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Oxfordian paleobiogeographic perturbation between the Iberian and Sicilian regions: the role of the Panormide Carbonate Platform

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Key-words: West-Tethys, palaeobiogeography, ammonites, Upper Jurassic, Panormide Platform.

The major stratigraphic gap recognized at the Middle/Upper Jurassic boundary across the western Tethys, in such distant regions as East Iberia (Iberian platforms) and West Sicily, has been the subject of various different interpretations including sea level changes and major tectonic events under a tectonic extensional regime in Tethys. Regional differences in thickness of Callovian deposits, and sequence development (and hence, width of the gap) have been attributed to local tectonics, as recorded in eastern Iberian platform. In turn, such features as the apparent synchronicity of shallowing to emersion episodes at the Callovian/Oxfordian boundary (in most of Submediterranean and Mediterranean provinces) and the recovery of somewhat deep marine subtidal conditions at the turn of Middle Oxfordian Plicatilis-Transversarium zones have rather called for eustatic cyclic factors.

The comparison of ammonite successions during this stratigraphic interval in different regions of Submediterranean Province in the South West European margin (Iberian platform) and areas belonging to the South Tethyan margin, or Mediterranean s.str., such as western Sicily might cast some light on this problem.

The compared study of Callovian – Early Kimmeridgian ammonite successions in pelagic carbonate sequences across the western Tethys between eastern Iberia and West Sicily shows a clear divergence in the biogeographic distribution of ammonite families: a certain taxonomic homogeneity of such groups as Perisphinctidae, Oppeliidae and Peltoceratinae during the Callovian in Submediterranean and Mediterranean provinces is followed by a sharp differentiation of some of them, mostly perisphinctids at the turn of Early-Middle Oxfordian: representatives of subfamily Perisphinctinae remain attached to Submediterranean-Subboreal provinces whilst Passendorferiinae spread widely throughout the southern margin of Tethys (Mediterranean Province) and the external margin of South European platforms. This biogeographical divergence seems to reflect a correlative change in the palaeogeographic setting of West Tethyan epicontinental and epioceanic platforms. Such palaeogeographic change is evidenced by the tectonic evolution of the NW-Sicilian Panormide block, where a long lasting emersion during the Oxfordian, subsequent to a Middle Jurassic pelagic platform stage, is documented by a widespread erosional surface including the development of bauxite deposits. The recover of neritic platform conditions during Kimmeridgian times is indicated by an unconformable succession of stromatolitic limestones. Such widespread emersion of the Panormide Platform, apparently anomalous in a period of maximum Tethyan extension, might have been produced by tectonic transpressive movements along the shear zone between Iberia and Africa.

An Early Jurassic flora from Puale Bay, Alaska

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Key-words: Jurassic, macroflora, palaeoecology, Alaska.

Early Jurassic plant macroremains were collected from the Kamishak Formation (Middle Hettangian) at Puale Bay (Alaska). The plant fragments, mainly leaves and also leafy shoots, were found in ammonite-bearing marine sedimentary strata. This is a new paleobotanical locality, the first Jurassic one in Alaska with preserved cuticle. The leaves belong to three genera of different gymnospermal groups: *Sagenopteris pualensis* sp. nov. (Pteridospermophyta), *Otozamites mimetes* and *O. tenuatus* (Bennettitales) and *Brachyphyllum crucis* (Coniferales). Their macro- and micromorphology show definite xeromorphic features that suggest either an arid environment or the influence of soil with increased salinity. Three of the four species from Puale Bay also occur in the Middle Jurassic Yorkshire flora but they are not known from any other locality. It suggests that similar conditions existed in both areas and implies that the xerophytic features of plants were controlled by salinity of the soil. In the context of global Jurassic palaeogeography, our locality belongs to the Peninsular Terrane of Alaska which formed in an island arc situated at low latitude, near the equator. Consequently, this area belonged to the summer-wet climatic zone, which is confirmed by the collected plant assemblage. The geographic position of Yorkshire during the Jurassic was similar to the present and was therefore within the warm temperate climatic zone. It appears that local conditions strongly influenced the vegetation. The difference between the localities of Puale Bay and Yorkshire are not only geographic and climatic, but there is also a ~40 Ma time difference (Early *vs.* Middle Jurassic). Terrane movements and/or plant migration can account for the observed floristical similarity.

The environmental setting of the La Voulte *Lagerstätte* (Callovian, France): new data

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Key-words: siliceous sponges, stalked crinoids, bathyal environment, *Lagerstätte*, Callovian, France.

The interest of the Callovian La Voulte *Lagerstätte* dates back to the 19th century. Although several spectacular cases of soft-bodied preservation have been succinctly described over the years (e.g. squids, octopuses, worms), no comprehensive analysis of the organisms and communities present in this exceptional biota has been made so far. Similarly, the paleoenvironmental setting and taphonomic processes

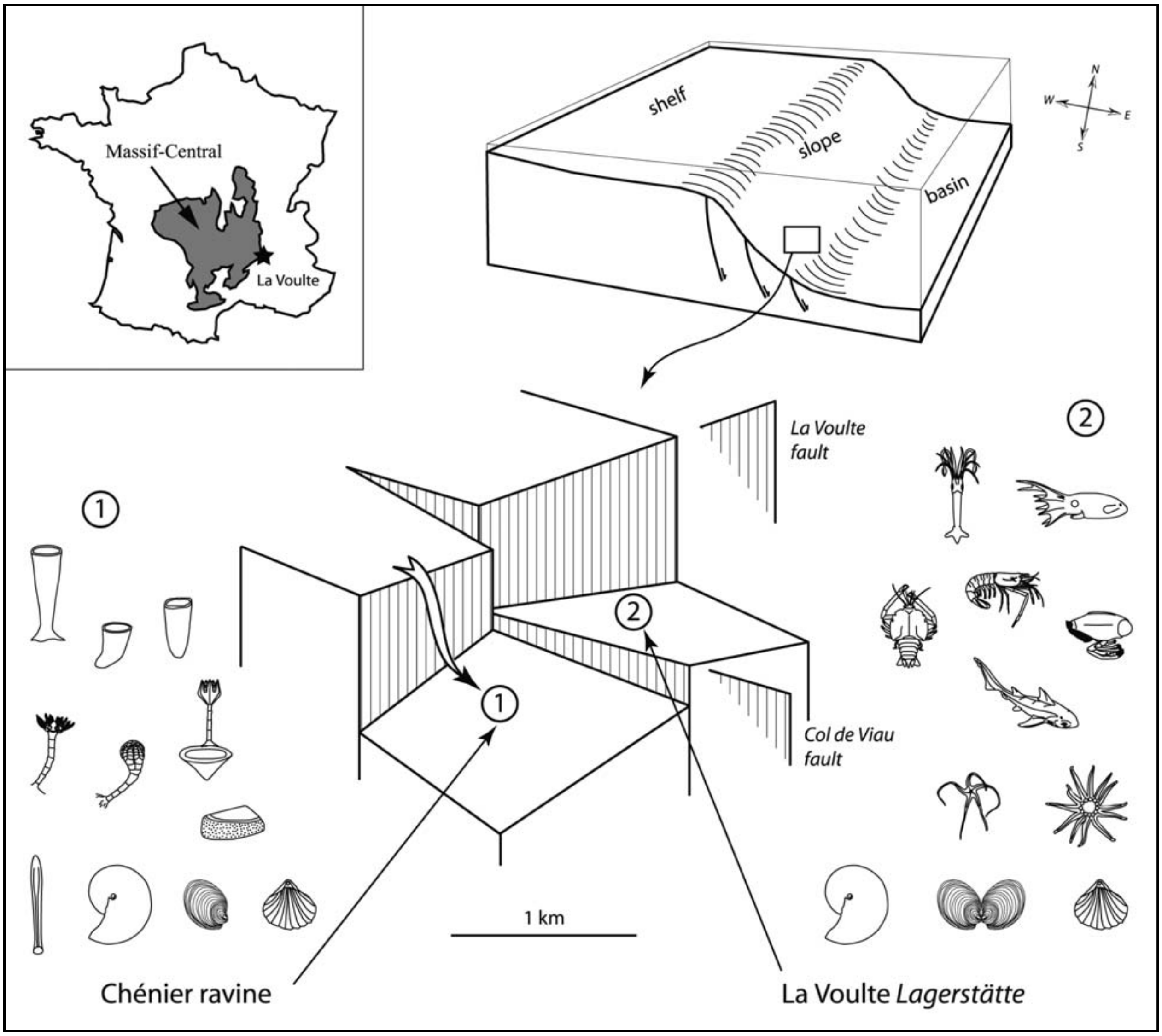

Fig. 1. Reconstruction of the palaeoenvironment of the La Voulte *Lagerstätte* across the slope-basin transition: 1 – the Chénier fauna (siliceous sponges and crinoids), 2 – the La Voulte fauna (soft-bodied organisms).

involved in the preservation of the fauna have received scant attention from scientists. Especially,the palaeobathymetry still remains an open issue. The *Lagerstätte* consists of a ca. 10 m thick layer dominated by dark platy marls with exceptional fossils (Fig. 1) that are commonly 3D-preserved in concretions (e.g. crustaceans). During the Callovian, the La Voulte area was situated along the western margin of the Subalpine Basin in a supposed relatively deep-water environment characterized by a complex submarine palaeotopography of titled blocks. Our study concentrated on the adjacent (although separated by a fault) Chénier Ravine where the succession is better exposed (ca. 30 m of marls and limestones) than in the Lagerstätte. This locality yielded abundant well-preserved siliceous sponges and small stalked crinoids that bring new information concerning the palaeoenvironment setting of the La Voulte area as a whole. **Siliceous sponges** are dominated by hexactinellids (78%; lithistids, 22%) which are reliable indicators of deep water settings. Although they are not preserved *in situ* and are scattered in sediments, their excellent preservation suggests limited post-mortem transportation and rapid burial. As typically observed in deep-sea sponges, conical shapes and erect morphologies are most frequent. The attachment on soft substrate is probably common but some specimens show a basal attachment on hard substrate. The absence of encrusting organisms (e.g. serpulids, bryozoans) and overgrowing microbialite suggests dim-light conditions and illustrates deeper conditions than the circalittoral Oxfordian sponge bioherms. **The stalked crinoids** are robust and dissymmetric and belong to Cyrtocrinina. The modern representatives of the group live on hard substrates in bathyal environments (e.g. in New Caledonia on the top of steep seamounts at nearly 500 m depth). This set of fossil data from both sponges and crinoids strongly supports the idea that the palaeoenvironment of La Voulte area was deep, possibly bathyal, and situated near the slope-basin transition (e.g. external part of the slope with steep topography and heterogeneous substrates favourable to the development of sponges and crinoids). If our interpretation is correct, then the La Voulte *Lagerstätte* may be one of the rare Jurassic *Lagerstätten*, if not the unique, to have fossilized a deep marine fauna.

Facies control *versus* geographical constraints in the evolution of the Early Jurassic gastropod faunas of the Peloritani Mountains (northeastern Sicily, Italy)

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Key-words: gastropods, Early Jurassic, Calabrian Arc, Peloritani Mountains, palaeobiogeography, Western Tethys, pelagic sediment.

The detailed systematic revision, currently in progress, of Gemmellaro's (1911) Pliensbachian gastropod fauna from Rocche Rosse (Galati Mamertino, Peloritani Mountains) is adding new data to the reconstruction of the palaeobiogeographical evolution of the Early Jurassic gastropod faunas of northeastern Sicily. Previous preliminary analyses (Monari *et al.*, in press) evidenced that the most significant aspect of the Rocche Rosse fauna is the high frequency of species exclusive of the areas characterized by pelagic sedimentation. Moreover, although the fauna is relatively rich and diversified, it does not contain species exclusive of the European epicontinental region. These features permit comparisons of Rocche Rosse fauna with those of northwestern Sicily and central Apennines (Italy), Hierlatz (Austria), Bakony Mountains (Hungary), and western Pontides (Turkey).

Another source of new data concerns the study of Pliensbachian gastropod faunas from a number of outcrops belonging to different stratigraphic-structural units of Peloritani Mountains. Their preliminary studies would confirm that the above features are generalized aspects of the Pliensbachian gastropod faunas of Peloritani Mountains. Thus, although the position of the Calabrian Arc was at the southern boundary of the European epicontinental seas during the Early Jurassic (Stampfli 2004), the gastropod faunas of this region are more closely related to those of the central regions of western Tethys than to the European ones.

In northeastern Sicily, the change from Sinemurian gastropod faunas, mainly showing European affinities, to Pliensbachian faunas characteristic of the pelagic facies is another relevant element of investigation.

All these aspects are analysed in the framework of facies control *versus* geographical constraints.

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New Jurassic jellyfish (Cerin, France): systematic, taphonomic and ecologic considerations

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Key-words: jellyfish, *Lagerstätte*, Cerin, Upper Jurassic, France, new taxa, systematic, taphonomy, ecology.

Well preserved jellyfish are described from the Cerin *Lagerstätte* (eastern France). The enclosing sediments are lithographic limestones deposited in an Upper Kimmeridgian lagoon lying on an emergent reef complex. A new taxon of Scyphozoa is proposed: *Paraurelia cerinensis*, and two new taxa of Cubozoa: *Bipedalia cerinensis* and *Paracarybdea lithographica*. Rapid covering by a microbial mat helped the preservation of the animals. More than 900 jellyfish occur at the top of a very uncommon bed. Many specimens of *Paraurelia cerinensis* are deformed by slippage down the palaeoslope which characterizes the margin of the lagoon. Their resultant morphology and their orientation clearly indicate the downslope direction. Tentacles of *Bipedalia cerinensis* and *Paracarybdea lithographica* are also orientated according to the palaeoslope. The jellyfish were probably dead individuals occasionally introduced in the Cerin lagoon. But another hypothesis may be considered referring to the model of the present-day jellyfish lakes from Palau (Caroline Islands, West Pacific). Jellyfish could live in the more oxygenated upper layer of water of the Cerin lagoon which allowed a pelagic life. This situation could correspond to short periods with an easier communication between the open sea and the lagoon. Jellyfish are only observed in the lower beds of the lithographic limestones and their distribution illustrates the supposed evolution of the Cerin lagoon. Initially, it was deeper, mainly flooded, with possibly autochthonous and allochthonous animals indicating clear marine influences. Finally, the lagoon shallowed and often emerged with a dominance of marginal marine burrows and plants indicating increasing terrestrial influences.

Jurassic global palaeoenvironment and palaeolithofacies maps

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Key-words: Jurassic, palaeogeography, plate tectonics.

Four time interval maps were constructed which depict the palaeoenvironment, palaeolithofacies, and plate tectonic configuration and palaeogeography during the Jurassic time. The maps were constructed using a plate tectonic model, which describes the relative motions between approximately 300 plates and terranes. This model was constructed using Plates and Paleomap software, which integrate computer graphics and data management technology with a highly structured and quantitative description of tectonic relationships. The details of the palaeoreconstruction and mapping methodology were described in details in the Golonka *et al*. (2003) paper. The detail information about the database, including the palaeopoles used can be found in the Plates homepage: *www.ig.utexas.edu/research/projects/plates/plates.htm*. Plates maintains an up-to-date oceanic magnetic and tectonic database, continuously adding new palaeomagnetic, hot spot, geological and geophysical data to extend the span and accuracy of global plate reconstructions. Plate's reconstructions are built around a comprehensive database of finite-difference poles of rotation, derived both from extensive plate motion research at UTIG, using the plates interactive plate modeling software, and from published studies. Updated plate motion models are in turn applied to regional tectonic studies by plates investigators and collaborators and by project sponsors. The generalized palaeofacies and palaeoenvironment database information were posted on base maps. For example the reef data (see Kiessling *et al.* 1999) were rotated together with plate's polygon maps. The calculated palaeolatitudes and palaeolongitudes were used to generate computer maps in the Microstation design format using the equal area Molweide projection.

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The origin and early evolution of planktic Foraminifera

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Key-words: Foraminifera, Jurassic, palaeogeography.

In the 1960s and 1970s Oberhauser and Fuchs described a range of new species from Austria, Northern Italy and Poland that were described as the "earliest" planktic foraminifera. Since the publication of these papers there has been a debate as to the validity of both the species and the interpretation of them as the earliest part of the Mesozoic plankton. Some authors have dismissed them, almost out of hand, while others have defended them as the ancestral forms of the planktic foraminifera.

In the last two years all the type specimens have been inspected and photographed in an environmental SEM. This has allowed the close matching of the original drawings (almost all of which are very accurate) with the new photographs. The evolutionary trends detected by Fuchs are almost certainly correct, although it is clear that the majority of the taxa are benthic in character. That said, it is also clear that *Oberhauserella* and *Praegubkinella* are possible ancestors of the Jurassic planktic fauna that appears at, or about, the level of the Toarcian oceanic anoxic event in Europe. Records of such taxa in other parts of the world [e.g., N.W. Australia – Apthorpe (pers. comm.)] have still to be fully assessed. It is quite clear that, by the Bajocian and Bathonian (in the Middle Jurassic) there was a relatively diverse fauna of *Conoglobigerina* (and possibly *Globuligerina*) present in oceanic sediments deposited over a wide area of the Tethyan Realm. In the mid-Upper Jurassic this fauna diversified and expanded its range as new ocean basins (e.g., the North Atlantic Ocean) developed. In places, such as the Carpathians of Southern Poland, some of these Jurassic limestones yield assemblages that can only be described as Jurassic "Foraminiferal ooze", so abundant is the fauna. There are very rare occurrences in the Upper Jurassic, but across the Jurassic/Cretaceous boundary the record is very incomplete. This gap in our knowledge is quite critical as the Jurassic taxa are regarded as being aragonitic in test composition, while those in the Lower Cretaceous are calcitic.

While there are still many questions to resolve, new data from Jurassic sediments throughout Europe are providing answers to the evolution of the planktic foraminifera.

Migration of the latest Triassic/earliest Jurassic bivalves – palaeobiogeography and geodynamic implications

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Key-words: bivalves, palaeobiogeography, Pangea, Triassic, Jurassic, Atlantic, Tethys.

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 Triassic stretching and rifting phase, continued during Early-Middle Jurassic time (Golonka 2002). Its onset began with the Early Triassic rifting. This rifting was magnified at the Triassic/Jurassic boundary. The Atlantic Ocean originated as a consequence of this breakup. The connection of the Panthalassa Ocean (Proto-Pacific) and western Tethys gradually started with the origin of the narrow sea strait (so-called "the Hispanic Corridor"). Therefore the widespread distribution of numerous fossil invertebrate groups took place during earliest Jurassic time (mainly Sinemurian-Pliensbachian) (Hallam 1983; Newton 1988; Smith & Tipper 1986; Damborenea 2000; Arias 2006).

Previously – in Triassic – the migration of sea fauna (Late Triassic crinoids, molluscs, crustaceans *etc.*) 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 had not 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 (Westermann 1981; Kristan-Tollmann & Tollmann 1985). 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).

On the other hand the paleobiogeographical 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 findings are known from the Late Triassic Sub-Arctic regions and the rapid worldwide spreading of species of this genus take place 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 parts 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).

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Ichnofabrics of the Middle Jurassic manganeouse radiolarites from the Branisko and Pieniny successions of the Pieniny Klippen Belt and their palaeoenvironmental implications

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Key-words: radiolarites, trace fossils, Middle Jurassic, Pieniny Klippen Belt.

Radiolarites are one of the most characteristic Jurassic deep-sea facies in the Tethyan realm. In the Pieniny Klippen Belt, they occur for the first time in the Middle Jurassic in the Branisko and Pieniny successions, where they are known as “manganouse radiolarites” or as the Sokolica Radiolarite Formation (about 20-25 m in thickness). They are dated to uppermost Bajocian – Upper Callovian. In the road-cut in the Flaki Range (Branisko Succession, Poland) they are underlain by grey crinoidal-cherty and greenish micritic limestones and green chamosite-bearing marls (Flaki Limestone Formation) and overlain by the Czajakowa Radiolarite Formation. In Halečkova (Pieniny Succession, Slovakia), the manganouse radiolarites crop out in tectonically overturned position in the old abandoned quarry. Stratigraphically, they overlie Bajocian *Fleckenmergel*-type facies of the Podzamcze Limestone Formation (former Supra-Posidonia Beds) and are overlain by grey-greenish radiolarites of the Podmajerz Member of the Sokolica Radiolarite Formation (Upper Callovian – Lower Tithonian).

Many radiolarite beds display normal graded bedding from silt to clay grain size. The lower boundary of the graded layers is sharp and the grain size changes gradually up the layer. A horizontal lamination is present in the lower, coarsest part. In most cases, bedding surfaces do not follow the graded layers: one bed can contain a few graded units. The layers are at least partly bioturbated. Intensity of bioturbation increases to the top. Trace fossils are very rare in the lower part of the layers. They are represented by common *Chondrites* and less common *Zoophycos*. They belong to the deep-tier ichnofauna. Common *Planolites*, *Chondrites*, less common *Taenidium* and *Teichichnus*, rare *Siphonichnus* and common undeterminable forms occur mostly in the upper part of the layers. They are visible against totally bioturbated background, which points to an intensive biogenic reworking of sediments on occurrence of the so-called mixed layer. Commonly, the bioturbational structures are concentrated just below the sharp base of the next layer. Such a distribution of ichnofabric suggests deposition of the graded layers by catastrophic, diluted density currents. Pelagic background sediments form the upper part of the layers. The concentration of trace fossils in the uppermost part of the beds is related to intensive colonization of the near bottom slowly accumulating background sediment. However, it is not excluded that very thin originally graded beds are completely homogenized by burrowers. The trace fossil association is typical of deep-sea fine-grained, well-oxygenated sediments. It seems that there are no specific trace fossils for radiolarites and that spiny radiolaria tests not influenced burrowers. Very little ichnological data come from radiolarites.

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Biological zonation of Oxfordian coral reefs

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Key-words: corals, reefs, Oxfordian, Kimmeridgian, zonation, bathymetry, climate.

In order to build a 500 m underground scientific research laboratory at Bure (Lorraine), the French National Radioactive Waste Management Agency (ANDRA) created two wide shafts (5 m in diameter), connecting the surface to underground facilities. Sinking operations provided a large amount of fossiliferous rocks from Lower Oxfordian to basal Tithonian, which are used in a multidisciplinary program. Among fossils, 1116 corals were identified and allowed studying the coral assemblages in a quantitative approach. These assemblages are located in a globally prograding succession, which corresponds to the infilling of the Paris Basin by a powerful carbonate factory. The global trend (basinal to lagoonal) is complicated by third order and shorter transgression-regression cycles, which were defined on sedimentological criteria (Carpentier 2004).

The installation of reefs begun by a low diverse community dominated by lamellar microsolenids *Dimorpharaea koechlini*. Progressively, and with well documented iterations due to sea level fluctuations, more diverse communities with a greater abundance of the thick platy *Microsolena* flourished. Then, branching forms such as *Calamophylliopsis* and *Dendraraea* got their maximum score in equitable communities. The maximum diversity is reached when *Comoseris* get their best score. Lagoonal characters are associated to assemblages enriched in plocoid colonies (*Stylina*, *Cryptocoenia*). Finally, last communities (probably Lower Kimmeridgian) are clearly marked by specific very shallow lagoonal assemblages.

A comparison can be made with Middle Oxfordian reefs in Northern Jura (Lathuilière *et al.* 2005). Most of coeval communities can be recognized. The new study brings strength to the bathymetric interpretation. The main difference is the weaker and different expression of the branching coral association, which is probably due to a particular sedimentation stress in the Northern Jura section.

A comparison can also be made with high latitude coeval reef communities (Martin-Garin 2005), which enables us to discard an alternative interpretation in exclusive terms of warming rather than shallowing. Such a comparison brings interest to the correspondence between the maximum abundance of *Thamnasteria* and the cold snap in the Bifurcatus Zone (Cecca *et al.* 2005).

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Middle Jurassic oysters from Romania

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Key-words: Middle Jurassic, oysters, Romania.

Three Romanian Middle Jurassic bivalve assemblages with oysters, discussed in the present paper, are known from the following localities: Anina (Resita-Moldova Noua Basin), Strunga-Strungulita (western flank of the Bucegi Mountains) and Tichilesti Valley (Central Dobrogea). The Middle Jurassic deposits from the first two localities belong to the sedimentary cover of the Getic Nappe, part of the Median Dacides, Southern Carpathians, while the last one belong to the sedimentary cover of the Central Dobrogean sector of the Moesian Platform. In all these localities, the bivalves represent the most abundant benthic organisms. The specific facies affinities are reflected by palaeoecological requirements of the oysters in relation to their taxonomic diversity observed for each assemblage.

The Middle Jurassic deposits from the Resita-Moldova Noua Basin have been studied since the 19th century (see Bucur 1997, for a complete history on the geological research activity). The studied oyster fauna was collected near Anina, from two quarries situated in the central part of the basin. The bivalves occur in the Bajocian – Lower Callovian interval, in sediments ranging from marls, silty marls to calcareous sandstones. The main taxa identified are: *Liostrea acuminata* (J. Sowerby), *Gryphaea* (*Bilobissa*) *dilobotes* Duff, *G.* (*Gryphaea*) sp., *Catinula* sp., *Praexogyra* sp., the last one being remarkable for the large number of individuals.

The western flank of Bucegi Mts. is remarkable for the wealth of the Jurassic (Bajocian-Bathonian) fossils. Lazăr (2004) gave an outline of the palaeontological researches in the area and a general account on the geology. The identified oyster taxa are: *Lopha costata* (J. Sowerby), *Lopha (Rastellum) eruca* (Defrance), *Lopha* (*Rastellum*) sp., *Liostrea acuminata* (J. Sowerby), *Lopha gregarea* (J. Sowerby), and were recovered from sediments ranging from calcareous sandstones to biocalcarenites. The small oysters like *L. costata* and *L. acuminata*, generated compact shell accumulations (0.5 m thick). These accumulations show a stratified structure with successive generations attached on the anterior populations.

The bivalve assemblages from Central Dobrogea are Late Bathonian – Early Callovian in age (Tichilesti Formation, Bârbulescu 1974). Numerous individuals of *Catinula matisconensis* (Lissajous) and *Liostrea hebridica* (Forbes) represent the main oyster taxa, associated with many others benthic organism.

Impressive specimens with xenomorphic sculpture after ammonite shells or wood fragments are recorded in *Catinula* specimens from Anina and Tichilesti.

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Trace fossils from the Lower Jurassic Ciechocinek Formation from SW Poland

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Key-words: trace fossils, muds, brackish environment, Lower Jurassic, Częstochowa-Wieluń region, Poland.

Ciechocinek Formation represents Lower Toarcian, brackish-marine deposits (Pieńkowski 2004), consisting of poorly consolidated mudstones and siltstones with lenses and subordinate intercalations of sands, sandstones and siderites. Body-fossils in these deposits are almost absent. On the contrary, trace fossils are common, however, the assemblage is not diversified and predominated by simple burrows of non-specialized deposit-feeders.

Ichnofossil association from deposits occurring in the Częstochowa-Wieluń region includes: *Planolites*, *Palaeophycus*, *Helminthopsis*, *Gyrohorte*, *Cruziana* and *Spongeliomorpha* as well as many small, unidentified traces, most probably of pascichnia type. Pieńkowski (1988, 2004) found also one specimen of *Diplocraterion parallelum* Torell. This association shows many features typical for brackish-water environments, such as: reduced diversity with simultaneous high population density, predomination of simple burrows made by trophic generalists, prevalence of infauna on epifauna as well as frequent size reduction of traces. Trace fossil suite from the lower part of the succession is more diversified, what points to the higher water salinity. Thus, it can be stated that the maximum of transgression fell into the lower part of the Ciechocinek Formation. Above, diversity of trace fossil suite gradually diminishes to the almost monospecific *Planolites* association, marking gradual falling in salinity and, at the end, regression.

Degree of bioturbation is usually low to moderate, however, intensively bioturbated intercalations as well as layers devoid of bioturbation commonly occur. Conditions in the bottom sediment were generally moderately favourable for benthic fauna activity, resulting from the lowered salinity of water and low oxygenation of sediment – the last one advocated by the presence of early diagenetic pyrite and common siderite mineralization in muds (Leonowicz 2005). They changed from place to place and along with time, probably due to fluctuations of the seafloor oxygenation. In places where bottom water was stagnant and sediment enriched in organic matter, anoxic conditions could develop, resulting in orign of non-bioturbated horizons. Episodes of bottom current activity could improve oxygenation of the sea-floor and lead to formation of high bioturbated levels.

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Toward a global Jurassic tetrapod biochronology

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Key-words: Jurassic, tetrapod, biostratigraphy, biochronology, provinciality.

Jurassic tetrapod fossils are known from all of the continents, and their distribution documents a critical palaeobiogeographic juncture in tetrapod evolution – the change from cosmopolitan Pangean tetrapod faunas to the provincialized faunas that characterize the late Mesozoic and Cenozoic. Two global tetrapod biochronological units (faunachrons) have been named for the earliest Jurassic – Wassonian and Dawan. Wassonian tetrapod assemblages are best known from the western USA (Moenave Formation), eastern Canada (McCoy Brook Formation) and southern Africa (upper Elliott Formation) and are characterized by protosuchid crocodylomorphs and prosauropods. Magnetostratigraphy and palynostratigraphy suggests that the Wassonian is equivalent to part of Hettangian time. Dawan tetrapod assemblages are best known from southern China (Lufeng Formation) and the western USA (Kayenta Formation). Index taxa of the Dawan include *Megapnosaurus*, *Dilophosaurus*, *Massospondylus* and *Oligokyphus*. The occurrence of the Dawan dinosaur *Scelidosaurus* in Lower Sinemurian marine strata indicates that Dawan time is equivalent to at least part of the Sinemurian.

However, after the Dawan, a scattered and poorly dated Middle Jurassic tetrapod record and a much better Upper Jurassic tetrapod record indicate significant provincialization of the global tetrapod fauna had begun by the Middle Jurassic. Middle Jurassic tetrapod assemblages are best known from Europe (e.g., "Great Oolite"), southern China (lower Shaximiao Formation of Sichuan) and Argentina (Cañodon Asfalto Formation). The fact that they yield distinct genera of sauropod dinosaurs – *Cetiosaurus*, *Datousaurus* and *Patagosaurus* – which are large, mobile terrestrial tetrapods, suggests marked provinciality by Bajocian time. The obvious provincialism of well known Chinese Middle-Upper Jurassic dinosaur faunas also documents the end of tetrapod cosmopolitanism.

Upper Jurassic tetrapod faunas are best known from the western USA (Morrison Formation), China (upper Shaximiao Formation in Sichuan) and eastern Africa (Tenduguru Formation). Distributions of some Late Jurassic dinosaur taxa clearly define a province that extended from the western USA through Europe into eastern Africa (northern Gondwana). Provincial tetrapod biochronologies have already been proposed for this province and for the separate eastern Asian Late Jurassic province. Thus, a single global biochronology of Middle-Late Jurassic tetrapods is not possible. Instead, after the earliest Jurassic, provincial tetrapod biochronologies are needed that must then be correlated to each other to arrive at a global scheme.

Gigantic theropod dinosaur tracks in the Lower Jurassic

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Key-words: earliest Jurassic, large theropods, global occurrence, ecological release.

Gigantic theropod dinosaur tracks were discovered in the Lower Jurassic deposits of the Newark Supergroup (eastern USA), Arizona (western USA) and in the Holy Cross Mountains (central Poland). These discoveries provide paleoichnological evidence for the global occurrence of very large predatory dinosaurs in the earliest Jurassic time. These intriguing Lower Jurassic gigantic ichnites are more similar to large tracks left by Middle-Late Jurassic theropods.

The gigantic theropod footprints (45-65 cm long) identified in Newark Supergroup came from the two Lower Jurassic tracksite at Granby and Holyoke. The Lower Jurassic Kayenta Formation of Arizona have yielded a four-step trackway of clawed very large tridactyl tracks (about 60 cm long). The Polish material are represented by seven specimens of gigantic theropod *Eubrontes*-like footprints (50-65 cm long) and were found in the Sołtyków tracksite. These tracks seem even larger because of their large metatarsophalangeal area. Relatively large metatarsophalangeal area is observed in the large theropod footprints from the post-Liassic strata, such as *Eubrontes glenrosensis* and/or *Megalosauripus*.

Gigantic theropod ichnofauna of the Early Jurassic age is enriched by ichnites of large, medium and small-sized theropods, ornithischians, sauropodomorphs, other non-dinosaur archosaurs, and mammal-like animals. Analysis of paleoichnological records suggests rapid increase in theropod body sizes near Tr/J boundary. The first phase of this evolutionary phenomenon was identified in the Late Rhaetian, and the second after Tr/J biotic turnover, what is also connected with distinct increase in dinosaur diversity and dinosaur-dominated communities in the Hettangian time. Rise of large Rhaetian and gigantic Hettangian theropods are linked with appearance of large herbivorous animals (prosauropods, sauropods) and effect of ecological release of dinosaurs after terrestrial faunal turnover.

Late Jurassic and Early Cretaceous climates of the northern high latitudes

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Key-words: Late Jurassic, Arctic, Scotland, Russia, Svalbard, belemnites.

The Jurassic and Cretaceous periods are widely accepted as being dominated by “greenhouse” conditions with elevated CO_2 levels and warm polar regions (e.g. Frakes 1979; Jenkyns *et al*. 2004). Although much compelling evidence to support this idea of global warmth exists, some recent studies propose that the greenhouse climate may at times have been punctuated by sub-freezing polar conditions and the presence of limited polar ice. The evidence however is somewhat equivocal and is both spatially and temporally limited with much of this research until now being concentrated in mid- to low latitudes, despite it being generally accepted that global climate is defined to a significant degree by prevailing conditions at the poles (e.g. Jenkyns *et al*. 2004). Existing data are also often plagued by poor sampling resolutions and dubious diagenetic histories (Price & Mutterlose 2004). It is therefore essential to collect robust data from high latitudes, which can be used to accurately reconstruct the climatic conditions of polar regions.

The research presented here comprises a range of geological data from biostratigraphically constrained localities in Scotland, Russia, Siberia and Svalbard. Various isotopic and geochemical analyses have been undertaken on material (primarily belemnites, but also sediment samples) collected from the aforementioned sites. Such analyses include oxygen and carbon isotopes, trace element analysis

(Fe, Mn, Ca, Mg, Sr, Ti, Ba), backscattered scanning electron microscopy (BSEM) and cathodoluminescence microscopy (CL), Total Organic Carbon (TOC), $\delta^{13}C$ of organic carbon (C_{org}) and Rock-eval measurements.

Preliminary results include the identification of glendonites in Svalbard (as observed in the field) and potentially subfreezing palaeotemperatures in Siberia (as calculated from oxygen isotope data). Such data indicates that cold conditions were indeed likely in the Late Jurassic and Early Cretaceous Arctic, and that at least limited polar ice could perhaps have developed at this time.

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Early Jurassic palaeoenvironment and climate in the Mount Flora, West Antarctica

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Key-words: palaeoenvironment, palaeoclimate, macroflora, Mount Flora, West Antarctica.

This study is based on macroflora from Mount Flora, West Antarctica. The 263 rock fragments containing remains of plants were collected by K. Birkenmajer (in 1987 and 1988) and by A. Gaździcki (in 1991).

In Early Jurassic time in the Mount Flora there were two different habitats: humid lowland and arid highland (Birkenmajer 1993). Both wet river valley and drier slopes of the mountains were inhabited by plant communities.

Species of *Equisetum*, such as *Equisetum laterale* Phillips emend. Harris, emend. Gould, *Sagenopteris nilssoniana* (Brongn.) Ward, *Nilssonia taeniopteroides* Halle, grew in the river valley. This group of plants was characteristic for wet placies (Vakhrameev 1991; Abbink 1998). Big ferns of genus *Cladophlebis*, such as *C. antarctica* Nathorst also occurred in this plant community.

In the slope of the mountains there were two type of forest: low and high. In the low forest bennettitales grew, such as *Otozamites linearis* Halle and *Zamites antarcticus* Halle emend. Archangelsky & Baldoni. The high forest consisted of trees of Taxodiaceae (such as *Sphenolepis* sp.), Araucariaceae (such as *Araucarites* sp.) and *Elatocladus confertus* (Oldham & Morris) Halle. In this plant community *Archangelskya furcata* Herbst emend. Rees & Cleal occurred. It was probably a liana (Rees & Cleal 1993). In the undergrowth of this forest there were ferns of Dicksoniaceae, such as *Coniopteris lobata* (Oldham & Morris) Halle.

Some of these plants give information on palaeoenvironment of the locality. Genus *Pachypteris* and bennettitales were characteristic for subtropical areas (Vakhrameev 1991). Genus *Nilssonia* grew in subtropical and in moderate – warm climate region (Vakhrameev 1991). In Mesozoic time presence of Araucariaceae was characteristic for warm climate without large seasonal amplitudes (Abbink 1998).

Nowaday Dicksoniaceae occur in tropics, in temperate areas they are rarely found (Kramer & Green 1990) and Taxodiaceae are found in warm – temperate climate (Kramer & Green 1990).

In conclusion: in Early Jurassic time in Mount Flora, West Antarctica climate was warm, between subtropical and moderate, without large seasonal amplitudes.

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Pterosaur tracks from the Early Kimmeridgian intertidal deposits of Wierzbica, Poland

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Key-words: pterosaur tracks, tidal flat, palaeogeography, Upper Jurassic, Poland.

In the Early Kimmeridgian (Hypselocyclum Zone) tidal flat carbonate deposits cropping out in a large Wierzbica quarry at northern slope of the Holy Cross Mountains (20 km south of the town of Radom), characteristic *Pteraichnus* sp. tracks have been found. These tracks are assigned to pterosaurs and represent the first pterosaur ichnites found in Poland. Seven specimens of pterosaur tracks (*pes* and *manus* prints) are described, although no trackway can be observed. The manual prints are asymmetric, digitigrade, and tridactyl. The pedal prints are elongate, symmetrical, plantigrade and functional-tetradactyl. Most likely these tracks were left by a small pterodactylid or rhamphorhynchoid pterosaur, with wingspans of about 0.5 to 1 m. The footprints have been preserved as a positive hyporelief at the bottom of tidal channel deposits. The palaeoenvironmental interpretation as tidal flat is confirmed by presence of vertically accreted tidal bundles, each representing deposition in one tidal cycle. Most likely, this was one of environments frequented by pterosaurs, which is shown by many other pterosaur tracks occurrences, where they are clearly associated with marine coastal facies. Similar behaviour is observed in modern birds, finding favourable feeding opportunities in this environment, as well as the safe resting places. On the other hand, the muddy-carbonate surface of the upper tidal flat provided an excellent medium for precise imprinting of delicate tracks made by a light animal. Presence of subaerial structures, like rhizoids, pterosaur tracks and dinosaur footprints in the Lower Kimmeridgian strata of the northern slope of the Holy Cross Mountains clearly points to emersions at that time. The East European land must have periodically extended far to the west. Naturally, pterosaurs could leave their tracks anywhere on dry land, also on ephemeral shoals in the sea too. However, presence of detrital quartz and quartzite fragments, large wood fragments, as well as occurrence of dinosaur footprints in Wierzbica and Ożarów quarry situated some 75 km to the SE, prove that the discussed pterosaur tracks were rather left on a shore the East European Land.

Invertebrate trace fossil assemblage from the Lower Hettangian of Sołtyków, Holy Cross Mountains, Poland

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Key-words: Hettangian, Lower Jurassic, invertebrate trace fossils, ichnofacies, Holy Cross Mountains, Poland.

This paper describes the occurrence of diverse and well preserved terrestrial invertebrate ichnocoenose from the Sołtyków outcrop (Lower Hettangian Zagaje Formation) in the Holy Cross Mts., central Poland, known from abundant tetrapod (mostly dinosaur) footprints. Sołtyków outcrop reveals a very diversified, rich and well-preserved invertebrate trace fossils assemblage, representing pascichnia, domichnia, fodinichnia, fugichnia and repichnia, of the lacustrine and fluvial environments. The following ichnotaxa were recognized: *Lockeia siliquaria* James 1879; *L. amygdaloides* (Seilacher 1953); *L. czarnockii* (Karaszewski 1974); cf. *Conostichus* isp.; *Conichnus* isp.; *Imbrichnus* isp.; *Scalichnus* isp.; cf. *Bergaueria* isp.; *Scoyenia* isp.; *Spongeliomorpha* isp.; *Steinichnus* isp.; *Cruziana problematica* (Schindewolf 1921); *Cruziana* isp.; *Rusophycus* isp.; *Diplichnites* isp.; *Celliforma* isp.; *Coprinisphaera* isp.; *Planolites* isp.; *Palaeophycus* isp.; *Cochlichnus* isp.; *Helminthoidichnites* isp.; *Helminthopsis* isp.; *Xylonichnus* isp. The new ichnotaxa representing bivalve dwelling, escape and locomotion traces can be identified. Three terrestrial ichnofacies are identified: the Mermia (entirely aquatic), Scoyenia and Coprinisphaera, from shallow lacustrine, to different subaerial fluvial environments. Bivalve trace fossils dominate in the aquatic environment, while subaerial ichnofacies are dominated by arthropod (mainly insect) trace fossils. Intriguing finds of nesting burrows resembling structures produced by solitary hymenoptera will be discussed.

Late Jurassic climate variation: new isotopic data from the Russian Platform

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Key-words: Kimmeridgian, Volgian Russian Platform, stable isotopes, belemnites.

Isotopic records of marine temperatures indicate a severe cooling and subsequent rapid warming during the Middle to Late Jurassic transition. Hence this time may represent one of the major turning points of the climate history of the Earth. A number of compilations of Jurassic isotopic data (largely belemnite-derived) have been considered as supportive of an icehouse-greenhouse transition. Such isotopic databases frequently consist, however, of data from numerous dispersed locations where presumably potential differences exist with respect to temperature and the isotopic composition of seawater, hence making any global palaeotemperature reconstruction inherently complex. This study presents new (belemnite-derived) isotopic data from the Kimmeridgian-Volgian of the Russian Platform (Gorodische, Belyaevka Village and Marievka) combined with existing Oxfordian and Volgian data also from the Russian Platform. A detailed ammonite zonation scheme for the Late Jurassic of the Russian Platform section permits these data to be placed within a recognized and detailed biostratigraphical scheme. The ^{18}O data presented for the Kimmeridgian-Volgian show surprisingly little variation (and considerably less scatter than some compilations of similar data) with values becoming steadily more negative. Superimposed upon this gradual trend are brief, more positive interludes. These positive δ^{18}O values (and hence minimum palaeotemperatures) seen at the top of Autissiodorensis, Sokolovi-Pseudoscythica Zones are coincident with ammonite faunas showing strong Subboreal affinities. The δ^{13}C curve shows decreasing values through the Kimmeridgian and Lower Volgian (possibly reflecting increasingly oligotrophic conditions), interrupted by a marked positive excursion in the Middle Volgian. The organic rich units of Gorodische fall only partly within the main positive segment of the δ^{13}C curve hence the variations documented in carbon record may be related to organic carbon production linked to increased primary productivity and the subsequent burial leading to a local enrichment of waters in δ^{13}C during Late Volgian times.

Ammonite palaeobiogeography of the Jurassic deposits in Koppeh Dagh Basin, NE Iran

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Key-words: Iran, Koppeh Dagh Basin, ammonites, palaeobiogeography.

The Koppeh Dagh sedimentary area in Northeast Iran is a fault-bounded basin, being developed after the Mid-Cimmerian orogenic phase in Late Bajocian (Seyed-Emami & Alavi-Naini 1990). It has a thick cover of Jurassic and Cenozoic rocks, being folded at the end of the Alpine phases in Late Tertiary (Afshar-Harb 1979, 1994). Lower Jurassic rocks (equivalent to Shemshak Formation) are missing here. The Jurassic Period coincides with a world-wide marine transgression in Late Bajocian, lasting until the end of the Jurassic. The Jurassic rocks in the Koppeh Dagh Basin have been subdivided from bottom to the top into three lithostratigraphic units i.e. Kashafrud, Chaman Bid and Mozduran formations (Afshar-Harb 1979, 1994).

The Kashafrud Formation (Upper Bajocian-Bathonian) is a thick (>1000 m), dark, often turbiditic and siliciclastic sequence, representing the very rapid infilling of a deep and narrow basin, at the southeastern margin of the Turan Plate. It overlies with a distinct angular unconformity some 10 m of Triassic or Permian coarse conglomerates. Towards west the Kashafrud Formation pinches out, lateraly giving way to the overlying Chaman Bid Formation. The Chaman Bid Formation (Upper Bajocian – Lower Tithonian) is a thick sequence of dark-grey to bluish, thin to medium-bedded micritic limestones with marly intercalations, being deposited on a deeper shelf or even slope environments. Its thickness varies from few ten meters in the east to more than 1,500 m to the west. The Chaman Bid Formation is succeeded diachronously by the light, ridge-forming platform carbonates of the Mozduran Formation (Oxfordian – Lower Neocomian).

The Jurassic strata of the Koppeh Dagh Basin contain locally a rich ammonite fauna, which has been studied fragmentarily. The genera and species of Phylloceratidae, Haploceratidae, Oppeliidae, Stephanoceratidae, Sphaeroceratidae, Parkinsoniidae, Morphoceratidae, Reinckeiidae and Perisphinctidae families are recorded. The ammonite fauna assemblage of the Koppeh Dagh Basin contains genera and species similar to those recorded from north (Alborz) and central Iran. Although the Koppeh Dagh Basin has been connected probably with the northern parts of Iran during Jurassic time, a possibility of sea-connection with central Iran needs to be studied in more detail. The ammonite fauna shows close relations to northwestern Tethys (Mediterranean and Sub-Mediterranean Provinces) allowing applicability of similar biozonation.

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Pliensbachian calcareous nannofossils from the Mont d'Or (France) and Lusitanian Basin (Portugal): palaeogeographic and palaeoenvironmental significance

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Key-words: Pliensbachian, calcareous nannofossils, abundance variation, event, palaeogeography, Mont d'Or Basin, Lusitanian Basin.

Calcareous nannofossil abundance was estimated in two sections of the Mont d'Or area (central France) and Lusitanian Basin (Peniche, Portugal), respectively. From a palaeogeographical point of view the localities analysed in this work belong to different domains: the Lusitanian Basin is related to the opening of Central Atlantic Ocean while the Mont d'Or area is linked to the westward opening of Tethys realm. The assemblage composition and its variation through time were analysed by means of multifactorial analysis (PCA).

The results of this study show that absolute and relative abundances of calcareous nannofossils, compared to the $CaCO_3$ evolution, indicate a common pattern in Mont d'Or area and Lusitanian Basin between Stokesi and Margaritatus ammonite zones (Late Pliensbachian). The main event recorded in the Mont d'Or area is the simultaneous decrease of $CaCO_3$ and of nannofossil semi-quantitative abundance. This is probably due to an important input of siliciclastic material from surrounding exposed lands. This event is also characterized by the high relative abundance of *L. barozi* (interpreted as shallow-dweller) with respect to *M. jansae* (a deep-dweller).

In the Peniche section (Lusitanian Basin), in the same ammonite and nannofossil zone as in the Mont d'Or, an increase of nannoplankton absolute abundance is recorded that is probably related to an increase in nutrient input. PCA analysis shows the opposition on the same factor of *L. barozi* (shallow-dweller) and *C. crassus* (deep-dweller), with *L. barozii* dominating in the same interval where nannofossil absolute abundances increase. These events are recorded in both sections just above the first occurrence of *Biscutum grande*, at the transition between Stokesi and Margaritatus ammonite zones.

It is possible that these events recorded in two different sedimentary basins, and in particular the dominance of *L. barozii* in coccolith assemblages, are related to the same, supra-regional event. Climatic changes (i.e. temperature decrease) are documented at that time by Rosales *et al.* (2004) on the basis of the study of oxygen isotope of belemnites from the Basque-Cantabrian Basin (Spain), palaeogeographically located half a way between the paleosettings of Mont d'Or and Peniche. The high relative abundance of *L. barozii* with respect to shallow-dweller species in both areas, and the high absolute abundances recorded at Peniche may argue in favour of the development of a shallow nutricline, probably related to the climatic/oceanographic changes occurring between Stokesi and Margaritatus ammonite zones.

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Foraminiferal assemblages as paleoenvironmental bioindicators in Jurassic siliciclastic and carbonate shelfs: relations with trophic conditions

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Key-words: Foraminifera, trophic conditions, carbonate shelf, siliciclastic shelf, Callovian, Oxfordian.

The analysis of composition, shell type, and life habit in foraminiferal assemblages from eco-sedimentary contexts belonging to the neritic shelf environment, reveals ecological impacts related to variations in sedimentation rates, organic matter contents and oxygenation degrees. Studied foraminiferal assemblages vary depending on nutrients types and their relation to both shore distance and the sedimentary context. Nutrients in comparatively proximal siliciclastic settings from the Boreal Domain (Brora section, Eastern Scotland) were dominated by inner-shelf primary production

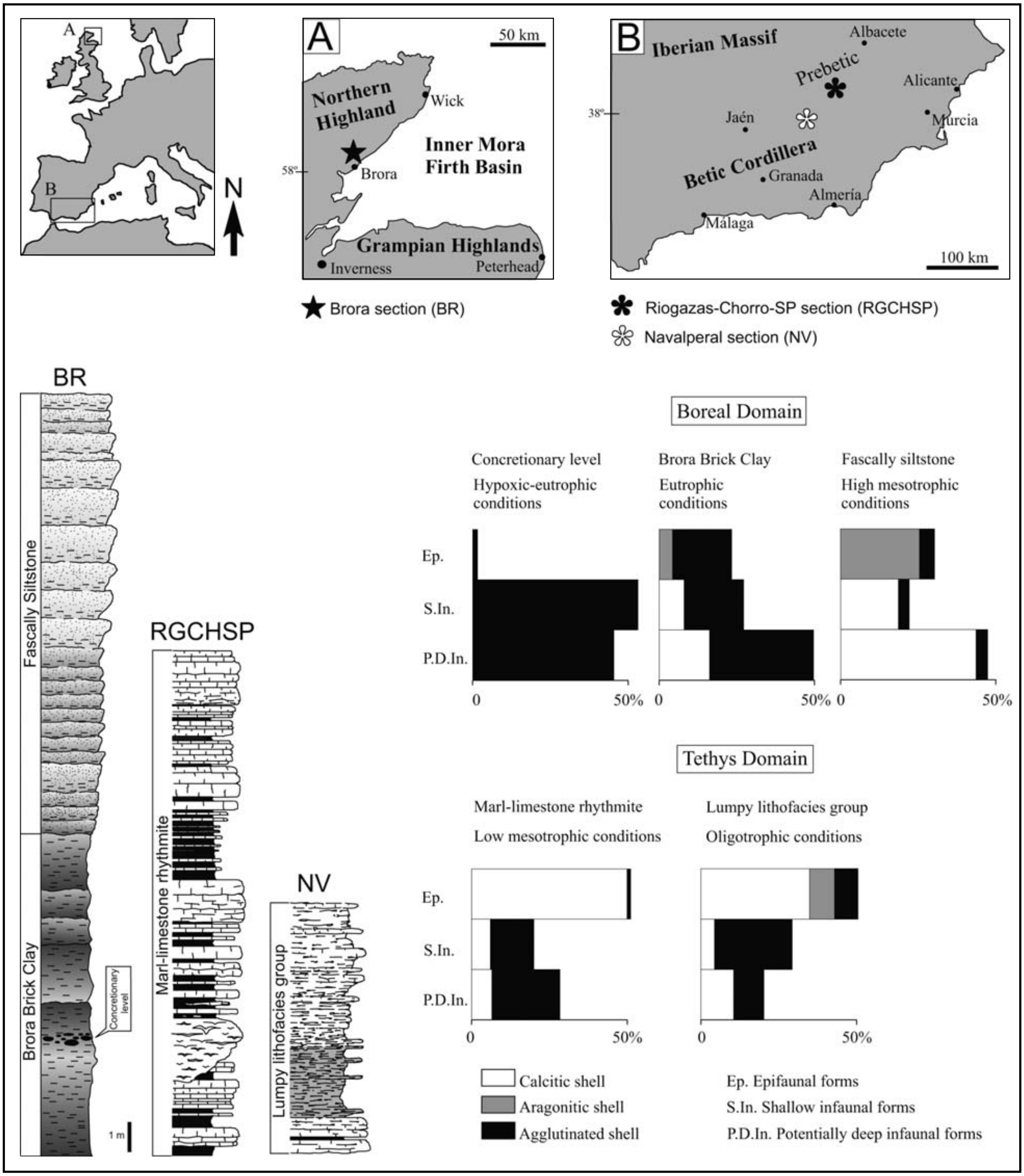

Fig. 1. Location of the sections studied at northeastern Scotland: A – Brora (BR), Inner Moray Firth Basin, Boreal Domain, and southeastern Spain: B – Riogazas-Chorro (RGCHSP) and Navalperal (NV), Prebetic Zone, Tethyan Domain. Lithological columns and mean values for proportions of shell types and life habits from foraminiferal assemblages in the samples studied.

either in the water column and sea-bottoms, while in relatively seawards mixed carbonate-siliciclastic settings from western Tethys (Prebetic Zone, Southern Spain) were characterized by nutrients mainly derived from inner-shelf exportation.

The proximal setting example (Brora Brick Clay Mb.) corresponds to Callovian inner-shelf deposits with high primary productivity and bottom accumulation of organic matter, but reduced sedimentation rate for siliciclastics. High organic matter content related with eutrophic conditions favoured to infaunal foraminifera. Transgressive peaks produced concretionary deposits, decreased oxygenation and organic-rich deposits where calcitic and aragonitic forams disappeared while agglutinated epifaunal and shallow infaunal ones proliferated (Nagy *et al.* 2001). Higher sedimentation rates and turbidity reduced euphotic-zone range depths and primary production (high-mesotrophic conditions) at inner shelf to shoreface transition areas – the Fascally Siltstone Mb. – which determined deposits with lower accumulation of organic matter. Foraminifera adapted with less agglutinated infauna but increased occurrence of calcitic and aragonitic epifauna, and calcitic opportunists such as *Lenticulina*.

Comparatively distal settings in the Prebetic revealed significant differences according to within-shelf location and local environment during Oxfordian times. Outer-shelf settings received lower nutrients input (relative oligotrophy) and organic matter accumulation on comparatively consistent substrates (the lumpy lithofacies group) showing dominance of calcitic epifaunal foraminifera (frequently sessile forms; Olóriz *et al.* 2003). Midshelf settings under higher sedimentation rate and nutrient influx (low mesotrophic conditions) favoured potentially deep infaunal forams in comparatively unconsolidated and nutrient-rich substrates submitted to instable redox boundary (the marl-limestone rhythmite lithofacies).

The Boreal and Tethyan benthic foraminiferal assemblages studied share increases in both diversity and the number of genera showing high ecological fidelity. These traits accord to higher oxygenation degree and lower nutrient contents. Foraminiferal assemblages show increased epifauna from eutrophic to oligotrophic conditions.

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Molluscan migrations and biogeographical ecotone in the Middle Russian Sea during the Jurassic

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Key-words: palaeobiogeography, ecotone, Middle-Late Jurassic, Middle Russian Sea.

So-called the Middle Russian Sea has flooded East European Platform during the Bajocian-Bathonian transitional time. Since this time and lately, over the long period of time, sea doesn't leave this area.

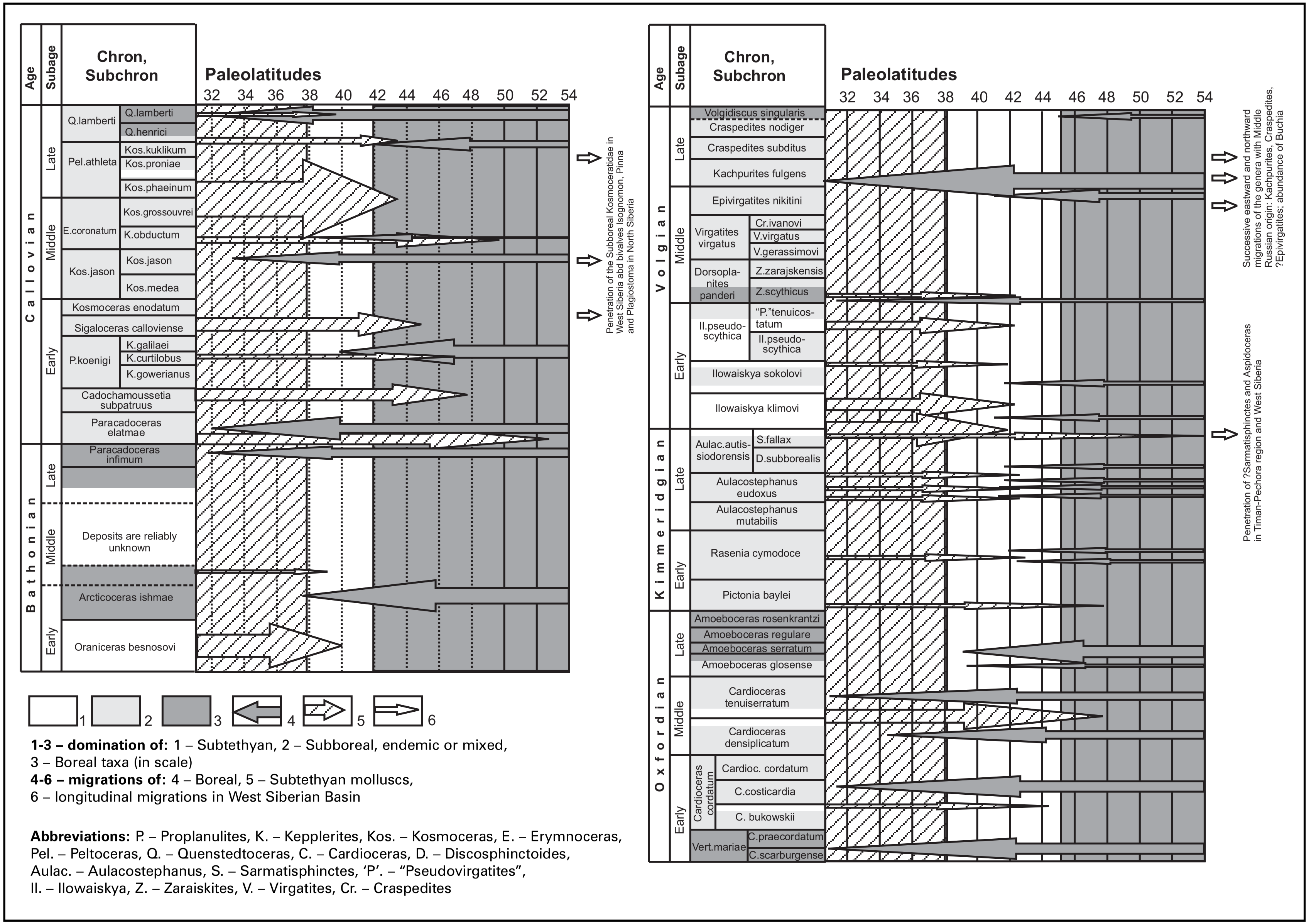

Fig. 1. Latitudinal and most important longitudinal migrations of Boreal, Subboreal and Subtethyan molluscs during the Middle and Late Jurassic of Central Russia; width of arrows roundly coincide with event duration.

During the ca. 30 Myr the Middle Russian Sea repeatedly changed its configuration, but always connected with Boreal Basin through Timan-Pechora Sea northwards. The sea spread also southwards, but direct connection with Peri-Tethyan (Caucasian) seas sometimes disappeared. Middle Russian Sea existed on the boundary zone of two climatic belts, Boreal and Tethyan. Analysis of the biogeographical distribution of molluscs shows permanent location of the biogeographical ecotone in this region (Zakharov & Rogov 2004). This is the reason of synchronous existence of the mixed Boreal, Subboreal and Subtethyan taxa in the bulk of Middle-Upper Jurassic zonal assemblages (Hantzpergue *et al.* 1998; Mitta & Seltzer 2002; Rogov 2004, among others). Middle Russian Sea was influenced by first Arctic, then Peri-Tethyan water masses. It is proved by temporal dynamics of the Boreal and Tethyan elements in molluscan faunas (Fig. 1). Boreal taxa were strictly dominating and widely scattered in the late Early Bathonian, earliest Callovian (when multidirectional migrations were important), in the latest Callovian and beginning of Oxfordian, in the Late Oxfordian, beginning of the Middle Volgian and near the Jurassic/Cretaceous boundary. Prolonged Tethyan influences were fixed in the earliest Bathonian, in the beginning of Late Callovian and during the Late Kimmeridgian – Early Volgian. Also two short but strong Tethyan events were restricted to Oxfordian: in the Early Oxfordian (Cordatum Chron, baccatum hemera) and Middle Oxfordian (Densiplicatum-Tenuiserratum Chrons). Late Kimmeridgian – Early Volgian penetration of the Peri-Tethyan ammonoids, such as Oppeliidae and Aspidoceratidae was most protracted in comparison with other Middle-Late Jurassic times. But even during this time predominance of Peri-Tethyan taxa was alternated with presence of numerous Boreal genera (Fig. 1). Analysis of the alterations in the fossil assemblages shows strong Boreal influence during the Middle-Late Jurassic. In spite of the mixed character of faunas, the Boreal taxa were prevailing during the Callovian, Oxfordian, Early Kimmeridgian and Middle-Late Volgian. Nevertheless, as the detailed elaboration of the outcrops situated in the East European Platform and accurate searching of the dwellers from south or north showed, both Peri-Tethyan and Boreal taxa are encountered within the nearly all ammonite zones.

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Paleoecology of the Middle Jurassic sediments in eastern Arabian Gulf

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Key-words: Middle Jurassic, Arabian Gulf, palaeoecology, Foraminifera, ecozone.

The eastern Arabian Peninsula was the shelf basin of the Tethys Sea that extended from the present day Mediterranean Sea to the Himalayas region. The Middle Jurassic sequences in eastern Arabia represent a major sedimentary transgression cycle within the Tethyan Sea which took place from the Toarcian and continued into the Late Jurassic.

Two surface sections in Saudi Arabia and three subsurface sections were investigated and logged to establish a palaeoecological and depositional environments. This study includes the use of the lithostratigraphy, microfacies and faunal characters to establish a palaeoecologic interpretation for the Middle Jurassic units in eastern Saudi Arabia and Qatar. Some palaeoecological parameters of the faunal assemblages are calculated for this interpretation. These parameters include arenaceous/calcareous ratio, the ratio of different suborders in different units, total number of species and number of arenaceous and calcareous species in every unit.

The Middle Jurassic successions in eastern Arabian Gulf are subdivided into twelve ecozones of which seven in eastern Saudi Arabia and five in Qatar.

Succession of Early Tithonian serpulid-dominated cavity-dwelling fauna (Pieniny Klippen Belt, West Carpathians, Slovakia)

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Key-words: coelobites, cryptic environment, polychaetes, palaeoecology, Tithonian, West Carpathians.

The Upper Jurassic cavity-dwelling communities dominated by serpulids inhabited an environment characterized by extremely low net sedimentation rate, moreover disturbed by multiple erosion phases, caused probably by strong currents. This sedimentation regime resulted in one of the most condensed sequence within the Czorsztyn Unit, situated on the southern slope of the pelagic carbonate platform. The cavities were eroded underneath the hardground covering the upper surface of the Bajocian crinoidal limestone and/or they represent the openings of the dense Middle Jurassic neptunian dyke system. The coelobite communities show a rather stable ecological succession. The scleractinian corals were the pioneer organisms that settled directly in the mineralised ceilings of the cavities. Later (probably after their death), the corals as well as the uncolonized parts of ceiling have been inhabited by dense serpulid populations which completely filled the space of the cavities. The serpulids *Vermiliopsis* sp. and *Neovermilia* gr. *conformis* were the most abundant species. Another six serpulid and spirorbid polychaetes, cyclostome bryozoans, thecideid brachiopods, small-sized oysters, benthic foraminifers, and rare sponges were subsidiary frame builders, mostly occupying the small free cavities within the serpulid aggregates and also from intermittent growth of the aggregates.

The later/final stages of community development indicate a rather physically controlled replacement, influenced by progressive filling of the cavities. The internal stratification of serpulid aggregates from dense aggregates made of small-sized adults or juveniles to more sparsely arranged bigger-sized specimens probably reflects the shift from relatively large to more restricted space conditions, accompanied by reduction of water movement and thus of food supply.

The growth of serpulid aggregates was accompanied by microbial encrustation of both live or dead organisms, which provoked a special settlement strategy of the serpulid larvae. They attached exclusively to the internal sides of fresh empty tubes. Due to extensive synchronous microbial encrustations, the tube interiors constituted probably the only suitable hard surfaces available for the settlement of the larvae.

Palaeoenvironmental significance of the foraminiferal assemblages from the Middle Jurassic deposits of the Częstochowa area

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Key-words: foraminifers, paleoenvironment, Middle Jurassic, Częstochowa area, Poland.

The paper presents preliminary results of micropaleontological studies of the Middle Jurassic deposits from Sowa, Leszczyński and Gliński exposures in the area of Częstochowa. The studied formation is represented by uppermost Bajocian to the Lower Bathonian (Matyja & Wierzbowski 2003) various clays with the horizons of the siderite nodules.

The foraminiferal morphogroups based on the models proposed by Jones & Charnock (1985), Koutsoukos *et al.* (1990) and Nagy (1992) are studied in terms of their environmental significance in the Middle Jurassic of Częstochowa region.

The foraminiferal associations from Sowa and Gliński sections (of uppermost Bajocian and lowermost Bathonian – Convergens and Macrescens subzones) contain the high diversity and number of calcareous benthic species. They are represented mainly by truncate morphotype of genus *Ophthalmidium*, but also by lenticular, elongate, planoconvex, trochospiral and discoidal forms. The agglutinated taxa are represented by rare tapered forms (*Reophax*) and by troch/planispiral morphotypes (*Trochammina*, *Trochamminoides* and *Glomospira*).

The foraminiferal assemblages from Sowa and Gliński sections composed predominantly of epifauna and semi-infauna deposit feeders suggest well-oxygenated bottom waters. The sedimentation took place in shallow shelf environments under high-energy conditions, where food was supplied by bottom currents.

In Leszczyński section two types of foraminiferal biofacies are recognized. The lower part of the section (of Lower Bathonian Yeovilensis Subzone) yields mainly benthic calcareous forms dominated by small size epifaunal deposit feeders of the genus *Epistomina*. Rare others calcareous taxa belong to various epifaunal morphotypes. Agglutinated forms belong to tapered infaunal (*Reophax*) and planispiral epifaunal morphotypes (*Ammodiscus*, *Glomospira*). The presence of low-diversity, epi/infaunal species and dominance of small size individuals indicate a degree of stress in the basin and suggest oxygen depleted shelf environment. The deposits of the upper part of the Leszczyński section (of Lower Bathonian

Tenuiplicatus Zone) yield predominantly various group of epifauna representing different microhabit preferences, which suggest well oxygenation of bottom waters. The sedimentation of these deposits took place under the high-energy condition in shallow shelf environment.

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Palaeoclimatic and palaeoceanographic changes during the Pliensbachian-Toarcian (Early Jurassic): new results from stable isotope analyses of brachiopod shells

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Key-words: Toarcian, brachiopods, oxygen isotopes, carbon isotopes, palaeotemperatures, cyclostratigraphy.

The Jurassic climate is generally considered as a typical "greenhouse climate", with elevated concentrations of carbon dioxide and reduced latitudinal thermal gradients. However, recent studies have suggested the existence of brief and global cooling phases during Late Callovian and at the Pliensbachian-Toarcian transition (Pl-To), with possible icecap development at high latitudes (Dromart *et al*. 2003; Morard *et al*. 2003). At the Pl-To transition, a change from limestone-dominated to marl-dominated sedimentation is well documented in Tethyan sections, interpreted as the result of an important crisis of carbonate platforms (Bassoullet & Baudin 1994). This event precedes the well-documented Early Toarcian mass extinction, generally considered as the consequence of the Toarcian Oceanic Anoxic Event (OAE). An important perturbation of the carbon cycle has also been recognized during the OAE in most Tethyan sections, on the basis of carbon-isotope analyses of carbonate bulk rock, organic matter and terrestrial wood (Kemp *et al*. 2005).

The current work focuses on the carbon and oxygen isotopes of well-preserved brachiopod shells from the Peniche section (GSSP candidate, Portugal) in order to understand the paleotemperature evolution and paleoceanographic changes in a well-constrained time interval, calibrated by biostratigraphy and cyclostratigraphy. An important cooling phase is confirmed by brachiopod isotope analysis at the Pl-To transition, and supports the hypothesis of icecap development at high latitude. The carbonate platform crisis may be related to these dramatic climatic changes. During the Lower Toarcian, a seawater warming of 6 to 7°C is evidenced. The duration of the entire carbon isotope excursion is estimated to ~600ky by means of cyclostratigraphy. Based on spectral analyses applied to $CaCO_3$, carbonate sedimentation displays a shift from an eccentricity-precession to an eccentricity-obliquity control during the negative carbon-isotope anomaly. These results may support an astronomical control both on carbonate record and the anoxic event, and open the way to new, interesting perspectives in the attempt of understanding the nature of climatic perturbations occurring before and during the Early Toarcian event.

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Late Jurassic planktonic foraminifers in the Northern Tethys (Polish Outer Carpathians)

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Key-words: planktonic foraminifers, palaeobiogeography, Tithonian, Cieszyn Beds, Silesian Basin, Polish Outer Carpathians, Northern Tethys.

For the first time Jurassic planktonic foraminifers were described in deposits of the Polish Outer Carpathians. These forms were sampled from nonflysch marly sediments (Tithonian Lower Cieszyn Shales) and turbidite carbonate complex intercalated with marls and marly shales (Upper Tithonian-Berriasian Cieszyn Limestones), which belong to the oldest sediments of the Polish Outer Carpathians (Cieszyn Beds). Small size specimens are poorly preserved and can not be determined in the details. They occur only as very rare elements of highly diverse and numerous benthic foraminiferal assemblages of the Late Tithonian age. Planktonic forms were noted in few samples and part of them is assigned to *Conoglobigerina*. Deposition of sampled rocks took place in the Silesian Basin, which was the initial basin in the Polish Outer Carpathians during the Kimmeridgian-Tithonian time. At the time geotectonic transformation of wide shelves on the southern margins of the Eastern European Platform influenced by the rifting of the Carpathian basin resulted in formation of marginal seas in the Northern Tethys (Golonka *et al.* 2000). Marginal seas, like the Silesian Basin, were extremely sensitive to changes in geotectonic activity, sea-level, and palaeogeography. These external settings followed by depositional and environmental instabilities in the Silesian Basin had fundamental influence on the migration and evolution of primitive Globigerinae preferring shelf environments at that time. Consequently the expansion of these forms into the Silesian Basin towards the Tethys was very restricted. In this case planktonic foraminifers could not have naturally migrated using the Carpathian sea-way via the Silesian Basin, and spread farther northwards through the Danish-Polish Through. Probably they migrated from the Mediterranean area through the Crimea-Caucasus province, and this way they spread to northern epicontinental seas of the northeastern Europe (Gorbachik & Kuznecova 1983).

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Dominance of brachiopods on a pelagic carbonate platform (Pieniny Klippen Belt, West Carpathians): effects of substrate, bottom currents and food supply

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Level-bottom benthic communities inhabiting the Middle Jurassic – earliest Cretaceous pelagic carbonate platform of the Czorsztyn Ridge (Pieniny Klippen Belt, West Carpathians) were dominated by pedunculate brachiopods and characterized by a distinctive guild structure with common epifaunal and rare or absent semi-infaunal and infaunal bivalves. Although micritic deposits show extensive signs of aragonite dissolution, a strong taphonomic bias against less durable infaunal bivalves can be excluded because ammonite concentrations with rare signs of dissolution are similarly dominated by brachiopods and epifaunal bivalves. In spite of a substantial temporal taxonomic turnover, this guild structure was constant in time and was typical also of other Jurassic pelagic platforms of the western Tethys. Rarity of infaunal bivalves on the pelagic platforms can be explained by increased substrate firmness due to combined effects of reduced sedimentation rates, aragonite dissolution and rapid calcite cementation. Brachiopods and epifaunal bivalves significantly differ in their abundance patterns. Brachiopod abundance decreased and bivalve abundance increased towards habitats with higher intensity of bottom currents on the scale of the Czorsztyn pelagic platform. Basin-scale qualitative data indicate that abundance of brachiopods and bivalves increased from deep sea to pelagic platform in the Pieniny Klippen Belt Basin (PKBB), although terebratulid brachiopods were able to inhabit deep-sea habitats. The platform-scale and PKBB-scale distribution patterns thus show that brachiopods preferred deeper or lower-energy habitats with lower particulate flux than epifaunal bivalves. The abundance of brachiopods in deeper parts of the Jurassic pelagic platforms might be explained by combined effects of firm substrate and better exploitation of depleted food in sluggish flows when compared to epifaunal bivalves. Brachiopod success on the Jurassic pelagic platforms was probably related to unique environmental conditions, rather than to historical effects of extinction of shallow-water incumbents on shallow pelagic platforms and their subsequent colonization by deep-sea brachiopods.