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Major Jurassic and Lower Cretaceous planktonic bio-events and their application for global event-stratigraphy

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Abstract: A series of diversification (population blooms, rapid radiations, colonization and immigration) bio-events and diversity reduction (population depletion, emigration, ecosystem shocks, mass mortality, extinction) bio-events recorded in the frame of calpionellid and calcareous dinoflagellate evolution lineagues show that these planktonic elements have sensitively recorded the whole complex of environmental changes like climate perturbations, sea-level fluctuations, nutrient distribution, etc.

Key words: Bio-events, global event stratigraphy, calpionellids, calcareous dinoflagellates, Jurassic, Cretaceous.

Introduction

Plankton has an important role in ecology of the world oceans. Besides calpionellids, there were also calcareous dinoflagellates, saccocomids, nannoconids, radiolarians and foraminifers which represented substantional planktonic element during Late Jurassic and Early Cretaceous. Due to very favourable conditions for the development of planktonic associations, a rich and structured ecosystems could originate in the photic zone of the Tethyan Realm during that time. Calpionellids formed loricas and certain dinoflagellate taxa formed a resistant calcareous/or sporopollenin cyst which were the only potentionally fossilisable stage of their life cycle. Better understanding of complexities of global and regional bio-events through very high-resolution stratigraphic analyses (HIRES) can serve as the base for better definition of their causes and their effects on Earth and life history. There were several Late Oxfordian to Upper Albian bio-events evoked by eustatic pulses. It seems, that the sea-level transgressive stages supported the development of calpionellid associations and the acme concentrations of cyst taxa were controlled by a sea-level high-stand phases. On the other hand, during the sea-level regressive stages several distinct diversity reduction events were recorded in the frame of both groups.

Event Stratigraphy

Late Oxfordian

The first widespread (covering shallow coastal and basinal areas) dinocyst diversification event appears in the frame of mass accumulations of dysaerobic bivalve fragments forming a persistent, substantional part of the Late Oxfordian black-shale facies. It coincided with the onset of a sea-level rise (Reháková, 2000). At the end of the Oxfordian a well-oxygenated settings became prevailing in which rapid radiation of planktonic foraminifers started (Mutterlose & Böckel, 1998). The global scale blooms of holoplanktonic (fully planktonic) Favusellacea provided that these organisms became the major rock-forming factor at this time. Their sudden appearance may have been related to rising eustatic sea-level which opened up new niches (Simmons et al., 1997).

Kimmeridgian

The second dinocyst rapid radiation started at the beginning of the Kimmeridgian. Planktonic foraminifers dominating in microfacies were substituted by mass abundance of globochaetes proving favourable environmental conditions for development of green algae. Shortly after, planktonic crinoids – saccocomids became rock-forming organisms. Saccocomids are abundant in facies which prograded on the epicontinental platforms of the passive northern Tethyan shelf during the Late Oxfordian/?Earliest Kimmeridgian and Late Kimmeridgian/ Early Tithonian respectively and they marks the late transgressive systems tract as well as the presumed high stand deposits Keupp & Matyszkiewicz (1997). Pelagic conditions were also suitable for radiation of calcareous dinoflagellates leading to the evolution of diversified orthopithonelloid associations.

Tithonian

The development of high diversified calcareous dinocyst associations persisted also during the Early Tithonian. Their two further acme accumulation intervals coincide with an elevated eustatic sea-level. During the Middle Tithonian, the first small chitinoidellids followed by the interval with more advanced and diversified ones appeared. On the other hand, coeval dinoflagellate association was poor in both, abundance and diversity. An abrupt ecoevent in calpionellid association: chitinoidellid exctinction triggered their substitution by hyaline calpionellid forms. Shortly before the first occurrence of hyaline calpionellids, marks of distinct erosion and redeposition with sedimentary breccia layers appeared. Breccia layers from the *Chitinoidella* and *Praetintinnopsella* transition beds are known from larger part of the Tethyan area. The overlying strata usually contain no chitinoidellids, but the first transitional calpionellids having an inner hyaline and an outer microgranular wall layer.

Correlating with the position of the global eustatic curves (Haq et al., 1988) it seems, that the global third-order sea-level fall (called as the *Hlboč Event*, Reháková, 2000) was also associated with a rapid turnover in calpionelid evolution. Among qualitatively new hyaline associations, several radiations, stagnant and extinction phases occured. As the first, more diversified calpionellid association with radiation of crassicollarian forms of larger size coinciding with the third-order sea-level rise appeared. Shortly afterwards, it was changed by interval of abundant small crassicollarian forms (r-strategists). This stagnant calpionellid phase coincides with the third-order sea-level fall. A new radiation phase in which diversified calpionellid association was dominated corresponds with the interval of huge dinocysts accumulation. Both, calpionellid maximum diversity and dinocyst radiation phase can be correlated with the sea-level transgression phase (Reháková, 2000).

Calcareous dinoflagellates decrease in abundance during the Late Tithonian. There was also extinction of high diversified crassicollarians which happened across the Tithonian – Berriasian boundary. Comparing with the interval of chitinoidellid disappearance, the same scenario of the environmental behaviour was also documented during the interval of crassicollarian retreat – marks of erosion accompanied by siliclastic input and several metres thick breccia bodies can serve as suitable example of environmental turnover. This abrupt change of the sedimentary conditions in the Western Carpathian area is defined as the *Zliechov Event* (Michalík et al., 1995). It coincides with a global third order sea-level fall interpreted as so called „Purbeckian regression“. Abundant „aberrant„ crassicollarian forms occurred in environments influenced by a distinct siliclastic input. More turbiditic water masses and enhanced productivity could lead to diminishing penetration of sunlight into the photic zone. These conditions have not been optimal for neither calcareous dinoflagellates nor calpionellids.

On a global scale, the Jurassic Cretaceous Boundary Bio-Event is characterized as a second-order mass extinction interval Barnes et al. (1996). It was spread through three short-term extinction events, or steps, at the base, middle and the end of the Tithonian Stage. Three distinct extinction steps were also documented among the planktonic associations of this time: sacoccomid extinction during the Early Tithonian, chitinoidellid extinction during the Middle Tithonian and crassicollarian extinction during the Late Tithonian.

Berriasian – Valanginian

Development of the calcareous dinoflagellates endurated in its stagnant phase since the Middle Berriasian. Free niches opened by the crassicollarian extinction were occupied by expanding nannoconids and small sphaerical calpionellids (r-strategists). *Calpionella alpina* LORENZ created a nearly monospecific calpionellid association, which persisted since the appearence of the first remaniellids. After a certain time following the innovation, strong calpionellid diversification started. Abundant dinocysts with obliquipithonelloid structure of the calcite crystals building a double-layered wall appeared in the interval of increasing calpionellid diversity. Their abundance varies from 35–50 % on pelagic elevations to 6–10 % of the planktonic remnants in basinal bottom sediments. After a longer break lasting since the end of Early Kimmeridgian, planktonic foraminifers appeared in the planktonic assemblage too. Enhanced calcareous dinoflagellate and calpionellid production, as well as sudden onset of non-keeled, globular foraminifers, organisms typical for the Boreal bioprovince (Gasiński, 1997), well coincide with a second-order eustatic rise (Reháková, 1998). It seems that a similar short communication between the biota of adjacent provinces as was documented during the Late Oxfordian, repeatedly renewed during the Late Berriasian sea-level highstand. An onset of more pelagic facies were accompanied by both, distinct change in micro- and macrofaunal composition. Sea-level rise influenced atmospheric and consequently also the hydrodynamic oceanic regime. Frequent intercalations rich in radiolaria appearing in the hitherto rather monotonous calpionellid wackestones indicate more intensive aeration of deeper layers of oceanic water influenced by upwelling activity (Reháková, 1998).

At the end of Late Berriasian distinct breccia bodies (in the W. Carpathians called the *Nozdrovice Event*) were accumulated in many places of Tethyan area. Third-order eustatic curve shows a rapid fall of the sea-level. Shortly afterwards, sudden siliclastic input disturbed previous monotonous basinal carbonate sedimentation. This broadly identified environmental change (similar to those shown in Late Tithonian) negatively influenced the amount of microplankton components. Calcareous dinoflagellates decreased in abundance. Previously high diversified calpionellid associations rapidly decreased in diversity and abundance, too. Abundant „aberrant„ calpionellid forms were observed in a global scale (Reháková, 2000). This regressive prephase, leading later to calpionellid extinction, ultimately caused an increase in evolutionary rate of nannoplankton associations.

Short intervals with dinocyst acme accumulation are known from the topmost part of the Lower Valanginian deposits. Calpionellids did not survive among a nannoconid blooming. Only several large forms successfully asserted in a strong selection stress. For a very short time lasting a new radiation calpionellid phase appeared. It coincides with a small third-order sea-level rise on a broad second-order sea-level fall (Reháková, 2000).

A new, stronger siliclastic input (*Oravice Event*) reflecting the rapid third-order sea-level fall presents an abrupt change in environmental conditions leading to total calpionellid decimation almost in the whole Tethyan region. It seems that it was the reason why calpionellids have never been observed in the Boreal realm. On the other hand, rapid evolution and spreading of nannoconid communities is documented as coeval event to „calpionellid crisis“. Only rare *Tintinnopsella carpathica* (Murgeanu and Filipescu) and less abundant dinocysts survived in the huge nannoconid blooms until the Late Valanginian, where marly limestones show a short interval of nannoconid depletion. Since that point, overlying thin turbiditic intercalations contain rich accumulations of bivalve fragments recording coeval low oxygenate conditions in the adjacent areas. The

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marks of widespread-level of the Late Valanginian transgression (Mutterlose, 1992) controlled by further environmental factors were recorded from many Tethyan areas (Michalík, et al., 1995). According to these interpretations, a positive excursion of the $\delta^{13}C$ corresponded with a short warm and humid climate interval preceding the mid-Cretaceous greenhouse state. Locally graded intercalations, rich in radiolaria and sponges could have been linked with the periodically active contour currents persisting until the Early Hauterivian.

Hauterivian – Barremian

The interval of low abundance but a highly diversified dinocyst associations were documented in both, the Tethyan and Boreal areas since the Hauterivian to the Late Barremian (Keupp, 1981, Reháková, 2000). Maximum diversity of calcareous dinoflagellates coincides with the trangressive phase recorded by the second-order eustatic curve. An ongoing transgression influenced a turbiditic regime documented practically through the whole Tethyan area. The factor responsible for its accumulation was regarded as the *Strážovce Event*. The evident depletion in dinoflagellate diversification is observed in Lower Barremian deposits. Nevertheless, the nannofloral speciation and development have still continued.

Aptian

At the beginning of the Early Aptian cadosinids became prevailing. Only minute forms of orthopithonelloid dinoforms survived. The Early Aptian global climatic change is mirrored in a basinal environments, too. The onset of the black shale deposition started. The most spectacular occurrence from the Kysuca Basin is known as the *Koňhora Event* (Michalík et al., 1999) which was correlated with the *„Selli Event"* of Erba (1994). Dramatic decrease in abundance of the *Nannoconus* was parallelized with the event called as „nannoconid crisis". Planktonic foraminifers became dominant components of planktonic communities. Marly limestone with rich accumulations of radiolarians and sponges, periodically intercalated by black shale sequence, point to a renewed contourite current activity.

At the beginning of the Middle Aptian new forms of microgranular praecolomiellids appeared in foraminiferal wackestones to packstones. The vertical span of the specified calpionellid is short, microgranular loricas are less frequent, but, on the other hand, their are twice or several times larger than those of Middle Tithonian chitinoidellids. Nomismogenesis of planktonic foraminifers lowered the selectional stress among calpionellids and such competitive environment led to a growth expansion of their loricas. The revival of microgranular calpionellids at this time level allows to speculate about a similar climatic and paleoceanographic conditions as were described previously in the Middle Tithonian (Reháková, 2000).

Albian

A restriction phase of calcareous dinocyst production is traceable at the beginning of the Albian, where, on the other hand, a new explosive phase of nannoconid evolution was recorded. Microgranular calpionellid forms disappeared. They were substituted by a new group of hyaline colomiellids. It seems that microgranular calpionellid forms gave rise to hyaline ones several times independently (Reháková & Michalík, 1997). The change of the lorica composition was synchronous with the Early Albian peak in nannoconid abundance (Erba & Quadrio, 1987), similarly as during previously described Late Tithonian change of a chitinoidellid microgranular structure. The development of last two mentioned calpionellid associations coincided with the elevated rate of the third-order sea-level rise (Reháková, 2000). Since the Middle until the Late Albian, favourable environmental conditions for calcareous dinoflagellate development originated in the Tethyan area. Their innovation and radiation phases may also be correlated with a broad second-order eustatic rise.

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