

Proposed Substages	CONODONTS			MIOSPORES
	OLD ZONATION	STANDARD ZONATION		
LOWER CARB.	<i>S. sulcata</i>	<i>sulcata</i>		
UPPERMOST FAMENNIAN	<i>L. Protognathodus</i>	<i>praesulcata</i>	L	<i>R. lepidophytia</i> LOB
	<i>U. costatus</i>		M	
	<i>M. costatus</i>	<i>expansa</i>	E	<i>R. lepidophytia</i> FOB
	<i>L. costatus</i>		L	
UPPER FAMENNIAN	<i>U. styriacus</i>	<i>postera</i>	M	
	<i>M. styriacus</i>		E	
	<i>L. styriacus</i>	<i>trachytera</i>	L	
	<i>U. velifer</i>		E	
	<i>M. velifer</i>	<i>marginifera</i>	L	<i>R. macroreticulata</i>
	<i>L. velifer</i>		E	
MIDDLE FAMENNIAN	<i>U. marginifera</i>	<i>rhomboidea</i>	L*	<i>G. famensis</i> FOB
	<i>L. marginifera</i>		E	
	<i>U. rhomboidea</i>	<i>crepida</i>	L	
	<i>L. rhomboidea</i>		E	
LOWER FAMENNIAN	<i>U. crepida</i>	<i>triangularis</i>	L*	<i>K. dedaleus</i> FOB
	<i>M. crepida</i>		L	
	<i>L. crepida</i>		M	
	<i>U. triangularis</i>	<i>linguiformis</i>	E	
	<i>M. triangularis</i>		L	
	<i>L. triangularis</i>		M	
FRASNIAN	<i>U.* gigas</i>	<i>rhenana</i>	E	
	<i>U. gigas</i>		L	
	<i>L. gigas</i>		E	

Fig. 1-Proposal for Famennian Substages after Streeel et al., in press, their correlation with current and old conodont zones and the occurrence of a few selected miospores (FOB = well defined first occurrence biohorizon, LOB = well defined last occurrence biohorizon).

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Proposal for a Strunian Substage and a subdivision of the Famennian Stage into four Substages

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Strunian Substage

1. The Strunian is based upon the Etroeungt Limestone ("Calcaire d'Etroeungt") and was introduced by de Lapparent (1900, p. 860) and later considered as a Stage by Barrois (1913, p. 16) and Maillieux & Demanet (1929), This limestone was studied by Gosselet (1857) in the Parcq Quarry at Etroeungt near Avesnes (Department of the North, France) and has been

updated by Sartenaer & Mamet (1964). The Strunian has been widely used, following Gosselet's guide-line, for beds containing a transitional fauna between the late Devonian and the early Carboniferous (as understood before the latest modification of the Devonian/Carboniferous boundary). The Strunian has been mentioned and investigated in almost one hundred sedimentary basins on most continents. Its faunas and floras have been studied by various authors and, in some regions,

the Strunian has even been subdivided into two or three parts according to their fossil content or sedimentary facies. The latter are concerned with the Velbert Anticline (Bergisches Land, Germany: Paul, 1939), North Devon (England: Goldring, 1957) or, in the type area, the Dinant Synclinorium (Conil, 1964). Strata assigned to the Strunian may reach a thickness of 180 m to 430 m in Algeria or 100 to 260 m in Armenia. We believe therefore that the term Strunian is worth being properly defined and retained (Sartenaer, 1997).

2. In this paper we do not intend to review the many interpretations of the term Strunian in the literature. We will focus on the relevant micro-faunas and -floras available in the type area, in Belgium and northern France. We shall keep in mind that all the Devonian Stages are characterized by the first occurrence of microfossils (basically conodonts). Consequently it would be important to use the same kind of criteria to define the Substages.

3. Foraminifers, miospores, and to a lesser extent, conodonts and ostracods have been discovered in many localities across the Dinant Synclinorium. However, it is in the eastern part of Belgium, notably in the Ourthe Valley, a classical area for the lithostratigraphy of the middle and late Famennian, that these biostratigraphical data are the most reliable. Correlation between the Chanxhe section and the Tohogne borehole using the first occurrence and biometric analysis of the populations of *Retispora lepidophyta* (Fig. 1; Streeel, 1966; Bouckaert et al., 1978; Dreesen et al., 1993; Maziane et al. in press; Maziane, unpublished) shows the following relevant biostratigraphical events. In ascending order these are: 1) first occurrence of *R. lepidophyta*, 2) foraminifers of the Df3d Zone, associated with conodonts belonging to the Late expansa Zone including *Bispathodus ultimus*, 3) first occurrence of *Quasiendothyra kobeitusana* (Df3e Zone)

4. The same sequence of miospores and foraminifers is observed in the type area (Avesnois, northern France), at levels situated more than 100 m below the Etroeungt Limestone, i.e., near the base of the Epinette Shales (Fig. 2). For this reason Conil & Lys (1980) have defined the Strunian in the Avesnelles and Saint Hilaire sections (France), at the first occurrence (in unit i) of *R. lepidophyta*, followed by bilaminated *Eoendothyra* (*E. communis radiata* and *E. radiata*), characterized by a radial inner layer. Many carbonate microproblematica (*Kamaena* spp, *Menselina* spp, ...) occur at the same levels.

5. If the Df3d foraminifer Zone obviously belongs to the Late expansa Zone (see 3 above), it is still unknown whether the base of the *R. lepidophyta* Zone also belongs to the same conodont Zone, or better to the uppermost part of the Middle expansa Zone. The latter zone is found in the nearby Esneux railway section some 55 m below the Late expansa Zone. Therefore, unlike Conil & Lys (1980), we do not propose to define the lower boundary of the Strunian Substage in the Franco-Belgian shelf area by foraminifers or miospores, but instead we recommend that boundary be defined at the base of the Late expansa Zone in a pelagic facies. The various sections of the reference Franco-Belgian area should thus be used as either "parastratotypes" or "auxiliary reference sections".

6. Ziegler & Sandberg (1997) proposed the base of the Early expansa Zone to define the base of the highest Substage

of the Famennian. However this would be well too below the base of the Strunian and would prevent any possibility of correlating this Substage in the shelf areas around the world, due to the scarcity of stratigraphically significant foraminifers or miospores at this level. On the contrary, the successive appearances of *R. lepidophyta* and double-walled *Eoendothyra*, which approximate the base of the Late expansa Zone, have been found in shelf facies in many places around the world, particularly in central and eastern Eurasia. *R. lepidophyta* probably evolved from *R. macroreticulata*. The double-walled *Eoendothyra* evolved from single-wall *Eoendothyra* (Df3g Zone) and gave rise to true *Quasiendothyra* which are typical of the uppermost Devonian Df3e Zone. Elements of these sequences of bioevents have been controlled worldwide (Fig. 3). Other paleontological groups display major changes at this level, such as the *Rugosa* which radiate after their decline during the late Frasnian (Poty, in press). We now have a precise correlation between conodont and ichthyolith Zones in the pelagic facies. The *Phoebodus limpidus* Zone equates with the expansa + praesulcata Zones (Ginter & Ivanov, 1995, and in press).

Other Substages of the Famennian

7. Ziegler & Sandberg's (1997) suggestion to subdivide the Famennian Stage into three Substages only, would significantly change the current usage of the Middle Famennian in the Belgian type area. Sartenaer (1969) has reemphasized a long-standing (Mourlon 1882) Middle Famennian subdivision corresponding to the "Macigno de Souverain-Pré", i.e., approximately to the Late and Latest marginifera Zones. A subdivision of the Famennian Stage which took into account this widely used "Middle Famennian" subdivision would be appropriate to avoid confusion. However a Substage corresponding to only two conodont zones would unbalance the subdivisions of the Stage, therefore we recommend the definition of a Middle Famennian Substage between the base of the Early rhomboidea Zone and the base of the Latest marginifera Zone (Fig. 4).

8. Consequently, we propose that the Famennian Stage be subdivided into four Substages, Substage 1 (Lower Famennian), defined at the base of the Early triangularis Zone and composed of 7 conodont zones, Substage 2 (Middle Famennian), defined at the base of the Early rhomboidea Zone and composed of 4 conodont zones, Substage 3 (Upper Famennian), defined at the base of the Latest marginifera Zone and composed of 7 conodont zones and Substage 4 (Uppermost Famennian or Strunian), defined at the base of the Late expansa Zone and composed of 4 conodont zones. The base of the Middle Famennian is nearly coincident with the Condroz Event (Thorez & Dreesen 1986 and in press, Dreesen et al. 1988, Becker 1993). The base of the Middle Famennian and the base of the Upper Famennian, would more or less correspond respectively to the two major falls of sea-level noted in Ile by Johnson et al. (1986). The base of the Uppermost Famennian corresponds to a new transgressive system which, in the Franco-Belgian area, brings limy sediments containing foraminifers.

9. In conclusion, a subdivision of the Famennian into four Substages as proposed here above appears appropriate for the following reasons:

• a more accurate definition of the Strunian allows the retention of this historical concept which has been widely used for about one century;

• the Substage boundaries based on conodonts will allow long-distance correlation to be made and facilitate correlation between shelf carbonates and deeper water facies;

• the classical "Middle Famennian" of the type area in Belgium becomes a Substage in the new subdivision;

• the proposed pattern appears rather well balanced in terms of conodont zones.

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Fig 1 - 1.50
 - 2 - 1.51
 - 3 - 1.52
 - 4 - 1.52

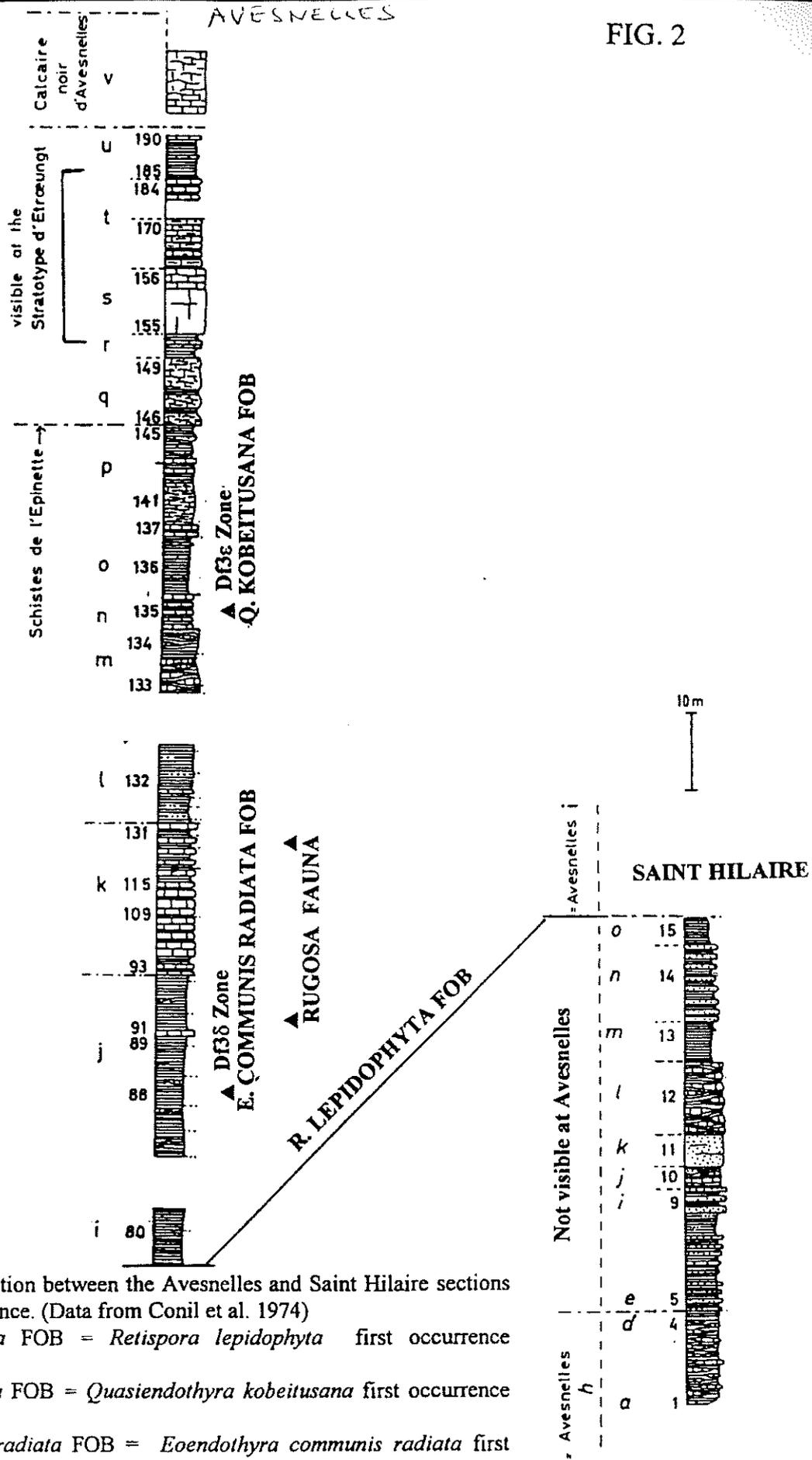


Fig. 2. Correlation between the Avesnelles and Saint Hilaire sections in northern France. (Data from Conil et al. 1974)

R. lepidophyta FOB = *Retispora lepidophyta* first occurrence biohorizon

Q. kobeitusana FOB = *Quasiendothya kobeitusana* first occurrence biohorizon

E. communis radiata FOB = *Eoendothya communis radiata* first occurrence biohorizon

Fig. 3. Geographical distribution of characteristic foraminifers and miospores of the Strunian Substage.

- ▲ = *Retispora lepidophyta* Zones
- ★ = *Quasiendothyra kobeitusana* Zone

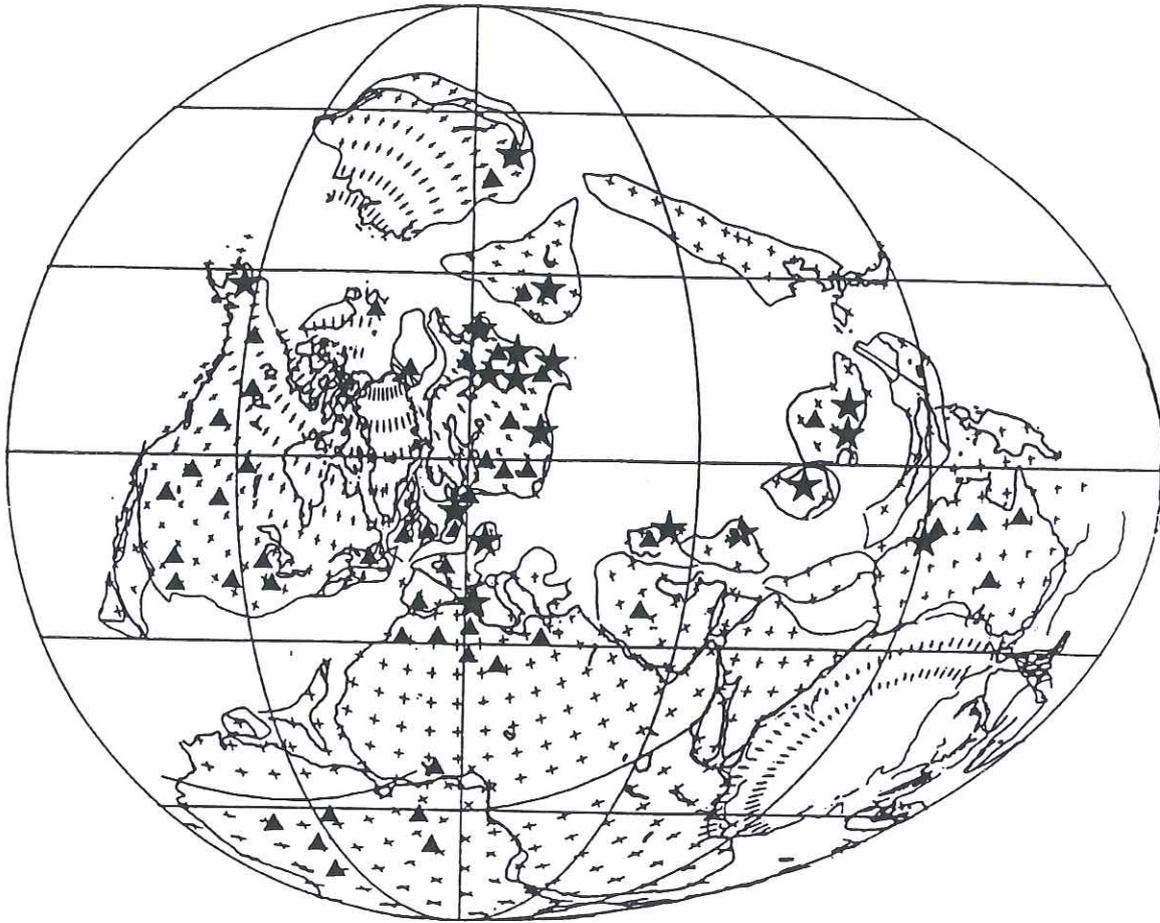


Fig. 4. Proposal for Famennian Substages and their correlation with current and old conodont zones.

FIG. 4

Proposed Substages	CONODONTS	
	OLD ZONATION	STANDARD ZONATION
LOWER CARB.	<i>S. sulcata</i>	<i>sulcata</i>
	<i>L. Protognathodus</i> 	<i>praesulcata</i>
UPPERMOST FAMENNIAN	<i>U. costatus</i>	<i>praesulcata</i>
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	<i>L. crepida</i>	<i>crepida</i>
	<i>U. triangularis</i>	<i>triangularis</i>
FRASNIAN	<i>M. triangularis</i>	<i>triangularis</i>
	<i>L. triangularis</i>	<i>triangularis</i>
	<i>U. gigas</i>	<i>linguiformis</i>
	<i>U. gigas</i>	<i>linguiformis</i>
	<i>L. gigas</i>	<i>linguiformis</i>
		<i>rhenana</i>
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