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AMMONITE ASSOCIATIONS AND BOREAL-TETHYAN CORRELATION OF THE J/K BOUNDARY

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A continued study of biostratigraphy from the top of the Volgian to the base of the Ryazanian has allowed the determination of the following successive ammonite associations in this interval on the Russian platform (Mitta, 2007):

Upper Jurassic Volgian Stage, Nodiger Zone.

Fauna *nodiger*: *Craspedites nodiger* (Eichwald), *Garniericeras subclypeiforme* (Milaschewitsch).

Fauna *milkovensis*: *Crapedites milkovensis* (Stremooukhov), *Garniericeras subclypeiforme* (Milaschewitsch).

Unnamed Zone (the Jurassic or Cretaceous, unknown).

Fauna *tolijense*: *Hectoroceras tolijense* (Nikitin).

Fauna *kochi*: *Hectoroceras kochi* Spath, *Pseudocraspedites* or *Praesurites* sp. juv.

Lower Cretaceous Ryazanian Stage, Rjasanensis Zone.

Fauna *swistowianus*: *Riasanites swistowianus* (Nikitin), Himalayitidae (?) gen. et sp. nov., *Subalpinites* sp. nov., *S.* aff. *fauriensis* Mazenot, *Mazenoticeras* spp. (including *M.* cf. *urukhense* Kalacheva et Sey), *Pseudocraspedites bogomolovi* Mitta, *Dalmasiceras crassicostatum* Djanelidze, Craspeditidae sp. nov. (close to Volgian *Craspedites* or Portlandian *Subcraspedites*).

Fauna *rjasanensis α*: *Riasanites rjasanensis* (Nikitin) morpha α, *Praesurites nikitini* (Gerasimov), *Pseudocraspedites bogomolovi* Mitta, *Ps. craspeditoides* Girmounsky, *Subalpinites krischtafowitschi* Mitta, *Malbosiceras nikolovi* Le Hegarat, *Dalmasiceras* ex gr. *djanelidzei* Mazenot, *Mazenoticeras* sp.

Fauna *transfigurabilis*: *Riasanites rjasanensis* (Nikitin) morpha β (including "*Prorjasanites*" Sasonova), *Surites spasskensis* (Nikitin), *Externiceras solowaticum* (Bogoslowsky), *Pronjaites bidevexus* (Bogoslovsky), *Transcaspiites transfigurabilis* (Bogoslowsky), "*Berriasella*" *rulevae* Mitta, *Malbosiceras* cf. *macphersoni* (Kilian), and others.

The reference of beds with *Hectoroceras tolijense* and *H. kochi* to the Jurassic or Cretaceous entirely depends on where exactly the boundary between these systems in Tethyan realm will be marked. The beds with *Praetollia olivikorum* and *Chetaites* cf./aff. *chetae*, which were found in Central Russia only in one section (Mitta, 2005), are probably located under the beds with *Hectoroceras*. Evidently, the interval from the beds with *Praetollia* and *Chetaites* up to the top of the Rjasanensis Zone is correlated to the Chetae, Sibiricus and Kochi zones of North Siberia (**table**). The beds with "*Volgidiscus singularis*", which were recently determined in Yaroslavl region as terminal for Central Russian Jurassic (Kiselev et al., 2003), are referred most likely to the Valanginian.

The most well-grounded correlation of the lowest part of the Ryazanian with Berriasian is possible through Northern Caucasus. The standard Berriasian Occitanica Zone, which is also subdivided into three subzones, was recognized (Kolpenskaya et al., 2002) in this region. The Rjasanensis Zone of Russian platform corresponds to the upper part of this zone and the lower part of Boissieri Zone.

<table>
<tr><th colspan="2">SE France</th><th>North Caucasus</th><th colspan="2">Central Russia</th><th colspan="2">North Siberia</th></tr>
<tr><td rowspan="2">Boissieri</td><td rowspan="2">Malbosiceras paramimounum</td><td>Euthymiceras euthymi</td><td>Transcaspiites transfigurabilis</td><td rowspan="3">Rjasanensis</td><td>Surites praeanalogus</td><td rowspan="3">Kochi</td></tr>
<tr><td>Spiticeras cautleyi</td><td>Riasanites rjasanensis</td><td>Borealites constans</td></tr>
<tr><td rowspan="3">Occitanica</td><td>Dalmasiceras dalmasi</td><td>Dalmasiceras tauricum</td><td>Riasanites swistowianus</td><td>Hectoroceras kochi</td></tr>
<tr><td>Berriasella privasensis</td><td>Subthurmannia occitanica</td><td colspan="2">Hectoroceras kochi</td><td>Chetaites sibiricus</td><td rowspan="2">Sibiricus</td></tr>
<tr><td>Subthurmannia subalpina</td><td>Malbosiceras malbosiforme</td><td colspan="2">Hectoroceras tolijense
Praetollia, Chetaites</td><td>Praetollia maynci</td></tr>
<tr><td rowspan="2">Jacobi</td><td>Pseudosubplanites grandis</td><td rowspan="2">not established</td><td colspan="2">Craspedites milkovensis</td><td colspan="2">Chetaites chetae</td></tr>
<tr><td>Berriasella jacobi</td><td colspan="2">Craspedites nodiger</td><td colspan="2">Craspedites taimyrensis</td></tr>
</table>

Table. Comparison of the ammonite associations [?= faunal horizons] of the Central Russia, Northern Siberia, Northern Caucasus and standard Berriasian.

The genus *Riasanites* Spath, presented in Central Russia by two consecutive dimorphic species, is revised from the Tethyan origin ammonites. The *R. swistowianus* (Nikitin) characterizes the lowest layers of the Rjasanensis Zone. Its descendant *R. rjasanensis* (Nikitin) is widespread in this zone above a section, including the layers with *Surites spasskensis* and *Externiceras solowaticum*. The Riasanites from Crimea and Northern Caucasus are referred to independent species *R. crassicostatus* (Kvantaliani et Lyssenko) and *R. maikopensis* Grigorieva, respectively. The most probable origin of *Riasanites* is from Submediterranean himalayitids, migrated from Western Tethys through the Polish Furrow into Central Russian basin, and only from here to Mangyshlak, Northern Caucasus and Crimea.

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INTEGRATED STRATIGRAPHY OF THE JURASSIC/CRETACEOUS BOUNDARY AT THE BRODNO SECTION (THE KYSUCA UNIT, PIENINY KLIPPEN BELT, WESTERN CARPATHIANS)

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Key words: biostratigraphy, isotope stratigraphy, Tithonian, Berriasian, Western Carpathians

The Brodno section, located in the Kysuca Gate narrows near Žilina in N Slovakia represents an important section documenting continuous pelagic limestone sequence of Tithonian-Berriasian age (Michalík et al. 2006). The lower part of the section is represented by the red nodular Ammonitico Rosso facies (the Czorsztyn Limestone Formation), the upper one by the Maiolica facies (the Pieniny Limestone Formation). Like in many other Tethyan areas, the Late Jurassic sedimentation rate in the Pieniny Klippen Belt has been low. Condensed red nodular limestones of the „Ammonitico Rosso Facies" (the Czorsztyn Formation), which represents Kimmeridgian and Tithonian part of the Kysuca Succession, received only limited terrigenous clastic support. On the other hand, Berriasian basins were characterized by a strong subsidence but mainly by great acceleration of „planktic rain" of organic matter and calcareous microskeletons. This change detectable in the majority of Western Carpathian successions produced also pelagic sediments of the „majolica" type (the Pieniny Limestone Formation). This sedimentary pattern persisted until Early Aptian in the Pieniny Klippen Belt.

The J/K boundary interval can be characterized by several calpionellid events – by the onset, diversification, and extinction of chitinoidellids (Middle Tithonian), by the onset, burst of diversification, and extinction of crassicollarians (Late Tithonian), and, finally, by onset of the monospecific *Calpionella alpina* association. Diversification of calcareous nannofossils at the J/K boundary resulted in *Conusphaera* domination of the middle Tithonian nannolith assemblage (this interval coincided with the chitinoidellid acme), and in Late Tithonian peak of *Polycostella* (well correlable with the abundant and diversified crassicollarian assemblage; it slowly decreased in abundance towards the end of Tithonian). The nannoconids become stable constituent of communities in Berriasian, when monospecific calpionellid association represented by small sphaerical *Calpionella alpina* prevailed.

During Berriasian, surface waters were relatively cooler that the Late Tithonian ones. The evolution of three large and heavily calcified nannofossil genera and three major calpionellid genera coincided with the paleoceanographical changes across the J/K boundary interval. Their evolution greatly increased the transfer and burial efficiency of carbonate and it influenced the global marine geochemical cycle.

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NEW CORRELATION CHART OF THE JURASSIC-CRETACEOUS BOUNDARY BEDS OF ARCTIC AND SOUTH EUROPE BASED ON MAGNETOSTRATIGRAPHY AND THE STATUS OF THE VOLGIAN STAGE

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Problem of terminal Jurassic Stage and global correlation of the J/K boundary beds has a long history. Since the creation of the Volgian Stage by S.N.Nikitin (1881) its correlation with Western European equivalents became controversial. Last decades an opinion concerning the Lower Cretaceous age of the Upper Volgian Substage became relatively widely accepted, but without direct evidences. Finally, in 1996 by the decision of the Interdepartmental Stratigraphical Committee of Russian Federation the Volgian Stage has been avoided from International Stratigraphical Scale, subdivided into Jurassic and Cretaceous parts, and replaced by Tithonian.

Nevertheless this correlation leave very tentative and invoked some objections (Zakharov, 2003). Unfortunately hitherto was impossible to use paleomagnetic method (except an attempt with Portlandian, see Ogg et al., 1994) in addition to micro- and macropaleontology approach for correlation of the marine Jurassic-Cretaceous boundary beds in two superrealms. Thus we undertook in 2003-2006 a joint bio-and-magnetostratigraphic study of the Jurassic--Cretaceous boundary beds in the Nordvik peninsula, North Siberia. This section shows continuous succession from the uppermost Middle Volgian to Valanginian at least, which exposed along west coast of the Anabar Bay (Laptev Sea), and has been studied biostratigraphically in details (Basov et al., 1970; Zakharov et al., 1983; Zakharov, 1989, among others). We collected 370 oriented samples from the 27-m-thick section with sample step from 2-4 cm (near to J/K boundary) to 10 cm at the marginal portion of the section. These samples have been analyzed for remanence magnetization for magnetostratigraphic purposes. As result of analysis of magnetostratigraphic data in the section studied continous succession of magnetozones correlative with chrons M20n-M17r is established. Inside the normal polarity zone corresponding to Chron M20n, a thin interval of reversed polarity, presumably an equivalent of the Kysuca Subzone (M20n.1r), is discovered. The other thin interval of reversed polarity established within the next normal polarity zone (M19n) is correlated with the Brodno Subzone (M19n.1r). The same succession of normal and reversed polarity zones has been discovered recently in the Jurassic-Cretaceous boundary beds of the Tethyan sections: in the Bosso Valley (Italy), at the Brodno (Slovak Republic) and Puerto Escaño (Spain) sites (Housa et al., 1999, 2004). Supposed correlative of the Kysuca Subzone discovered within M20n Chron attain thickness of 17 cm only in the studied section. As well as within the Brodno section this Subzone situated slightly above the middle of the M20n Zone. Correlative of the Brodno Subzone, which has been found in the upper part of the normal polarity zone M20n, attain thickness of 77 cm. Correlation of the successions established has show, that boundary between the Jurassic and Cretaceous Systems, determined at the base of Calpionella Zone of the Tethyan succession, corresponds to the level within Craspedites taimyrensis Zone of the Upper Volgian Substage in terms of Boreal scale (fig.). New version of correlation of the Upper Volgian, Upper Tithonian and lowermost Berriasian, supposed on the base of magtetostratigraphic data corresponds very close to traditional zone-by-zone correlation scheme of the Jurassic-Cretaceous boundary. Inasmuch as Craspedites taimyrensis Zone, within the limits of which the Jurassic-Cretaceous boundary is located according to magnetostratigraphic data, entirely corresponds to C. nodiger Zone, hence the former zone of Siberia could be also considered within the Volgian Stage. However correlation of the Berriasian and Boreal Berriasian (=Ryazanian) still remains ambiguous. New records of the Tethyan and Boreal ammonites in the lowermost Ryazanian of the Moscow region confirm at least the correlation between the lowermost Riasanites Beds (the Riasanites swistowianus assemblage) and the Occitanica Zone upper part (Mitta, 2007). Two additional underlying ammonite assemblages of exceptionally Boreal ammonoids occurring in the same succession as in Arctic areas (*Shulginites -Hectoroceras*). Hence, biostratigraphic data do not define position of the Berriasian base in the Boreal succession. However biostratigraphy certainly proves that the base of the Boreal Kochi Zone should be older than upper part of the Tethyan Occitanica Zone. This conclusion corresponds well with paleomagnetic results.

At the base of the Praetollia maynci Zone of the Nordvik section existence of the iridium anomaly has been revealed (Zakharov et al., 1993), which lately was discovered also at the Barents Sea shelf (Dypvik et al., 1996; Dypvik, Smelror, 2006). This level, corresponding, following to magnetostratigraphy, to unknown level within the Tethyan Jacobi Zone, could be a good marker of the base of Cretaceous in Arctic, which could be recognized by geochemistry.

New results obtained lead us to conclusion that the Volgian Stage should be remained within the Jurassic System as an approximate equivalent of the Tithonian Stage. We propose to put the Volgian Stage in the International Scale as terminal Jurassic Stage for Panboreal Superrealm as a secondary standard stage.

The study has been supported by the Russian Foundation for Basic Research, project nos. 03-05-64297 and 06-05-64284, Program no.14 of the Earthscience Division RAS, and by the GAČR agency, grant nos. 205-07-1365, 205-06-0842, MSM 0021620855. Private sponsorship by F. Shidlovsky and A. Zakharov should also acknowledged.

INTEGRATED BIOSTRATIGRAPHY (AMMONITES, CALPIONELLIDS) OF THE UPPER TITHONIAN-MIDDLE BERRIASIAN SERIES OF ATLASIC TUNISIA. CORRELATIONS WITHIN THE MAGHREB SOUTH-WESTERN TETHYS MARGIN

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The Upper Tithonian-Middle Berriasian ammonite-and-calpionellid-bearing series of Atlasic Tunisia include the Sidi Khalif and Béni Kleb formations, for central and northern Tunisia, respectively. Recent biostratigraphic investigations within numerous key sections in these areas allowed the establishment of updated stratigraphic charts where most classic zones and subzones of ammonites and calpionellids were identified. The ammonite assemblages and the extent of characteristic taxa fit the stratigraphic reference proposed by the G.F.E.J (1997) for Upper Tithonian and the standard of the 'Kilian Group' (Hoedemaker et al., 2003) for Lower and Middle Berriasian. The calpionellid faunas, relaying or associated to ammonites, have been useful for dating levels where the latters are absent and for the proposal of a stratigraphic chart based on first occurences of taxa, easily correlated with the standard of Remane et al. (1986) and other recent scales obtained in west mediterranean areas all fitted to the ammonite chart around the Jurassic-Cretaceous boundary.

In the North-South Axis of Central Tunisia, major lithological discontinuities are located close to the limits underlying the different Tithonian and Berriasian substages and correspond to evidenced diachronous base and top of Sidi Khalif formation interpreted as due to deposition on tilted blocks. Coeval limestone Béni Kleb successions of northern Tunisia grade into the overlying Séroula Fm. flysch deposits the base of which is dated of Middle Berriasian corresponding to nearly the same age given to the onset of coeval siliciclastic facies in many west-mediterranean regions.

Within the Maghrebian Range; three major facies groups of Upper-Tithonian-Middle Berriasian series can be characterized: the successions of the Tello-Rifan external zones can be connected to those of the 'Tunisian Trough' of northern Tunisia; southern nearby facies of the 'Tunisian Dorsale' and North-South Axis being correlatd to the Hodna and northern Aurès Ranges of Algeria. All these facies are different from the flyschs domain ones and opposed to coeval, more internal units of the Kabylo-Rifan 'Dorsale' and ancient massifs. These affinities and differences confirm, on the one hand, the common geological history of the external segments of the African Margin and, on the other hand, the distinct palaeogeographical evolution of the inner domain including the 'dorsales calcaires' and related ancient massifs, both being separated by intermediate flyschs zone segments.

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INTEGRATED STRATIGRAPHY OF THE TRIASSIC/JURASSIC BOUNDARY IN THE TATRA MTS (KRÍŽNA UNIT, CENTRAL WESTERN CARPATHIANS)

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Key words: biostratigraphy, sequence stratigraphy, isotope stratigraphy, Rhaetian, Hettangian, Western Carpathians

Rhaetian and Hettangian sequence of the Fatra- and the Kopieniec formations (the Zliechov Basin in central Western Carpathians) comprises records of several environmental crises which could contributed to the global Triassic / Jurassic „Boundary Events". The Upper Triassic Fatra Formation is characterised by bioclastic limestones and fine-grained clastics. The diversity of benthic fauna decreases upwards from the base of the uppermost member of the Fatra Formation ("Transition Beds"). The fauna comprises important index forms of bivalve mollusks (e.g. *Chlamys valoniensis*), corals, brachiopods (*Rhaetina gregaria, Austrirhynchia cornigera*) and foraminifers (*Triasina hantkeni,* etc.). Many corals, foraminifers and dasycladal algae comprises forms, which never appear in younger strata again. High nutrient level favoured opportunistic fauna, represented by ostracods and microgastropods. The palynofacies is dominated by terrestrial components (*Ricciisporites tuberculatus*) and by high amount of phytoclasts. Few marine organic particles (e.g. *Rhaetogonyaulax rhaetica* dinoflagellate cysts) indicate a very shallow marine depositional environment. Eutrophic conditions supported phytoplankton blooms which led to oxygen depletion of the water column and stress of benthic life. In the Cycle 13, the oxygen and carbon isotope anomalies are parallel with lithological changes and with extinction levels of microfauna. The most significant C and O isotope excursion is followed by thin „microsphaeres" layer(s) with peculiar lithological composition.

An expressive terrigene event, indicating the first important fresh water input was recorded in the uppermost part of the Fatra Formation. Continental run-off caused eutrophication of the basin and resulted in elimination of oligotrophic carbonate platform ecosystems. The boundary between the Fatra Formation and dark claystones with sandstone channel fillings (non-carbonate "Boundary Clay" and the "Cardinia Sandstone") of the Kopieniec Formation above it is sharp, denoted by sudden termination of carbonate sedimentation. The macrofauna is rather poor, being represented mostly by calcite-shell bivalve molluscs, crinoids, ostracods and foraminifers. The palynomorph assemblage of the Kopieniec Formation is characterised by a significant increase of trilete laevigate spores, mainly *Deltoispora* spp. and *Concavisporites* spp. The dinoflagellate cyst *Dapcodinium priscum* replaces *Rhaetogonyaulax rhaetica* in the marine fraction. These changes may have been caused by an important fresh water input and by a regression at the Triassic/Jurassic boundary.

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TRIASSIC/JURASSIC BOUNDARY IN THE NORTH-WEST OF THE UK

N. Morton

DEFINITION AND RECOGNITION OF THE TRIASSIC-JURASSIC TRANSITION: OBSERVATIONS FROM CANADA AND TIBET.

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In our attempts to standardize the Triassic-Jurassic boundary, it is important to underline the difference between definition and recognition. Definition relies on a single unique event such as the evolution (or at least first appearance) of a species or the presence of a carbon isotope anomaly. Identifying a single event globally is either unlikely in the case of a taxonomic event or technically demanding in the case of an anomaly. More pragmatically, it is the overlapping ranges of numerous taxa above and below the boundary (however defined) that allow us to recognize the transitional interval elsewhere in the world and thereby effect correlation.

The second issue of importance is the consideration of primary versus secondary taxa. The ammonites are less than ideal index fossils for the Triassic-Jurassic interval because they barely survived the extinction event, are relatively rare, show a markedly low diversity in the basal Hettangian and are not usually well preserved. Perhaps the most useful discovery about the ammonoid succession in recent years is that the choristoceratids, which were once thought to be characteristically Triassic, are now known to range upwards and co-occur with the psiloceratids. This provides a useful new interval of overlap. The radiolarians are abundant, well preserved and show a dramatic evolutionary turnover within the T-J transition. There is also overlap of what were once considered typical Triassic and typical Jurassic forms.

In this presentation we will consider the Triassic-Jurassic sequences of North America and Asia and possible approaches to both the definition of the T-J boundary and the recognition of the T-J succession.

THE WATER COLUMN DYNAMIC IN RESPONSE TO THE ENVIRONMENTAL PERTURBATIONS AT THE T/J BOUNDARY: DATA FROM AUSTRIA AND ENGLAND

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The Triassic-Jurassic (T/J) transition is a crucial time for both Earth's environment and biota. Global environmental change across the T/J is marked by two closely spaced negative

$\delta^{13}C$ anomalies. The first one is coincident with the end-Triassic biotic crisis, showing a perturbation of the global carbon cycle. The second 'main' isotope excursion occurs in the Early Hettangian and it is associated with a relative sea-level increase, high burial organic matter, major flora changes and faunal (radiolaria and ammonites) radiation starting. Coeval volcanism led to the formation of a large igneous province, the Central Atlantic Magmatic Province (CAMP).

The role of the marine productivity before, during and after the mass extinction and its possible link with the volcanism was investigated in the sedimentary record of Tiefenbachgraben and Kendelbachgraben sections (Nothern Calcareous Alps) and Doniford section (Somerset, UK). Our approach consists of synecological analyses of benthic foraminifers and calcareous nannofossils integrated with geochemical analyses, in order to better understand the water column dynamic during the T/J boundary.

Late Rhaetian calcareous nannofossil and benthic foraminifer assemblages are abundant and diverse. The presence of calcareous dinoflagellate cysts (*P. triassica ; Thoracosphaera* sp. *; C. tripartita ; Nannoconus* sp.*; C. tollmaniae*), associated with the first coccolithophores (*C. minutus*, *C. primulus*, *A. koessenesis*) and the presence of large-sized benthic foraminifers (*Nodosaria* sp., *Ichtyolaria* sp., *Eoguttulina* sp., *Prodentalina* sp., *Lenticulina* sp.) indicate optimal environmental conditions and efficiency of the biological carbon pump.

The T/J interval marks the beginning of a marine environmental deterioration process characterized by a decrease of surface water productivity as attested by a major drop in calcareous dinoflagellate abundance, coupled with disappearance of Coccolithophores. In the same time, the new species *S. punctulata*, probably profiting of the progressive disappearance of *P. triassica* (dominant in the Rhaetian assemblages) occurs. At the sea-bottom, benthic foraminifer assemblages are affected by a severe decrease of Rhaetian fauna and the appearance of agglutinated (*Trochammina* sp., *Ammobaculites* sp., *Haplophragmoïdes* sp.) and opportunistic taxa (*Reinholdella* sp.; *Lingulina tenera*).

These results attest of a highly perturbed environment, stress conditions and a biological carbon pump severely affected by the T/J mass extinction event.

EARLY TOARCIAN MARGINAL-MARINE SEDIMENTATION IN POLAND: RESPONSE TO GLOBAL CHANGES?

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It is now well-established that the Early Toarcian was characterized by major disturbances to the carbon cycle, as evidenced by large carbon-isotope excursions in a range of materials including terrestrial plant matter. Environmental changes likely taking place at the same time included climate-driven variations of weathering and erosion rates in terrigenous-sediment source areas. Eustatic sea-level changes also undoubtedly occurred, including a major sea-level rise during the Early Toarcian. Work in progress on the Toarcian of the Polish Basin, which will include construction of a high-resolution carbon-isotope curve based upon analysis of the phytoclast-fraction of palynomorph preparations, seeks to determine if the transgression-regression cycles and/or relative sea-level cycles recorded in Poland have any unambiguous relationship to carbon-cycle perturbations and inferred relative sea-level changes documented from other European basins. In particular we hope to correlate at a high-resolution to the well-documented early Toarcian sections of Yorkshire (Cleveland Basin, England) and Peniche (Lusitanian Basin, Portugal).

Subsidence in the Early Jurassic Polish Basin (particularly in the Mid-Polish Trough) created an eastward extension of the Laurasian Seaway in which marginal marine, continental and occasionally marine sediments were deposited. On the basis of an extensive array of borehole data transgressive and regressive events can be reconstructed for much of the Early Jurassic. From these data it is clear that in the Early Toarcian the area of marginal marine deposition in the Polish Basin reached its maximum extent. The Early Toarcian Ciechocinek Formation, which occurs throughout the entire area of Polish Basin, is composed of characteristic greenish grey or grey mudstones and heteroliths, and subordinate sandstones, deposited in a large brackish-marine embayment or lagoon fringed by deltaic environment. In the middle part of this formation sandstones of deltaic, nearshore/barrier or alluvial origin represent a conspicuous shallowing event observed in the whole basin. We hypothesize that this shallowing event is the expression of enhanced progradation that resulted from intensification of the hydrological cycle during the Early Toarcian Oceanic Anoxic Event.

THE J-K BOUNDARY IN THE BUREYA BASIN (RUSSIAN FAR EAST) BASED ON PALYNOLOGICAL DATA

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Palynostratigraphy is the most reliable method for locating the J-K boundary in nonmarine rocks. The palynological database includes a great deal of taxa. The relative abundance or presence or absence data were recorded in the Late Jurassic and Early Cretaceous palynofloras of Bureya basin, which is located in the eastern part of Russia.

The Lower, Middle and Upper Jurassic sediments of marine origin have a widespread distribution in Bureya basin. In general, the thickness of Jurassic strata is about 4500-6000 m. The coal-bearing Upper Jurassic to Lower Cretaceous deposits overlie them (thickness is about 200-3000 m). This sequence commenced by Talanja Formation is composed of gravels, sandstones, shales, mudstones, tuffs, tuffites and coals (more than 20 seams). The thickness of this stratigraphic unit is 500 m. The Urgal Formation overlies the Talanja Formation conformably or with local unconformity and consists of conglomerates, gravels, sandstones, shales, mudstones and coals (about 50 seams). Thickness is about 600 m. The Urgal Formation is divided into Dublikan and Soloni Subformations, some geologists range these stratigraphic units into Formations. The Urgal Formation underlies Chegdomyn and Chemchukin Formations including thin coal seams, their thickness is up to 150 m and 800-900 m respectively.

The sequence was sampled from every bed with special emphasis on coals. Localities where both the Upper Jurassic and Lower Cretaceous uncovered (5 bore holes and 1 outcrop) were sampled. Using the standard methods, more than 200 samples were processed, 120 samples contained well-preserved abundant spores and pollen.

Palynological assemblage from middle part of the Talanja Formation characterized by predominance of fern spores, mainly have been assigned to osmundaceous and cyatheaceous ferns (up to 90%). The participation of diverse mosses is considerable. Gymnosperms are dominated by pollen close to Pinaceae and *Ginkgocycadophytus*. In palynological assemblages from upper part of Talanja Formation fern spores decreases in abundance with increase of taxonomical diversity. Amount of gymnosperms rises. Gymnospermous pollen is represented by close to Pinaceae (up to 70%) and *Ginkgocycadophytus* (up to 40%). The spores of ferns *Staplinisporites pocockii, Camptotriletes cerebriformis, C. nitida, Cingulatisporites sanguinolentus* disappeared. This palynoflora has much in common with the Late Jurassic palynofloras of the Eastern Siberia.

The abundant fossil plants have been found in deposits of Talanja Formation. The fossil flora is represented by horse-tails, mosses, lycopods, ferns, cycadophytes, ginkgophytes, czekanowskialeans and conifers. Their age is considered as the Late Jurassic (most probably end of the Jurassic).

The peculiarity of palynological assemblage from Dublikan Formation (Subformation) is considerable amount of fern spores (up to 84%). Palynoflora is dominated by Cyatheaceae, Dicksoniaceae, *Duplexisporites* and *Classopollis*. The palynomorphs *Stereisporites bujargiensis, Neoraistrickia rotundiformis, Contignisporites dorsostriatus, Appendicisporites tricostatus, Concavissimisporites asper* appeared. The diversity and amount of *Duplexisporites* spores rise, among them *D.gyratus* and *D.rotundatus* appeared. In Dublikan palynoflora so called "cheirolepidiaceous peak" is common to the Berriasian palynofloras of the East Asia, well-defined. This palynoflora is correlated with the Berriasian palynofloras of Siberia and Primorye region. Thus, the J-K boundary can be put at base of the Dublikan Fm.

Palynological assemblages from middle and upper parts of Talanja Formation are similar to assemblages of Chonok Formation containing the Volgian Buchias (Vilyui syneclise), Sytogin Formation (Proverkhoyansky depression), the upper Volgian deposits of Kheta River basin and Paks Peninsula (Eastern Siberia).

Palynological assemblage of Dublikan Formation is close to assemblages from Tauhe Formation of marine origin, containing ammonites and bivalves, from Ustinovka Formation with the Berriasian fossil plants (Primorye region, Coastal Uplift). определить

Thus, the J-K boundary is shown to be coincident with the Talanja-Dublikan formational contact.

BIOSTRATIGRAPHY OF THE UPPER JURASSIC OF WESTERN CAUCASUS BY FORAMINIFERS AND THEIR CORRELATIVE POTENTIAL

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Keywords: Upper Jurassic, Western Caucasus, foraminifers, correlation.

Six paleotectonic zones were proposed in the Late Jurassic on the territory of the Western Caucasus: Laba, Lagonaki, Abino-Gunajskaya, Novorossijsko-Lazarevskaya, Akhtsu-Katsirkha, and Western Cuban flexure. Two local foraminiferal zones in the Upper Jurassic of the Western Caucasus were established. *Spirillina* cf. *kuebleri* local zone (lower part of the Upper Tithonian) was presented in the western part of the Abino-Gunajskaya paleotectonic zone and *Marssonella doneziana - Ophthalmidium strumosum* local zone (Oxfordian-Kimmeridgian) - Laba paleotectonic zones. Besides, several foraminiferal assemblages were described in the Novorossijsko-Lazarevskaya, Abino-Gunajskaya and western part of the Lagonaki barrier reef paleotectonic (Lagonaki zone) zones.

At the beginning of this century the foraminiferal zonation for the Upper Jurassic of the eastern part of the Lagonaki zone (Western Caucasus) was proposed with two local foraminiferal zones: *Alveosepta jaccardi* (Oxfordian-Kimmeridgian) and *Melathrokerion spirialis* (Tithonian). Moreover, analysis of the foraminiferal distribution in the Upper Jurassic of the Lagonaki (western part), Abino-Gunajskaya (western part), Novorossijsko-Lazarevskaya zones allows us to suggest the name (typical species) for each assemblage and local zones with the same names. Thus, *Alveosepta ukrainica* (?) association is typical for Oxfordian-Kimmeridgian of the southern part of the Novorossijsko-Lazarevskaya zone, eastern part of the Abino-Gunajskaya zone and western part of the Lagonaki zone. *Anchispirocyclina jurassica – Lenticulina ponderosa* assemblage is characteristic for Tithonian of the northern part of the Novorossijsko-Lazarevskaya zone, eastern part of the Abino-Gunajskaya zone and western part of the Lagonaki zone. So, in the Upper Jurassic for the most part of the Western Caucasus there is foraminiferal zonation, which includes two local foraminiferal zones: *Alveosepta ukrainica* (?) (Oxfordian-Kimmeridgian) and *Anchispirocyclina jurassica – Lenticulina ponderosa* (Tithonian). Besides, there are two local foraminiferal zones *Alveosepta jaccardi* (Oxfordian-Kimmeridgian) and *Melathrokerion spirialis* (Tithonian) in the eastern part of the Lagonaki zone, which are in the same stratigraphic interval. Consequently, the correlative potential of this foraminiferal zonation is very high for the Western Caucasus, because above mentioned local zones are typical for the most part of this territory and it allows us to divide the Upper Jurassic of this area.

In XX century there are only two Caucasus regions which have the detailed schemes of the foraminiferal zonation for dividing the Upper Jurassic deposits - the Kabarda-Dagestan zone (Eastern Caucasus) of Russia and Tsesi-Korta zone of Georgia. The above-mentioned foraminiferal zonation for the Upper Jurassic of the Western Caucasus from one side and such zonations of the Kabarda-Dagestan zone (Eastern Caucasus) and Tsesi-Korta zones of Georgia another side not coincide. On the southern territory of the Russian platform (Ul'yano-Saratov flexure) there is one Late Jurassic assemblages *Lenticulina ponderosa - Flabellammina lidiae*, which corresponds to the middle part of the Upper Tithonian. The taxonomic compositions of the last association and *Anchispirocyclina jurassica – Lenticulina ponderosa* assemblage from Tithonian of the Western Caucasus have some similar elements. The Tithonian foraminiferal associations of the Crimea have species, which are in the coeval levels of the Western Caucasus. So, the Late Jurassic foraminiferal assemblages of the Western Caucasus have several common species with coeval foraminiferal associations of the Crimea and Ul'yano-Saratov flexure, but there is not possibility to correlate the local foraminiferal zones of the Western Caucasus to the local foraminiferal zones from the adjacent areas.

The isolation of the Caucasus paleobasins in the Late Jurassic went up and led to the appearance of the various paleoenvironments in the different parts of the Caucasus and adjacent areas, and original successions of the foraminiferal communities for considered regions. Nevertheless, the Late Jurassic foraminiferal associations of the Western Caucasus in the most part of paleotectonic zones indicate similar conditions for development. Thus, the presented analysis of the distribution of the Late Jurassic foraminiferal assemblages in the different parts of Caucasus (Western, Eastern, and Southern) shows those coeval communities developed with asynchronous event levels.

This work is a contribution to the IGCP 506.

FLORAS FROM THE LATE JURASSIC OF NORTHEASTERN THAILAND

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Non-marine Jurassic outcrops occur predominantly in northeastern, but also in northern, eastern, and southern Thailand. In the northeast, the Phu Kradung Formation is considered to be Late Jurassic or possibly Early Cretaceous in age. Although animal fossils from this formation have been rather extensively collected and studied, fewer plant remains have been studied. A large silicified trunk of *Araucaryoxylon* sp. (= *Agathoxylon* sp.) was described by Srisuk in 2000. Four species of conifer wood were described by Philippe et al. in 2004: *Agathoxylon saravanensis*, *Brachyoxylon boureaui*, *B. orientale*, and *B.* sp. Wang and colleagues in 2004 reported wood of *Araucaryoxylon* and *Protocedroxylon*. Additional fossils have been collected of fragments of fern fronds, a conifer twig, and possible pteridosperm reproductive structures. Palynomorphs, including *Cyathidites*, *Baculatisporites*, and *Corollina*, were reported by Racey and colleagues in 2004. To increase the knowledge of Jurassic plants, additional fossils, including silicified wood, were collected from Nakhon Ratchasima province in the southern part of Northeast Thailand. The wood was found to comprise at least two types of conifers. The first type has uniseriate rays composed of parenchyma and reaching a height of at least 17 cells. The radial pitting on the tracheids is mostly uniseriate with contiguous or slightly separated rounded bordered pits. Some radial pitting is biseriate for part of the length of the tracheid with opposite or subopposite pits. The crossfields appear to bear up to approximately 6 small pits. This wood type is thought to have affinity with *Brachyoxylon*. The second wood type has uniseriate parenchymatous rays. The pitting of the radial wall of the tracheids is variable. Most tracheids have two rows of alternately arranged pits that are rounded or polygonal, although some have three rows. Some tracheids have two rows of opposite squarish pits, and others have single rows of rounded contiguous or slightly separated pits or compressed pits. Pits were not observed in the crossfields. This wood type can be placed into *Agathoxylon*. Lack of clear annual rings in the wood specimens suggests a climate without strong seasonal variation.

THE SAUDI ARABIAN LATE TRIASSIC TO EARLY CRETACEOUS BIOSTRATIGRAPHY AND PALAEOENVIRONMENTS

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The Late Triassic to Early Cretaceous succession is well exposed in central Saudi Arabia, and has been penetrated in hundreds of exploration and development wells. Carbonates are dominant except for Late Triassic and earliest Jurassic sandstones, and the Kimmeridgian to Tithonian evaporites. They were deposited on the west flank of the Tethys at around equatorial latitudes. Source rocks, reservoirs and seals are all well represented. The succession is moderately well chronostratigraphically constrained by ammonites at outcrop, and by existing and ongoing micropalaeontology, nannopalaeontology and palynology in the subsurface. Nine depositional sequences are represented spanning at least 70 Ma, each of which span 3 Ma. They are separated by hiatuses that display a decrease in duration upwards through the succession. Rates of subsidence varied considerably during deposition, and are reflected in the palaeoenvironments of each sequence, but maximum subsidence was during the Callovian.

Period boundaries are chronostratigraphic constrained with reasonable certainty. The Triassic-Jurassic boundary is lithologically and biostratigraphically very well defined. The Late Triassic age is based on the presence of the palynomorph *Sulcatisporites interpositus*, of Carnian to Late Triassic age, but as the underlying Jilh Formation is of Carnian age, it is probable that the Minjur is of Norian to Rhaetian age. This is supported by the presence, in the more marine facies to the north, of the conodont *Metapolygnathus abneptis abneptis* of Norian age. Plant impressions include the late Triassic *Dadoxylon* spp. Evidence for the Early Jurassic age for the Marrat Formation includes the presence of Toarcian ammonites including *Bouleiceras nitiscens, B. marraticum, Hildaites* cf. *sanderi*, *Protogrammoceras madagascariensis* and *Nejdia bramkampi*, the brachiopod *Liospiriferina undulata* and the benthonic foraminifera *Pseudocyclammina liasica*. The Jurassic-Cretaceous more difficult to determine as it lies within a continuous carbonate succession and is currently based on coccolith evidence alone. The Tithonian carbonates include the Jurassic benthonic foraminifera *Redmondoides lugeoni* and *Nautiloculina oolithica*, whereas the basal Berriasian is marked by the coccolith evidence and followed by species of the Cretaceous benthonic foraminifera *Anderselina* together with Ps*eudocyclammina lituus*, in the absence of *Kurnubia palastiniensis*, *Mangashtia vienotti* and *Pfenderina salernitana*.

The Minjur Formation is of late Triassic age based on subsurface palynomorphs, and consists of red and purple sandstones that were deposited in a marginal to shallow marine environment. It is unconformably overlain by the pan-Jurassic Shaqra Group, of which interbedded red sandstones and carbonates of the Marrat Formation (Toarcian) were deposited under marginal to shallow marine conditions. A further significant hiatus separates the Marrat from the Dhruma Formation, which consists of a succession of shoaling upwards, generally shallow marine, lagoon carbonates that form a sequence that spans the Late Bajocian to Late Bathonian. The Tuwaiq Mountain Formation forms another depositional sequence that ranges from the Early (?) to Late Callovian and includes a moderately deep transgressive marl-dominated succession assigned to the Hisyan Member. The upper Tuwaiq consists of stromatoporoid shoals along the flanks of an intra-shelf basin that occupied the central Arabian platform. The Hanifa Formation lies with possible unconformity over the Tuwaiq Mountain Formation, and includes a deeper, transgressive, Early (?) to Middle Oxfordian, lower Hawtah Member, and a generally shallower, upper Ulayyah Member of Late Oxfordian age. This Formation also forms a discrete sequence and was also deposited on a palaeobathymetrically differentiated platform with environments spanning shallow lagoon to deep intra-shelf basin. The Jubaila Formation, of Kimmeridgian age, lies unconformably on the Hanifa, and represents a sequence that was deposited mostly under deep marine conditions. It is overlain by the Arab Formation, of Kimmeridgian age, which consists of four interbedded carbonate and evaporite couplets that were deposited under shallow to moderately shallow, hypersaline marine conditions respectively. The Hith Formation is a thick evaporite unit of Tithonian age that is predominantly evaporitic. Tithonian carbonates that overlie these evaporites are proposed as a new Manifa Formation and were deposited under shallow marine conditions. A significant transgression marks the base of the Sulaiy Formation that was deposited during the Late Tithonian under deep marine conditions. The Tithonian-Berriasian boundary lies within this Formation.

THE NON-MARINE JURASSIC SYSTEM IN THE SICHUAN BASIN, CHINA: STRATIGRAPHIC SEQUENCES AND RECENT PROGRESS

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Located in SW China and the eastern border of the Qinghai-Tibet plateau, the Sichuan Basin is one of the largest terrestrial basins in China with rich oil and gas resources being found in the Paleozoic and Mesozoic strata. The wide distribution and extensively developed Jurassic outcrops yielding diverse biota make this basin one of the best known areas for the Jurassic of China. The Jurassic system in the central part of this basin is up to 2400-3700 m in total thickness and is represented by the red-color terrestrial clastic rocks, covering the majority area of the basin.

The Jurassic sequences are well developed in the Sichuan Basin and consists of the Lower, Middle and Upper Jurassic succession. The Zhenzhuchong and Ziliujing Formations are representatives of the Lower Jurassic sequence consist of the shell limestones, purple red mudstone and limestones with sandstone or variegated bed. The former formation is the basal part of the sequence (ca. corresponding to the Hettangian), and it conformably overlies the Upper Triassic Hsuchiho Formation; the Ziliujing Formation may roughly correspond to Sinemurian to Toracian. The fossils are abundant including bivalves, conchastracas, ostracodes, plants as well as spores and pollen grains.

The Middle Jurassic strata are well cropped out in the basin attaining a total thickness up to 1500 m. It's a series of fluvial and lacustrine clastic rock deposit forming under the arid climatic condition. Three lithostratigraphical units are recognized, including the Xintiangou Fm. (ca. Aalenian to Bajocian), the Lower Shaximiao Fm. (ca. Bajocian to Bathonian) and the Upper

Shaximiao Fm. (ca. Bathonian to Collovian). Fossil fauna are abundant in the Middle Jurassic including ostracodes, bivalves, dinosaur, turtles and conchstracas.

The Suining and the Penglaizhen formations form up the Upper Jurassic sequences, and are widely distributed in the basin. They are characterized by the purple red mud stones, with intercalations of siltstone and sandstones. The Upper Jurassic is represented by the fluvial and lacustrine deposits that is formed under the arid and hot climatic conditions. The fossils are dominated by the conchastracas, ostracodes and charophytes. Abundant fossil petrified woods are the remarkable fossil plant remains which have been documented in recent years from the Penglaizhen Formation in Shehong region of the basin.

The Triassic/Jurassic boundary is defined in between the Hsuchiaho Fm. (Xujiahe Fm.) (= Rhaetic of the Upper Triassic) and the Lower Jurassic Zhenzhuchong Fm. The J/K boundary is a unconformity in between the Penglaizhen Fm. (Upper Jurassic) and the Lower Cretaceous Cangxi Fm. which is characterized by the pale yellowish grey sandstones and purplish red sandy mudstones□siltstones, and conglomerates. These two boundaries are distinct in the field by the lithological features.

Previous investigations have established diverse fossil remains and various assemblages for the Lower to Upper Jurassic, including bivalves, conchastracas, ostracodes, vertebrate fossils, spores-pollen and plant. These assemblages provide informative data for understanding the biodiversity and variation of the Jurassic biota, and are also helpful for defining the roughly geological ages. Further work is needed for refining the correlations with corresponding marine and marine-nonmarine alternations Jurassic deposits.

Our recent investigations provide some new data for the Jurassic deposits in this basin. The seismites have been found in the Upper Jurassic Penglaizhen Formation, implies a potential strong earthquake event during the Late Jurassic. Such deposits are closely associated with fossil woods and charcoals in the same horizon, therefore infer the palaeoecological significances. Additionally, some new sedimentary face indicator evidences, fossil plant fragments and possible vertebrate remains have been found in our investigations. These supply further evidences for our understanding of the palaeotectonics, palaeoclimate, palaeoenvironmental and biodiversity aspects of the Sichuan Basin in the Jurassic period.

STRATIGRAPHY NEAR THE JURASSIC–CRETACEOOUS BOUNDARY OF NORTHEASTERN CHINA: THE AGE OF THE JEHOL GROUP

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There are marine and non-marine stratigraphic sections crossing the Jurassic–Cretaceous boundary in northeastern China.

The marine Jurassic–Cretaceous boundary sections are limited in Dong'an and Suibin areas of eastern Heilongjiang. The Dong'an section is exposed at the bank of the Wusuli River, Dong'an Town, Raohe County. It is composed of the Dong'anzhen Formation which comprises yellowish-green silty shales in the lower part of the formation and dark grey and grayish-green clayish siltstones, silty claystones and greywackes in the upper part. It yields four *Buchia* assemblages ranging from the upper Tithonian to lower Valanginian. In ascending order, they are upper Tithonian *Buchia russiensis-Buchia fischeriana* assemblage, lower Berriasian *Buchia fischeriana-Buchia unschensis* assemblage, Berriasian (except for its base) *Buchia volgensis-Buchia* cf. *subokensis-Buchia* cf. *okensis-Buchia unschensis* assemblage. The base of *Buchia* *unschensis* is approximately coincident with the base-Berriasian Stage. In Suibin area of Suibin County, the formation spanning the Jurassic–Cretaceous boundary is the Dongrong Formation in boreholes SB86-11 and SB79-1. It is mainly composed of dark grey to grayish-white fine to medium-grained sandstones and siltstones. In ascending order, it yields the uppermost Oxfordian–Kimmeridgian *Buchia* cf. *concentrica* assemblage, upper Kimmeridgian *Buchia tenuistriata* assemblage, Tithonian *Buchia* cf. *mosquensis-Buchia* cf. *rugosa* assemblage, *Buchia* ex gr. *russiensis*, and *Buchia* ex gr. *taimyrensis* association, and upper Tithonian–lower Berriasian *Buchia fischeriana* bed, associated with the Oxfordian–basal upper Kimmeridgian *Gonyaulacysta jurassica*, Kimmeridgian–lower Berriasian *Amphorala delicata* and Berriasian–Valanginian *Oligosphaeridium pulcherrimum* dinoflagellate cyst assemblages. The base-Cretaceous is probably represented by the base of *Oligosphaeridium pulcherrimum* dinoflagellate cyst assemblage (Sha et al., 2006).

The argufying non-marine Jurassic–Cretaceous boundary sections are widely distributed in northeastern China. The point at issue is that the Jehol Group yielding Jehol Biota is completely Jurassic, Jurassic–Cretaceous, or wholly Cretaceous in age. This Group consists, in ascending order, of the Yixian Formation, Jiufotang Formation and Fuxin Formation, and unconformably overlies the Precambrian–Mesozoic rocks. In Beipiao Basin of western Liaoning Province, the Jehol Group or the Yixian Formation is resting unconformably on the Tuchenghzi Formation. The Yixian and Tuchengzi formations both contain volcanic rocks including tuffs and lavas. The former yields charophytes, plant mega- and microfossils including angiosperms, conchostracans including *Eosestheria* spp., ostracods, shrimps, insects including *Ephemeropsis trisetalis*, brackish-water gastropods such as *Probaicalia gerassimovi* and *Probaicalia vitimensis*, bivalves such as *Arguniella* cf. *quadrata*, *Arguniella* cf. *ventricosa* and *Sphaerium anderssoni* (= *Sphaerium jehoense*), fish including *Lycoptera muroii*, amphibians, reptiles including feathered dinosaurs, birds and mammals. The latter contains spores and pollen grains. Both the correlation of non-marine and marine beds, and the radiometric dating have confirmed that the Yixian Formation and the whole Jehol Group to be Hauterivian/Barremian–Aptian/early Albian age, and the base of the Yixian Formation could not be older than Hauterivian in age. A mean age of 139.4± 0.19 (1SD) ± 0.05 (SE) Ma from tuff of the Tuchengzi Formation has been got, implying that the non-marine Jurassic–Cretaceous boundary in northeastern China is probably within the Tuchengzi Formation or beneath (Sha, 2007; Sha et al., 2007).

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THE SITUATION OF THE J/K BOUNDARY IN MONGOLIA

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Upper Jurassic- Lower Cretaceous non-marine sedimentary rocks are widely distributed in the territory of Mongolia and usually developed in tectonically different provinces. Sedimentary basins of this interval are divided into 'compressional'- in Western part, 'hybrid or transitional-?'-in Central part and 'extensional'- in Eastern part of Mongolia [3].

The most complete compressional stratigraphic section exposed at the Dariv locality, which is situated about 15 km Southwest of the town of Dariv in the Eastern foothills of the Altai Mountains. They are exposed in Lower to Middle Jurassic through Lower Cretaceous non-marine strata and divided into five lithologically distinct suites: Jargalant (Lower to Middle Jurassic), Dariv (Upper Jurassic), Ikhes Nuur (Upper Jurassic-Lower Cretaceous) and Gurvan Ereen, Zerik (the Lower Cretaceous) [4]. According, to the new codex of the Mongolian Stratigraphical Commission, the Russian terminology 'suite' was renamed by International one as Formation later on. D.J.Sjostrom et al., [7] described the Upper Jurassic Dariv Formation as represented by medium to coarse grained sandstone interbedded with red siltstone and mudstone. It is sharply overlaid by angular-clast conglomerate of Upper Jurassic-Lower Cretaceous Ihes Nuur Formation and consists of about 600m of interbedded conglomerate and coarse sandstone with local meter-scale boulders that attest to its proximal depositional position. Imbrication is abundant and indicates transportation (movement) to the North-Northwest. The last one indicates an abrupt change in depositional style that was likely related to Mesozoic tectonism, which represented by coarse-grained bedload-dominated fluvial deposits in proximal braided river systems or on the proximal parts of stream-dominated alluvial fans.

Coarse-grained strata of the Ihkes Nuur Formation are gradationally overlain by shale and siltstone of the Lower Cretaceous Gurvan Ereen Formation.

Graham et al.,[1] and Johnson et al.,[2] have studied sedimentary sequences of rifted portions of the East Gobi basin which is located along the Northeastern margin of the basin at Har Hotol. Here the sequence was accumulated between ca. 155-131 Ma (Late Jurassic-Early Cretaceous) and dominantly reflects mature deltaic-fluvial-lacustraine depositional environment and numerous volcanic-ash-dispersal events.

The initiation of extension is marked in the synrift stratigraphic sequence by 250 m of distinctive thick basal, fluvial conglomerate composed of rounded , imbrecated and mainly basement-derived clasts. This conglomerate fines upward abruptly into siltstone and sandstone units with volcanic ash beds (155+/-1Ma), which is erosionally covered by 75m thick conglomerate-sandstone red beds that includes subaerial exposure surfaces and paleosoils. This conglomerate also fines upward into siltstone and sandstone units with fluvially resedimented volcanic ash beds which is capped by interbedded basalt flows (131+/-1 Ma), ash layers, and sandstone and conglomerate of braided fluvial origin. This conglomerate, previously was established as basal conglomerate of Upper Cretaceous sequence [8]. A 75 m conglomerate could be correlated with Sharilin Formation which is dated as uppermost Jurassic [5].

G.G. Martinson et.al., [5] studied Mesozoic strata in' transitional-?' tectonic setting of Central Mongolia and described Upper Jurassic- Lower Cretaceous sequence as Toromhon (suite) Formation (Upper Jurassic) which is consists of fluvial conglomerate , Undurukhaa (suite) Formation where represented by limnic sedimentary rocks with some volcanic rock intercalation

(Late Jurassic-Early Cretaceous). Later, S.M. Sinitsa [6] redefined stratigraphy of Mesozoic strata in this region on the base of geological mapping and paleontological study of ostracod assemblages as Dundaralant Group (Upper Jurassic), Undurukhaa Formation (Upper Jurassic to Lower Cretaceous) and Boontsagaan Group (Upper Cretaceous). The strata of the Dundargalant Group represents two major sedimentation cycles of different origin: the lower part dominated by alluvial red conglomerates, while upward appears volcanoclastic sandstones and minor shale of Limnic origin. The strata of Undurukhaa Formation unconformably overlie Dundargalant Group limnic sediment and are also unconformably overlain by Upper Cretaceous deposits of Boontsagaan Group.

The composition many of faunas and floras are changed from Upper Jurassic to Early Cretaceous.

As a whole to establish the boundary of Upper Jurassic and Lower Cretaceous is one of complicated problems in Mongolia. The condition of sedimentological and paleontological studies is unequal in the type regions. It is needs more detail and complex studies.

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MIDDLE-UPPER VOLGIAN BOUNDARY BEDS OF THE RUSSIAN PLATE AND THEIR CORRELATION WITH PORTLANDIAN SUCCESSIONS BY AMMONITES

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1. Ammonite assemblages of the Russian Platform

For the last few years precise sampling of ammonites from the famous section of the Volgian Stage leads us to the recognition of the following faunal horizons within the Nikitini Zone (from down to up, after Kiselev & Rogov (2005), corrected):

I. *Bipliciformis* horizon– with *Epivirgatites bipliciformis* and *Lomonossovella lomonossovi* as well as first huge ammonites with thick ribbing, resemble some English ones (such as *Galbanites* or *Titanites*).

II. *Lahuseni* (“*Paracraspedites*”) horizon – *Epivirgatites lahuseni*, *E.* cf. *variabilis*, *Lomonossovella* cf. *lomonossovi*, “*Paracraspedites*” sp.[1], “*Titanites*” sp[2].

III. *Nikitini* horizon – should be subdivided further on two levels, recognizable in at least three sections situated in few hundreds one from another a) with numerous *E.nikitini*, *E.lahuseni*, rare *Kashpurites* sp.A. and “*Titanites*”; b) with numerous *Kashpurites* sp.A and rare *E.nikitini*

IV. *Laugeites* sp.nov.1 horizon – *Laugeites* sp.nov.1, *Kashpurites* sp.B., *E.nikitini* (extremely rare), *Subcraspedites sowerbyi*, *S.* cf. *preplicomphalus.*

V. *Laugeites sp.nov.2* horizon - *Laugeites* sp.nov.2, *Kashpurites* sp.B.; in Kashpir this level also characterized by small coarse-ribbed “*Glottoptychitites*” (close to *G.trifurcatus* sensu Casey)

Above this succession typical Upper Volgian basal assemblage with *Kachpurites fulgens*, *Craspedites okensis*, *Garniericeras catenulatum* occur (fig.1).

2. On the systematic position of the English “*Epivirgatites*”

Albani Zone of England and Northern France contains ammonites which show close affinities with *Epivirgatites nikitini* and were assigned to this species by Cope and subsequently re-determined as “*Epivirgatites*... not *E.nikitini*” (Callomon, Cope, 1995).

M.S.Mesezhnikov (1982) was first person who addressed his criticism to these determinations. His objections were briefly reviewed by J.Cope (1984) who again pointed out the close affinity of the ammonites under consideration, appeared in presence of “unique rib style of this genus, having constrictions preceded by a four-branched rib”. But type of this four-branched rib is different in English (consists from the triplicate and simple rib) and Russian (chiefly consists from bidichotomous rib) specimens. Moreover, this ribbing is uncommon in *Epivirgatites*. In *E.nikitini* species constrictions are usually bounded by the bifurcate or trifurcate ribs. This feature is clearly indicated in diagnosis of nikitini species by Mitta (1993, see also his illustrations), who pointed out constrictions of this species, bounded by simple and triplicate ribs. Other *Epivirgatites* (*bipliciformis, lahuseni, vatiabilis*) usually bear bifurcate to trifurcate ribs before constriction. Moreover, type of ribbing ascribing to *E.nikitini* by Cope is not unique. Four-branched ribs near constriction are usual in other dorsoplanitids, such as *Paravirgatites* (Spath, 1936, pl.4, fig.5) and *Epipallasiceras* (Callomon, Birkelund, 1982, pl.4, fig.1). Thus “*Epivirgatites*” of the Albani Zone suggested being homoeomorphs of the true *Epivirgatites*. Perhaps English *Epivirgatites* could belongs to *Epipallasiceras* or related dorsoplanitid genera.

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[1] Russian “*Paracraspedites*” also clearly resemble *Taimyrosphinctes* by their abrupt changes in coiling from involute to evolute

[2] This is preliminary name for Russian giant ammonites from the Nikitini Zone, as it has been used by Sasonova & Sasonov (1979)

3. About the gaps within the Middle-Upper Volgian succession of the Russian Platform.

The complex structure of the lithological succession of the uppermost Middle to Upper Volgian is a well-known. All proceeds from clays to sands and sandstones, usually with numerous phosphate nodules or other features of condensation (belemnite guards on the bedding planes, ferruginous crusts, etc), are established. Nevertheless, there are no evidences for the presence of biostratigraphical gaps in succession..

There are the following evidences for the absence of biostratigraphically significant gaps at the Middle-Upper Volgian transition:

1) Close affinities of ammonoids from the succeeded faunal horizons and zones. There are no abrupt changes except the Volgian-Ryazanian transition.
2) Very wide range of the same succession of faunal horizons within the different facies of the Russian platform. For example, virgatus z. (a) - *bipliciformis* (b) – *lahuseni* (c) – nikitini (d) – *Laugeites* spp. (e) – K.fulgens (f) zones/horizons consist from 1) condensed sandstones with re-worked ammonites (a) - greenish sandstone with phosphate nodules (b-c) and numerous phosphate nodules in sandstone matrix (d) – silts with crushed ammonites (e, f) (Kashpir); 2) thick bedded yellow sandstones with phosphate nodules (a, b) – thin-bedded sandstones (c) – sands with sandstone concretions (c-f) (Gorodischi section); 3) green to yellow sands (a) – sands to sandstones (b-c), sands and (in upper parts) sandstones with numerous phosphate nodules (d), and the same sandstone with nodules (e-f) (Sundukovo section). Sections mentioned above situated at distance ca 200 km
3) The same succession of zones through the Russian platform and the same ammonite genera through the Arctic margins from northern regions of the Russian Platform to Northern Siberia, Spitsbergen and Greenland.

5. Possible equivalents of the Nikitini Zone

The same succession of the ammonites (*Epivirgatites* - *Laugeites* sp.nov.1,2 – *Craspedites okensis*) leads us to understanding of the correlation of Nikitini Zone with Siberian succession, i.e. to assuming the Variabilis and Exoticus Zones as close equivalents of Nikitini Zone (see key events for correlation at the table). Correlation with Greenland and Spitsbergen should be based upon *Laugeites* and *Praechateites* records. Recent excavation at Svalbard shows nearly the same succession of *Laugeites* – *Praechetaites* as in Nordvik section. Groenlandicus Zone of East Greenland perhaps coincides with the lowermost part of Nikitini Zone (proven by *Laugeites* and *Epivirgatites* co-occurrences in Arctic). Lower part of Nikitini Zone poorly correlate directly with English succession, while *Laugeites* sp.1 horizon includes some *Subcraspedites* providing its correlation with basal 'Upper Volgian' of England sensu Casey, 1973. The presence of ammonoids with transitional features from *Laugeites* to *Subcraspedites* (Donovan, 1964) at level without *Praechetaites* in East Greenland is very remarkable, because it is independent evidence of such correlation.

Conclusions.

The main results of recent studies of the Middle-Upper Volgian beds of the Russian Platform and Arctic are the following: 1) Nikitini Zone and its equivalents could be subdivided further up to level of faunal horizons, providing wide correlation with other Boreal successions 2) Biostratigraphically significant gaps within the Middle – Upper Volgian Substages (except the uppermost Upper Volgian) is absence at the succession studied

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THE JURASSIC-CRETACEOUS TRANSITION AT ERIKSDAL, SWEDEN

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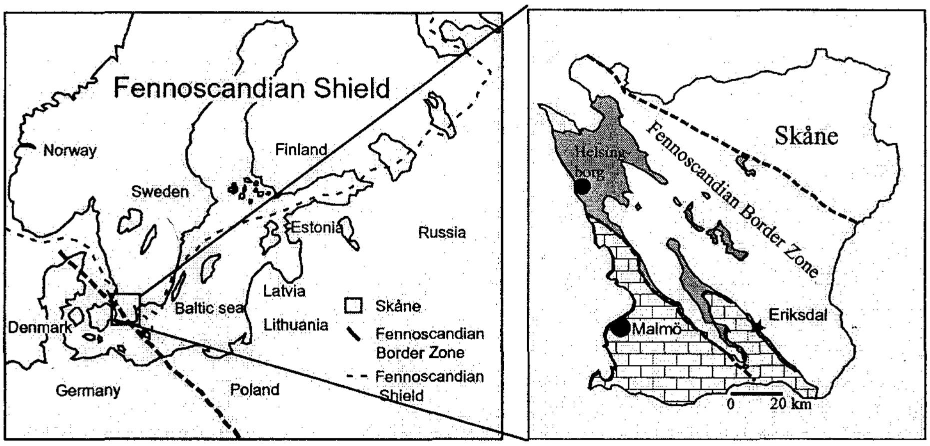
Identifying the Jurassic-Cretaceous boundary in Northern European terrestrial successions has met with several problems due to the absence of significant lithological and/or biostratigraphic indicators. In Sweden, the sediments of the Late Jurassic - Early Cretaceous transition are represented only in the southernmost province, Skåne, where sediments are preserved in a depression at the southern margin of the Fennoscandian Shield.

The boundary between the Jurassic and Cretaceous has traditionally been placed within the Vitabäck Clay, exposed near Eriksdal, Skåne, but the biostratigraphic evidence for precise placement of the boundary has been tenuous.

The Vitabäck Clay is assumed to be 30-40 m thick and it is dominated by greenish to dark grey clay, containing only terrestrial palynomorphs. However, an anomalous 1.5 m thick sandy unit occurs within the lower part of this homogenous, impermeable, green clay. Organic matter, iron (siderite, hematite), gypsum and sulphur characterize specific layers within the sand. The anomalous unit is divided into three repetitive lithological packages separated by erosional surfaces. The lowermost bed starts with a reddish-brown iron-cemented coquina, 5-30 cm thick, erosively incised into the underlying clay. This bed contains a rich mixture of invertebrate fossils, such as *Neomiodon* and *Isognomon*, shark teeth (hybodont species *Egertonodus basanus, Hybodus parvidens, Lissodus rugianus*), and crocodile remains. The fossil assemblage is indicative of marine conditions by the first records of dinoflagellates in Vitabäck. The coquina represents a local stratigraphic marker and is overlain by 50 cm of clay and silty-clay with a high content of organic debris in the basal part. The succeeding unit starts with a distinct yellowish sand layer (20-60 cm) with an erosive base followed by 20 cm of clay with organic debris and coalified plant fragments. The topmost bed consists of a 10 cm thick shell bed overlain by 30 cm fine sand.

The palynological investigation of the sand layer within the Vitabäck Clay, revealed well-preserved assemblages of terrestrial pollen and spores, together with abundant algae (*Botryococcus*), and sparse dinoflagellates. The diverse and abundant palynoflora of Eriksdal is indicative of a warm, temperate climate with vegetation dominated by podocarpaceous, pinaceous, and taxodiaceous conifers with a significant understorey of tree- and ground-ferns. Angiosperms made up a very small component of the flora and their palaeoecology is unclear. The presence of cheirolepidiacean pollen could be interpreted as indicating semi-arid environments but the abundance of fern and fossil green algae imply consistently moist environments as would be expected in a coastal setting.

A Berriasian age is corroborated for the Vitabäck Clay based on the general composition of the palynoflora and, more specifically, the presence of the following index species: *Cicatricosisporites australiensis, Trilobosporites bernissartensis* and *Pilosisporites trichopapillosus.* The Jurassic-Cretaceous boundary is placed around the contact of this unit with the underlying "Nytorp Sand". and the presence of the dinoflagellate *Cyclonephelium* sp. cf. *C. compactum* supports an Early Cretaceous age for these sediments. The presence of both terrestrial and marine fossils in these Jurassic-Cretaceous boundary beds may provide an important tool for correlation of marine and terrestrial J-K sequences elsewhere.



OCCURRENCE OF ORGANIC MATTER-RICH BEDS IN EARLY CRETACEOUS COASTAL EVAPORITIC SETTING (DORSET, UK): A LINK TO LONG-TERM PALAEOCLIMATE CHANGES?

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In the Dorset area (southern U.K.), the Durlston Bay and Lulworth Cove sections expose an earliest Cretaceous coastal marine and non-marine, partly evaporitic, sedimentary succession (Purbeckian facies). An interval rich in organic matter is recognized in both sections. This organic-rich interval reaches 20 m in thickness in the middle part of the Durlston Bay section. Within these beds, a large organic matter accumulation is recorded, the total organic carbon (TOC) being up to 8.5 wt%. High hydrogen index (HI) values (up to 956 mgHC/gTOC) point to a Type I organic matter, that is generally considered as derived from algal-bacterial biomass. In palynofacies slides, this organic matter shows dominating well-preserved amorphous flakes and/or, occasionally, large amounts of *Botryococcus*-type algae. This contrasts with the organic matter present in underlying and overlying intervals, that generally shows lower TOC and HI values, and consists of more altered, slightly orange to brown-grey amorphous organic matter (AOM) flakes and/or a dominating continental derived organic matter, mainly composed of vascular plant-debris and spores-pollen grains, together with other palynomorphs. The organic-rich accumulation can be interpreted as a period of enhanced primary productivity within coastal lagoonal/lacustrine settings in times of low sea-level and/or can correspond to more reducing waters. A very questioning feature is the coincidence of the main organic-rich beds occurrence with a previously established long-term palaeoclimatic evolution scheme. In the Dorset area, a

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latest Jurassic (late Tithonian)-early Cretaceous (early Berriasian) semi-arid climate is replaced during the middle-late Berriasian by a more humid climate. This pattern is recorded elsewhere on both margins of Tethys, indicating a widespread climatic change. In the Dorset, the deposition of the organic-rich beds occurs quite exactly at the transition between the two climatic regimes, probably during a first trend toward rising humidity and enhanced freshwater inputs into the coastal lakes and lagoons. This suggests a direct or indirect climatic control upon local development of primary productivity and/or anoxia/dysoxia within restricted shallow coastal water masses. A tentative environmental model is thus proposed, that links organic matter production and preservation and changing climate-driven hydrological regime.

PALAEOSALINITY CONTROLS ON THE DISTRIBUTION OF JURASSIC AND EARLY CRETACEOUS SHARKS AND RAYS

C. Underwood

The Jurassic and Early Cretaceous saw major changes in selachian faunas, with dramatic radiation of the neoselachians ("modern-type" sharks and rays) and decline of the hybodonts, especially within marine habitats. Although there are relatively few well known Jurassic and Lower Cretaceous shark assemblages, it is possible to recognise very strong palaeoenvironmental specificity of many (particularly neoselachian) taxa alongside very cosmopolitan distribution of some hybodonts.

Most known Hettangian to Pliensbachian selachian assemblages are from open marine settings, and include diverse hybodonts and a small diversity of basal neoselachians. Diverse neoselachians are first known from the Toarcian, and many of the extant neoselachian orders are known from Bathonian assemblages.

Selachian remains are known from a wide range of Bathonian palaeoenvironments, from open marine to freshwater lagoon. Many Bathonian neoselachians showed extremely strong palaeoenvironmental specificity. Some orders were only present in offshore facies, whilst others being present within a wider range of settings, even though particular species were commonly restricted to very specific palaeoenvironments. Although neoselachians are well known from reduced salinity lagoon facies, they have not been recorded from freshwater palaeoenvironments. Some hybodonts also showed strong palaeoenvironmental specificity, but others were very wide ranging, with at least three species being found across many facies ranging from carbonate shelf to freshwater lagoon. The latter therefore offer great potential for marine to non marine correlation.

Palaeoenvironmental distribution of Callovian to Barremian selachians is less well known than in the Bathonian, but appear to show a similar pattern, with neoselachians common in open marine to restricted marine settings, and hybodonts found in all palaeoenvironments, including fluvial and coastal lacustrine (although by the Early Cretaceous they were very rare in open marine facies). The appearance of new neoselacian groups in the 'mid' Cretaceous coincided with the first occurrences of a small diversity of specialised neoselachian sharks and rays in fluvial palaeoenvironments, a situation that persists to the present.

NEWS ON THE VOLGIAN OF SPITSBERGEN: AMMONITE RANGES, ZONAL SUBDIVISION AND CORRELATION WITH ADJACENT AREAS

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The Volgian Stage of Arctic areas has an unusual significance due to widely scattered oil-and-gas fields of this age. Hence more detailed stratigraphical studies also are absolutely necessary. Spitzbergen additionally has implications as link between North-West Europe and Greenland with Arctic and located along migration routes of many sea animals, including ammonoids. In spite of the numerous records of the Volgian ammonites (cf. Frebold, 1928; Ershova, 1969, 1983, among the others), there are some uncertainties concerning ammonite biostratigraphy and completeness of the Volgian of Svalbard. In addition to rarity of ammonite records within some stratigraphical levels it also should be explained by the rarity of the well-studied sections with precise showing ammonite ranges.

During our field works of 2006 we have studied one of the most famous Mesozoic locality of Spitsbergen, the Festningen section, situated along the south coast of Icefjord and along the Festningen river some 2-3 km westwards from Barentzburg town (fig.1). Volgian deposits here consists from shales alternated with siltstones and sandstones and contained numerous bands of siderite concretions of the total thickness about the 100 m (fig. 2). Its lower boundary was not determined due to existence of significant gap between highest records of Kimmeridgian ammonites and lowermost records of the Volgian ones. All gathered ammonoids are more or less crushed and compressed, but peculiarities of their ribbing and coiling usually permits to make precise determinations.

Range of the Lower Volgian deposits of Spitsbergen still unknown. There is only figure of Pectinatites from the Agardbukta (Birkenmajer et al., 1982, pl.37, fig.8) but due to very high position within the section and some morphological features this fossil apparently belongs to Middle to Upper Volgian *Praechetaites* resembling type species of this genus, *P.exoticus*. Other Lower Volgian ammonites, such as *Subplanites* and *Pectinatites*, were mentioned by Ershova (1983), but without mentions of their precise position within the sections.

At Festningen section some portion of the Oppdalssata member lack of ammonites and buchiids can belongs to Lower Volgian. Alternatively Lower Volgian may be eroded during the Middle Volgian, as widely occurs in Arctic.

Middle Volgian deposits much more well-studied and Middle Volgian ammonites remains one of the most numerous and widely ranged Upper Jurassic fossils of Spitsbergen. Ershova (1983) have subdivided Middle Volgian on the following zones, close to those of Subpolar Urals and Russian Platform (bottom-up): Dorsoplanites panderi, D. maximus and Laugeites groenlandicus. Recent studies of the Middle-Upper Volgian boundary of the other areas also (Zakharov et al., 2006) strictly supported Middle Volgian age of the tenuicostatus Beds, allocated by Ershova at the base of the Upper Volgian. In additional to these units for the first time one can restrict the Pavlovia Zone at the base of the Lower Volgian. Pavloviids occurred here represented by coarse and widely-spaced ribbed species close to *P.raricostata* of Subpolar Urals, *P.rugosa* of East Greenland or *P. concinna* of England, all characterized upper Pavlovia Zone (Strajewskii, Rugosa and Rotunda, respectively). After predominating species *Pavlovia rugosa* this zone tentatively can be called as Rugosa Zone. This fauna marked beginning of the Middle Volgian was widely ranged through Arctic and Subboreal regions, perhaps due to sea-level high-stand.

Slightly above this zone at Festningen an assemblage rich in crushed *Dorsoplanites* occurs. Bulks of these *Dorsoplanites* are small and bears chiefly bifurcate ribs. Some of them are close to *D.panderi* species, but perhaps they more close to Arctic species *D.sibiriakovi*, *D.antiquus* and *D.gracilis*, which are characteristic for Ilovaiskii Zone of Subpolar Urals and

Siberia (Mesezhnikov, 1984) and Gracilis Zone of Greenland. By the absence of big-sized Pavloviids this fauna more close to those of Urals and hence Uralian zonation should be acceptable. Some big dorsoplanitids resembling *D.maximus* were recovered from the upper *Dorsoplanites* level of the small locality at the bank of the Festningen river as well as from the other localities (cf. Ershova, 1983), and it is possible to recognize the Maximus Zone here.

It seems to be very interesting record of *Crendonites* resembling Greenland and Subpolar Ural species between the first *Laugeites* and last *Dorsoplanites*. Thus it is possible to recognize Crendonites zone at Spitsbergen for the first time.

Uppermost portion of the Middle Volgian consists from two distinct assemblages, lower one with numerous *Laugeites* (including *L.groenlandicus*) and upper one with predominating *Praechetaites* and more rare *Laugeites* with smooth outer whorls. These assemblages are characteristic for Groenlandicus and Exoticus Zones, respectively. Later zone in additional to ammonites mentioned above contains also uncommon ?*Paracraspedites* or *Taimyrosphinctes* and unique *Pseudophylloceras* of the *knoxvillense* group gathered from small outcrops along Festningen river.

Upper Volgian ammonites firstly mentioned from Festningen by Spath (1921) were accurately described on the base of well-preserved specimens by Ershova (1969). Bulk of these ammonites came from Agardbukta with exception of *Craspedites mosquensis* (Ershova, 1969, pl. VII, fig.1-2) recorded from few meter below ‘niveau 21’ at Festningen, which has considered as lowermost Cretaceous by all scientists who studied this section, including Ershova herself (1983). Perhaps level with *Craspedites mosquensis* belongs to analogues of the Taimyrensis Zone, albeit some *Craspedites* occur in the lowermost Ryazanian.

At Festningen Upper Volgian attain a very small thickness in comparison to Middle Volgian and, possibly, covered by Ryazanian with stratigraphical gap. Now we have here good evidences for Craspedites okensis Zone, the basal zone of the Upper Volgian.

Through the all Volgian succession Svalbard ammonite faunas show close affinities to those of Subpolar Urals and more or less distinct distinguished from faunas of East Greenland. Albeit Greenland-Norwegian seaway provided direct link between Arctic and North-West Europe, it is certainly was a not best way for ammonite routes.

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EVIDENCE FOR A GLOBAL OCEAN ACIDIFICATION EVENT AT THE TRIASSIC-JURASSIC BOUNDARY

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Extensive volcanism led to a sudden increase of atmospheric carbon dioxide (CO_2) across the Triassic-Jurassic boundary, which was reinforced by the dissociation and oxidization of marine gas hydrates (e.g., Pálfy 2003). A substantial part of this CO_2 was taken up by the oceans, which altered the chemistry of seawater by enhancing the hydrogen ion concentration, i.e. seawater became more acid. This increased acidity had a profound effect on the marine calcium carbonate balance by producing a short-term undersaturation of seawater with respect to aragonite and, to a minor extent, calcite (Hautmann 2004, 2006). As a consequence, carbonate sedimentation temporarily ceased across the Triassic-Jurassic boundary, leading to either a depositional hiatus or a shift from carbonate to siliciclastic sedimentation. A cause-and-effect relationship of this change in the sedimentary regime with increased CO_2 concentration is confirmed by a synchronous negative excursion of delta 13 C, which reflects the emission of isotopically light CO_2 from volcanic outgassing and dissociated gas hydrates. Analyses of marine mass extinction at the end of the Triassic shows that taxa with thick and/or aragonitic skeletons suffered above average, indicating difficulties of marine organisms to secrete calcareous skeletons in disequilibrium with the ambient seawater.

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LATEST TRIASSIC/EARLIEST JURASSIC GEODYNAMIC EVOLUTION OF THE PANGEA – BIVALVE MIGRATION PATTERN AND MASS EXTINCTION

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The supercontinent Pangea was formed during the Carboniferous time as the result of the Hercynian orogeny. The separation of North America and Gondwana, which was initiated by the Early Triassic stretching, continued during the Late Triassic rifting phase. Formation of ocean basins, rifts and microplates in the western Tethys region, and continuos northward drift of the Cimmerian plates occurred during this time. Neotethys Ocen was wide open (Golonka, 2007).

Continental clastics and volcanics prevailed in the area between Africa and North America near Triassic/Jurassic boundary. The earliest Jurassic was the time of complete assembly of eastern Pangea and of onset of the break-up of the supercontinent and separation of Gondwana and North America. The color of these rocks changed from red to grey along the Triassic-Jurassic boundary due to increased wetness and global transition from oxic to anoxic conditions.

Carbonate sedimentation predominated along the Neotethyan margins (Leinfelder *et al.*, 2002). The northwestern Neotethys region consisted of numerous horst blocks capped by carbonate platforms with adjacent grabens filled with deeper-water black mudstone and organic-rich shale facies. Reef communities were rare at that time. The time around the Triassic-Jurassic boundary marked the very important extinction event (Hallam & Wignall, 1999). From the plate tectonic and paleogeographic point of view the several events could have influenced the extinction of biotas – (1) closure of Paleotethys and assembly of the Asian part of Pangea; (2) the break-up of Pangea in the future Central Atlantic area and transition from rifting to drifting phase; (3) the very extensive volcanism and origin of Large Igneous Provinces type of basalts; (4) sea level fluctuation; (5) anoxia. It was related to the formation of restricted basins and nutrient oversupply caused perhaps by volcanic activity and sea-level fluctuations.

The separation of Laurusia and Gondwana, which was initiated by the Triassic break-up of Pangaea, continued during Early-Middle Jurassic time (Golonka, 2007). The Early Triassic continental rifting was magnified at the Triassic/Jurassic boundary and the Atlantic Ocean originated as a consequence of this break-up. In effect, the origin of the narrow sea strait, so-called „Hispanic Corridor", took place between these two continents and connection of the

Panthalassa Ocean (Proto-Pacific) and western (Alpine) Tethys gradually started in Early Jurassic, most probably in Sinemurian-Pliensbachian times. Therefore the widespread distribution of numerous fossil invertebrate groups took place during these times (Hallam, 1983; Damborenea, 2000; Arias, 2006).

From palaeobiogeographical point of view latest Triassic/earliest Jurassic time was connected with migration of many type of benthic fauna. For example, the distribution of the cosmopolitan *Cardinia* bivalves could serve as a tool of reconstruction of their migration ways from the area of their first appearance. The oldest founding's are known from the Late Triassic Sub-Arctic regions and the rapid worldwide spreading of species of this genus during the earliest Jurassic (probably Hettangian). They are known from open-marine clastic/carbonate Hettangian facies in Europe up to even poorly oxygenated and brackish, almost fresh water environments (in Poland: Holy Cross Mts margin and Carpathians – Tatra Mts and Slovakian and Ukrainian part of the Pieniny Klippen Belt). Such high paleoenvironmental opportunism of these species facilitated their fast migration. They are numerous indication that the Sub-Arctic *Cardinia* genus initiated the early Hettangian presence of these bivalves in Central Europe by utilization of the primarily ephemeric sea and continental basins at the Triassic/Jurassic boundary, which existed in this part of Pangea (recently between Greenland and Scandinavia).

Previously – in Triassic – the migration of sea fauna (late Triassic crinoids, mollusks, crustaceans and so on) was going through the vast eastern Tethys branch of the Panthalassa Ocean which is perfectly visible in the distribution of the typical „Alpine" fauna of the western Tethys found in the numerous terranes along the western coasts of South and North America. The fauna did not have a possibility to migrate westward, but it could use the numerous terranes within Panthalassa as *„stepping-stones"* allowing relatively free migration eastward from the Alpine Tethys. Another hypothesis suggests migration of these fauna by means of ocean currents (Arias, 2006). Early Jurassic migration direction was demonstrated by distribution of reef-building Early Jurassic (Pliensbachian-Toarcian) oyster-like bivalves (*Lithiotis*- and *Cochlearites*-type). The huge, up to 40 cm long, *Lithiotis*, *Cochlearites* and *Lithioperna* bivalves, which dominated within "*Lithiotis*" facies (*sensu* – Fraser *et al.*, 2004), are most significant representatives of buildup-maker of shallow marine/lagoonal bivalve mounds (reefs) in numerous places of Tethyan-Panthalassa margins during Pleinsbachian-Early Toarcian times. Their distribution from Western (Spain, Italy) and Middle Europe (Slovenia, Croatia, Albania) trough north Africa (Morocco) and Arabian Peninsula (Oman, Arabian Emirates) up to Timor and western margin of both Americas (USA, Peru) indicates world-wide, rapid expansion of such *Lithiotis*-type bivalves (Leinfelder *et al.*, 2002; Fraser *et al.*, 2004). The Early Jurassic migration routes were connected both with break-up of Pangaea and oceanic circulation, which facilitated high speed of distribution of larva's of such oyster-like bivalves.

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A GSSP PROPOSAL FOR THE T-J BOUNDARY AT LARNE, NORTHERN IRELAND

M. Simms

CALLOVIAN FORAMINIFERAL ASSOCIATIONS AND THEIR APPLICATIONS IN PALAEOENVIRONMENT AND CORRELATION, SAUDI ARABIA.

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Key Words: Saudi Arabia, Jurassic, Callovian, Dhruma Formation,Tuwaiq Mountain Formation and micropalaeontology.

The Callovian carbonate is the thickest succession in the Arabian Jurassic carbonate platform and a large morphological feature in central Saudi Arabia. The detailed studies on the carbonate reservoirs of this carbonate have revealed many stratigraphically and biostratigrphically complexities. Using the combination of the environmental sensitivity of benthic foraminifera with their associated microfossils and macrofossils and sedimentology can provide a potentially valuable technique for determining the local subtle variations in depositional environment and also provide a proxy for regional correlations.

The Callovian carbonate consists of the upper Dhruma Formation and the Tuwaiq Mountain Formation. The upper Dhruma Formation has two members, Atash and Hisyan. Tuwaiq Mountain Formation is divided into three informal members, from bottom to top, T1, T2 and T3. The T1 and T3 members of the Tuwaiq Mountain Formation contain the Upper Fadhili and the Hadriya reservoirs respectively. The assigned age for the upper Dhruma Formation is middle Callovian and middle to late Callovian for the Tuwaiq Mountain Formation. The upper Dhruma Formation is overlying a stratigraphic hiatus could represent the middle to late Bathonian and the early Callovian. The Tuwaiq Mountain Formation is also underlying another hiatus spans from uppermost late Callovian to lowermost early Oxfordian. These two signatures of the maximum sea-level drop may be manifested as a regional unconformities.

Hundreds of thin sections have been micropalaeontologically analysized from two carbonate reservoirs in eastern Saudi Arabia. Additionally, samples were collected form age-equivalent outcrops in central Saudi Arabia. Studying of the vertical successive appearance of various species in samples from cored oil wells and exposed sections, and their relationship to the host carbonate fabrics shows two shallowing-upward deposional sequences. Each sequece starts with open marine mud-dominated succession with a *Lenticulina-Nodosaria*-spicule dominated assemblage in lower part, which is considered as linked with a transgressive system tracts. In the upper part of each sequence, the packstone-coral-stromatoporoid dominated succession with shallow marine foraminifera and calcareous algae assemblages. These shallow marine assemblages are characterized by the presence of *Palaeopfenderina trochoidea*, *Meyendorffina bathonica*, *Andersenolina elongata* and *Redmondoides lugeoni* and are correspondingly attributed to highstand shallowing depositional sequences.

Using both the micropalaeontology and sedimentology can strength the ability to provide evidence for palaeobathymetric and palaeoenvironmental variations and potential reservoir stratifications that we can regionally correlate.

ORIGIN OF THE VOLGIAN OIL SHALES IN THE NORTHEAST EUROPEAN PLATFORM

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In the northeast of the European Platform (NEEP) Upper Jurassic - Lower Cretaceous deposits, containing up to 20 oil shale (OS) bands, are widespread throughout a vast area and occur in the Timan-Pechora and the Vychegda oil shale basins (OSB). In the Timan-Pechora OSB oil shales are developed in two isolated areas referred as the Bolshaya Zemlya and the Izhma regions; in the Vychegda OSB they are distributed in the Sysola and Yarenga regions. The OS are mostly known, and have been studied, in subsurface on depth ranging up to 220-300m and rare in exposures. The OS formation rests with an unconformity on the Callovian stage deposits and is overlaid by Upper Cretaceous and/or Quaternary deposits with erosionally. The thickness of the formation ranges from the first meters and exceeds sometimes 200 m.

The OS formation is characterised by fauna of foraminifera, ammonites, pelecypodae and belemnites. The age of the OS formation have been established on the basis of ammonite fauna that sometimes shows a high degree endemism. That is why in the Middle Volgian substage deposits of the Dorsoplanites maximus Zone were established, which is considered to correspond to the Virgatus Zone of the Volga Basin and the Moscow Region of the Russian Platform [1,2]

In the area there are some stratigraphic levels the OS are timed to. The most ancient OS are of the Late Oxfordian (Amoeboceras alternans Zone) age. They are developed only in the Bolshaya Zemlya region and are just centimeters thick. This suggests that in the region accumulation of OS deposits started much earlier than in the Vychegda OSB. The next levels of OS are timed to the Dorsoplanites panderi and Epivirgatites nikitini Zones (Middle Volgian Substage) and Craspedites subditus+Craspedites nodiger Zones (Upper Volgian Substage). In the Timan- Pechora OSB the oil shales of the Volgian stage are developed only in the Bolshaya Zemlya region, whereas in the Vychegda OSB they are widespread and occur everywhere in the entire territory of development of the Volgian Stage deposits.

The latest stratigraphic levels with OS are known from deposits of the Berriasian (?) and the Lower Valanginian Stages. However, they are just some centimetres thick and of restricted development.

Of the most economic and scientific interest in the NEEP are the OS occurred in the D. panderi Zone. The deposits are subdivided onto two lithological units. The lower unit consists of intercalating grey-green claystones, marly claystones, kerogen-enriched claystones, oil shales and rare limestones. All these rocks are characteristically enriched with calcareous material (up to 27-35%), represented by abundant shell detritus of ammonites, pelecypods and belemnites that sometimes form a coquina layer in the top of the unit. In the lower part of the unit there is the lowest oil shale Bed III with the highest heat of combustion. The Bed III consists of either one band or usually of series of 5-7 thin OS bands, separated by host rocks, with total thickness ranging from first centimetres to 0.9m. The total thickness of the unit ranges from 3-4m up to 12m.

The upper unit is composed of dark grey claystones, kerogen enriched claystones and oil shales. There are two oil shale beds: the Bed II and the Bed I. They both consist of series of thin OS bands separated with kerogen-enriched clays. The total thickness of the unit exceeds 10m.

The fauna in the D. panderi Zone is represented by abundant molluscs (bivalves, gastropods, cephalopods) and rare by lingulid brachiopods.

The basic constituents of the OS are organic matter (OM), clayey minerals, carbonates, framboidal pyrite, numerous autigenous and allotigenous minerals such as opal, chalcedon, feldspar, garnet, zircon, and other. OM is represented by kerogen of the II type of sapropelic nature (on B. Tisso and D. Velte, 1981), which characteristically has a very high content of sulphur (up to 10%) and some elements such as Ni, V, Mo, etc. In the calcareous varieties of the shales kerogen is represented by colloalginite, and in the clayey shales pseudovitrinite is predominant. The OM content in the OS ranges from 0 up to 30%, sometimes 55%; its main source is supposed to be organic components of coccolithophorids, possibly cyanobacterias and in a less degree higher terrestrial plants. The clayey minerals are represented mostly by interstratified layered silicates of hydromica-montmorillonite type with variable amount of montmorrilonite layers, and in much less quantity by allotigenous caolinite and chlorite. Carbonate minerals are predominantly calcite which is supposed to originate mainly from coccolithophorids and in fewer amounts from shelly fauna.

The analysis of the petrology, mineralogy and geochemistry of the OS studied suggests that the formation of the Middle Volgian OS in the northeast part of the European Platform is a regional reflection of Late Jurassic-Early Cretaceous sub-global events in the northern hemisphere that led to a widespread accumulation of clayey sediments with significant amount of organic matter and subsequent formation of oil shales. The OM input is thought to be controlled by a high productivity of phytoplankton occurring, probably, during its seasonal blooms. The OM rich deposits were accumulated in bottom depressions of a shallow epicontinental sea as well in its gulf and creeks in environment characterised by disoxic conditions favourable for the preservation of OM.

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RHAETIAN ECHINODERMS FROM THE TATRA MOUNTAINS (WESTERN CARPATHIANS, SLOVAKIA)

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Key words: Western Carpathians, Rhaetian, echinoids, crinoids, ophiuroids

The Fatra Formation sequence of the Krížna Nappe of central Western Carpathians is famous of abundant fossil content represented by rests of Rhaetian shallow-water benthic fauna. Low diversified echinoderm fauna was collected from gray organodetritical limestone of the Fatra Formation, Tatra- and Malé Karpaty Mountains. The obtained echinoderm fauna consists of moderately preserved echinoid specimens belonging to *Paracidaris* cf. *jeanneti*, isolated and low preserved crinoid cirrals and stem ossicles referred to the family Isocrinidae and of ophiuroid traces recently described as ichnospecies *Ophioichnus aysenensis*. The echinoderm rests namely (echinoids and ophiuroid traces) occur rarely if compared with crinoidal ossicles which form a significant component of organodetrital material. The paucity of echinoid findings in the Fatra Formation is evidently related to the low resistance of their skeleton to transport and wave activity as well as to their lower population density.

EARLY RHAETIAN COLONIZATION OF A RESTRICTED MARINE BASIN BY BENTHIC BIVALVE COMMUNITIES (FATRA FORMATION, WESTERN CARPATHIANS, SLOVAKIA)

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The Norian/Rhaetian boundary of the Fatra basin in the Western Carpathians is known as a transition from the lagoonal or limnic environments to the typical marine conditions. The marine transgression recorded in these deposits represents onset of new live habits, with bivalves being the early successional organisms which inhabited the sea bottom. The section Kardolína exposes Norian-Rhaetian sediments rich in fossils, which pass into the Lower Jurassic.

First bivalves were found in a lenticular limestone of the bed number 2 at the base of the Fatra Formation (probably Lower Rhaetian). The fossils are irregularly dispersed while on one side of the section abundant vertebrate remnants were found (ribs, fish-scales, vertebras, but mainly teeth of *Sargodon tomicus* and *Placodus* sp.). Small infaunal bivalves and fragments of *Placunopsis alpina* shells occur rarely. Approximately 50 meters eastwards along the section, in the same bed these limestone lenticules comprise abundant fragments of *Placunopsis alpina*, rarely *Gervillaria inflata* and pleurotomarid gastropods. Below the bed 2.3 disarticulated right and left valves of the epifaunal species *Rhaetavicula contorta* are dominant. Fragments of *Chlamys* cf. *mayeri* and of the semiinfaunal bivalves *Gervillaria inflata*, *Bakevellia* sp., and *Modiolus* sp. are less common. The assemblage of bed 4 is characterized by *Rhaetavicula contorta*, *Placunopsis alpina*, *Propeamussium (Parvamussium) schafhaeutli*, *Gervillaria inflata*, and *Modiolus minutus*. The bed 5. 1 is a 10 cm-thick tempestitic shell bed with very well preserved, disarticulated right and left valves, which have preserved imprints of soft body parts on the inner side. Predominantly convex down valves of large *Gervillaria inflata* are present at the base of the bed. Species such as *Triaphorus* sp., *Bakevellia* sp., and semiinfaunal and infaunal bivalves probably belonging *to Botulopis*, *Nuculana*, *Elegantinia*, *Neoschizodus* and

Isocyprina are mainly common. The upper part of this bed is more marly and contaings large, up to 6 cm-high oysters of *Liostrea hinnites* (as solitary specimens or colonies) with attached shells of *Atreta intusstriata. Placunopsis alpina* and *Modiolus minutus* are also present. The boundary interval between beds 5/6 yields small fragments of *Rhaetavicula contorta*, *Chlamys* sp., *Placunopsis alpina*, and *Atreta* cf. *intusstriata*. 0.5 cm-thick concentration of the infaunal bivalves *Protocardia rhaetica*, *Isocyprina* sp. a *Neoschizodus* sp. is present at the base of the bed 7. Clusters of *Rhaetavicula contorta*, and rarely of *Modiolus minutus* are preserved on the upper bedding plane

THE AGE OF JEHOL BIOTA BASED ON PALAEOBOTANICAL DATA

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The volcanogenic deposits, containing abundant lacustrine biota Jehol, are widely distributed on the territory of North-East China, Mongolia and Transbaikalia. The palaeontological remains have attracted attention, when the feathered dinosaurs, ancient birds and flowering plants have been found in beds of Yixian Formation (West Liaoning). Opinions of geologists and palaeontologists about geological age of this stratigraphical unit vary from the Jurassic to Aptian.

Last June during the pre-Congress field excursion the plant fossils were collected. Fossil flora of Yixian Formation has much in common with the Barremian-Aptian flora of Transbaikalia and Mongolia. The common plants are *Botrychites reheensis* Wu, *Neozamites verchojanensis* Vachr., *Baikalophyllum lobatum* Bugd., *Pityolepis pseudotsugaoides* Sun et Zheng, *Podocarpidites reheensis* (Wu), *Brachyphyllum longispicum* Sun, Zheng et Mei, *Scarburgia hilii* Harris, *Baikalophyllum lobatum* Bugd., *Baiera valida* Sun et Zheng, cf. *Lindleycladus lanceolatus* (L. et H.) Harris, *Ephedrites chenii* (Cao et Wu), *Carpolithus multiseminalis* Sun et Zheng, *C. pachythelis* Sun et Zheng, *Baisia hirsuta* Krassil.

The Barremian-Aptian flora of Transbaikalia is highly diverse, in particular cycadophytes and various conifers. Principal index fossil are *Baisia hirsuta*, *Pseudolarix* and bennettite *Otozamites lacustris.*

The significant systematic diversity of this flora facilitates correlation with adjoining regions. Related floras occur in the Chegdomyn and Chemchukin Formations of the Bureya basin, the age of which is between Barremian and Aptian. The Ussuri (Barremian) and Lipovtsy (Aptian) Formations of Razdolnoe basin and the Severosuchan Formation (Aptian) of Partizansk basin (Southern Primorye) contain *Cladophlebidium dahuricum* Pryn., which is typical for flora of Transbaikalia.

The Transbaikalia flora would correlate with the Aptian flora of Yakutiya (Siberia). These floras contain such typical taxa as *Gleichenia lobata* Vachr. and *Neozamites verchojanensis* Vachr.

Four characteristic assemblages are recognized in the Early Cretaceous of Mongolia: 1) *Baiera manchurica* (Berriasian?); 2) *Otozamites lacustris-Paseudolarix erensis* (Barremian-Aptian); 3) *Baierella hastata-Araucaria mongolica* (Aptian); 4) *Limnothetis-Limnoniobe* (Aptian to ? early Albian). The leaves of *Otozamites* and *Pseudolarix* have been found in Transbaikalia flora, and morphological and epidermal studies shown a similarity with *Otozamites lacustris* from Mongolia. These plants permit correlation of Transbaikalia flora with the Early Cretaceous Mongolian flora from Bon-Tsagan, Manlaj, and Gurvan-Eren.

The Yixian and Mongolian floras contain such common taxa, as *Girvanella*, some conifers and gnetophytes.

Thus, in our opinion, the age of Yixian Formation is not Late Jurassic or boundary Jurassic-Cretaceous. Judging from the palaeobotanical data, we can conclude, that the age of this famous stratigraphical unit is the Barremian-Aptian.

ON THE PRESENCE OF *PECTINATITES* IN THE TWO LOWERMOST ZONES OF THE VOLGIAN STAGE OF THE SUBPOLAR URALS AND ITS SIGNIFICANCE FOR BIOSTRATIGRAPHY AND PALAEOBIOGEOGRAPHY

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Outcrops of the Kimmeridgian and Volgian boundary beds situated on the east slope of Subpolar Ural Mountains are known more than 100 years. Last decades these deposits were intensively studied through localities along banks of rivers Yatria, Lopsia and Tol'ja (Mikhailov, 1964; Zakharov, Mesezhnikov, 1974; Mesezhnikov, 1984, among others). Since M.S.Mesezhnikov's investigations Kimmeridgian and Volgian boundary was traced in the base of Eosphinctoceras magnum Zone (Zakharov, Mesezhnikov, 1974; Mesezhnikov, 1977, 1984; Zakharov et al., 1997; 2005). Its Early Volgian age has been proved by the *Gravesia* records and absent of the Kimmeridgian *Aulacostephanus*. Magnum Zone, as a usual, was considered by the Russian authors as equivalent of the two basal zones of Bolonian Stage (Elegans and Scitulus), Klimovi Zone of the Volgian Stage of Russian Platform as well as Hybonotum Zone of Tithonian Stage. Nevertheless ammonite assemblages of Subpolar Ural prevent from precise correlation with coeval strata of other areas. Recently *Gravesia*, figured by Zakharov & Mesezhnikov (1974), were revised by Hantzpergue (1989) and Schweigert (1993) and partially ascribing to Kimmeridgian species *G. lafaugiana* Hantzpergue. This data joined with records of ammonoids resemble *Eosphinctoceras magnum* in German Upper Kimmeridgian, leaded Schweigert (1993) to opinion regarding Kimmeridgian age of the Magnum Zone. From the other hand, combined records of *Sphinctoceras* and *Eosphinctoceras* cf./aff.*magnum* in the Wheatleyensis Zone of East Greenland allow to supposed that Magnum Zone corresponds at least the part of Wheatleyensis Zone (Callomon & Birkelund, 1982; Callomon, 1994).

Ammonite succession of the Upper Kimmeridgian and Lower Volgian of the Subpolar Ural close resemble the same of East Greenland and England (Mesezhnikov, 1984). Nevertheless *Pectinatites* widespread in the England and East Greenland throughout the Lower Volgian and its equivalents but to present day records of this genus in Siberia were restricted only by the Pectinatus Zone. At the same time ranges of *Eosphinctoceras* and *Subdichotomoceras* possibly are distinguished from each other in different regions and creation of the correlative chart based only on these genera leads to some contradictions.

Suddenly few Pectinatites, resembling English species *Pectinatites* (*Arkellites*) cf. *damoni* and *P.* (*Virgatosphinctoides*) *elegans* were gathered (both in situ and from loose blocks) from the Magnum Zone during the field works held in the 2001 at classical section on Yatria river (Rogov, 2003). Soon after *Pectinatites* (*Arkellites*) *hudlestoni* and *P.* cf. *donovani* of the Subcrassum Zone were determined in Mesezhnikov's collection (including some '*Ilowaiskya*' figured in Zakharov & Mesezhnikov, 1974). Additional *Pectinatites* (mentioned as *Subdichotomoceras* in Zakharov et al., 2005), tentatively ascribing to *P.*cf.*smedmorensis* and *P.groenlandicus* were determined from Subcrassum Zone of the Lopsia river.

Ammonoids of the *Pectinatites* genus are one of the most characteristic ones among the Boreal ammonite assemblages of the North-East Europe. New *Pectinatites* records as well as revision of the previously collected faunas leads to conclusion about the wide faunal exchange within Boreal basin during the whole Early Volgian. Perhaps, unfigured *Ilowaiskya* from the

Lena Basin, Yakutia (Djinoridze, Meledina, 1965; Bidjiev, Mikhailov, 1966) possibly also belongs to *Pectinatites* (Rogov, 2004). New *Pectinatites* records are testify to connections between ammonite faunas of England and Subpolar Ural, permanently existed during the Early Volgian. However intensity and predominating direction of immigrations changes in time. Magnum Chron characterized by the isolated eastwards straying (in terms of Rawson, 1973) of *Pectinatites*, while mutual penetrations of the typical Uralian ammonoids are unknown. During the Subcrassum Chron multidirectional migrations of the little intensity occur. *Eosphinctoceras* and *Subdichotomoceras* are penetrated westwards until East Greenland and Britain and southwards until South-West Germany, simultaneously with eastward *Pectinatites* migration. Pectinatus Chron has been marked by the vast sea level rise and practically the same ammonite assemblages inhabited Boreal seas from England until Northern Siberia. Eudemic *Eosphinctoceras-Subdichotomoceras* lineage of Subpolar Ural became extinct near to Subcrassum/Pectinatum boundary.

Correlation of the Magnum Zone with Wheatleyensis Zone (Callomon, Birkelund, 1982, fauna 25) based on the records of *Eosphinctoceras* cf./aff. *magnum* Mesezhn. within supposed Wheatleyensis Zone. English representatives of *Sphinctoceras* and *Eosphinctoceras* were described by Neaverson (1925) from the same zone, but his Wheatleyensis Zone corresponds to Scitulus Zone and basal beds of Wheatleyensis Zone *sensu* Cope (1967). In the Subpolar Ural last *Eosphinctoceras* (including those with high rib coefficient) yet occur in the Subcrassum Zone, accompanied by some characteristic *Pectinatites* species. This is allow to suppose, that Magnum Zone should be correlated with lowermost Bolonian, whereas Wheatleyensis Zone records of *Eosphinctoceras* and *Subdichotomoceras* correspond to the those of the Subcrassum Zone. This point of view also supported by recently collected early *Pectinatites* joint with *Eopshinctoceras magnum*.

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CALCAREOUS NANNOFOSSIL DATA AND MAGNETOSTRATIGRAPHY FROM THE ATLANTIC AND TETHYS OCEANS - AN INTEGRATED APPROACH TO APPROXIMATE THE JURASSIC/CRETACEOUS (J/K) BOUNDARY IN LOW-LATITUDINAL PELAGIC AND HEMIPELAGIC SEQUENCES

Cristina
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The Tithonian – Early Berriasian interval is characterized by a major calcareous nannofossil speciation event: several Cretaceous genera and species first appear and rapidly evolve (Bralower et al., 1989). Progressive increases in diversity, abundance and degree of calcification (Nannofossil Calcification Event – NCE; Bornemann et al., 2003) have also been documented. Integrated magneto- and calcareous nannofossil biostratigraphy across the Jurassic/Cretaceous (J/K) boundary have been independently investigated in Tethyan land sections (Torre de Busi and Foza, Southern Alps) and at Atlantic Ocean DSDP sites (534A, Blake Bahama Basin and 105, Hatteras Basin).

Calcareous nannofossil biostratigraphy, absolute and relative abundances have been obtained using three different techniques: random settling slides (Geisen et al., 1999), simple smear slides and ultra-thin sections (7-8 μm thick). Similar variations in nannofloral abundance and composition, including the NCE, have been documented in both Atlantic and Tethys oceans (low latitude associations).

All known calcareous nannofossil Zones and corresponding Subzones, following the biostratigraphic scheme of Bralower et al. (1989), have been recognized: NJ-19b; NJ-20a, NJ-20b; NJK-A, NJK-B, NJK-C across J/K boundary, NJK-D; NK-1

In the Middle Tithonian the nannoliths taxa *C. mexicana minor*, *C. mexicana mexicana*, and *P. beckmannii* increase significantly in abundance (Bornemann et al., 2003; Tremolada et al., 2006): the maximum relative abundance is reached between the calcareous nannofossil Zone NJ-20B and early NJK-A (Atlantic Ocean) or NJK-B (Tethys Ocean), followed by a decrease through NJK-A and NJK-B. Nannoconids appear and rapidly evolve across the J/K boundary reaching high relative abundances in the lowermost Berriasian (from calcareous nannofossil Subzone NJK-C to NK-1).

Quantitative and morphometric studies have identified new potential events. Relative abundances of the placolith genera *Watznaueria* and the nannolith genera *Conusphaera* show opposite trends, while morphometric analysis show a size increase of placoliths, nannoliths and nannoconids during NCEs both in the Atlantic and Tethyan sections: calibration with magnetostratigraphy indicate that these trends are useful as additional bio-horizons for locating the J/K boundary.

Calcareous nannofossil zonations and abundance variations of tethyan Torre de Busi section have also been correlated with calpionellid biostratigraphy, which has been investigated on the same samples used for the calcareous nannofossil study. It has been possible to identify the *Chitinoidella*, *Crassicollaria* and *Calpionella* Zones across the J/K boundary (Remane, 1986; Pop, 1994b and Reháková and Michalík, 1997).

Six polarity chrons (from CM22 to CM17) have been identified in DSDP site 534A, and in the tethyan land sections.

The speciation of highly-calcified and dissolution resistant calcareous nannofossil forms, and related remarkable abundance and size increases, and the relative trends between genera *Watznaueria* and *Conusphaera* could provide new reliable stratigraphic tools for the approximation of the J/K boundary in low latitudinal pelagic and hemipelagic sequences in the Atlantic and Tethyan Oceans. In conclusion integrated stratigraphy, derived from the correlation among several calcareous nannofossils events, capionellid zonation and magnetostratigraphic events, can be used to characterize the J/K boundary interval, and is believed essential for defining the Jurassic/Cretaceous boundary particularly in the absence of orthostratigraphic markers (e.g. ammonites).

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CARDIOCERATIDS AND KOSMOCERATIDS BOREAL-TETHYAN CORRELATION OF THE UPPER BATHONIAN – LOWER CALLOVIAN

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Until recently the most developed and proved schemes by ammonite distribution for Upper Bathonian – Lower Callovian were the schemes of Western Europe (the primary, or Tethyan, standard) and Eastern Greenland (the secondary Boreal standard). In Greenland this stratigraphical interval is characterized almost exclusively by ammonites of two families – Cardioceratidae (genera *Arcticoceras*, *Cadoceras*, etc.), and Kosmoceratidae (genus *Kepplerites*). The rarity of these ammonites finds in the Western Europe, especially in Bathonian and basal parts of the Callovian, has caused some conventionality of these two regions' stratigraphical schemes correlation, and also Bathonian/Callovian boundary in Boreal and Tethyan realms. The Bathonian parts of Central Russian ammonite complexes are close to East Greenland, the Callovian ones – to West-European. It allows to offer a specified variant of this interval correlation (see the table). For simplification only cardioceratids and kosmoceratid taxa are shown on the scheme, though all the groups of ammonites (Macrocephalitidae, Perisphinctidae, Oppeliidae and Spiroceratidae) were involved for correlation. Intervals without kosmoceratids are displayed by color – in most cases these lacunas couldn't be explained by the incompleteness of geological annals or collections. The initial *Kepplerites* (*Kepplerites*) appeared at first in Greenland, then in Russia, and only after that– in Western Europe; the extinction of this subgenus [the last of species – *K.* (*K.*) *keppleri* (Oppel)] takes place simultaneously in all three regions. In the same sequence subgenus *Kepplerites* (*Gowericeras*) was spreading – if our variant of correlation is correct, it is an indication to the ways of ammonites migration.

The Bathonian/Callovian boundary was established by the appearance of *K. keppleri* (Oppel). The similar morphospecies, *K. traillensis* Donovan, could be found both in the highest levels of the Bathonian, and in bottoms of the Callovian; its definition (and a recognition of specific independence) very often depends on different standpoints of different researchers.

No section which is suitable for the Callovian GSSP is revealed on Russian platform now. Besides, there are not any typical Tethyan ammonites (*Clydoniceras*, etc.) in Central Russian

Upper Bathonian. This interval hasn't been studied sufficiently yet in Northern Caucasus and Central Asia. The section near Albstadt-Pfeffingen, South Germany, should be considered a stratotype of the Bathonian/Callovian boundary (offered by Callomon & Dietl, 2000).

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Table. Stratigraphical distribution of kosmoceratids and cardioceratids in the Upper Bathonian – part of the Lower Callovian in Western Europe, Russia and Greenland, after Callomon, 1993; Dietl & Callomon, 1988; Schairer, 1990; Mitta, 2005, etc., by interpretation of author. Abbreviations: *A. – Arcticoceras*, *C. – Cadoceras*, *Ch. – Chamoussetia*, *K. – Kepplerites* (*Kepplerites*), *G. – Kepplerites* (*Gowericeras*), *P. – Paracadoceras*, FH – faunal horizons, M. Bath. – Middle Bathonian.

Notes:

- Apertum Zone – new for Russian platform. The basal faunal horizon of zone, *Cadoceras apertum*, described by Mitta, 2005. This zone in my opinion is terminal for Bathonian in Boreal realm.
- *Kepplerites* (*Kepplerites*) *aigii* sp. nov. (Mitta, 2007, in press), the species close to *K. (K.) peramplus* Spath, but not identical.

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South Germany			**Central Russia**		**East Greenland**		
Substage, Zone		**Ammonites**	**Zone**	**Ammonites**	**Zone**	**FH**	**Ammonites**
Lower Callovian	Calloviense	*S. calloviense*	Calloviense	*S. calloviense,* *C. geerzense*	Calloviense	35	*S. calloviense,* *C.* aff. *geerzense*
	Koenigi	*G. galilaeii*	Gowerianus	*G. galilaeii,* *C. sokolovi*	Koenigi	34	*G. galilaeii,* *C. coriniense*?
		G. densicostatus, *Ch.* sp.		*C. sokolovi,* *Ch. buckmani,* *G. curtilobus*		33	*Ch. buckmani,* *G. gowerianus,* *C.* aff. *sokolovi*
		G. metorchus, *C.* aff. *tolype*		*Ch. buckmani,* *G. gowerianus*			
	Herveyi Camptus Subzone	*G. toricelli*	Elatmae Subpatruus Subzone	*Ch. stuckenbergi,* *G.* aff. *toricelli*	?	?	?
		no data		*Ch. subpatruus,* *G. russiensis*			
				Ch. surensis, *G. russiensis*			
				C. stupachenkoi, *G. russiensis*			
	Herveyi Keppleri Subzone	*C. suevicum* beta	Elatmae Elatmae Subzone	*C. tschernyschewi, C. suevicum, G.* sp. juv.	?	32	*C* .gr. *falsum/simulans, C.* aff. *frearsi., C.* cf. *elatmae/suevicum,* *K.*(*G.*) ex gr. *russiensis/toricelli*
		C. suevicum alpha					
		C. quenstedti		*C. elatmae,* *C. simulans*			
				C. falsum, *C.* aff. *frearsi*		31	*C. septentrionale,* *C.* aff. *frearsi,* *C.* aff. *falsum*
		K. keppleri, *K. traillensis,* *C.* sp.	Elatmae Keppleri Subzone	*C. frearsi, K. keppleri*	Nordens-kjoeldi	30	*C. nordenskjoeldi,* *K.* cf. *keppleri*
				C. nordenskjoeldi, *C. bodylevskyi,* *K. traillensis*		29	*C. nordenskjoeldi,* *K. traillensis*
Upper Bathonian	Discus	no data	Apertum	?	Apertum	28	*K.* aff. *traillensis,* *C.* cf. *breve*
						27	*K. tenuifasciculatus*
				C. apertum		24-26	*C. apertum, K.* ex gr. *traillensis/keppleri*
	Orbis	*K. dietli,* *K.* aff. *peramplus*	Keuppi	*K. vardekloeftensis,* *K.* aff. *dietli*	Calyx	23	*K. vardekloeftensis,* *C. calyx*
				K. svalbardensis, *K.* aff. *peramplus,* *P.* sp., *C. calyx*		22	*K. peramplus,* *K. svalbardensis, C.* ex gr. *franciscus/perrarum*
	Hodsoni	no data		*P. keuppi, K. aigii,* *K. svalbardensis*	Variabile	21	*K. rosenkrantzi,* *C. variabile, P.* sp.
				P. nageli, P. efimovi, *K.* aff. *inflatus,* *K.* aff. *stephanoides,* *K. aigii*		20	*K. inflatus,* *P.* sp. aff. *C. variabile*
M. Bath.	Morrisi		not studied, no data		Crano-cephaloide	19	*K. tychonis,* *C.* sp. aff. *A. cranocephaloide*
						18	*A. cranocephaloide,* *K. stephanoides*

The J-K boundary interval – cracking the correlative 'nut', criteria for selecting a useful boundary level, and then choosing a GSSP

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In other parts of the Phanerozoic, subcommissions have taken radical actions, and have simply dropped traditional stratotype sections, choosing new GSSPs, and in some cases placed them on the other side of the world. But, it seems reasonable to try to define a J-K boundary while maintaining continuity with more recent historical understanding of the scope of the uppermost Jurassic and the lowest Cretaceous – thus to choose somewhere a GSSP that is close to the traditional biozonal definition of a Berriasian base, and one therefore in the marine sequences.

Historically, a division was made between the marine Portland beds and the overlying, largely non-marine, Purbeck. For d'Orbigny and many who came afterwards that formational junction was the J-K boundary. Recognition of the diachronous nature of these non-marine facies (from Portlandian to Valanginian) in southern England, northern France and the Jura came much later. The name Neocomian (=marine Purbeckian of Alps) had already been coined, and Berriasian (=infraValanginian) was erected forty years after that. Later attempts to fix a Neocomian base in marine successions have brought suggested ammonite bases that fluctuated up and down, or remained vague. What were later recognised as Tithonian faunas were used to define the Berriasian: and Toucas even placed the stage in the Jurassic. And the facies and fossils that defined Berriasian in its type area were at the outset known to be far from global.

It is possible now to go beyond the two Cretaceous colloquia, gatherings of specialists who predominantly worked in the western Mediterranean and founded their decision on consideration of Tethyan ammonites only. Paucity of ammonites or endemism in some parts of Tethys, then and now, limit placing of a boundary, but, subsequently, the overwhelming majority of authors have continued to use a *jacobi/grandis* zone. And even in the large part of the World outside Tethys, work trying to fix a boundary has concentrated on correlating with a *jacobi/grandis* zone. Attempts at ammonite-based correlations predominant in the Boreal realm still centre on the maybe illusory goal of correlation with Tethyan biozonations. But even in the Boreal areas (Greenland, UK and N. France, Andoya , Poland, Siberia and Russian platform etc) there is no single "realm": faunal uniformity is mostly lacking above the Bononian, and it is only when *Chetaites* , *Riasanites* and *Hecterocera*s faunas are reached in the upper Berriasian that there is any approach to it. And the draughting conventions used in ammonite zonations are in themselves a hindrance to progress. Nevertheless, other methods are bringing results (Figure 1).

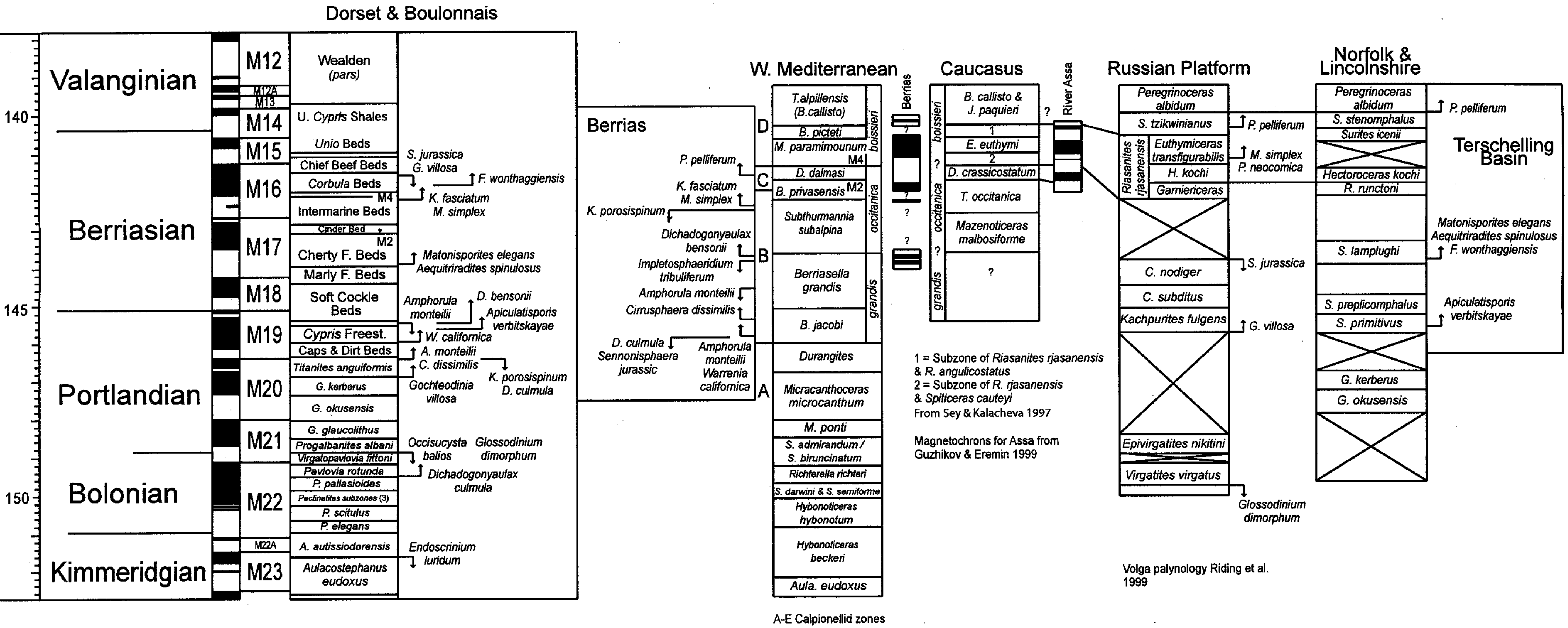
If we use all 'tools' at our disposal, and truly multidisciplinary approaches, we can at last break the impasse that has existed for generations of workers, who founded their opinions on only one or two fossil groups.

We are indeed in a different stratigraphic world to that at the time of the earlier conferences: no longer constrained by one or two groups of fossils, and sometimes by a very limited number of taxa within these. In the 1970s, no agreement was possible even on the equivalence of the Portlandian, Volgian and Tithonian, nor of where a J-K boundary might sit in areas outside the western Mediterranean. On magnetostratigraphic and palynological grounds, the Portlandian-Berriasian boundary level has now been localised in western Europe, and the L-M Volgian is now seen to span the Tithonian (Bolonian (=Upper Kimmeridgian) and Portlandian), and, even two decades ago, using the above methods it could be suggested that the Upper Volgian has a ?latest Portlandian, but mostly Berriasian, age.

Thus the stratigraphic world and the possibilities for Berrisian correlation have move on considerably in the last thirty years. Substantial work has been carried out in several regions outside the western Mediterranean: notably in Ukraine, the Caucasus, and the Russian far-east, as well as China and Japan. Substantial progress has been made in identifying Tethyan ammonites in Russian sequences. And also in European Russia and Britain and in those regions of western Europe with largely non-marine facies. Correlation between non-marine and marine, once totally conjectural, is now possible in a number of geographic areas based on integration of palynomorphs and shelly fossils.

Wider and effective use of a *jacobi* subzone (or *grandis*), following colloquium decision, or any other alternative used in a global sense, still requires considerable thought. This maximisation of correlative precision demands work on useful surrogate indicators or proxies, alternatives to the ammonites - a whole suite of alternative microfossil indicators, geochemical and palaeomagnetic techniques can be brought to bear, rembering the special circumstances of restricted basins and extreme faunal and floral provinciality.

The Berriasian is not a "marine stage", as one sees written sometimes: it is the one and only initial stage of the Cretaceous System, and the first "age" of the period. It needs to be definable in a GSSP, yes, but that datum must also be readily correlatable, traceable as much as possible around a world – utility is a major consideration. In Tethys, colleagues are happily working using calpionellid zonations and markers, lacking ammonite zonal indices. These give a working framework for an approximation to the J-K boundary. In carrying out ICS requirements in setting a GSSP, there is a need for similar flexibility. The first need to identify possible markers and assess their usefulness, before we can apply them to specific localities. There are a number of datums which approximate, at least, to the base of the *grandis* zone, and provide potential proxies for its recognition and definition: the base of the *Kachpurites fulgens* ammonite zone, the FADs for *Apiculatisporis verbitskaya*, *Amphorula monteilii* and *Warrenia californica*, perhaps *Gochteodinia villosa,* and LADs for *Dichadogonyaulax culmula* and *Sennonisphaera jurassica*, magnetozone M18, calpionellid zone B, and so on. If the base of the jacobi subzone and its proxies is not practical, then higher stratigraphic levels will need to be considered.



1 = Subzone of *Riasanites rjasanensis* & *R. angulicostatus*
2 = Subzone of *R. rjasanensis* & *Spiticeras cauteyi*
From Sey & Kalacheva 1997

Magnetochrons for Assa from Guzhikov & Eremin 1999

Volga palynology Riding et al. 1999

A-E Calpionellid zones

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