresponding time slice, we have studied and compared some key sections. Pueblo (CO) and Kalaat Senan (Tunisia) may be calibrated with ammonites, when French (around Vergons) and Italian sections (around Gubbio) allow precise correlation; the three last areas concern the famous Bahloul, Thomel and Bonarelli levels which record the anoxia peak.

The **PUEBLO** section (Rock Canyon) is surely one of the best known and most studied place for the C/T boundary. Precise sampling on the classical litho-succession (from bed 63 to bed 105) allows to indicate that :

1- *R. greenhornensis* is absent after bed 67 when *R. cushmani* is present up to bed 73. The last Rotalipora morphotype *(Anaticinella)* may be observed just below bed 86, i.e. at the very top of the *Juddii* Zone.

2- *W. praehelvetica* appears at bed 67, and *H. helvetica* at the base of bed 86, i.e. the very base of the *Devonense* Zone.

Based on all stratigraphical data, the time interval between the last rotaliporid morphotypes and the F.O. of *H. helvetica* is here of some (tens of) ky.

KALAAT SENAN area offers many sections with can be easily correlated. SM intercepts the C/T boundary that appears at the very top (or near the top) of the Bahloul anoxic interval. In any case the last rotaliporid disappears just at the base of the Bahloul interval (m115), when *W. praehelvetica* appears just above (m131) and *H. helvetica* somewhat higher, i.e. in the *Nodosoides* Zone. The L.O. of rotaliporas is here in the *Naviculare* Zone. This means a time interval of about 1,5 Ma.

Near **VERGONS** different sections have been investigated which may be precisely correlated along a 20 km long profile; the Thomel (anoxic) level shows important thickness variations (10-20 m) due to a local gap in the basal part. In the more complete sections, the last Rotaliporas occur up to the first third of the Thomel when *H. helvetica* may appear together or 15 m higher; *W. praehelvetica* F.O. may be observed below or inside the Thomel level.

Umbria Marche basin has been intensively studied around **GUBBIO**, in the upper part of the Scaglia Bianca and its famous Bonarelli black level (about 1 m thick). The C/T boundary seems to be located, based on Radiolarians, at the first third of the Bonarelli. Even if the F.O. of *R. cushmani*, the F.O. and L.O. of *R. reicheli* are largely diachronous, the L.O. of *R. cushmani* takes place just before the Bonarelli (about 150 ka before the boundary). On the other hand the F.O. of *W. praehelvetica* and *H. helvetica* are also time-crossing, up to 0,5 Ma after the boundary.

Comparing all these data, it appears that the duration of the *"Archeocretacea"* interval, defined between the L.O. of rotaliporas and the F.O. of *H. helvetica*, is highly variable, from about nothing up to 1 Ma or more : both "limits" are diachronous, deeply influenced by the imprint of anoxia at different scales, regional and/or local ones. The *"Archeocretacea"* interval cannot be longer taken as a datum plane, but as a mirror of anoxia.

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The turnover of calcareous phytoplankton from the Barremian/Aptian boundary interval in NW Europe.

In NW Europe and elsewhere the Barremian/Aptian boundary interval is marked by a major change of the palaeoceanographic setting. Due to a widespread transgression in the earliest Aptian palaeoceanographic and sedimentary patterns changed both in NW Germany and in S England. A major floral and faunal turnover occurs at the Barremian/Aptian boundary interval. Restricted conditions prevailing in the latest Barremian and earliest Aptian, which are expressed by anoxic sediments, changed to a pelagic setting in the late earlyAptian. The composition of calcareous nannofossil assemblages, however, does not change abruptly. The main results of an integrated multidisciplinary study may be summarised as follows:

1. Nineteen nannofossils events (first occurrences, last occurrences, acmes) characterise the late Barremian to early Aptian sediments of NW Europe. Most of these events can be recognised throughout NW Europe (NW Germany, North sea) and allow a correlation throughout the North Sea.
2. There is a general shift from endemic assemblages, dominating in the Barremian, towards cosmopolitan ones in the Aptian.
3. The extinction and the onset of new floras is spread throughout the earliest Aptian. The biological turnover is gradual.
4. The first new cosmopolitan species (*C. litterarius, R. irregularis. E. floralis, F. oblonga, R. angustus)* occur well below the significant sedimentological change (Fischschiefer).
5. The calcareous phytoplankton of the early Aptian Fischschiefer suggests deposition under warm water conditions during a regressive phase.
6. The Fischschiefer, a Corg-rich sediment deposited under anoxic conditions, is considered to be a regional phenomenon. Data from organic geochemistry suggest rather preservation than productivity as the cause for the black shale sedimentation.

It has been suggested, that increased spreading rates and abnormal intraplate volcanism in the Aptian may have caused the onset of the mid-Cretaceous greenhouse. This would have caused global warming, high humidity and sluggish oceanic circulation, resulting in an accelerated carbon cycling and increased availability of nutrients. Our data, however, do not support the idea of higher productivity. Thus it seems more likely to explain the floral and faunal turnover by changes of the sea level and changes in the circulation pattern of the epeiric NW European sea.

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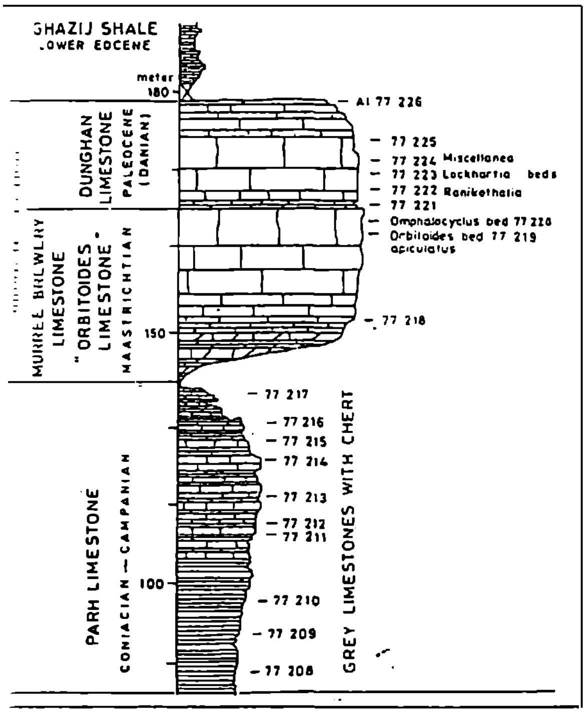
The status of the K-T Boundary in Pakistan.

Although the Upper Cretaceous - Lower Tertiary Succession is widespread in Pakistan, it is in Southern Pakistan that, on the basis of foraminiferal biostratigraphy, continuous succession across the Cretaceous - Tertiary boundary is considered to be present, either among the shallow shelf carbonate succession (Murree-Brewery Gorge Sections around the main town of Quetta) or the deeper water KORARA SHALE in the Kirthar Range or the Pab Range.



g.1: Upper Cretaceous, K-T boundary in the rbonate succession at the Murree-Brewery Gorge, etta (modified after ALLEMAN, 1979).

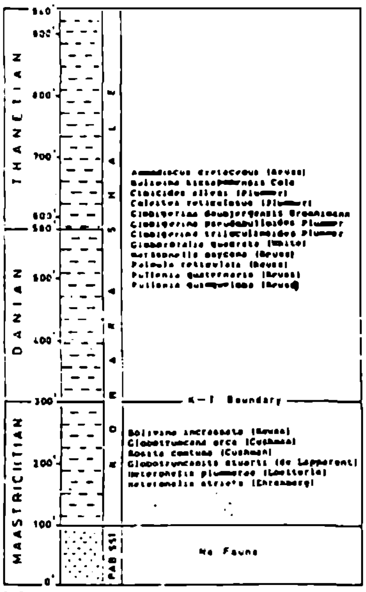


Fig.2: Foraminiferal distribution in the Korara Shale from section near Pabni Chauki, southern end of the Pab Range (modified after NAGAPPA, 1960).

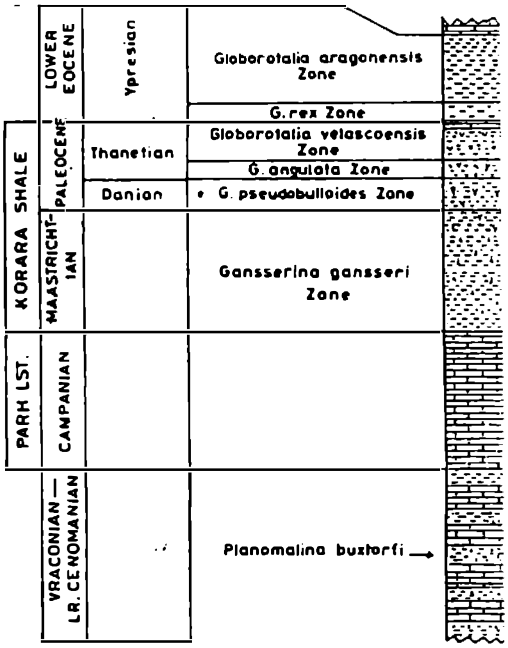


Fig.3: Unbroken sequence across the K-T boundary from the Kirthar Range (Western Gaj River section); Southern Pakistan (modified after DORREEN, 1974). DORREEN recorded G.compressa and G.trilocul inoides in G.pseudobulloides zone.

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The K-T Boundary in Libya.

The Sirte Basin, the Ghadamas Basin, the Cyrenaica Shelf or the Pelagian Platform are the structural units in northern Libya which constitute the Cretaceous-Tertiary succession. It is in fact the petroliferous Sirte Basin that demonstrates a well-documented K-T boundary among the outer neritic sedimentary facies where the globotruncanid-bearing Maastrichtian argillaceous Kalash Limestone is overlain by the globrotaliid- bearing Danian Hagfa Shale in the subsurface section. Among its reefal or shallow shelf carbonate environments, stratigraphically important shallow water benthonic larger foraminifera occur only in the Maastrichtian segments.

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Stratigraphical distribution of rudists in the Algerian Upper Cretaceous.

Better knowledge of rudistid faunas allows to present their stratigraphical distribution in Algeria.

Some are confirmed by associated foraminifera assemblages (Upper Cenomanian), others agree with the renewal of some communities related to sequence stratigraphy. Thus Turonian limestones with *H. requieni* and *D. cornupastoris* are replaced by Coniacian marls with *H. socialis* and *Plagyoptychus*.

The results are given in the following table. Similarities with many Mediterranean Cretaceous studies are noticeable.

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Late Campanian *Belemnitella* from the Zeven Wegen Member (Gulpen Formation) at the CPL quarry (Haccourt, NE Belgium)

Specimens of *Belemnitella* collected bed by bed from the Zeven Wegen Member (thickness 29 m) at the CPL quarry (Haccourt) have been analysed and compared with species recently described from Norfolk by Christensen (*Belemnitella* from the Upper Campanian and Lower Maastrichtian Chalk of Norfolk, England. *Special Papers in Palaeontology*, 51 (1995)).

The interval 0-5 m above the base of the Zeven Wegen Member is characterised by *Belemnitella mucronata* (Schlotheim, 1813) (mean values: Schatzky distance SD = 9.4 mm, fissure angle FA = 18.1 °, alveolar angle AA = 19.4 °, Birkelund Index BI = 3.5; n = 16). This part of the member is here correlated with the Pre-Weybourne 1-3 Chalk of Norfolk. No belemnite guards were available from the interval 5-10 m.

The interval 10-16 m yielded early forms of *B. woodi* Christensen, 1995 (mean values: SD = 8.6 mm, FA = 24.8 °, AA = 18.8 °, BI = 3.6; n = 23). This sample differs from the *B. mucronata* neotype population from Misburg (Germany) in its significantly larger Schatzky distance and significantly smaller alveolar angle, but it corresponds well with the type series of *B. woodi* from Keswick (England). The interval 10-16 m of the Zeven Wegen Member is here correlated with the Pre-Weybourne and the Weybourne Chalk of Norfolk. Late forms of *B. woodi* occur in the interval 17-28 m of the Zeven Wegen Member (mean values: SD = 8.0 mm, FA = 25.9 °, AA = 18.9 °, BI = 3.9; n = 61). They differ from earlier forms of that species in being more slender and from *B. minor* Jeletzky, 1951 in being smaller and less vascularised. The interval 17-28 m is here correlated with the Weybourne 2-3 Chalk of Norfolk. Judging from the thickness of the interval with late forms of *B. woodi*, equivalents of the Weybourne 3 Chalk are represented in the uppermost Zeven Wegen Member. It cannot at present be determined whether equivalents of the topmost Weybourne Chalk (Catton Sponge Bed), characterised by the appearance of *B. minor*, are represented since no belemnite guards from the uppermost metre of the Zeven Wegen Member were available.

A tentative correlation between the Upper Campanian Chalk of Norfolk with the Late Campanian biozonation of NW Germany as illustrated by Christensen (1995) suggests that the Zeven Wegen Member may be correlated with the latter zonation on the basis of belemnites as follows:

The interval 0-10/13 m is correlatable with the *conica/mucronata* and *basiplana/spiniger* zones. The top of the *basiplana/spiniger* Zone lies within the interval with early forms of *B. woodi*, about 10-13 m above the base of the Zeven Wegen Member. The interval 10/13-28 m is correlated with the NW German *roemeri* Zone. It is assumed that the *polyplocum* Zone is not represented in the uppermost Zeven Wegen Member, since neither the index species *Nostoceras* (*Bostrychoceras*) *polyplocum* (Roemer, 1841) nor *B. minor* have as yet been found at the CPL quarry.

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A study of Albian rocks of Trichinopoly district, Tamil Nadu, India.

The Cretaceous rock formations of South India are exposed in four distinct patches along the eastern (Coromandel) coast of India. The rocks of Trichinopoly sub-basin are the best developed and have the largest aerial extent. Of these the Utatur is the oldest marine group ranging in age from the ? Late Aptian-Early Albian to Turonian. Delineating the rocks of Albian age is attempted by collecting a total of 730 rock samples along six measured sections at a close interval (approximately 30 cm) covering the major part of the Utatur Group.

Transgressive-regressive phases of the sea-level are resolved using sequence stratigraphic techniques. These along with the clastic ratio, carbonate percentage considered with faecal and glauconite pebble counts help in deciphering the lithological and facies variations within the sub-basin. Major oxides and trace element chemistry of chosen samples are also considered.

Biostratigraphy proposed by Kumar (1980) using ammonites and foraminifera, and Kale (1988) using calcareous nannoplankton when superposed on the litho- and sequence stratigraphic observations form an excellent correlation device for various sections in the sub-basin.

A depositional model of the Albian environment is drawn from all these observations.

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Radiolarian biostratigraphy in Late Cretaceous siliceous sediments in the Northern and Central Apennines and in the Southern Alps.

Siliceous sediments are present in Late Cretaceous formations of Northern and Central Apennines and of the Southern Alps. The radiolarian distribution in these formations has been studied in order to identify events useful for correlation of sequences deposited in different palaeogeographical settings.

Sediments from four formations have been compared: the Scaglia Bianca in the Umbria-Marche succession, the Scisti Policromi in the Tuscan succession, the Scaglia Variegata in the Southern Alps and the Fosso Cupo Fm. in northern Latium.

In all these formations, siliceous sediments contain many well-preserved radiolaria associated with organic carbon, and in some cases with manganese oxides, though calcareous plankton and other fossils groups are often absent. For this reason, radiolaria are very important in the biostratigraphy of these regions to fill the gap of other macro- and microfossil groups.

Biostratigraphical data reveal that the radiolarian assemblages from the siliceous sediments are similar and can be attributed to Late Cretaceous time, from Late Cenomanian to Early Coniacian, on the base of current zonations. Siliceous horizons in the Umbria Marche Apennines and in the Southern Alps were deposited from the Late Cenomanian onwards. The siliceous sedimentation in the Scisti Policromi is of Turonian age. In the Fosso Cupo Fm. the siliceous levels are of Turonian- early Coniacian age.

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Ostracoda across the Turonian-Coniacian Boundary at Dover S.E. England.

Ostracods are not well suited to long range biostratigraphical correlations due to their benthonic habit and local facies dependence. However, when complete assemblages rather than individual species are studied, trends are discovered which may be of more wide ranging use. The present work examines a series of 39 samples taken over the Turonian-Coniacian boundary interval at Langdon Stairs, Dover, S.E.England, and analyses the fauna in terms of higher taxonomic levels, diversity patterns and statistical clustering.

No previous taxonomic or biostratigraphical work has been done on the ostracods at this level. Horne *et al.* (1990) carried out a preliminary study of the Turonian, and a faunal list of 27 species for the Turonian-Coniacian of Langdon Stairs was given by Horne (1988).

All samples were processed by the freeze-thaw method, which yielded 7349 specimens. Eighty-two species and subspecies have been recovered, which can be broken down into stratigraphical range groups. 36 species are long ranging throughout the section; members of this group show useful diversity changes. 18 species are confined to the Turonian, 7 to the Coniacian. The remainder can be divided into a group of 18 originating in the Late Turonian and continuing into the Coniacian, and a group of 3 Turonian species which become extinct in the Early Coniacian.

An analysis of the fauna by the CCBC plot (Dingle 1981), shows a change in water depth from deep (500m) in the *lata* Zone to shallowing (300-500m) over the Bridgewick Hardgrounds, then further shallowing (200-500m) over the Kingston Nodular Chalks and the Navigation Hardgrounds. The lowest sea-level occurs in the Early Coniacian *cortestudinarium* Zone, over the Cliffe and Hope Gap Hardgrounds, (100-300m). Above this level the depths increase to the 500m field. All depths are taken from an analysis of the Late Cretaceous ostracod faunas of south-east Africa, and can only be approximate, but the trends, I believe, are still valid.

Diversity data collected over the interval demonstrates an increase in faunal richness just below the boundary. A longer term view of the diversity shows low levels in the Early Turonian, a diversity peak some metres below the boundary and then a diversity decrease in the Late Coniacian. The standard model for shelf seas which correlates diversity with water depth therefore has to be adjusted such that Dover is at the deep end of the optimum zone; transgression will cause the optimum zone to move shorewards and decrease diversity, while regression will move the zone basinwards increasing diversity.

A stratigraphically constrained cluster analysis was carried out using the CONISS program. The square-root transformation was used as this upweights the rare variables. Most Late Cretaceous assemblages are dominated by long ranging species, with just a few rare types supplying the stratigraphical information. This shows a significant division below the accepted boundary at Dover, but coinciding with the Zoophycos maximum, below Navigation Hardground 1.

Last occurrences at this horizon include *Bythocypris brownei* and *Golcocythere calkeri.* First appearances are *Pterygocythere* cf. *sphenoides, Pterygocythereis serrata, Bythoceratina* sp. C, *Schuleridea* cf. *babinoti* and *Monoceratina trentoniensis.* A good marker for the boundary at Navigation Hardground 3 is the flood occurrence of *Xestoleberis marssoni.*