GEOLOGICA BELGICA
2024, Vol. 27/3-4, 155–192
https://doi.org/10.20341/gb.2024.009

Middle Devonian lithostratigraphy of Belgium

Julien DENAYER

Evolution & Diversity Dynamics Lab, Geology Department, University of Liège, allée du Six-Août, B18, 4000 Liège, Belgium; ***corresponding author:*** *julien.denayer@uliege.be.*

Marie COEN-AUBERT

D.O. Terre et Histoire de la Vie, Institut royal des Sciences naturelles de Belgique, rue Vautier 29, B 1000 Brussels, Belgium; mcoenaubert@naturalsciences.be.

Jean-Marc MARION

Evolution & Diversity Dynamics Lab, Geology Department, University of Liège, allée du Six-Août, B18, 4000 Liège, Belgium; jmmarion@uliege.be.

Bernard MOTTEQUIN

D.O. Terre et Histoire de la Vie, Institut royal des Sciences naturelles de Belgique, rue Vautier 29, B 1000 Brussels, Belgium; bmottequin@naturalsciences.be.

ABSTRACT

The revision of the lithostratigraphic scale of southern Belgium, based on the revised geological map of Wallonia and recent stratigraphic and sedimentological works, has led to the re-definition of 63 lithostratigraphic units for the Middle Devonian Series. Although most of the units described in the present overview are classical subdivisions of the Belgian lithostratigraphic scale, updates on their definition, boundaries and age were required and are provided herein. New terms are introduced for remarkable beds and facies. Groups are introduced to gather formations that are difficult to separate on geological maps, whereas some previously described formations are here retrograded to member status. The Middle Devonian units recorded the development of the carbonate factory in the Eifelian, interrupted by siliciclastic deposits followed by the development of a wide carbonate shelf during the Givetian. Reefs occur both in the Eifelian (offshore bioherms, biostromes on platforms) and in the Givetian (biostromes).
The vertical succession and lateral correlation of the lithostratigraphic units allow to reconstruct the evolution of the shelf from the early Eifelian to the demise of the carbonate shelf at the end of the Givetian.

KEYWORDS

Eifelian,
Givetian,
Couvinian,
limestone,
reef,
platform

Article history

Received 21.08.2024, accepted in revised form 14.12.2024, available online 31.12.2024.

1. Introduction

Since the pioneer works of Dumont (1832), Gosselet (1860, 1888) and Dewalque (1868), the Devonian lithostratigraphic scale was developed patiently through dating and correlations. The geological mapping program of the Belgian territory in the last 1800s and early 1900s produced a stratigraphic framework characterised by its precision such as the one proposed by Maillieux & Demanet (1929). The Middle Devonian attracted much attention for its numerous fossils and its large panel of building stones. Therefore, it was soon acknowledged that the Ardenne (southern Belgium and northern France) was a type area for the Middle Devonian succession. Couvin and Givet became important localities thanks to their nice and accessible outcrops and consequently gave their name to the Middle Devonian stages at the end of the 19th century, namely the Couvinian (disused nowadays) and the Givetian (e.g. Bultynck, 2006; Préat et al., 2006). Important works on the stratigraphy of the Middle Devonian succession are due to Maillieux (1938), Fourmarier (1954), Lecompte (1960), Tsien (1972), Errera et al. (1972) and Brice (1980, 2016). In the years 1960–1970, the search for a stratotype for the base of the Middle Devonian led M. Lecompte to a series of monographies on biostratigraphy, namely produced by Godefroid (1968), Tsien (1969) and

Bultynck (1970), which still serve today as references.

A lithostratigraphic scheme aiming at defining mappable units was published by Bultynck et al. (1991). Since this summary, new units were introduced on the revised sheets of the Geological Map of Wallonia (*Carte géologique de Wallonie*) at a scale of 1/25,000 and detailed in the explanatory booklets. The objectives of the present paper are to update and supplement the stratigraphic lexicon edited by Bultynck et al. (1991), Weddige (2000, tables R410dm00 and R412dm00) and Bultynck & Dejonghe (2002) through the compilation of the work produced by the geological cartographers and stratigraphers who worked on the Middle Devonian.

2. Geological settings

The Middle Devonian formations occupy a narrow band between the Ardenne s.s. and Famenne areas of southern Belgium and south of the Haine–Sambre–Meuse axis (Fig. 1, Mottequin & Denayer, 2024). In the Ardenne Allochthon, these formations crop out along the northern, south-eastern and southern limbs of the Dinant Synclinorium. The Middle Devonian also crops out in the Haine–Sambre–Meuse Overturned Thrust sheets (Belanger et al., 2012; Fig. 1), north of the Midi–Eifel Thrust Fault. Additionally, the Middle Devonian formations are present in the Theux Window (and Bolland drillhole) and in the Vesdre area. There are few Middle Devonian rocks known in the Brabant Parautochthon and the Campine Basin. In the latter area, they are only encountered in drillholes.

Strong and rapid variations in the lithological composition of the Eifelian succession occur along the southern limb of the Dinant Synclinorium (see Dumoulin & Blockmans, 2008; Denayer, 2019). Conversely, the Givetian succession is very regular along the southern limb of the Dinant Synclinorium, between Momignies near the French border and Hotton in the Ourthe River valley, with a greater lateral continuity of the sedimentary units (Tsien, 1971, 1974; Préat & Mamet, 1989).

3. Chronostratigraphy of the Middle Devonian

The division of the Middle Devonian into two stages has been acknowledged since d'Omalius d'Halloy (1862), based on lithological characteristics and fossil content. Historically, the lower part of the Middle Devonian was named Couvinian (*Couvinien*) and corresponds to the *système du calcaire de Couvin* of d'Omalius d'Halloy (1862, p. 512) (or *l'étage des schistes à calcéoles* of Gosselet, 1860, p. 46) that begins at the first carbonate unit ending the thick siliciclastic sequence of the Lower Devonian. These first carbonate beds are nowadays included in the latest Emsian since the Eifelian Stage was adopted by the International Commission on Stratigraphy at Moscow in 1984 (e.g. Ziegler & Klapper, 1985; Becker et al., 2020). The Givetian Stage—second stage of the Middle Devonian and corresponding to the traditional *calcaire de Givet* (d'Omalius d'Halloy, 1828, p. 162), *calcaire de Givet, ou calcaire à strigocephales* (Gosselet, 1860, p. 53) or *Calcaire à Stringocephalus burtini* of the literature—was established on the southern limb of the Dinant Synclinorium, though its top was

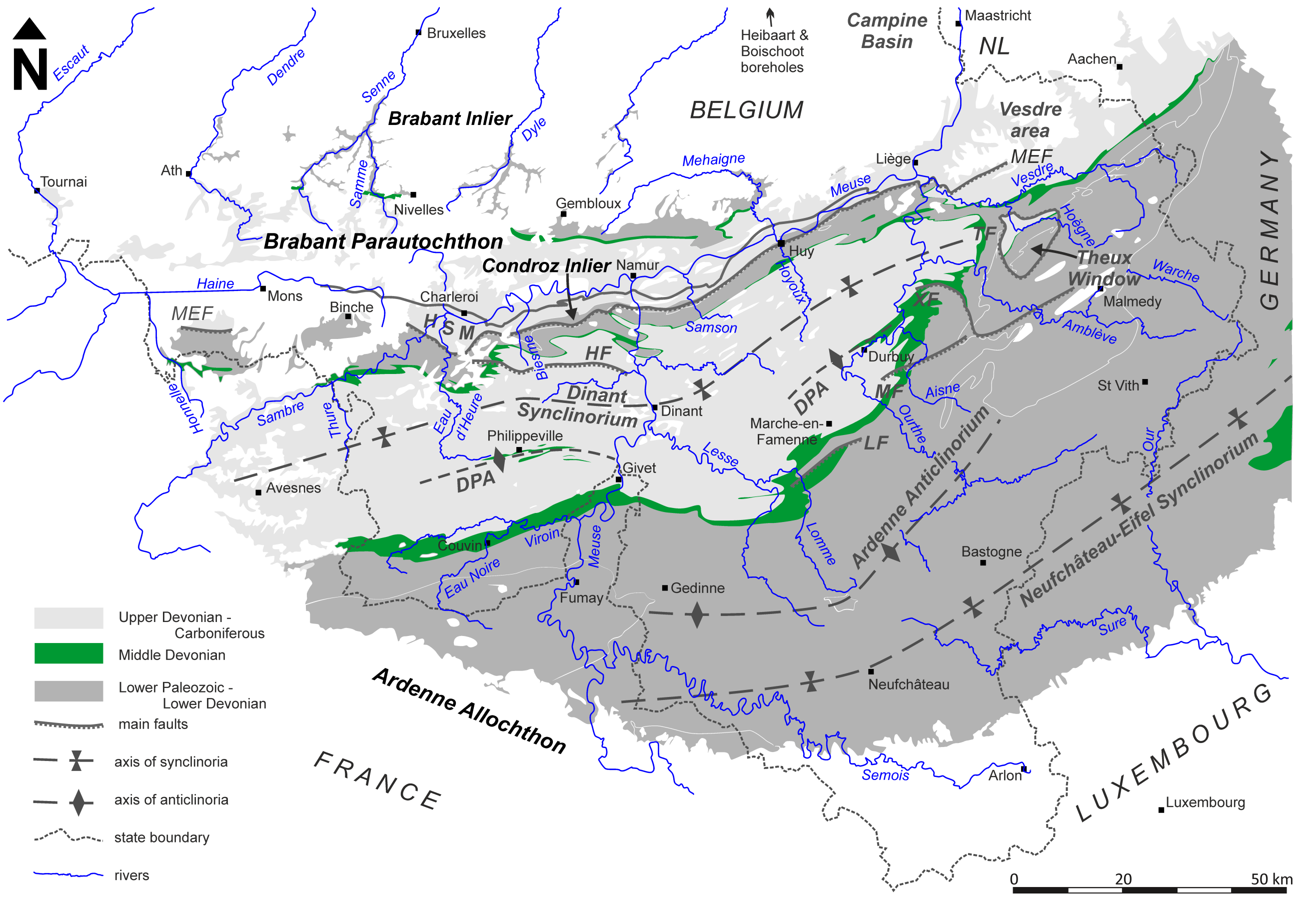

Figure 1. Simplified geological map of the Middle Devonian of southern Belgium and neighbouring countries (adapted from de Béthune, 1954), with indication of the main structural units, to the exception of most of the Caledonian inliers. Abbreviations: DPA, Durbuy–Philippeville Anticlinorium; HSM, Haine–Sambre–Meuse Overturned Thrust sheets. Major fault abbreviations: HF, Hanzinne Fault; LF, Lamsoul Fault; MF, Mormont Fault; MEF, Midi–Eifel Thrust Fault; TF, Theux Fault; XF, Xhoris Fault.

modified several times (see Bultynck, 1974).

In the Global Stratotype Section and Point (GSSP) of the Eifelian Stage situated at Wetteldorf (Germany, Eifel), the base of the Eifelian, and therefore that of the Middle Devonian Series, is situated at the base of the *partitus* conodont Zone, defined by the first appearance of the conodont *Polygnathus costatus partitus* (Weddige et al., 1979; Ziegler & Klapper, 1985); this subspecies was then given a specific status (e.g. Gouwy et al., 2013). In southern Belgium, this lower boundary is positioned within the upper part of the Eau Noire Member of the Moulin de la Foulerie Formation (Bultynck et al., 2000) (Fig. 2). A single occurrence of the marker taxon *P. partitus* is documented in the Grupont section (Bultynck et al., 2000), 7 m below the upper boundary of the Eau Noire Member, so its biostratigraphical value is not demonstrated in Belgium. However, *Icriodus retrodepressus* acting as a secondary marker for the base of the Eifelian, appears in the last 30 m of the Eau Noire Member in the type section in Couvin. On the northern limb of the Dinant Synclinorium, the first *I. retrodepressus* appears 18 m above the base of the Rouillon Member of the Rivière Formation (Bultynck & Boonen, 1976). Besides conodonts, the brachiopods prove to be useful markers, notably species of the *Arduspirifer arduennensis* group that disappear near the base of the *patulus* conodont Zone (base of the former Couvinian stage), and *Paraspirifer* (*P.*) *cultrijugatus cultrijugatus* that disappears near the base of the Eifelian Stage (Godefroid, 1977) (Fig. 2). A similar distribution is observed in the GSSP at Wetteldorf (Struve & Werner, 1982). Corals, though useful markers, have an insufficient resolution to mark the boundary (Denayer, 2024). The typical Eifelian taxa, notably *Heliolites porosus*, *Calceola sandalina*, *Acanthophyllum radiatum*, *Tabulophyllum lissingenensis* and cystimorph rugose corals, appear at different levels in the Emsian part of the Eau Noire Member (Fig. 3I–J, N).

Spores are less precise in positioning the lower boundary of the Eifelian Stage as the latter falls within the AP Interval Zone, between the acme zones of *Acinosporites kedoae* and *Acinosporites netterheimensis* (Streel et al., 1987). Nevertheless, the first occurrence of *Grandispora velata*, though slightly higher than the base of the *partitus* conodont Zone, can be used to approach the Emsian–Eifelian boundary (Streel et al., 2000).

The historical concept of the Givetian Stage in its historical type area has varied through time (Errera et al., 1972; Brice, 1980, 2016; Préat et al., 2006), notably the position of its base. The latter is defined at the base of the *Polygnathus hemiansatus* conodont Zone in the GSSP located at Jebel Mech Irdane in southern Morocco (Walliser et al., 1995). Due to facies unsuitable for the polygnathids across the Eifelian–Givetian boundary in southern Belgium, the use of *Icriodus obliquimarginatus* as a marker for the boundary was recommended by Bultynck et al. (2000). The first occurrence datum (FOD) of *I. obliquimarginatus* falls within the Hanonet Formation, 42 m below the top of the Formation in the Couvin area (Bultynck et al., 2000), in a darkish argillaceous limestone unit that also yielded *P. hemiansatus* (Bultynck & Hollevoet, 1999). This c. 10 m thick unit, situated at the base of the Hanonet Formation, yielded an unusual coral fauna (Fig. 4N) that was interpreted by Jamart & Denayer (2020) as a marker of the global Kačak Event.

Though the base of the Givetian is situated in the lower part of the Hanonet Formation, which was formerly considered as the top of the Couvinian in the Belgian literature, the entry of the typically Givetian fauna occurs near the base of the overlying Trois-Fontaines Formation. The latter yielded the brachiopods *Undispirifer givefex* (Fig. 4L), *Stringocephalus burtini* (Godefroid, 1995) and *Bornhardtina* spp. (Godefroid & Mottequin, 2005), the rugose corals *Beugniesastraea kunthi* (Fig. 4G) and *B. parvistella* as well as the last *Calceola sandalina* (Fig. 3N) (Coen-Aubert, 1988a, 2000a). These macrofaunas are particularly useful for the correlation of the Belgian Givetian with the contemporaneous succession of the Eifel Hills (Bultynck et al., 2000).

The spore *Geminospora lemurata* enters slightly above the base of the *hemiansatus* conodont Zone and serves as a good marker for the base of the Givetian in siliciclastic successions (Streel et al., 2000).

Neither the Eifelian nor the Givetian have been officially divided into substages, but proposals introduced by the Subcommission of the Devonian Stratigraphy for a two-fold Eifelian Stage and a three-fold Givetian Stage await ratification from the International Commission on Stratigraphy (Becker et al., 2020).

4. Geochronology

The Middle Devonian extends from 394.3 Ma to 378.9 Ma and is divided into two ages, Eifelian (394.3 Ma–385.3 Ma) and Givetian (385.3 Ma–378.9 Ma) (Becker et al., 2020).

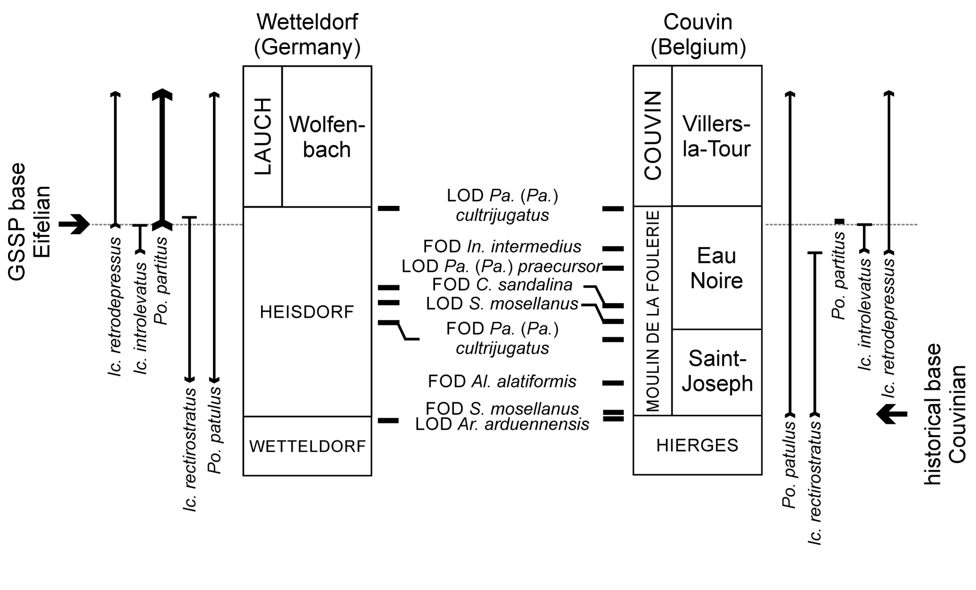

Figure 2. Correlation of the Emsian–Eifelian and Emsian–Couvinian boundaries in Germany (GSSP) and Belgium. Belgian conodont and brachiopod data after Godefroid (1968), Bultynck (1970), Bultynck et al. (2000) and Gouwy & Bultynck (2003b), German data after Weddige et al. (1979). Abbreviations: *Al.*, *Alatiformia*; *Ar.*, *Arduspirifer*; *C.*, *Calceola*; FOD, first occurrence datum; GSSP, Global Stratotype Section and Point; *Ic.*, *Icriodus*; *In.*, *Intermedites*; LOD, last occurrence datum; *Pa.*, *Paraspirifer*; *Po.*, *Polygnathus*; *S.*, *Sollispirifer*. Formations in capital letters, members in regular letters.

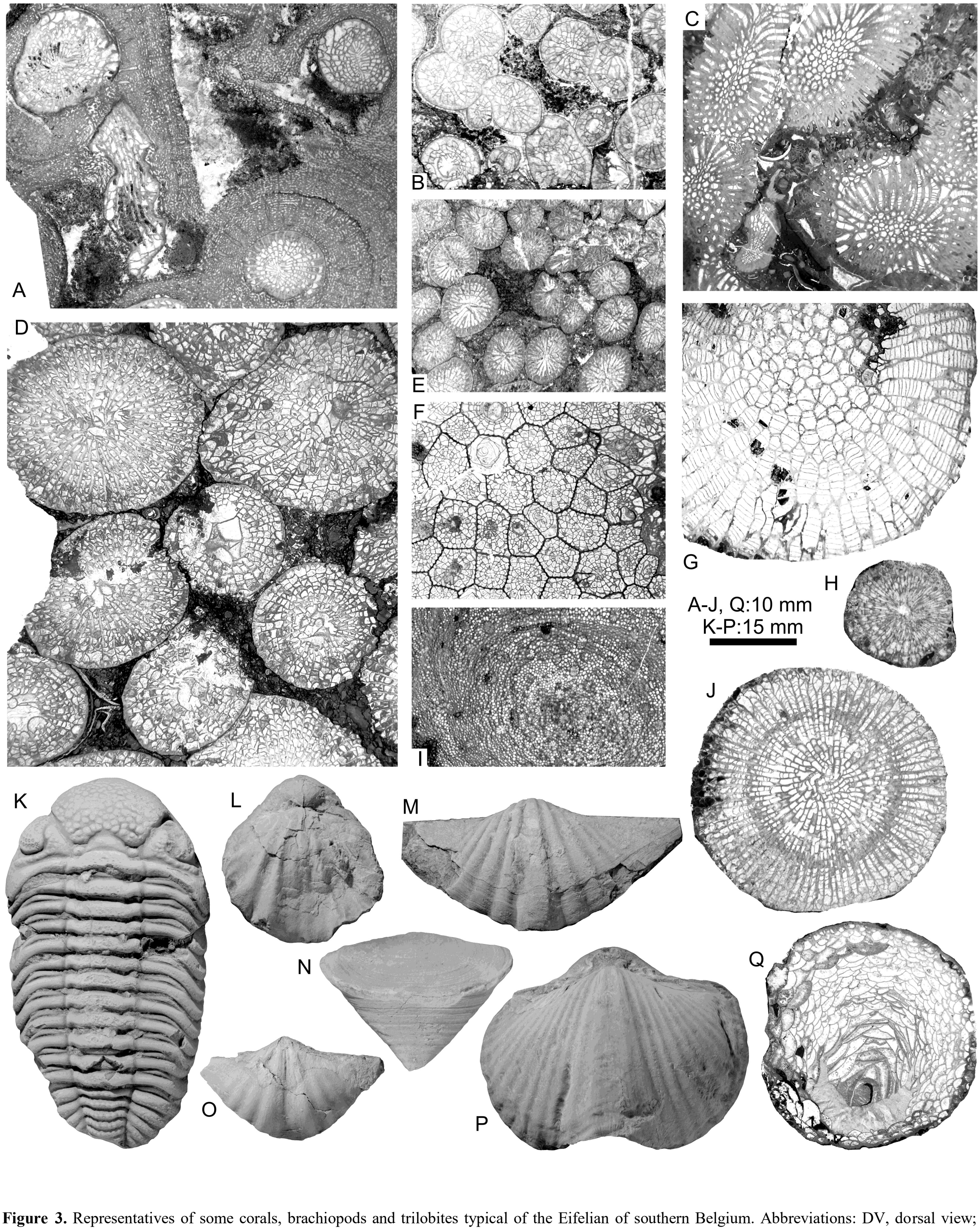

Figure 3. Representatives of some corals, brachiopods and trilobites typical of the Eifelian of southern Belgium. Abbreviations: DV, dorsal view; TTS, transverse thin section. **A.** *Sociophyllum rolfwerneri*, TTS (PAULg-CEII/c-1a); Petigny, Villers-la-Tour Member. **B.** *Fasciphyllum varium*, TTS (PAULg-CEI/1-9a); Petigny, Cul d'Èfer Member. **C.** *Thamnopora tumefacta*, longitudinal thin section (PAULg-WN-IV/1a); Wancennes, Wancennes Formation. **D.** *Mesophyllum vesiculosum*, TTS (PAULg-CEII/c-1a); Petigny, Cul d'Èfer Member. **E.** *Dendrostella rhenana*, TTS (PAULg-CEII/H-2); Petigny, Villers-la-Tour Member. **F.** *Spongophyllum* sp., TTS (PAULg-WPE-V/1); Wancennes, Wancennes Formation. **G.** *Favosites goldfussi*, thin section into hemisphaerical colony (PAULg-WLM/12); Les Marlières, Wellin Formation. **H.** *Stringophyllum inflatum*, TTS (VTR-I/14); Villers-la-Tour section, Villers-la-Tour Member. **I.** *Heliolites porosus*, TTS (PAULg-CouH/20); Haine quarry in Couvin, Hanonet Formation. **J.** *Acanthophyllum radiatum*, TTS (PAULg-VVM/2); Vierves-sur-Viroin, Couvin Formation. **K.** *Phacops sartenaeri*, sub-complete specimen in DV (RBINS a2613, holotype); Petigny, Jemelle Formation. **L.** *Pseudosieberella corrugata*, articulated specimen in DV (RBINS a173, holotype); Couvin, Jemelle Formation. **M.** *Intermedites* gr. *supraspeciosus*, sub-complete dorsal valve (RBINS a14022); Rochefort, Jemelle Formation. **N.** *Calceola sandalina*; external view (PAULg-20240205/1); Olloy-sur-Viroin, Chavées Member. **O.** *Intermedites intermedius*, partly exfoliated articulated specimen in ventral view (RBINS a9847); Couvin, Eau Noire Member. **P.** *Spinocyrtia ostiolata*, exfoliated articulated specimen in DV (RBINS a14023); Couvin, Jemelle Formation. **Q.** *Nardophyllum macrocystis*, TTS (PAULg-CouH/12); Haine quarry in Couvin, Hanonet Formation.

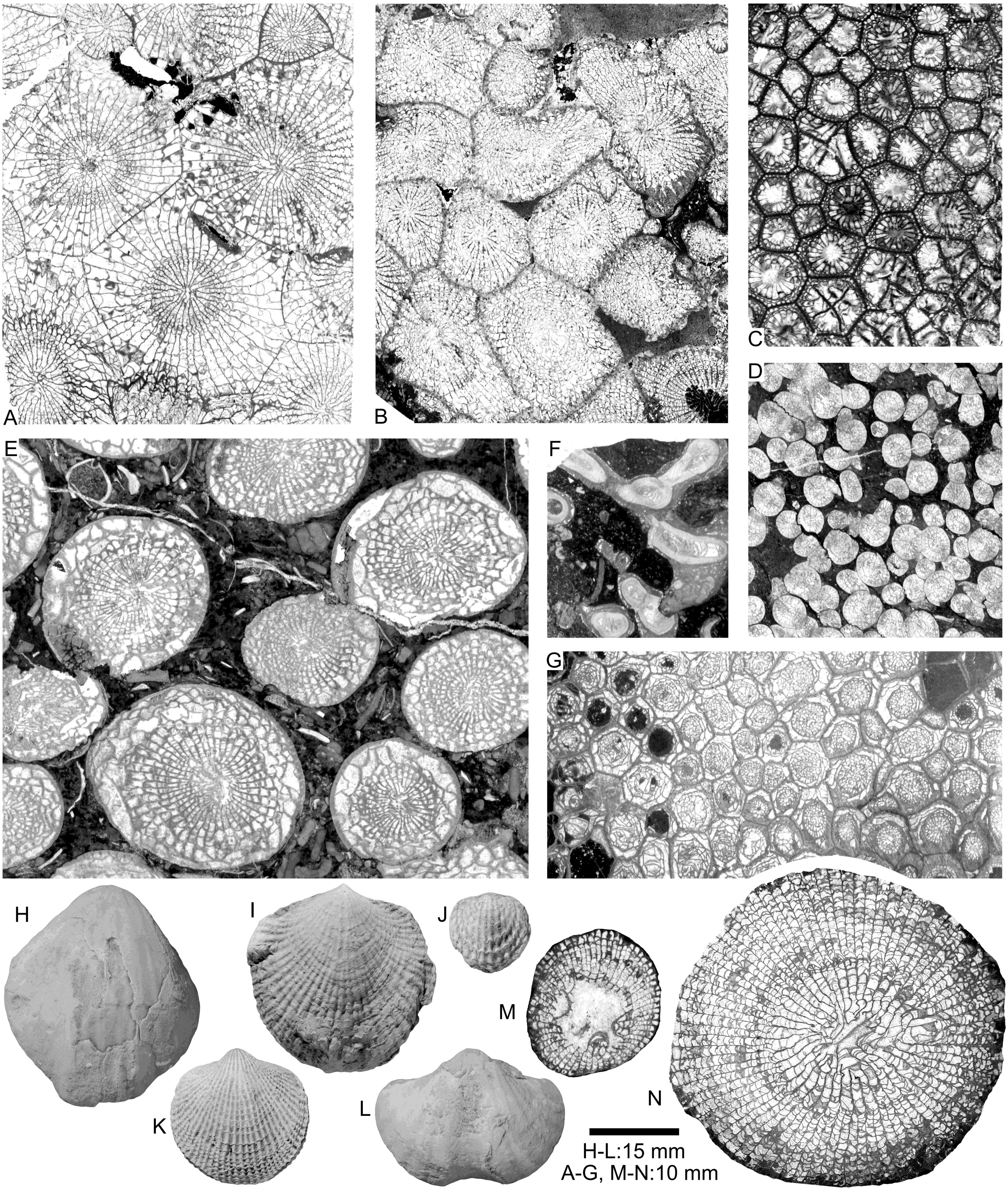

Figure 4. Representatives of some corals and brachiopods typical of the upper Eifelian and lower Givetian of southern Belgium. Abbreviations: TTS, transverse thin section; VV, ventral view. **A.** *Cyathophyllum multicarinatum*, TTS (PAULg-FdV-II/4); Fond-des-Vaux, Wellin Formation. **B.** *Xystriphyllum pachythecum*, TTS (PAULg-FdV-I/10b); Fond-des-Vaux, Wellin Formation. **C.** *Columnaria intermedia*, TTS (PAULg-MAR/6); Marenne quarry, Trois-Fontaines Formation. **D.** *Fasciphyllum conglomeratum*, TTS (PAULg-HH2001/1a); Hampteau quarry, Trois-Fontaines Formation. **E.** *Sociophyllum torosum*, TTS (PAULg-MAR/7-2); Marenne quarry, Trois-Fontaines Formation. **F.** *Remesia crispa*, longitudinal thin section (PAULg-CouH/1-1); Haine quarry in Couvin, Hanonet Formation. **G.** *Beugniesastraea kunthi*, TTS (PAULg-RES-IV/14a); Resteigne quarry, Trois-Fontaines Formation. **H.** *Gypidula abunda abunda*, partly exfoliated ventral valve (RBINS a10159); Pondrôme, Hanonet Formation. **I.** *Atryparia (Atryparia) instita*, articulated specimen in VV (RBINS a10200); Pondrôme, Hanonet Formation. **J.** *Invertrypa kelusiana*, articulated specimen in VV (RBINS a10212); Pondrôme, Hanonet Formation. **K.** *Spinatrypina* (*Spinatrypina*) *fontis*, articulated specimen in VV (RBINS a12039, holotype); Pondrôme, Hanonet Formation. **L.** *Undispirifer givefex*, articulated specimen in VV (RBINS a10243); Haine quarry in Couvin, Hanonet Formation. **M.** *Aristophyllum luetti*, TTS (PAULg-RES-III/9-2); Resteigne quarry, Hanonet Formation. **N.** *Heliophyllum halleri*, TTS (PAULg-RES2015-09-29/1); Resteigne quarry, Hanonet Formation.

5. Biostratigraphy of the Middle Devonian

Thanks to carbonate facies, the Middle Devonian strata yielded stratigraphically useful fossils such as conodonts, brachiopods and corals (Fig. 5). In more proximal areas, the palynomorphs are still of significative importance. Ostracods and other invertebrates prove to be of poor stratigraphical use due to the dominance of long-ranging species in the fossil assemblages (Coen, 1985).

5.1. Conodonts

The Middle Devonian conodont stratigraphy was explored by Godefroid (1968), Bultynck (1970, 1974, 1987), Bultynck & Boonen (1976), Bultynck & Hollevoet (1999) and Bultynck et al. (2000). A synopsis was published by Gouwy & Bultynck (2003a), covering the revised stratigraphic range of c. 80 conodont species covering the latest Emsian–earliest Frasnian interval. Few conodont standard zones are indeed identified in the Namur–Dinant Basin due to the lack of guide species. However, alternative guides have been used, allowing the recognition of some standard zones (e.g. icriodid alternative zonation of Bultynck, 1987, emended by Narkiewicz & Bultynck, 2010, Fig. 5). Therefore, the zonation is applied with some changes as the Eifelian *australis* conodont Zone and the Givetian *latifossatus/semialternans*, *hermanni–cristatus* and *disparilis* conodont zones are not recognised in Belgium (Gouwy & Bultynck, 2003a). However, Gouwy & Bultynck (2002) used graphic correlations with the Moroccan sections to project these conodont zones on the Belgian succession where they fall within the Fromelennes Formation.

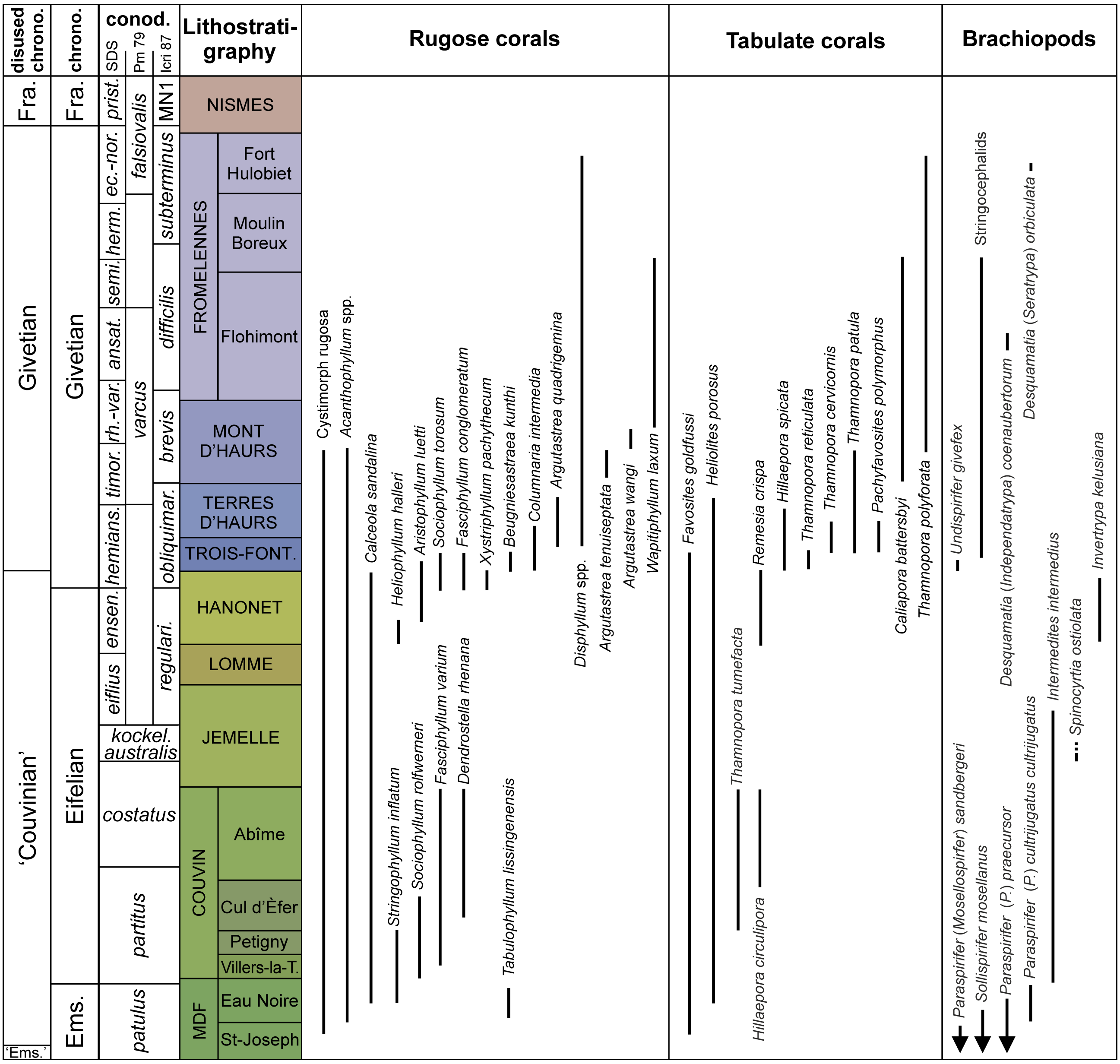

Figure 5. Biostratigraphic zonations (conodonts) of the Middle Devonian of the southern limb of the Dinant Synclinorium and range of selected corals (compilation from Bultynck et al., 1991, 2000, Boulvain et al., 2011, and Denayer, 2019) and brachiopods (compilation from Bultynck et al., 1991, 2000 and Godefroid, 1995). Formations in capital letters, members in regular letters. Conodont zones: SDS, standard conodont zone of the Subcommission on Devonian Stratigraphy (update after Becker et al., 2020); Pm 79, alternative polygnathid/mesotaxid zonation after Klapper & Ziegler (1979); Icri 87, alternative icriodid zonation after Bultynck (1987) emended by Narkiewicz & Bultynck (2010). Conodont zone abbreviations: *ansat.*, *ansatus*; *ec.-nor.*, *ectypus–norissi*; *ensen.*, *ensensis*; *hemians.*, *hemiansatus*; *herm.*, *hermani*; *kockel.*, *kockelianus*; *obliqui.*, *obliquimarginatus*; *prist.*, *pristina*; *regulari.*, *regularicrescens*; *rh.–var.*, *rhenanus–varcus*; *semi.*, *semialternans*; *timor.*, *timorensis*. Other abbreviations: chrono., chronostratigraphy; conod., conodont; Ems., Emsian; Fra., Frasnian; MDF, Moulin de la Foulerie Formation; Trois-Font., Trois-Fontaines; Villers-la-T., Villers-la-Tour.

5.2. Brachiopods

Though no official brachiopod-based stratigraphic scale exists, brachiopods allow detailed correlations notably across the Emsian–Eifelian boundary (Godefroid 1968, 1977), in the late Eifelian and across the Eifelian–Givetian boundary (Godefroid 1995), and at the top of the Givetian (Godefroid & Jacobs, 1986). Middle Devonian brachiopod faunas from the Namur–Dinant Basin are diverse (e.g. Asselberghs, 1923; Maillieux, 1938, 1940, 1941a, 1941b, 1942; Vandercammen, 1956, 1963; Godefroid & Mottequin, 2005; Mottequin & Godefroid, 2016; Mottequin, 2019; Jansen et al., 2025) and brachiopods (Figs 3L–P, 4H–L, 6, 7J–K) are particularly abundant in the mixed siliciclastic-carbonate facies. Nevertheless, the presence of massive limestone in many stratigraphic intervals generally precludes their systematic study due to difficulties extracting them from these rocks. In the Namur–Dinant Basin, Givetian rocks are characterised by the great development of the Family Stringocephalidae (Fig. 6A–G) whose shells are thick, commonly smooth and often very large. As indicated by Brice et al. (2008), many smooth and large stringocephalid shells, which form coquina beds in the Belgian Givetian, were probably erroneously identified as *Stringocephalus burtini* in the literature (Fig. 6A). As reflected by the former faunal lists and recent research (see references above), this family is much more diverse and includes several subfamilies that still require a thorough taxonomic study: Stringocephalinae (*Stringocephalus*, *Parastringocephalus*, *Newberria*, Fig. 6A–C, E), Rensselandiinae (*Chascothyris*, Fig. 6D), and Bornhardtininae (*Bornhardtina*, *Hessenhausia*, Fig. 6F–G). On the southern and south-eastern flanks of the Dinant Synclinorium, stringocephalids first appear slightly above the base of the Trois-Fontaines Formation, i.e. in the *hemiansatus* conodont Zone (Boucot et al., 1966; Préat & Tourneur, 1991a; Préat et al., 2006), and persist until the base of the Moulin Boreux Member (Fromelennes Formation) according to Coen & Coen-Aubert (1971) and Coen-Aubert (2004), i.e. the *rhenanus*/*varcus* and *ansatus* conodont zones (Fig. 5). On the northern margin of the

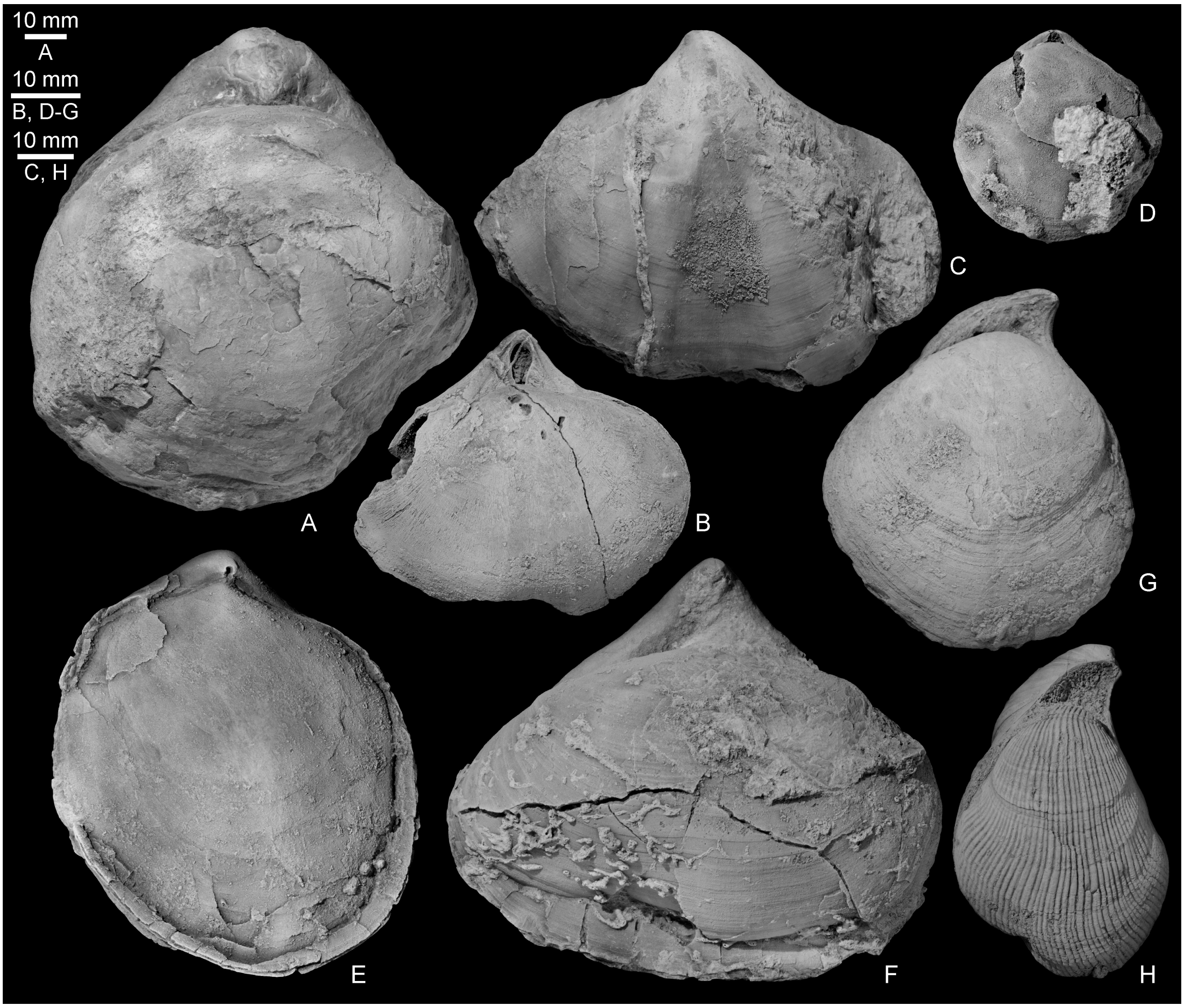

Figure 6. Representatives of the families Stringocephalidae (terebratulide brachiopods) and Uncitidae (possible athyridide brachiopods) from the Givetian of southern Belgium. Abbreviation: DV, dorsal view. **A.** *Stringocephalus burtini*, distorted articulated specimen in DV (CGF II.591); Arbre, Névremont Formation. **B–C.** *Parastringocephalus* gr. *dorsalis*. B. Incomplete articulated specimen in DV (RBINS a14026); Couvin, Trois-Fontaines Formation. C. Distorted articulated specimen in ventral view (RBINS a14027); Nismes (Les Abannets), Mont d'Haurs Formation. **D.** *Chascothyris*? sp., articulated specimen in DV (RBINS a14028); Jemelle, Trois-Fontaines Formation. **E.** *Newberria* sp.; distorted articulated specimen in DV (RBINS a14029); Olloy-sur-Viroin, Mont d'Haurs Formation. **F.** *Bornhardtina equitis*, slightly crushed specimen in DV (RBINS a12071, holotype); Marenne quarry, Trois-Fontaines Formation. **G.** *Bornhardtina* sp., articulated specimen in DV (RBINS a14030); Nismes (Les Abannets), Mont d'Haurs Formation. **H.** *Uncites* (*Uncites*) gr. *gryphus*, articulated specimen in DV (RBINS a14031); Nismes (Les Abannets), Mont d'Haurs Formation.

Dinant Synclinorium, stringocephalids are known from the Névremont and Le Roux formations (Delcambre & Pingot, 2018, a, b) as it is the case in the Haine–Sambre–Meuse Overturned Thrust sheets (Coen-Aubert, 1991a, 2004, 2019). In the Brabant Parautochthon, they are reported from the Bois de Bordeaux Group (Asselberghs, 1936; Lacroix, 1991a). In the Vesdre area, stringocephalids occur 11 m below the top of the Pepinster Formation, well above the Heusy Member (Dejonghe et al., 1991b), and disappear within the Le Roux Formation (D'Heur, 1970; Coen-Aubert, 1974). Their extinction at the top of the middle Givetian (*ansatus* conodont Zone), after a large-scale adaptive radiation (Sun & Boucot, 1999), is probably linked to the Taghanic Crisis according to García-Alcalde (in Brice et al., 2000). For Coen-Aubert (2004), it is likely that this singular event is recognised just above the last level yielding stringocephalids within the middle part of the Moulin Boreux Member. The possible athyridide genus *Uncites* (Fig. 6H) is characterised by its asymmetric, ribbed and elongate shell. It is restricted to the Givetian carbonate and reefal environments, notably those of the Trois-Fontaines and Mont d'Haurs formations (Maillieux, 1940) in southern Belgium. It was interpreted by Jux & Strauch (1966) as probably living in the spaces occurring between the reef builders.

5.3. Corals

The limestone yielded an abundant coral fauna from which many taxa have a significant stratigraphic interest (Coen-Aubert, 1988a, 1990a, 1996, 1997, 1998, 2000b, 2002, 2003, 2004, 2008, 2019; Coen-Aubert et al., 1991; Denayer, 2019, 2024). Many taxa with a rather short stratigraphic extension allow intra- and extra-basin correlations, notably in the early Givetian (e.g. Bultynck et al., 2000; Boulvain et al., 2011). Rugose coral-based biostratigraphy has not been formalised in the Middle Devonian of Belgium but stratigraphic ranges, notably of colonial genera, are useful for correlations (Figs 3A–J, Q, 4A–G, M–N, 7A–J). Coral zonation designed for the Rhenish Massif by Brühl (1998) and Lütte & Schröder (1998) is only partly applicable because of the facies-related distribution of some marker taxa. Rugose coral-based correlations are listed in Coen-Aubert (2000a).

5.4. Palynomorphs

The siliciclastic facies, in more proximal areas, still yield palynomorph assemblages of great stratigraphic value allowing the recognition of four Oppel zones and five interval zones between the early Eifelian and the Givetian–Frasnian boundary (Loboziak & Streel, 1980; Streel & Loboziak, 1987; Streel et al., 1987; Tourneur et al., 1989, see also de Ville de Goyet et al., 2007).

6. Evolution of the Namur–Dinant Basin during the Middle Devonian

The Namur–Dinant Basin belongs to the passive margin of the Laurussian continent during the Devonian. Its Cambrian–Silurian basement is visible in the so-called Caledonian Inliers (or massifs) of Belgium, namely the Brabant Inlier, north of the basin, and the Rocroi, Givonne, Serpont, and Stavelot–Venn Inliers in its southern part, whereas the Ordovician–Silurian Condroz Inlier occupies an intermediate position (Fig. 1, see also Mottequin & Denayer, 2024). By the end of the Early Devonian, fully marine conditions existed in the southern part of the basin, with the deposition of carbonate and mixed carbonate-siliciclastic sediments in the latest Emsian. The sedimentation was driven both by the palaeotopography of the basin and by eustacy. A carbonate platform developed in the Couvin area during the early Eifelian, whereas isolated reefs developed in the east of the Meuse River valley (Denayer, 2023). Both were separated by troughs that were subsequently filled with fine-grained siliciclastic material and displaying rapid changes of facies laterally (Dumoulin & Blockmans, 2008). The upper part of the Eifelian recorded fine-grained siliciclastic deposition in the southern areas of the basin and coarser-grained material in its northern part as the transgression reached the Condroz Inlier. Isolated reefs formed in the Chimay, Couvin and Wellin area and were then embedded in siliciclastics, including sandstone that recorded a lowstand of sea level ("Struve's Great Gap", Bultynck & Hollevoet, 1999). The Eifelian–Givetian transition recorded the return of the carbonate sedimentation in the distal part of the basin and the arrival of marine sediments among red beds on its proximal margins. The lithostratigraphic succession defines several sedimentation areas described as seven blocks by Denayer (2019) (Fig. 8).

The Givetian carbonate platform covered the southern and eastern parts of the Namur–Dinant Basin, from Trelon (France) to Aachen (Germany), whereas the coastline was pushed northwards on the Brabant Inlier where proximal siliciclastics rest on a basal conglomerate. Various carbonate environments from bioherm to lagoon, with marine siliciclastic intercalations developed during the Givetian (Boulvain et al., 2009). The final emersion of the platform near the Givetian–Frasnian boundary terminated the carbonate deposition, overlain by the fine-grained siliciclastics reflecting the onset of the Frasnian transgression.

7. Description of the lithostratigraphic units

7.1. Preliminary remarks

All the lithostratigraphic units (Fig. 9) are listed alphabetically as a lexicon, regardless of their age and geographic distribution. The reader is referred to Figures 9 and 10 for further information concerning the latter data.

We have indicated the oldest references, which may explain certain discrepancies between the present work and previous ones (Bultynck et al., 1991; Bultynck & Dejonghe, 2002), as is the case for the Rivière Formation. A history of the subdivisions of the Middle Devonian of the Dinant Synclinorium and the Vesdre area was provided by Bultynck et al. (1991) and complements those published by Fourmarier (1954), Godefroid (1968), Bultynck (1970) and Errera et al. (1972).

Most of the descriptions provided in this chapter are synthetised from previous publications such as the abovementioned lithostratigraphic charts, supplemented by more recently published data, including those from the revised geological map of Wallonia. To be coherent with the latter, new names are proposed here for units that were previously grouped for mapping purposes such as the Forrières Group introduced for the 'SJ' grouping of formations (Saint-Joseph, Eau Noire and Jemelle formations); the Mautiennes, Alvaux and Mazy formations, previously used as members of the Bois de Bordeau Formation, now considered as a group; etc., see details below. Informal members (e.g. *Poudingue de Marchin*, 'bioherms' of the Jemelle Formation, etc.), remarkable beds (e.g. *Poudingue de Naninne*, etc.) and facies (e.g. Reumont Dolomitic Facies, *Grès de Najauge*, etc.) are also introduced with formal definitions. Existing names have been retained as much as possible unless their use would be confusing or had previously been used for other units.

7.2. Descriptions

Abîme Member – ABI

See Couvin Formation.

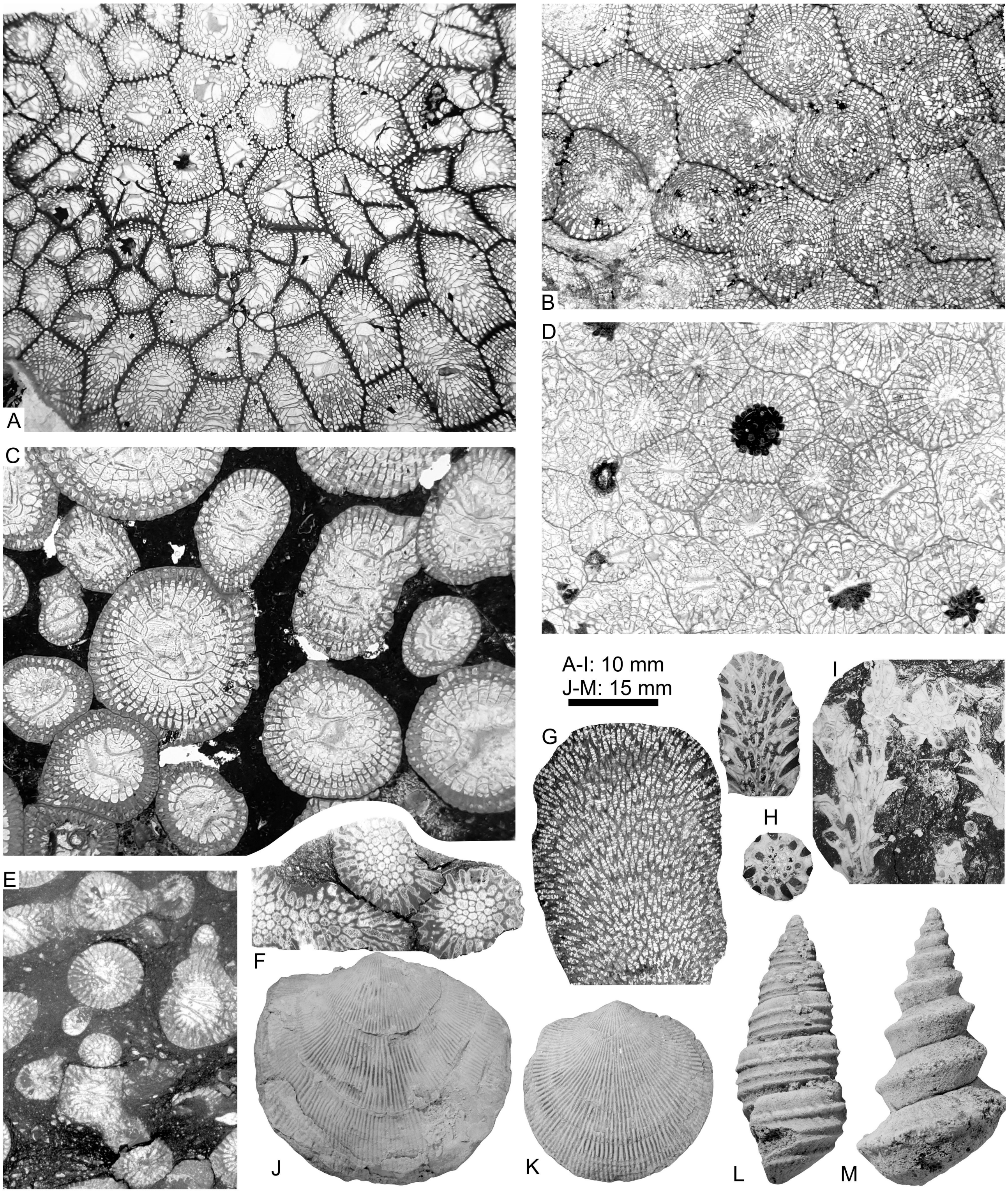

Figure 7. Representatives of some corals, brachiopods and gastropods typical of the Givetian of southern Belgium. Abbreviations: TTS, transverse thin section; VV, ventral view. **A.** *Argutastrea quadrigemina*, TTS (PAULg-RES-III/2a); Resteigne quarry, base of Terres d'Haurs Formation. **B.** *Argutastrea tenuiseptata*, TTS (PAULg-20161223/35); Petigny, Mont d'Haurs Formation. **C.** *Disphyllum oekentorpi*, TTS (PAULg-MAR/18); Marenne quarry, Trois-Fontaines Formation. **D.** *Wapitiphyllum laxum*, TTS (PAULg-20161223/99); Horrues, Bois de Bordeaux Group. **E.** *Disphyllum virgatum*, TTS (PAULg-PrA/4a); Préalle quarry in Aisne, Fort Hulobiet Member. **F.** *Thamnopora cervicornis*, partially transverse thin section (PAULg-HH-IIIB/47); Hampteau quarry, Trois-Fontaines Formation. **G.** *Caliapora battersbyi*, longitudinal thin section (PAULg-Han/48), Han-sur-Lesse, Mont d'Haurs Formation. **H.** *Thamnopora polyforata*, transverse and longitudinal sections (PAULg-15421); Fromelennes, Fort Hulobiet Member. **I.** *Hillaepora spicata*, longitudinal thin section (PAULg-HH-IV/62-5); Hampteau quarry, Trois-Fontaines Formation. **J.** *Desquamatia* (*Independatrypa*) *coenaubertorum*, articulated specimen in VV (RBINS a2370, holotype); Fromelennes, Flohimont Member. **K.** *Desquamatia* (*Seratrypa*) *orbiculata*, articulated specimen in VV (RBINS a2377, holotype); Nismes, Fort Hulobiet Member. **L.** *Murchisonia coronata* (fide Maillieux), complete shell in lateral view (RBINS a14024); Dourbes (Les Abannets), Mont d'Haurs Formation. **M.** *Murchisonia angulata* (fide Maillieux), almost complete shell in lateral view (RBINS a14025); Nismes (Les Abannets), Mont d'Haurs Formation.

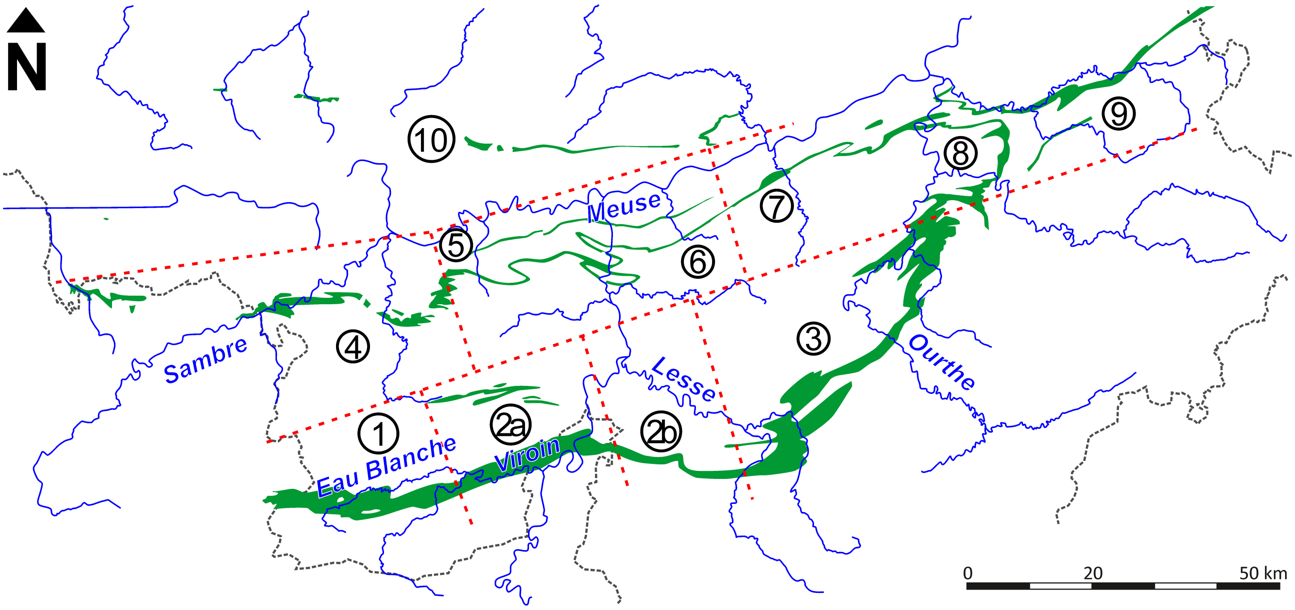

Figure 8. Tectonostratigraphic blocks defined in the Middle Devonian of the Namur–Dinant Basin after Denayer (2019). 1: Eau Blanche block, 2a: Viroin block, 2b: Lesse block, 3: Ourthe block, 4: Sambre block, 5–6: Meuse block, 7: Condroz block (W), 8: Condroz block (E), 9: Vesdre block, 10: Brabant Parautochthon. The lithostratigraphy of each block is detailed in Figs 9 and 10.

Aisne Sandstone Facies

See Jemelle Formation.

Alvaux Formation – ALV

Origin of name. After the Alvaux village in the Orneau River valley, *Calcaire d'Alvaux D*$^{\delta}$ in Gosselet (1860, p. 90) or *Calcaires d'Humerée* in Stainier (1887, p. 75).

Description. The Alvaux Formation consists of dark grey or bluish well-bedded limestone, crinoidal and bioclastic at the base, then finer-grained, with an increasing proportion of calcshale and nodular argillaceous limestone upwards. The base is still locally sandy. Some beds are relatively rich in fossils (brachiopods, rugose and tabulate corals, stromatoporoids, trilobites); a metre-thick stromatoporoid biostrome is recognised near the top (Lacroix, 1974b). This last limestone bed is overlain by a few metres of nodular calcshale rich in brachiopods. In subsurface, the unit is known to include anhydrite horizons (Coen-Aubert et al., 1980).

Stratotype and sections. The Alvaux Formation is partly exposed in the disused quarries on both sides of the Orneau River valley in Alvaux (also spelled Al vau) (Delcambre & Pingot, 2008).

Area and lateral variations. The Alvaux Formation is present all along the northern margin of the Brabant Parautochthon from the Mehaigne River valley to the Dyle River valley. The transition between the Alvaux Formation and the Bois du Planti Formation, described by Lacroix (1991a), occurs between the Dyle River and Samme River valleys (Delcambre & Pingot, 2008; Hennebert & Eggermont, 2002). The Alvaux Formation is also known in subsurface from the Hermalle-sous-Argenteau, Tournai and Leuze boreholes and from boreholes in the Lille area (Graulich et al., 1975; Coen-Aubert et al., 1980, Lagrou & Coen-Aubert, 2017).

Thickness. In the type section, the Formation is 67 m thick (Delcambre & Pingot, 2008) but it decreases rapidly westwards and eastwards (Hennebert & Eggermont, 2002; Delcambre, 2023) and thins out in the Mehaigne River valley (Delcambre & Pingot, 2014a).

Age. Lacroix (1974b) reported the conodont *Icriodus eslaensis* in the upper part of the Alvaux Formation indicating the late Givetian *timorensis* to *rhenanus–varcus* conodont zones. *Polygnathus denisbriceae*, reported from the upper part of the Formation, suggests the *ansatus* conodont Zone (Gouwy & Bultynck, 2003b). The coral assemblage allows the correlation of the Alvaux Formation with the Névremont and Mont d'Haurs formations (Lacroix, 1991a). Both emblematic fossils of the Alvaux Member (*Calcaire d'Humerée à Dechenella striata* et *Spirifer pentameroïdes* [sic] (= *Kelusia pentameroides*) in Malaise & Stainier, 1892) were recently discussed in Mottequin (2019, 2021).

Use. The limestone of the Alvaux Formation has long been quarried in the Orneau River valley for the production building stone and lime (Cauchy, 1827).

Main contributions. Stainier (1894), Asselberghs (1936), Lacroix (1972, 1974a, 1974b, 1991a), Coen-Aubert et al. (1980), Delcambre & Pingot (2008, 2014a), Lagrou & Coen-Aubert (2017).

Bois de Bordeaux Group – BOR

Origin of name. After the Bois de Bordeaux, between Les Mautiennes and Mazy in the Orneau River valley, *Formation du Bois de Bordeaux* in Lacroix (1991a, p. 81).

Remark. The group is a three-fold assemblage consisting of a carbonate unit intercalated between two siliciclastic and usually reddish units. In the type area, the three lithologies were described as three members corresponding, in the classical literature to three units (*Poudingue d'Alvaux*, *Calcaire d'Alvaux* and *Roches rouges de Mazy* in Stainier, 1894) or two *assises* (*Assise d'Alvaux* and *Assise de Mazy* in Asselberghs, 1936). However, the lithological contrasts and sufficient thickness allow considering the three units as formations gathered in a group. Lacroix (1974a, 1974b, 1991a) summarized the equivalence between the published names.

Content. From the base to the top, the Group is composed of the Mautiennes, Alvaux and Mazy formations. In the western part of the Brabant Parautochthon, the middle formation is replaced by the Bois du Planti Formation. In the eastern part of the Parautochthon, the distinction between these units is not obvious as the carbonate middle part is reduced (Delcambre & Pingot, 2014a), or possibly lacking.

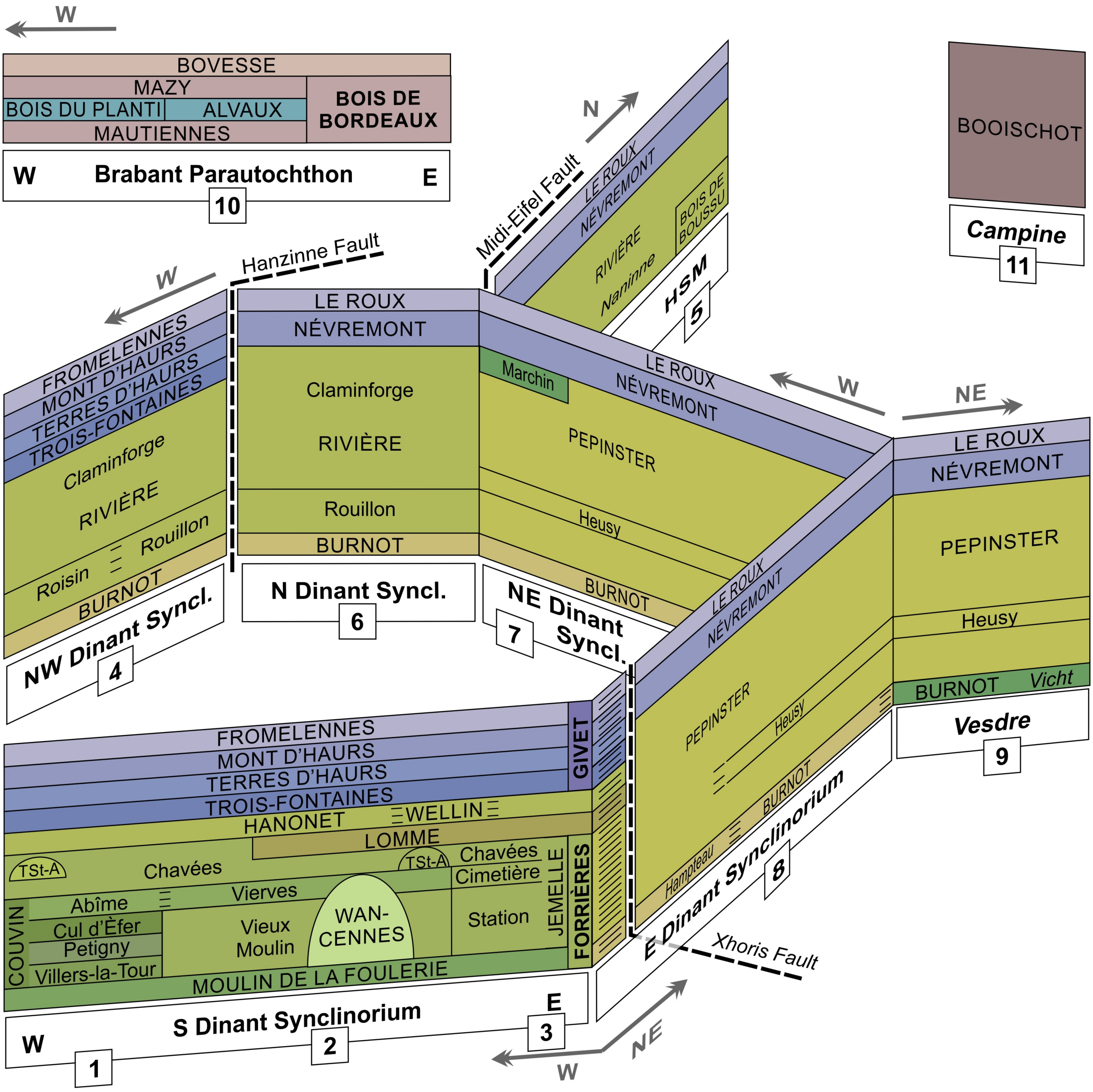

Figure 9. Schematic vertical and lateral relationships of the Middle Devonian units of Belgium. Abbreviations: HSM, Haine–Sambre–Meuse Overturned Thrust sheets; Syncl., Synclinorium; TSt-A, Tienne Sainte-Anne Member. Numbers 1-10 refers to geographical zones in Fig. 8. Groups are in bold and capital letters, formations in capital letters, members in regular letters, remarkable beds and facies in italics.

Type section. The type section of the group is a composite section along the path on the eastern side of the Orneau River between the hamlet of Les Mautiennes and the village of Mazy (Delcambre & Pingot, 2008).

Bois de Boussu Formation – BBO

Origin of name. After the village of Bois de Boussu (now Boussu-Bois), west of Mons, where the conglomerate was recognised in several coal mine shafts and boreholes, *poudingue de Boussu* (Cornet & Briart, 1877, p. 86), *Poudingue du Bois de Boussu* (Rutot & Cornet, 1902).

Description. This unit is a conglomerate with few matrix and centimetre- to decimetre-sized pebbles of dark green sandstone and white quartz, often angular in shape (Fig. 11A). It includes some coarse-grained brownish sandstone beds and it rests unconformably on Lower Paleozoic shale.

Stratotype and sections. Boussu borehole (Dejonghe et al., 1973) between 172.26 m and 175.55 m. A discontinuous outcrop is visible along the disused railway between Warquignies and Boussu-Bois.

Area and lateral variations. Only known in the Boussu Massif, west of Mons (Delmer, 2004).

Thickness. Highly variable, from 3 m in the Boussu borehole to 35 m in the Saint-Homme mine shaft at Boussu-Bois (Asselberghs, 1949).

Age. A Middle Devonian age is supposed, based on the overlying Névremont Formation but no fossil has been found so far in this unit. This conglomerate is probably a lateral equivalent of the Naninne Conglomerate of the Rivière Formation.

Use. Nil.

Main contributions. Rutot & Cornet (1902), Marlière (1969), Dejonghe et al. (1973).

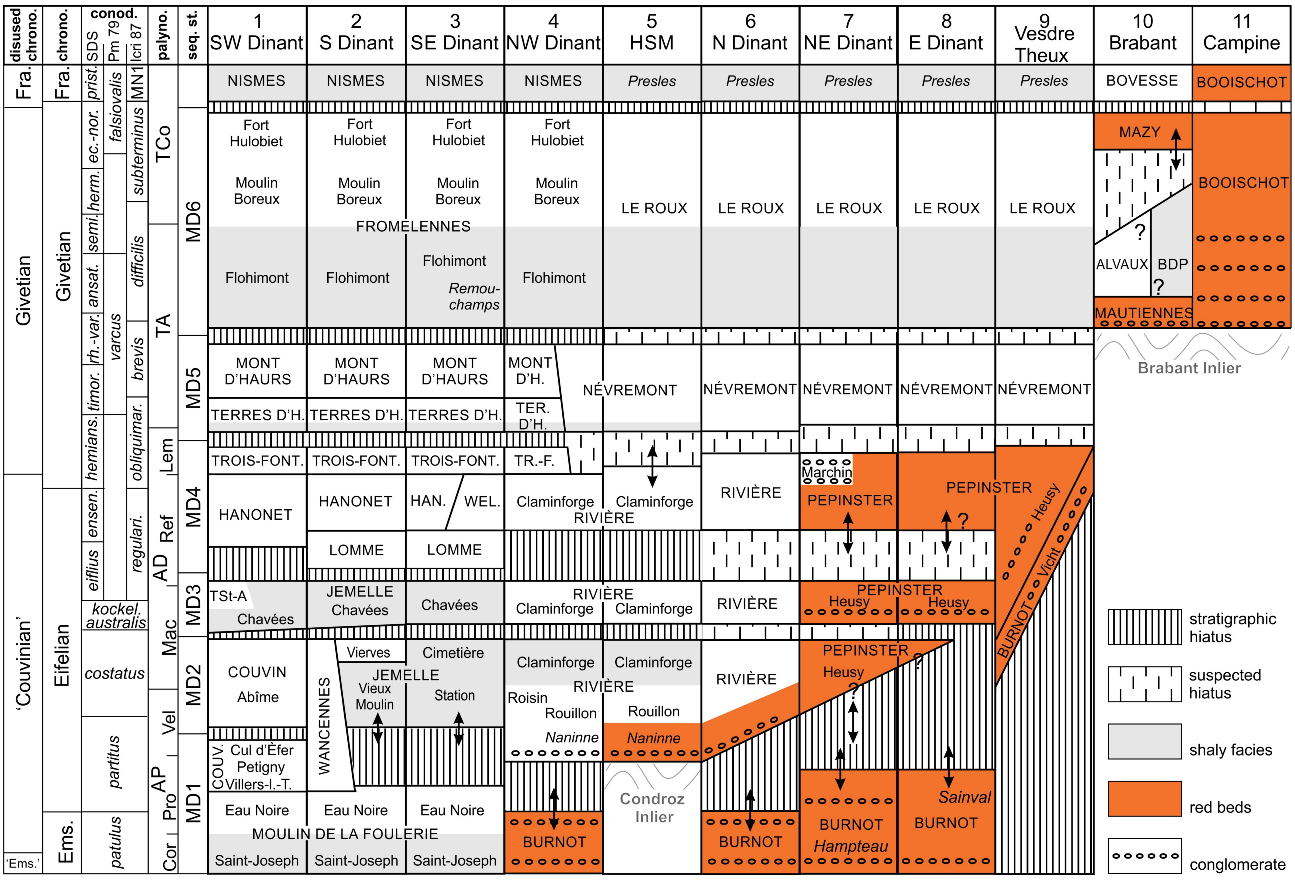

Figure 10. Chronostratigraphic chart of the Middle Devonian strata of Belgium (origin of data: see main text); numbers 1-10 refer to geographical zones and tectonostratigraphic blocks (see Fig. 8). Formations are in capital letters, members in regular letters, remarkable beds and facies in italics. Abbreviations: BDP, Bois du Planti Formation; chrono., chronostratigraphy; conod., conodont zones; COUV., Couvin Formation; HAN., Hanonet Formation; HSM, Haine–Sambre–Meuse Overturned Thrust sheets; MONT d'H., Mont d'Haurs Formation; NÉV., Névremont Formation; palyno., palynostratigraphy; seq. st., sequence stratigraphy; TER. d'H., TERRES d'H., Terres d'Haurs Formation; TR.-F., TROIS-FONT., Trois-Fontaines Formation; TSt-A, Tienne Sainte-Anne Member; Villers-l.-T., Villers-la-Tour Member; WEL., Wellin Formation. For conodont zones and abbreviations, see Fig. 5.

Bois du Planti Formation – BDP

Origin of name. After the Bois du Planti near Monstreux (Nivelles), *Membre du Bois du Planti* in Hennbert & Eggermont (2002, p. 19).

Description. The Formation displays a succession of greyish sandstone with oblique stratifications, greyish to reddish shale with thin sandy intercalations and an upper unit of greyish, brownish or black sandstone, siltstone and shale which is extremely rich in coalified plant remains (Fig. 11B). This unit yielded the renowned Ronquières fossil flora (Stockmans, 1968; Gerrienne et al., 2004; de Ville de Goyet et al., 2007; Cornet et al., 2012 and references therein). Dolomitic horizons occur near the top.

Stratotype and sections. The Bois du Planti Formation is discontinuously exposed in the banks of the Thisnes and Pont-à-Mousson rivers west of Monstreux (Nivelles). It is also particularly well exposed along the *Plan incliné de Ronquières* (Hennebert & Eggermont, 2002).

Area and lateral variations. The Bois du Planti Formation is present along the norther margin of the Brabant Parautochthon west of the Dyle River valley. Eastwards, it passes to the Alvaux Formation west of Sombreffe (Lacroix, 1991a; Delcambre & Pingot, 2008).

Thickness. In the type section, the Formation is 15–17 m thick (Hennebert & Eggermont, 2002).

Age. Based on the palynological content of the fossiliferous horizons within the Bois du Planti Formation, Gerrienne et al. (2004) and de Ville de Goyet et al. (2007) indicate a middle to late Givetian age (uppermost part of the Lem Interval Zone to the lowermost part of the TCo Oppel Zone). The supposed Couvinian age for this lithological unit indicated by Legrand (1967) is therefore ruled out.

Use. Nil.

Main contributions. Legrand (1967, 1973), Hennebert & Eggermont (2002), de Ville de Goyet et al. (2007).

Booischot Formation – PBI

Origin of name. Named after Booischot, a village in south-western Campine (province of Antwerp), Booischot Formation in Lagrou & Laenen (2015).

Description. This thick formation resting unconformably on the Silurian of the Brabant Inlier is dominated by red, green and variegated siliciclastic rocks that can be divided into two units. The lower unit is dominated by conglomerate with large quartz and quartzite pebbles and subordinated sandstone and shale in the lower part (Legrand, 1964). The conglomerate is green in the lower part, then the wine-red colour becomes dominant upsection; palaeosols occur sporadically. The upper unit is made of alternating red, green and variegated conglomerate, green and grey sandstone and quartzitic sandstone and rare thin beds of red shale associated with palaeosols (Lagrou & Coen-Aubert, 2017). Plant remains are abundant in some horizons, particularly

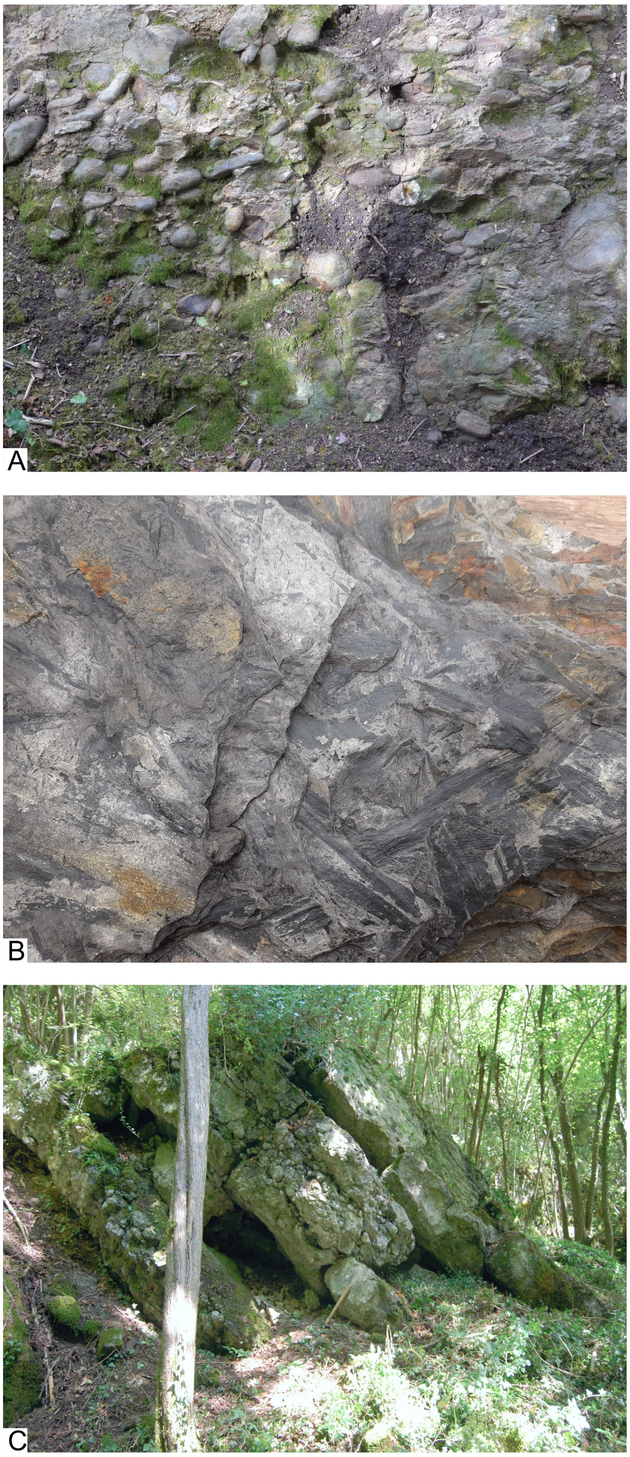

Figure 11. Illustration of some Middle Devonian units. **A.** Conglomerate of the Bois de Boussu Formation. Boussu-Bois section. **B.** Typical facies with charcoalified plant remains of the Bois du Planti Member. Hand sample from Ronquières section (width of the section: 15 cm). **C.** Biostromes of the Cul d'Èfer Member. Cul d'Èfer section at Petigny.

in the lower part of this second unit. A sandstone bed with haematitic oolites marks the base of the overlying Aisemont Formation of late Frasnian age (Coen-Aubert, 2014).

Stratotype and sections. Borehole GeoDoc 059E146 (KB132, Booischot), at a depth of 892–1288 m (Legrand, 1964).

Area and lateral variations. The development of the Booischot Formation varies laterally in the Campine Basin and seems to be driven by that of a half-graben system along the northern margin of the Brabant Inlier (Muchez & Langenaeker, 1993). Comparable coarse-grained rocks developed in the vicinity of the Krefeld High in western Germany might be the equivalent of the Booischot Formation eastwards, with a more marine character as it yielded brachiopods, corals and stromatoporoids.

Thickness. In the Booischot borehole, the Formation is 396 m thick. In the Heibaart borehole, situated c. 40 km north of Booischot, this unit is entirely lacking and the first deposits resting on the Brabant Inlier are attributed to the Frasnian Huccorgne Formation (Lagrou & Coen-Aubert, 2017).

Age. Streel (1965) and Streel & Loboziak (1987) identified several miospore assemblages between the depths of 900.5 m and 1120 m that allow the identification of the TA, TCo, BJ, BM and IV zones indicating a late Givetian to late Frasnian age. The Booischot Formation is overlain by the Aisemont Formation of late Frasnian age (Coen-Aubert, 2014). The occurrence of isolated sporangia attributed to *Svalbardia* or *Archaeopteris* by Streel (1965) at a depth of 1258 m suggests that the lower part of the Formation is already Frasnian as both taxa are characteristic of the Upper Devonian.

Use. Nil.

Main contributions. Legrand (1964), Streel (1965), Streel & Loboziak (1987), Muchez & Langenaeker (1993), Coen-Aubert (2014), Lagrou & Laenen (2015), Lagrou & Coen-Aubert (2017).

Chaieneu former member

Disused unit now included in the Burnot Formation (see Denayer & Mottequin, 2024).

Charlemont formation

Disused unit introduced by Pel (1975, p. 77) corresponding nowadays to the Trois-Fontaines, Terres d'Haurs and Mont d'Haurs formations.

Chavées Member – CVE

See Jemelle Formation.

Cimetière Member – CIM

See Jemelle Formation.

Claminforge Member – CLA

See Rivière Formation.

Couvin Formation – CVN

Origin of name. After the town of Couvin, *Calcaire de Couvin* in Gosselet (1860, p. 46–50).

Remark. The Couvin Formation was almost entirely based on the stratotype sections along the Eau Noire River and in the Abîme cliff in Couvin (Lecompte, 1960; Tsien, 1969; Bultynck, 1970, 1991a). In these type sections, Bultynck (1970) described four lithological units: the 'first biostrome' (unit 1, sub-units i–k in Bultynck, 1970); the 'first subsidence period' (unit 2, sub-unit l); the 'second biostrome' (unit 3, sub-units m–q); and then the 'third biostrome' (unit 4, sub-units r–z). Bultynck (1991a, p. 21) introduced two members: the Foulerie member including the units 1–3 and the Abîme Member for the last unit (except sub-unit r still in the Foulerie Member). However, the Foulerie Member groups three lithological units that were described as distinct members by Denayer (2019). The Abîme Member is preserved without change even if lithological variations are detected, notably based on sections in Villers-la-Tour (Bertrand et al., 1993) and Nismes (Denayer, 2019).

Description. The base of the Couvin Formation is defined above the last thick shaly bed of the Moulin de la Foulerie Formation (Denayer & Mottequin, 2024). The lower member of the Formation is the **Villers-la-Tour Member – VLR**

(Denayer, 2019, p. 151 = unit 1: *premier biostrome* in Bultynck, 1970; member I in Bultynck & Godefroid, 1974), a unit dominated by bluish finely bioclastic argillaceous limestone with shaly interbeds. Above a basal c. 10 m thick unit, there is a first roughly stratified biostromal unit (c. 22–25 m thick) that is made of large lamellar stromatoporoids and corals encrusting a coarse-grained crinoidal rudstone (Fig. 3A). The biostrome is an autobiostrome with in situ elements in the lower part and a parabiostrome with reworked and broken stromatoporoids randomly accumulated in the upper part. The biostromes display a cyclic pattern with large stromatoporoids and corals at the base and fining-upwards with crinoidal and bioclastic limestone.

The **Petigny Member – PET** (Denayer, 2019, p. 152 = unit 2: *première période de subsidence* in Bultynck, 1970; member II in Bultynck & Godefroid, 1974) is a c. 40 m thick unit of dark grey or bluish-grey, argillaceous and fine-grained limestone alternating with some shaly beds. The bioclasts (crinoids, bryozoans and brachiopods) are scarce in a matrix containing up to 25% of clay and silt in the lower part (Bultynck, 1970). Large bivalves are the most notable faunal component of the Petigny Member (Denayer, 2019).

The **Cul d'Èfer Member – CUE** (Denayer, 2019, p. 152 = unit 3: *second biostrome* in Bultynck, 1970; member III in Bultynck & Godefroid, 1974) contains two phases. The first is a c. 25 m thick unit of autobiostromes composed of globular stromatoporoids and tabulate corals that alternate with crinoidal rudstone. The second part essentially comprises cyclic deposits (Fig. 11C). Each cycle starts with coarse bioclastic rudstone passing to large bulbous stromatoporoids, *Heliolites* colonies and large solitary rugose corals forming parabiostromes. They pass upwards to finer-grained bioclastic grainstone, then to darker wackestone with abundant amphiporids, small coral branches (mostly *Dendrostella* and *Fasciphyllum*, Fig. 3B, E) and common cystimorph rugose corals. The cycles vary in thickness from 2 m to 9 m and some of them show a clear shallowing-upwards trend. The reworked aspect of the fauna also suggests a deposition under high hydrodynamic settings. The upper part of the Member is thickly bedded and often dolomitized.

The **Abîme Member – ABI** (*Membre de l'Abîme* in Bultynck, 1991a, p. 21 = unit 4: *troisième biostrome* in Bultynck, 1970; members IV-V in Bultynck & Godefroid, 1974) starts with bedded stromatoporoid and tabulate coral parabiostromes with an abundant packstone matrix. An interval c. 4–6 m thick of dark argillaceous limestone can be recognised in the Eau Noire section and in the Villers-la-Tour, Saint-Remy (Chimay) and Saint-Joseph (Nismes) quarries. The facies is darker but the fauna is abundant and includes thin laminar stromatoporoids and tabulate corals, solitary rugose corals, brachiopods, ostracods and trilobites. This dark argillaceous limestone constitutes the **Saint-Remy Facies** (Denayer, 2019, p. 154). Above, the development of cyclic biostrome starts again in the Couvin area (Fig. 12A). One to 5 m thick stromatoporoid biostromes alternate with accumulations of broken branches of corals (ramose tabulate and branched rugose corals) and amphiporid stromatoporoids. These facies seem to disappear westwards where they are replaced by massive accumulations of coarse-grained bioclastic rudstone with stromatoporoids and corals (e.g. in the Villers-la-Tour quarry, Denayer, 2019). East of Nismes the 'third biostrome' and associated facies are the only remnants of the Abîme Member, and the lower members of the Couvin Formation are replaced by siliciclastics of the Jemelle Formation (see this name for more details). At the Roche Trouée (Nismes), a similar succession is exposed: a 15 m thick unit of thinly bedded bioclastic packstone to grainstone with rare tabulate corals is overlain by a c. 5 m thick stromatoporoid and tabulate coral biostrome that serves as a basis for a small bioherm c. 50 m in diameter and 20 m in height (here defined as the **Roche Trouée Facies**). This peculiar facies is very rich in bulbous stromatoporoids, large colonies of dendroid rugose corals and ramose tabulate corals (Fig. 12B). The bioclastic matrix is abundant. The bioherm passes laterally to bioclastic rudstone beds still rich in corals and stromatoporoids. Upwards, the bioherm is capped by a poorly stratified bioclastic limestone (wackestone to packstone) unit containing layered accumulations of small branches of tabulate corals and amphiporids.

At the Roche Trouée, only the upper 100 metres of the l'Abîme Member are still present, but the thickness of the limestone decreases drastically eastwards, reaching less than 10 m in Olloy-sur-Viroin, then increases again to 50 m in Vierves-sur-Viroin before decreasing again as far as Givet. In parallel, the facies changes, becoming more argillaceous where the thickness is minimum. This limestone unit, well individualised between two shaly members of the Jemelle Formation, is defined as the **Vierves Member – VRV** (Denayer, 2019, p. 155). In the Vierves-sur-Viroin road section, the base of the Vierves Member is defined by the first laterally continuous bed of bioclastic limestone (mudstone to wackestone) overlying the calcareous siltstone and shale of the Vieux Moulin Member (see Jemelle Formation). Shaly and silty interbeds are 1 to 10 cm thick and often contain calcareous nodules and abundant bryozoans, brachiopods, trilobites, ostracods, solitary rugose and lamellar tabulate corals. Upsection the argillaceous content of the limestone decreases and the shaly interbeds disappear. Solitary rugose corals (including cystimorph rugose corals and *Calceola sandalina*), *Heliolites* and alveolitids forming large colonies are also present, whereas stromatoporoids are uncommon. The upper part of the Member is thickly bedded, less argillaceous, and even dolomitic at the top. The boundary with the overlying Chavées Member of the Jemelle Formation is not clear-cut as shaly interbeds reappear in the latter. The argillaceous character is less marked east of the Meuse River valley. Conversely, east of Pondrôme, the dolomitization increases progressively and affects the entire member in Wellin (**Reumont Dolomitic Facies**, new term).

Stratotypes and sections. The stratotype of the Couvin Formation is situated along the Eau Noire River, completed by the Abîme cliff in Couvin. The Villers-la-Tour Member is defined along the disused railway south-east of Villers-la-Tour, 3 km south-west of Chimay. The stratotype of the Petigny Member is situated in small disused quarries along the *rue Augile*, south of Petigny, 1.5 km east of Couvin. The Cul d'Èfer section is an open sky cryptokarst in the woody hills west of Petigny. The Abîme section in Couvin exposes the eponymous member but it can also be observed in the Villers-la-Tour and Saint-Remy (Chimay) quarries. The Roche Trouée Facies is defined in the Roche Trouée cliff in Nismes. The Vierves Member is defined along the road N99 at Vierves-sur-Viroin. East of the Meuse River valley, there are good exposures of this member in Eclaye and in Tienne de Reumont in Wellin where the Member is dolomitic.

Area and lateral variations. The Couvin Formation can be traced along the southern limb of the Dinant Synclinorium from Nismes to Glageon (France) where it disappears below the post-Paleozoic cover. This area constitutes the Eau Blanche block sensu Denayer (2019) (Fig. 8). Eastwards, the Couvin Formation is replaced by the siliciclastics of the Jemelle Formation, apart from the Vierves Member that is recognised between Nismes and Wellin on the Viroin and Lesse blocks (Denayer, 2019) (Fig. 8).

Thickness. In Couvin, the Formation is 380 m thick. The thickness of the Villers-la-Tour Member reaches 40 m, whereas the Petigny and Cul d'Èfer members are 45–50 m and 130–

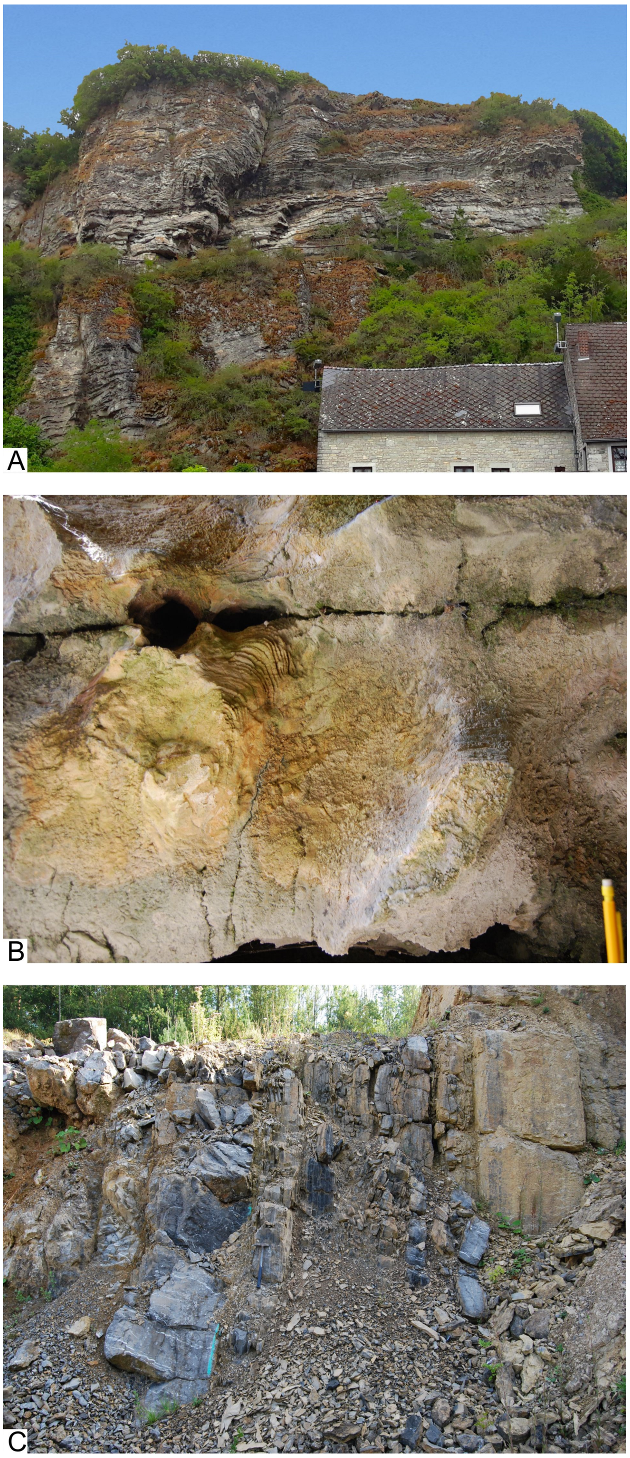

Figure 12. Illustration of some Middle Devonian units. **A.** Abîme Member at the Abîme cliff in Couvin. **B.** Roche Trouée Facies showing reefal facies with corals and stromatoporoids. La Roche Trouée site south-east of Nismes. **C.** Argillaceous limestone of the Flohimont Member. La Préalle quarry, Aisne.

135 m thick, respectively. The Abîme Member is 160 m thick in Couvin but decreases to c. 100 m in Nismes. The Vierves Member is 50 m thick in Vierves-sur-Viroin, less than 10 m in Olloy-sur-Viroin and c. 50 m thick in Wellin.

Age. Bultynck (1970, 1991a) reported the occurrence of conodonts indicative of the lower part of the *partitus* conodont Zone within the basal beds of the Couvin Formation, including *Icriodus retrodepressus*. The lower three members of the Formation are included in the *partitus* conodont Zone whereas the Abîme Member yields conodonts indicating the *costatus* conodont Zone. Dumoulin & Blockmans (2008) only reported *Bipennatus montensis* from the Vierves Member, a species characteristic of the *costatus* conodont Zone. Therefore, the Vierves Member is correlated with the top of the Abîme Member and the hypothesis of a diachronism of the limestone unit, proposed by Dumoulin et al. (2006) and Dumoulin & Blockmans (2008), can be rejected (see also discussion on the age of the Jemelle Formation). The Couvin Formation recorded the third-order sequences MD1 and MD2 (Denayer, 2019) (Fig. 10).

Use. The limestone of the Villers-la-Tour, Cul d'Èfer and Abîme members were quarried as building stone and for the production of lime in the Couvin and Chimay areas. Nowadays, the Abîme Member is still quarried in Villers-la-Tour to produce aggregates. The dark limestone of the Petigny Member was used at a very small scale and for a short period as a black marble (Kaisin, 1935).

Main contributions. Tsien (1969), Bultynck (1970), Bultynck & Godefroid (1974), Bultynck (1991a), Bertrand et al. (1993), Marion & Barchy (1999), Dumoulin & Coen (2008), Denayer (2019).

Cul d'Èfer Member – CUE

See Couvin Formation.

Eau Noire Member – ENR

See Moulin de la Foulerie Formation in Denayer & Mottequin (2024).

Flohimont Member – FLH

See Fromelennes Formation.

Fond des Valennes Member – FVA

See Lomme Formation.

Forrières Group – FOR

Origin of name. After the village of Forrières, south of Jemelle (new term).

Content. This Group gathers the poorly differentiated Moulin de la Foulerie (Saint-Joseph and Eau Noire members) and Jemelle formations along the south-eastern limb of the Dinant Synclinorium between Grupont and Izier (near Durbuy).

Type area. Composite section made of outcrops on both sides of the Lomme River valley in Forrières, between the Grande Ramée and the Forrières-Notre-Dame bridge.

Fort Hulobiet Member – FHB

See Fromelennes Formation.

Foulerie member

Disused subdivision of the Couvin Formation, here split into the Villers-la-Tour, Petigny and Cul d'Èfer members (see Couvin Formation).

Fromelennes Formation – FRO

Origin of name. After the Fromelennes village near Givet (France), *assise de Fromelennes* in Maillieux (1922a, p. 15, 1922b, p. 15).

Description. The Fromelennes Formation is made of three members, from the base to the top: the Flohimont, Moulin Boreux and Fort Hulobiet members.

The **Flohimont Member – FLH** (*Membre de Flohimont* in Coen-Aubert, 1991b, p. 61 = sequence 25 pro parte in Errera et al., 1972) consists of dark grey argillaceous or silty limestone and calcshale in decimetre- to metre-thick beds, with some brachiopod coquina beds (Fig. 12C). The shale is commonly dolomitic and gets a yellowish colour where weathered. Thin beds, lenses and nodules of fine-grained limestone, often dolomitic, are intercalated in the argillaceous beds. They contain crinoids, brachiopods, ostracods and corals, usually fragmented. In the eastern areas, sandy siltstone and sandstone progressively replace the shale (Waleffe, 1962; Coen & Coen-Aubert, 1971). These lithologies are here designated as the **Remouchamps Sandstone Facies**. The first thick bed of limestone defines the base of the **Moulin Boreux Member – MBO** (*Membre du Moulin Boreux* in Coen-Aubert, 1991b, p. 61 = sequence 25 pro parte to sequence 29 in Errera et al., 1972). This member is characterised by shallowing-upwards and fining-upwards sequences starting with biostromes and ending with stromatolites. The biostromes form metre-thick beds with massive and ramose stromatoporoids, ramose tabulate corals and fasciculate rugose corals. They pass upwards to thinner beds of bioclastic limestone with fragments of corals and stromatoporoids. The top of the sequences consists of thinly bedded, dark micritic laminites and loferites (Boulvain & Préat, 1987; Préat & Carliez, 1996). Some thin argillaceous intercalations with desiccation cracks are developed at the top of some sequences (Maillet et al., 2011). Parts of the Member are locally dolomitic. The **Fort Hulobiet Member – FHB** (*Membre du Fort Hulobiet* in Coen-Aubert, 1991b, p. 61 = sequences 30 to 32 in Errera et al., 1972) is made up of decimetre-thick beds of argillaceous limestone, often nodular, with numerous brachiopod and gastropod coquina beds near the base, passing upwards to accumulations of stromatoporoid and coral fragments, occasionally forming parabiostromes. In the Givet area, its upper part displays nodular limestone poor in fauna (Maillet et al., 2011), but in the Wellin area and eastwards, these lithologies are unknown and the Member ends with accumulations of rolled globular and dendroid stromatoporoids (*bancs à boules* in Coen & Coen-Aubert, 1971; Bultynck, 1974; Barchy & Marion, 2014; Fig. 13A). In all areas, the last bed of limestone marks the upper boundary of the Fromelennes Formation.

Stratotype and sections. Section along the local road D46 between Fromelennes and Flohimont (France) completed by the disused Cul de Houille quarry on the left bank of the Houille River, about 3 km south-east of Givet. The Moulin Boreux and Fort Hulobiet members are defined in the Moulin Boreux cliff along the Houille River at Fromelennes. The Remouchamps Sandstone Facies is exposed in the railway section south-east of the disused eponymous station.

Area and lateral variations. The Fromelennes Formation exists along the southern, south-eastern and northern limbs of the Dinant Synclinorium and in the Durbuy–Philippeville Anticlinorium (Dumoulin & Marion, 1998; Marion & Barchy, in press, a). The three members are recognised from Glageon (France) to Hotton; however, the facies of the Fort Hulobiet and Moulin Boreux members are similar in the Durbuy–Philippeville Anticlinorium Massif and to the north-east of the Ourthe River valley. The Remouchamps Sandstone Facies tends to individualise from the Aisne River valley and northwards. In the Amblève River valley, the Fromelennes Formation passes to the Le Roux Formation with a drastic change in thickness and an increase of the proportion of fine-grained dolostone. The Fromelennes Formation is also present along the northern limb of the Dinant Synclinorium from Bettrechies (France) to Hanzinne. In the area between Somzée and Gerpinnes, the proportion of siltstone and shale increases, as well as the proportion of fine-grained dolostone (Delcambre & Pingot, 2000). North of the Hanzinne Fault, the Fromelennes Formation is dominated by fine-grained dolostone and passes to the Le Roux Formation (Delcambre & Pingot, 2004).

Thickness. The Fromelennes Formation is c. 135 m thick in its stratotype and keeps similar values eastwards: 140 m in Wellin (Dumoulin & Blockmans, 2013a), 130 m in Marche-en-Famenne (Barchy & Marion, 2014). It then decreases northwards to 80 m in Remouchamps (Marion et al., in press). In the western part of the Durbuy–Philippeville Anticlinorium, it reaches 90 m (Coen, 1978; Dumoulin & Marion, 1998). In Gerpinnes, it is c. 40 m thick (Delcambre & Pingot, 2000) and increases westwards to 90 m in the Thure River valley (Hennebert, 2008).

Age. Middle to late Givetian. In the stratotype section, the basal part of the Flohimont Member yielded a conodont assemblage typical of the *rhenanus–varcus* and *ansatus* conodont zones (Bultynck, 1987) but there are very few conodonts in the rest of the Member; therefore, its age is not well constrained. The Moulin Boreux Member yielded rare *Icriodus subterminus* indicating the eponymous zone (Narkiewicz & Bultynck, 2010). The Fort Hulobiet Member is assigned to the lower *falsiovalis* conodont Zone (Bultynck & Gouwy, 2002), i.e. the middle–upper *subterminus* conodont Zone of the alternative icriodid zonation (Narkiewicz & Bultynck, 2010) (Fig. 10). The rugose coral *Wapitiphyllum laxum*, known at the top of the Mont d’Haurs Formation reappears at the base of the Moulin Boreux Member (Coen-Aubert, 2004, 2019). The scarcity of corals in the Flohimont Member and their extinction in the Moulin Boreux Member were interpreted by Coen-Aubert (2004) as the effects of the Taghanic Crisis. Atrypide brachiopods (Fig. 7J–K) were studied by Godefroid & Jacobs (1986). Note that Maillieux & Demanet (1929) included the Fromelennes Formation at the base of the Frasnian as was subsequently the case also on the geological maps; this unit was re-attributed to the Givetian only in the years 1970 (see Bultynck, 1974 for history).

Use. The limestone of the Fromelennes Formation has been quarried in many areas as a building stone and for the production of hydraulic lime. In the Rochefort–Hotton area, the thinly bedded limestone of the Fort Hulobiet Member was used as an ornamental stone, mostly in floor tiles (Camerman et al., 1947).

Main contributions. Waleffe (1962), Coen & Coen-Aubert (1971), Errera et al. (1972), Bultynck (1974), Coen et al. (1974), Casier (1987), Boulvain & Préat (1987), Coen-Aubert (1991b, 2004), Préat & Carliez (1996), Narkiewicz & Bultynck (2010), Maillet et al. (2011, 2013, 2016), Pas et al. (2017).

Givet Group – GIV

Origin of name. After the town of Givet (France), *Groupe de Givet* in Errera et al. (1972, p. 34).

Remark. The Givet Group includes the Givetian carbonate formations developed along the south and south-eastern limbs of the Dinant Synclinorium. These lithological units are often hard to distinguish in the field and are usually regrouped in the geological maps. In the original description, Errera et al. (1972) divided the Givet Group into three formations that are, in ascending order, the Trois-Fontaines, Mont d’Haurs and Fromelennes formations. On the contrary, Pel (1975) recognised only two formations in the Givet Group, named Charlemont formation (with the Hotton, Terres d’Haurs and Mont d’Haurs members) and Fromelennes Formation.

Content. From the base to the top, this group includes the Trois-Fontaines, Terres d’Haurs, Mont d’Haurs and Fromelennes formations sensu Bultynck et al. (1991).

Type area. Discontinuous section on the flanks of the Meuse River and Houille River valleys in Givet (Fig. 13B).

Hamoûle member

Disused member of the Hampteau formation now regarded as a facies of the Burnot Formation (Denayer & Mottequin, 2024).

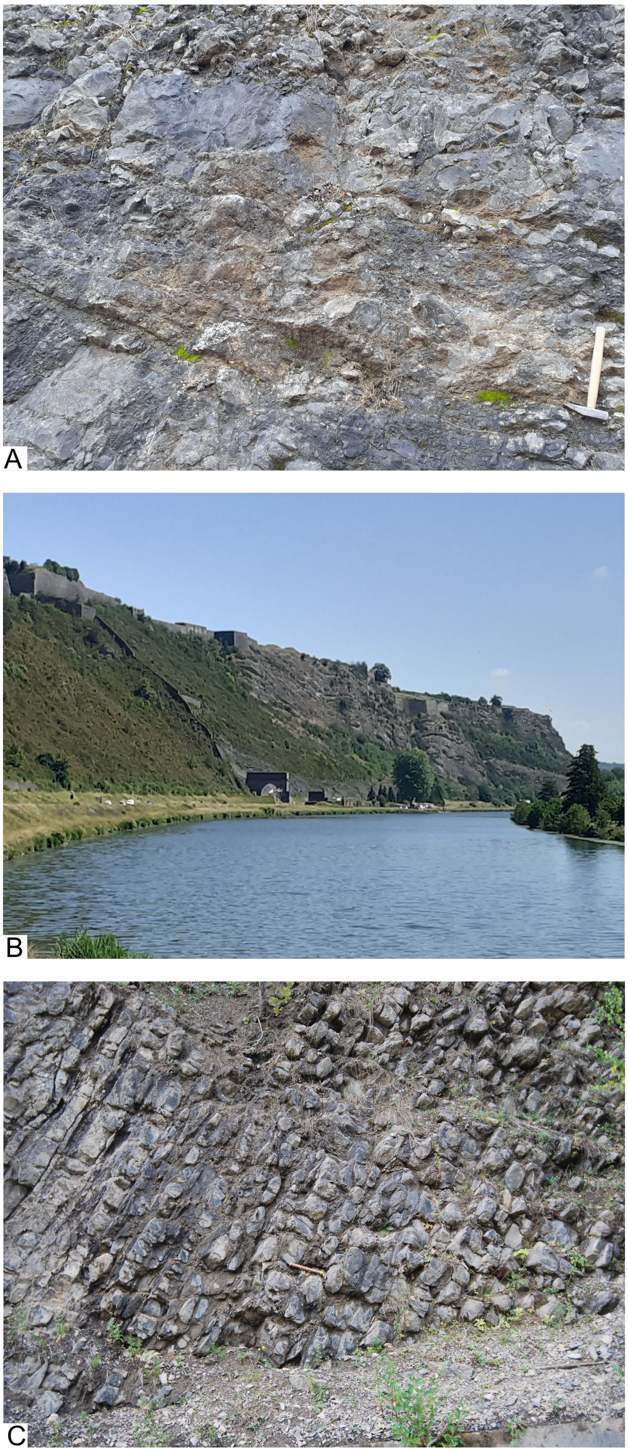

Figure 13. Illustration of some Middle Devonian units. **A.** Limestone beds of the Fort Hulobiet Member with stromatoporoids (*bancs à boules*). Section along the railway at Marche-en-Famenne. **B.** Charlemont cliff in the Meuse River valley upstream Givet, made of the limestone of the Givet Group. **C.** Argillaceous limestone and shaly interbeds of the lower part of the Hanonet Formation. Resteigne quarry.

Hampteau Facies

See Burnot Formation (Denayer & Mottequin, 2024).

Hanonet Formation – HNT

Origin of name. After the Hanonet hill north of Couvin, *Formation d'Hanonet* in Tsien (1976, p. 264).

Description. In the historical stratotype (La Couvinoise quarry in Couvin), the base of the Hanonet Formation is not exposed. Bultynck (1970) and Bultynck & Hollevoet (1999) divided the lithological succession into three units. The lower unit ('a' in Bultynck, 1970, c. 15 m thick) consists of an alternation of dark argillaceous and pyritic fine-grained limestone with an abundant, but poorly diverse, macrofauna. The middle unit ('b' in Bultynck, 1970, c. 25 m thick) is dominated by shale whereas the limestone is lighter in colour and rich in ramose tabulate corals (including abundant *Remesia crispa*, Fig. 4F), *Calceola sandalina*, cystimorph rugose corals (Fig. 3Q) and atrypide and pentameride brachiopods (Fig. 4H–K). The upper unit ('c, d, e' in Bultynck, 1970, c. 15 m thick) displays two horizons rich in lamellar stromatoporoids and tabulate corals forming biostromes in a very argillaceous matrix. Away from the stratotype, the biostromes are not developed and the dark argillaceous limestone facies is predominant throughout the Formation, passing to carbonate shale and siltstone as observed in the disused Resteigne quarry (Coen-Aubert, 1996; Jamart & Denayer, 2020; Fig. 13C). The top of the Formation is defined by the first occurrence of thick beds of light grey, coarse-grained and bioclastic limestone of the Trois-Fontaines Formation. However, in La Couvinoise quarry, the boundary between the typical facies of the Hanonet and Trois-Fontaines formations is transitional (unit f in Bultynck, 1970). This 5 m thick unit, composed of shaly and silty limestone passing to calcareous shale, is known as the 'Gia' in the literature (Maillieux & Demanet, 1929).

The Pondrôme member introduced by Godefroid (1995, p. 80) at the top of the Jemelle Formation in the eponymous section yielded the same fauna than the lower part of the Hanonet Formation in its stratotype (Bultynck & Hollevoet, 1999). Therefore, it is considered as a local facies of the latter unit characterised by the abundance of shaly beds (see also Coen-Aubert, 1988a and Blockmans & Dumoulin, in press).

Stratotype and sections. La Couvinoise quarry (or Haine, or Collard quarry) in Couvin is the historical stratotype or the Hanonet Formation, but its lower part is not exposed there and the contact with the overlying Trois-Fontaines Formation is not clear and difficult to access, depending on the works of the quarry. Consequently, the disused Resteigne quarry (also known as the Lesse quarry) is proposed as a neostratotype as it exposes all the typical facies of the Formation as well as its lower and upper boundaries. Furthermore, it is more perennial. The boundary between the Lomme and Hanonet formations is also exposed in the nearby section along the Lesse River (Coen-Aubert, 1996).

Area and lateral variations. The Formation is known along the southern and south-eastern limbs of the Dinant Synclinorium from Trélon (France) to Ferrières where the marine limestone is replaced by the red siliciclastics of the Pepinster Formation between Izier and Ferrières (Marion & Barchy, in press, a).

Thickness. The Hanonet Formation is 75–80 m thick in Couvin, Pondrôme and Resteigne (Marion & Barchy, 1999; Dumoulin & Blockmans, 2013a). Eastwards, it decreases to reach only 12 m in Hampteau and a few tens of metres in Ferrières (Marion & Barchy, in press, a).

Age. Latest Eifelian to early Givetian. Bultynck & Hollevoet (1999) reported *Polygnathus ensensis* from the lower part of the Formation in Couvin, pointing to the *ensensis* conodont Zone. The base of the *hemiansatus* conodont Zone (base of the Givetian) marked by the first entry of *P. hemiansatus* is recognised in the upper part of the unit 'a', 42 m below the base of the Trois-Fontaines Formation. Eastwards, where the Lomme Formation is well developed, the base of the Hanonet Formation might be slightly younger (Bultynck et al., 2000). The Hanonet Formation recorded the transgressive system tracts of the third-order sequence MD4 of Denayer (2019) (Fig. 10).

Use. The argillaceous limestone of the Hanonet Formation was abundantly used to produce hydraulic lime and aggregates.

The unit is still quarried nowadays (Baileux, Couvin, Olloy-sur-Viroin, Wellin) for the production of aggregates.

Main contributions. Tsien (1969), Bultynck (1970), Bultynck & Godefroid (1974), Casier & Préat (1990), Coen-Aubert et al. (1991), Préat & Tourneur (1991b), Godefroid (1995), Coen-Aubert (1996), Bultynck & Hollevoet (1999).

Héblon Facies

See Terres d'Haurs Formation.

Heusy Member – HEU

See Pepinster Formation.

Hotton member

Disused unit corresponding nowadays to the Trois-Fontaines Formation (see this name).

Jemelle Formation – JEM

Origin of name. After outcrops along the road near the Jemelle station, Jemelle Formation in Bultynck & Godefroid (1974, p. 11).

Description. In the Jemelle stratotype section, the Formation was divided into three members, which are in ascending order: the Station, Cimetière and Chavées members (Godefroid, 1991a). The Vieux Moulin Member is developed westwards (Dumoulin & Blockmans, 2008).

The **Station Member – STA** (*Membre de la Station* in Godefroid, 1991a, p. 31) is distinctly composed of shale to silty shale with thin beds of sandstone, often micaceous (Godefroid, 1968). The fossils are rare and usually decalcified. At the base of the Jemelle Formation, in the Aisne River valley, Lessuise et al. (1979), Dusar (1989) and Marion & Barchy (in press, b) indicated the occurrence of a sandstone unit consisting of bedded arkosic sandstone alternating with bioturbated shaly carbonate interbeds and containing some dissolved brachiopod shells. Denayer (2019, p. 156) proposed to designate these siliciclastic deposits as the **Aisne Sandstone Facies**. This facies increases in thickness north-eastwards and then replaces the shaly Jemelle Formation between the Xhoris and Rouge-Minière faults (Asselberghs & Yans, 1952) where it acquires a reddish colour announcing the Pepinster Formation. Nevertheless, the red colour invades the entire succession just south of the Xhoris Fault (Asselberghs, 1952).

The Station Member passes westwards to the **Vieux Moulin Member – VXM** (*Membre du Vieux Moulin* in Dumoulin & Blockmans, 2008, p. 26), a thick and homogeneous succession of shale and siltstone where the cleavage is usually well developed. It is mostly shaly in the lower half and often dark in colour. Carbonate intercalations and fossils are uncommon. The famous *Mur des Douaniers* trilobite locality in Vireux (France) exposes these facies (Dumoulin & Blockmans, 2008). The upper half of the Member is dominantly silty with some carbonate coquina beds that yields a more diverse fauna. The upper silty part is lighter in colour than the lower shaly part and reminds the facies of the Cimetière Member. Slightly carbonate sandstone known as the *Grès de Najauge* (Dumoulin & Coen, 2008, p. 38) (**Najauge Sandstone Facies**) occurs locally at the top of the Member in the Viroin River and Meuse River valleys (Fig. 14A) and sandy shale in similar stratigraphic position are known in the Wellin area (Godefroid, 1968). This sandstone might be the local expression of the Aisne Sandstone Facies that is well developed eastwards. The Vieux Moulin Member is overlain by the Vierves Member of the Couvin Formation that is marked by an increase of carbonate content in the siltstone and the reduction of the shaly interbeds separating the limestone beds.

The **Cimetière Member – CIM** (*Membre du Cimetière* in Godefroid, 1991a, p. 31) is dominantly shaly and dark in colour, with some beds of argillaceous limestone, relatively fossiliferous limestone and nodules in the upper part (Fig. 14B). Eastwards, the Cimetière Member is not distinguishable from the underlying Station Member. It passes upwards to the lighter-coloured and more fossiliferous Chavées Member that has a higher carbonate content.

In the type area, the **Chavées Member – CVE** (*Membre des Chavées* in Godefroid, 1991a, p. 31) starts with a first 40 m thick unit ('Co2c I' in Bultynck, 1970) where numerous thin beds and nodules of limestone are intercalated within shale (Godefroid, 1968, 1991a). The fauna is abundant and diverse (solitary rugose corals, brachiopods, bivalves and trilobites, particularly in the lower part) (Fig. 3K–N, P). A second 60 m thick unit ('Co2c II') is characterised by the abundance of limestone nodules. Thin biostromes composed of lamellar and massive alveolitids, stromatoporoids and occasional *Heliolites* with associated solitary rugose corals and brachiopods are developed in these beds. The next unit ('Co2c III') is c. 100 m thick and composed of carbonate shale with intercalated beds of argillaceous limestone rich in brachiopods and rugose corals. The overlying 40 m thick unit ('Co2c IV' is richer in limestone beds and nodules and includes a diverse fauna. Laterally to this shale are developed the limestone bioherms of the Tienne Sainte -Anne Member. The last 10 m thick unit ('Co2c V') is composed of sandy shale alternating with sandy limestone and calcareous, commonly micaceous sandstone with decalcified brachiopods and bryozoans. These sandy lenticular bodies of several hundred metres in length are sandwiched between the underlying shale and overlying limestone of the Hanonet Formation. This horizon corresponds probably to the westwards expression of the Fond des Valennes Member of the Lomme Formation (Denayer, 2019).

The **Tienne Sainte-Anne Member – TSA** (Denayer, 2019, p. 159 = 'Co2c R' in Bultynck (1970), 'BI' on the geological maps of Wallonia) corresponds to bioherms developed in the upper part of the Jemelle Formation. It starts with yellowish, thick, roughly bedded, crinoidal rudstone covered by massive and lamellar stromatoporoids and tabulate corals. Upwards, finer-grained facies develops, with reddish bioclastic wackestone including stromatactoid cavities and abundant chaetetid sponge layers (Fig. 14C). This core facies was observed only in larger bioherms. The uppermost facies is an often whitish bioclastic wackestone to packstone with stromatoporoids and massive colonies of the rugose coral *Cyathophyllum* and tabulate corals. The Tienne Sainte-Anne Member is entirely embedded in the shale and siltstone of the Jemelle Formation.

Stratotype and sections. The stratotype of the Jemelle Formation is a composite section including the Jemelle–Forrières road section near the Jemelle train station (Station and Cimetière members) and the trench of the disused railway Jemelle–Rochefort (Cimetière and Chavées members) at Jemelle. The sandy facies of the base is visible in the Aisne River between Aisne and Roche-à-Frêne. The Vieux Moulin Member is exposed along the Treignes–Vireux road in the Viroin River valley. The Tienne Sainte-Anne Member is exposed at the base of the Sainte-Anne hill south-east of Nismes.

Area and lateral variations. The Jemelle Formation crops out along the southern and south-eastern limbs of the Dinant Synclinorium between Trélon (France) and Ferrières where it passes to the Pepinster Formation. The Station Member is not recognised west of the Jemelle area and is hardly distinguishable from the overlying Cimetière Member east of the type locality. The Vieux-Moulin Member is known from the Viroin and Lesse blocks (Fig. 8) but the transition to the Station

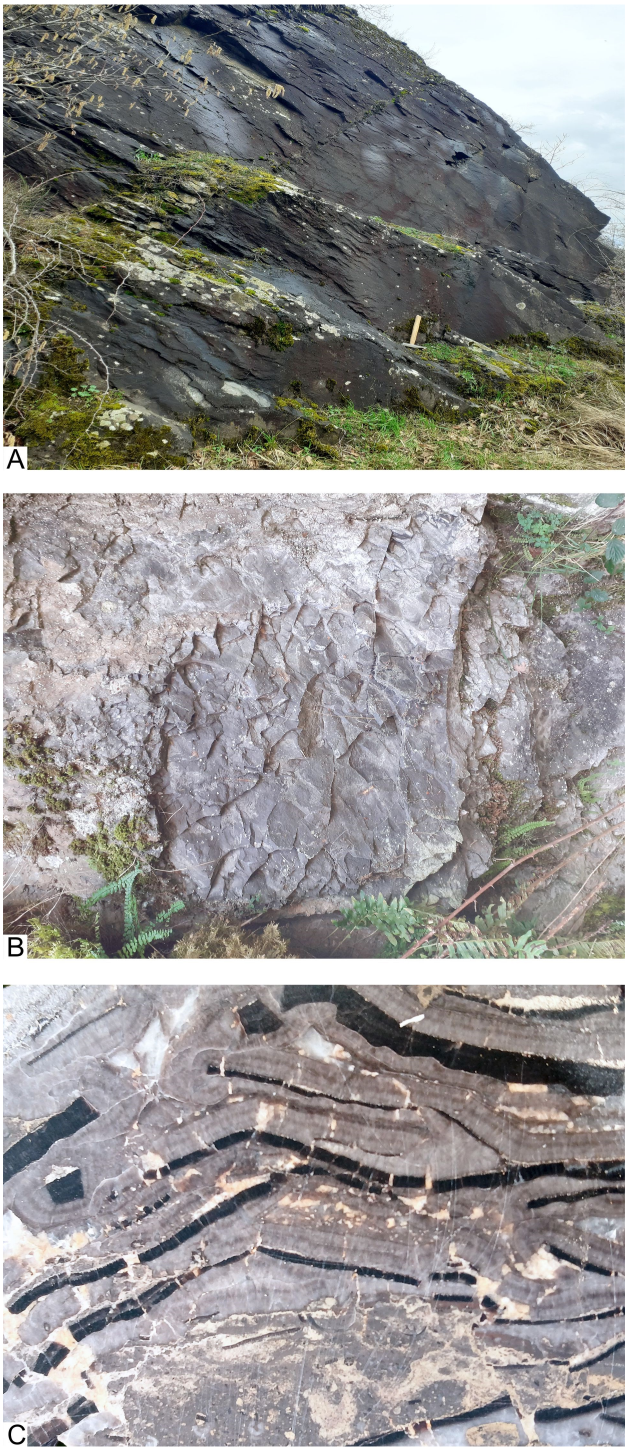

Figure 14. Illustration of some Middle Devonian units. **A.** Najauge Sandstone Facies in the upper part of the Vieux Moulin Member. Najauge road section near Treignes. **B.** Dark shale of the Cimetière Member. Section along the disused railway between Jemelle and Rochefort. **C.** Reefal facies of the Tienne Sainte-Anne Member. Disused quarry on the left bank of the Fond-des-Vaux River, north of Wellin. Polished hand sample (width of the picture c. 10 cm).

and Cimetière members is not well understood. The Chavées Member extends on the Eau Blanche, Viroin, Lesse and Ourthe blocks. The bioherms of the Tienne Sainte-Anne Member occur mainly in two zones: between Macon and Nismes, including the type section in Tienne Sainte-Anne, and in Wellin. In this latter locality, the bioherm is particularly big and rests directly on the Vierves Member of the Couvin Formation, hence the lower part of the Chavées Member is absent.

Thickness. In the type section, the Jemelle Formation is c. 350 m thick (40 m for the Station Member, 110–115 m for the Cimetière Member and 190–195 m for the Chavées Member; Godefroid, 1991a). The Vieux Moulin Member varies in thickness from c. 170 m in Grupont to 250 m in Wellin (Godefroid, 1968) and reaches 260 m in thickness in the stratotype in Treignes (Dumoulin & Coen, 2008). The largest bioherm of the Tienne Sainte-Anne Member, exposed in Les Marlières (Wellin), reaches 200 m in thickness and c. 1000 m in width, but most of the others are c. 100 m thick and a few hundred of metres in diameter. In its type section in Nismes, the Member is c. 50 m thick (Bultynck, 1970).

Age. The siliciclastic sediments of the Station Member produced no diagnostic conodont fauna. From the Cimetière Member, Godefroid (1968) reported the spiriferide brachiopods *Intermedites intermedius, I. supraspeciosus* and *Spinocyrtia ostiolata* (Fig. 3M, O, P), suggesting the *costatus* conodont Zone. In Villers-Sainte-Gertrude, the Aisne Sandstone Facies yielded the brachiopod *I. intermedius* and the spore *Grandispora velata* (Lessuise et al., 1979). The joined occurrences indicate the upper *partitus* conodont Zone (Fig. 10). The age of the Vieux Moulin Member is not constrained biostratigraphically because facies suitable for conodonts are uncommon. However, it seems logical that it could be the lateral time-equivalent of the Station and Cimetière members known eastwards. In the Grupont area, Godefroid (1968) reported the conodonts *Polygnathus partitus* and *Icriodus retrodepressus* indicative of the *costatus* conodont Zone c. 15 m above the base of the Formation. In the Couvin area, the base of the Chavées Member yielded *P. costatus costatus* and *P. linguiformis* forma γ (Bultynck & Godefroid, 1974), indicating the *costatus* to *australis* conodont zones for the oldest part (Godefroid, 1991a), and a rich brachiopod fauna (e.g. *S. ostiolata*) (Bultynck, 1970).

The middle part of the Chavées Member yielded *P. pseudofoliatus* (Bultynck & Godefroid, 1974). In the same area, the bioherms of the Tienne Sainte-Anne Member and the beds immediately below yielded conodonts indicative of the *kockelianus* conodont Zone (Bultynck, 1965; Bultynck & Godefroid, 1974). In the Wellin area, the argillaceous limestone overlying the Vierves Member yielded *Icriodus costatus/ pseudofoliatus* transitional forms (Dumoulin & Blockmans, 2008) suggesting a correlation with the middle part of the Chavées Member. Therefore, a depositional hiatus covers the lower part of the Chavées Member, and the first deposit on top of the Vierves Member is equivalent to the upper part of the Chavées and Tienne Sainte-Anne members. In the Jemelle type section, the lower part of the Chavées Member yielded *S. ostiolata* and *Cyrtinopsis* representatives (Godefroid, 1968; see also Mottequin, 2019 for discussion) that are typical of the *kockelianus* conodont Zone interval in the Couvin area. Hence, it points to a hiatus at the base of the Chavées Member in the Jemelle area.

In Couvin, *P. ensensis* has been observed by Bultynck & Hollevoet (1999) at the top of the Jemelle Formation from Couvin, in a sandy facies reminiscent of the Lomme Formation. This suggests that the growth of the Tienne Sainte-Anne bioherm (i.e. *eiflius* or uppermost *kockelianus* conodont zones) was terminated before the deposition of the sandy deposits of the Lomme Formation and its equivalents.

The Station and Vieux Moulin members are interpreted as the transgressive system tract of the third-order sequence MD2 whereas the Cimetière Member is tentatively interpreted as the highstand system tract of this sequence. The Chavées and Tienne Sainte-Anne members belong to the sequence MD3 but the uppermost sandy units of the Chavées Member probably represent the lowstand system tract of the sequence MD4 (Denayer, 2019) (Fig. 10).

Use. The limestone of the Tienne Sainte-Anne Member was quarried near Chimay and Wellin for the production of lime. The sandstone of the Najauge Sandstone Facies was used very locally as a building stone.

Main contributions. Bultynck (1965, 1970), Godefroid (1968, 1991a), Godefroid (1991a), Dumoulin & Blockmans (2008), Denayer (2019, 2024).

Le Roux Formation – ROU

Origin of name. After the village of Le Roux near Aisemont where the Formation is exposed in a disused quarry, *Macigno de Roux* in de Dorlodot (1893, p. 420).

Description. The formation starts with a unit dominated by siliciclastics: calcareous siltstone and sandstone, calcshale, shale with carbonate nodules, with some argillaceous limestone beds and lenses. Locally, micaceous sandstone beds are present. The colour is typically brownish. Upwards, the shale becomes dolomitic and passes to dolostone or dolomitic limestone, often argillaceous or sandy. The dolostone is greenish-grey and becomes brownish or rust-coloured where weathered. The upper part of the formation is made of light-coloured micritic and bioclastic limestone with local accumulations of stromatoporoids. The last (dolomitic) limestone bed defines the top of the Le Roux Formation.

Stratotype and sections. The original stratotype defined in the access trench of the Moreau quarry (Aisemont; Coen-Aubert, 1991a) is nowadays partly infilled. A good section exists nearby along the road between Le Roux and Falisolle (Delcambre & Pingot, 2014b).

Area and lateral variations. The formation is known along the northern limb of the Dinant Synclinorium from the Eau d'Heure River to the Ourthe River valleys (Coen-Aubert & Coen, 1975). Westwards, in the Gerpinnes vicinity, it rapidly passes to the Fromelennes Formation (Delcambre & Pingot, 2000, 2004). The same transition is documented along the north-eastern limb of the Dinant Synclinorium in the Amblève River valley (Marion et al., in press). The formation is also known in the Haine–Sambre–Meuse Overturned Thrust sheets, from the Biesme River to the Samson River valleys where it disappears (Coen-Aubert & Lacroix, 1979). In the Ourthe River valley (Hony, Tilff), the Le Roux Formation is similar to the succession known in the type section of Aisemont (Coen & Coen-Aubert, 1971; Coen-Aubert, 1974). In the Vesdre River valley, the evolution of the facies between Trooz and Membach has been followed by Coen & Coen-Aubert (1971). Eastwards, however, the limestone is progressively more developed in the upper part of the unit (Coen-Aubert, 2004) whereas only the basal part remains dolomitic and sandy (Laloux et al., 1996). In Germany, south of Aachen, the equivalent unit is the *Obere Stringocephalen-Schichten* (Kasig & Reissner, 2008).

Thickness. The formation is c. 30 m thick in its stratotype and reaches c. 40 m in the Meuse River valley (Delcambre & Pingot, 2017), then its thickness decreases eastwards, and the formation disappears in the Samson River valley (Coen-Aubert & Lacroix, 1979) and re-appears in the Hoyoux River valley (c. 10 m, Coen-Aubert, 1973; Mottequin et al., 2021). In the Ourthe River valley, it is locally absent (e.g. Colonster, Coen-Aubert, 1974) but its thickness reaches 47 m south of Verviers in the Vesdre River valley (Laloux et al., 1996; Coen-Aubert, 2004).

Age. The Le Roux Formation is poor in conodonts. Its basal part yielded some conodonts, including *Icriodus latecarinatus* and *Polygnathus denisbriceae* (Gouwy & Bultynck, 2003b; Coen-Aubert et al., 1986), characterising the middle/upper *varcus* interval suggesting a middle to late Givetian age (Fig. 10). Hence the Le Roux Formation is considered as a lateral equivalent of the Fromelennes Formation. Both lithostratigraphic units display, above the basal siliciclastic facies, some limestone beds rich in stringocephalid brachiopods associated with stromatoporoids and corals. Among them, *Wapitiphyllum laxum* is frequent (Coen-Aubert, 2004, 2019).

Use. Locally used as building stone.

Main contributions. Coen & Coen-Aubert (1971), Coen-Aubert (1991a, 2004), Gouwy & Bultynck (2003a).

Lomme Formation – LOM

Origin of name. After the Lomme River, *Formation de la Lomme* in Godefroid (1991b, p. 33).

Description. The Lomme Formation is a dominantly sandstone unit divided into two members in the type section in Jemelle, from base to top: the Fond des Valennes and Wamme members.

The **Fond des Valennes Member – FVA** (*Membre du Fond des Valennes* in Godefroid, 1991b, p. 33) is mainly shaly and silty with frequent thin beds of arkosic and/or micaceous sandstone, usually poorly fossiliferous, occurring above the calcareous shale of the Jemelle Formation (Fig. 15A). In Forrières and Mesnil-Favay, small metre-sized stromatoporoid-tabulate corals bioherms are developed in the uppermost part of the Fond des Valennes Member (Godefroid, 1968; Denayer, 2019).

The **Wamme Member – WAM** (*Membre de la Wamme* in Godefroid, 1991b, p. 33) is dominated by thick beds of micaceous sandstone with plant remains and intercalated beds of sandy shale and some carbonate nodules in its upper part. The top of the Formation is marked by the progressive increase in carbonate announcing the overlying Hanonet Formation.

Stratotype and sections. Jemelle disused railway section. The section in the Jemelle quarry, which was cited by Godefroid (1991b), is now poorly exposed. Good exposures, though discontinuous, exist along the railway north-east of the Jemelle station and north of Forrières-Notre-Dame.

Area and lateral variations. The Lomme Formation is present along the southern limb of the Dinant Synclinorium, mostly between Ferrières and Wellin (Ourthe block, Fig. 8) but the sandstone which appears at the top of the Jemelle Formation westwards, could be included in the Lomme Formation as well (Bultynck, 1970; Godefroid, 1991b).

Thickness. In the type area, the Fond des Valennes and the Wamme members are 70 m and 40 m thick, respectively (Godefroid, 1991b). The thickness of the Formation increases eastwards from Wellin to Resteigne where it reaches 130 m (Dumoulin & Blockmans, 2013a).

Age. Latest Eifelian. In the Jemelle section, the joined occurrences of the brachiopod *Intermedites intermedius* and the conodont *Polygnathus angustipennatus* indicate the upper Eifelian *eiflius* to *ensensis* conodont zones (Godefroid, 1968, 1991b). Bultynck (1970) and Bultynck & Hollevoet (1999) reported the conodonts *Tortodus intermedius* and *P. ensensis* from the calcareous sandstone sandwiched between the Jemelle and Hanonet Formations in Couvin, both indicating the upper Eifelian *ensensis* conodont Zone. The Lomme Formation is interpreted as the lowstand system tract of the third-order sequence MD4 (Denayer, 2019).

Remark. The reef reported as 'Co2d' by Lessuise et al. (1979) in the *Grotte de Magni* section near Marenne is in fact the lower Givetian biostrome at the base of the Trois-Fontaines Formation, there developed within the sandy facies of the Marenne Member (Barchy et al., 2004). Similarly, the sandy facies that Dejonghe & Hance (2008) ascribed to the Lomme Formation corresponds also to the Marenne Member, hence their interpretation of the lenticular morphology of the Hanonet and Lomme formations is not supported.

Use. The sandstone has been abundantly quarried as a building stone (Fig. 15A).

Figure 15. Illustration of some Middle Devonian units. **A.** Brown sandstone of the Lomme Formation used as building blocks in the 11th-century Saint-Étienne church of Waha (width of the picture c. 120 cm). **B.** Basal beds of the Mautiennes Formation resting unconformably on Silurian slates. Outcrop along the Orneau River. **C.** Stromatoporoid and coral parabiostrome of the Mont d'Haurs Formation. Section in the Han-sur-Lesse cave (width of the picture c. 3 m).

Main contributions. Godefroid (1968, 1991b), Lessuise et al. (1979).

Marchin Member – MRC

See Pepinster Formation.

Marenne Member – MRN

See Trois-Fontaines Formation.

Mautiennes Formation – MAU

Origin of name. After Les Mautiennes locality in the Orneau River valley, *Membre des Mautiennes* in Lacroix (1991a, p. 81) starting on the Silurian basement by a conglomerate (*poudingue d'Alvaux* in Gosselet, 1863, p. 773, renamed *Poudingue des Mautiennes* by Lacroix, 1991a, corresponding to the *formation détritique de base* of Coen-Aubert et al., 1980; Fig. 15B).

Description. It consists of small quartz and quartzite pebbles, centimetric in size, and occasional small, flattened pebbles of weathered slate enclosed in a reddish sandstone matrix. The conglomerate is usually matrix-supported or passes to gravelly sandstone with small plant debris. The matrix is slightly carbonated and includes bioclasts (Lacroix, 1972). Strong variations in composition and thickness advocate for the lenticular development of the conglomerate and it is absent locally (e.g. Hingeon, Asselberghs, 1936). In the Samme River valley, the matrix of the conglomerate is a loose and poorly stratified sandy siltstone, reddish or mottled (Legrand, 1967). Above these beds occur sandstone and siltstone with shaly interbeds, greenish, reddish or variegated, with frequent plant debris.

Stratotype and sections. The type section of the Formation is a composite section along the path on the eastern side of the Orneau River between the hamlet of Les Mautiennes and the village of Mazy (Delcambre & Pingot, 2008).

Area and lateral variations. The Mautiennes Formation is present all along the northern margin of the Brabant Parautochthon from the Mehaigne River valley to the Dendre River valley. It is also known in subsurface from the Hermalle-sous-Argenteau, Tournai and Leuze boreholes and from boreholes in the Lille area (Graulich et al., 1975; Coen-Aubert et al., 1980, Lagrou & Coen-Aubert, 2017). Although it varies in composition, it is recognisable in all outcropping areas.

Thickness. In the type section, the Formation is 17 m thick. Eastwards, it thins to a few metres in the Mehaigne River valley (Delcambre & Pingot, 2014a).

Age. The Givetian age of the basal conglomerate, established on the occurrence of *Stringocephalus burtini*, has been known for a long time (Dewalque, 1877; Stainier, 1894). Gouwy & Bultynck (2003a) reported the conodont *Polygnathus xylus* from the basal conglomerate of the Mautiennes Formation, confirming this age.

Use. Nil.

Main contributions. Stainier (1894), Asselberghs (1936), Legrand (1967, 1973), Lacroix (1972, 1974a, 1974b, 1991a), Coen-Aubert et al. (1980), Delcambre & Pingot (2008, 2014a), Delcambre (2023).

Mazy Formation – MAZ

Origin of name. After the Mazy village in the Orneau River valley, *Grès et poudingue de Mazy* D^5 in Gosselet (1860, p. 93) and *grès de Mazy* in Stainier (1894, p. 198).

Description. The Formation is characterised by the occurrence of siliciclastic red beds. The composition of this member is very variable laterally, but commonly starts with red shale passing to sandstone and conglomerate of various colours. Greyish to pinkish carbonate sandstone and sandy limestone, bioclastic or dolomitic, are present in its middle part and are overlain by reddish clayey sandstone and siltstone. These rocks are typically poorly stratified and display no cleavage (*roches rouges* in Legrand, 1967). Palaeosols and rhizocretions are frequent in these lithologies. The base of the overlying Bovesse Formation (see Mottequin et al., 2024) is marked by a ferruginous conglomerate.

Stratotype and sections. The type section of the Formation is a composite section along the path on the eastern side of the Orneau River valley upstream the village of Mazy (Delcambre

& Pingot, 2008).

Area and lateral variations. The Mazy Formation is present all along the margin of the Brabant Parautochthon from the Mehaigne River valley to the Dendre River valley. It is also known in subsurface from the Tournai and Leuze boreholes and from boreholes in the Lille area (Coen-Aubert et al., 1980; Lagrou & Coen-Aubert, 2017).

Thickness. In the type section, the Formation is 45 m thick (Delcambre & Pingot, 2008) but its thickness decreases rapidly eastwards (Delcambre, 2023) before disappearing almost entirely in the Mehaigne River valley (Delcambre & Pingot, 2014a).

Age. The red beds of the Mazy Formation yielded no diagnostic element for dating but the Givetian age is inferred from the respective ages of the underlying and overlying formations.

Use. Nil.

Main contributions. Stainier (1894), Asselberghs (1936), Legrand (1967, 1973), Lacroix (1972, 1974a, 1974b, 1991a), Delcambre & Pingot (2008, 2014a), Delcambre (2023).

Mont d'Haurs Formation – MHR

Origin of name. After the Mont d'Haurs hill in Givet (France), *Assise du Mont d'Haurs* in Bonte & Ricour (1949, p. 26).

Remark. In Bonte & Ricour (1949), Errera et al. (1972) and Bultynck (1987), the Mont d'Haurs Formation includes all the limestone and argillaceous limestone comprised between the Trois-Fontaines and Fromelennes formations. Pel (1975) restricted the definition of the Mont d'Haurs member of his Charlemont formation to the limestone rich in stromatoporoids and corals, and therefore excluded the lower unit of argillaceous limestone, calcshale and shale. This statement was followed by Préat & Tourneur (1991c) who promoted this unit to the formation status. Therefore, the Mont d'Haurs Formation in its current definition covers only the upper part of the Mont d'Haurs formation (= phases 10 to 24 in Errera et al., 1972) as described in the literature anterior to 1991.

Description. The Mont d'Haurs Formation starts with the first bed of massive limestone rich in stromatoporoids overlying the shaly top of the Terres d'Haurs Formation. In most sections, it is divided into two limestone units separated by a marker interval (see below). The lower unit is a relatively homogeneous alternation of decimetre-thick beds of bluish-grey fine-grained limestone, often argillaceous, with debris of corals, stromatoporoids, crinoids and brachiopods, and metre-thick biostromal beds relatively rich in massive stromatoporoids and corals. Most of these biostromal beds are parabiostromes made of debris accumulated as tempestites (Boulvain et al., 2009) and contain an abundant macrofauna (Fig. 15C). The marker interval is either a thin biostrome interbedded with thinly bedded limestone or a massive bioclastic bed intercalated in a shalier unit (e.g. in the Givet area, Hubert, 2008a). In the upper unit the thick beds are dominant, with massive stromatoporoids, ramose tabulate corals, and solitary and colonial rugose corals (Coen-Aubert, 1999, 2000b). Some beds are capped by laminated limestone with abundant gastropods (Fig. 7L–M). Dolomitization occurs sporadically in the upper(most) part of the Formation. The top of the Formation is marked by the first shale bed of the Flohimont Member of the overlying Fromelennes Formation.

Stratotype and sections. The type section is situated along the fortifications of the Mont d'Haurs in Givet (Bonte & Ricour, 1949; Bultynck, 1987; Hubert, 2008a). Good sections are also visible at Glageon (France) (Boulvain et al., 1995; Hubert, 2008b) and in the Les Limites quarry in Wellin (Coen-Aubert, 1999, 2000b).

Area and lateral variations. The Mont d'Haurs Formation is developed along the southern and south-eastern limbs of the Dinant Synclinorium from Glageon to Filot, near Hamoir, where it passes to the Névremont Formation (Marion & Barchy, in press, a). However, between the Lomme River and Ourthe River valleys, the argillaceous character increases progressively (Barchy & Marion, 2014). Along the northern limb of the Dinant Synclinorium, the Mont d'Haurs Formation is developed between Bettrechies (France) to Gerpinnes (Delcambre & Pingot, 2000). North of the Hanzinne Fault, it passes to the Névremont Formation as well. The Mont d'Haurs Formation is also known in the Durbuy–Philippeville Anticlinorium (Fig. 1), however, its base is not exposed as it crops out only in the core of some anticlines (Coen, 1978; Dumoulin & Marion, 1998).

Thickness. West of the Meuse River valley, the thickness varies from 130 m in Glageon (Boulvain et al., 1995) to 150 m in Nismes (Dumoulin & Coen, 2008). In the stratotype, south of Givet, in the Meuse River valley, a thickness of 160 m is reported by Bultynck (1987) and Lemonne & Dumoulin (1999). Between the Lesse River and Aisne River valleys, the thickness of the Formation is rather constant and reaches 180 m (Coen-Aubert, 1999; Dumoulin & Blockmans, 2013a; Marion & Barchy, in press, b) then it decreases to 80 m in the Lembrée River valley near Ferrières (Marion & Barchy, in press, a). Along the northern limb of the Dinant Synclinorium, it varies from 120 m in the Thure River valley (Hennebert, 2008) to 140 m in the Eau d'Heure River valley (Delcambre & Pingot, 2000).

Age. Lower to middle Givetian after Coen-Aubert (2019). According to Gouwy & Bultynck (2003a) and Boulvain et al. (2011), the Mont d'Haurs Formation lies in the *Polygnathus timorensis* to the *P. rhenanus/varcus* conodont zones in the standard zonation whereas it corresponds to the *Icriodus brevis* conodont Zone in the alternative zonation of Bultynck (1987), as figured by Narkiewicz & Bultynck (2010) (Fig. 10). The successive occurrences among others of the rugose corals *Argutastrea tenuiseptata* and *Wapitiphyllum laxum* in the Mont d'Haurs Formation allow to make correlations with the different parts of the Névremont Formation (Coen-Aubert, 1999, 2019).

Use. Locally used as a building stone. More recently, the massive limestone was quarried in Cour-sur-Heure, Aisne and Wellin (still nowadays) for the production of aggregates.

Main contributions. Pel (1965, 1967, 1975), Errera et al. (1972), Coen et al. (1974), Bultynck (1987), Coen-Aubert (1999, 2000b), Hubert (2008a, b), Casier & Préat (2013).

Moulin Boreux Member – MBO

See Fromelennes Formation.

Moulin de la Foulerie Formation – MFL

See Denayer & Mottequin (2024).

Najauge Sandstone Facies

See Jemelle Formation.

Naninne Conglomerate

See Rivière Formation.

Névremont Formation – NEV

Origin of name. After the village of Névremont near Fosses-la-Ville, *Formation de Névremont* in Lacroix (1974a, p. 14), (sometimes spelled Nèvremont, e.g. Bultynck & Boonen, 1976).

Remark. Lacroix (1974a, 1974b) originally placed the lower boundary of the Névremont Formation at the base of a 15 m thick unit of argillaceous limestone rich in corals (= unit A in Lacroix, 1974b) overlying the last sandstone bed of the Rivière Formation. However, Bultynck & Boonen (1976) modified the

Figure 16. Illustration of some Middle Devonian units. **A.** Biostromal bed of the Névremont Formation. Chawresse section south of Tilff. **B.** Pinkish conglomeratic beds of the Heusy Member of the Pepinster Formation. Road section in the Hoyoux River valley. **C.** Brick-red siltstone and sandstone of the Pepinster Formation. Disused quarry at Remouchamps.

definition, pushing upwards the base of the Névremont Formation at the first limestone bed overlying this unit A, therefore placed in the Rivière Formation (Bultynck, 1991b; Lacroix, 1991b). The original definition has been used by Coen-Aubert (2000b), Bultynck & Dejonghe (2002) and Gouwy & Bultynck (2003a). Coen-Aubert (2000b) discussed the advantage of using the initial definition as argillaceous limestone beds with marine fauna also occur above the basal unit of the Névremont Formation. Besides the type section, this basal unit is only known form the Wépion borehole (Graulich, 1961; Coen-Aubert, 1988b) and the Dave section on the eastern bank of the Meuse River valley (Lacroix, 1974c). The argillaceous character disappears rapidly eastwards; in this case, the base of the Névremont Formation coincides with the first limestone beds. Nevertheless, on the geological map Tamines–Fosses-la-Ville (Delcambre & Pingot, 2014b), this basal unit of argillaceous limestone was included in the top of the heterolithic Rivière Formation (see Delcambre & Pingot, 2017).

Description. The Névremont Formation starts locally with the first argillaceous limestone bed with marine fauna (corals, brachiopods) overlying the carbonate shale of the Rivière Formation (unit A in Lacroix, 1974b). It passes upwards to bedded limestone of various compositions (micritic, bioclastic, dolomitic, argillaceous) with thin calcshale intercalations (i.e. units B to E in Lacroix, 1974b). This first half (26 m thick) contains brachiopods, bryozoans, tabulate and rugose corals. The second part (units F–G in Lacroix, 1974b), 27 m thick in the stratotype, is dominated by coarser-grained bioclastic limestone and includes several horizons rich in stromatoporoids and corals, especially in the uppermost part (Fig. 16A). The limestone of this second unit is commonly dolomitized. One bed of nodular limestone constitutes the top of the Névremont Formation (Coen-Aubert, 2000b; Gouwy & Bultynck, 2003a).

Stratotype and sections. The type section, situated along the disused railway south of Aisemont, exposes the whole formation (Delcambre & Pingot, 2014b). Good sections exist along the disused railway at Gerpinnes (Coen-Aubert, 2000b) and along the Vesdre River valley in Pepinster (Coen-Aubert, 1974).

Area and lateral variations. The Formation has a relatively constant composition along the northern limb of the Dinant Synclinorium from the Eau d'Heure River to the Ourthe River valleys. Westwards, in the Gerpinnes vicinity, it rapidly passes to a thick limestone succession where the Trois-Fontaines, Terres d'Haurs and Mont d'Haurs formations can be recognised (Delcambre & Pingot, 2000). In the Haine–Sambre–Meuse Overturned Thrust sheets, the Formation is present from the Mons area (Boussu and Saint-Symphorien boreholes, Stainier, 1940; Dejonghe et al., 1973; Errera, 1976) to the Meuse River valley. Eastwards, it fades out and lacks between the Samson River and Hoyoux River valleys (Delcambre & Pingot, 2017; Delcambre, 2023). The Formation is present in the Ourthe River and Vesdre River valleys where it overlies the red siltstone of the Pepinster Formation. Its two units are well distinct but locally very dolomitized east of Trooz (Coen-Aubert, 1974). In the German part of the Vesdre area, the *Untere Stringocephalen-Schichten* (also mapped as *quadrigeminum-Schichten*) is roughly equivalent to the Névremont Formation (Kasig, 1967; Kasig & Reissner, 2008).

Thickness. The Névremont Formation is 71 m thick in the stratotype (Coen-Aubert, 2000b) and decreases eastwards in the Haine–Sambre–Meuse Overturned Thrust sheets. It is 15 m thick in the Meuse River and Samson River valleys (Delcambre & Pingot, 2017, 2018a) and disappears eastwards (Delcambre & Pingot, 2018a). In the Dinant Synclinorium, it varies from 20 m in the Ourthe River and Hoyoux River valleys (Coen-Aubert, 1974; Mottequin et al., 2021), 45 m in the Meuse River valley (Delcambre & Pingot, 2017), to 200 m in the vicinity of Gerpinnes (Delcambre & Pingot, 2000). In the Vesdre area its thickness varies between 40 m and 50 m, but this unit thins out locally, between Fraipont and Trooz and re-appears westwards, near Chaudfontaine (Coen-Aubert, 1974; Laloux et al., 1996).

Age. Early to middle Givetian. From the type section, Gouwy & Bultynck (2003b) reported *Icriodus brevis* and *I. lindensis* from the basal part of the Névremont Formation, thus indicating the *timorensis* to the *rhenanus*/*varcus* conodont zones

(Fig. 10). Since the top beds of the underlying Rivière Formation yielded *I. amabilis* indicating the *ensensis* conodont Zone, a hiatus covering the *hemiansatus* conodont Zone is suspected between the two formations. In the Meuse River valley, on both sides of the Condroz Inlier, the base of the Névremont Formation yielded *I. eslaensis* indicating the *timorensis* to *ansatus* conodont zones (Bultynck & Boonen, 1976); therefore, its basal beds are younger eastwards. In Aisemont, a diverse rugose coral association with *Argutastrea tenuiseptata* and *Wapitiphyllum laxum* (Fig. 7B, D) is present and allows the correlation of the Névremont Formation with the Mont d'Haurs Formation known from the southern limb of the Dinant Synclinorium (Coen-Aubert, 2000b, 2019).

Use. Locally used as building stone.

Main contributions. Liégeois (1955), Kasig (1967), Groessens (1970), Coen-Aubert & Coen (1975), Coen-Aubert (1974, 2000b), Lacroix (1974a, 1991b), Bultynck & Boonen (1976), Errera (1976), Ribbert (1998).

Pepinster Formation – PER

Origin of name. After the village of Pepinster (also spelled Pépinster) where the Formation is well exposed, *Formation de Pépinster* in Dejonghe et al. (1991a, p. 93).

Description. In the type section and in the Vesdre River valley, the Pepinster Formation starts with a c. 12 m thick unit of dark then red and green shale and siltstone with carbonate and sulphate nodules overlying the basal conglomerate of the Vicht Member of the Burnot Formation (see below and Denayer & Mottequin, 2024). A 24 m thick package of greenish arkosic ('kaolinic') sandstone and conglomeratic sandstone is individualised as the **Heusy Member – HEU** (*Membre d'Heusy*, Hance et al., 1989, p. 5). The conglomerate has a distinct pinkish colour with pink quartz pebbles (Fig. 16B). Plant macrofossils occur in the lower part whereas the upper one is calcareous and rich in marine fossils such as crinoids, brachiopods and tentaculites. The latter has the typical characters of the *Grauwacke de Rouillon*, i.e. decalcified fossiliferous sandstone with dissolved fossils (Asselberghs, 1955). Within this member, a conglomeratic horizon with quartz and limestone is fossiliferous and yielded stringocephalid brachiopods. It is considered as marking the base of the Givetian in the Vesdre River valley (Liégeois, 1955). The rest of the Formation is dominated by red shale and siltstone (Fig. 16C) in which sandy limestone or dolomitic beds with stringocephalids occurs near the top, forming the transition to the overlying Névremont Formation (Liégeois, 1955, 1956; D'Heur, 1970; Coen-Aubert, 1974).

Along the eastern limb of the Dinant Synclinorium, the Pepinster Formation is divided into three units (three *assises* in Asselberghs, 1955 or three *formations* in Liégeois, 1955). The lower one, starting on top of the last conglomeratic bed of the Burnot Formation is an alternation of reddish and greenish sandstone and siltstone with dissolved carbonate nodules. The middle one includes carbonate sandstone with decalcified fossils (crinoids, brachiopods, tentaculites) reminding the *Grauwacke de Rouillon* but interstratified with wine-red siltstone and shale. The upper unit is made of wine-red micaceous sandy siltstone with decalcified nodules and sandstone with dissolved crinoids and occasional haematite oolites. Marine intercalations are more frequent in the middle unit, particularly south of Harzé. Westwards, in the Hoyoux valley, the Formation starts with a first thin conglomeratic bed, probably a lateral equivalent of the Tailfer Conglomerate of the Rivière Formation, characterised by its light grey to green colour and its content in decalcified crinoids (Thonon, 1980). Its passes upwards to variegated then red siltstone and sandstone with palaeosols and root traces (Molenaar, 1984), then a thick package of conglomerate corresponding to the Heusy Member (Fig. 16B). A third conglomeratic unit, referred as the **Marchin Member – MRC** by Mottequin et al. (2021, p. 34: *Membre de Marchin*; *Poudingue de Marchin* in Forir, 1897, p.177), is a homogenous conglomerate in metre-thick beds, with dominant white quartz pebbles in a light grey to white quartzitic matrix (Fig. 17A). The first bed of limestone marks the base of the overlying Névremont Formation.

Stratotype and sections. Section along the left bank of the Hoëgne River between El Fagne and Mousset in Pepinster. Sections along the railway towards Verviers and Spa serve as complementary stratotypes. The Heusy Member was defined in the embankment of the E42 motorway, but this section is particularly overgrown nowadays. An alternative type section is situated in the Gileppe River valley near Goé (Hance et al., 1996). The Marchin Member is exposed on both sides of the Hoyoux River at Marchin. The railway section near the disused Remouchamps station is also a good hypostratotype of the Pepinster Formation.

Area and lateral variation. The Pepinster Formation is known from the Vesdre area and the Theux Window as well as along the northern and north-eastern limbs of the Dinant Synclinorium. South of the Vesdre River valley, the composition changes slightly. In the Amblève River valley, the Formation is reduced in thickness and consists of a lower unit of coarse-grained badly washed greenish sandstone and an upper unit of reddish sandy siltstone; then the three-fold division described by Asselberghs (1955) and Liégeois (1955) develops up to Xhoris where the red colour disappears progressively from the middle part and then in the lower and upper parts. Southwards, it passes to the marine facies of the Forrières Group (Asselberghs & Jans, 1952; Marion & Barchy, in press, a). In the Ourthe River area, the Pepinster Formation exists only south of Tilff (Liégeois, 1955; Bellière, 2015). Westwards, it passes laterally to the Rivière Formation between the Hoyoux River and Samson River valleys (Delcambre, 2023). In the Vesdre area, it passes in Germany, south of Aachen, to the *Friesenrather-Schichten* (Kasig & Reissner, 2008).

Thickness. The Formation is c. 100 m thick (24 m for the Heusy Member) in the type area but decreases westwards (c. 50 m in Prayon, Coen-Aubert, 1974). It increases southwards (>200 m in Remouchamps) and eastwards (>450 m in Vicht) (Dejonghe et al., 1991a). In the Hoyoux River valley, the Pepinster Formation reaches 180 m, including c. 20 m for the conglomeratic Marchin Member (Mottequin et al., 2021).

Age. In the northern part of the Vesdre area (Goé Nappe), the basal shale beds of the Pepinster Formation are dated of the early Givetian 'Lem' subzone of the AD palynozone, encompassing the Eifelian–Givetian boundary. In Goé, however, the co-occurrence of the spores *Rhabdosporites langii* and *Grandispora protea* suggests an older age (not older than the 'Vel' subzone, equivalent to the *costatus* conodont Zone). However, in the southern part of the Vesdre area (Gileppe Nappe), the Pepinster Formation is dated 'pre-Lem' (Hance et al., 1996). In Remouchamps, the basal part of the Formation yielded *Icriodus corniger* and *I. retrodepressus* that both indicate the *partitus* conodont Zone (de Decker, 1994), i.e. the lower part of the Eifelian. The occurrence of stringocephalid brachiopods and the rugose coral *Argutastrea tenuiseptata*, c. 10 m below the top of the Formation confirms that the upper part of the Pepinster Formation is Givetian in age, in the *timorensis* conodont Zone characterising the top of the lower Givetian (Gouwy & Bultynck, 2003a; Coen-Aubert, 2019). The Heusy Member yields macrofauna that were attributed to the early Eifelian (Kayser, 1895; Asselberghs, 1922, 1923). The Formation is clearly diachronous, and its base is older in the Dinant Synclinorium than in the Vesdre area. Thin shaly

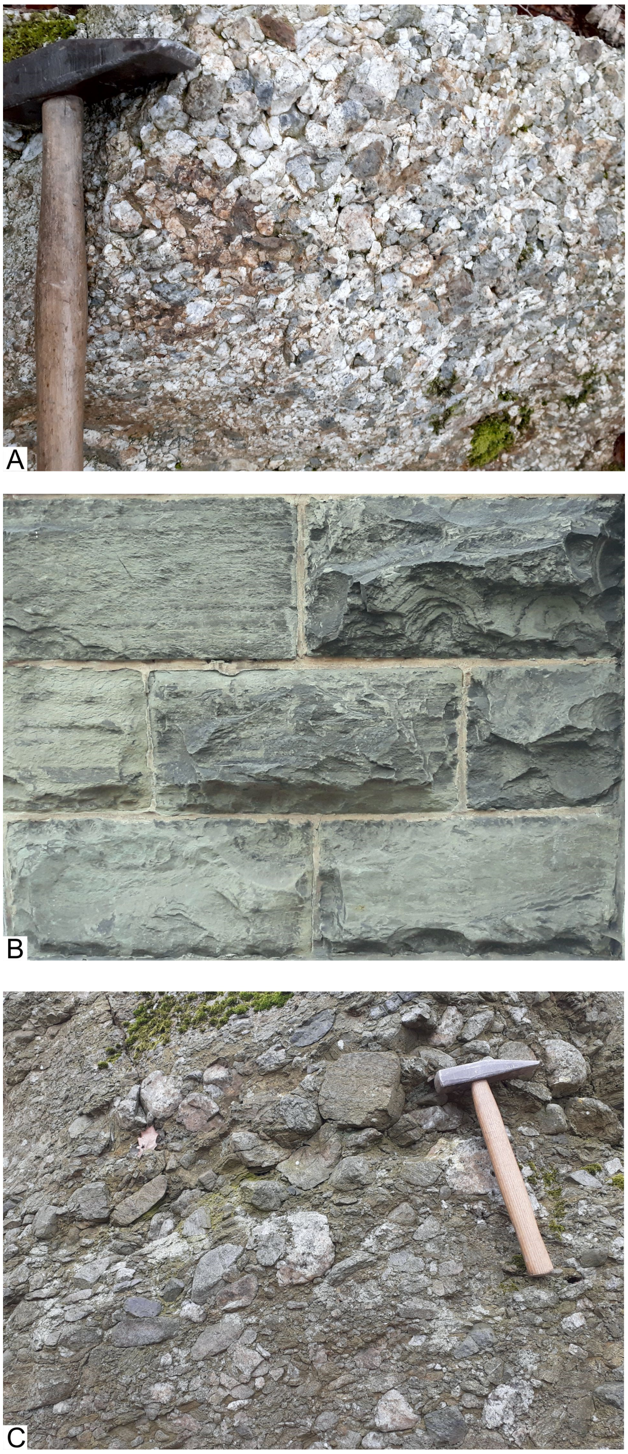

Figure 17. Illustration of some Middle Devonian units. **A.** White and grey conglomerate of the Marchin Member. Disused quarry on the right bank of the Hoyoux River valley at Marchin. **B.** Typical facies of the *Grès (verts) de la Gileppe*, Heusy Member, wall of the old post office of Verviers (width of the picture c. 60 cm). **C.** Greenish-coloured Naninne Conglomerate. Outcrop near Arville (Assesse).

intercalations within the Marchin Member yielded palynomorphs indicative of the earliest Givetian (Steemans in Mottequin et al., 2021).

The Formation is interpreted as the lowstand and transgressive system tract of the third-order sequence MD4 (Denayer, 2019) but a part, at least in the Dinant Synclinorium, should correspond to the sequence MD1 pro parte.

Use. The sandstone and conglomerate of the Heusy Member were locally used for building purposes (e.g. Ourthe River valley). The red siltstone was punctually used as clay for tennis court (Marion et al., in press). The conglomerate of the Marchin Member was quarried until the First World War as a refractory material used in furnaces and for the production of millstone (Macar et al., 1947). The green sandstone of the Heusy Member has been quarried in the Gileppe River valley and traditionally used as building stone for sub-bases of building and known as the *Grès (verts) de la Gileppe* (Camerman, 1961) (Fig. 17B).

Main contributions. Asselberghs (1922, 1923, 1951, 1952, 1955), Fourmarier & Aderca (1955), Liégeois (1955, 1956), Wégria (1965), Kasig & Neumann-Mahlkau (1969), Coen-Aubert (1970), D'Heur (1970), Thonon (1980), Burnotte & Coen (1981), Hance et al. (1989, 1992, 1996), Dejonghe et al (1991a), de Decker (1994).

Petigny Member – PET

See Couvin Formation.

Pondrôme member

Disused member (Godefroid, 1995, p. 80) attributed to the Jemelle Formation, equivalent to the base of the Hanonet Formation after Dumoulin & Blockmans (2013a).

Remouchamps Sandstone Facies

See Fromelennes Formation.

Reumont Dolomitic Facies

See Couvin Formation.

Rivière Formation – RIV

Origin of name. After the village of Rivière in the Meuse River valley, *Formation de Rivière* in Bultynck (1991b, p. 65) grouping the *Grauwacke de Rouillon* (Gosselet, 1873, p. 5) and the *Macigno de Claminforge* (de Dorlodot, 1895, p. 94).

Description. Along the northern limb of the Dinant Synclinorium, in the Meuse River valley, the Rivière Formation begins above the last bed of the red conglomerate from the Burnot Formation (Bultynck, 1991b; Delcambre & Pingot, 2017, 2018b). It was traditionally subdivided in ascending order into the Rouillon and Claminforge members.

The **Rouillon Member – RLL** begins with a c. 15 m thick unit of shaly and sandy red and greenish beds with plant fragments. Within these sandstone and shale, a second thin (c. 1 m thick) conglomeratic horizon, known as the **Tailfer Conglomerate** (*poudingue de Tailfer* in Stainier, 1890, p. 26), consists of a poorly cemented conglomerate and coarse-grained sandstone with small quartz pebbles embedded in a light-coloured greenish, often ferruginous matrix with small cavities left by dissolved fossils. They are associated with micaceous coarse-grained sandstone rich in plant remains (Groessens, 1970). It is overlain by a second unit of greenish to reddish shale and sandstone with scarce, often dissolved, bioclastic limestone intercalations (*Grauwacke de Rouillon* sensu Gosselet, 1873 and Asselberghs, 1955) (Fig. 18A). The abundance of fossil varies from section to section (Delcambre & Pingot, 2018b).

North of the Condroz Inlier, where these beds are the first deposit resting unconformably on the Ordovician–Silurian bedrock (Fig. 17C), the Rivière Formation starts with the **Naninne Conglomerate** (*Poudingue de Naninne* in Gosselet, 1888, p. 439), composed of small pebbles of quartz, sandstone and tourmalinite embedded in a fine-grained light-coloured matrix, often ferruginous. The Naninne Conglomeratic Bed is locally double, separated by sandstone and passes locally to coarse-grained sandstone or disappears. These beds are overlain by greenish siltstone and sandy siltstone with plant remains and coarse-grained sandstone that possibly corresponds to a proximal development of the Tailfer Conglomeratic Bed, itself overlain with reddish sandstone and siltstone.

In the Honnelle River valley, the lower part of the Rivière Formation displays a facies somewhat different from those known in the type area. This facies is designated as a new unit: the **Roisin Member – ROI** (*grauwacke supérieure de Roisin* in Cornet, 1923, p. 186; *Macigno de Roisin* in Marlière, 1970, p. 13). This member is composed of brownish to greenish fine-grained argillaceous and micaceous sandstone alternating with micaceous shale beds with abundant internal moulds of brachiopods and crinoids. It passes upwards to poorly bedded sandstone showing numerous load-casts (*miches* in Marlière, 1970) (Fig. 18B). The upper part of the Member is composed of yellowish sandstone with numerous lenticular beds rich in dissolved bioclasts.

The **Claminforge Member – CLA** mainly consists of light greyish, fine-grained, fossiliferous and calcareous sandstone (often laminated) and calcareous shale with intercalations of reddish and greenish shale; occasionally, nodular and rare beds of limestone and dolostone are present (Fig. 18A; Groessens, 1970; Lacroix, 1974a). The limestone content and marine character increase upwards and westwards. Between the Biesme and Honnelle River valleys, the limestone is more developed and locally nodular (Ladrière, 1875, 1905). Its upper boundary is marked by the last bed of sandstone or sandy limestone underlying the limestone of the Névremont Formation (Coen-Aubert, 2000b; see discussion for the Névremont Formation).

Stratotype and sections. No good section exposing the entire formation is known but each member has its stratotype section. The Rouillon Member is exposed along the Namur–Dinant road at Rivière on the left bank of the Meuse River. The stratotype of the Claminforge Member is situated along the disused railway south of Aisemont. The Naninne Conglomerate is exposed along the railway south of the eponymous station. The Roisin Member is exposed in the Honnelle valley, south of the place known as the Caillou-qui-Bique.

Area and lateral variations. Along the northern limb of the Dinant Synclinorium, the Rivière Formation occurs between Roisin and west of the Hoyoux River valley where it passes laterally to the Pepinster Formation through progressive development of reddish facies (Delcambre & Pingot, 2018a; Mottequin et al., 2021; Delcambre, 2023). In the Haine–Sambre–Meuse Overturned Thrust sheets, the Formation is known from Presles to Huy but the Claminforge Member is less developed or even lacking (Lacroix, 1974c; Coen-Aubert & Lacroix, 1979). The transition between the Rouillon and Roisin members occurs in the Thuin area, whereas more carbonate facies are already developed in the Eau d'Heure River valley (Delcambre & Pingot, 2000) (Fig. 9). In the Honnelle River valley, Bultynck & Boonen (1976) considered the argillaceous limestone above the Roisin Member to be a distinct unit (their Formation A), but it appears that these lithologies are not different from those of the Claminforge Member.

Thickness. On the northern limb of the Dinant Synclinorium, the Rivière Formation is thickest in the Eau d'Heure River and Honnelle River valleys (120 m, Delcambre & Pingot, 2000; Hennebert, 2008) and decreases eastwards (70 m-thick in the Meuse River valley, Delcambre & Pingot, 2017). This reduction in thickness affects mostly the Claminforge Member (45 m in Roisin, 25 m in Aisemont, Delcambre & Pingot, 2014b). Northwards, the Formation is absent in Huy but reaches 80 m in thickness in the Samson River valley, then decreases up to c. 20 m in Naninne and increases again westwards up to 80 m in Aisemont (Delcambre & Pingot, 2014b, 2017).

Age. According to Bultynck & Boonen (1976), the basal beds of the Rouillon Member yielded *Icriodus retrodepressus*, indicating the *partitus* to *costatus* conodont zones boundary interval (Bultynck, 1991b). The Claminforge Member yielded conodonts, including *I. amabilis*, indicating the upper part of the *costatus* to *ensensis* conodont zones (Delcambre & Pingot, 2000; Gouwy & Bultynck, 2003b). Hence the Rivière Formation spans the complete Eifelian stage but only the highstand system tracts of sequences 1 to 4 are recorded, separated by hiatuses (Denayer, 2019) (Fig. 10).

Remark. The term *Poudingue de Naninne*, introduced by Gosselet (1888) (in replacement of the *Poudingue du Pairy-Bony* (in Gosselet, 1876a, p. 69) because the place known as Pairy-Bony has been removed from the military topographic maps), predates the introduction of the term *Assise de Naninne* (a Silurian shaly unit of the Condroz Inlier) introduced by Malaise (1900). Though the latter name is commonly used, it should be abandoned.

Use. Locally, the various lithologies were used for building purposes. In the Honnelle River valley, one fine-grained sandstone bed of the Roisin Member was quarried as grinding stone (*rabats,* Ladrière, 1875).

Main contributions. Ladrière (1875, 1905), Stainier (1890), de Dorlodot (1895), Bayet (1895), Anthoine (1919), Groessens (1970), Bultynck & Boonen (1976), Coen-Aubert (2000b), Delcambre & Pingot (2000, 2014b).

Roche Trouée Facies

See Couvin Formation.

Roisin Member – ROI

See Rivière Formation.

Rouillon Member – RLL

See Rivière Formation.

Saint-Remy Facies

See Couvin Formation.

Station Member – STA

See Jemelle Formation.

Tailfer Conglomerate

See Rivière Formation.

Terres d'Haurs Formation – TRH

Origin of name. After Les Terres d'Haurs locality on the right bank of the Meuse River in Givet, *Membre des Terres d'Haurs* in Pel (1975, p. 78).

Description. The Terres d'Haurs Formation is a limestone unit richer in argillaceous material than the underlying Trois-Fontaines Formation and overlying Mont d'Haurs Formation. Although the argillaceous character is very variable laterally, this unit crops out usually poorly.

The lower part of the Formation starts with a coral bed rich in *Argutastrea quadrigemina*, *Thamnopora cervicornis* and *Pachyfavosites polymorphus* forming locally a 1–3 m thick biostrome or patch-reefs (Préat et al., 1984) (Fig. 18C). Where the corals are not present, this basal horizon is commonly a bioclastic argillaceous limestone. It is overlain by well-bedded dark coloured limestone and shale alternation forming metre to decametre-thick parasequences (= sequences 7 to 12 in Pel, 1965; phases 7 to 9 in Errera et al., 1972, see Bultynck, 1987). Each parasequence starts with argillaceous bioclastic limestone passing to coral-rich beds then to micritic limestone with laminites or coquina beds. The relative proportion of each lithology varies from one parasequence to another (Pel, 1975) as well as laterally. The basal part of the parasequences appears either as calcshale, argillaceous limestone or pure bioclastic limestone. The capping beds are either bioclastic, or laminate, or

Figure 18. Illustration of some Middle Devonian units. **A.** Transition from red siltstone of the Rouillon Member to greenish-grey and pinkish nodular limestone of the Claminforge Member of the Rivière Formation, section along the Namur–Dinant road at Tailfer. **B.** Sandstone beds with large load-casts (*miches* in Marlière, 1970) typical of the Roisin Member. Outcrop along the Honnelle River valley. **C.** Coral bed with *Argutastrea quadrigemina* marking the base of the Terres d'Haurs Formation. Resteigne quarry.

micritic limestone with birdseyes and leperditid ostracods reminiscent of the upper part of the Trois-Fontaines Formation (Coen-Aubert, 2003, Barchy et al., 2004). From one locality to another, the Formation appears either more argillaceous (e.g. in Glageon, Givet, Wellin, Marenne, Boulvain et al., 1995; Coen-Aubert, 2003, 2019; Hubert, 2008b) or more carbonate (e.g. Baileux, Hotton, Pel, 1975; Mabille & Boulvain, 2008).

The upper part of the Formation is made of coarser-grained bioclastic, crinoidal or oolitic, limestone with less argillaceous interbeds than below. In Hotton and Givet the argillaceous interval is situated in the upper part whereas the lower part displays more carbonate restricted facies (Coen-Aubert, 2003; Barchy et al., 2004). This unusual development is referred here as the **Héblon Facies** (from the Héblon castle facing the disused Hotton quarry, since the name Hotton was previously used to designate the Trois-Fontaines Formation).

Stratotype and sections. The stratotype is a composite section along the fortifications of the Mont d'Haurs citadel in Givet (Errera et al., 1972; Bultynck, 1987; Hubert, 2008a). It can be completed by the sections of the quarries at Glageon (Boulvain et al., 1995), Resteigne (Préat & Tourneur, 1991d) and Hotton (Pel, 1965).

Area and lateral variations. The Terres d'Haurs Formation is present along the southern and south-eastern limbs of the Dinant Synclinorium from Glageon (France) to Filot where it passes to the Névremont Formation (Marion & Barchy, in press, a). It displays important changes in facies and thickness. Along the north-western limb of the Dinant Synclinorium, it is developed between Bettrechies (France) to Gerpinnes (Delcambre & Pingot, 2000). North of the Hanzinne Fault, it passes to the Névremont Formation (Fig. 9).

Thickness. In parallel to the facies changes, the thickness varies laterally from 45 m in Glageon (Boulvain et al., 1995), 82 m in Givet (Hubert, 2008a), 75 m in Resteigne and 61 m in Wellin (Coen-Aubert, 2003), and reaches 110 m in Hotton (Barchy et al., 2004) and 90 m in Ferrières (Pel, 1965). In Cour-sur-Heure, the Formation is only 57 m thick (Coen-Aubert, 2000b).

Age. Early Givetian. The conodont assemblages from the type section indicate the upper part of the *obliquimarginatus* conodont Zone to the lower part of the *brevis* conodont Zone of the alternative icriodid zonation (Bultynck, 1987), i.e. upper *hemiansatus* to *timorensis* conodont zones of the standard zonation (Narkiewicz & Bultynck, 2010). The rugose and tabulate corals from the basal beds include *Argutastrea quadrigemina*, *Pachyfavosites polymorphus* and *Thamnopora cervicornis* (Fig. 7A, F). They are typical of the southern margin of the Dinant Synclinorium though they already appear in the upper part of the underlying Trois-Fontaines Formation (Préat & Tourneur, 1991a, 1991d; Coen-Aubert, 2003, 2019).

Use. Usually quarried together with the Trois-Fontaines and Mont d'Haurs formations for the production of aggregates. However, the argillaceous parts compromise their quality.

Main contributions. Pel (1965, 1975), Errera et al. (1972), Coen et al. (1974), Bultynck (1987), Préat & Tourneur (1991d), Boulvain et al. (1995), Coen-Aubert (2003), Hubert (2008a, 2008b), Mabille & Boulvain (2008), Casier et al. (2011).

Tienne Sainte-Anne Member – TSA

See Jemelle Formation.

Trois-Fontaines Formation – TRF

Origin of name. Les Trois-Fontaines site along the Meuse River south-west of Givet, *Calcaire des Trois-Fontaines* in Gosselet (1876b, p. 47). It corresponds to the Hotton member of the Charlemont formation (Pel, 1975).

Description. The Trois-Fontaines Formation, starts at the first thick pure limestone bed resting above the argillaceous or bioclastic limestone of the Hanonet Formation. It is typically made of three successive units: a coarse-grained crinoidal limestone at the base, a middle biostromal unit (*premier biostrome* in the literature) and an upper unit dominated by fine-grained limestone (*lagon* in the literature). Although the composition is more variable than usually published, the three-fold division is rather stable.

The lower unit is a 30 m thick package of thickly bedded, coarse-grained, badly washed crinoidal and bioclastic limestone rich in large crinoid columnals and fragments of brachiopods. It is locally argillaceous (e.g. Couvin) but becomes richer in siltstone and sandstone from Marenne and eastwards (Hotton, Mesnil-Favay, Aisne). This facies was described as the **Marenne Member – MRN** by Mabille et al. (2008, p. 217, 220), on the basis of the geological map of Barchy & Marion (2014, p. 24, *Membre de Marenne*) that was still in press in 2008. The Marenne Member corresponds to a bedded bioclastic limestone with c. 30% of detrital quartz (up to 80% in the Aisne River valley, Monjoie, 1965). It is commonly poor in fossils (crinoids, brachiopods, tentaculites after Jarnaz, 1969) and often displays cross-stratifications (Fig. 19A).

The middle unit is a 10–20 m thick massive biostromal limestone built by stromatoporoids and corals. The rugose and tabulate corals are particularly diverse (Figs 4C–E, G, 7C). The transition with the underlying unit is either progressive, with an increase of lamellar and globular stromatoporoids and massive and ramose tabulate corals, or more clear-cut. The composition of this reefal unit varies from one locality to another: massive stromatoporoids and tabulate corals in Glageon (Boulvain et al., 1995) and Couvin (Tsien, 1974), globular stromatoporoids in Nismes (Préat et al., 2007) (Fig. 19B) and Wellin (Mamet & Préat, 2005), mixed fauna in Resteigne (Préat et al., 1984), ramose and massive corals in Marenne and Hotton (Barchy et al., 2004, Coen-Aubert, 2008). It also yielded an abundant microflora of calcareous algae described by Mamet & Préat (1987). The biostrome is not continuous laterally but appears as a belt of individual reefal lenses of several hundreds of metres in width. East of Marche-en-Famenne, the size of the lenses diminishes where the sandy Marenne Member develops. The reefs are overlain by stringocephalid brachiopod coquina beds rich in fauna (Fig. 19C), capped by an erosive surface locally developing palaeosols with desiccation cracks (Boulvain et al., 2009).

The third unit is the most continuous laterally and made of thinly bedded fine-grained limestone with a relatively poorly diverse fauna (leperditid ostracods, murchisonid gastropods), reaching 20 m in thickness. Coral (abundant *Hillaepora spicata*, Fig. 7I) and brachiopod debris are accumulated as tempestites. Laminar stromatolites are locally developed (Olloy, Vaucelles, Resteigne, Préat & Boulvain, 1982, 1987). Calcshale beds occur sporadically in this upper part. The top of the Formation corresponds to an emersion surface.

Within the three units, the deposits form plurimetric fining- and shallowing-upwards parasequences (= sequences 1 to 6 in Pel, 1965 and 1 to 7 in Monjoie, 1965, = phases 1 to 6 in Errera et al., 1972) in which the proportion of sandy/bioclastic/coral-stromatoporoid and micritic facies varies. These sequences are arranged in a shallowing-upwards trend (*période I* in Pel, 1975) corresponding to the highstand and falling-stage system tracts of the third order sequence (MD4 of Denayer, 2019) that started in the late Eifelian (Fig. 10).

Stratotype and sections. The type section, situated in the Trois-Fontaines quarry (Gosselet, 1876b), has been poorly studied as many works focused on the Mont d'Haurs Hill sections. Excellent sections exist in quarries at Glageon (France), Mont de Baileux, Couvin, Wellin, Resteigne, Marenne and Hotton.

Area and lateral variations. The Formation is known along the southern and south-eastern limbs of the Dinant Synclinorium from Glageon (France) to Filot, south of the Xhoris Fault, where it passes laterally to the upper part of the Pepinster Formation (Marion & Barchy, in press, a). Along the northern flank of the Dinant Synclinorium, the Trois-Fontaines Formation is recognised from Bettrechies (France) to Tarciennes and fades away north of the Hanzinne Fault near Gerpinnes (Delcambre & Pingot, 2000) (Fig. 9).

Thickness. Variable: 70 m in Glageon (Boulvain et al., 1995), 90 m in Couvin, 80 m in Givet (Bultynck, 1987), 75 m in Beauraing (Dumoulin & Blockmans, 2013b), up to 130 m in Wellin (Dumoulin & Blockmans, 2013a), 130 m in Jemelle (Jarnaz, 1969), 85 m in Marenne (Barchy et al., 2004), 105 m in Hampteau (Pel, 1965), 90 m in Aisne (Monjoie, 1965), 75 m in the Eau d'Heure River valley (Delcambre & Pingot, 2000), 160 m in Autreppe in the Honnelle River valley (Hennebert & Delaby, in press).

Age. The Trois-Fontaines Formation is entirely included in the *Polygnathus hemiansatus* conodont Zone, and in the *Icriodus obliquimarginatus* conodont Zone of the alternative icriodid zonation of Bultynck (1987). *Ozarkodina bidentata* and *Bipennatus bipennatus bipennatus* are useful secondary guides to identify the *hemiansatus* conodont Zone when the eponymous conodont species is missing (Gouwy & Bultynck, 2003a). From the brachiopod viewpoint, this formation is characterised by the first occurrence of stringocephalids near its base and their diversification (e.g. *Stringocephalus*, *Parastringocephalus* (Fig. 6B), *Bornhardtina* (Fig. 6F), *Hessenhausia*) (e.g. Bultynck et al., 2000; Godefroid & Mottequin, 2005). The spiriferide *Undispirifer givefex* is the guide of its basal part (Godefroid, 1995).

Use. The pure limestone of the base of the Formation was used for the production of lime, whereas the other limestone units are still quarried (Glageon, Baileux, Givet, Wellin, Marenne) for aggregates. In the past, the latter were extracted for building purposes. In the Givet area, the limestone was quarried as an ornamental stone that was given many names in the literature: *marbre de Givet* (black with numerous white calcite veins), *marbre de Rancennes* (greyish with stringocephalid shells, sometimes called *marbre Sainte-Anne*, though this name is generally reserved for Frasnian limestone (see Mottequin et al., 2024)), *marbre Charlemagne* or *Charlemont* (greyish with numerous brachiopod shells), *marbre Florence* (greyish with abundant stromatoporoids and corals) or Braël (Brayelles, a variety of *marbre Sainte-Anne*) (Groessens, 2009). The same units were also quarried in Glageon (*marbres de Glageon*, several varieties) and in the Roisin-Bettrechies area (*marbre à boules de neige*, *marbre fleuri*, *marbre à amandes*, *marbre Saint-Vicent*, etc.) (Ladrière, 1875; Camerman et al., 1947). In the Viroin River valley, small quarries extracted the same beds under the name *marbre Sainte-Anne* (black matrix with white (calcitic) bioclasts and gastropod shells) (Gosselet, 1876b).

Main contributions. Monjoie (1965), Pel (1965, 1967, 1975), Jarnaz (1969), Errera et al. (1972), Coen et al. (1974), Préat & Boulvain (1982), Préat et al. (1984, 1987), Bultynck (1987), Coen-Aubert (1988a, 1990a, 1990b, 1992, 1996, 1998, 2008), Préat & Mamet (1989), Coen-Aubert et al. (1991), Préat & Tourneur (1991a), Casier et al. (1992), Kasimi & Préat (1996).

Vicht Member – VIC

See Burnot Formation in Denayer & Mottequin (2024).

Remarks. In the Vesdre River valley, the Burnot Formation is reduced to a tongue of conglomerate resting paraconformably on the Pragian rocks and previously named Vicht Formation (*Vichter Konglomerat* in Holzapfel, 1910, p. 210; *Formation de Vicht* in Dejonghe et al., 1991b, p. 87) that is here considered as a member. It consists in metric beds of conglomerate and conglomeratic sandstone containing centimetric to pluricentimetric pebbles of quartz, quartzite, sandstone and occasional tourmalinite with frequent siltstone intercalations

Figure 19. Illustration of some Middle Devonian units. **A.** Sandstone with parallel laminae of the Marenne Member. Marenne quarry. **B.** Massive limestone with stromatoporoid forming a reef lens at the base of the Trois-Fontaines Formation. Fondry des Chiens, Nismes (width of the picture c. 4 m). **C.** Coarse bioclastic coquina bed (tempestite) with stringocephalid brachiopods in the Trois-Fontaines Formation. Resteigne quarry.

(Fig. 20A). The wine-red colour is dominant but tends to fade away westwards with more and more greenish to greyish intercalations (Dejonghe et al., 1991b). The Member appears as a series of finning-upwards sequences with erosive bases formed by a succession of 10–100 m wide lens-like bodies (Kasig & Neumann-Mahlkau, 1969; Neumann-Mahlkau & Ribbert, 1998). In the Eupen area, the Vicht Member is latest Eifelian to earliest Givetian in age (for more information, see Hance et al., 1996 and Denayer & Mottequin, 2024).

Vierves Member – VRV

See Couvin Formation.

Vieux Moulin Member – VXM

See Jemelle Formation.

Villers-la-Tour Member – VLR

See Couvin Formation.

Wamme Member – WAM

See Lomme Formation.

Wancennes Formation – WAN

Origin of name. After the village of Wancennes, Wancennes Formation in Denayer (2019, p. 156).

Remark. The Wancennes Formation was not recognised on the geological map Felennes–Vencimont, where Dumoulin & Blockmans (2013b) interpreted this limestone unit as a recurrence of the Couvin Formation. However, the facies and geometry are clearly distinct, and a new term was introduced by Denayer (2019).

Description. The Wancennes Formation is dominated by massive light grey limestone rich in reefal organisms. The basal 20 m of the Formation consist of light grey crinoidal rudstone that include large lamellar stromatoporoids and is extremely rich in brachiopods, gastropods, trilobites and tabulate corals; upwards, corals and stromatoporoids display bulbous shapes. Above, a 40 m thick massive unit is almost entirely composed of large lamellar stromatoporoids with few corals and light grey crinoidal rudstone. The middle part of the Formation is composed of c. 40 m of massive light grey framestone with lamellar and bulbous stromatoporoids, ramose (pachyporid, e.g. *Thamnopora*, Fig. 3C), lamellar and dome-shaped tabulate (alveolitid) and rugose corals (*Fasciphyllum*, *Australophyllum*, *Sociophyllum*) (Fig. 20B). Locally, the crinoidal and bioclastic matrix is abundant, as are the cemented cavities. A 10–20 m thick unit of fine-grained, argillaceous wackestone, usually rich in *Fasciphyllum* and ramose tabulate corals, appears on the top of this middle part. The rest of the reef displays similar light grey framestone on a thickness of 70–80 m, with an extremely diverse coral fauna (Fig. 3B–C, F), including very large colonies. The reef-crests are dominated by large bulbous stromatoporoids and *Heliolites* colonies embedded in thick accumulations (up to 25 m) of whitish crinoidal rudstone with fragments of branched coral colonies (Denayer, 2023). The top of the reef is overlain by the shale of the Chavées Member of the Jemelle Formation.

Stratotype and sections. Section along the creek and in the crops north-east of Wancennes, 1 km south of Beauraing (Denayer, 2019, 2023).

Area and lateral variations. The Formation is only developed between Dion and Pondrôme, along the southern margin of the Dinant Synclinorium (Lesse block of Denayer, 2019) (Fig. 8).

Thickness. The Wancennes bioherm is 275–300 m thick and 3000 m long, whereas that exposed in Dion is smaller (100 m thick and 300 m long, Denayer, 2019).

Age. Eifelian. No data on conodonts is available but the reef is bracketed by the Moulin de la Foulerie Formation (*partitus* conodont Zone) and the Chavées Member of the Jemelle Formation (*costatus* conodont Zone). Moreover, the top of the Wancennes Formation yields cerioid *Fasciphyllum varium* (= *Beugniesastraea varia* sensu Coen-Aubert, 1988a) that is only known from the upper part of the Abîme and Vierves members of the Couvin Formation in the Couvin area (Coen-Aubert, 1988a; Denayer, 2019); therefore, this species provides a significant correlation.

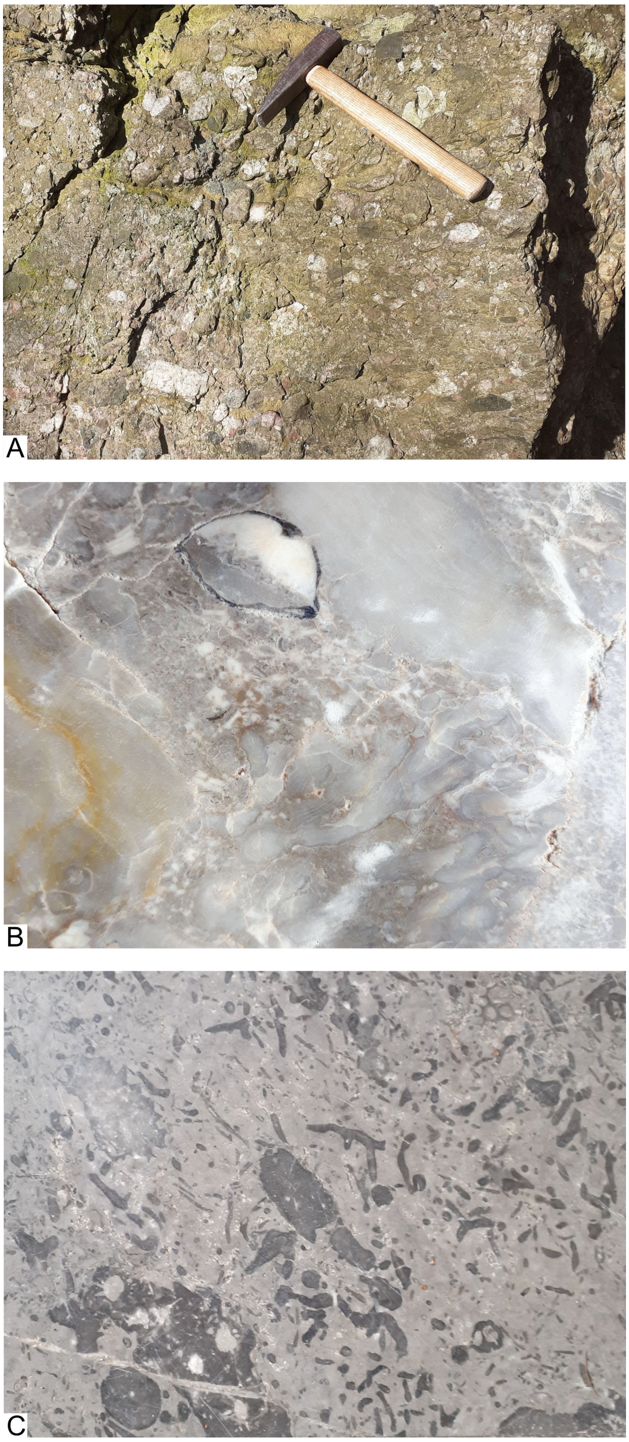

Figure 20. Illustration of some Middle Devonian units. **A.** Conglomeratic horizon in the Vicht Member. Pepinster railway section. **B.** Typical light grey reefal facies with brachiopods, stromatoporoids and corals, Wancennes Formation. Hand sample from Wancennes (width of the picture c. 5 cm). **C.** Wellin-Agate ornamental stone (*Marbre Wellin-Agat(h)e*), coarse bioclastic limestone with light grey matrix, from the Wellin Formation. Floor tile in the Saint-Martin church in Beauraing (width of the picture c. 20 cm).

The reef recorded two third-order sequences (MD1 and MD2), the argillaceous limestone occurring within the reef marks the first sequence boundary, whereas the sharp surface capping the reef corresponds to the sequence boundary of the sequence MD2 (Denayer, 2019) (Fig. 10).

Use. The top of the Formation was exploited in small quarries for the production of lime.

Main contributions. Dumoulin & Blockmans (2013b), Denayer (2019, 2023).

Wellin Formation – WEL

Origin of name. After the village of Wellin where the Formation is exposed along the Fond des Vaux River valley, Wellin Member in Denayer (2019, p. 163).

Remark. Locally, the typical argillaceous limestone of the Hanonet Formation is replaced by coarse-grained bioclastic and crinoidal grainstone that was described by Coen-Aubert (1990a, 1991c) and Coen-Aubert et al. (1991) under the provisional name of *Formation X*, whereas Denayer (2019) assigned them to a new member (Wellin member) of the Hanonet Formation. Astonishingly, Coen-Aubert (1991c, p. 41) proposed the acronym WEL for this *Formation X*, implicitly acknowledging the future name to come. Denayer's (2019) Wellin member is here promoted to formation status.

Description. The Wellin Formation starts with greenish-grey, well-bedded coarse-grained crinoidal grainstone and shaly interbeds with an abundant fauna of corals and stromatoporoids (Coen-Aubert et al., 1991) (Fig. 20C). It passes upwards to a massive light grey limestone rich in large bulbous and domal stromatoporoids. The matrix between the stromatoporoids is often abundant and rich in tabulate and rugose corals (Fig. 4A, B). Coarse-grained crinoidal rudstone with abundant stromatoporoids and tabulate corals are recurrent in its upper part. Thin shaly interbeds occur throughout the unit. In the Fondry des Chiens (Nismes), the unit is mostly dominated by bedded crinoidal rudstone below the massive stromatoporoidal framestone forming the basal biostrome of the Trois-Fontaines Formation. Laterally, the crinoidal grainstone passes progressively to the typical facies of the Hanonet Formation via an intermediate facies, notably at Baileux (Monts de Baileux quarry) and Nismes (disused Roche Nanette quarry) (Denayer, 2019).

Upwards, the crinoidal limestone of the Wellin Formation inconspicuously grade into the purer ones of the Trois-Fontaines Formation (Coen-Aubert, 1990a; Coen-Aubert et al., 1991), though the top of the Wellin Formation is irregular, and interdigitations of the Hanonet Formation exists as in the Fond-des-Vaux section in Wellin (Coen-Aubert et al., 1991). The boundary between both units is thus not clear-cut. Nevertheless, the massive aspect of the basal beds of the Trois-Fontaines Formation compared with the bedded limestone of the Wellin Formation and the disappearance of the shaly interbeds are the most conspicuous differences between the two formations.

Stratotype and sections. The Wellin Formation is exposed in road embankments and disused quarries along the Fond-des-Vaux creek north of Wellin (Coen-Aubert et al., 1991). The discontinuous outcrop south of the Fondry des Chiens in Nismes also exposes the crinoidal facies of the Wellin Formation.

Area and lateral variations. Besides the stratotypic area, the Wellin Formation also crops out at Nismes (Coen-Aubert, 1992) and Baileux (Jamart & Denayer, 2020); therefore, it is developed locally on the Lesse and Eau Blanche blocks (Denayer, 2019) (Fig. 8).

Thickness. The Wellin Formation is c. 100–120 m thick in Wellin in the Monts de Baileux but in the Fondry des Chiens sections, it reaches only 45 m (Préat et al., 2007; Mabille & Boulvain, 2008) with a limited development of reefal facies.

Age. The conodont *Polygnathus ensensis* indicating the eponymous zone has been reported from the middle part of the Wellin Formation (Bultynck, 1987; Coen-Aubert et al., 1991) and its top locally enters the *hemiansatus* conodont Zone, notably in the Fondry des Chiens (Coen-Aubert, 1992). It recorded the transgressive system tract of the third-order sequence MD4 of Denayer (2019).

Use. The limestone was used for the production of lime. The massive limestone beds were quarried in the Fond-des-Vaux in Wellin as an ornamental stone named *Marbre Wellin-Agat(h)e* (Dumon & Maillieux, 1937) (Fig. 20C).

Main contributions. Bultynck & Godefroid (1974), Coen-Aubert (1991c), Coen-Aubert et al. (1991), Denayer (2019).

Acknowledgements

The authors thank the geologists, stratigraphers and palaeontologists involved in the revision of the Geological Map of Wallonia who inspired the revision of the Middle Devonian lithostratigraphic scale: Laurent Barchy, Sabine Blockmans, Frédéric Boulvain, Léon Dejonghe, Serge Delaby, Bernard Delcambre, Virginie Dumoulin, Benedicte Eggermont, Jacques Godefroid, Luc Hance, Michel Hennebert, Daniel Lacroix, Eric Lemonne, Jean-Louis Pingot, Alain Préat, Philippe Steemans, Hsien Ho Tsien and the late Pierre Bultynck, Michel Coen, Philippe Gerrienne and Jacques Pel.

The paper benefited from the constructive reviews of Sophie Gouwy (Geological Survey of Canada), Edouard Poty (Université de Liège) and Francis Tourneur (Service géologique de Wallonie).

Author contribution

JD and BM conceptualised the synopsis, JD, BM and JMM revised the field data, JD and BM contributed to the writing of the manuscript and the preparation of figures, JMM and MCA brought their long-standing expertise and improved the text. Stratigraphic and sequential interpretations (Fig. 9) were previously unpublished, only the first author is responsible for that part.

Data availability

The fossils and rock samples illustrated herein are stored at the Service géologique de Wallonie (Namur), Royal Belgian Institute of Natural Sciences (prefixed RBINS, Brussels), University of Liège (palaeontological collections; prefixed PAULg, Liège), and Centre Grégoire Fournier of the Maredsous Abbey (prefixed CGF, Denée).

References

Anthoine, R., 1919. Observations sur le bord nord du bassin de Dinant entre les méridiens d'Acoz et de Binche. Annales de la Société géologique de Belgique, 42/1, M3–M88.

Asselberghs, E., 1922. Notes sur le niveau fossilifère de la Grauwacke de Rouillon. Annales de la Société géologique de Belgique, 44/2, B130–B135.

Asselberghs, E., 1923 . La faune de la Grauwacke de Rouillon (base du Dévonien moyen). Mémoires du Musée royal d'Histoire naturelle de Belgique, 33, 1–73.

Asselberghs, E., 1936. Le Dévonien du bord nord du Bassin de Namur. Mémoires de l'Institut géologique de l'Université de Louvain, 10, 231–325.

Asselberghs, E., 1949. Les formations antéhouillères du massif de Boussu au sondage du Jardiné à Thulin. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, 57/3 (pro 1948), 490–518.

Asselberghs, E., 1951. Note sur la base du Givetien au Nord-Est du bassin de Dinant. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, 59/3 (pro 1950), 351–355.

Asselberghs, E., 1952. Le Dévonien moyen dans la région de Harzé (bord oriental du bassin de Dinant). Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, 60/3 (pro 1951), 342–361.

Asselberghs, E., 1955. La grauwacke de Rouillon (Couvinien) du bord oriental du bassin de Dinant. Mémoires de l'Institut géologique de l'Université de Louvain, 19, 177–221.

Asselberghs, E. & Yans, H., 1952. Un faciès spécial du Couvinien à Ferrières. Académie royale de Belgique, Bulletin de la Classe des Sciences, 5e série, 38/8-9, 780–782. https://doi.org/10.3406/barb.1952.69705

Barchy, L. & Marion, J.M., 2014. Carte géologique de Wallonie : Aye – Marche-en-Famenne 54/7-8. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 90 p.

Barchy, L., Coen-Aubert, M., Marion, J.-M. & Coen, M., 2004. Mise en évidence de la Faille de Marenne sur la carte géologique Aye – Marche-en-Famenne. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 74, 59–71.

Bayet, L., 1895. Étude sur les étages dévoniens de la bande nord du Bassin méridional dans l'Entre-Sambre-et-Meuse (première note). Annales de la Société géologique de Belgique, 22, Mémoires, 129–161.

Becker, R.T., Marshall, J.E.A., Da Silva, A.-C., Agterberg, F.P., Gradstein, F.M. & Ogg, J.G., 2020. The Devonian Period. In Gradstein, F.M., Ogg, J.G., Schmitz, M.D. & Ogg, G.M. (eds), Geologic Time Scale 2020, vol. 2. Elsevier, Amsterdam, 733–810. https://doi.org/10.1016/B978-0-12-824360-2.00022-X

Belanger, I., Delaby, S., Delcambre, B., Ghysel, P., Hennebert, M., Laloux, M., Marion, J.-M., Mottequin, B. & Pingot, J.-L., 2012. Redéfinition des unités structurales du front varisque utilisées dans le cadre de la nouvelle Carte géologique de Wallonie (Belgique). Geologica Belgica, 15/3, 169–175.

Bellière, J., 2015. Carte géologique de Wallonie : Tavier – Esneux 49/1-2. 1/25 000. Service public de Wallonie, Direction générale de l'Agriculture, des Ressources naturelles et de l'Environnement, Namur, and its explanatory booklet, 68 p.

Bertrand, M., Coen-Aubert, M., Dumoulin, V., Préat, A. & Tourneur, F., 1993. Sédimentologie et paléoécologie de l'Emsien supérieur et de l'Eifelien inférieur des régions de Couvin et de Villers-la-Tour (bord sud du Synclinorium de Dinant, Belgique). Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 188/2, 177–211.

Blockmans, S. & Dumoulin, V., in press. Carte géologique de Wallonie : Houyet – Han-sur-Lesse 59/1-2. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet.

Bonte, A. & Ricour, J., 1949. Contribution à la stratigraphie du Givétien. Annales de la Société géologique du Nord, 68 (pro 1948), 25–36.

Boucot, A.J., Johnson, J.G. & Struve, W., 1966. *Stringocephalus*, ontogeny and distribution. Journal of Paleontology, 40/6, 1349–1364.

Boulvain, F. & Préat, A., 1987. Les calcaires laminaires du Givétien supérieur du bord sud du Bassin de Dinant (Belgique, France) : témoins d'une évolution paléoclimatique. Annales de la Société géologique de Belgique, 109/2 (pro 1986), 609–619.

Boulvain, F., Coen-Aubert, M., Mansy, J.-L., Proust, J.-N. & Tourneur, F., 1995. Glageon : une coupe du Givetien en Avesnois (France). Sédimentologie, Coraux, géologie régionale, diagenèse. Bulletin de la Société belge de Géologie, 103/1-2 (pro 1994), 171–203.

Boulvain, F., Mabille, C., Poulain, G. & Da Silva, A.-C., 2009. Towards a palaeogeographical and sequential framework for the Givetian of Belgium. Geologica Belgica, 12/3-4, 161–178.

Boulvain, F., Coen-Aubert, M., Da Silva, A. C., Kershaw, S., Tourneur, F., Denayer, J., Mottequin, B. & Poty, E., 2011. Field trip 1: Givetian and Frasnian of Southern Belgium. Kölner Forum für Geologie und Paläontologie, 20, 5–49.

Brice, D., 1980. Givétien. In Cavelier, C. & Roger, J. (eds), Les étages français et leurs stratotypes. Mémoires du B.R.G.M., 109, 9–25.

Brice, D. (coord.), 2016. Stratotype Givétien. Muséum national d'Histoire naturelle, Paris; Biotope, Mèze, 272 p.

Brice, D., Carls, P., Cocks, L.R.M., Copper, P., García-Alcade, J.L., Godefroid, J. & Racheboeuf, P.R., 2000. Brachiopoda. In Bultynck, P. (ed.), Subcommission on Devonian Stratigraphy. Fossil groups important for boundary definition. Courier Forschungsinstitut Senckenberg, 220, 65–86.

Brice, D., Mottequin, B. & Loones, C., 2008. Découverte de nouveaux brachiopodes dans le Givétien (Dévonien) du Boulonnais (N. France). Annales de la Société géologique du Nord, 2e série, 15, 1–14.

Brühl, D., 1998. Anmerkungen zur Devon-Korrelationstabelle, B140di97–B140dm97: Tabulata; Eifel. Senckenbergiana lethaea, 77, 267–268. https://doi.org/10.1007/bf03043746

Bultynck, P., 1965. Contribution à l'étude des corrélations stratigraphiques entre le massif schisto-rhénan et l'Ardenne – Étude d'une faunule à conodontes dans un petit bioherme du Couvinien supérieur à Couvin. Annales de la Société géologique de Belgique, 88/3, B61–B72.

Bultynck, P., 1970. Révision stratigraphique et paléontologique (brachiopodes et conodontes) de la coupe type du Couvinien. Mémoires de l'Institut géologique de l'Université de Louvain, 26, 1–150.

Bultynck, P., 1974. Conodontes de la Formation de Fromelennes du Givetien de l'Ardenne franco-belge. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 50/10, 1–30.

Bultynck, P., 1987. Pelagic and neritic conodont successions from the Givetian of pre-Sahara Morocco and the Ardennes. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 57, 149–181.

Bultynck, P., 1991a. CVN Formation de Couvin. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 18–29.

Bultynck, P., 1991b. RIV Formation de Rivière. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 65–71.

Bultynck, P., 2006. Couvinian. Geologica Belgica, 9/1-2, 147–150.

Bultynck, P. & Boonen, P., 1976. Conodontes des formations de Rouillon, de Claminforge et de Nèvremont – Mésodévonien du bord nord du Synclinorium de Dinant. Annales de la Société géologique de Belgique, 99/2, 481–509.

Bultynck, P. & Dejonghe, L., 2002. Devonian lithostratigraphic units (Belgium). Geologica Belgica, 4/1-2 (pro-2001), 39–69. https://doi.org/10.20341/gb.2014.043

Bultynck, P. & Godefroid, J., 1974. Excursion G. In Bouckaert, J. & Streel, M. (eds), International Symposium on Belgian micropaleontological limits from Emsian to Visean: Namur, September 1st to 10th, 1974. Guidebook. Geological Survey of Belgium, Brussels, 44 p.

Bultynck, P. & Gouwy, S., 2002. Towards a standardization of global Givetian substages. In Yushkin, N.P., Tsyganko, V.S. & Mannik, P. (eds), Geology of the Devonian system, Proceedings of the International Symposium, Syktyvkar, Komi Republic, July 9-12, 2002. Geoprint, Syktyvkar, 142–144.

Bultynck, P. & Hollevoet, C., 1999. The Eifelian-Givetian boundary and Struve's Middle Devonian Great Gap in the Couvin area (Ardennes, southern Belgium). Senckenbergiana lethaea, 79/1, 3–11. https://doi.org/10.1007/BF03043209

Bultynck, P., Coen-Aubert, M., Dejonghe, L., Godefroid, J., Hance, L., Lacroix, D., Préat, A., Stainier, X., Steemans, P., Streel, M. & Tourneur, F., 1991. Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 1–106.

Bultynck, P., Coen-Aubert, M. & Godefroid, J., 2000. Summary of the state of correlation in the Devonian of the Ardennes (Belgium-NE France) resulting from the decisions of the SDS. In Bultynck, P. (ed.), Recognition of Devonian series and stage boundaries in geological areas. Subcommission on Devonian Stratigraphy. Courier Forschungsinstitut Senckenberg, 225, 91–114.

Burnotte, E. & Coen, M., 1981. Étude des couches de passage Couvinien-Givétien entre la vallée de l'Ourthe et la vallée de l'Aisne. Annales de la Société géologique de Belgique, 104/1, 127–134.

Camerman, C., 1961. Les pierres naturelles de construction. Annales des Travaux Publics de Belgique, 1960/4, 325–372.

Camerman, C., avec la collaboration de Bienvenu, C., Bourguignon, P., Calembert, L., Dumon, P., Guilleaume, C., Gulinck, M., Legrand, R., Macar, P., Marlière, R., Tavernier, R. & Van Leckwijck, W., 1947. Les roches calcaires de la Belgique. In Centenaire de l'Association des Ingénieurs sortis de l'École de Liège (A.I.Lg), Congrès 1947, Section Géologie. A.I.Lg, Liège, 317–381.

Casier, J.-G., 1987. Etude biostratigraphique et paléoécologique des ostracodes du sommet du Givétien et de la base du Frasnien à Ave-et-Auffe (Bord sud du bassin de Dinant, Belgique). Bulletin de la Société belge de Géologie, 96/1, 23–34.

Casier, J.-G. & Préat, A., 1990. Sédimentologie et Ostracodes de la limite Eifelien-Givetien à Resteigne (bord sud du bassin de Dinant, Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 60, 75–105.

Casier, J.-G. & Préat, A., 2013. Ostracodes et lithologie du stratotype de la Formation du Mont d'Haurs (Givétien, Synclinorium de Dinant). Revue de Paléobiologie, 32/2, 481–501.

Casier, J.-G., Préat, A. & Kasimi, R., 1992. Ostracodes et sédimentologie du sommet de l'Eifelien et de la base du Givetien, à Couvin (bord sud du Bassin de Dinant, Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 62, 75–108.

Casier, J. G., Devleeschouwer, X., Moreau, J., Petitclerc, E. & Préat, A., 2011. Ostracods, rock facies and magnetic susceptibility records from the stratotype of the Terres d'Haurs Formation (Givetian) at the Mont d'Haurs (Givet, France). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 81, 97–128.

Cauchy, P.-F., 1827. Sur la pierre calcaire fournissant une chaux hydraulique, que l'on extrait dans une carrière ouverte au lieu dit Humerée, dépendant de la commune de Sombreffe, province de Namur, et sur quelques autres pierres calcaires analogues. Mémoires de l'Académie royale de Belgique, 4, 256–270.

Coen, M., 1978. Le Givetien et le Frasnien dans le contournement routier de Philippeville. Comparaison avec la coupe de Neuville. Annales de la Société géologique de Belgique, 100, 23–30.

Coen, M., 1985. Ostracodes givétiens de l'Ardenne. Mémoires de l'Institut géologique de l'Université de Louvain, 32, 1–48.

Coen, M. & Coen-Aubert M., 1971. L'assise de Fromelennes aux bords sud et est du bassin de Dinant et dans le massif de la Vesdre. Annales de la Société géologique de Belgique, 94/1, 5–20.

Coen, M., Bultynck, P. & Pel, J., 1974. Excursion E. In Bouckaert, J. & Streel, M. (eds), International Symposium on Belgian micropaleontological limits from Emsian to Visean: Namur, September 1st to 10th, 1974, Guidebook. Geological Survey of Belgium, Bruxelles, 1–20.

Coen Aubert, M., 1970. Le Givetien et le Frasnien inférieur de Pepinster. Annales de la Société géologique de Belgique, 92, 383–395.

Coen Aubert, M., 1973. Le Givetien et le Frasnien de la vallée du Hoyoux. Service géologique de Belgique, Professional Papers, 1973/6, 1–12.

Coen-Aubert, M., 1974. Le Givetien et le Frasnien du massif de la Vesdre. Stratigraphie et Paléogéographie. Académie royale de Belgique, Mémoires de la Classe des Sciences, in-4o, 2e série, 18/2, 1–146.

Coen-Aubert, M., 1988a. Représentants des genres *Sociophyllum* Birenheide, 1962 et *Beugniesastraea* n. gen. à la base du Calcaire de Givet de Pondrôme et de Resteigne (bord sud du Bassin de Dinant, Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 58, 5–31.

Coen-Aubert, M., 1988b. Les unités lithostratigraphiques du Dévonien moyen et du Frasnien dans le sondage de Wépion. Service géologique de Belgique, Professional Papers, 1988/1, 1–26.

Coen-Aubert, M., 1990a. Description de quelques Rugueux coloniaux du Couvinien supérieur de Wellin (bord sud du Bassin de Dinant, Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 59 (pro 1989), 15–35.

Coen-Aubert, M., 1990b. Deuxième note sur les Rugueux coloniaux de l'Eifelien supérieur et de la base du Givetien à Wellin (bord sud du Bassin de Dinant, Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 60, 5–28.

Coen-Aubert, M., 1991a. ROU Formation du Roux. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 77–79.

Coen-Aubert, M., 1991b. FRO Formation de Fromelennes. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 61–64.

Coen-Aubert, M., 1991c. WEL Formation X. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 41–44.

Coen-Aubert, M., 1992. Rugueux coloniaux mésodévoniens du Fondry des Chiens à Nismes (Ardenne, Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 62, 5–21.

Coen-Aubert, M., 1996. Siphonophrentides et Cyathophyllides près de la limite Eifelien-Givetien à Resteigne (Ardenne, Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 66, 19–36.

Coen-Aubert, M., 1997. Rugueux solitaires près de la limite Eifelien-Givetien à Pondrôme (Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 67, 5–24.

Coen-Aubert, M., 1998. Thamnophyllides et Acanthophyllides près de la limite Eifelien-Givetien à Wellin et Pondrôme (Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 68, 5–24.

Coen-Aubert, M., 1999. Description de quelques Rugueux coloniaux de la Formation givetienne du Mont d'Haurs en Ardenne. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 69, 27–46.

Coen-Aubert, M., 2000a. Annotation to the Devonian Correlation Table, B142dm00 – B142ds00: Stratigraphic distribution of the Middle Devonian and Frasnian rugose corals from Belgium. Senckenbergiana lethaea, 80/2, 743–745. https://doi.org/10.1007/bf03043374

Coen-Aubert, M., 2000b. Stratigraphy and additional rugose corals from the Givetian Mont d'Haurs Formation in the Ardennes. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 70, 5–23.

Coen-Aubert, M., 2002. Temnophyllids and Spinophyllids (Rugosa) from the Givetian Mont d'Haurs Formation in Belgium. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 72, 5–24.

Coen-Aubert, M., 2003. Description of a few rugose corals from the Givetian Terres d'Haurs Formation in Belgium. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 73, 11–27.

Coen-Aubert, M., 2004. Two new species of Temnophyllids (Rugosa) from the Upper Givetian of Belgium. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 74, 19–34.

Coen-Aubert, M., 2008. Fasciculate Disphyllids (Rugosa) from the Early Givetian Trois-Fontaines Formation in Belgium. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 78, 21–50.

Coen-Aubert, M., 2014. Revision of the Frasnian marine deposits from the Booischot borehole (Campine Basin, Belgium). Geologica Belgica, 17/3-4, 333–337.

Coen-Aubert, M., 2019. Investigation of some Givetian rugose corals from the Mont d'Haurs Formation in southern Belgium. Geologica Belgica, 22/3-4, 121–138. https://doi.org/10.20341/gb.2019.008

Coen-Aubert, M. & Coen, M., 1975. Le Givetien et le Frasnien dans la vallée de la Meuse de Tailfer à Yvoir (bord nord du Bassin de Dinant). Annales de la Société géologique de Belgique, 97 (pro 1974), 499–524.

Coen-Aubert, M. & Lacroix, D., 1979. Le Frasnien dans la partie orientale du bord sud du Synclinorium de Namur. Annales de la Société géologique de Belgique, 101 (pro 1978), 269–279.

Coen-Aubert, M., Groessens, E. & Legrand, R., 1980. Les formations paléozoïques des sondages de Tournai et de Leuze. Bulletin de la Société belge de Géologie, 89/4, 241–275.

Coen-Aubert, M., Préat, A. & Tourneur, F., 1986. Compte rendu de l'excursion de la Société belge de Géologie du 6 novembre 1985 consacrée à l'étude du sommet du Couvinien et du Givétien au bord sud du bassin de Dinant, de Resteigne à Beauraing. Bulletin de la Société belge de Géologie, 95/4, 247–256.

Coen-Aubert, M., Mamet, B., Préat, A. & Tourneur, F., 1991. Sédimentologie, paléoécologie et paléontologie des calcaires crinoïdiques au voisinage de la limite Couvinien-Givetien à Wellin (bord sud du Synclinorium de Dinant, Belgique). Mémoire pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 31, 1–61.

Cornet, F.-L. & Briart, A., 1877. Sur le relief du sol en Belgique après les temps paléozoïques. Annales de la Société géologique de Belgique, 4, Mémoires, 71–115.

Cornet, J., 1923. Géologie. Tome 4. Géologie stratigraphique. C. Leich, Mons, 779 p.

Cornet, L., Gerrienne, P., Meyer-Berthaud, B. & Prestianni, C., 2012. A Middle Devonian *Callixylon* (Archaeopteridales) from Ronquières, Belgium. Review of Palaeobotany and Palynology, 183, 1–8. https://doi.org/10.1016/j.revpalbo.2012.07.004

de Béthune, P., 1954. Carte géologique de Belgique. 1/500 000. Atlas de Belgique, planche 8. In Fourmarier, P. (ed.), Prodrome d'une description géologique de la Belgique. Société géologique de Belgique, Liège, Annexe 1.

de Decker, M., 1994. Etude biostratigraphique de la Formation de Pepinster du Dévonien moyen : conodontes, spores et ostracodes. Unpublished Master Thesis, Université catholique de Louvain, Louvain-la-Neuve, 49 p.

de Dorlodot, H., 1893. Recherches sur le prolongement occidental du Silurien de Sambre-et-Meuse et sur la terminaison orientale de la faille du Midi. Annales de la Société géologique de Belgique, 20, Mémoires, 289–424.

de Dorlodot, H., 1895. Sur l'âge du poudingue de Naninne et sur la présence du Couvinien dans le bassin de Namur. Annales de la Société géologique de Belgique, 22, Mémoires, 87–121.

Dejonghe, L. & Hance, L., 2008. Carte géologique de Wallonie : Hotton – Dochamps 55/5-6. 1/25 000. Ministère de la Région wallonne, Direction générale de l'Agriculture, des Ressources naturelles et de l'Environnement, Namur, and its explanatory booklet, 88 p.

Dejonghe, L., Bultynck, P., Groessens, E., Delmer, A., Hahn, G., Legrand, R. & Tsien, H.H., 1973. Le sondage de Boussu, Pl. Saint-Ghislain - 150 E, n° 386 (IV b). Service géologique de Belgique, Professional Papers, 1973/3, 1–110.

Dejonghe, L., Hance, L. & Steemans, P., 1991a. PER Formation de Pepinster. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 93–96.

Dejonghe, L., Hance, L. & Steemans, P., 1991b. VIC Formation de Vicht. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 87–91.

Delcambre, B., 2023. Carte géologique de Wallonie : Andenne – Couthuin 48/1-2. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 162 p.

Delcambre, B. & Pingot, J.-L., 2000. Carte géologique de Wallonie : Gozée – Nalinnes 52/3-4. 1/25 000. Ministère de la Région wallonne, Direction générale de l'Agriculture, des Ressources naturelles et de l'Environnement, Namur, and its explanatory booklet, 105 p.

Delcambre, B. & Pingot, J.-L., 2004. Carte géologique de Wallonie : Biesme – Mettet 53/1-2. 1/25 000. Ministère de la Région wallonne, Direction générale de l'Agriculture, des Ressources naturelles et de l'Environnement, Namur, and its explanatory booklet, 82 p.

Delcambre, B. & Pingot, J.-L., 2008. Carte géologique de Wallonie : Fleurus – Spy 47/1-2. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 130 p.

Delcambre, B. & Pingot, J.-L., 2014a. Carte géologique de Wallonie : Wasseiges – Braives 41/5-6. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 112 p.

Delcambre, B. & Pingot, J.-L., 2014b. Carte géologique de Wallonie : Tamines – Fosses-la-Ville 47/5-6. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 106 p.

Delcambre, B. & Pingot, J.-L., 2017. Carte géologique de Wallonie : Malonne – Naninne 47/7-8. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 130 p.

Delcambre, B. & Pingot, J.-L., 2018a. Carte géologique de Wallonie : Gesves – Ohey 48/5-6. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 120 p.

Delcambre, B. & Pingot, J.-L., 2018b. Carte géologique de Wallonie : Bioul – Yvoir 53/3-4. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 127 p.

Delmer, A., 2004. Structure tectonique du bassin houiller du Hainaut. Mémoires du Service géologique de Belgique, 50, 1–61.

Denayer, J., 2019. Revised stratigraphy of the Eifelian (Middle Devonian) of southern Belgium: sequence stratigraphy, global events, reef development and basin structuration. Geologica Belgica, 22/3-4, 149–173. https://doi.org/10.20341/gb.2019.009

Denayer, J., 2023. From mud to limestone: Birth and growth of a giant reef in the Eifelian (Middle Devonian) of S Belgium. Palaeogeography, Palaeoclimatology, Palaeoecology, 627, 111748. https://doi.org/10.1016/j.palaeo.2023.111748

Denayer, J., 2024. Rugose corals across the Early-Middle Devonian boundary in southern Belgium. Palaeobiodiversity and Palaeoenvironments. https://doi.org/10.1007/s12549-024-00627-0

Denayer, J. & Mottequin, B., 2024. Lower Devonian lithostratigraphy of Belgium. Geologica Belgica, 27/3-4, 115–154. https://doi.org/10.20341/gb.2024.004

de Ville de Goyet, F., Breuer, P., Gerrienne, P., Prestianni, C., Streel, M. & Steemans, P., 2007. Middle Devonian (Givetian) megaspores from Belgium (Ronquières) and Libya (A1-69 borehole). Carnets de Géologie, 2007/01/11, 68–73.

Dewalque, G., 1868. Prodrome d'une description géologique de la Belgique. Librairie polytechnique De Decq, Bruxelles, Liège, 442 p.

Dewalque, G., 1877. Nouvelles géologiques : 2° Age du poudingue d'Alvaux. Annales de la Société géologique de Belgique, 4, Bulletin, 92–94.

D'Heur, M., 1970. Étude sédimentologique du Givetien du massif de la Vesdre (région de Verviers). Annales de la Société géologique de Belgique, 93/3, 509–522.

d'Omalius d'Halloy, J.J., 1828. Mémoires pour servir à la description géologique des Pays-Bas, de la France et de quelques contrées voisines. D. Gérard, Namur, 307 p.

d'Omalius d'Halloy, J.J., 1862. Abrégé de géologie. 7e éd. A. Schnée, Bruxelles and Leipzig, F.J. Leiber, Paris, 626 p.

Dumon, P. & Maillieux, E., 1937. Contribution à la connaissance du Dévonien de l'Ardenne, I. Le Couvinien et le Givetien au Nord de Wellin. Bulletin du Musée royal d'Histoire naturelle de Belgique, 13/37, 1–6.

Dumont, A.-H., 1832. Mémoire sur la constitution géologique de la province de Liége. Mémoires couronnés par l'Académie royale des Sciences et Belles-Lettres de Bruxelles, 8/3, 1–374.

Dumoulin, V. & Blockmans, S., 2008. Le passage latéral entre les formations de Couvin et de Jemelle (Eifelien) au bord sud du Synclinorium de Dinant (Belgique) : Introduction du Membre du Vieux Moulin – Formation de Jemelle. Geologica Belgica, 11/1-2, 25–33.

Dumoulin, V. & Blockmans, S., 2013a. Carte géologique de Wallonie : Pondrôme – Wellin 59/5-6. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 84 p.

Dumoulin, V. & Blockmans, S., 2013b. Carte géologique de Wallonie : Felenne – Vencimont 58/7-8. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 59 p.

Dumoulin, V. & Coen, M., 2008. Carte géologique de Wallonie : Olloy-sur-Viroin – Treignes 58/5-6. 1/25 000. Ministère de la Région wallonne, Direction générale de l'Agriculture, des Ressources naturelles et de l'Environnement, Namur, and its explanatory booklet, 103 p.

Dumoulin, V. & Marion, J.-M., 1998. Carte géologique de Wallonie : Sautour – Surice 58/1-2. 1/25 000. Ministère de la Région wallonne, Direction générale de l'Agriculture, des Ressources naturelles et de l'Environnement, Namur, and its explanatory booklet, 70 p.

Dumoulin, V., Coen, M. & Blockmans, S., 2006. Les coupes de référence et au-delà… la cartographie géologique. Le cas de la Formation de Couvin et le passage de celle-ci à la Formation de Jemelle. Géologie de la France, 1-2, 41–44.

Dusar, M., 1989. Stratigraphie et tectonique dans la région d'Hamoir-sur-Ourthe. Aardkundige Mededelingen, 4, 1–46.

Errera, M., 1976. Etude sédimentologique du Dévonien moyen du sondage de Boussu (Hainaut, Belgique), Pl. Saint-Ghislain 150 E, n°386 (IV b). Service géologique de Belgique, Professional Papers, 1976/2, 1–33.

Errera, M., Mamet, B. & Sartenaer, P., 1972. Le Calcaire de Givet et le Givetien à Givet. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 48/1, 1–59.

Forir, H., 1897. Compte rendu de la session extraordinaire de la Société géologique de Belgique, tenue à Huy, du 2 au 5 octobre 1897. Annales de la Société géologique de Belgique, 24, Bulletin, 149–203.

Fourmarier, P., 1954. Le Mésodévonien. In Fourmarier, P. (ed.), Prodrome d'une description géologique de la Belgique. Société géologique de Belgique, Liège, 119–141.

Fourmarier, P. & Aderca, B., 1955. Les failles transversales dans la région de la Gileppe. Académie royale de Belgique, Bulletin de la Classe des Sciences, 5e série, 41, 540–550. https://doi.org/10.3406/barb.1955.69374

Gerrienne, P., Meyer-Berthaud, B., Fairon-Demaret, M., Streel, M. & Steemans, P., 2004. *Runcaria*, a Middle Devonian seed plant precursor. Science, 306, 856–858. https://doi.org/10.1126/science.1102491

Godefroid, J., 1968. Contribution à l'étude du Couvinien entre Wellin et Jemelle (bord sud du bassin de Dinant). Académie royale de Belgique, Mémoires de la Classe des Sciences, in-4°, 2e série, 17/3, 1–87.

Godefroid, J., 1977. Le genre *Paraspirifer* Wedekind, 1926 (Spiriferida – Brachiopode) dans l'Emsien et le Couvinien de la Belgique. Annales de la Société géologique du Nord, 97/1, 27–44.

Godefroid, J., 1991a. JEM Formation de Jemelle. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 31–32.

Godefroid, J., 1991b. LOM Formation de la Lomme. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 33–40.

Godefroid, J., 1995. Les brachiopodes (Pentamerida, Atrypida et Spiriferida) de la fin de l'Eifelien et du début du Givetien à Pondrôme (Belgique, bord sud du Synclinorium de Dinant). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 65, 69–116.

Godefroid, J. & Jacobs, L., 1986. Atrypidae (Brachiopoda) de la Formation de Fromelennes (fin du Givetien) et de la partie inférieure de la Formation de Nismes (début du Frasnien) aux bords sud et sud-est du Synclinorium de Dinant (Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 56, 67–136.

Godefroid, J. & Mottequin, B., 2005. Givetian brachiopods from the Trois-Fontaines Formation at Marenne (Belgium, Dinant Synclinorium). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 75, 5–23.

Gosselet, J., 1860. Mémoire sur les terrains primaires de la Belgique, des environs d'Avesnes et du Boulonnais. L. Martinet, Paris, 164 p.

Gosselet, J., 1863. Observations sur les dislocations brusques éprouvées par les terrains primaires de la Belgique. Bulletin de la Société géologique de France, 2e série, 20, 770–777.

Gosselet, J., 1873. Le Système du Poudingue de Burnot. Annales des Sciences géologiques, 4/7, 1–32.

Gosselet, J., 1876a. Le Calcaire de Givet, 2e partie : le Calcaire de Givet sur les deux côtés de la crête silurienne du Condros et de la grande faille. Annales de la Société géologique du Nord, 3, 54–75.

Gosselet, J., 1876b. Le Calcaire de Givet, 1re partie : le Calcaire de Givet sur le littoral de l'Ardenne dans l'Entre-Sambre-et-Meuse. Annales de la Société géologique du Nord, 3, 36–54.

Gosselet, J., 1888. L'Ardenne. Ministère des travaux publics, Mémoires pour servir à l'Explication de la Carte géologique détaillée de la France. Baudry & Cie, Paris, 889 p.

Gouwy, S. & Bultynck, P., 2002. Graphic correlation of Middle Devonian sections in the Ardenne region (Belgium) and the Mader-Tafilalt region (Morocco): development of a Middle Devonian composite standard. In Degryse, P. & Sintubin, M. (eds), Contributions to the Geology of Belgium and Northwest Europe. Proceedings of the first Geologica Belgica International Meeting, Leuven, 11-15 September 2002. Aardkundige Mededelingen, 12, 105–109.

Gouwy, S. & Bultynck, P., 2003a. Conodont based graphic correlation of the Middle Devonian formations of the Ardenne (Belgium): implications for stratigraphy and construction of a regional composite. Revista Española de Micropaleontología, 35, 315–344.

Gouwy, S. & Bultynck, P., 2003b. Conodont data across the Eifelian-Givetian boundary at Aisemont, southern Namur Synclinorium, Belgium: correlation and implications. Courier Forschungsinstitut Senckenberg, 242, 239–256.

Gouwy, S., Liao, J.-C. & Valenzuela-Ríos, J.I., 2013. Eifelian (Middle Devonian) to Lower Frasnian (Upper Devonian) conodont biostratigraphy in the Villech section (Spanish Central Pyrenees). Bulletin of Geosciences, 88/2, 315–338. https://doi.org/10.3140/bull.geosci.1341

Graulich, J.-M., 1961. Le sondage de Wépion. Mémoires pour servir à l'explication des Cartes géologiques et minières de Belgique, 2, 1–86.

Graulich, J.-M., Coen-Aubert, M. & Conil, R., 1975. Le sondage de Hermalle-sous-Argenteau. Service géologique de Belgique, Professional Papers, 1975/4, 1–12.

Groessens, E., 1970. Le Dévonien au bord nord du Bassin de Dinant. Etude préliminaire. Unpublished Master Thesis, Université catholique de Louvain, Louvain, 65 p.

Groessens, E., 2009. Les carrières, pierres de taille et marbres de Givet (France) et du Givetien. Annales de la Société géologique du Nord, 2e série, 15, 15–24.

Hance, L., Dejonghe, L., Graulich, J.-M. & Steemans, P., 1989. Géologie de l'autoroute E42 Verviers – Saint-Vith à Heusy et à Ensival. Service géologique de Belgique, Professional Papers, 1989/2, 1–48.

Hance, L., Dejonghe, L. & Steemans, P., 1992. Stratigraphie du Dévonien inférieur dans le Massif de la Vesdre (Belgique). Annales de la Société géologique de Belgique, 115/1, 119–134.

Hance, L., Dejonghe, L., Fairon-Demaret, M. & Steemans, P., 1996. La Formation de Pepinster dans le Synclinorium de Verviers, entre Pepinster et Eupen (Belgique) – Contexte structural et stratigraphique. Annales de la Société géologique de Belgique, 117/1 (pro 1994), 75–93.

Hennebert, M., 2008. Carte géologique de Wallonie : Merbes-le-Château – Thuin 52/1-2. 1/25 000. Namur, Service Public de Wallonie, Agriculture, Ressources naturelles et Environnement, and its explanatory booklet, 64 p.

Hennebert, M. & Delaby, S., in press. Carte géologique de Wallonie : Roisin – Erquennes 51/1-2. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet.

Hennebert, M. & Eggermont, B., 2002. Carte géologique de Wallonie : Braine-le-Comte – Feluy 39/5-6. 1/25 000. Ministère de la Région wallonne, Direction générale de l'Agriculture, des Ressources naturelles et de l'Environnement, Namur, and its explanatory booklet, 63 p.

Holzapfel, E., 1910. Die Geologie des Nordabfalls der Eifel mit besonderer Berücksichtigung der Gegend von Aachen. Abhandlungen der Königlich Preuischen Geologischen Landesanstalt, Neue Folge, 66, 1–218.

Hubert, B., 2008a. Detailed lithology and faunal occurrence of the historical Givetian section: the fortifications of the Mont d'Haurs (Givet, France). Annales de la Société géologique du Nord, 2e série, 15, 53–65.

Hubert, B., 2008b. Glageon quarry: lithostratigraphy and faunal occurrence in the Middle Givetian (Devonian) of Avesnois, France. Annales de la Société géologique du Nord, 2e série, 15, 67–75.

Jamart, V. & Denayer, J., 2020. The Kačák event (late Eifelian, Middle Devonian) on the Belgian shelf and its effects on rugose coral palaeobiodiversity. Bulletin of Geosciences, 95/3, 279–311. https://doi.org/10.3140/bull.geosci.1788

Jansen, U., Halamski, A.T. & Mottequin, B., 2025. Silurian to lower Carboniferous brachiopods of Central Europe – palaeogeographic and palaeobathymetric constraints. In Linnemann, U. (ed.), The Variscan Orogen of Central Europe. Geodynamics – Geochronology – Geobiology. Springer, Cham.

Jarnaz, M., 1969. Contribution à l'étude du Givetien inférieur du bord oriental du Synclinorium de Dinant. Académie royale de Belgique, Bulletin de la Classe des Sciences, 5e série, 55/1, 1017–1030.

Jux, U. & Strauch, F., 1966. Die mitteldevonische Brachiopoden-Gattung *Uncites* Defrance 1825. Palaeontographica, Abteilung A, 125/4-6, 176–222.

Kaisin, F., 1935. Le faciès 'marbre noir' dans le Paléozoïque de la Belgique. Mémoires de l'Institut géologique de l'Université de Louvain, 8, 81–131.

Kasig, W., 1967. Biofazielle und Feinstratigraphische Untersuchungenim Givetium und Frasnium am Nordrand des Stavelot-Venn-Massivs. Genehmigte Dissertation von der Mathematisch-Naturwissenschaftlichen Fakultät der Rheinisch-Westfälischen Technischen Hochschule Aachen zur Erlangung des akademischen Grades eines Doktors der Naturwissenschaften, Aachen, 179 p.

Kasig, W. & Neumann-Mahlkau, P., 1969. Die Entwicklung des Eifeliums in Old-Red-Fazies zur Riff-Fazies im Givetium und

Unteren Frasnium am Nordrand des Hohen Venns (Belgien-Deutschland). Geologische Mitteilungen, 8, 327–388.

Kasig, W. & Reissner, B., 2008. Aachen–Hohes Venn. In Deutsche Stratigraphische Kommission (Ed.), Stratigraphie von Deutschland VIII. Devon. Schriftenreihe der Deutschen Gesellschaft für Geowissenschaften, 52, 267–286.

Kasimi, R. & Préat, A., 1996. Sédimentation de rampe mixte silico-carbonatée des couches de transition eiféliennes-givétiennes franco-belges. Deuxième partie : cyclostratigraphie et paléostructuration. Bulletin des Centres de Recherche Exploration-Production Elf-Aquitaine, 20/1, 61–90.

Kayser, E., 1895. Sur une faune du sommet de la série rhénane à Pepinster, Goé et Tilff. Annales de la Société géologique de Belgique, 22, Mémoires, 175–216.

Klapper, G. & Ziegler, W., 1979. Devonian conodont biostratigraphy. Special Papers in Palaeontology, 23, 199–224.

Lacroix, D., 1972. La sous-assise du Poudingue d'Alvaux dans la vallée de l'Orneau. Service géologique de Belgique, Professional Papers, 1972/3, 1–6.

Lacroix, D., 1974a. Sur la stratigraphie du Mésodévonien et du Frasnien du bord sud du Synclinorium de Namur. Annales de la Société géologique de Belgique, 97/1, 11–22.

Lacroix, D., 1974b. Lithostratigraphie comparée du Givetien aux bords nord et sud du Synclinorium de Namur. Annales de la Société géologique de Belgique, 97/1, 59–65.

Lacroix, D., 1974c. Le Mésodévonien et le Frasnien à Dave (bord sud du Synclinorium de Namur). Lithostratigraphie et comparaison avec les coupes d'Aisemont et de Tailfer. Service géologique de Belgique, Professional Papers, 1974/5, 1–11.

Lacroix, D., 1991a. BOR Bois de Bordeaux. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 81–85.

Lacroix, D., 1991b. NEV Formation de Névremont. In Bultynck, P. et al., Les Formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 73–76.

Ladrière, J., 1875. Note sur le terrain dévonien de la vallée de l'Hogneau. Annales de la Société géologique du Nord, 2, 74–80.

Ladrière, J., 1905. Les affleurements du Terrain Dévonien dans les environs de Bavai. Annales de la Société géologique du Nord, 34, 205–264.

Lagrou, D. & Coen-Aubert, M., 2017. Update of the Devonian lithostratigraphic subdivision in the subsurface of the Campine Basin (northern Belgium). Geologica Belgica, 20/1-2, 1–13. http://dx.doi.org/10.20341/gb.2016.017

Lagrou, D. & Laenen, B., 2015. Introduction of the Booischot Formation, a new formal lithostratigraphic unit for the Devonian in the Campine Basin (N Belgium). National Commission for Stratigraphy in Belgium. https://ncs-old.naturalsciences.be/devonian/booischot-formation, accessed 02/14/2024.

Laloux, M., Dejonghe, L., Ghysel, P. & Hance, L., 1996. Carte géologique de Wallonie : Fléron – Verviers 42/7-8. 1/25 000. Ministère de la Région wallonne, Direction générale de l'Agriculture, des Ressources naturelles et de l'Environnement, Namur, and its explanatory booklet, 150 p.

Lecompte, M., 1960. Compte rendu de la session extraordinaire de la Société géologique de Belgique et de la Société belge de Géologie, de Paléontologie et d'Hydrologie, consacrée à l'étude du phénomène récifal dévonien dans la partie occidentale du bassin de Dinant et du bassin de Namur, du 25 au 28 septembre 1959. Annales de la Société géologique de Belgique, 83, 1–134.

Legrand, R., 1964. Coupe résumée du forage de Booischot (province d'Anvers). Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, 72, 407–409.

Legrand, R., 1967. Ronquières - Documents géologiques. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 6, 1–60.

Legrand, R., 1973. Le Mésodévonien à Sart-Dames-Avelines. Service géologique de Belgique, Professional Papers, 1973/14, 1–19.

Lemonne, E. & Dumoulin, V., 1999. Carte géologique de Wallonie : Agimont – Beauraing 58/3-4. 1/25 000. Ministère de la Région wallonne, Direction générale de l'Agriculture, des Ressources naturelles et de l'Environnement, Namur, and its explanatory booklet, 66 p.

Lessuise, A., Streel, M. & Vanguestaine, M., 1979. Observations palynologiques dans le Couvinien (Emsien terminal et Eifelien) du bord oriental du Synclinorium de Dinant, Belgique. Annales de la Société géologique de Belgique, 102/1, 325–355.

Liégeois, R., 1955. Le Mésodévonien du Massif de la Vesdre. Unpublished complementary Master Thesis in geological engineering, Université de Liège, Liège, 94 p.

Liégeois, R., 1956. Excursion dans le Mésodévonien de l'est du Synclinorium de Dinant et du Massif de la Vesdre. Annales de la Société géologique de Belgique, 80, 95–127.

Loboziak, S. & Streel, M., 1980. Miospores in Givetian to lower Frasnian sediments dated by conodonts from the Boulonnais, France. Review of Palaeobotany and Palynology, 29, 285–299. https://doi.org/10.1016/0034-6667(80)90065-2

Lütte, B.-P. & Schröder, S., 1998. Anmerkungen zur Devon-Korrelationstabelle, B141dm97: Rugosa; Eifel. Senckenbergiana lethaea, 77/1-2, 273-275.

Mabille, C. & Boulvain, F., 2008. Les Monts de Baileux section: detailed sedimentology and magnetic susceptibility of Hanonet, Trois-Fontaines and Terres d'Haurs formations (Eifelian-Givetian boundary and Lower Givetian, SW Belgium). Geologica Belgica, 11/3-4, 93–121.

Mabille, C., De Wilde, C., Hubert, B., Boulvain, F. & Da Silva, A.-C., 2008. Detailed sedimentological study of a non-classical succession for Trois-Fontaines and Terres d'Haurs formations (Lower Givetian, Marenne, Belgium) – Introduction of the Marenne Member. Geologica Belgica, 11/3-4, 217–237.

Macar, P., Gulinck, M & Guilleaume, C., 1947. Les roches siliceuses et conglomératiques exploitées en Belgique. In Centenaire de l'Association des Ingénieurs sortis de l'École de Liège (A.I.Lg.), Congrès 1947, Section Géologie. A.I.Lg., Liège, 123–161.

Maillet, S., Milhau, B. & Pinte, E., 2011. Detailled lithology and faunal occurrence of the Fromelennes Formation in the type are (Middle/Upper Givetian, southern part of the Dinant Synclinorium, Ardenne). Annales de la Société géologique du Nord, 2e série, 18, 11–36.

Maillet, S., Dojen, C. & Milhau, B., 2013. Stratigraphical distribution of Givetian ostracods in the type-area of the Fromelennes Formation (Fromelennes, Ardennes, France) and their relationship to global events. Bulletin of Geosciences, 88/4, 865–892. https://doi.org/10.3140/bull.geosci.1424

Maillet, S., Danelian, T. & Casier, J.-G., 2016. Middle/Late Givetian ostracod assemblages from the Aisne quarry (Durbuy area, Ardenne, Belgium). Biostratigraphic and palaeoecological implications. Annales de Paléontologie, 102, 11–29. https://doi.org/10.1016/j.annpal.2015.12.002

Maillieux, E., 1922a. The Geology of Belgium, II: The Palaeozoic formations of the southern part of the Dinant Basin. Proceedings of the Geologists' Association, 33/1, 9–19. https://doi.org/10.1016/S0016-7878(22)80013-4

Maillieux, E., 1922b. 1re partie. Le Dévonien du bord méridional du Synclinal de Dinant. In Kaisin, E., Maillieux, E. & Asselberghs, E. (eds), Excursion A2 : Traversée centrale de la Belgique par la vallée de la Meuse et ses affluents de la rive gauche. Congrès Géologique International, livret guide pour la XIIIe Session, Belgique, du 1er au 9 août 1922. Vaillant-Carmanne, Liège, 8–31.

Maillieux, E. 1938. Le Couvinien de l'Ardenne et ses faunes. Mémoires du Musée royal d'Histoire naturelle de Belgique, 83, 1–57.

Maillieux, E., 1940. Documents pour servir à l'étude du Givetien de l'Ardenne. Bulletin du Musée royal d'Histoire naturelle de Belgique, 16/7, 1–13.

Maillieux, E., 1941a. Répartition des brachiopodes dans le Dévonien de l'Ardenne. Bulletin du Musée royal d'Histoire naturelle de Belgique, 17/30, 1–14.

Maillieux, E., 1941b. Répartition des Spiriferidae et des Spiriferinidae dans le Dévonien de l'Ardenne. Bulletin du Musée royal d'Histoire naturelle de Belgique, 17/13, 1–6.

Maillieux, E., 1942. Contribution à la connaissance de l'assise de Fromelennes (Frasnien inférieur). Bulletin du Musée royal d'Histoire naturelle de Belgique, 18/14, 1–18.

Maillieux, E. & Demanet, F., 1929. L'échelle stratigraphique des terrains primaires de la Belgique. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, 38/2 (pro 1928), Procès-verbaux, 124–131.

Malaise, C., 1900. Etat actuel de nos connaissances sur le Silurien de la Belgique. Annales de la Société géologique de Belgique, liber memorialis, 25 bis, in-4°, 179–221.

Malaise, C. & Stainier, X, 1892. Documents concernant le Dévonien du bassin de Namur. Annales de la Société géologique de Belgique, 19, Bulletin, 297–302.

Mamet, B. & Préat, A., 1987. Algues givétiennes du bord sud du Bassin de Dinant et des régions limitrophes. Annales de la Société géologique de Belgique, 109/2 (pro 1986), 431–454.

Mamet, B. & Préat, A., 2005. Microfaciès d'une lentille biohermale à la limite Eifelien/Givétien (Wellin, bord sud du Synclinorium de Dinant). Geologica Belgica, 8/3, 85–111.

Marion, J.-M. & Barchy, L., 1999. Carte géologique de Wallonie : Chimay – Couvin 57/7-8. 1/25 000. Ministère de la Région wallonne, Direction générale de l'Agriculture, des Ressources naturelles et de l'Environnement, Namur, and its explanatory booklet, 90 p.

Marion, J.-M. & Barchy, L., in press, a. Carte géologique de Wallonie : Hamoir – Ferrières 49/1-2. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet.

Marion, J.-M. & Barchy, L., in press, b. Carte géologique de Wallonie : Durbuy – Mormont 49/5-6. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet.

Marion, J.-M., Geukens, F., Lamberty, P. & Mottequin, B., in press. Carte géologique de Wallonie : Louveigné – Spa 49/3-4. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet.

Marlière, R., 1969. Carte géologique de Belgique : Quievrain – Saint-Ghislain n°150. 1/25 000. Service géologique de Belgique, Bruxelles, and its explanatory booklet, 73 p.

Marlière, R., 1970. Carte géologique de Belgique : Roisin – Erquennes n°161. 1/25 000. Service géologique de Belgique, Bruxelles, and its explanatory booklet, 30 p.

Molenaar, N., 1984. Palaeopedogenic features and their palaeoclimatological significance for the Nèvremont Formation (Lower Givetian), the northern Ardennes, Belgium. Palaeogeography, Palaeoclimatology, Palaeoecology, 46/4, 325–344. https://doi.org/10.1016/0031-0182(84)90005-1

Monjoie, A., 1965. Contribution à l'étude du Givetien d'Aisne (bord N-E du Synclinorium de Dinant). Annales de la Société géologique de Belgique, 88/1-4, 125–149.

Mottequin, B., 2019. An annotated catalogue of types of Silurian–Devonian brachiopod species from southern Belgium and northern France in the Royal Belgian Institute of Natural Sciences (1870–1945), with notes on those curated in other Belgian and foreign institutions. Geologica Belgica, 22/1-2, 47–89. https://doi.org/10.20341/gb.2019.005

Mottequin, B., 2021. Earth science collections of the Centre Grégoire Fournier (Maredsous) with comments on Middle Devonian–Carboniferous brachiopods and trilobites from southern Belgium. Geologica Belgica, 24/1-2, 33–68. https://doi.org/10.20341/gb.2020.028

Mottequin, B. & Denayer, J., 2024. Revised lithostratigraphic scale of the Devonian of Belgium: An introduction and an homage to Pierre Bultynck. Geologica Belgica, 27/3-4, 105–114. https://doi.org/10.20341/gb.2024.008

Mottequin, B. & Godefroid, J., 2016. Les brachiopodes. In Brice, D. (coord.), Stratotype Givétien. Muséum national d'Histoire naturelle, Paris; Biotope, Mèze, 154–155.

Mottequin, B., Marion, J.-M. & Delcambre, B., 2021. Carte géologique de Wallonie : Huy – Nandrin 48/3-4. 1/25 000. Service public de Wallonie, Agriculture, Ressources naturelles et Environnement, Namur, and its explanatory booklet, 84 p.

Mottequin, B., Denayer, J., Delcambre, B., Marion, J.-M. & Poty, E., 2024. Upper Devonian lithostratigraphy of Belgium. Geologica Belgica, 27/3-4, 193–270. https://doi.org/10.20341/gb.2024.009

Muchez, P. & Langenaeker, V., 1993. Middle Devonian to Dinantian sedimentation in the Campine Basin (northern Belgium): its relation to Variscan tectonism. Special Publication of the International Association of Sedimentologists, 20, 171–181.

Narkiewicz, K. & Bultynck, P., 2010. The Upper Givetian (Middle Devonian) *subterminus* conodont Zone in North America, Europe and North Africa. Journal of Paleontology, 84/4, 588–625. https://doi.org/10.1017/s0022336000058352

Neumann-Mahlkau, P. & Ribbert, K.H., 1998. Die Konglomerate der Givet-Stufe östlich des Brabanter Massivs. Fortschritte in der Geologie von Rheinland und Westfalen, 37, 393–421.

Pas, D., Da Silva, A. C., Devleeschouwer, X., De Vleeschouwer, D., Cornet, P., Labaye, C. & Boulvain, F., 2017. Insights into a million-year-scale Rhenohercynian carbonate platform evolution through a multi-disciplinary approach: example of a Givetian carbonate record from Belgium. Geological Magazine, 154/4, 707–739. https://doi.org/10.1017/s0016756816000261

Pel, J., 1965. Etude du Givetien à sédimentation rythmique de la région de Hotton-Hampteau. Annales de la Société géologique de Belgique, 88/8, 1–51.

Pel, J., 1967. Etude sédimentologique du givetien au Nord-est de Givet. In Oswald, D.H. (ed.), International Symposium on the Devonian System, Calgary, 1967. Volume II. Alberta Society of Petroleum Geologists, 441–452.

Pel., J., 1975. Etude sédimentologique et stratigraphique du Givetien, Synclinorium de Dinant, de Givet à Liège. Collection des publications de la Faculté des sciences appliquées de l'Université de Liège, 53, 61–113.

Préat, A. & Boulvain, F., 1982. Etude sédimentologique des calcaires givetiens à Vaucelles (bord sud du Synclinorium de Dinant). Annales de la Société géologique de Belgique, 105/1-2, 273–281.

Préat, A. & Boulvain, F., 1987. Les calcaires laminaires du Givétien inférieur du Bassin de Dinant : témoins paléogéographiques et paléoclimatiques. Annales de la Société géologique du Nord, 106/1 (pro 1986), 49–64.

Préat, A. & Carliez, D., 1996. Microfaciès et cyclicité dans le Givetien supérieur de Fromelennes (Synclinorium de Dinant). Annales de la Société géologique de Belgique, 117/1-2, 227–243.

Préat, A. & Mamet, B., 1989. Sédimentation de la plate-forme carbonatée givétienne franco-belge. Bulletin des Centres de Recherche Exploration-Production Elf-Aquitaine, 13/1, 47–86.

Préat, A. & Tourneur, F., 1991a. TRF Formation de Trois-Fontaines. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 49–52.

Préat, A. & Tourneur, F., 1991b. HNT Formation de Hanonet. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 45–48.

Préat, A. & Tourneur, F., 1991c. MHR Formation du Mont d'Haurs. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 55–59.

Préat, A. & Tourneur, F., 1991d. THR Formation des Terres d'Haurs. In Bultynck, P. et al., Les formations du Dévonien moyen de la Belgique. Mémoires pour servir à l'Explication des Cartes géologiques et minières de la Belgique, 30, 53–54.

Préat, A., Coen-Aubert, M., Mamet, B. & Tourneur, F., 1984. Sédimentologie et paléoécologie de trois niveaux récifaux du Givétien inférieur de Resteigne (bord sud du Bassin de Dinant, Belgique). Bulletin de la Société belge de Géologie, 93/1-2, 227–239.

Préat, A., Celeneer, G. & Boulvain, F., 1987. Etude sédimentologique des calcaires du Givétien inférieur d'Olloy-sur-Viroin (Bord sud du Synclinorium de Dinant, Belgique). Annales de la Société géologique du Nord, 106/3 (pro 1986), 251–265.

Préat, A., Bultynck, P. & Brice, D., 2006. Givetian. Geologica Belgica, 9/1-2, 9–18.

Préat, A., Blockmans, S., Capette, L., Dumoulin, V. & Mamet, B., 2007. Microfaciès d'une lentille biohermale à la limite Eifelien/Givetien ('Fondry des Chiens', Nismes, bord sud du Synclinorium de Dinant). Geologica Belgica, 10/1-2, 3–25.

Ribbert, K.H., 1998. Die devonische Carbonatfazies und die Honseler Fazies im Bereich der Krefelder Achsenaufwölbung und ihrer Randgebiete. Fortschritte in der Geologie von Rheinland und Westfalen, 37, 109–139.

Rutot, A. & Cornet, J., 1902. Carte géologique de Belgique Quievrain – Saint-Ghislain n°150. 1/40 000. Commission géologique de Belgique, Bruxelles.

Stainier, X., 1887. Note sur un trilobite nouveau et sur les *Pentamerus* des calcaires d'Humerée. Annales de la Société géologique de Belgique, 14, Mémoires, 75–85.

Stainier, X., 1890. Étude sur l'assise de Rouillon. Annales de la Société géologique de Belgique, 18, Mémoires, 25–41.

Stainier, X., 1894. Compte rendu de l'excursion de la Société belge de Géologie dans la vallée de l'Orneau, le 29 avril 1894. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, 8, Mémoires, 195–204.

Stainier, X., 1940. Etude sur le lambeau de poussée de Saint-Symphorien. Annales de la Société géologique de Belgique, 64/2, 21–56.

Stockmans, F., 1968. Végétaux mésodévoniens récoltés aux confins du Massif du Brabant (Belgique). Mémoires de l'Institut royal des Sciences naturelles de Belgique, 159, 1–49.

Streel, M., 1965. Étude palynologique du Dévonien du sondage de Booischot. Note préliminaire. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, 73/2, 172–185.

Streel, M. & Loboziak, S., 1987. Nouvelle datation par miospores du Givetien-Frasnien des sédiments non marins du sondage de Booischot (Bassin de Campine, Belgique). Bulletin de la Société belge de Géologie, 96/2, 99–106.

Streel, M., Higgs, K., Loboziak, S., Riegel, W. & Steemans, P., 1987. Spore stratigraphy and correlation with faunas and floras in the type marine Devonian of the Ardenne-Rhenish regions. Review of Palaeobotany and Palynology, 50/3, 211–229. https://doi.org/10.1016/0034-6667(87)90001-7

Streel, M., Loboziak, S., Steemans, P. & Bultynck, P., 2000. Devonian miospore stratigraphy and correlation with the global stratotype sections and points. Courier Forschungsinstitut Senckenberg, 220, 9–23.

Struve, W. & Werner, R., 1982. The lower/middle Devonian boundary and the Eifelian stage in the "Type Eifelian" region. In Plodowski, G., Werner, R. & Ziegler, W. (eds), Field meeting on Lower and Lower Middle Devonian stages in the Ardenno-Rhenish type area. Senckenbergische naturforschende Gesellschaft, Frankfurt am Main, 81–151.

Sun, Y.L. & Boucot, A.J., 1999. Ontogeny of *Stringocephalus gubiensis* and the origin of *Stringocephalus*. Journal of Paleontology, 73/5, 860–871 https://doi.org/10.1017/s0022336000040701

Thonon, G., 1980. Etude sédimentologique des psammites du Couvinien de la région d'Aywaille-Remouchamps. Unpublished Master Thesis, Université de Liège, Liège, 109 p.

Tourneur, F., Babin, C., Bigey, F., Boulvain, F., Brice, D., Coen-Aubert, M., Dreesen, R., Dusar, M., Loboziak, S., Loy, W. & Streel, M., 1989. Le Dévonien du sondage de Nieuwkerke (Flandre occidentale, Belgique, extrémité occidentale du Synclinorium de Namur). Annales de la Société géologique du Nord, 108, 85–112.

Tsien, H.H., 1969. Contribution à l'étude des Rugosa du Couvinien dans la région de Couvin. Mémoires de l'Institut géologique de l'Université de Louvain, 25, 1–174.

Tsien, H.H., 1971.The Middle and Upper Devonian reef-complexes of Belgium. Petroleum Geology of Taiwan, 8, 119–173.

Tsien, H.H., [1972]. Document n°7: Middle Devonian and Frasnian Stratigraphy of Belgium. Conseil géologique, Commissions nationales de Stratigraphie, Service géologique de Belgique, Bruxelles, 25 p.

Tsien, H.H., 1974. Excursion J. In Bouckaert, J. & Streel, M. (eds), International Symposium on Belgian micropaleontological limits from Emsian to Visean: Namur, September 1st to 10th, 1974. Guidebook. Geological Survey of Belgium, Brussels, 34 p.

Tsien, H.H., 1976. Espèces du genre *Tabulophyllum* (Rugosa) dans le Dévonien moyen et le Frasnien de la Belgique. Annales de la Société géologique de Belgique, 99/2, 263–282.

Vandercammen, A., 1956. Révision des Ambocoeliinae du Dévonien de la Belgique. Bulletin de l'Institut royal des Sciences naturelles de Belgique, 32/43, 1–51.

Vandercammen, A., 1963. Spiriferidae du Dévonien de la Belgique. Mémoires de l'Institut royal des Sciences naturelles de Belgique, 150, 1–179.

Waleffe, A., 1962. Observations sur le Mésodévonien et le Frasnien inférieur de Remouchamps. Académie royale de Belgique, Bulletin de la Classe des Sciences, 5e série, 48, 561–582.

Walliser, O.H., Bultynck, P., Weddige, K., Becker, R.T. & House, M.R., 1995. Definition of the Eifelian-Givetian stage boundary. Episodes, 18/3, 107–115. https://doi.org/10.18814/epiiugs/1995/v18i3/002

Weddige, K. (ed.), 2000. Devonian correlation table. Senckenbergiana lethaea, 80/2, 691–726. https://doi.org/10.1007/BF03043370

Weddige, K., Werner, R. & Ziegler, W., 1979. The Emsian–Eifelian boundary. An attempt at correlation between the Eifel and Ardennes regions. Newsletters on Stratigraphy, 8/2, 159–169. https://doi.org/10.1127/nos/8/1979/159

Wégria, H., 1965. Les variations de faciès du Mésodévonien, bord nord du Synclinorium de Dinant, Hoyoux-Ourthe. Unpublished Master Thesis, Université de Liège, Liège, 85 p.

Ziegler, W.T. & Klapper, G., 1985. Stages of the Devonian System. Episodes, 8/2, 104–109. https://doi.org/10.18814/epiiugs/1985/v8i2/006