

PALYNO-MORPH DISTRIBUTION AND BATHYMETRY IN THE CHANXHE SECTION (EASTERN BELGIUM), REFERENCE FOR THE NERITIC LATE TO LATEST FAMENNIAN TRANSITION (LATE DEVONIAN)

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(3 figures)

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Introduction

Since the I.U.G.S. Subcommission on Devonian Stratigraphy (SDS) has decided, in 2004, to subdivide the Famennian Stage into four substages, the base of the Latest Famennian has been proposed at the base of the conodont Upper *expansa* Zone (Strel 2005, Strel *et al.* 2005). A reference section for neritic facies ("Strunian"), has been suggested in the Ourthe Valley (eastern Belgium), at the Chanxhe locality (Strel *et al.* 2007). In addition to macrofossils (algae, brachiopods, corals, crinoids, stromatoporoids, etc), the faunal and floral microfossils at Chanxhe are represented by miospores, acritarchs, conodonts, foraminifers and ostracods, which allow accurate correlations with other well known sections from western to eastern Europe.

We emphasize here the palynomorph contribution to stratigraphy and bathymetry. The miospore zonation (Strel *et al.* 1987) has been reviewed by Maziane *et al.* (1999) and the biometric zonation based on *R. lepidophyta* diameter sizes (Strel 1966), by Maziane *et al.* (2002). A quantitative analysis of miospores and acritarchs in more than one hundred shaly samples, part of Maziane's unpublished thesis (1999) and used in Strel *et al.* (2007), is explained and discussed below.

Description of the palynomorph record

At Chanxhe, quantitative changes in the amount of miospores and acritarchs per g of sediment and acritarch diversity allow to subdivide the section into five major sequences. Bed numbers are from Conil (1964).

1/ The lowermost sequence (Fig. 1) coincides with the uppermost part of the Evieux Formation (EV Fm) and contains, alternatively, moderate amount of small *Leiosphaeridia* and miospores (about 5.000 / g) or larger amount of small *Gorgonisphaeridium* (about 10.000 / g

or more) but almost no miospores. Another prasinophyte (*sensu* Tyson 1995), *Synsphaeridium*, is also present. Such alternant prasinophyte assemblages are comparable with the observations made in the late Famennian outcropping at the Esneux Railway in the Ourthe Valley (Strel 1999, p. 203), suggesting back-barrier restricted marine to intermediate marine environments. The first specimen of *Retispora lepidophyta lepidophyta* (base of the LL miospore Zone) is recorded at about 2 m below the top of the EV Fm and the first *Knoxisporites literatus* immediately above the top. The first *Vallatisporites hystricosus* and *Apiculiretusispora verrucosus* (base of the VH miospore Zone) are recorded about 6 m below the top of the EV Fm.

2/ The lower sequence (Fig. 1) starts with the Comblain-au-Pont Formation (CBP Fm) at bed 94 and extends into bed 103. The contact between the EV Fm and the CBP Fm is rather sharp suggesting that some *hiatus* is possible. The respective amounts of miospores and acritarchs in the lower sequence are still moderate (increasing slightly to 5.000 / g in the upper part) but the diversity of acritarchs has increased significantly. Large *Gorgonisphaeridium* (*Gorgon >*) are almost as abundant as small *Gorgonisphaeridium* (*Gorgon <*) and as small *Leiosphaeridia* (*Leiosph <20*). *Synsphaeridium* (*Syns*) is no longer present but other prasinophytes like *Cymatosphaera* and *Pterospermella* (*Cym-Pt*) do occur. The most significant change concerns however the occurrence of small spiny acritarchs like *Verybachium* (*Verybach*) and *Micrhystridium* group (*Micr++*) as well as other larger acritarchs like *Solisphaeridium* (*Soli*) and *Stellinium* (*Stel*). Significantly also is the presence (1%) of *Maranhites* where the prasinophytes are reduced to about 25%. At Hony, another locality of the Ourthe Valley, *Maranhites* is much more abundant. Following Strel *et al.* (2000b) the high amount of *Maranhites* corresponds to the maximum of the last Frasnian transgression and to an Oxygen Minimum Zone (OMZ). The transgressive character of the lower sequence at Chanxhe is obvious and is corroborated by a large proportion of miospores

(*Diducites* spp.) originating from “coal” swamps which are more abundant than in the next sequences, as a probable consequence of a high fresh water level on the continent (Maziane *et al.* 2002).

3/ The middle sequence (Figs 1 and 2) starts from bed 103 with the miospore *Tumulispora rarituberculatus* and extends to the bed 146. Miospores are much more abundant (up to 25.000 / g) than in the former sequences although acritarchs are still moderately present. The sudden change at the base of this sequence suggests the possibility of some *hiatus* in the sedimentation. The middle sequence can be subdivided into several subsequences in accordance with the respective proportion in the acritarch population.

31/ From bed 103 to bed 110, the acritarch genera proportion is rather similar as that of the lower sequence. The Refrath borehole (western Germany, about 100 km east of Chaxhe) has Middle *expansa* conodont Zone and Early *hemisphaerica-dichotoma* ostracod Zone with large specimens of *R. l. lepidophyta* allowing a correlation with the subsequence 31 (Strel & Hartkopf-Fröder 2006).

32/ Between beds 111 and 115, the acritarch diversity decreases in favour of small prasinophytes (*Leiosphaeridia*) and small spiny acritarchs (*Veryhachium*). The *R. lepidophyta* diameter sizes are maximum (55 – 78 µm: i.e. *R. l. lepidophyta*). Bed 111 contains the conodont *Bispathodus ultimus* marking the base of the Uppermost Famennian Substage (Strunian). Bed 115 contains the first foraminifer *Quasiendothyra kobeitusana kobeitusana*.

33/ Between beds 116 and 146, the acritarch genera proportion is rather similar to that of the lower sequence, with some emphasis on small spiny acritarchs (*Veryhachium*). The acritarch diversity is again high in the lower part of the subsequence where *Maranhites* (2%) is also present. From the lower part to the upper part of the subsequence, the proportion of prasinophytes increases as well as the number of miospores which reaches 25.000 / g. The *R. lepidophyta* diameter sizes are significantly reduced (42 – 54 µm: i.e. *R. l. minor*).

4/ The upper sequence (Fig. 2), between beds 147 and 155, starts with *Indotriradites explanatus* (base of LE miospore Zone). The acritarch genera proportion is rather similar to the upper part of the lowermost sequence (small *Leiosphaeridia* versus small *Gorgonisphaeridium*, and few miospores). The sudden change at the base of this sequence suggests again the possibility of some *hiatus* in the sedimentation.

5/ The uppermost sequence (Fig. 2), from bed 156 to bed 162, is obviously incomplete: the section is interrupted by a fault which hampers the observation of the transition to the Tournaisian beds. As it starts with a possible *hiatus* at the top of the upper sequence, the uppermost sequence is not analyzed here. The possibility that it might belong to the next miospore LN Zone is currently investigated.

Discussion

Taking into account the sedimentology and the sequential pattern (Strel *et al.* 2007) as well as the palynomorph distribution (Fig. 3), one can attribute the basal part (cf. lower sequence S2) of the Comblain-au-Pont Formation from the Chaxhe section to a general transgressive trend, the Epinette transgression, up to just above the chronostratigraphic boundary marking the base of the Strunian. The remaining upper part of the formation better fits with a general Highstand Systems Tract (HST) as suggested by Van Steenwinkel (1988) who wrote that the Strunian part of the CBP Fm represents a time interval during which sea level was slowly falling at a rate lower than that of subsidence, the net effect being a relative rise. However, synsedimentary tectonics i.e. contemporaneously listric fault activity affected in particular the tilted block which includes the Chaxhe section (Maziane *et al.* 2002). The tectonic activity is also materialized by the occurrence of three ball-and-pillow levels in the upper part of the Comblain-au-Pont Formation. Although the prasinophytes are characteristic of both lagoonal and offshore facies (Montenari & Leppig 2003), quantitative palynomorph analysis suggests that the increasing miospore abundance observed in the sequence 33 does not fit with an offshore facies. Shallowing trend in sequences 33 and 4 is corroborated by the increasing quantity and diversity from bed 123 to bed 152 of shallow water ostracod species belonging to the suborders Platycopina and Paraparachiticopina (Casier *et al.* 2005).

The palynomorph distribution in the Strunian part of the Chaxhe section shows an obvious cyclicity (Strel *et al.* 2007, fig. 2) which is in line with recent ^{13}C and ^{18}O isotopes data (Kaiser *et al.* 2006, 2007). Two positive carbon isotope excursions are known within the LL to LN miospore Zones time-range indicating global changes in the isotopic composition of the marine dissolved inorganic carbon and the atmospheric CO_2 . As prasinophytes have affinity with dysoxic-anoxic facies (Tyson 1995, p. 301), their abundance might well be used as a proxy to be correlated with such global changes (Hartkopf-Fröder *et al.* 2007). The positive carbon isotope excursion and decrease of the oxygen isotope values of conodont apatite as reported in Middle and Upper *expansa* micrites of the Carnic Alps, indicate an episode of occurrence of high seawater temperatures possibly to become correlated, in the future, with the cosmopolitan “evolution” from *R. l. lepidophyta* abundance to *R. l. minor* abundance. The early-middle Famennian vegetation crisis (Strel 2007) was underlined also by an unexpected phenomenon affecting the mean size of miospores which are significantly smaller in the Famennian than in the Frasnian. The suggestion that the early-middle Famennian vegetation crisis might well be explained by a global cooling (Strel *et al.* 2000a) is not matched by the dominantly transgressive curve in the lower half of the T-R cycle IIe of Johnson *et al.* (1985). On the contrary, alternation of cold temperatures,

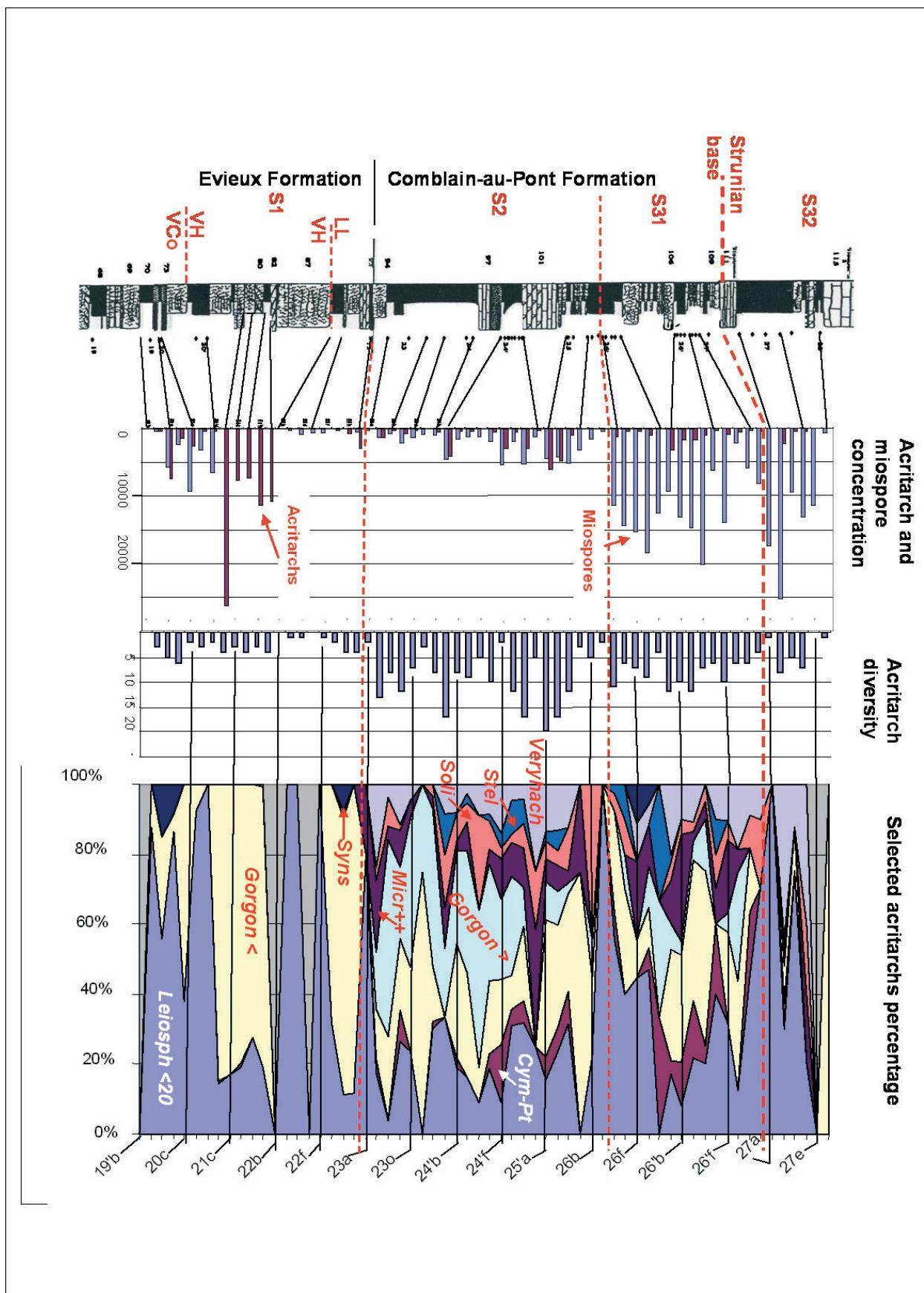


Figure 1: Acritarch (including prasinophytes) and miospore quantitative data in the lower (mainly Upper Famennian) part of the Chaxhe section.

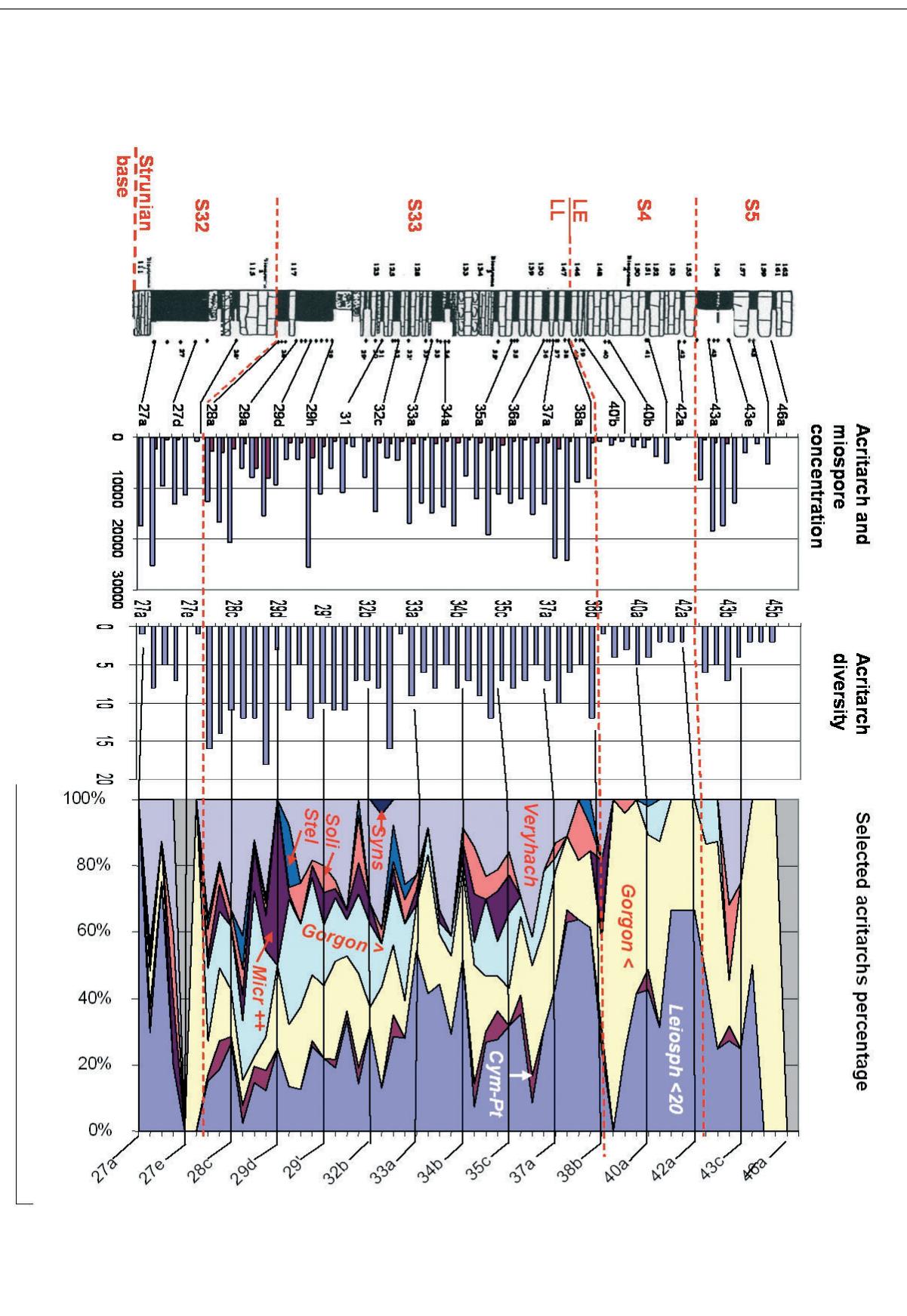


Figure 2: Acritharch (including prasinophytes) and miospore quantitative data in the upper (Uppermost Famennian) part of the Chaxhe section.

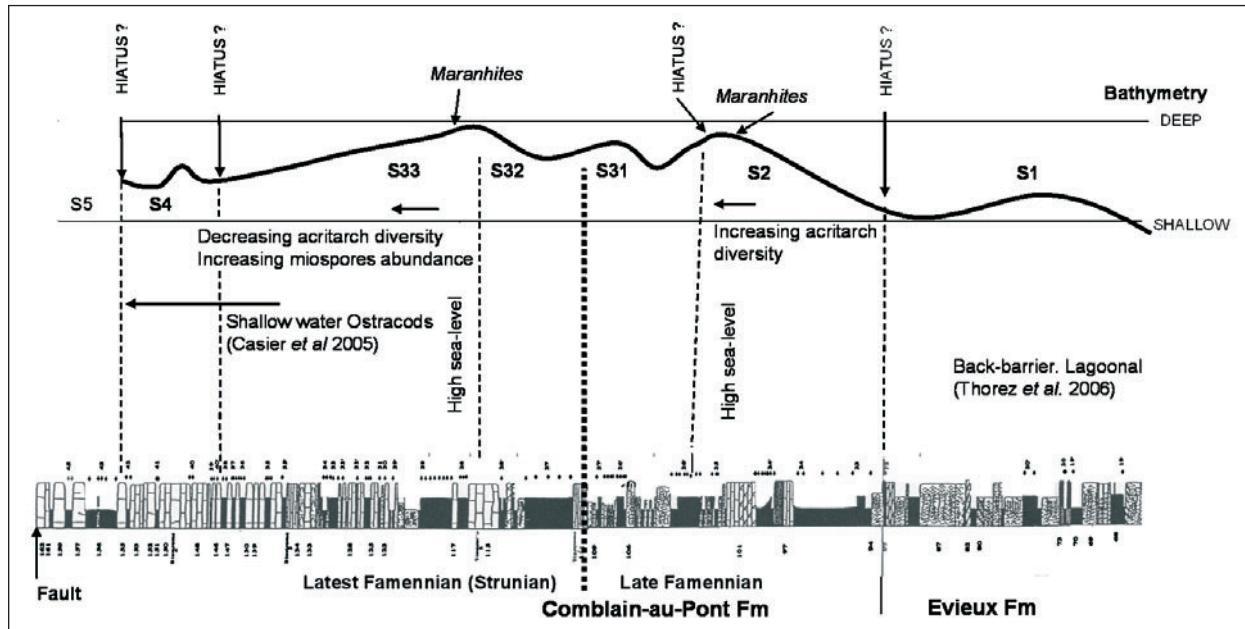


Figure 3: Suggested bathymetry in the Chanxhe section.

right at the Frasnian/Famennian boundary (Joachimski *et al.* 2002), followed by rather high temperatures in the intertropical belt during the early-middle Famennian might as well explain the vegetation crisis. We see the biometric change within *R. lepidophyta* population as a proxy to recognize the base of the Uppermost Famennian in continental facies, reflecting a change in the climate probably less important than at the base of the Famennian and therefore affecting selectively only the coastal, marginal swampy vegetation (Maziane *et al.* 2002).

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