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UPPER AND UPPERMOST FAMENNIAN MIOSPORE AND CONODONT CORRELATION IN THE ARDENNE-RHENISH AREA.

Maurice Streel
Paleobotany, Paleopalynology, Micropaleontology Unit, Department of Geology, University of Liège, Belgium (Maurice.Streel@ulg.ac.be).

1. The Upper Famennian in the Condroz Sandstones of Belgium

Dreesen *et al.*(1986, fig.1) indicate that, due to unfavourable facies, the stratigraphic interval Upper *trachytera* to Lower *expansa* in the Condroz Sandstones in Belgium lacks the characteristic conodonts of the "standard.zonation" (Ziegler & Sandberg 1990). The Oppel Zone VCo (*Diducites versabilis – Grandispora cornuta*) covers most of the stratigraphic interval where characteristic conodonts are poorly present.

The base of the VCo Oppel Zone (Streel et al., 1987), marked by the first occurrence of *G. cornuta, Retusotriletes phillipsii* and *Rugospora radiata*, matches the base of the *Rugospora flexuosa* (now *radiata*) – *Grandispora cornuta* Assemblage Zone of Richardson & McGregor (1986). These authors (p. 21 and fig. 7) and also Streel & Loboziak (1994, fig. 2) have tried to evaluate the respective control by faunas of both zones. The VCo Oppel Zone base is obviously not older that the conodont Upper *trachytera* Zone (See *G. cornuta* FOB). The "*flexuosa-cornuta*" Ass. Zone might however well start in the middle Famennian part of the conodont *marginifera* Zone if the poor lithological correlation between a few faunas and the rich miospore assemblages in USA is confirmed.

The *Grandispora cornuta* FOB marks the base of the VCo Zone. The *Grandispora cornuta* FOB was found in the; now almost inaccessible, locality of the lower part (sample 36) of the Evieux Formation, in the La Gombe /Montfort section, Dinant Synclinorium, Ardenne region (Bouckaert *et al.* 1971, fig. 6; Bouckaert & Streel 1974; Thorez *et al.* 1977, p. 18). Ten samples (from an interval between 50 and 180 m below sample 36 contained miospores lacking *G. cornuta*. *Scaphignathus velifer velifer* (first occurrence in the conodont Latest *marginifera* Zone) is known 162 m below sample 36 in the same section. *G. cornuta* first occurrence is also present in sample 54, above the base of the Evieux Fm in the Comblain-au-Pont "Bon-Mariage" section at a level believed to correspond to the conodont *postera* Zone (Streel 1986, Streel et al. 2003, fig. 2). Indeed conodonts have been restudied by Dreesen & Thorez (1994, p. 175) in a parallel section (Comblain-la-Tour) distant of 4 km only. They have proposed an Upper *trachytera* Zone at a lithostratigraphic level slightly below sample 54 of the Comblain-au-Pont section.

The *Vallatisporites hystricosus* FOB marks the top of the VCo Zone and the base of the *Apiculiretusispora verrucosa – Vallatisporites hystricosus* or VH Zone. The *Vallatisporites hystricosus* FOB is found in sample 20'd 10 m below the top of the Evieux Fm (Maziane *et al.* 1999, fig. 3 and Streel *et al.* 2007, fig.1). 11 samples without *V. hystricosus* are known below this sample in the same section and the same formation. The first occurrence of the conodont Late *expansa* Zone is known (Dreesen et al. 1993, Streel & Hartkopf-Fröder 2005, Streel *et al.* 2007) from the Comblain-au-Pont Fm in the same section, about 28 m higher than Bed 20'd. Conodonts of the Middle *expansa* Zone occur (Dreesen et al. 1993, p.23) in the underlying Evieux Formation of the Esneux railway section, 3 km from Chanxhe.

2. The uppermost Famennian and the Devonian/ Carboniferous boundary.

Almost all recently published papers on the Strunian as a chronostratigraphic unit refer to the old, now disused, "Fa2d" which base was correlated with the *Retispora lepidophyta* FOB at about the level as the Epinette event. Although the *R. lepidophyta* FOB is an excellent marker, the species reaching, higher in the sequences, sometimes 50 % of the miospore assemblages, and having a worldwide distribution in continental and neritic facies, it is unfortunately not matched by any well defined conodont limit. Therefore

the Uppermost Famennian Substage base, at the base of the conodont Upper *expansa* Zone and a reference section for neritic facies (Strunian) were proposed by Streel (2002, 2005) and Streel *et al.* (2003, 2005, 2006, 2007).

Richardson & Ahmed (1988, fig. 5) and Avkhimovitch and Richardson (1996) had proposed respectively to separate the lower part of the *Vallatisporites pusillites (sensu lato) - Retispora lepidophyta* Zone of Richardson & McGregor (1986) as an *Apiculiretusispora fructicosa* (now *verrucosa)* – *V. pusillites* Subzone (1988) or as a *V. pusillites- Knoxisporites literatus* PLi Zone (1996). They correlate the base of these (sub)zones with the base of the old (now disused) "Fa2d" in Belgium (starting in the conodont Middle *expansa* Zone) but also with the base of the Cattaraugus Fm, equivalent to the Uppermost *marginifera* in marine sediment after Kirchgasser and Oliver (1993, fig. 1) and Kirchgasser (2000). Such contradiction might depend on the diachronous character of the Catskyll facies. As long as this situation is not clarified, these miospore zone subdivisions will not be taken in consideration here.

The transition from the Upper Famennian to the Carboniferous is covered by six conodont zones (from Middle *expansa* to *sulcata*), by three miospore Interval Zones i.e. the *Retispora lepidophyta – Knoxisporites literatus* , *R. lepidophyta – Indotriradites explanatus,* and *R. lepidophyta – Verrucosisporites nitidus* (respectively LL, LE, LN), and by one Assemblage Zone i.e. the *Vallatisporites vallatus - Retusotriletes incohatus* (VI) which extends across the Devonian – Carboniferous Boundary. The LL Interval Zone includes now (Maziane et al. 1999) the former LV Zone (Streel *et al.* 1987) and could be further subdivided by the first occurrence of *Tumulispora rarituberculatus* and the sudden change in abundance from *R. lepidophyta lepidophyta* to *R. lepidophyta minor* almost at the base of the Upper *expansa* Zone (Maziane *et al.* 2007). The extinction of *R. lepidophyta* seems to occur step by step. In the Sauerland (Germany) it is announced by the disappearance of peat swamps which produced *Diducites plicabilis,* followed by a strong reduction of the proportion of *R. lepidophyta* (from 30 % to 1 or 2 %, Higgs et al. 1993) suggesting the also progressive reduction of the related swamp margin environment which seems to temporary disappear soon after, together with other swamp margin environments characterized by other species *(Vallatisporites hystricosus, Auroraspora asperella,...)* (Streel 1999). These miospore events partly correspond to, and immediately succeeded the Hangenberg event, a sedimentary cycle constituted of a transgression (the Hangenberg Black Shale) and a deep regression (the Hangenberg Sandstone and Shale) (Bless *et al.* 1993). The regression can be correlated by miospores with the glacial episode known in Gondwana (Streel *et al.* 2000, Melo & Loboziak 2003). The complete extinction of *Retispora lepidophyta* immediately below the base of the Carboniferous System, as defined by the first occurrence of the conodont *sulcata* Zone, is well known around the world (Streel 1986, Higgs *et al.* 1993, Loboziak *et al.* 1993, Streel & Loboziak 1996). It corresponds to the change from the LN Zone to the VI Zone. The VI Assemblage Zone is poorly defined, the two nominal species being present below the top of the LN Zone. Its base corresponds to the *Retispora lepidophyta* LOB

The *Retispora lepidophyta* FOB is found in samples 22, 2 m below the top of the Evieux Fm in the Chanxhe section, Dinant Synclinorium, Ardenne region (Maziane *et al.* 1999, fig. 3 and Streel *et al.* 2007, fig.1) i.e. 14 samples without this species are known below these samples in the same section and the same formation. The first occurrence of the conodont Late *expansa* Zone is known (Dreesen et al. 1993, Streel *et al.* 2007) from the Comblain-au-Pont Fm in the Bed 111 of the same section, about 20 m higher than samples 22. Conodonts of the Middle *expansa* Zone occur (Dreesen et al. 1993, p.23) in the underlying Evieux Formation of the Esneux railway section, 3 km from Chanxhe where the Fontin event has been traced in the VCo Oppel Zone (Streel 1999, p.203-205). The lower part of the Comblain-au-Pont Fm contains abundant large specimens (var. *lepidophyta*) of *R. lepidophyta* (Streel 1966, Maziane *et al.* 2002) as in the Refrath 1 Borehole (Bergisch Gladbach-Paffrath Syncline, Germany) which contains a Middle *expansa* Zone (Streel & Hartkopf-Fröder 2006). Therefore the *R. lepidophyta* FOB is in the Middle *expansa* Zone.

The *Indotriradites explanatus* FOB is found in sample Rh10 in the greenish silty shales (Hangenberg Schiefer equivalent) of the Riescheid section, Remscheid Altena Anticline, Sauerland, Germany (Higgs & Streel 1984, fig. 3). Three samples in the underlying 2.5 m interval lacked *I. explanatus* (Higgs & Streel 1994). The conodont *costatus* Zone, after Lane & Ziegler (in Paproth & Streel 1982), was found in almost the same bed (equivalent to the conodont Lower or Middle *praesulcata* Zone ?). Another, better dated, sample is 50 cm below the top of the Wocklum Kalk, at Hasselbachtal (28 km east of Riescheid), same anticline (Higgs & Streel 1994). It is a single sample (Hbl) in the latest part of the conodont Lower *praesulcata* Zone, which occurs 35 cm below the base of the Middle *praesulcata* Zone. The latter conodont zone occurs 20 cm below the top of the Wocklum Kalk (Becker et al. 1984, p. 189). However no samples with miospores are known below this single sample. Consequently, the *I. explanatus* FOB is in the late part of the Upper *expansa* Zone or in the Lower *praesulcata* Zone.

The *Verrucosisporites nitidus* FOB is found in a sample collected in a 5-22 cm interval above the base of the Hangenberg Black Shale, i.e. on top of the Wocklum Kalk, at Hasselbachtal section, Remscheid Altena Anticline, Sauerland, Germany. Two specimens of *V. nitidus* have small (3µm) verrucate ornaments which fall within the lower part of the morphological range of the species. The presence of the Middle *praesulcata* Zone (See *I. explanatus* FOB) 20 cm below the top of the Wocklum Kalk in the same section allows to assign the *V. nitidus* FOB to the Middle *praesulcata* Zone.

The *Retispora lepidophyta* last Occurrence Biohorizon or LOB can be observed in sample Hb 18-19 in the Bed 85 of the Hangenberg Schiefer of the Hasselbachtal section, Remscheid Altena Anticline, Sauerland (Higgs & Streel 1984, figs. 5 and 6). Six samples in the overlying 14 cm did not yield *R. lepidophyta* but were dominated by simple laevigate taxa. The *sulcata* conodont zone occurs 14cm higher than the *R. lepidophyta* LOB.

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