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MOLINIACIAN

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(6 figures)

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ABSTRACT. The Moliniacian is the basal division of the Viséan in Belgium (regional Substage). Its base is identified by the entry of the foraminifer *Eoparastaffella simplex* in the Salet road section and correlates with the base of the Viséan Stage. Its top is defined by the base of the Livian Substage and coincides with a major bentonite, the 'Banc d'or de Bachant'. It correlates with the late Chadian to Arundian of the British Isles and it provides a record of the final stage of the evolution of the Namur-Dinant Basin from a homoclinal ramp (in the Tournaisian) to a broad shelf of regional extend (end of the Moliniacian). It is characterized by varied facies reflecting different sedimentary environments across the basin and rich foraminifer and coral faunas that allow good biostratigraphic correlation. It is known from numerous sections in Belgium and Northern France.

KEYWORDS: Moliniacian, Viséan, Lithostratigraphy, Biostratigraphy, Sequence Stratigraphy, Palaeogeography.

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1. Name

Moliniacian (English), Moliniaciaan (Dutch), Moliniacium (German), Moliniacien (French).

2. Age

The Moliniacian is the basal Substage of the Viséan Stage (which had a duration of ~19 Ma according to Gradstein *et al.*, 2004) in Belgium (see Hance *et al.*, this volume). It lasted for ~5 to 7 Ma depending on the time scale used (maximum and minimum ages respectively, Menning *et al.*, 2001). In its original definition (Conil *et al.,* 1977) the Moliniacian included the uppermost Tournaisian and was therefore ~1.5 to 2 Ma longer (Menning *et al.*, ibid.). These figures are indicative, as available radiometric dates are scarce and poorly constrained stratigraphically.

3. Authors

The Moliniacian was introduced by Conil *et al.* (1977) in an attempt to replace the ambiguous old lithostratigraphical/chronostratigraphical notation (Tn1a, V1a, etc.). However, subsequent research showed the original definition was inadequate (Conil *et al.*, 1989; Conil *et al.*, 1991; Hance *et al.*, 1994; Lees, 1997). It was recently emended by Poty *et al.* (in press) to restore the coincidence between its base and the base of the Viséan.

The base of the Substage is now defined in the Salet section (Figs 1, 2) at the base of bed 124 (Fig. 3), in which the first *Eoparastaffella simplex* (foraminifer) is found. The boundary is included within the Leffe Formation (sensu Poty *et al.*, 2002). The Substage corresponds to the *Eoparastaffella* Zone (Cf4) of Conil *et al.* (1977). It is capped by a, locally pedogenized, bentonite of regional extend ('Banc d'or de Bachant', L1 of Delcambre, 1989) which coincides with the base of the Livian Substage (see Poty & Hance, this volume). The Sovet railway section (Fig. 1; Segura, 1967; Hance, 1988) is a parastratotype for the Moliniacian Substage.

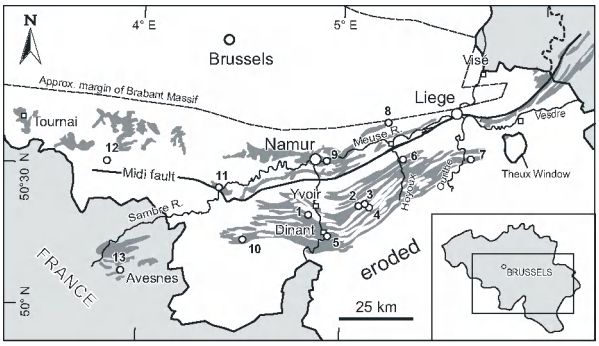

Figure 1. Location of the sections mentioned in the text. The shaded area represents Lower Carboniferous outcrops. 1. Salet; 2. Sovet; 3. Braibant; 4. Halloy; 5. Bastion; 6. Royseux; 7. Belle-Roche; 8. Vinalmont; 9. Beez-Lives; 10. Yves-Gomezée; 11. Landelies; 12. St.-Ghislain (borehole); 13. Godin.

Remark: In the present contribution, Poty *et al.* (2002) are followed for the formations names except where otherwise stated and sedimentation areas are sensu Hance *et al.* (2001).

4. Historical type area

The Moliniacian is named after the Molignée River, a tributary of the Meuse River, between the cities of Namur and Dinant. The stratotype is the section along the small road ('Rue des Bruyères') that runs from the N971 ('Rue de la Molignée') to the village of Salet, on the left flank of the Molignée valley, about 4 km WSW of Yvoir (Fig. 2).

Belgian Geological Survey reference number: BGS 166W91. Geological map n°166 (Bioul-Yvoir, 1908) and new geological map of Wallonia Anhée-Yvoir (53/3-4; in preparation).

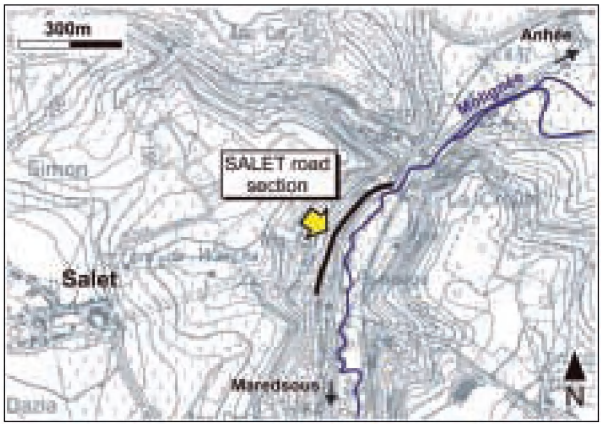

Figure 2. Location of the Salet road section, stratotype of the base of the Moliniacian.

5. Description

The stratotype exposes a complete section of the Moliniacian in the central part of the Dinant Sedimentation Area (DSA) where it is at its thickest in the Namur-Dinant Basin (265 m). Its base is taken at the base of bed 124 in the upper part of the Leffe Fm (15m below its top; Fig. 3). The Substage encompasses the Molignée Fm (55 m), the Salet Fm (76 m) and the relatively poorly exposed and partly dolomitized Neffe Fm (119 m). Dark violet-grey wackestones, commonly cherty and almost devoid of macrofauna, constitute the dominant facies of the Moliniacian part of the Leffe Fm. The passage to the overlying Molignée Fm (bed 162) is gradational. The Molignée Fm consists of alternating thin-bedded (centimetric to decimetric), black mudstones to packstones and fine-grained, sorted grainstones, and thicker

Figure 3. Base of the Moliniacian in the Salet road section, stratigraphical top toward right of picture. Hammer for scale (photography by L. Hance).

bedded (decimetric to metric), dark-grey mudstones to wackestones (Fig.5). The thick-bedded units are made of a facies very similar to that of the Leffe Fm and locally contain chert. The Molignée Fm is also extremely poor in macrofauna. The overlying Salet Fm (sensu Poty *et al.*, 2002; bed 295) consists of medium-bedded, light-grey to grey bioclastic pack- to grainstones, partly dolomitized in the upper part (first 'V2a sequence' of Conil & Naum, 1977). A limestone conglomerate with centimetre-scale clasts of various lithologies, including dolomite, occurs at the base. Macrofauna is rare. The Neffe Fm (sensu Poty *et al.*, 2002; bed 481) is thick-bedded. Light-grey medium to coarse-grained bioclastic grainstones constitute the dominant facies. Finer-grained facies develop in the upper part, and locally contain oncoids and stromatolites. The 'Banc d'or de Bachant' (L1 of Delcambre, 1989) is present at the top of the Neffe Fm.

6. Historical background

The Moliniacian was considered until recently as the first *Stage* of the Viséan *Series* (Conil *et al.*, 1991). Following the recent ratification of the Viséan as a *Stage* (Carboniferous period, Mississippian Epoch) by the IUGS Subcommission on Carboniferous Stratigraphy (Heckel, 2004), the Moliniacian is now considered as a *regional Substage*.

Its base was originally defined at the first thin beds (bed 52) of 'Black Marble' (black fine grained limestone typical of the Molignée Fm) appearing in the upper part of the Leffe Fm in the Salet road section (Conil *et al.*, 1977). That level corresponds approximately to the top of the *S. anchoralis europensis* local range (bed 54) and is about 2m below the entry of *Mestognathus praebeckmanni* (bed 60, Fig. 4) but is devoid of plurilocular foraminifer (Belka & Groessens, 1986; Conil *et al.*, 1989). It was first thought to correlate with the base of the Viséan in the Bastion section (Fig. 1; historical stratotype for the base of the Viséan; SCCS, 1969; see Hance *et al.*, this volume for a

summary) where *Eoparastaffella* and *Gnathodus homopunctatus* appear.

After reinvestigations in the Bastion section and the discovery of a previously unknown part of the Salet section with plurilocular foraminifers and conodonts previously thought to be limited to the Viséan *below* the base of the Viséan ratified in 1969, Conil *et al.* (1989) proposed a different correlation between the Viséan and Moliniacian stratotypes, shifting upward the base of the Viséan up to bed 124 (not 123 as reported by Conil *et al.* 1989 and previous papers) in the Salet section, where the first *Eoparastaffella simplex* is found. As a consequence, the lower 19 metres of the type-Moliniacian, included between the base of bed 52 and the top of bed 123 were now assigned a late Tournaisian age (Fig. 4). Conil *et al.* (1989) solved the zonation problem by splitting the Cf4α Zone, covering the whole Moliniacian in the original definition (Conil *et al.*, 1977), into two subzones, Cf4α1 and Cf4α2 for its Tournaisian and Viséan parts respectively. However, they did not modify the definition of the base of the Moliniacian.

Lees (1997) proposed the informal term 'Freyrian' for the interval comprised between the base of the Moliniacian and the base of the Viséan. Devuyst & Hance (in Poty *et al.*, in press) emend the definition of the Moliniacian in order to restore its original coincidence with the base of the Viséan. The new lower boundary is defined at the base of bed 124 in the Salet stratotype, where *Eoparastaffella simplex* is first recorded (Fig.4). The Sovet railway section (DSA, Fig. 1; Conil, 1967; Segura, 1973; Hance, 1988) yields the most complete and fossiliferous succession (foraminifers, conodonts) straddling the T-V boundary known so far in the Franco-Belgian Basin but the transitional beds are dolomitic (Devuyst and Hance unpublished data). It is proposed as a parastratotype for the base of the Moliniacian by Devuyst & Hance (in Poty *et al.*, in press).

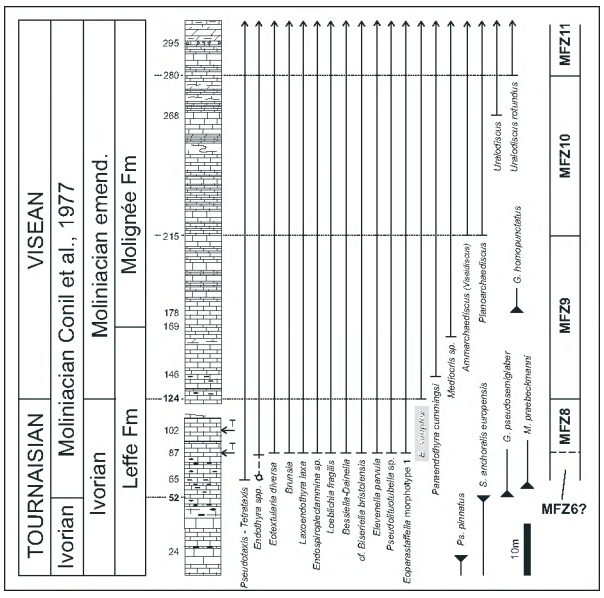

Figure 4. Biostratigraphy of the early Moliniacian in the stratotype, the Salet road section. Conodont data from Belka & Groessens (1986) and Conil *et al.* (1989). MFZ : Mississippian Foraminifer Zone of Hance and Devuyst in Poty *et al.* (in press) ; T: tempestite ; G : *Gnathodus* ; Ps : *Pseudopolygnathus* ; S : *Scaliognathus* ; M : *Mestognathus*.

7. Lithology

The Moliniacian is characterized by a wide range of lithologies, reflecting very different sedimentary environments, from the proximal peritidal facies of the Terwagne Fm to the outer-ramp/restricted basinal facies (~100-200 m) of the Leffe and Molignée Formations.

Variation from the type sequence in the central part of the DSA (see point 5) can be summarized as follows (Fig. 6):

In the northern part of the DSA, at the shelf edge, in the Sovet-Braibant area, the Moliniacian is 217 m-thick. It comprises the Sovet Fm except its lowermost part (121,5 m), the Terwagne Fm (25.5 m) and the Neffe Fm (70 m). The Sovet Fm is restricted to the platform margin while the Molignée Fm is developed only in the central part of the DSA between the prograding platform and the Waulsortian complex (Hance *et al.*, 2001). The Sovet Fm is composed mainly of dark-coloured medium-bedded bioclastic packstones to grainstones and subordinate dolomite, devoid of cherts. Reworked ooids are abundant in the lower part and a metre-thick limestone conglomerate with centimetric to decimetric clasts of various facies occurs at the base of the Moliniacian. The Braibant Mb. (sensu Poty *et al.*, 2002) forms the upper part of the formation. It consists of thick-bedded, bioclastic dolomites overlain by thick-bedded, pale to white, bioclastic pack- to grainstones with ooids, intraclasts and lithoclasts. Macrofauna is present in the upper half of the formation (brachiopods, corals).

In the Namur Sedimentation Area (NSA), the Moliniacian succession is incomplete and much thinner (~ 70 m). There is a stratigraphical gap corresponding to the lowermost Viséan between the Terwagne / Neffe formations and the Ivorian Longpré Fm. In the Avesnes Sedimentation area (ASA), the succession is similar to that observed in the NSA, with the Terwagne (92 m) and Neffe (50 m) formations resting directly on the late Ivorian Godin Fm, a lateral equivalent to the upper part of the Longpré Fm. The Terwagne Fm is developed only on the platform top and margin (NSA, CSA, northern DSA and ASA). In all areas, it is characterized by varied peritidal facies, ranging from fenestral mudstones to fine-grained oolitic or peloidal grainstones. Thin bioclastic beds occur in the upper part. The formation is dolomitized locally and brecciated in the eastern part of the CSA (Belle Roche Breccia). The Neffe Fm display similar characters throughout the Franco-Belgian Basin with thick-bedded, light-coloured pack- to grainstone facies.

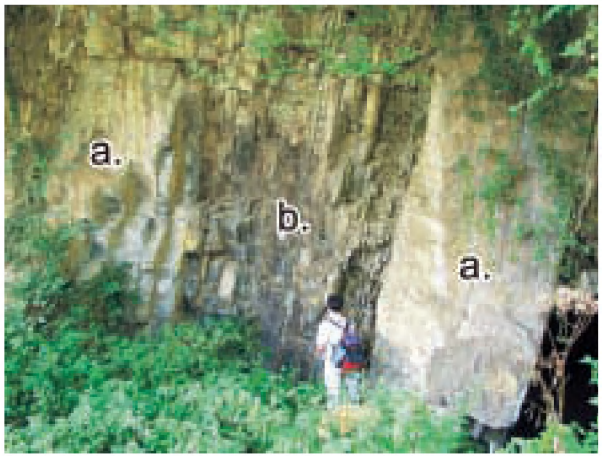

Figure 5. Molignée Fm in the Salet road section at the level of bed 215 showing the alternating thicker bedded (a) and thinner bedded units (b) (photography by G. Forbes). See text for explanation.

In the rapidly subsiding Hainaut Sedimentation Area (HAS), the Moliniacian is best known in the sub-surface in the St-Ghislain borehole where it has its maximum known thickness in the Franco-Belgian Basin (~600 m). The succession was misinterpreted by Groessens *et al.* (1982). The succession included between -2950 m and -3653 m (Dolomies et Calcaires de la Dendre Fm) is here assigned to the late Ivorian (MFZ7-MFZ8 of Devuyst & Hance in Poty *et al.*, in press) and not to the lower Viséan. The specimens of the conodont *Scaliognathus anchoralis* found at -2927 m are not reworked but in agreement with a late Tournaisian age. The base of the Viséan is not precisely located to date but the Moliniacian encompasses part of the Calcaire de Basècle Fm (black argillaceous mudstones to packstones with cherts and thin bioclastic grainstones in the lower part and slumps, 'black marble' levels and conglomerates in the upper part) and a lateral equivalent to the Calcaires d'Ecacherie-Thieusies Fm which is characterized by abundant evaporites and breccias (Groessens *et al.*, 1982).

8. Sedimentology and palaeogeography

During the Moliniacian, Belgium was located in the inter-tropical zone south of the palaeo-equator and carbonate production was active around the London-Brabant Massif. The Namur-Dinant Basin was located on the S-SE margin of the massif in a back-arc extensional setting (see Hance *et al.*, 2001 and Hance *et al.*, this volume).
The Moliniacian Substage includes sequences 5, except its lowermost part, and 6 of Hance *et al.* (2001). This interval is characterized by drastic lateral facies changes in the Namur-Dinant Basin, as a result of the topographic irregularities inherited from the late Tournaisian and due to the development of the Waulsortian complex in the South (Lees, 1997) and to the progradation of the platform margin toward the basin centre in the North (Fig. 6). By the end of the Moliniacian a wide and shallow platform extended over S-SE Belgium and adjacent countries and only a small residual depression remained in the central DSA (Hance *et al.* 2001).
Sequence 5 is recorded only in the DSA due to the drastic late Tournaisian sea-level drop and resulting basinward shore-line migration. It is mostly missing on the platform but it is possible that the lowermost part of the Terwagne Fm – restricted lagoon and tidal-flats - in the CSA is a lateral equivalent of the Braibant Mbr (high-energy shelf-margin barrier). Because of the absence of biostratigraphic guides at that level in the Terwagne Fm this is difficult to prove. The lowstand systems tract (LST) is well characterized in the lower part of the Sovet Fm – distal to proximal slope - in the Sovet section. It is more difficult to recognize in other part of the basin. The lower half of the Sovet and Molignée (restricted residual basin) Fms is attributed to the transgressive systems tract (TST) while the Higstand Systems Tract (HST) is thought to be represented by the Braibant Mb of the Sovet Fm and by the upper part of the Molignée Fm, from the thickest black marble unit upward. Mega-clinoform progradation can be recognized in the Sovet Fm by the stacking of major parasequences.
Sequence 6 marks a major flooding of the platform and subsequent progressive smoothing of the topographical irregularities of the basin. Schematically, after deposition

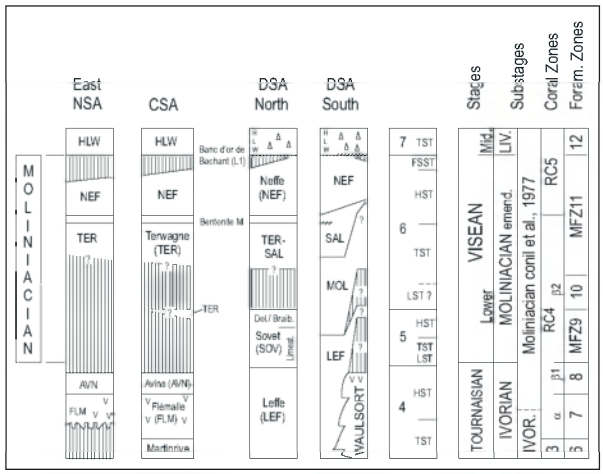

Figure 6. Interpretative chronostratigraphic diagram of the late Tournaisian and early Viséan of the Namur-Dinant Basin. 3rd order sequences after Hance *et al.* (2001) and biozones (corals and foraminifers) from Poty *et al.*, in press. LST, lowstand systems tract; TST, trangressive systems tract; HST, highstand systems tract; FSST, falling stage systems tracts (sensu Plint & Nummedal, 2000); Dol./Braib., dolomite and Braibant member; HLW, Haut-le-Wastia Mbr (basal member of the Lives Fm); Limest., limestone member of the Sovet Fm; LIV., Livian; MOL, Molignée Fm; SAL, Salet Fm.

of sequence 5, the Braibant ridge (Hance, 1988) separates the platform-top Terwagne Fm from the open marine – mainly slope facies - Salet Fm, both formations attributed to the TST of sequence 6. The Neffe Fm – mainly shallow high-energy facies – is interpreted as the HST and its upper part recently as a Falling Stage Systems Tract (FSST, equivalent to a late HST) by Pirotte (2005). The stacking pattern of the sequence is characterized by aggradation in the TST, evolving progressively to progradation in the HST and late HST. In its upper part the Neffe Fm is highly progradational. The sequence boundary is marked by a bentonite ('Banc d'or de Bachant') and pedogenic alteration of the upper few metres of the Neffe Fm (Fig. 6).

9. Palaeontology

9.1 Foraminifers

The Moliniacian emend. correlates with zones MFZ9 to 11 of Devuyst & Hance in Poty *et al.* (in press) and Cf4α2-δ subzones of Conil *et al.* (1991). Its base coincides with that of the Viséan and is identified by the entry of *Eoparastaffella simplex*. Foraminifers are abundant and diversified throughout the substage. Most of the rich microfauna of the latest Tournaisian MFZ 8 persists in the Moliniacian.

All the foraminifers (except *Tetrataxis* and *Eotextularia*) observed in the Salet section in the early Moliniacian are allochtonous and were brought to the basin by downslope transport resulting from high-energy events (Lees, 1997). These events are recorded as thin-bedded, fine grained, sorted packstones-grainstones with foraminifers. Below bed 124 there are two such levels (bed 87 and 102), the lower containing the richest fauna (Fig. 4). Above bed 124 these levels become common and the foraminifer record is much more continuous (Hance, 1988). There is therefore an uncertainty regarding the exact position of the base of the Viséan in the section but it is small. The situation is identical across the DSA and the boundary interval is missing in the shallower CSA-NSA (Hance *et al.*, 2001).

MFZ9 is best documented in the Sovet Fm. *Eoendothyranopsis donica robusta* enters in the middle part of the zone and *Eostaffella* spp. in the upper part. In addition to these index taxa, the genera *Pseudolituotubella, Spinobrunsiina, Bessiella, Florennella, Endothyra, Latiendothyranopsis* and *Globoendothyra* have numerous representatives.

MFZ10 corresponds to the lower and middle parts of the Cf4β Subzone of Conil *et al.* (1977, 1991). Its base is defined by the entry of the first primitive *Planoarchaediscus* and *Ammarchaediscus* (senior synonym of *Viseidiscus*). *Glomodiscus* and primitive *Uralodiscus* enter higher in the zone. This evolutionary sequence is well documented in the Molignée Fm of the Substage stratotype (Salet road section). Most of the taxa present below coexist at this level.

The MFZ11 Zone includes the upper part of the Cf4β Subzone and the Cf4γ–δ subzones of Conil *et al.* (1977, 1991). The guide for the base of this zone is *Uralodiscus rotundus. Latiendothyranopsis menneri solida* enters in the middle part of the zone. MFZ11 cannot be identified in the CSA and NSA where the restricted shallow water facies of the Terwagne Fm contain a poorly diversified foraminifer association, lacking archaediscids. In the DSA, MFZ11 records the last occurrences of 'typical Moliniacian taxa' including *Eotextularia diversa, Pseudolituotubella, Paraendothyra, Granuliferella, L. menneri solida, Spinoendothyra, Endospiroplectammina conili/venusta, Laxoendothyra laxa, Loeblichia fragilis, Eoparastaffella, Florennella, Bessiella, Dainella* and *Uralodiscus*.

9.2 Conodonts

In contrast to the foraminifers, conodonts are much less diversified and useful for biostratigraphy in the Moliniacian than in the Ivorian, as numerous taxa became extinct in the late Tournaisian. The distribution of conodonts in the stratotype is given by Belka & Groessens (1986) and reviewed in Conil *et al.* (1991) for the Tournaisian-Viséan transition. The base of the Moliniacian emend. falls 17 m below the cryptic entry of *Gnathodus homopunctatus* and about 16m above the last *Scaliognathus anchoralis europensis* and the entry of *Mestognathus praebeckmanni* in the Salet road section (Fig. 4). In the Bastion section, *G. homopunctatus* is reported less than 1 m above the base of the Viséan (Conil *et al.* 1991).

Conodont data for the Middle Moliniacian are scarce. *Gnathodus cracoviensis and G. austini*, typical Arundian taxa, are found at short distance above the entry of primitive archaediscids (Webster & Groessens, 1991; Conil *et al.*, 1991). The shallow water facies of the Salet, Terwagne and Neffe Fms. are unsuitable for conodonts and reconnaissance samples yielded only stratigraphically non-diagnostic gnathodids.

9.3 Rugose corals

The Moliniacian comprises the Rugose Coral Zones RC4β2 and RC5α,β. The base of the RC4β2 Subzone correlates approximately with the base of the Moliniacian emend. It is characterized by the appearance of *Haplolasma* and *Axophyllum*, and the reappearance of the genus *Clisiophyllum*, which had disappeared with the Hangenberg event. The RC4α and the RC4β1 Subzones are now regarded as characteristic of the latest Tournaisian (Poty in Poty *et al.*, in press), but were previously considered as earliest Viséan (Conil *et al.* 1989, 1991).

The base of the RC5 Zone corresponds to the arrival of the genus *Siphonodendron* (*S. ondulosum*). In Belgium and northern France, *S. ondulosum* is known from the base of the Neffe Fm. *Dorlodotia briarti* was formerly considered as appearing a little before *S. ondulosum*, i.e. at the top of the Terwagne Fm (Poty, 1985; Conil *et al.* 1991), and therefore

considered as a guide for the RC5 Zone (ibid.). However, since then, *D. briarti* has been found lower, in the RC4 Zone, and therefore it cannot be considered any longer as characteristic only of the RC5 Zone, although it becomes common in the lower part of this Zone (RC5α Subzone in Belgium and northern France). Other significant species of the zone include *Siphonodendron martini* and *Axophyllum mendipense*, which appear in the RC5α Subzone, and *Corphalia mosae*, which is characteristic of the local RC5β Subzone in Belgium and Northern France.

9.4 Other fossils

Brachiopods (Chonetids, Productids, Spiriferids etc.) are common in the middle-late Moliniacian and have been the main zonal guides in the Lower Carboniferous until the advent of micropalaeontology (e.g. de Koninck, 1842-1844; Delépine, 1911; Demanet, 1958) but the origin – and therefore age - of specimens in old reference collections is usually not known with precision and a systematic revision is urgently needed. The Neffe Fm was for instance for long known as 'Calcaire à *Productus* (*Linoproductus*) *cora*'. Ammonoids are present but do not allow high-resolution biostratigraphy at these levels. Trilobites are extremely rare; only a few species are known (Hahn & Hahn, 1988).
The Molignée Fm ('Marbre noir de Dinant/Denée) is a "Lagerstätte" which yield an exceptionally well preserved but rare fauna, including notably large fishes, echinoids, brachiopods, molluscs, bryozoans, graptolites and cephalopods (Delépine, 1928; Fournier & Kaisin, 1928; Fournier & Pruvost, 1928; Demanet, 1929; Demanet, 1958; Mottequin, 2004).

10. Chronostratigraphy

Figure 6 gives the Foraminiferal and Coral Zonations used in Western Europe and their correlation with other biozonations. The Moliniacian correlates with foraminifer biozones MFZ 9 to 11 and coral biozones RC4 to RC5β (Poty *et al.*, in press). It is equivalent to the late Chadian (sensu Riley, 1995) and Arundian in the British Isles.

11. Geochronology

No radiometric dates are available for the Moliniacian in Belgium yet but work is in progress. Dating of zircon populations from bentonite levels M and L1 of Delcambre (1989) in the late Moliniacian is currently being attempted and first results are encouraging. The time scale used here for the Moliniacian is based on two dates obtained respectively from Germany and Eastern Australia (Menning *et al.*, 2000, 2001, see also Hance *et al.*, this volume for the base of the Viséan). However both dates are stratigraphically relatively poorly constrained (Menning *et al.*, 2000, 2001).

12. Structural setting

Moliniacian deposits in Belgium have been strongly affected by the Variscan Orogeny resulting from the collision between Laurussia and Gondwanna and intercalated microplates. The DSA and the CSA are included in the 'Dinant Synclinorium' that is part of the Ardenne Allochthon. The Lower Carboniferous formations and the Famennian siliciclastics constitute respectively the core of synclines and anticlines. The Ardennes Allochthon is thought to have been thrust 10 to 40 km northwards depending on position relative to the Brabant Massif (Hance *et al.*, 1999). The HSA and the northern part of the NSA belong to the Brabant Parautochthon (northern flank of the Namur 'Synclinorium'). The southern part of the NSA is exposed in thrust sheets distributed along the Midi fault. The Midi Fault thus separates outcrops belts which were once parts of the same depositional basin (Fig. 1). Hance *et al.* (2001) estimated the shortening due to folding in the 'Dinant Synclinorium' to be ~50%.

13. Important reference sections in Belgium and north of France

The Moliniacian is documented by numerous sections (Fig. 1), among the best are:

Dinant Sedimentation Area (DSA)
- Salet road section: *stratotype* (Belka & Groessens, 1986; Hance, 1988; Conil *et al.*, 1989 ; 1990; Hance *et al.*, 1994 ; Poty *et al.*, in press).
- Sovet railway section: *parastratotype* (Segura, 1973; Hance, 1988; Conil *et al.*, 1988; Poty *et al.*, in press).
- Bastion section and Lambert quarry (Conil, 1969; Conil *et al.*, 1988; 1989; Groessens & Noël, 1977; Hance, 1988).
- Halloy road and railway section and Braibant railway section (Hance, 1988 and references herein).
- Yves-Gomezée railway section (Conil *et al.*, 1974; Groessens, 1975).

Condroz Sedimentation Area (CSA)
- Belle-Roche quarry (Ourthe Valley, Groessens, 1975; Conil *et al.*, 1988)
- Royseux (Hoyoux Valley, Hance, 1988).

Namur Sedimentation Area (NSA)
- Landelies quarry (Mamet *et al.*, 1970; Groessens *et al.*, 1977).
- Beez-Lives road section (Hance, 1979).
- Vinalmont (Hance, 1982).

Hainaut Sedimentation Area (HAS)
- Saint-Ghislain borehole (Groessens *et al.*, 1982).

Avesnes Sedimentation Area (ASA)
- Godin quarry (Mansy *et al.*, 1989).

14. Main contributions

Conil *et al.*, 1977; Paproth *et al.*, 1983; Conil *et al.*, 1989; Conil *et al.*, 1991; Hance *et al.*, 1991; Lees, 1997; Poty *et al,* in press.

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