Extinctions and survivals
in a Mediterranean Early Jurassic brachiopod fauna
(Bakony Mts, Hungary)

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(with 7 figures)

Abstract

Detailed analysis of diversity, turnover and extinction rate has been undertaken for the Pliensbachian brachiopod fauna of the Bakony Mts (Hungary). There is an early peak of diversity in the Ibex Zone, then a steady decline to the Stokesi Zone and a second peak in the Margaritatus Zone. The Early Toarcian crisis is preceded by a rapid fall in the Spinatum Zone. The gradual decline of the Pliensbachian brachiopod fauna is thought to reflect decreasing food supply due to the gradual subsidence of the sea bottom in the Bakony area. The diversity peaks in the Ibex and Margaritatus Zones coincide with episodes of local tectonic movements along fault scarps bordering submarine horsts. These might produce fresh, empty rock surfaces and talus blocks at the foot of the escarpments. This sudden increase in the available rock surfaces greatly enhanced the growth of brachiopod communities. Another factor, possibly related to rejuvenation of tectonic movements, may be the activity of submarine cold seeps carrying nutrients to the starving environment and supporting chemosynthetically based communities.

Key words: Brachiopoda, Early Jurassic, diversity, Bakony, Hungary

Introduction

As the modest descendants of their glorious Paleozoic ancestors, Mesozoic brachiopods passed into the shadow of bivalves in the course of this Era and were forced into the role of a second player in the marine benthonic communities. The end-Triassic and early Toarcian mass extinctions and crises affected them more seriously than the other benthonic groups. Perhaps the Early Jurassic was the last good time for brachiopods, when, in most places, they outnumbered the bivalves and reached really high diversity in the faunal provinces around the Tethys (AGER 1967, VÖRÖS 1993a).

In a compilation on Jurassic brachiopods by ALMÉRAS (1964), the number of brachiopod species per ages increa-

ses from the Hettangian (80) to the Pliensbachian (490), falls down to 120 in the Toarcian and never reaches again the high species diversity of the Pliensbachian. A similar, Pliensbachian diversity maximum and a Toarcian "bottleneck" was pointed out by VÖRÖS (1993b) who suggested, that the faunal crisis was caused by the Early Toarcian anoxic event (see JENKYNS 1988). However, the detailed study of the Pliensbachian brachiopod fauna of the Bakony Mts (Hungary) has shown that the "crisis" was preceded by a "prelude": the demise of the extremely rich Pliensbachian fauna was heralded by a gradual decrease of diversity.

Material

Fauna

In previous papers (Vörös 1983, 1993b) I gave comprehensive information (list of species, stratigraphical distribution) on the Pliensbachian brachiopod fauna of the Bakony Mts.

The vast majority of the fauna was collected by the workers of the Hungarian Geological Institute (MÁFI) in the frame of a very ambitious research project in the 60s and early 70s, for gathering reliable information on the Jurassic and Cretaceous stratigraphy of the Bakony Mts. Several dozens of trenches were dug to reveal stratigraphy in soil-covered areas and to collect fossils bed-by-bed. This project was stimulated and controlled by Dr. J. Konda, former director of the Hungarian Geological Institute. The extremely rich Pliensbachian fauna (mainly ammonoids, but also brachiopods, bivalves and gastropods) was forwarded to the Paleontological Department of the Eötvös University (Budapest) for a detailed study. The ammonoids have been determined and evaluated by Prof. B. Géczy who, at the same time, entrusted me with the study of brachiopods.

The brachiopod material consists of more than 6000 specimens. A monograph is planned to give the systematic description of the fauna. In the course of the studies, some of my earlier determinations have been changed, therefore the following species list slightly differs from that published in my earlier papers referred above. Moreover, a few species, collected from detritus or from not well determined stratigraphic horizon, have not been taken into account in the present study. The list of species:

Pisirhynchia pisoides (Zittel)
Pisirhynchia retroplicata (Zittel)
Pisirhynchia inversa (Oppel)
Pisirhynchia ? uhligi (Haas)
Pisirhynchia n.sp., aff. *uhligi* (Haas) A
Pisirhynchia n.sp., aff. *uhligi* (Haas) B
Pisirhynchia n.sp., aff. *uhligi* (Haas) C
Kericserella inversaeformis (Schlosser)
Calcirhynchia ? plicatissima (Quenstedt)
Calcirhynchia ? cf. fascicostata (Uhlig)
Cirpa ? subcostellata (Gemmellaro)
Prionorhynchia polyptycha (Oppel)
Prionorhynchia pseudopolyptycha (Böckh)
Prionorhynchia n.sp., aff. *greppini* (Oppel)
Prionorhynchia ? flabellum (Gemmellaro)
Lokutella palmaeformis (Haas)
Lokutella liasina (Principi)
Lokutella kondai Vörös
Pseudogibbirhynchia ? cf. verrii (Parona)
Stolmorhynchia ? reynesi (Gemmellaro)
Stolmorhynchia ? gemmellaroi (Parona)
Stolmorhynchia ? bulga (Parona)
Stolmorhynchia ? n.sp., aff. bulga (Parona)
Apringia paolii (Canavari)

Apringia piccininii (Zittel)
Apringia mariotti (Zittel)
Apringia aptyga (Canavari)
Apringia deltoidea (Canavari)
Apringia fraudatrix (Böse)
Apringia ? stoppanii (Parona)
Apringia ? altesinuata (Böse)
Apringia ? atlaeformis (Böse)
Apringia ? cf. suetii (Haas)
Homoeorhynchia acuta (Sowerby)
Homoeorhynchia ? lubrica (Uhlig)
Homoeorhynchia ? ptinoides (Di Stefano)
Gibbirhynchia ? orsinii (Gemmellaro)
Gibbirhynchia ? sordellii (Parona)
Gibbirhynchia ? n.sp., aff. urkutica (Böckh)
Cuneirhynchia palmata (Oppel)
Cuneirhynchia cf. rastuensis Benigni
Piarorhynchia ? caroli (Gemmellaro)
Amphiclinodonta liasina Bittner
Koninckodonta cf. waehneri (Bittner)
Koninckodonta fuggeri Bittner
Koninckodonta n.sp., aff. *fuggeri* Bittner
Koninckodonta ? n.sp., aff. alfurica (Wanner)
Liospiriferina alpina (Oppel)
Liospiriferina cf. brevirostris (Oppel)
Liospiriferina cf. obtusa (Oppel)
Liospiriferina sicula (Gemmellaro)
Liospiriferina darwini (Gemmellaro)
Liospiriferina gryphoidea (Uhlig)
Liospiriferina meneghiniana (Canavari)
Liospiriferina apenninica (Canavari)
Liospiriferina cf. handeli (Di Stefano)
Liospiriferina cf. globosa (Böse)
Dispiriferina cf. segregata (Di Stefano)
Orthotoma apenninica (Canavari)
Orthotoma n.sp., aff. *apenninica* (Canavari)
Lobothyris punctata (Sowerby)
Lobothyris cf. andleri (Oppel)
Rhapidothyris ? n.sp., aff. beyrichi (Oppel)
Viallithyris gozzanensis (Parona)
Viallithyris ? delorenzoi (Böse)
Linguithyris aspasia (Zittel)
Linguithyris cf. linguata (Böckh)
Linguithyris cornicolana (Canavari)
Securithyris adnethensis (Suess)
Securithyris filosa (Canavari)
Securithyris paronai (Canavari)
Papodina bittneri (Geyer)
Hesperithyris renierii (Catullo)
Hesperithyris cf. pacheia (Uhlig)
Hesperithyris ? cf. costata (Dubar)
Hesperithyris ? n.sp., aff. renierii (Catullo)
Lychnothyris rotzoana (Schauroth)
Phymatothyris cerasulum (Zittel)
Zeilleria mutabilis (Oppel)
Zeilleria cf. waehneri Gemmellaro
Zeilleria livingstonei Gemmellaro
Zeilleria alpina (Geyer)
Zeilleria oenana (Böse) ?
Zeilleria bicolor (Böse) ?

Zeilleria aquilina (FRANCESCHI)
Antiptychina ? rothpletzi (DI STEFANO)
Antiptychina ? bellunensis (DAL PIAZ)
Antiptychina ? n.sp., aff. gastaldii (PARONA)
Aulacothyris ? amygdaloides (CANAVARI)
Aulacothyris ? cf. fuggeri (BÖSE)
Aulacothyris ? ballinensis (HAAS)
Bakonyithyris apenninica (ZITTEL)
Bakonyithyris avicula (UHLIG)
Bakonyithyris pedemontana (PARONA)
Bakonyithyris meneghinii (PARONA)
Bakonyithyris ovimontana (BÖSE)
Bakonyithyris ? n.sp., aff. ovimontana (BÖSE)
Securina hierlatzica (OPPEL)

Localities

Pliensbachian brachiopods have been found at almost 30 localities in the Bakony Mts. Most of them are indistinct outcrops or not well dated by ammonoids. In the present compilation only 11 sections have been used, mainly those, where the ammonoid biostratigraphy and the zonal subdivision was made by GÉCZY (1971a, 1971b, 1972, 1974, 1976); his zonal scheme is used consequently in the present paper. The location of the sections and outcrops is shown in Fig. 1.

Lithological columns of the sections were published by GÉCZY (1976). The Pliensbachian stage consists of varied, chiefly carbonate, lithologies (Fig. 2) suggesting a dissected submarine bottom topography. Descriptions of these lithologies and paleogeographical interpretations of the differences can be found in KONDA (1970), GALÁCZ &

VÖRÖS (1972), VÖRÖS (1974, 1986), VÖRÖS & GALÁCZ (in press). A summarized description and current interpretation of the main types of Pliensbachian lithologies of the Bakony Mts is as follows:

Red, massive or well-bedded biomicrites with bioclasts encrusted or stained by ferro-manganese oxyde. Condensed sequences with frequent stratigraphic gaps and hardgrounds. Depositional environment: top of submarine highs ("seamounts") or neptunian dykes.

Hierlatz limestones (see VÖRÖS 1991 for details). Usually white to pink biosparites (grainstones). The coquina consists mainly of brachiopod, ammonoid and echinoderm skeletal debris cemented by at least two generations of spar; micrite infiltration form geopetal structures. Depositional environment: flanks or feet of submarine highs, or neptunian dykes.

Variegated crinoidal, spiculitic or cherty limestones (Isztimér Limestone). Found in more or less continuous, relatively thick, allodapic sequences of alternating and interfingering spiculitic biomicrites, crinoidal biosparites and cherty beds. Depositional environment: basin between submarine highs.

Ammonitico rosso limestones. Red, nodular, ammonitic wackestones to mudstones with variable degree of nodularity and clay content. Widespread in continuous sequences, sometimes interfingered with the previous lithology. Depositional environment: pelagic, distal part of basins.

Fig. 2. shows that the sections providing the brachiopod fauna encompass all the main lithologies and depositional environments of the Pliensbachian of the Bakony Mts. This is thought to be a reliable basis for speculations on changes of faunal diversity.
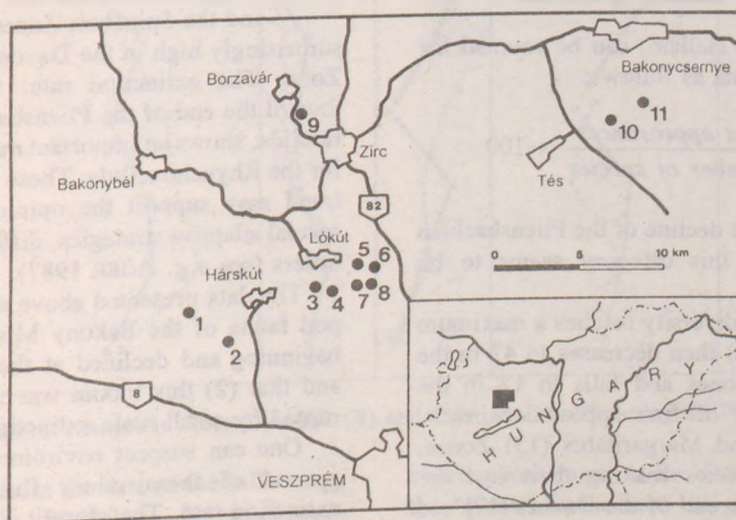

Fig. 1. Map showing the the most important Pliensbachian brachiopod localities of the Bakony Mts.

Diversity changes and faunal turnover

The stratigraphic distribution of the Pliensbachian brachiopod species is given in VÖRÖS (1983), all further data are taken from there. A lot of Pliensbachian species cross the Sinemurian/Pliensbachian boundary, while only

one (*Linguithyris aspasia*) survives in the Toarcian (reappears in the Bifrons Zone).

In order to follow the changes of diversity, turnover and extinctions during the Pliensbachian, the method
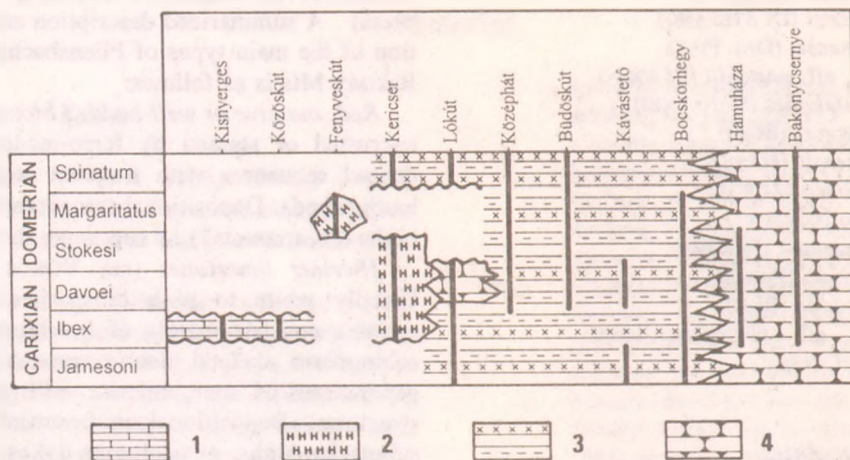
Fig. 2. Chronostratigraphic scheme for the Pliensbachian of the Bakony Mts showing the ranges encompassed by the sections studied. Legend: **1**: massive or well bedded, red biomicrites with manganese coated fossils and hard-grounds, **2**: Hierlatz limestones, **3**: alternation of crinoidal, spiculitic and cherty limestone beds (Isztimér Formation), **4**: Ammonitico Rosso limestones.

developed by HALLAM (1976, 1987) was used in a slightly modified form.

Diversity is expressed here simply by the *number of species* by zones. The categories "*first appearances*" and "*last appearances*" are, in fact, self-explanatory; they are used in the sense of HALLAM (1976, 1987), i.e. they does not necessarily mean origination or extinction on a global scale but refer to the Bakony area. *Turnover rate* is counted for each zone from the above data, as follows:

$$Turnover\ rate = \frac{(first\ appearances\ +\ last\ appearances)/2}{number\ of\ species} \times 100$$

Extinction rate (not used by Hallam) can be counted for each zone from the above data as follows:

$$Extinction\ rate = \frac{last\ appearances}{number\ of\ species} \times 100$$

Since this paper discusses the decline of the Pliensbachian fauna, the introduction of this category seems to be reasonable.

As it is shown in Fig. 3, diversity reaches a maximum in the Ibex Zone (60 species) then decreases to 47 in the Stokesi and Margaritatus Zones and falls to 17 in the Spinatum Zone. The graph of first appearances show maxima in the Ibex (25) and Margaritatus (13) Zones, whereas the number of species making their last appearance is the highest at the end of the Davoei (17) and Margaritatus (30) Zones. The turnover rate is high in the Ibex Zone (34) and after a slight decrease, reaches extremely high value close to the end of the Pliensbachian. The extinction rate is low initially, with a small maximum in the Davoei Zone (at the end of this zone the 30 % of the species disappears) and dramatically increases toward the base of the Toarcian.

Similar calculations have been made separately for the three brachiopod orders represented in the fauna. Fig. 4.

shows the graphs concerning Rhynchonellida (42 species) and Terebratulida (40 species). The data for Spiriferida (16 species) were not plotted because these fit almost perfectly the trend of Terebratulida.

A simple comparison shows convincingly that the temporal changes of Terebratulida follows very closely those of the whole fauna. On the other hand, rhynchonellids show remarkable deviations. The diversity maximum in the Ibex Zone is not at all so conspicuous, whereas the peak in the Margaritatus Zone is accentuated. The graph of the last appearances has no peak in the Margaritatus Zone but at the end of the Davoei and the Spinatum Zones. The turnover rate is surprisingly high in the Davoei Zone, instead of the Ibex Zone. The extinction rate, which gradually increases toward the end of the Pliensbachian in the case of Terebratulids, shows an important maximum in the Davoei Zone for the Rhynchonellida. These deviations from the general trend may support the opinion that rhynchonellids had special adaptive strategies, different from other brachiopod orders (see e.g. AGER 1987).

The data presented above suggest that (1) the brachiopod fauna of the Bakony Mts became diversified at the beginning and declined at the end of the Pliensbachian, and that (2) this bloom was not uniform but was interrupted by small-scale extinctions and renewals.

One can suspect environmental changes in the background of these minor fluctuations of diversity and extinction rate. Therefore it is reasonable to try to follow these changes in different environmental settings. Four main Pliensbachian paleoenvironments ("seamount top", "seamount slope and foot", "basin margin" and "basin interior") have been differentiated in the Bakony Mts (VÖRÖS 1986). Brachiopod specimen number is insufficient for a detailed study in some of these (e.g. seamount top), therefore in the following, the data set of "seamount slope" will be compared to a cumulative value of the "basin" environments. The "slope" fauna is thought to

represent the biotic association of the rocky escarpment of the submarine elevations, while the "basin" fauna reflects the communities of a wider, deep-water, muddy environ-ment. In the present study, the changes of the "slope" fauna were counted from the material of the localities Fenyveskút and Kericser, whereas the graphs of the
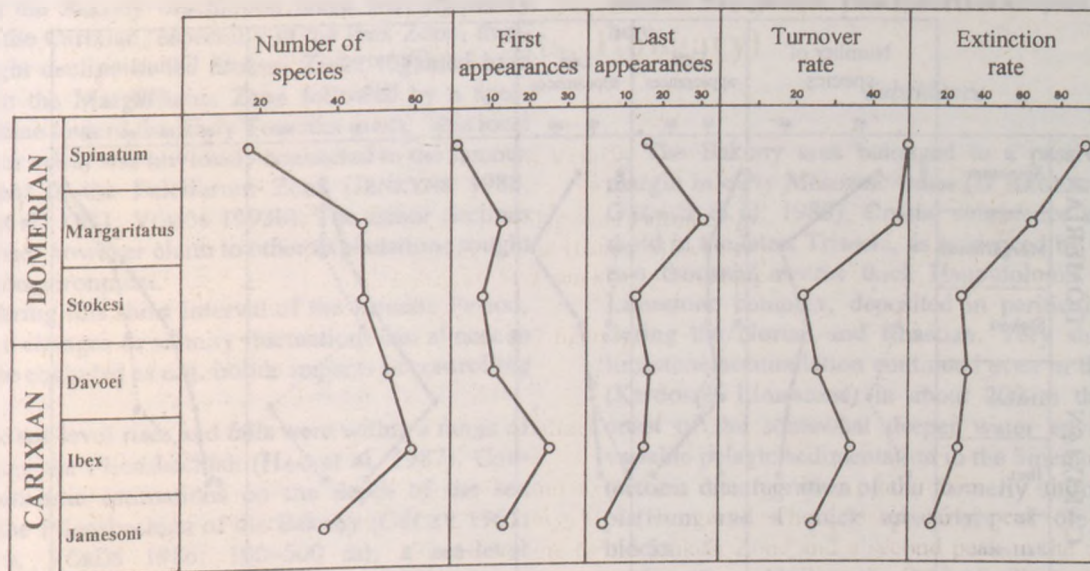

Fig. 3. Graphs showing the temporal changes in the Pliensbachian brachiopod fauna of the Bakony Mts.
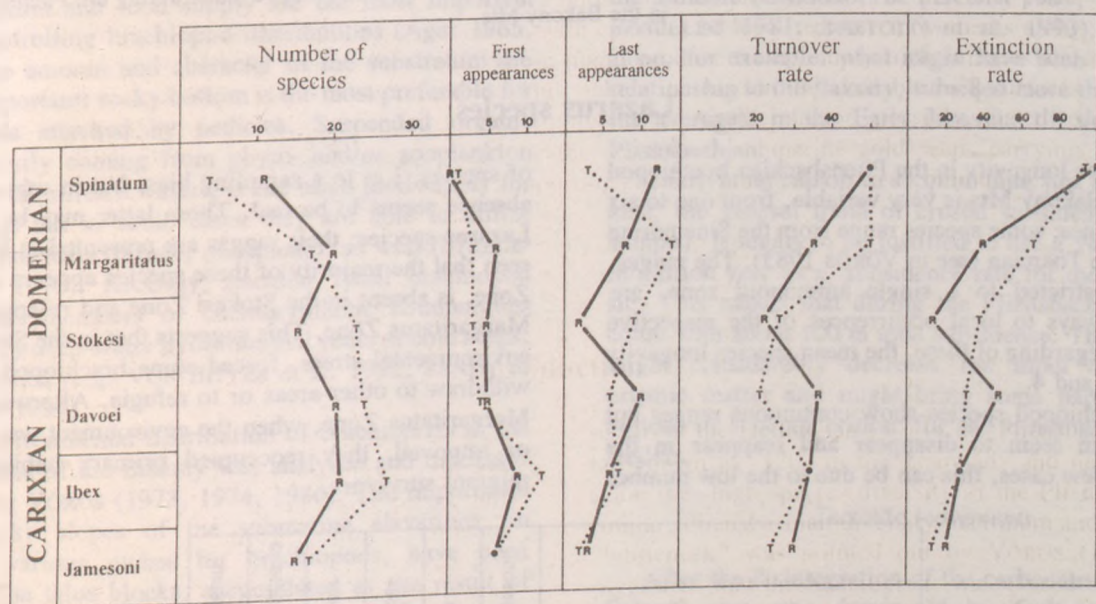

Fig. 4. Graphs showing the temporal changes in Rhynchonellida (R) and Terebratulida (T) during the Pliensbachian of the Bakony Mts.

"basin" fauna are compiled from the data of the following sections: Lókút, Kõzéphát, Büdöskút, Bocskorhegy, Hamuháza, Bakonycsernye (see Fig. 2).

The "slope" fauna is about ten times more abundant than the "basin" fauna (around 4000, and 300 specimens, respectively) and the diversity (i.e. the number of species) shows similar difference (Fig. 5). The temporal changes are remarkable: the "slope" fauna is very diverse in the Carixian, then, after a minimum in the Stokesi Zone, reaches a maximum in the Margaritatus Zone. On the other hand, the low diversity "basin" fauna shows a

striking maximum in the Davoei Zone. The deviation of the "basin" fauna from the general trends in the Davoei Zone can be seen on the other graphs as well. This involves a drastical increase of the extinction rate at the boundary of the Davoei/Stokesi zones which considerably predates the decline of the "slope" fauna.

The "slope" fauna shows almost perfectly the same temporal changes as the bulk Pliensbachian fauna (cf. Fig. 3); these together, can be interpreted as reflecting regional changes of the environment. The end-Pliensbachian decline is evident, the Ibex and Margaritatus Zones may

be highlighted for their diversity maxima, whereas the Stokesi Zone appears as a slight minimum. The early increase in the extinction rate graph of the "basin" fauna may suggest that the processes causing the decline of the

Pliensbachian brachiopod communities of the Bakony started earlier in the basins than on the submarine elevations.
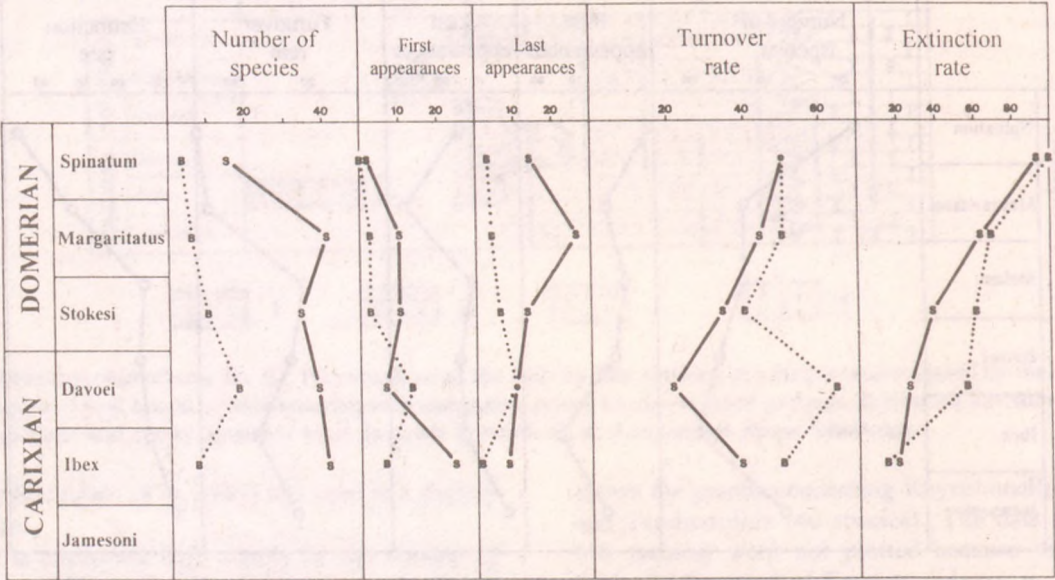

Fig. 5. Graphs showing the temporal changes of the "slope" (S) and "basin" (B) brachiopod fauna during the Pliensbachian in the Bakony Mts.

Lazarus species

The species longevity in the Pliensbachian brachiopod fauna of the Bakony Mts is very variable, from one to six ammonoid zones; some species range from the Sinemurian or even to the Toarcian (see in VÖRÖS 1983). The ranges, seemingly restricted to a single ammonoid zone, are connected always to local occurrences of the respective species. Disregarding of these, the mean species longevity is between 3 and 4.

Most brachiopod species show continuous ranges but some of them seem to disappear and reappear in the record. In a few cases, this can be due to the low number

of species, i.e. to a sampling bias, but in other cases the absence seems to be real. These latter may be termed as Lazarus species; their ranges are presented in Fig. 6. It is seen that the majority of these species appears in the Ibex Zone, is absent in the Stokesi Zone and re-appears in the Margaritatus Zone. This suggests that in the Stokesi Zone environmental stress forced some brachiopod species to withdraw to other areas or to refugia. Afterwards, in the Margaritatus Zone, when the environment was stabilized or impoved, they reoccupied primary habitats as immigrant survivors.
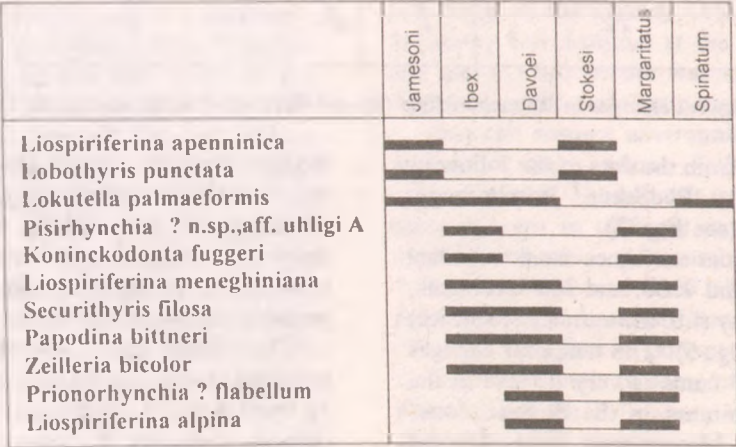

Fig. 6. Range chart of the "Lazarus species" of the Pliensbachian brachiopod fauna of the Bakony Mts.

Discussion

Summarizing the data sets presented above, it can be stated that the Bakony brachiopod fauna was extremely diverse in the Carixian, especially in the Ibex Zone, then, after a slight decline in the Stokesi Zone, regained high diversity in the Margaritatus Zone followed by a spectacular delcine toward the Early Toarcian crash. This local extinction or crisis was obviously connected to the famous anoxic event in the Falciferum Zone (JENKYNS 1988, JENKYNS et al. 1991, VÖRÖS 1993b). The minor declines and recoveries however claim to other explanations sought in the paleoenvironment.

Considering this short interval of the Jurassic Period, temperature changes or salinity fluctuations can almost as definitely be ecxluded as e.g. bolide impacts as controlling factors.

Eustatic sea-level rises and falls were within a range of 40 m during the Pliensbachian (HAQ et al. 1987). Considering authentic estimations on the depth of the sea bottom in the Pliensbachian of the Bakony (GÉCZY 1961: 100–150 m; VÖRÖS 1986: 100–500 m), a sea-level fluctuation of a few tens of meters could not exert direct control on the benthonic communities.

Substratum and food supply are the most important factors controlling brachiopod distributions (Ager 1965, 1967). The amount and character of the substratum are equally important; rocky bottom is the most preferable for brachiopods attached by pedicles. Suspended organic matter, mostly coming from phyto- and/or zooplankton floating in the surface waters, is the basic food supply for brachiopods but in some cases they are able to utilize inorganic nutrients (nitrate, phosphate), as well (STEELE-PETROVIĆ 1976). Recently, peculiar fossil brachiopod associations, members of chemosynthetic communities supported by deep-water hydrothermal vents or cold seeps, were described (e.g. VON BITTER et al. 1992, SANDY & CAMPBELL 1994).

The environmental distribution of brachiopods in the Pliensbachian of the Bakony was analysed and discussed in length by VÖRÖS (1973, 1974, 1986). The importance of the rocky slopes of the submarine elevations, in providing various niches for brachiopods, have been stressed. The talus blocks, accumulated as the result of rockfalls at the feet of the rocky escarpments, were also important sites for brachiopod colonization, because the blocks protruded above the otherwise muddy bottom (VÖRÖS 1991).

The supply of suspended food might have been uniform in the surface waters within the area, but because of the microbial decomposition during the slow fall of organic matter, the net input was much lower at the bottom of the deeper, basinal areas. Consequently, food supply and therefore diversity decreased with increasing depth (VÖRÖS 1973, 1986).

Considering the above principles, VÖRÖS (1993b) concluded that the changes of the Jurassic brachiopod fauna of the Bakony have been controlled mainly by local factors, i.e. the gradual subsidence and the episodic tectonic movements. This opinion is adopted and improved here.

Subsidence

The Bakony area belonged to a passive continental margin in early Mesozoic times (D'ARGENIO et al. 1980, GALÁCZ et al. 1985). Crustal subsidence was extremely rapid in the latest Triassic, as evidenced by the more than two thousand metres thick Hauptdolomit + Dachstein Limestone complex, deposited in peritidal environment during the Norian and Rhaetian. Very shallow marine limestone accumulation continued even in the Hettangian (Kardosrét Limestone) in about 200 m thickness. The onset of the somewhat deeper water environment and variable pelagic sedimentation in the Sinemurian indicates tectonic disintegration of the formerly uniform carbonate platform and a quick subsidence of the downfaulted blocks.

In other Alpine areas of similar early Mesozoic evolution, continuing subsidence has been postulated for the Jurassic (GARRISON & FISCHER 1969, WINTERER & BOSELLINI 1981, BERTOTTI et al. 1993). The Trento Zone, for example, what might have been in the closest relationship to the Bakony, subsided more than 400 m (on the average), in the Early Jurassic, till the end of the Pliensbachian.

There is no reason to suppose that, just in the Bakony area, the general trend of crustal subsidence have been stopped. It seems to be justified to use a value of 10–15 m/million year as a subsidence rate for the Early Jurassic. This means that during the Pliensbachian, we may count with about 100 m total subsidence. This subsidence might considerably decrease the input of suspended organic matter and might bring some parts of the sea bottom to a depth critical for the benthonic suspension feeders.

Tectonic movements

After the disintegration of the carbonate platform, the Bakony area was dominated by fault-scarp bounded submarine horsts and an intervening basin system. Steep rocky escarpments and rock avalanches (scarp breccias) were resulted by repeated tectonic movements along the fault zones bordering the horsts (VÖRÖS 1986, GALÁCZ 1988). The major tectonic movements have been evidenced by the opening phases of neptunian dykes and the deposition of scarp breccias (talus blocks); these episodes have been dated biostratigraphically (see GALÁCZ 1988, VÖRÖS 1993b). Two of them occurred in the Pliensbachian: (1) in the Ibex Zone, and (2) in the Margaritatus Zone. Looking back to the previous chapter (Figs. 3–5), the close correlation between the phases of tectonic movements and the peaks of brachiopod diversity is clear.

One very important aspect of this relationship, notably, the role of tectonic movements in providing hard substratum for brachiopods was discussed above (and in details by VÖRÖS 1986). In longer, tectonically quiet periods, the basinal areas surrounding the submarine horsts were characterized by more or less uniform muddy or sandy, calcareous sediments, unfavourable for brachiopod colonization. The rejuvenation of tectonic movements produced fresh, empty rock surfaces and triggered rock avalanches, spreading talus blocks around the escarpments. This sudden increase in the available rock surfaces greatly enhanced the growth of brachiopod communities (Fig. 7).

Another factor, possibly related to rejuvenation of tectonic movements, may be the activity of submarine cold seeps carrying nutrients to the starving environment and supporting chemosynthetically based communities. Chemosynthesis, as a possible base of higher life communities is a recent discovery of marine research and the methods of its recognition in the fossil record are not well developed. The detailed discussion of this subject and its possible application to the Early Jurassic of the Bakony might be the scope of another paper; here the "cold seep hypothesis" is used only as a theoretical possibility.

The cold seep related interpretation of many "unusual" Mesozoic brachiopod occurrences was put forward by SANDY (1993). In the Tithonian case described in detail (SANDY & CAMPBELL 1994) the source of the seeping

fluids was the overpressured accretionary prism along a fossil subduction zone. In the present case, we may use the modern Florida escarpment as a better analogy. Here, oversaturated, dense brines are the inherent part of the hydrodynamic system of the Florida platform. These brines (rich in methane, ammonia and sulphides) flow outwards and discharge at the foot of the escarpment or sometimes on terraces above the escarpment base. Especially methane is metabolized by bacteria and this carbon source is used by dense communities of bivalves and tubeworms. At the same time, the environment is supersaturated for calcium carbonate which results in very rapid precipitation and cementation (PAULL & NEUMANN, 1987, PAULL et al. 1991, 1992, CHANTON et al. 1991).

Obviously, the analogy between the Florida escarpment and the Bakony "seamounts" is far from being perfect. Especially, the huge platform seems to be missing in the background of the Bakony, though, if the close paleogeographic vicinity to the Trento Platform is accepted, the necessary hydrodynamic system might work. Bivalves and tube worms are not especially frequent in the Pliensbachian fossil communities of the Bakony. A possible evidence for the cold seep activity along the fault scarps is the enormous amount of carbonate cement, producing the early lithification of Hierlatz limestones, the origin of which was not at all understood previously (see VÖRÖS 1991). Further positive evidence is expected from studies on stable isotopes of carbon and oxygen.
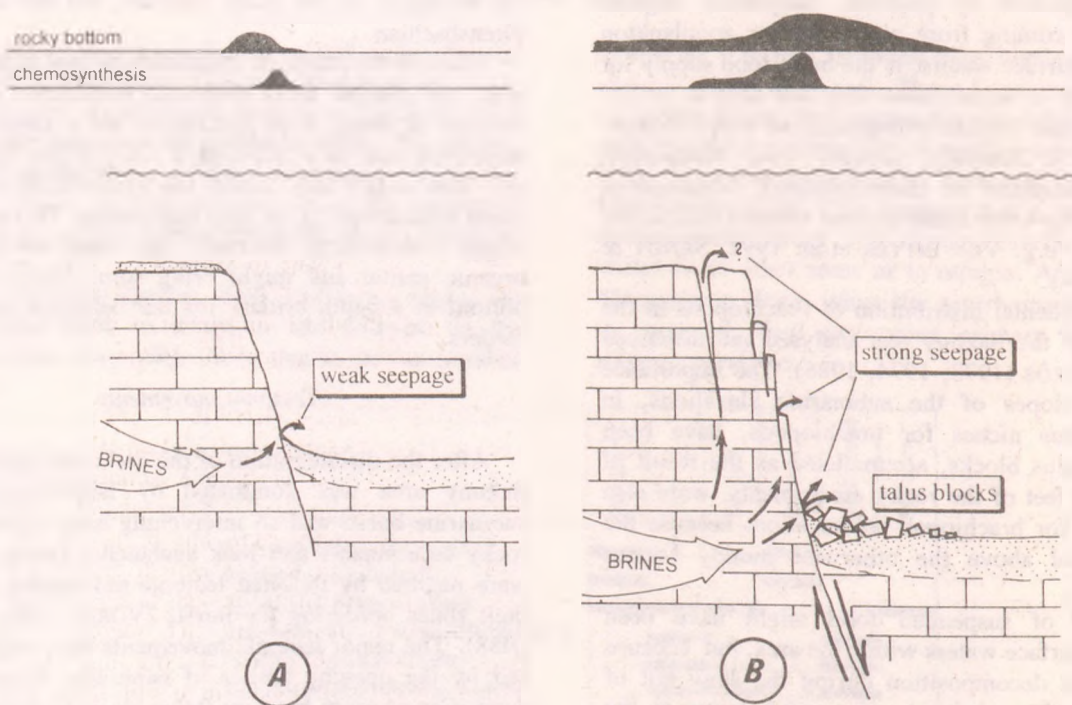

Fig. 7. Cartoon showing the environmental changes caused by rejuvenation of tectonic movements along the fault-scarps bordering the submarine horsts in the Pliensbachian of the Bakony Mts. A: tectonically quiet period, B: shortly after rejuvenation of faulting. The area of rocky bottom, favourable for attachment and colonization for brachiopods, is greatly increased after tectonic movements. Chemosynthesis, as a possible food supply, is also enhanced by tectonic movements, because fault planes, fractures and fissures might serve as conduits for the nutrient-rich brines seeping out of the submerged platform.

If cold seeps worked along the fault zones bordering the submarine horsts of the Bakony area in Pliensbachian times, their activity was probably increased in episodes of tectonic rejuvenation because the fault planes, and the

resulted fissures and fractures might serve as conduits for fluid movements (Fig. 7). The increase in the amount of nutrients and chemosynthetic bacteria might produce an excess of food supply even in the deeper areas.

Acknowledgements

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