BIOTIC ASPECTS

OF THE

EARLY–MIDDLE FRASNIAN EVENTFUL TRANSITION

Guest Editors:

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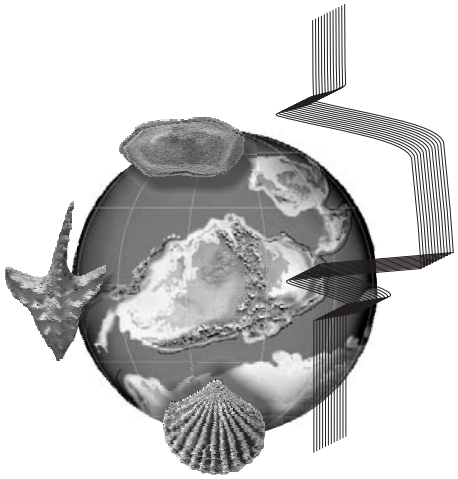

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Preface

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Early–Middle Frasnian transition: Biotic response to a major perturbation of the global carbon budget

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The Devonian was a period of profound evolutionary and geological events, notably promoted by the progressive colonization of terrestrial habitats by land plants and animals, a transition from greenhouse climate to Late Paleozoic icehouse mode, and the earliest phases of Variscan orogenic movements. These far-reaching transformations in the global ecosystem would be expected to leave a range of geochemical and biotic signatures in marine sedimentary record, in short intervals directly related to major perturbations in the global carbon cycle. These might include periodic expansion of oxygen-depleted conditions contemporaneous with ecological turnovers and extinction events. Advanced studies have focused primarily on one of the severest Phanerozoic diversity crises, close to the Frasnian–Famennian (F–F) boundary (see review in House 2002 and Sandberg et al. 2002). However, of generally unappreciated significance is the fact that important changes in the global carbon budget are not always associated with recognized Devonian biotic events (Racki 2005): they can still be found during quiet 'background' intervals, as exemplified by the Silurian–Devonian boundary interval that appears to coincide with one of the largest carbon isotope excursions in the Phanerozoic (Buggisch and Mann 2004). An even larger $\delta^{13}C$ spike has been discovered recently in the Early–Middle Frasnian (E–MF) passage beds of Ardennes (Yans et al. in press). A high stratigraphical resolution of the brachiopod calcite record at intra-zonal scale has permitted Alain Preat's group to identify an abrupt negative $\delta^{13}C$ excursion in the *Palmatolepis punctata* Zone (from 5.85‰ to –1.20‰) which interrupts the slower, at least regionally greatest Devonian positive $\delta^{13}C$ shift initiated during the Early Frasnian *Palmatolepis transitans* Zone; similar large-scale isotopic signals are reported from the Early–Middle Frasnian timespan of Moravia and South China, suggesting that it is a supra-regional, and possibly even global event. In light of literature data, the biogeochemical turnover in the *Pa. punctata* Zone was linked with neither a main sea-level change, nor essential climatic and evolutionary turning points (see summary in Yans et al. in press).

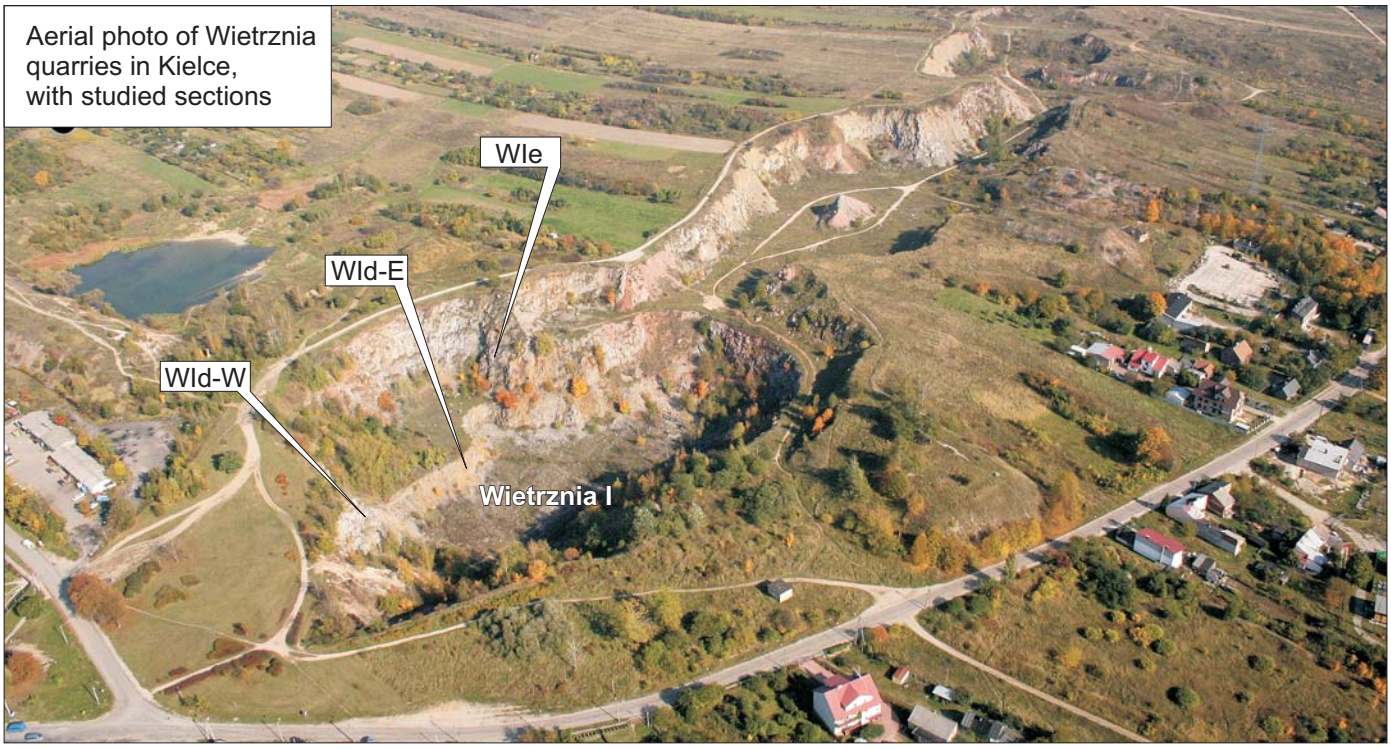
The multidisciplinary study of Frasnian localities of the South Polish-Moravian shelf (mainly in Holy Cross Mountains) has refined this general ecosystem pattern. In fact, the project was inspired by the results of previous Belgian-Polish geochemical study presented in Yans et al. (in press; see also Racki et al. 2004). The collective works were carried out within the international research programme "Ecosystem aspects of major carbon isotope anomaly in the Lower–Middle Frasnian transition" (grant 3 P04D 040 22 to G. Racki), funded from 2002 to 2005 by the Committee for Scientific Research in Poland, and the comprehensive geochemical results will be presented in a monograph volume elsewhere. The main aim of this thematic issue of *Acta Palaeontologica Polonica* is to present the spectrum of biotic responses to the major Frasnian perturbations in the carbon cycle, as well as to integrate the event pattern for the reference successions.

The main results of 11 studies are presented in this volume by contributors from Poland, Russia, Belgium, China, USA, and Germany. Papers are ordered reflecting paleogeographical location, and the main suite of papers is devoted to the reference South Polish epeiric domain, based on the Holy Cross and Cracow regions.

The opening paper by Pisarzowska et al. is a regional event-stratigraphical synopsis, based on high-resolution and multi-proxy biotic and geochemical records, thought to be representative of at least the south-eastern Laurussian carbonate shelf. With introductory emphasis on improved conodont zonal framework and combined bio- and chemostratigraphic correlations, the authors as a final point outline the regional reef ecosystem response to the pronounced biogeochemical perturbations, superimposed on large-scale sea-level fluctuations referred to Timan, Middlesex, and Rhinestreet global events (House 2002). In particular, temporal trends in nektonic conodont faunas, partly mirrored by benthic communities, indicate that the faunal turnover steps correlate well with the main $\delta^{13}C$ excursions, and probably record related habitat adjustments, which are still poorly understood. In particular, negative carbon isotopic spikes are associated with diversity loss and other biotic responses to a high-stress setting, which seems to suggest an extensive fluctuation in primary production levels (see Racki et al. 2004). Nevertheless, with the exception of collapsed endemic biota of the Kadzielnia-type mud-mound, and moderate biodiversity loss due to overall ecosystem stagnation and transient breakdown of carbonate production, no significant crisis can be proved in the regional perspective.

As a comprehensive documentation of the overview inferences, the first group consists of five articles dealing with the succession of particular fossil groups across the key Frasnian interval on the South Polish carbonate shelf, with emphasis on the foreslope section of the Dyminy reef complex at Wietrznia in Kielce (see the aerial photograph on the next page).

The extensive paper by Baliński describes succession and taxonomic composition of the Early–Middle Frasnian bottom-level brachiopod faunas in three localities, where despite distinctive lateral variation, the greatest taxonomic diversity



and abundance of rhynchonellid-dominated brachiopods are confined to the *Palmatolepis transitans* Zone. In the following *Pa. punctata* Zone, brachiopods are rare or absent, suggesting a serious deterioration of the environmental conditions probably linked to periodic benthic anoxia–dysoxia and/or an anomalous trophic regime in Middle Frasnian macrobenthic niches. Krawczyński records the comparable gastropod response to a marked carbon isotopic geochemical anomaly across the E–MF transition, based on the combined Dyminy Reef example. Gastropods are represented by three reefal associations (with the highly diverse Kadzielnia-type fauna), and an impoverished open-shelf assemblage. The most severe diversity depletion is connected by the author to the vanishing of local low-energy muddy habitats, thought to be a result of a transgressive pulse, and a benthic habitat decline tied to strongly fluctuating carbon cycling. Likewise, Głuchowski et al. suggest that the distribution patterns of ostracods and crinoids in the Wietrznia succession reflect harsh environmental conditions coinciding with the E–MF biogeochemical perturbation. The ostracod assemblage changes from moderately diverse in the early part of *Palmatolepis transitans* Zone to poorly diverse in its later interval, and to absent through the E–MF passage timespan. Rock-forming crinoids reveal also relatively high diversity in the *Pa. transitans* Zone and decline in the latest part of the zone, followed by a temporary partial recovery in the early Middle Frasnian.

Jagt-Yazykova et al. examine the unique goniatite-rich pyritic level, exposed at Kostomłoty (Holy Cross Mountains). This level represents a distinct, local biotic event corresponding to the inception of Early Frasnian major carbon isotopic anomaly in the stagnant deep-water and oxygen-deficient intrashelf habitat. The authors determine paleoenvironmental history, based on goniatitids, orthoconic nautiloids, gastropods, and bivalves, in reference to circulation changes within the basin. Sobstel et al. study the conodont biofacies dynamics in representative sites, where conodont communities are characterized by the highly varying participation of shallow-water polygnathid, icriodontid and/or ancyrodellid biofacies. The authors interpret temporal patterns in the conodont abundance, mortality and diversity as a response to main changes in carbon cycling, possibly as a result of shifting trophic and redox states. In particular, an overturn from short-term negative to the extended positive $\delta^{13}C$ anomaly across the E–MF transitional interval is distinguished by noticeable replacement of a relatively diversified reef-inhabiting ancyrodellid fauna by finally a more homogenous impoverished biofacies. The Middle Frasnian timespan is also marked by a second large-scale ecological remodeling in the pelagic realm during the major Rhinestreet sea-level rise, whilst a stabilization of carbon cycling coincides with renewed diversity rise, especially the recovering of reef-related biota and a major immigration episode.

The next supplementary suite are three papers that, in a matching way, document paleoecological aspects of the Early–Middle Frasnian timespan over adjoined inner shelf habitats in the north-west domain of East European Platform (Main Devonian Field). Zhuravlev et al. summarize successional changes in facies, brachiopod, ostracod and conodont associations controlled by sea-level fluctuations paired with synsedimentary tectonic activity, but also regarded them in the context of positive-negative carbon isotopic excursions, firstly detected in brachiopod calcites from this region. The authors conclusively suggest that the positive $\delta^{13}C$ shift of 2.6 ‰ is probably linked with enhanced primary production in high-nutrient epeiric regimes, especially as implied from conodont and brachiopod

(i.e., cyrtospiriferid acme) records. Deepening pulses correspond to an increase in diversity of both the benthic and nektonic communities whilst the most important demise event coincided with the profound late Early Frasnian regression, responsible for consequent habitat decline in semi-isolated seas.

Sokiran documents the stratigraphical distribution and taxonomic composition of cyrtospiriferid brachiopod faunas where they are one of the most abundant Middle Frasnian macrofossils, and a traditional Late Devonian index taxa. This macrobenthos diversification is primarily linked with significant sea-level rise improving the life conditions of intra-platform shelly biotas. The article by Evdokimova presents the coeval rich benthic ostracod associations (above 80 taxa), particularly their response to the E–MF regression-transgression couplet, finalized in recovered circulation in the extremely shallow-water shelf seas. Thus, the ostracod dynamic trends point to a less restricted site of microbenthic niches in the Middle Frasnian seas.

The last pair of papers provide significant comparative Early–Middle Frasnian biotic records from the distant areas of South China and western Laurussian shelves. In South China Ma et al. document at length a distinct Frasnian brachiopod overturn, markedly constrained to the *Palmatolepis punctata–Pa. hassi* zonal boundary (and not to the E–MF boundary). The faunal change is characterized by about a 35% loss of existing brachiopod species, mostly rhynchonellids. On the other hand, *Cyrtospirifer* and allied spiriferids colonized the area in this timespan wheras atrypids do not exhibit any significant diversity change. According to the authors, the benthic changes revealed were related to a large-scale deepening event linked also to the introduction of biogeographically new pelagic fauna into some intra-shelf habitats.

Casier et al. consider the influence of the well-proved Alamo Impact Event on shallow-marine environments in the E–MF interval in Nevada (see Sandberg et al. 2002). They analyze the ostracod, conodont, and microfacies succession of the lower member of the type Devils Gate Limestone, which ranges from quiet-water open-marine environments to hypersaline lagoons. The authors significantly demonstrate that the distribution and abundance of ostracods was controlled mainly by strong salinity variations, whilst the Alamo Event did not result in an extermination of the microbenthic biota in the shallow-shelf setting.

As described above, this special issue successfully presents an integrated bio- and chemostratigraphical approaches, and all contributions assess and more or less combine various ecosystem parameters, altogether leading to a better understanding of a previously undervalued Late Devonian interval from paleobiological and biogeographical viewpoints. In particular, various records of the Domanic Crisis, recognized by Kuzmin et al. (1997) in Early–Middle Frasnian deep-marine biotas of the South Timan, north-eastern East European Platform, are shown. In summary, the broadly-defined E–MF passage timespan is correlated with neither a catastrophic environmental nor radical biotic change in worldwide scale. This is a surprising biotic response because the contemporary turnovers in carbon cycling are of distinctly higher-amplitude than the highlighted perturbation related to the F–F extinction (maximal positive $\delta^{13}C$ excursion to 3.5‰; see summary in Yans et al. in press), strengthened by at least one medium-size marine icy bolide strike (and even a comet shower is presumed; McGhee 2001). Therefore, the goal of this thematic issue begins to explore some of the intricate Late Devonian ocean-climate-biosphere interactions as recorded at length in tropical epeiric realms. This inference emphasizes an urgent need of similarly comprehensive data especially from high-latitude and/or deep-water, oceanic paleogeographical domains (Racki 2005).

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