

GIVETIAN

Alain PREAT¹ & Pierre BULTYNCK²
in collaboration with Denise BRICE³

(7 figures)

1. Université Libre de Bruxelles, Département des Sciences de la Terre et de l'Environnement, Géologie-CP160/02, 50 av FD Roosevelt, B 1050 Bruxelles, Belgique; E-mail: apreat@ulb.ac.be.
2. Royal Belgian Institute of Natural Sciences, Department of Palaeontology, Vautierstraat, 29, B-1000 Brussels, Belgium; E-mail: pierre.bultynck@belgacom.net.
3. Laboratoire de Paléontologie stratigraphique, Faculté Libre des Sciences, rue de Toul, 13, F-59046 Lille cedex, France; E-mail: denise.brice@fls.fupl.asso.fr.

ABSTRACT. The Givetian Stage in the Givet area is represented by the main part of the Hanonet Fm, the Trois-Fontaines Fm, the Terres d'Haus Fm, the Mont d'Haus Fm, the Fromelennes Fm and the lowest part of the Nismes Fm. During Eifelian-Givetian transition, the sedimentary systems evolved from a mixed siliciclastic-carbonate ramp to a carbonate platform dominated by cyclic tidal-flat and lagoonal wackestones with local patch reefs or corallgal banks. The shelf had an ESE-WNW trend and extended from the Avesnois basin (northern France) in the west to Aachen (western Germany). The sedimentation in the Ardennes consists of shallow water regressive metric (around 5 m or less) cycles. Stromatopores, corals, brachiopods, algae and cyanobacteria are abundant. Due to this general shallow water setting, the base of the Givetian Stage has been defined by the IUGS Subcommittee on Devonian Stratigraphy in a GSSP in southern Morocco referring to the first occurrence of the conodont species *Polygnathus hemiansatus*. The conodont species *Icriodus obliquimarginatus* appears approximately at the same level in Belgium.

KEYWORDS: Givetian, lagoons, tidal flats, patch reefs, corallgal banks, carbonate platform.

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1. Name

Givetian (English), Givetiaan (Dutch), Givetium (German), Givetien (French)

2. Age

391.8 to 385.3 Ma from Gradstein & Ogg (2004).

3. Author

Gosselet (1879) : Description géologique du canton de Maubeuge. Annales de la Société Géologique du Nord, 6 : 129-211. Introducing the name « *Givétien* », Gosselet (1879, p.132) refers to his description of the Givet Limestone (Gosselet, 1876) : « *Le Calcaire de Givet est évidemment celui qui forme les escarpements des bords de la Meuse, au Sud de Givet, sous la forteresse de Charlemont et qui se suit sans interruption depuis Givet dans les Ardennes jusqu'à Rocquigny dans le Nord.* ».

4. Historical type area

Escarpments on the north-western banks of the River Meuse, to the south-west of Givet (France), along RN 51 between les Trois-Fontaines and St-Hilaire, topographic

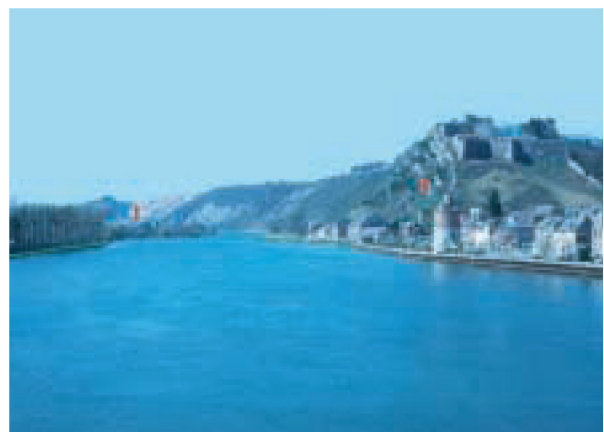


Figure 1. Type section of the Givet Limestone on the left bank of the Meuse River, south of Givet. 1 = Trois-Fontaines Formation; 4 = Fromelennes Fm.

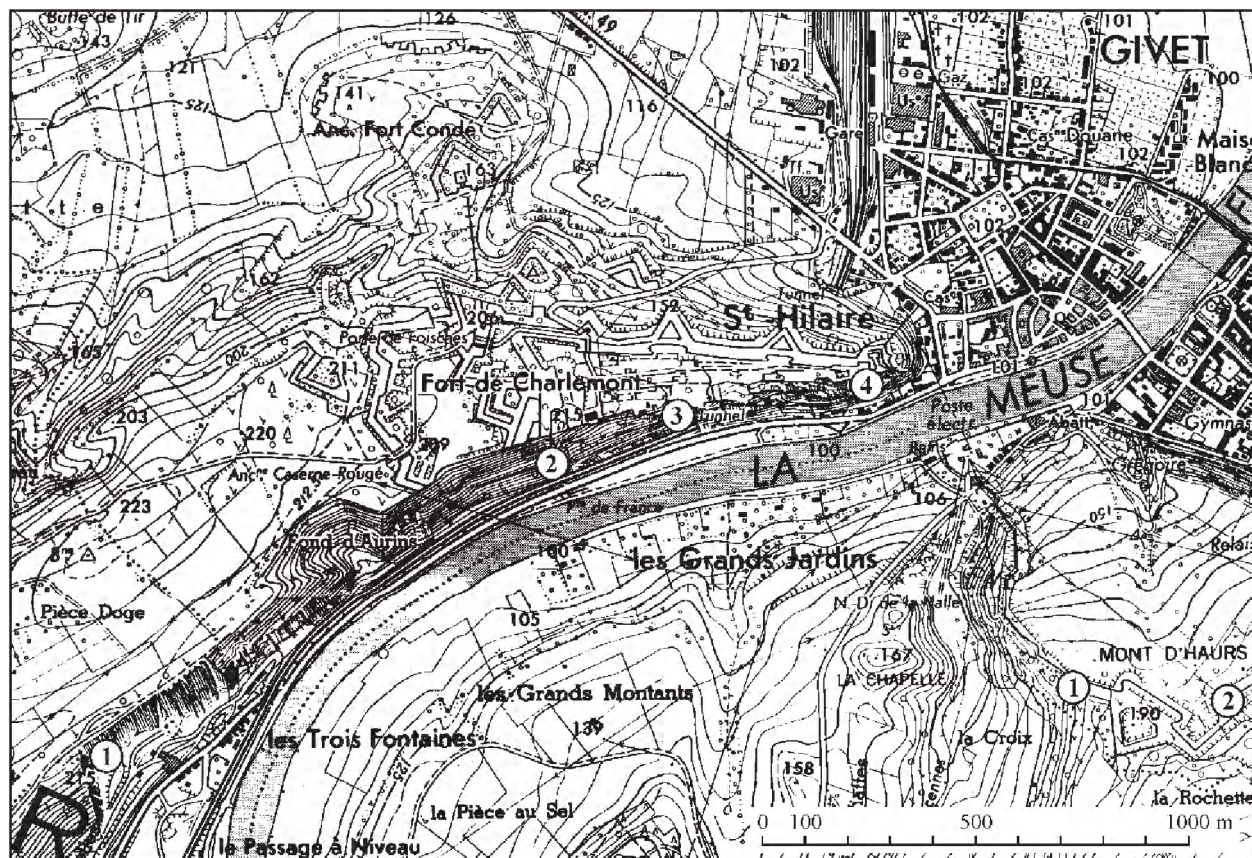


Figure 2. Part of topographic map 1:10,000 Agimont 58/3 (slightly reduced) showing the location of the type section of the Givet Limestone. 1 = Trois-Fontaines Fm; 2 = Terres d'Haur Fm; 3 = Mont d'Haur Fm; 4 = Fromelennes Fm. The positions of 1 and 4 are also shown in Fig. 1.

map 1:10,000 Agimont 58/3 (Figs 1 & 2). Corresponding geological map : carte géologique de Wallonie 1:25,000 Agimont-Beauraing 58/3-4 (Lemonne & Dumoulin, 1999).

5. Description

According to the definition of the Global Stratotype Section and Point (GSSP) for the base of the Givetian (Walliser *et al.*, 1995) and for the base of the Frasnian (Klapper *et al.*, 1987), the Givetian Stage in the Givet area is represented by the main part of the Hanonet Fm, the Trois-Fontaines Fm, the Terres d'Haur Fm, the Mont d'Haur Fm, the Fromelennes Fm and the lowest part of the Nismes Fm. Biostromal beds and fine grained micritic limestones prevail. Two shaly parts with nodular limestones occur, the Terres d'Haur Fm and the Flohimont Mbr of the Fromelennes Fm.

6. Historical background

A very detailed summary of the various concepts of the 'Givetian' and 'Calcaire de Givet' terms was published

by Sartenaer & Errera (1972). In a special volume of the BRGM, Service Géologique National de France, devoted to French stratotypes, Brice (1980) gave an historical overview of the term Givetian and its lithostratigraphic and biostratigraphic characteristics. Herein attention is paid only to the most important changes in the meaning of the term Givetian. For more detailed information the reader is referred to the two above-mentioned references. According to Gosselet (1879, p. 130, 131) the term 'Givétien' he introduced corresponds to the 'Calcaire de Givet', exposed along the Meuse River south of Givet, which he described earlier (1876). Using the current lithostratigraphic terminology, the 'Givétien' of Gosselet (1879) includes the Trois-Fontaines Fm (without the 5-6 m of dark bluish limestones at the base), the Terres d'Haur Fm, the Mont d'Haur Fm and the Fromelennes Fm without the Fort Hulobiet Mbr. This current lithostratigraphic terminology will be used for describing the major changes in the concept of the term Givetian. Between 1884 and 1900 Gosselet used the term Givetian in a more restricted meaning. It is only represented by the Trois-Fontaines Fm (without the 5-6 m of limestones at the base), the Terres d'Haur Fm and the Mont d'Haur Fm. On different 'Givet' map sheets of the French Geological map between 1882 and 1970 and also in the

different explanatory notes of the Belgian Geological map between 1896 and 1929, the Givetian includes the Trois-Fontaines Fm (without the 5–6 m of limestone at the base), the Terres d’Hairs Fm and the Mont d’Hairs Fm (these three formations are represented by Gva on the Belgian maps) and the Fromelennes Fm (= Gvb on the Belgian maps).

Since Maillieux (1910) many Belgian authors have used the term Givetian in a more restricted meaning including the Trois-Fontaines Fm, the Terres d’Hairs Fm and the Mont d’Hairs Fm. They assign the Fromelennes Fm to the Frasnian.

Sartenaer & Errera (1972) define a Givet Group (= Calcaire de Givet) composed of the Trois-Fontaines Fm, the Mont d’Hairs Fm and the Fromelennes Fm. They propose that a Givetian stage should approximatively represent the period of time for deposition of the Givet Limestone. This approach has been followed by most Belgian authors since 1972. Pr  at & Tourneur (1991) introduced the Terres d’Hairs Fm corresponding to the uppermost part of the Trois-Fontaines Fm and the lowest part of the Mont d’Hairs Fm sensu Sartenaer & Errera (1972).

In 1981 the IUGS Subcommittee on Devonian Stratigraphy (SDS) decided to retain the name Givetian as international chronostratigraphic term for the upper stage of the Middle Devonian. However, in the type area for the name of the stage, the Givetian is mainly represented by shallow water platform carbonates. Corals, stromatopores and brachiopods, at some levels, are the most common fossil groups, useful for regional-interregional biostratigraphy but not for worldwide correlation. The base of all Devonian stages, with the exception of the Lochkovian, have been defined by SDS using conodonts because they provided the best results for worldwide correlation. The base of the Givetian stage was defined in a Global Stratotype Section and Point (GSSP) in southern Morocco referring to the first occurrence of the conodont species *Polygnathus hemiansatus*; another conodont *Icriodus obliquimarginatus* appears approximately at the same level (Walliser *et al.*, 1995). Conodonts are generally sparse in the Givet Limestone and the underlying Hanonet Fm. However, Bultynck & Hollevoet (1999) demonstrated that the index species and also *I. obliquimarginatus* first occur near the top of the lower part of the Hanonet Fm as described herein. Coen-Aubert (1992) recorded the two conodont species in the lower part of Fm “X” in Nismes. The base of the Frasnian (= top of Givetian) has been defined by SDS (Klapper *et al.*, 1987) in a GSSP (Montagne Noire, Southern France) by the first occurrence of an early morphotype of the conodont *Ancyrodella rotundiloba*. This species appears slightly above the base of the Nismes Fm in many sections of the Ardennes (Bultynck *et al.*, 1988).

7. Lithology

The Givetian of the type area is represented by the main part of the Hanonet Fm, The Trois-Fontaines, Terres d’Hairs, Mont d’Hairs and Fromelennes formations and the lowest part of the Nismes Fm (Fig. 3).

7.1. Hanonet Fm

The top of the lower part of this Fm is of Early Givetian age as indicated above. The Fm consists of blackish, argillaceous, pyritic nodular thin limestone beds with thin calcareous shale beds (lower part), dark thin bluish limestones beds with corals (middle part), and two biostromal units (stromatopores, rugose and tabulate corals) separated by an interval with argillaceous limestones and shales (upper part) (Fig. 4). Thickness : 30 to 70 m. Lateral variations : important since the biostromal units can be reduced or can pass to large reefal lenses (bioherms) on a scale of less than a few kilometers. These lenses belong to Fm X (Coen-Aubert, 1991).



Figure 4. Uppermost part of the Hanonet Fm with dark nodular limestone beds alternating with thin calcareous shale beds overlaid by the basal limestone beds of the Trois-Fontaines Fm. Mont d’Hairs section, the location is shown in Fig. 2.



Figure 5. Middle part of the Mont d'Hairs Fm exposed in the Mont d'Hairs section and showing typical massive biostromal bed (1.30 m thick). The white spots are domical stromatopore-roids. The location is shown in Fig. 2.

sive rugose and tabulate corals, upper boundary : base of the Mont d'Hairs Fm. Thickness : around 60–70 m.

7.4. *Mont d'Hairs Fm*

Medium- to thick-bedded biostromal (stromatopores, rugose and tabulate corals, brachiopods), alternating with fine-grained micritic limestones and dolomitic shales and limestones (Fig. 5). Lower boundary : first massive biostromal bed with abundant stromatopores and corals. Upper boundary : base of the Fromelennes Fm. Thickness : 160 m at Givet.

7.5. *Fromelennes Fm*

Thin-, medium- and thick-bedded limestones and shaly limestones with increasing shale levels towards the top. Three members have been defined (Coen-Aubert, 1991) : Flohimont Mbr, 29 m of brachiopod-rich argillaceous limestones with shaly intervals at the top ; Moulin Boreux Mbr, 82 m of biostromal and massive cryptalgal limestones, Fort Hulobiet Mbr, 24 m of calcshales and argillaceous bioclastic limestones (Fig. 6). Lower boundary : first brachiopod-rich argillaceous bed overlying the

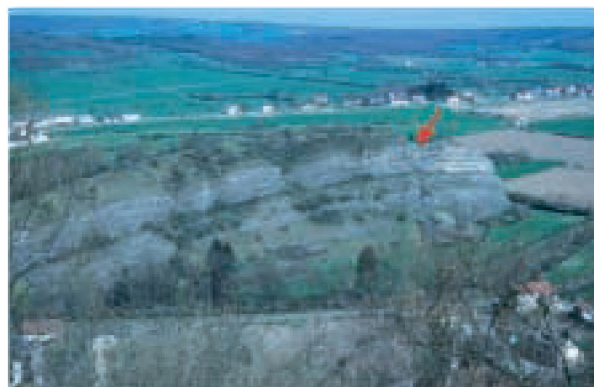


Figure 6. South-western face of the Moulin Boreux hill, 1.5 km south-east of Givet, showing the upper 49m of the Moulin Boreux Member of the Fromelennes Fm. The Fort Hulobiet Mbr is exposed in a trench at the top of the hill, indicated by an arrow.

massive biostromal bed of the preceding formation. Upper boundary : base of the Nismes Fm (beginning with the 'Zone des Monstres' i.e. nodular limestone with very abundant large brachiopods). Lateral variations : the Fm is 15 m thicker to the east, and decreases to the NE. In the Philippeville Massif the thickness is about 80 m.

8. Sedimentology and palaeogeography

The general evolution is transgressive over the Old Red Continent from late Emsian to late Frasnian and parallels the global eustatic curve of Johnson *et al.* (1985) for the Devonian System of Euramerica with a few discrepancies observed in late Givetian and middle Frasnian times. On a larger European scale, the transgression was in a northerly direction, reaching the southern Ardennes by lower Eifelian and western Germany by the middle Givetian. During Eifelian-Givetian transition, the sedimentary systems consisted of the evolution from a mixed siliciclastic-carbonate ramp to a carbonate platform (Kasimi & Pr  at, 1996) dominated by cyclic tidal-flat and lagoonal wackestones with local patch reefs or corallgal banks. The transition of the ramp to the platform system is diachronous since both systems were locally coeval in southern Belgium and northern France (Pr  at, 2004). The shelf had an ESE-WNW trend and extended from the Avesnois basin (northern France) in the west to Aachen (western Germany) in the east. Isolated carbonate complexes developed East of the Rhine river in the Rheinische Schiefergebirge, and in southwest England. The platform had a complex internal structure and the reefs were positioned either on the shelf-edge, within the shelf or upon topographic highs within the basin. Synsedimentary tectonism (France, Belgium, England ?) and volcanism (Germany) are conspicuous. The development of this barrier-reef system enabled back-reef sedimentation to occur in a broad-shelf lagoon (Pr  at & Boulvain, 1988).

Thirteen major microfacies are recognized in a sedimentological model for the Givetian carbonate succession of the Avesnes, Dinant and Namur basins (Préat & Mamet, 1989; Préat, 2004). They range from open-marine, under the wave action zone, to reefal complexes, lagoons (algal and fenestral wackestones) and evaporitic sebkhas with microbial laminites and paleosols (calcretes and dolocretes). The sedimentation is composed of regressive metric (1 to 3 m thick) cycles. A complete cycle within the restricted belt consists of a subtidal to lower-intertidal unit overlain by an upper-intertidal to supratidal unit that records upward shoaling conditions. The faunal and microfloral diversities are low as a result of important salinity variations and temperature fluctuations indicated by isotope analyses (Weis & Préat, 1994). The milieu is either dominated by ostracods with subordinate *Amphipora* and calciphaerids, or by nodular codiaceans and sponges with a few kamaenids. A model based on a steady subsidence and on the variation of the local carbonate productivity with respect to the progradation of the sediments is inferred. A rather steady subsidence persisted during Givetian times and the carbonate production counterbalanced the subsidence. Regional study shows that the Givetian carbonate belt was composed of numerous tilted blocks a few km wide suggesting broad epeirogenic movements or passive distention in a backarc setting. Sequence stratigraphy can also match accommodation space either within each block and over the whole area with reasonable values for carbonate production, subsidence rates and long term sea-level rise. The magnitude of sea-level change was on the order of 1–3 m (Préat, 2004).

9. Palaeontology

The macrofauna consists mainly of corals, stromatopores and brachiopods. They are important for regional and interregional correlation. Acritarchs, spores, algae, conodonts and ostracods are the microfaunal groups that have been thoroughly studied during the last three decades. Some of them are important for worldwide correlation.

9.1 Brachiopods

Brachiopods are omnipresent. The base of the Givetian corresponds to an interval within the Hanonet Fm in which *Spinatrypa* (*Invertrypa*) *kelusiana* and *S. (I.) fasciplicata* occur together, *Gerolsteinites givefex* occurs near the base of the Trois-Fontaines Fm (Godefroid, 1995; Bultynck & Hollevoet, 1999). The first stringocephalids occur in the Trois-Fontaines Fm and disappear in the lower part of the Moulin Boreux Mbr. The Flohimont Mbr contains rich atrypid faunas (Godefroid & Jacobs, 1986) and cyrtospiriferids, in the past assigned to *Cyrtospirifer verneuilli* and *Tenticospirifer tenticulum*.

9.2 Corals

Rugose corals from the Eifelian–Givetian boundary interval were studied by Coen–Aubert (1989, 1996, 1997). *Keriophyllum mailleuxi* and *Sociophyllum torosum* appear above the Eifelian–Givetian boundary. *Sociophyllum elongatum* and *Beugniesastraea kunthi* are restricted to the base of the Trois-Fontaines Fm. *Argutastraea quadrigemina* occurs in the uppermost part of the Trois-Fontaines Fm and in the Terre d’Haur Fm; *A. tenuiseptata* is restricted to the Mont d’Haur Fm (Coen–Aubert & Lütte, 1990). *Wapitiphyllum luxum*, *Sunophyllum beichuanense* and *Temnophyllum delmeri* appear in the upper part of the Mont d’Haur Fm and disappear in the lower part of the Moulin Boreux Mbr (Coen–Aubert, 2004). The upper part of the Fort Hulobiet Mbr is characterized by *Disphyllum virgatum* (Coen–Aubert, 1991).

9.3 Ostracods

Rich ostracod faunas occur in the Hanonet Fm and the Trois-Fontaines Fm of the Couvin area (Casier *et al.*, 1992) and in Resteigne (Casier & Préat, 1990, 1991). They are important for palaeoenvironmental analyses.

9.4 Conodonts

Conodont faunas are generally sparse; the most abundant faunas occur in the Terres d’Haur Fm, at the base of the Mont d’Haur Fm and in the Flohimont Mbr (Bultynck, 1974, 1982, 1987; Bultynck & Hollevoet, 1999). They permit correlation with the Givetian conodont Standard zonation (see 10. chronostratigraphy).

9.5 Algae

Rich algal microfloras (blue-green, green and red algae) are present throughout the Givetian. They cannot be used for precise age determination as they are facies related. Semi-restricted lagoons (Trois-Fontaines Fm, Mont d’Haur Fm and Fromelennes Fm) have abundant dasyclads, calcispheres, palaeosiphonocladales, cyanobacteria and nodular codiaceans (Préat *et al.*, 1984; Préat & Mamet, 1989). Restricted lagoons have calcispheres (Trois-Fontaines Fm), cyanobacteria, spongiostromids (Mont d’Haur Fm), few dasycladals and umbellinids (Fromelennes Fm). Microcodiaceans developed in lagoons associated with pre-evaporitic conditions or in supratidal environments with vadose cementation. The algal diversity is higher around the Eifelian–Givetian boundary interval which is characterized by udoteaceans (*Paralitanaia bailleuxensis*, *Pseudopalaeoporella lummatonensis*) (Mamet & Préat, 1985), ‘giant’ dasyclad *Givetianella tsienii* (Mamet & Préat, 1982) and giant ‘phylloid’ *Resteignella resteignensis* (Mamet & Préat, 1983).

The stratigraphic ranges of Givetian acritarchs, spores, corals, brachiopods and conodonts have been incorpo-

rated in a Middle Devonian Composite Standard established using the graphic correlation method (Gouwpy & Bultynck, 2003).

10. Chronostratigraphy

Correlation with the internationally agreed IUGS chronostratigraphic time scale is based on conodonts (Fig. 7). *Polygnathus hemiansatus*, the index species for the base of the Givetian, occurs near the top of the lower part of the Hanonet Fm (Bultynck & Hollevoet, 1999). Due to shallow water facies, conodonts are sparse at that level. But because also *Icriodus obliquimarginatus* first occurs at the same level, the positioning of the boundary is considered reliable.

An early morphotype of *Ancyrodella rotundiloba*, the index taxon for the base of the Frasnian (= top of the Givetian), occurs 1.50m above the base of the Nismes Fm in Nismes in rich conodont faunas and in a phylogenetic succession (Bultynck *et al.*, 1988).

Different parts of the Givet Limestone can be correlated with the Devonian conodont standard zonation. The Trois-Fontaines Fm belongs to the *hemiansatus* Zone and the Terres d'Hauts and the lower part of the Mont d'Hauts Fm to the *timorensis* Zone (= lower part of Lower *varcus* Zone) (Bultynck, 1987). The uppermost

part of the Mont d'Hauts Fm and the lower part of the Flohimont Mbr belong to the *rhenanus/varcus* Zone (= upper part of Lower *varcus* Zone) and the upper part of this member is assigned to the *ansatus* Zone (= Middle *varcus* Zone) (Bultynck *et al.*, 2001). The Fort Hulobiet Mbr is assigned to the lowest part of the *falsiovalis* Zone (Bultynck *et al.*, 2000).

11. Geochronology

No radiometric data are available.

12. Structural setting

The Givet area belongs to the southern border of the Dinant Synclinorium. This latter is located in the northern part of the Ardennes allochthon and forms part of the Rhenohercynian belt of the Mid-European Variscides. The outcrops occur in several folds characterized by N-NE disymmetrical structures with subhorizontal elongated flanks ('plateaux') and subvertical short flanks ('dressants'). These structures display a slightly S-SE dipping schistosity. The amplitude and wavelength of the folds occur on a kilometric scale (Lacquement *et al.*, in press).

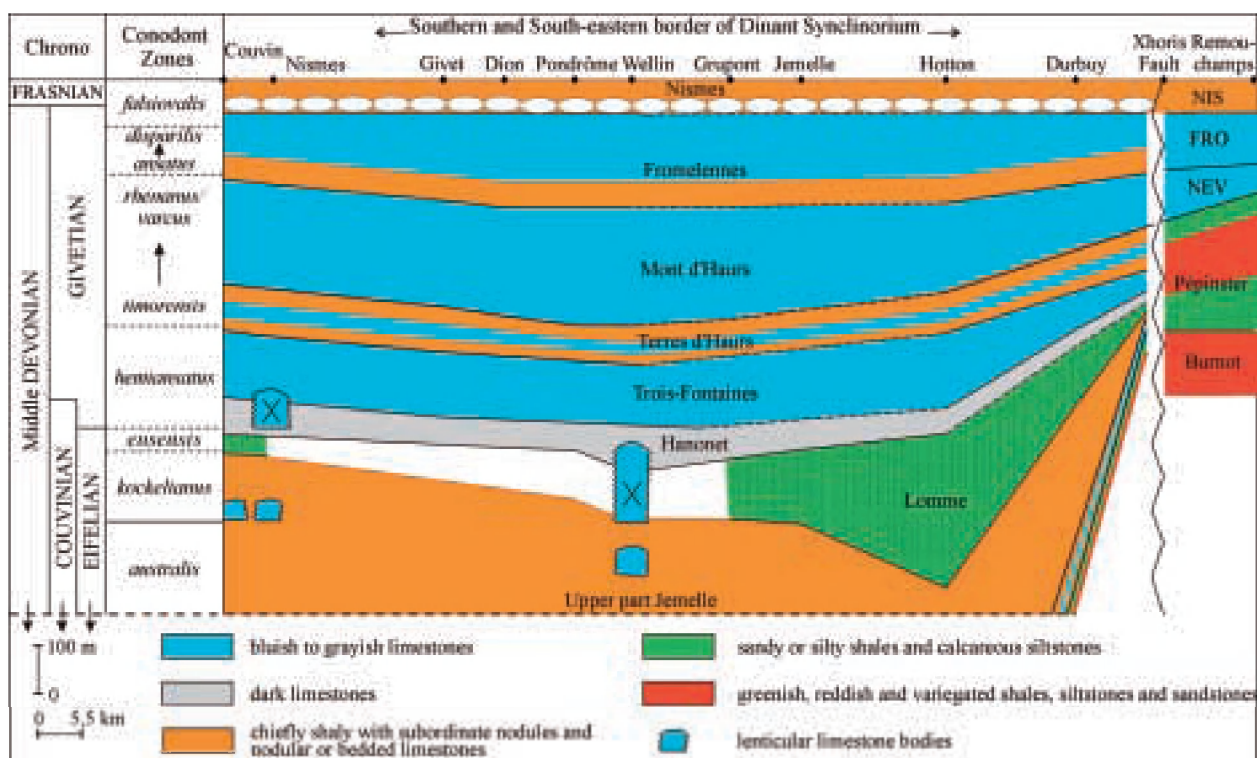


Figure 7. Generalized lithostratigraphic cross-section of uppermost Eifelian, Givetian and lowermost Frasnian formations across the southern and south-eastern border of the Dinant Synclinorium (after Bultynck & Dejonghe, 2001).

13. Reference sections in Belgium and GSSP

The GSSP boundary for the Eifelian–Givetian is located in a section at Jebel Mech Irdane in the Tafilat of Morocco (Walliser *et al.*, 1995). The position of the boundary was selected by the Subcommission on Devonian Stratigraphy in 1992 to coincide with the level at which *Polygnathus foliatus* changes to *Polygnathus hemiansatus* (conodonts). In Belgium, the old Resteigne quarry (Préat *et al.*, 1984) is the best section showing over 200 m the Hanonet Fm, the Trois-Fontaines Fm, the Terres d’Hairs Fm and the lower part of the Mont d’Hairs Fm. The stratotype section of the Nismes Fm (Bultynck & Coen, 1999) shows the Fort Hulobiet Mbr of the Fromelennes Fm in direct contact with the Nismes Fm. The Sourd d’Ave outcrop exposes the upper part of the Fromelennes Fm and its contact with the Nismes Fm.

14. Main contributions

Bultynck, 1974, 1987; Bultynck & Dejonghe, 2001; Bultynck *et al.*, 1991, 2000, 2001; Coen–Aubert, 1991; Errera *et al.*, 1972; Kasimi & Préat; 1996, Préat & Mamet, 1989; Préat & Kasimi, 1995; Préat & Tourneur, 1991; Weis & Préat 1994; Walliser *et al.*, 1995.

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