

SOME UPPERMOST DEVONIAN MEGAFLORES : A STRATIGRAPHICAL REVIEW

by

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(1 figure)

ABSTRACT. - This brief review is an attempt to gather recently published biostratigraphical data, obtained mainly from miospore studies, and dealing with some uppermost Devonian macrofloras. The apparently time-restricted distribution of *Cyclostigma kiltorkense* is emphasized.

RESUME. - Cette brève revue tente de rassembler les données biostratigraphiques récentes basées principalement sur les miospores, et qui ont trait à des macroflores du Dévonien terminal. La courte distribution stratigraphique apparente de *Cyclostigma Kiltorkense* est mise en évidence.

Any attempt to use plant macrofossils for precise biostratigraphical purposes during the Devonian period often faces unsolvable problems. Reasons for this situation have been surveyed by Banks (1980) who nevertheless provided an original plant-based subdivision of the Siluro-Devonian period into seven zones. His floral assemblage-zones are defined by the appearance of new morphological characteristics rather than by an exhaustive listing of all the taxa recorded from each time span. This zonal scheme is easy to use; however positioning of floras recorded near the vicinity of the zone boundaries is often difficult because of unavoidable overlap of critical genera resulting either from their natural longevity or from the looseness of their known stratigraphical records.

This paper is an endeavour to precise the stratigraphical position of some floras in the uppermost Devonian zone VII of Banks, especially of those recorded near the Devonian-Carboniferous boundary. It is based on recently published data stemming mainly from miospore studies. Own observations of Upper Devonian plant remains in Belgium supplement this compilation which is by no means exhaustive.

Critical floras which have been or are still regarded as crossing the Devonian-Carboniferous boundary will be considered first, namely those from the New Albany Shale (Cross & Hoskins, 1951) and the Pocono Formation (Read, 1955) in the U.S.A., from the Kiltorcan Formation (cf. Chaloner in Holland, 1981) and from the Slieve Bloom area (Feehan, 1979) in Ireland, from the Tunheim Series (Schweitzer, 1967, 1969)

in Bear Island and from the Rudny-Altai and Saïan-Altai regions (Ananiev, 1979) in the U.S.S.R.

In the New Albany Shale, permineralized plant remains are particularly noticeable in phosphatic nodules within a thin zone of deposits distributed over southern Illinois, southern Indiana and central Kentucky. *Callixylon* is one of the most common genera recorded; several species have been identified (Beck, 1962) within the nodule bed, the Falling Run bed. Regarded as Early Mississippian by Cross & Hoskins (1951), the Falling Run Bed is currently positioned near the base of the Cu I goniatite zone (Rheinbold, 1984). It may be ? Tn1b in age (Sandberg *et al.*, in Scott *et al.*, 1984).

At the Horse Shoe Curve section in Pennsylvania, the Devonian-Carboniferous boundary lies in the lower half of the Middle Sandstone and Shale Member of the Pocono Formation (Streel & Traverse, 1978) more precisely between spore samples 4 and 5 (Streel, pers. communication, 1985) positioned on Fig. 2 in Streel & Traverse's paper. The *Archaeopteris* compression remains are located below the LN spore assemblage and are upper Devonian in age whilst the first *Adiantites spectabilis* specimens (see Swartz, 1965 for discussion of position of the plant fossils in the section) apparently belong to the early Mississippian. On the other hand the various taxonomic treatments of the *Archaeopteris* fragments recorded in the Horse Shoe Curve section

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		Banks floral assemblage zone VII					
		Wocklumeria		Cu I Cu II α Cu II β-γ		Goniatite zonation	
DEVONIAN				CARBON		System	
FAMENNIAN		STRUNIAN		TOURNAISIAN		Series	
Fazb		Fazc		Tn3		Old Subdivisions	
GM		VCo		Tn2		Miospore zonation	
		Fazd		Tn1a			
		Tn1b		Tn1c			
		LV		LN			
		PL LL		VI			
		LE		HD			
				BP			
				P C			
				C M			
		x x o				1 Hampshire Fm	
		x *				2 Oswayo Fm	
		x		x		3 Pocono Horse Shoe Curve	
		Falling Run Bed		x		4 New Albany shale	
		*				5 Taff Gorge	
				o		6 Avon Gorge	
		*				7 Baggy Beds	
		*				8 Kerry Head	
		x ● *		x ● *		9 Kiltorcan Fm	
				O.R.S. facies		10 Slieve Bloom	
				Marine transgr.		11 Foulden	
				*		12 Hook Head	
		x x o				13 Evieux Fm	
		x				14 "Trooz Fm"	
		x ●				15 Tunheim (Kolbukta)	
		o x x *				16 Bielorussie Torchyn "Fm"	
		x				17 Donbass	
				x		18 Ural	
		Xuefeng Fm		●		19 China Xuefeng Fm	
		Bystryansk + Altaisk. suites		x		20 21 22. Altai	
		Tarchansk. suite		x o			
		Tubinsk "Fm"		x *			

- x Archaeopteris
- * Seeds
- o Rhacophyton
- Cyclostigma kiltorkense
- ⊗ Adiantites
- Aneimites acadica

illustrate the difficulties in species and even generic delimitation within the *Archaeopteris-Callixylon* and related plant groups (as summarized by Beck, 1981). Determined as *A. latifolia* by Arnold (1939) they have been referred to *Rhacopteris*, as *R. latifolia* by Read (1955) but they appear to be actually a species of *Archaeopteris* (Skog & Gensel, 1980).

The well known Kiltorcan flora in Co. Kilkenny, Ireland, contains remains of *Archaeopteris hibernica*, *Cyclostigma kiltorkense*, *Ginkophyllum kiltorkense*, *Sphenopteris hookeri*, *Lepidodendropsis* sp., cf. *Rhacopteris* sp., *Bythotrephes* sp. (Chaloner in Holland, 1981) and the platyspermic seed *Spermolithus devonicus* (Chaloner et al., 1977). Palynological assemblages from the plant beds have not been described. However, an assemblage recorded from the base of the Kiltorcan Formation near Portlaoise is characteristic of the LL Subzone (Higgs in Keegan & Feehan, 1981) and approximately 40 m above the highest of the exposed plant bed, Clayton et al. (1977) described a lower VI Subzone assemblage.

In the Slieve Bloom area, no secure *Archaeopteris* remains have been recorded. The small pinnules which have been collected in the lacustrine sequences on top of the Old Red Sandstone facies are referred to *Aneimites acadica* (Feehan, 1979). The status of these leaflets remains however debatable according to Chaloner (in Feehan, 1979) who doubts that they can be identified specifically. Miospore assemblages indicate the occurrence of the LE and VI Subzones (Keegan & Feehan, 1981) in the plant-bearing Cadamstown Formation. If

the taxonomic position of the above mentioned plant fragments could be confirmed, it might be one of the oldest records of *A. acadica* which is usually regarded as a Lower Carboniferous plant, more especially as it is considered as probably conspecific with *Adiantites spectabilis* Read by Bell (1960).

In the Tunheim Series at Kolbukta in Bear Island, *Archaeopteris* and *Cyclostigma kiltorkense* occur together as at the Kiltorcan locality. They are accompanied by the distinctive *Pseudobornia ursina*. Remains of that plant are often mentioned from Upper Devonian deposits in a variety of localities; the specimens of Alaska only show the characteristic leaves (Mamay, 1962) of the taxon and constitute the sole secured occurrence of *P. ursina* outside the type-locality (Schweitzer, 1967). Miospore assemblages recorded by Kaiser (1970) from the Tunheim Series belong to the LV Subzone at Kolbukta and the LE at Skredneset (Streel, pers. communication, 1985). The Bear Island pre-*Adiantites* flora still belongs to the Devonian.

The floras from the USSR are particularly difficult to correlate with the Western stratigraphical zonation. The lower boundary of the Carboniferous in the USSR is placed at the base of the *Wocklumeria* zone (standard section in Germany) which in Belgium is an equivalent of the base of the Fa2d (Streel, 1986). In the Rudny-Altai area, the "Tarchanskaya suite" and in the Saian-Altai, the "Bystryanskaya and Altaiskaya suites" are regarded as equivalents of the Zavolz/Malev on the basis of miospores studies (Grishina, in Vakhrameev et al., 1978, p. 40). They yield remains of *Archaeopteris*, *Cyclostigma kiltorkense* and *Pseudolepidodendropsis carneggianum* (Ananiev in Vakhrameev et al., 1978) which are representative of the L-1 plant assemblage of Meyen (1982) and they are more or less equivalent of the Tunheim Series. The overlying L-2 assemblage recorded in the Minusa basin contains along with remains of several lycopods, *Aneimites acadica* and three species of *Adiantites* (Ananiev, 1979; Meyen, 1982). Occurring above the *lepidophytus* spore assemblage it is Carboniferous in age.

The stratigraphic extension of *Cyclostigma kiltorkense* needs further comments. According to Schweitzer (1969) the Siberian specimens together with the material of Bear Island are the only ascertained occurrence of *C. kiltorkense* outside the type-locality of Kiltorcan. Recently remains of the species have been recorded also from two localities of Southeastern and South China, in the Legutai Member of the Wutong Formation of the lower Yangtze valley (Li Xingxue et al., 1984) and in the Oujiachang Member of the Xuefeng Formation of Hunan (Huang Daxin, 1978; see also Hou, 1986). The fossils in this last member are mainly fishes and plants; they occur together with *R. lepidophyta* and are Strunian in age. In the Legutai Member on the contrary the exact age of *C. kiltorkense* is not known. On the one hand, the remains of the plant occur in a section at some one hundred kilometers from the nearest section

Figure 1. - Stratigraphical position of some uppermost Devonian macrofloras

1. Gillespie et al., 1981.
2. Pettitt & Beck, 1968; Gillespie et al., 1981.
3. Swartz, 1965; Streel & Traverse, 1978; Streel pers. communication, 1985.
4. Cross & Hoskins, 1951; Reinbold, 1984; Scott et al., 1984.
5. Gayer et al., 1973; Allen & Robson, 1981.
6. Utting & Neves, 1970; Higgs & Clayton, 1984.
7. Arber & Goode, 1915; Dolby, 1970; Higgs & Clayton, 1984.
8. Bridge et al., 1980; Matten et al., 1980.
9. Chaloner, 1968; Chaloner et al., 1977; Clayton et al., 1980.
10. Feehan, 1979; Keegan & Feehan, 1981.
11. Scott & Meyer-Berthaud, 1985.
12. Matten et al., 1978; Sleeman et al., 1983; Higgs & Clayton, 1984.
13. Streel in Bouckaert et al., 1970; Stockmans, 1948.
14. Unpublished.
15. Schweitzer, 1967; Kaiser, 1970; Streel, pers. communication, 1985.
16. Ishchenko & Sorokina, 1968; Vakhrameev et al., 1978.
17. Zalesky, 1931; Meyen, 1982.
18. Vakhrameev et al., 1978; Reitlinger et al., 1984.
19. Huang Daxin, 1978; Hou, 1986.
- 20, 21, 22. Petrosyan, 1968; Ananiev, 1979; Meyen, 1982.

of the same Member dated by spores and, on the other hand, the recorded spores suggest that the Legutai Member might cross the Devonian-Carboniferous boundary (see Streeel, 1986). However the plant might be actually restricted to the Strunian. It is not known below the PL zone and whether it crosses the Devonian-Carboniferous boundary at Kiltorcan, is still to be demonstrated. Its stratigraphically restricted record (already noticed by Schweitzer, 1969) is indicative of its index value for an upper subzone in Banks' floral assemblage zone VII.

Archaeopteris occurs together with *Cyclostigma kiltorkense* in the above mentioned plant remain assemblages. Members of the *Archaeopteris-Callixylon* group are overwhelmingly abundant throughout the whole Upper Devonian during which they were the dominant element of the flora (for references to localities, see Beck, 1981). In Belgium definite *Callixylon* has been collected recently in strata of the LV palynological zone (top of the Fa2d; Trooz quarry; unpublished). It is the youngest occurrence of the genus in the area. *A. latifolia* from the Oswayo Formation of Pennsylvania (Arnold, 1939) which is probably at the top of the Fa2d also (Gillespie *et al.*, 1981) is almost of the same age. Younger occurrence of the group in the Uppermost Devonian is indubitable but its persistence in the Lower Carboniferous is still depending on precise dating of critical localities as in the New Albany Shale and in the Kiltorcan Formation.

In Belgium, the oldest known occurrence of the *Archaeopteris-Callixylon* group is that of *C. velinense* Marcelle from the upper part of the "assise de Mazy" (Marcelle, 1951). The "assise de Mazy" is regarded as a lateral equivalent of the Fromelennes Formation which is now included according to Conodont data in the uppermost Givetian (Ziegler & Klapper, 1983). *C. velinense* has been found associated with remains referred to *Svalbardia avelinesiana* and *S. boyi* by Stockmans 1968. The status of these associated plants is far from clear. According to Stockmans (1968, p. 25) both species might be synonymous; moreover, as stressed by Carluccio *et al.* (1966), *S. boyi* shows close similarities to *Archaeopteris macilenta* and may be an *Archaeopteris*. Obviously, *S. boyi* specimens need revision.

In the Fa2c Evieux flora, remains of typical *Archaeopteris* are present in almost every plant locality (see Stockmans, 1948 who justifies his maintaining of *A. roemeriana* versus *A. hibernica*); concentrations of drifted logs of *Callixylon* are not rare. Fossils of the group occur also in the underlying Monfort Formation ("assise de Monfort" in Stockmans, 1948) that might be slightly older than the Evieux Formation. However, the Monfort Formation is strongly diachronous and partly still belongs to the VCo spore zone (as renamed by Streeel, in Paproth *et al.*, 1983) at several localities in the Ourthe Valley (Becker *et al.*, 1974) as well as in the Walheim area near Aachen (Kasig *et al.*, 1979). *Rhacophyton condrusorum* from the "assise de Mon-

fort" in the Walheim area (Schultka, 1978) might be of the same age as *R. condrusorum* in the type locality.

Rhacophyton is well represented in the Evieux flora but is not as widespread as remains of *Archaeopteris-Callixylon*. Despite the fact that these are mentioned together in floral lists they often occur in distinct strata or lenses in many localities of the Dinant Synclinalorium. As already pointed out by Leclercq (1951), *Rhacophyton* commonly depicts a botanical pure stand. Only sporadic remains of other plants are recorded in a *Rhacophyton* bed. Moreover these extraneous remains show definitely more obvious transportation than the *Rhacophyton* specimens. In the Hoyoux valley for example, the delicate remarkably well preserved *R. zygopteroides* still demonstrates organic connexion of all parts (Leclercq, 1951). It contrasts with the shaggy appearance of the rare detached fructification of *Eviostachya* (Leclercq, 1957) and the macerated aspect of the single Lycopod cone *Barsostrobus* found associated (Fairon-Demaret, 1977). *Rhacophyton* was growing nearer to the site of deposition than most of the other plants of the Fa2c assemblages as demonstrated by paleoecological studies in the Hampshire Formation of West Virginia by Scheckler (1986). The tightly facies-bound remains of *Rhacophyton* are not mentioned in deposits of the PL zone (see fig. 1). But the genus apparently persists in lowermost Carboniferous (Utting & Neves, 1970); the "Rhacophyton beds" in the Avon Gorge section yield many specimens which have not yet been systematically studied, together with a miospore assemblage which is regarded as representative of the VI zone (Higgs & Clayton, 1984).

The most evolutionary significant event in Banks' floral assemblage zone VII is the widely spread occurrence of seeds. They are known in and above the VCo miospore zone (see fig. 1) without break in the records during the whole uppermost Devonian. Recent studies (Chaloner *et al.*, 1977; Matten *et al.*, 1980; Gillespie *et al.*, 1981, for example) demonstrate their variety (radiospermic and platyspermic seeds) and complexity (cupule, integument, adnate nucellus); seed plants were already well established and diverse.

Figure 1 gathers all the above mentioned data; it is tentative and provisional and hopefully new data will allow future changes and greater precision.

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