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West Gondwanan and Euramerican climate impact on early Famennian to latest Viséan miospor assemblages

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Accurate Upper Devonian biostratigraphy is based on conodonts, marine microfossils. Dating non-marine or marine deposits which do not contain conodonts, often depends on miospores, which are produced in huge quantities by terrestrial plants and are abundantly dispersed in contemporaneous marine sediments. Most of the correlation between conodont and miospore stratigraphies has been established in Western Europe, notably in the Ardennes-Rhine area. Because the same Frasnian and Famennian miospore zones (the *Cymbosporites* Realm in Streel & Marshall 2006) occur in both Southern Euramerica and Western Gondwana (implying close proximity of these continents) they allow transfer of Southern Euramerica conodont stratigraphy to Western Gondwana. When reconciling the Famennian conodont and miospore zones with the new, now widely accepted chronostratigraphy (Kaufmann 2006) and using the substage nomenclature proposed by Streel *et al.* 2000 and Streel 2005 (**Fig. 1**), three steps are recorded which might be climatically controlled (**1** to **3**). Climatic and / or tectonic control is also obvious during the Mississippian (**4**).

1) In Southern Euramerica, the Lower-Middle Famennian vegetation crisis (at least 5 Myr) corresponds to very poorly diversified miospore zones (Raymond & Metz 1995, Streel *et al.* 2000). This crisis seems to extend stratigraphically to the Upper Famennian in cold temperate to subpolar Western Gondwana and may be therefore climatically control.

2) The Upper Famennian miospore zones are based on a succession of species of *Grandispora* occurring in the same stratigraphic order in western and eastern Europe (Higgs *et al.* 2000). The bases of the Upper Famennian VCo and VH miospore Zones in USA (Richardson & Ahmed 1988) are poorly controlled by marine fossils which often occur as single specimens at long distance from rich miospore assemblages (Streel & Loboziak 1994). Correlation is then based on lithostratigraphy despite their diachronous character. Maybe, however, a belated arrival of VCo and VH characteristic miospores in the Upper Famennian of Belgium could have been controlled by the arid climate (Streel & Marshall 2006) if rain-bearing winds were deflected into Gondwana as proposed in the Tournaisian by Wright (1990). This alternative is called here the Upper Famennian correlation challenge (at least 5 Myr). Tectonic control of regional climates may be inferred in mapping the unconformities around the Old Red Continent.
During the Upper and Uppermost Famennian characteristic conodont taxa (Kaiser 2005) show shorter stratigraphic ranges and are more numerous than characteristic miospores. Both microfossils mark an obvious turnover near the Upper / Uppermost Famennian limit.

3) Glacial and interglacial cycles, during a period called here the quick changing climate Uppermost Famennian (less than 3 Myr), are quite evident after the sharp climate change occurring during the late Upper Famennian within the Middle *expansa* Zone and introducing a new, almost cosmopolitan vegetation belt characterized by the miospore *Retispora lepidophyta*. But the best documented part is obviously the Uppermost Famennian age, when glacial deposits containing the LE-LN Zones reached the sea-level in Western Gondwana. Based on miospore (and locally on acritarch) quantitative data, cycles are very obvious in arid equatorial (Greenland) as well as in tropical (Ardennes-Rhine) regions (Streel & Marshall 2006). They allow also very detailed correlation of the Hangenberg Crisis (Streel 1999, Kaiser *et al.* 2006), in the Middle to Upper *praesulcata* Zone, with new geochemical data from tropical (Western Europe) and subtropical (Southern France and Morocco) regions and detailed correlation with warm temperate subtropical Pocono Fm (Pennsylvania) and the glacial events in Western Gondwana (South America).

4) Late Middle to early Late Tournaisian rare glacial evidences in Western Gondwana might correspond to mountain glacier at proximity of the Eohercynian uplift of the Andean Range.
Upper Viséan (Holkerian-Asbian or late Meramecian) rocks in Western Gondwana have also some glacial evidences but might sometimes display a very Warm-Temperate Floral Belt (Alleman & Pfefferkorn 1988). This apparent paradox is explained by alternation of mean temperatures during 4 My as demonstrated by isotopic data in Southern Euramerica (Bruckschen & Veizer 1997) allowing alternation of glacial versus very warm climates in Western Gondwana.

In Western Gondwana **(Fig. 2),** cold and dry climates with rather poor vegetation (Holocene Barren Grounds climate type) seem to alternate with less cold but wetter climates with glacier extensions and richer vegetation.

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Legend of Fig. 1

Correlation of conodont and miospore stratigraphies

Relation between chronostratigraphy and conodont stratigraphy reproduced from Kaufmann 2006 (* in Conodont Zonation column for *trachytera* Zone)

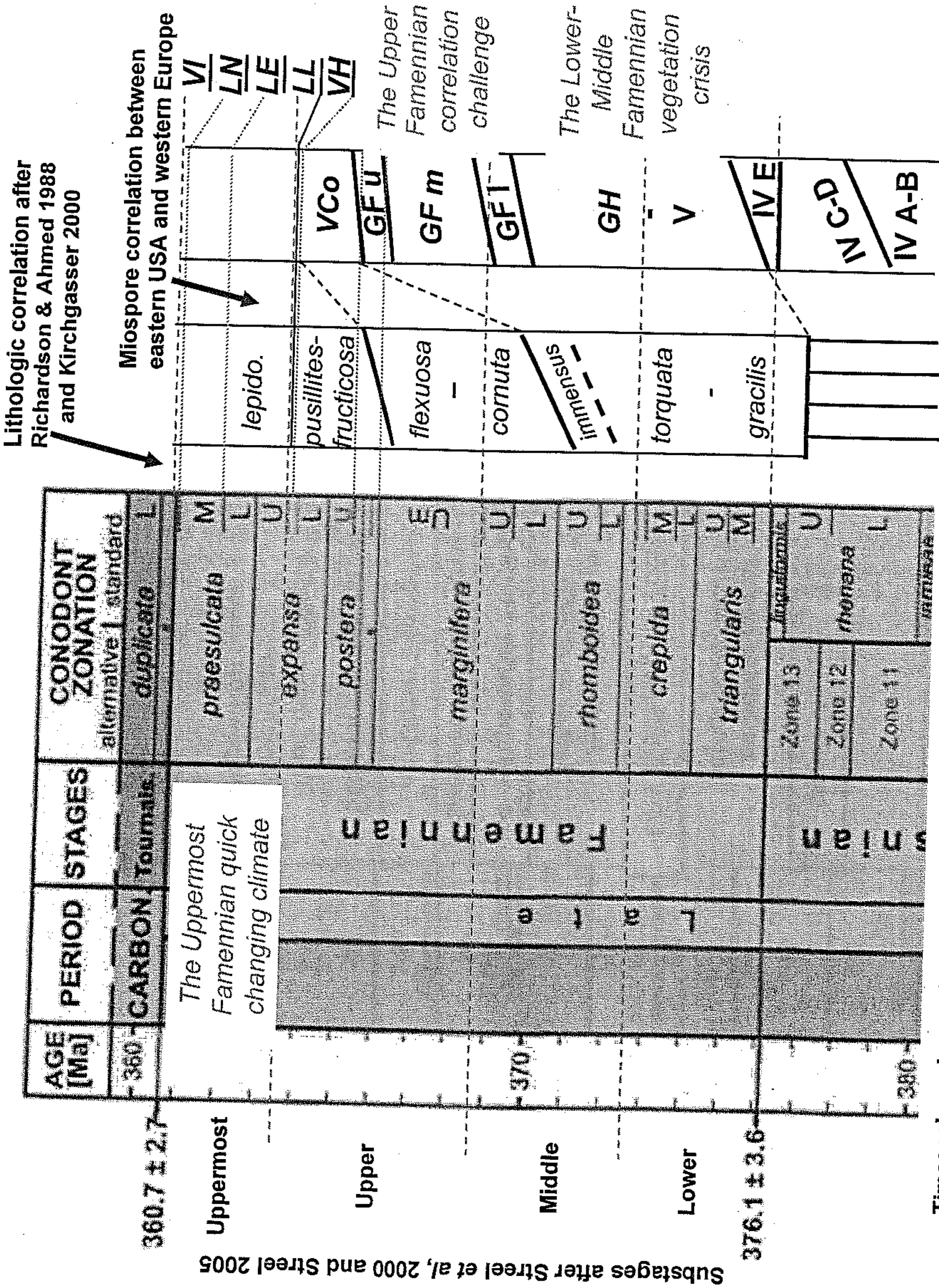
Miospore correlation between eastern USA and western Europe mainly based on Richardson & Ahmed 1988. Miospore / conodont correlation in eastern USA based on Richardson & Ahmed 1988 and Streel & Loboziak 1994. Lithologic correlation after Kirchgasser 2000.

The type Belgian lithostratigraphic data (Thorez *et al.* 2006) suggest that, in Kaufmann 2006, the Uppermost *marginifera* conodont Zone (Um) duration is probably too long and the Middle *expansa* conodont Zone (unlabelled), probably too short, the last-one displaying 3 miospore Zones (VCo, VH, LL).

Legend of Fig. 2

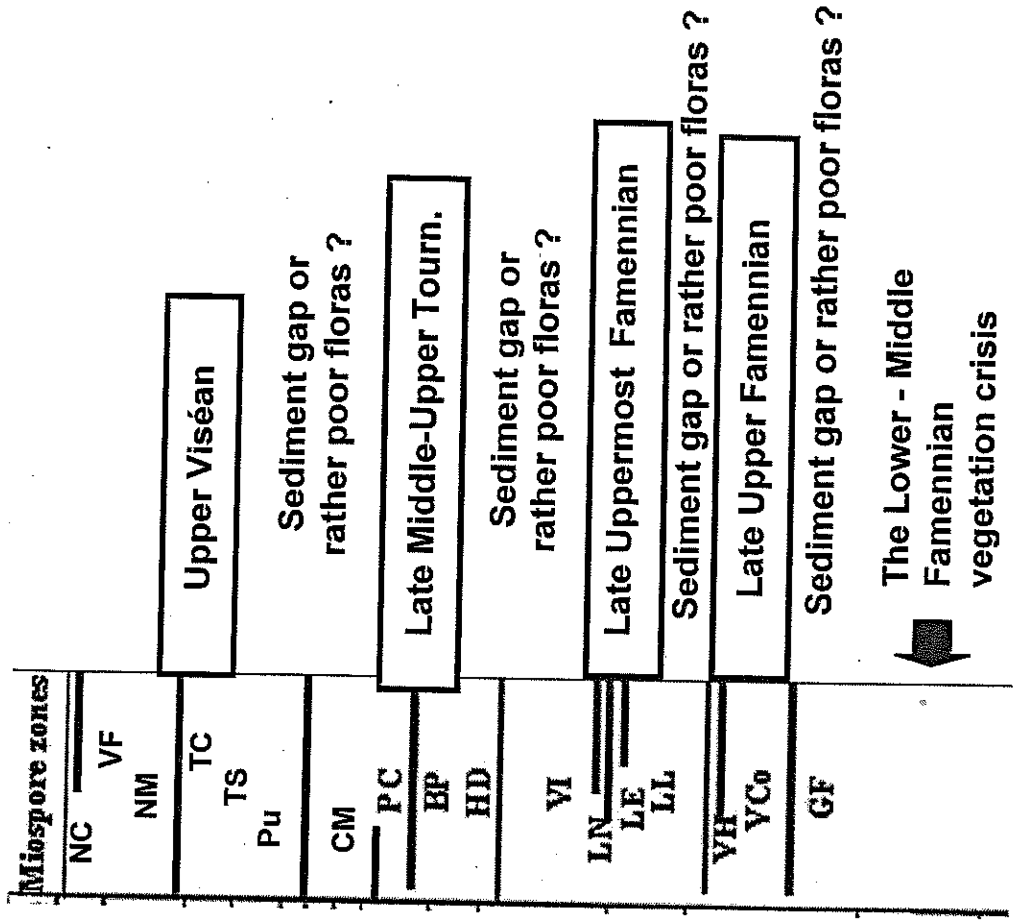
Ages of miospore zones recorded in Western Gondwana

After Melo & Loboziak (2003).



Timescale and conodont zones duration after Kaufmann 2006

Fig. 1



Miospore zones
NC
VF
NM
TC
TS
Pu
CM
PC
BP
HD
VI
LN
LE
LL
VH
VCo
GF
Upper Viséan
Sediment gap or rather poor floras ?
Late Middle-Upper Tourn.
Sediment gap or rather poor floras ?
Late Uppermost Famennian
Sediment gap or rather poor floras ?
Late Upper Famennian
Sediment gap or rather poor floras ?
The Lower - Middle Famennian vegetation crisis

Fig. 2