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THE STRATIGRAPHY OF THE TYPE LOCALITY OF THE ?LATE WENLOCK/EARLY LUDLOW MONT GODART FORMATION AND THE EARLY LUDLOW RONQUIERES FORMATION, BRABANT MASSIF, BELGIUM[1]

(by)

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(9 figures)

ABSTRACT.- The Silurian of the Brabant Massif crops out in the Sennette valley, near Ronquières. From these outcrops, the Mont Godart Formation is defined and the formerly poorly defined Ronquières Formation is redescribed in detail. Seven informal units, four of them divided into subunits, are distinguished in the Ronquières Formation. Based on Chitinozoa and graptolites, the age of the Mont Godart Formation is estimated possibly latest Homerian (Wenlock) or earliest Gorstian (Ludlow) and that of the Ronquières Formation as Gorstian (Ludlow). Four sedimentological facies occur: mud-grade turbidites predominate and are interbedded in anoxic laminated hemipelagites. Oxic bioturbated hemipelagites and metabentonites occur rarely. The palaeoenvironment of the sedimentary basin is interpreted as a turbiditic fan system directed to the east in a E-W trending trough with apparently northward directed currents. A major megacycle spans both formations. Relatively high energy sediments are present in the bottom of the Mont Godart Formation and in the top of the Ronquières Formation. Less energetic sediments, indicating a deeper sea environment, are found in between. A similar cycle of deepening and shallowing has also been observed in the late Wenlock and early Ludlow of the Welsh Borderland and of Gotland on the Baltic platform.

RESUME.- Dans la vallée de la Sennette à Ronquières, où affleure le Silurien du Massif du Brabant, la Formation du Mont Godart est définie et la Formation de Ronquières, jusqu'à présent mal définie, est redécrite en détail. Sept unités, parfois divisibles en sous-unités, sont distinguées dans cette dernière Formation. Les chitinozoaires et graptolites suggèrent que la Formation du Mont Godart date du Gorstien inférieur (Ludlovien) ou peut-être de l'Homerien supérieur (Wenlockien), tandis que la Formation de Ronquières date du Gorstien (Ludlovien). Quatre faciès sédimentologiques sont présents. Les turbidites argilo-silteuses, interstratifiées entre des hémipélagites laminées anoxiques, prédominent. Plus rares sont les hémipélagites oxiques bioturbées et les métabentonites. Le paléo-environnement du bassin sédimentaire est interprété comme un système de cônes turbiditiques orienté vers l'est, dans un auge est-ouest, à direction apparente des courants vers le nord. Un mégacycle majeur englobe les deux Formations. Des sédiments d'énergie relativement haute, sont présents à la base de la Formation du Mont Godart et au sommet de la Formation de Ronquières. Les couches intercalées à sédiments de plus faible énergie, indiquent un environnement plus profond. Un même cycle de changements de profondeur a été observé au Wenlockien supérieur et Ludlovien inférieur du Pays de Galles et de l'île de Gotland sur la plateforme Baltique.

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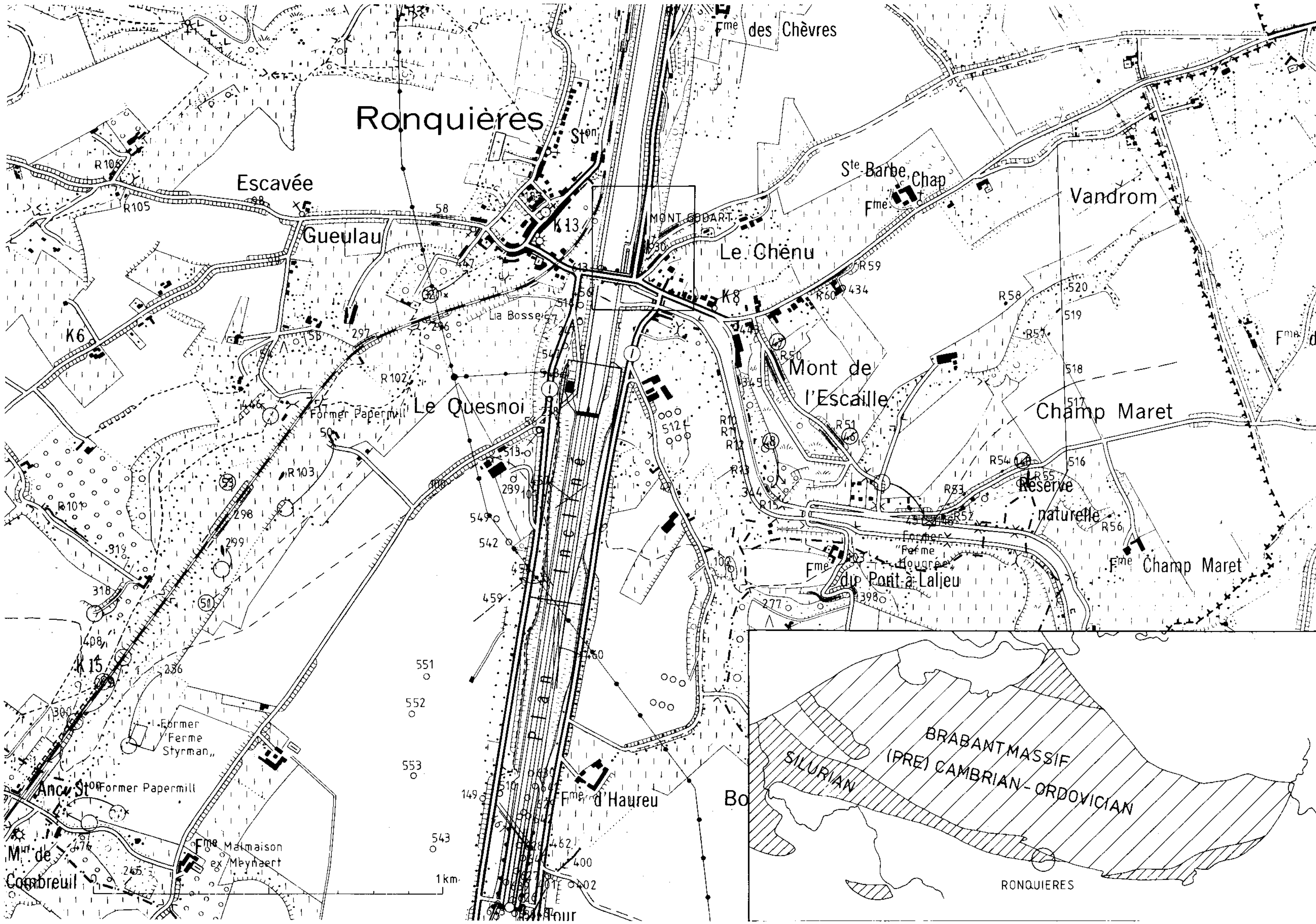

Fig. 1.- Location map of the Ronquières area. Accurately located observations are marked with a dot for smaller outcrops, a line for longer outcrops and a small circle for boreholes, with their number. Numbers in a barred large circle are unusable data located on the same spot as on the archive map of the GSB. Circles with a full line arrow indicate the previous locations of accurately relocated numbers and with a broken line arrow the probable position of relocated numbers. Inset, the location of Ronquières in the Brabant Massif.

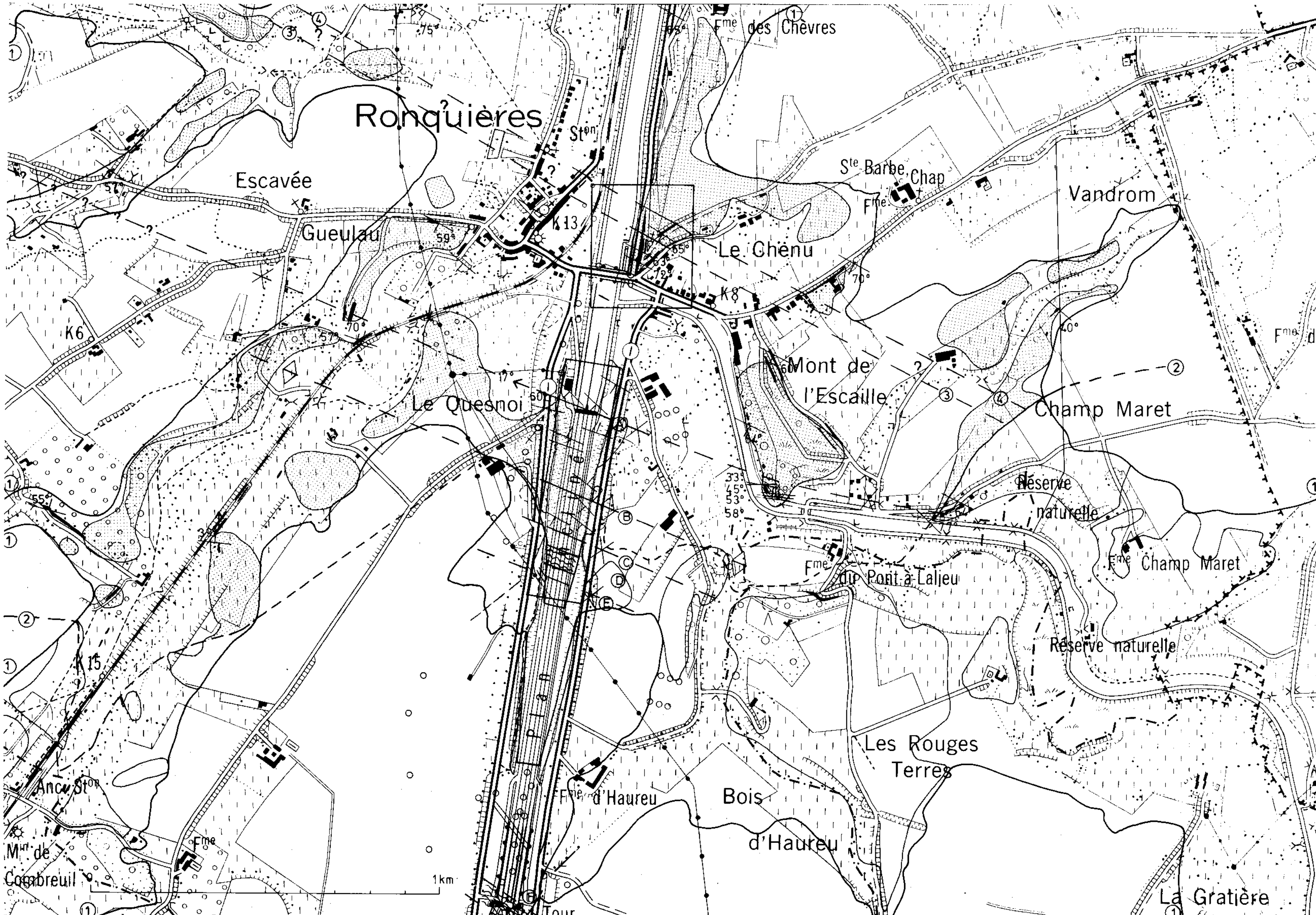

Fig. 2.- Geological map of the Ronquières area. Spot, or lines indicate the location of the outcrops and circles the boreholes (nos. on fig. 1); medium dots: shallow Silurian basement (less than 1.2 m depth), fine dots: Devonian; line 1: base of the Tertiary cover, line 2: base of the Devonian; line 3: northern and lower limit of the Ronquières Formation; line 4: northern and lower limit of the know extension of the Mont Godart Formation. All lines are dotted when not precisely located. North of line 4: unstudied Silurian strata. Structural data: strike and dip of the stratification is given, with the angle of dip in °; a single arrow indicates an inaccurate dip direction. A: Porte Aval syncline; B: Central anticline; C: Belvedere syncline; D: tectonized Silurian zone, vertically dipping; E: southern syncline, not mentioned on fig. 7; F: tectonized Silurian zone under the Porte Amont, vertically dipping (Legrand, 1967).

1.- INTRODUCTION

The present study forms a part of an ongoing research project on the detailled lithostratigraphy and biostratigraphy of the Silurian of the Brabant Massif and the Condroz Ridge («Bande Sambre-Meuse»). Verniers (1976 ms, 1982, 1983) and Verniers & Rickards (1979) demonstrated that a detailed litho- and biostratigraphy is possible in the thick, slaty sediments of the Silurian of the Brabant Massif (Mehaigne area). Another area of the Silurian of the Brabant Massif was investigated preliminarily, *viz.* the Orneau Valley (fig. 1), where three of the four type localities of the Silurian formations («Assises») are situated (Verniers, 1982). The present knowledge on the Silurian in the Brabant Massif was reviewed in Verniers & Van Grootel (1991).

The Ronquières area in the Sennette Valley is the fourth type locality in the Brabant Massif. Apart from three small outcrops in the Mehaigne area, it is the sole locality where Ludlow sediments are extensively developed and well exposed. The type locality was described only in general lithological terms in 1954 by Michot. The aim of this paper is to describe the stratigraphy of this type locality, to date it more accurately, to define its lower and upper boundaries, to define the Mont Godart Formation and to redefine the Ronquières Formation. Preliminary work started in 1975 (Verniers, 1976 ms), it was continued as the subject of two M. Sc. dissertations (Louwye, 1984 ms, Van Grootel, 1984 ms) and was followed by subsequent research by the three authors.

Preliminary results were published in the excursion guide of the «International Meeting on the Caledonides of the Midlands and the Brabant Massif, Brussels, 1989» (André *et al.*, 1989, 1991). The detailed descriptions of the outcrops and the evaluation of the previous descriptions is published separately (Verniers, Louwye & Van Grootel, in press), as is the biostratigraphy with graptolites and Chitinozoa (Van Grootel, Rickards, Louwye & Verniers, in prep.). The present paper gives the formal description and redefinition of the formations.

The Ronquières study area is situated at the confluence of two rivers, the Sennette and the Samme (fig. 1). It is bordered to the south by the southwards dipping Devonian and to the east and west by the Ypresian cover, with its undulating base between 86 and 97 m height, indicating the existence of important palaeo-valleys. The description of the Devonian and Tertiary is given by Legrand (1967, 1969). The study area is limited to the north by a large area devoid of outcrops. The parallel of the disused railway station of Ronquières is chosen arbitrarily as the northern limit. However, some outcrops (R7 and R39) situated more to the north are mentioned in the historical review and on the geological map (fig. 2). As explained in Verniers *et al.* (in press), we used the soil map of Louis & Tavernier (1960) to map the places with shallow Silurian or Devonian basement.

2.- HISTORY OF THE «ASSISE DE RONQUIERES» AND THE TYPE LOCALITY

2.1.- CHANGING LOCATION OF THE TYPE LOCALITY

The type locality of the «Assise de Ronquières» is defined in the literature as «the outcrop near the bridge of Ronquières». One should take into account that until now, there have been several bridges at Ronquières (no. 1 to 7 on fig. 3). Old cadaster maps, topographic maps and old photographs allow an approximative reconstruction of the location of each of the three successive «outcrop(s) near the bridge of Ronquières» (fig. 3): (3A) before the first canal was dug in 1830; (3B) between 1830 and 1912; (3C) between 1912 and 1963; (3D) from 1967 to the present-day.

The most important bridge in the last century was the bridge of the road from Nivelles to Braine-le-Comte crossing the Samme (bridge no. 3) and since 1830 crossing the canal over lock no. 39 (bridge no. 4). This bridge was moved later two times over distances up to 230 m, due to the digging and successive enlargements of the canal Brussels-Charleroi canal in the last 160 years (bridges no. 6 and 7).

Following the reconstruction (fig. 3), it is estimated that the outcrop described by Dumont (1848), Gosselet (1871) and Malaise (1883a) has completely disappeared and has to be located a few meters north of the present-day bridge (figs. 3 & 6) at about 6 to 13 m above the present water level, and situated at about 5 to 15 m above the top layers of the southernmost outcrop of the lock section. We estimate furthermore that the outcrop

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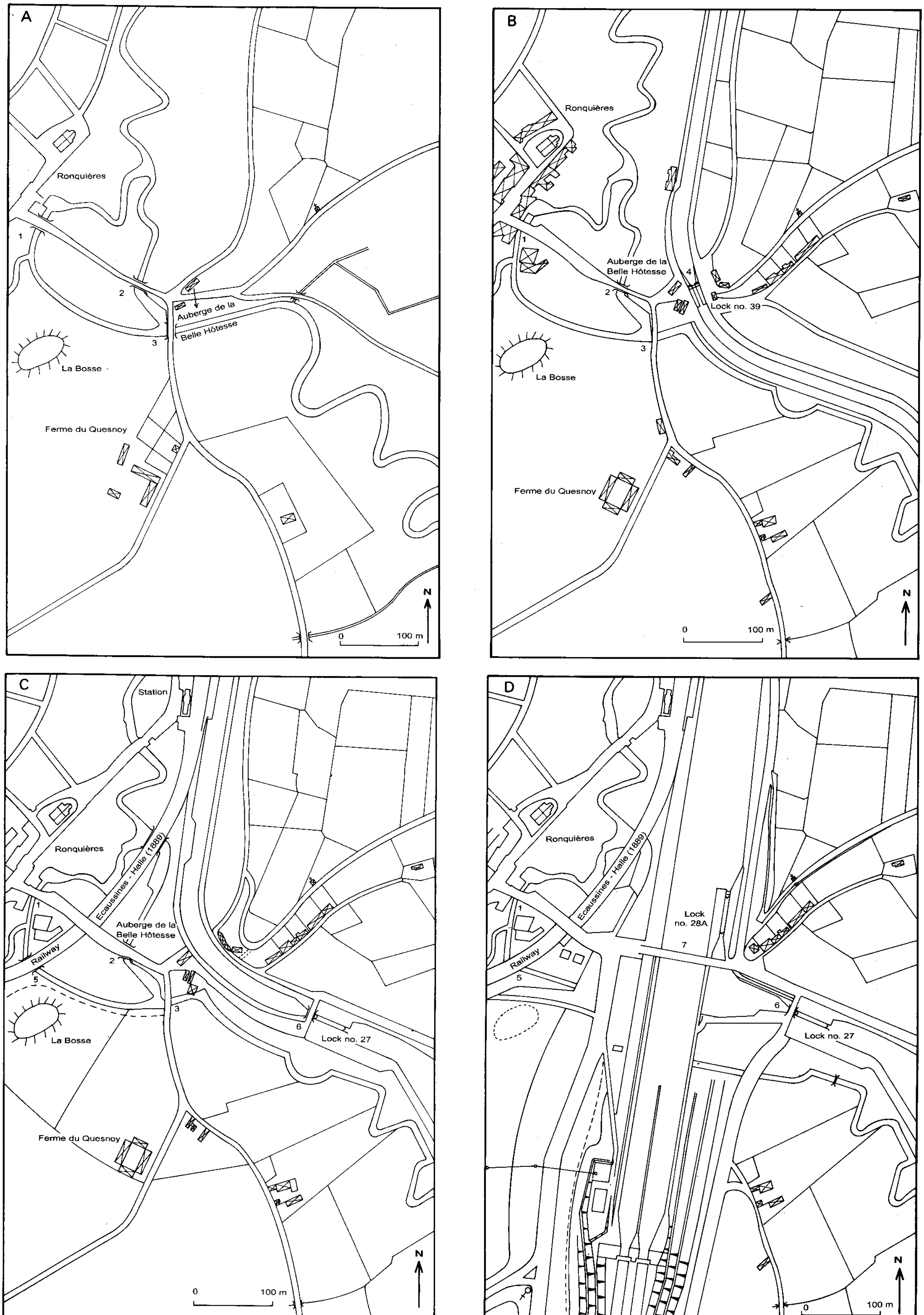
Fig. 3.- Maps showing the different position of the canal and locks in the Ronquières area. 3A: period before 1830 (situation in 1775, Ferraris map); 3B: period from 1830 to 1912 (situation in 1840, from the first cadaster map), 3C: period from 1912 to 1962 (from the topographic map of 1955-1962); 3D: period from 1967 till the present-day (from the topographic map of 1981, maps of the Ministry of Public Works and own measurements). The location and number of the seven bridges of Ronquières is shown for the different periods.


A
Ronquières
1
2
3
Auberge de la
Belle Hôtesse
La Bosse
Ferme du Quesnoy
N
0
100 m
B
Ronquières
1
2
3
4
Auberge de la
Belle Hôtesse
Lock no. 39
La Bosse
Ferme du Quesnoy
N
0
100 m
C
Station
Ronquières
Ecaussines - Halle (1889)
Auberge de la
Belle Hôtesse
1
2
3
5
6
Railway
Lock no. 27
La Bosse
Ferme du Quesnoy
N
0
100 m
D
Ronquières
Ecaussines - Halle (1889)
Lock
no. 28A
1
5
6
7
Railway
Lock no. 27
N
0
100 m

Author	Fieldwork	Publications
1830 - Digging of the first canal		
DUMONT	before 1848	1848
GOSSELET	before 1860	1860a, b, 1880, 1888
MALAISE	before 1865	1865, 1873
DELVAUX	1876	Arch. GSB
1876: Excursion Société belge de Géologie		report in FALY, 1876
MALAISE	1879	Arch. GSB
1880-1881 - Construction of a new railway		
MALAISE	1881	Arch. GSB
MOURLON	1885, 1889	Arch. GSB
BRIART	1892	Arch. GSB
1896: Excursion Société belge de Géologie		report in CUVELIER & PAQUET, 1908
Geological map of Belgium (MALAISE *et al.*, 1902, 1/40.000)		
1903: Excursion Société belge de Géologie		report in FALY, 1908
FOURMARIER	before 1912	(1912) 1921
1912 - Enlargement of the canal		
LERICHE	1912	1912, 1935
1913: Geological excursion "Université de Bruxelles"		report in LERICHE, 1913
ASSELBERGHS	1919	Arch. GSB
1922: Excursion International Geological Congres		report in LERICHE, 1922, 1926
ASSELBERGHS	1922	Arch. GSB
	1925	Arch. GSB
CORIN	1938	Arch. GSB
Soil map 1/20.000	before 1960	LOUIS & TAVERNIER, 1960
LEGRAND & TAVERNIER	1945-1961	Arch. GSB, LEGRAND & TAVERNIER, 1948
1962-1967 - Enlargement of the canal and digging of the "Plan Incliné"		
LEGRAND	1962-1967	Arch. GSB, LEGRAND, 1967, 1969; CORIN, 1962a,b, 1964, 1965
1968 Excursion "La Géographie"		LEGRAND, 1969
BEUGNIES	before 1973	1973
MARTIN	1964-1967	1969
MARTIN	1977-1978	1979
LOUWYE, VAN GROOTEL, VERNIERS	1975-1985	VERNIERS, 1976 ms, LOUWYE 1984 ms, VAN GROOTEL 1984 ms, ANDRE, al., 1987, MEILLIEZ, *et al.*, 1988, VAN GROOTEL, 1990 ms, VERNIERS, et al., in press, VAN GROOTEL, *et al.*, 1992 in prep.
1986: Excursion Société belge de Géologie		LOUWYE, *et al.*, 1986
1989: Excursion "International Meeting on the Caledonides of the Midlands and the Brabant Massif"		ANDRE, *et al.*, 1989, 1991

Fig. 4.- History of research on the Silurian of the Ronquières area. The estimated period of fieldwork for each author is followed by their subsequent publications. The excursions to the area resulting in a paper are also mentioned.

Arch. GSB : Archives of the Geological Survey of Belgium.

with graptolites found by Leriche (1912) would be located in mid air, just north of the present-day bridge (no. 7 on fig. 3D) west of the lock at about 6 to 13 m above the water level (figs. 3 & 6). Its stratigraphical position is situated somewhere in the uppermost 10 m of the lock section, where we collected the best preserved fossils, or in the 10 m above this level, now disappeared.

Leriche (1922, 1935) calls this promontory the Mont Godart. Although this toponym is not marked on the topographic maps of the National Geographic Institute, it is mentioned on the older cadaster maps as «Rue Godart», once for the NE-SW road on top of the hill along the old chapel «Chapelle du Bon Dieu de Pitié» (*anno* 1553) and once for NE-SW street at the bottom of the same hill side. On a recent street map, the «Rue Godart» is the road climbing to the old chapel and along the top of the hill side east of the old chapel (fig. 6).

According to the definition of the «Assise de Ronquières» by Michot (1954), the type locality of the Ronquières Formation is formed by the three outcrops at the Mont Godart: along the lock, along the road from Ronquières to Fauqué and along the climbing path to old chapel (fig. 6). With the extended definition by Legrand (1967), another large outcrop is added as type locality: i.e. the Silurian in the east and west flanks of the 1250 m long trench of the Plan Incliné (fig. 7).

The outcrop where the new Mont Godart Formation is defined, has never been described or referred to in the literature or the archives of the Belgian Geological Survey and is situated from 8.5 to 85 m NE of the old chapel in the «rue Mont Godart» and called the Chapel Section (fig. 6).

2.2.- HISTORY OF THE CHANGING STRATIGRAPHICAL CONTENT OF THE «ASSISE DE RONQUIERES»

2.2.1.- Introduction

The «outcrop near the bridge of Ronquières» has not only moved three times in location due to the enlargements of the canal, but it also was four times the type locality for a stratigraphic unit each time with a different meaning, respectively between 1871 and 1880, between 1883 and 1900, in 1954 and in 1967 (figs. 4 & 5).

2.2.2.- Dumont (1848)

Dumont (1848, p. 265-273, 282-283) was the first to describe six outcrops and to use informally the term «phyllades de Ronquières, compactes, subzonaires et sans grès» for an outcrop unclearly situated «at Ronquières». From his description of the other outcrops, old photographs and old maps, one can reasonably assume that he referred to the outcrop of the Mont Godart. It must have been located near the bridge over lock no. 39 and nowadays situated north of the present-day bridge (see above and figs. 3 & 6).

2.2.3.- Gosselet (1860a, 1860b)

Gosselet (1860a, p. 32; 1860b, p. 498) describes the lithology of two outcrops (one which we think is situated near the «Ferme des Chèvres» and one in front of the bridge of Ronquières) as «un schiste grossier qui se divise par le clivage en parallélipipèdes obliques et dans chacun de ces parallélipipèdes, les éléments sont disposés en zones concentriques». He claims that Dumont called it a «quartzophyllade zonaire», although, to our knowledge, this is never mentioned in the papers by Dumont. This description refers probably to the concentric weathering colours, observed in outcrops exposed for a longer time to the surface. These secondary lithological features disappeared after 1911 when the outcrop was cut back.

2.2.4.- «Assise de Ronquières» *sensu* Gosselet (1971)

Gosselet (1871, p. 15 & 29) defines in the Brabant Massif a unit of «Schistes zonaires, bien individualisés à Ronquières» and places it on top of the «Assise de Gembloux».

However, Malaise (1873, p. 14) incorporates the outcrop near the bridge of Ronquières in his «Assise de Gembloux» which spans the entire Ordovician and Silurian, a view followed later by Gosselet (1880, p. 35-36). Malaise (*ibid*., p. 19) describes an outcrop with «quartzites feuilletés», and a badly preserved impression of what resembles a lot to *Graptolithus priodon*. After our fieldwork and an analysis of the literature, we can reasonably well situate this outcrop 1.3-1.4 km north of the bridge of Ronquières. The acritarchs from this outcrop (Martin & Rickards, 1979) suggest a late Llandovery, Telychian age. However, we see that from 1873 on several authors (Gosselet, 1888, p. 149; Cuvelier & Paquet, 1908) mention inadvertently that the «Schistes de Ronquières» (which include the outcrop near the bridge of Ronquières) do contain *Monograptus priodon*.

2.2.5.- «Assise de Ronquières» *sensu* Malaise (1883a, 1883b)

Malaise (1883a, 1883b) divides his large «Assise de Gembloux» into two «assises». Besides the Ordovician fauna («seconde faune») found in several places, he encountered Silurian fossils («troisième faune») in several other places, *viz.* Grand-Manil, Monstreux and Malonne. The «Assise de Gembloux» (S2) was restricted to the

SYSTEM	SERIES	STAGES	BIOSTRATIGRAPHY	DUMONT 1848	GOSSELET 1871	MALAISE 1873	MALAISE 1883	MALAISE 1890	MALAISE 1900	MALAISE 1903	MALAISE 1908	MALAISE 1910 1913 1914	MICHOT 1954 1957	LEGRAND 1967	THIS STUDY
DEVON.	LOWER DEVONIAN	LOCHKOVIAN	*Monograptus uniformis*												
SILURIAN	PRIDOLI		*Monograptus ultimus*												
	LUDLOW	LUDFORDIAN	*Bohemograptus*												
			Saetograptus leintwardinensis						Schistes ou Phyllades de Monstreux Sl2c	Assise de Monstreux	Assise de Monstreux (Ludlow)	Assise de Vichenet Sl2b'	Assise de Ronquières (III)	Assise de Ronquières (IV)	
		GORSTIAN	*Pristiograptus tumescens*												Ronquières Formation V
			Lobograptus scanicus	Phyllade de Ronquières											
			Neodiversograptus nilssoni												Mt. Godart Fm.
	WENLOCK	HOMERIAN	*Monograptus ludensis*												
			Gothograptus nassa												
			Cyrtograptus lundgreni						Schistes et phyllades de Corroy-le-Château Sl2b						
		SHEINWOODIAN	*Cyrtograptus ellesae*												
			Cyrtograptus flexilis							Assise de Corroy		Assise de Corroy Sl2b			
			Cyrtograptus rigidus												
			Monograptus riccartonensis		Assise de Ronquières (I)		Assise de Ronquières S3 (II) S3a S3b	Assise de Ronquières S3 (II')							
			Cyrtograptus murchisoni												
			Cyrtograptus centrifugus												
	LLANDOVERY	TELYCHIAN	*Monoclimacis crenulata*												
			Monoclimacis griestoniensis												
			Monograptus crispus												
			Monograptus turriculatus												
		AERONIAN	*Monograptus sedgwickii*												
			Monograptus convolutus			Assise de Gembloux			Schistes, quartzite stratoïde, psammite feuilleté de Grand-Manil Sl2a	Assise de Grand-Manil		Assise de Grand-Manil Sl2a			
			Coronograptus gregarius — *argenteus*												
			magnus												
			triangulatus												
		RHUDDANIAN	*Coronograptus cyphus* — *cyphus*												
			acinaces												
			Cystograptus vesiculosus = *atavus*												
			Parakidograptus acuminatus												
ORDOVICIAN	ASHGILL														
	CARADOC						Assise de Gembloux S2	Assise de Gembloux S2c S2b S2a							
	LLANDEILO														
	LLANVIRN														
	ARENIG						Assise de Villers-la-Ville S1								
	TREMADOC														

Fig. 5.- The changing stratigraphical content in the literature for the successive definitions of the «Assise de Ronquières», and the definition proposed in this work.

Ordovician, while the «Assise de Ronquières» (S3) is recreated to contain the Silurian of the Brabant Massif. The latter comprises quartzites, sandstones and slates with *Monograptus priodon* (troisième faune) and has an approximate thickness of 600m. It is subdivided into two units: S3b containing shales or slates, bluish or blackish grey, dull, more or less cleaved, yellowish or greyish by alteration (trace of limestone and aragonite and exploration for slates), with *Monograptus priodon*. S3a contains «stratoid» quartzite, sandstone or laminated psammite («psammite feuilleté»), greenish or yellowish grey, with *Monograptus priodon*.

Malaise (*ibid.*) claims to have found *Monograptus priodon* already in 1873 in Grand-Manil. He states that the latter species is a guide fossil of the «Assise de Ronquières» but he does not situate where it was found. We assume that Malaise found *M. priodon* 1.3-1.4km north of the bridge, the only place in the Sennette Valley where the fossil is mentioned in the archives of the Belgian Geological Survey and the literature. Furthermore, the S3a description resembles much that of the outcrops near the «Ferme des Chèvres», while the reference to exploration of slates in the description of S3b, refers to the disappeared gallery no. 48 near outcrop 344 (fig. 1), SE of the bridge of Ronquières. This latter can reasonably well be correlated with the upper half of the Plan Incliné section (Ronquières Formation, units L part, M & N). The latter definition puts all Silurian outcrops of the Sennette Valley into one «Assise» (S3).

Later, Malaise (1890, p. 449) lowers the lower limit of the «Assise» S3 to include a.o. the graptolite-rich *Climacograptus scalaris* beds, considered now as Caradoc and/or early Asghill.

Malaise (1900, p. 272) abolishes the «Assise de Ronquières» by dividing it into three units: the «Schiste, quartzite stratoïde et psammite feuilleté ... Grand-Manil, Sl2a», the «Schiste et phyllade ... de Corroy-le-Château, Sl2b» and the «Schistes ou phyllades ... de Monstreux, Sl2c». In 1902, the detailed geological map (Malaise, 1902) is published and reflects only partly that vision: the term Sl2a is used in the same sense, but on the map Sl2b combines Sl2b and Sl2c in the sense of Malaise (1900). In the report on the excursion in the Orneau Valley (1903), the three new units are formally called «Assises»: the Assises of Grand-Manil, Corroy and Monstreux. They are correlated with the threefold division of the Silurian in Wales and the Welsh Borderland (UK): the Llandovery, Wenlock, and Ludlow (Malaise, 1903). In the same year 1903, during an excursion in the Sennette Valley, Malaise (1908, p. 61-62) places the outcrop near the bridge of Ronquières in his newly erected «Assise de Monstreux». His only argument was a lithological similarity with the (not accurately located and until now undated) Monstreux sections. It is merely a matter of luck that Leriche could prove in 1912 the Ludlow age of the Ronquières outcrop.

Malaise explains in 1910 that the definition of the «Assise de Monstreux» was based on a wrongly determined graptolite fauna. He renames it the «Assise de Vichenet», representing the Ludlow in the Brabant Massif. However, as Michot (1954) argues, the site with graptolites in the new type locality of Vichenet in the Orneau Valley was never clearly situated and the fossil collection was destroyed during World War II.

2.2.6.- During the widening of the canal in 1911-1912, a relatively large outcrop became visible near the place of the old lock no. 39 (fig. 3B & 3C). On a visit with his students, Leriche (1912, p. 134-135) discovered in this outcrop quite a number of graptolites in a «quartzophyllade» layer: *Monograptus bohemicus, M.* cf. *nilssoni* and *M. colonus*. He describes these finds in several excursion guides (Leriche, 1913, 1922, 1926, 1935). With this findings, he established for the first time irrefutably the presence of Ludlow rocks in the Brabant Massif. However, this new evidence was not used during the next 42 years to describe more accurately the stratigraphy of the Silurian.

2.2.7.- «Assise de Ronquières» *sensu* MICHOT (1954)

The outcrop «at the proximity of the bridge of Ronquières», where Leriche (1912) found early Ludlow graptolites, is redefined as the type locality of the newly defined «Assise de Ronquières» (Michot, 1954, p. 71), however with no more lithological description than «quartzophyllades and very fine psammites».

Michot (1957, p. 345) defines more clearly the lithology of the «Assise de Ronquières» (in the type locality?) as: «Ensemble de quartzophyllades, psammites très fins et phyllades, contenant à la partie inférieure la zone à *Monograptus nilssoni*».

Corin (1962b, p. 515-517; 1964, p. 45; 1965, p. 75) examines finely laminated shales, collected by Legrand in the «classic» outcrop of Ronquières. He describes two light coloured, very fine grained layers, 15 to 20mm thick, which, according to him, could be very fine volcanic ashes.

2.2.8.- «Assise de Ronquières» *sensu* Legrand (1967)

Between 1962 and 1966, major public works were undertaken south of the bridge of Ronquières for the construction of an inclined ship lift, the Plan

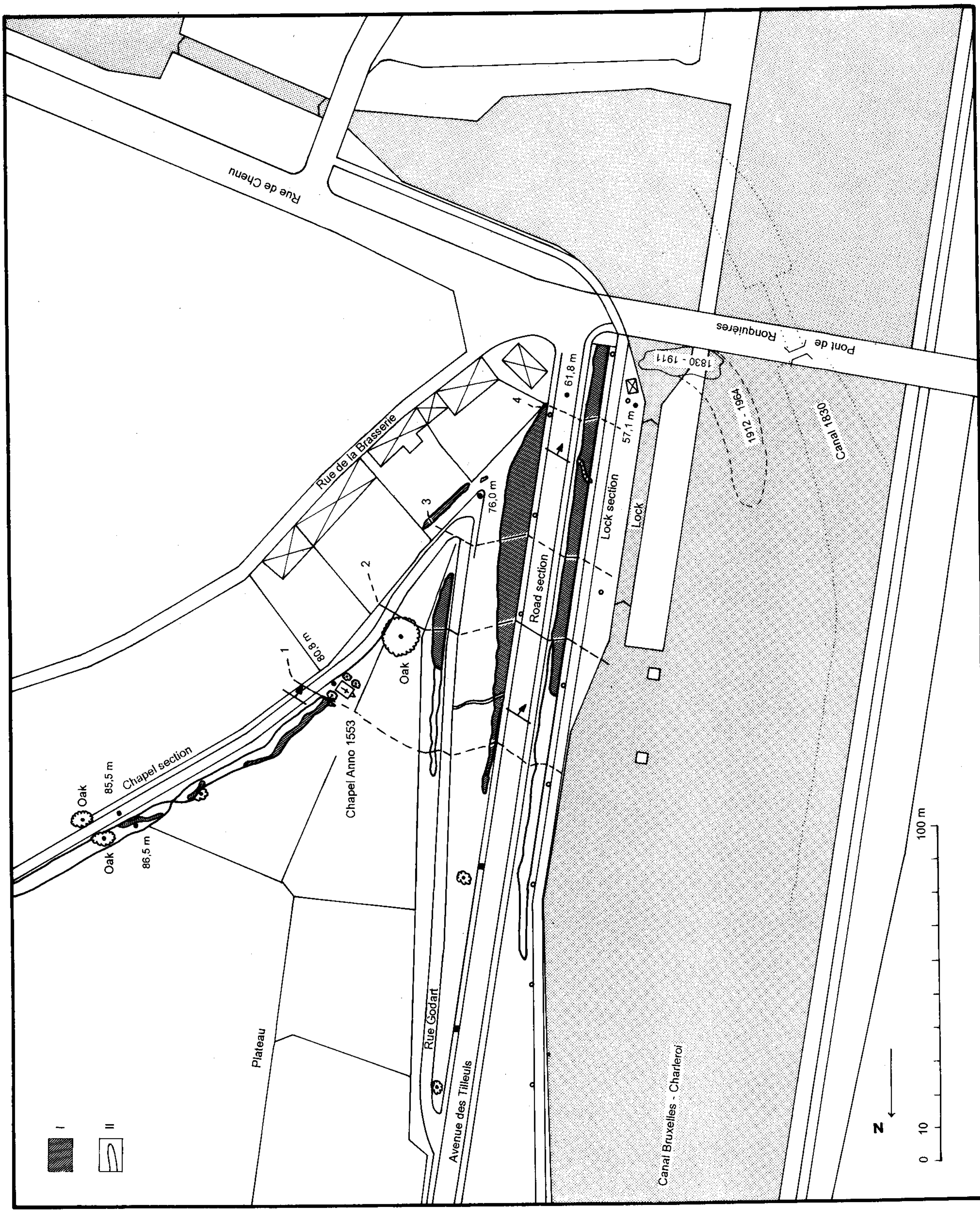


Fig. 6.- The Mont Godart outcrops: I. distinct outcrops, II. outcrops with only rock fragments; location of the previous type localities (1830-1911, 1912-1964), the old canal and the lock (1830-1911). Line 1: limit Ronquières-Mont Godart Formations; line 2: limit between units B and C; line 3: limit between units C and D; line 4: limit between units E and F.

Incliné. After removing 2.5M tons of rock, very large outcrops became visible in the flanks of the huge trench. The valley flank of the Mont Godart, the «classic outcrop of Ronquières», was also deeply excavated and cut back about 100 m (fig. 3), destroying the original type locality. Much larger outcrops then the former ones were created. Nowadays, stratigraphical columns of at least 206 m and 186 m are present in respectively the Plan Incliné and the Mont Godart. According to old photographs, about 5 to 10 m of sediments were exposed in Dumont's time (1848), and about 20 m in Leriche's time (1912).

Legrand (1967, p. 30-31) estimates that the new large outcrops at the Mont Godart, situated about 100 m east of the old type locality, contain the same rocks as the «Assise de Ronquières». He expands Michot's (1954) definition to incorporate the sediments of the Plan Incliné. He estimates a total thickness of about 500 m. The lithology consists of slaty shales, blackish by the presence of a very fine, dispersed pyrite. Characteristic of these 500 m is the remarkable regularity of the sedimentation and the extraordinary rhytmicity. The zoned aspect is caused by an alternation of centimetric siltstone/very fine sandstone strata and centimetric or decimetric compact-layered silty shales. These strata are formed by several tens of straticules of sandy silt in a blackish clayey matrix. He admits that neither the upper, nor the lower limit of the formation can be fixed. According to him, only a basal part of about 100 m is defined with graptolites, belonging to the *Monograptus nilssoni* Zone. Only two poorly preserved *M. dubius* are found by Gulinck in 1964 in profile no. 75 (25 m south of pole no. 8) in the Plan Incliné section very close to the Devonian unconformity, and one crinoid *Siphocrinites* with no exact location. Both finds are reported by Legrand (1967). He estimates nevertheless that all strata in Ronquières have an early Ludlow age.

Samples were collected by Martin (1969, p. 59) and Martin & Rickards (1979, p. 194) but no determinable organic microfossils could be separated from these samples.

Beugnies (1973, p. 95) describes in a geological field guide the essentials of both large outcrops without adding new information.

3.- DETAILED CARTOGRAPHY AND LOGGING OF THE OUTCROPS

The detailed cartography of the existing outcrops and the analysis of the descriptions of the outcrops in the literature (37 papers) and the archives of the Belgian Geological Survey is published separately (Verniers *et al.*, in press). Forty-five Silurian outcrops are accepted as valid after the elimination of the wrongly located outcrops, the untraceable outcrops, the unusable descriptions due to typographic errors and the descriptions attributable to the same outcrops. Thirty were described previously in the literature or in the archives. Twenty one have disappeared since under a soil or a vegetation cover but are well located and described, nine outcrops are still present and fifteen are newly described. Although 56% of the described outcrops are proven or suspected to be wrongly located over a few tens or hundreds of meters, the analysis allowed to acknowledge the presence of a possible new graptolite site and descriptions of 21 disappeared outcrops. They represent 47% of the well located outcrops.

The detailed log is measured in nine outcrops and totals 429 m and 2653 elementary sequences (Verniers *et al., ibid.*).

Four measured sections are situated on the eastern side in the Plan Incliné (fig. 7): (1) the longest section is situated between the top of the syncline at the «Porte Aval» (lower head of the ship lift) and the middle of the central anticline; (2) the second section lays in the syncline under the Belvédère (fig. 7); (3) the third section is an outcrop (height between 43 and 47 m) inside the buildings of the Plan Incliné, north of the «Porte Aval» syncline; (4) the fourth section lays in the top of the syncline north of the «Porte Aval» between 63 and 66 m altitude.

The Chapel section and the northern part of the Road section, both at the Mont Godart, belong to the Mont Godart Formation. All other outçrops in the Ronquières area, including the Lock section, the southern part of the Road section and the Path section, belong to the Ronquières Formation according to lithological, sedimentological and geometric arguments. Several profiles were measured to check the lateral variation in the sedimentation: smaller sections in the Plan Incliné, the Church section, the Railway section and the Canal section (figs. 1 & 2).

The thickness of each stratum was measured on a millimetric scale. Attention was paid to the sedimentological characters as compact or graded bedding, current ripple or parallel laminations (usually 3-5 lamellae per mm), estimated granulometry, description of the wavy bedding planes, fossil and sampling levels. The consistency, colour and presence of specific minerals (a.o. pyrite, pyritospheres) is occasionally recorded. The strata were grouped into elementary sequences, *viz.* a sedimentary unit deposited by one turbidity current (Bouma sequence Tabcde, Tbcde, Tcde, Tde or Te) often underlain by a laminated hemipelagite bed. Each turbidite sequence or

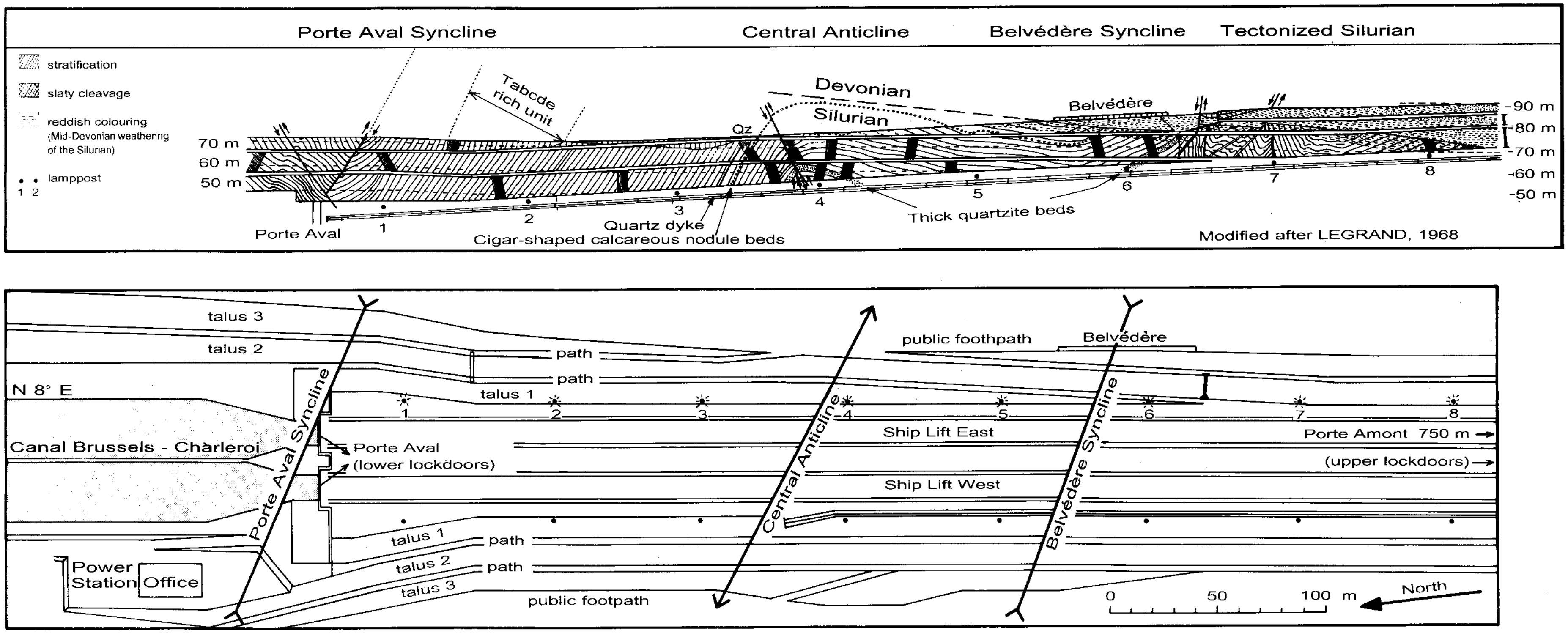


Fig. 7.- The Plan Incliné (Inclined Ship Lift) area: below: overview of the northern part; above: geological section of the eastern talus displaying the Silurian - Devonian unconformity. The 206 m thick log is measured between the Porte Aval and the core of the central anticline (between the first and the fourth lamppost); thick quartzite beds are situated in subunits K2 and K3, the cigar-shaped calcareous nodule beds in unit K7, the quartz dyke in unit K9, the Tabcde rich unit corresponds to unit M.

couple of laminated hemipelagite covered by a turbidite sequence is given a cumulative number (see detailed logs in Verniers *et al., ibid.*).

There is one limitation to the descriptions in the logs. The detailed description of the sections was effectuated between 1983 and 1985, i.e. before the study on pelagic sedimentation in the deep oceans was more widely used to interpret some of the Palaeozoic sediments. Previously, some studies had already interpreted Lower Palaeozoic sediments as pelagic, e.g. in the U.K. (Warren, 1963) and in the Silurian of Belgium (sapropelic: Corin, 1962b, «varves» Martin, 1971, 1974). From 1985 onwards, several studies established firmly the presence of Silurian hemipelagic and pelagic sediments in many localities in the U.K. and worldwide (Kemp, ms 1985, 1991; Tyler & Woodcock, 1987; Dimberline & Woodcock, 1987; Dimberline *et al.,* in press). Many layers in the Ronquières area can be interpreted as laminated hemipelagites. They are not recorded as such in the logs, but were interpreted on the field as dark coloured Td or Tb divisions. A new (and time consuming) field campaign will have to check the presence of true Bouma sequences, laminated hemipelagites or other non-Bouma sequences.

4.- SEDIMENTOLOGICAL AND PEROGRAPHICAL FEATURES

4.1.- The sediments in the study area consist of four different facies groups. The main facies is built up of Bouma sequences and interpreted as turbidites, interbedded between thin strata of the second facies, consisting of dark laminated slate and interpreted as anoxic laminated hemipelagite (type 3i of Cave, 1979). A third facies consists of oxic bioturbated hemipelagites (type 3ii of Cave, 1979) and a fourth (less than 0.05 % in thickness) consists of light coloured, extremely fine grained sediments, interpreted as metabentonites (see fig. 6 in Verniers & Van Grootel, 1991, or fig. 36 in André *et al.,* 1989, 1991). Besides the samples of metabentonites studied by Van den Haute (see below), twelve other samples were briefly analyzed in thin sections and fifteen by X-ray diffractogram analyses (Dr. G. De Geyter, pers. comm.).

4.2.- TURBIDITE FACIES

The repetitive or rhythmic nature of the Silurian sediments in the Brabant Massif was noticed previously by most authors when they described the rocks as zoned shales (schistes zonaires, quartzophyllades zonaires). It was clearly illustrated for the first time in the Ronquières area by Corin (Archives Belgian Geological Survey, 1938) and described by Legrand (1967). The presence of pyrite globules was described by Corin (1962a). The turbidite nature of these repetitive sediments was demonstrated in the Mehaigne Valley (Verniers & Richards, 1979; Verniers, 1982, 1983). As in the latest Llandovery and Wenlock of the Mehaigne area, mostly incomplete Bouma sequence occur: Tbcde, Tcde, Tde, Te. It is only in the upper part of the Ronquières Formation in unit M that Tabcde sequences are present, until now the only level in the Brabant Massif with complete turbidite sequences.

A thin section in one sample of a Ta division shows a moderately sorted, coarse siltstone or very fine sandstone (94 % of the grains between 20 and 125μm, mean 45μm, and 52 % coarser than 50μm).

Thin sections of two samples (M.G. 684, P.I. 1670) of a Tc division with current ripple stratification are medium grained siltstones with a mean of 20-30μm (90% between 8 and 40μm). The 100-200μm thick lamination is due to changes in the amount of matrix, i.e. an alternation of bands with a reticular structure and an empathic structure or with a reticular structure and a quartzitic structure. Mainly quartz, some muscovite and chlorite is present, rarely pyrite. They can be classified as alternating siltstones and silty pelites (*sensu* Bouma, 1962), alternating micropsammites to pelitopsammites and micropsammoslates to pelitoslates (*sensu* Michot, 1958), or laminated siltstones (*sensu* Lundegard & Samuels, 1980).

Thin sections of two samples (M.G. 539, P.I. 1245) in a layer with parallel lamination show an alternation of bands with a reticular and an empathic structure. The quartz grains in this matrix measure between 20-30μm, other minerals are chlorite, illite, muscovite and some pyrite.

Thin sections of two samples (M.G. 682, P.I. 163) in a Te division show an empathic structure where the quartz grains (up to 20μm) are dispersed in a matrix that forms half to three quarters of the sediment. Other minerals are muscovite, chlorite and pyrite (up to 20μm) or pyritospheres (up to 10μm). The micas align more or less in the direction of the slaty cleavage at 40° with the bedding. This alignment is pronounced by the presence of quartz grain rich bands alternating with quartz grain poor bands. Mostly indeterminate organic matter is also present in the thin sections. Rarely spherical acritarchs (Leiosphaeridia) can be seen or fragments of Chitinozoa. X-ray diffractogram analysis of five samples (P.I. 163, P.I. 334, P.I. 570, P.I. 1245, P.I. 1680) shows the presence of illite, that, together with chlorite, is the main mineral constituent. It can be classified as a coarse pelitoslate (*sensu* Michot, 1958), a clayey pelite (*sensu* Bouma, 1962) or a mudstone or claystone (*sensu* Lundegard & Samuels, 1980).

Calcareous nodules are present over 1.25 m in seven levels, between the sequences P.I. 226 and 237. These calcareous nodules are interstratified in the middle of a laminated hemipelagite (six levels) or in a Te division (one level). They are cigar-shaped, about 10 to 20 cm long and with a diameter of 1.5-5 cm in the middle. They are orientated parallel to the strike of the bedding and the slaty cleavage. They consist of the same material as the surrounding rocks, except for the calcareous cement. The slaty cleavage in the compact P.I. 226 Te division is broadening around the nodule and only vaguely present in it, indicating a cleavage posterior to the nodule formation.

4.3.- HEMIPELAGITE FACIES

4.3.1.- Anoxic laminated hemipelagite facies

In unit C of the Ronquières Formation (Mont Godart section), 31 m of laminated slates are interstratified with a few, sometimes light coloured, compact bedded layers. There is a gradual transition at the top and the bottom into the turbidite facies with a decreasing thickness of the interstratified laminated hemipelagites. Thin sections of two samples (M.G. 471/109.8 m and M.G. 471/113.1 m) show an empathic, slightly reticular structure in which angular quartz grains (20 to 30 μm), muscovite, some chlorite and pyrite are dispersed. An X-ray diffractogram analysis of sample M.G. 471/113.0 m shows that the matrix consists of illite, chlorite and some quartz. The lamination is due to the irregular, often lenticular bands of quartz grains alternating with bands rich in pyrite, pyritospheres or organic matter. An alignment along the cleavage direction is visible. They can be named coarse pelitoslate or fine micropsammoslate (*sensu* Michot, 1958) or clayey pelite (*sensu* Bouma, 1962).

4.3.2.- Oxic hemipelagite facies

A core from borehole 549 contains a 3.4 cm thick strongly bioturbated mudstone in between a Te mud-grade turbidite (below) and an anoxic laminated hemipelagite (above). It has been described in Verniers *et al.* (in press) and interpreted as an oxic hemipelagite (type 3ii of Cave, 1979).

Pyritospheres caused by bioturbation, occur at the top of several Te divisions in unit K. The thin strata in which the pyritospheres occur are also interpreted as oxic hemipelagites.

4.4.- THE «METABENTONITES» IN THE LOWER LUDLOW RONQUIERES FORMATION AT THE MONT GODART SECTION

by **Peter Van den haute** (Research Associate NFSCR (Belgium), Geologisch Instituut, Laboratorium voor Aardkunde, Universiteit Gent).

Six light-coloured (grayish olive, 5Y5/3) beds (MB1 to 6, thickness: from 0.5 to 6.5 cm) intercalated in the dark grey laminated slates close to the Ronquières bridge (Mont Godart section), were tentatively called metabentonites by Verniers *et al.* (1992) during their field work. This use of this name was based on following arguments:

- the light colour and aphanitic appearance of the beds together with their entirely abiotic composition (no organic residue is left on attack with HF),
- a thin section analysis of two similar beds from the same locality by Corin (1962, 1964, 1965), who describes them as fine volcanic ash layers. The stratigraphic position of these two beds is discussed in Verniers *et al.* (1992).

A new thin section analysis puts the pyroclastic nature of the six beds observed in the Mont Godart section beyond doubt. They are typically composed of pumice fragments ranging in size from about 50 to 250 μm and angular (mostly untwinned) feldspar and quartz grains of smaller size (25-100 μm). All these fragments float in a very fine grained matrix which makes up the bulk of the rock (75% to more than 95%). Normal grading in grain size of the fragments is common, the coarsest pumice and crystal grains forming an almost continuous layer at the base of each bed. The somewhat tabular pumice fragments are arranged parallel to stratification and flattened. The volume content of the crystal fragments rapidly decreases upwards. Zircon and especially apatite are quite common accessories (up to 100 μm apatite grains occur at the base of MB3).

Most constituents are completely altered by different agents (weathering, diagenesis and incipient metamorphism). The pumice glass is decomposed to a muscovite-chlorite aggregate while the feldspar grains are strongly resorbed. Small secondary sphene aggregates, partly altered to leucoxene and nearly spherical opaque ore grains (10-30 μm across) with brown rims, occur dispersed in the matrix together with very fine grained material which forms dark slightly undulating faint streaks up to about 100 μm in length and parallel to bedding. The fine grained matrix itself is completely recrystallized to minute sericite, oriented parallel to the cleavage, standing at an angle of about 45-50° to the stratification. Around the pumice and crystal fragments, pressure shadows have developed.

Several of the above characteristics have already been described by Corin. Nevertheless, he did not mention the heavy minerals and seems to have overlooked the nature of the pumice fragments which he described as ordinary micas.

Besides the differences in thickness there is also some compositional difference between the pyroclastic beds. In MB1 the pumice fragments are largely predominant over the crystal fragments. MB2 contains abundant mineral grains (to some extent also present in MB4 and MB5) which are completely decomposed into fine brown ore, relatively coarse grained white mica and other fine grained material. MB3 contains the highest amount (approx. 25 %) of sand sized fragments, quartz and feldspar being relatively abundant. In MB4 the content of fragments only amounts to a few percent on the average, the upper part of the bed being almost exclusively composed of fine sericite. The two thickest beds (MB2 and MB4) exhibit signs of plastic deformation at their bottom and are penetrated by small cracks (filled with calcite), which may be related to water expulsion phenomena. The streaks parallel to the bedding quoted above might also represent small scale water escape structures.

It is clear that the six beds of the Mont Godart section are marine fall-out deposits resulting from highly explosive volcanic activity during the lower Ludlow. The centres of this activity are to be searched at a distance of several hundred km and hence, the deposits do not witness any volcanic activity in the Brabant basement itself during this period. They are altered and slightly metamorphosed ash and dust tuffs and in the sense of Bohor *et al.* (1979) the term metabentonite is completely appropriate for them. To which extent the fine dust originally was composed of swelling smectite (i.e. clay-mineralogical bentonite) cannot be established. A chemical analysis (AAS, J. Van Hende) of the upper part of MB4 yields:

major elements (%)		trace elements (ppm)	
SiO_2 :	47.02	Co :	< 5
TiO_2 :	1.22	Co :	< 5
Al_2O_3 :	31.66	Cr :	< 10
Fe_2O_3 :	1.32	Ni :	< 5
MgO :	1.70	Li :	32
CaO :	0.23	Rb :	379
Na_2O :	0.11	Sr :	40
K_2O :	10.74	Zn :	29
MnO :	< 0.01		
P_2O_5 :	0.11		
H_2O :	5.6		

Recalculation of the major element analysis in the mica formula yields $(K_{1.83}, Na_{0.03}, Ca_{0.03})$ $(Al_{3.27}, Fe_{0.13}, Ti_{0.12}, Mg_{0.34})$ $(Si_{6.3}, Al_{1.7})$ $(OH)_{5.2}$ which closely approaches a (hydro)-muscovite composition. An X-ray diffractogram of this bed also essentialy reveals a muscovite structure. Hence, metamorphic sericitization related to the development of pressure cleavage appears to be the main factor which governs the present chemical composition of the metabentonites.

One similar light coloured bed occurs in subunit L4 of the Plan Incliné section (0.8 cm thick) and is interbedded between thin laminated hemipelagite beds. It is probably also a metabentonite but still unstudied.

5.- LATERAL AND VERTICAL VARIATION OF THE TURBIDITES

5.1.- LATERAL VARIATION OF THE TURBIDITES

Nine sections are recorded in detail and overlap in at least six places. It allows to observe the lateral variation in the sedimentation. In contrast with the laterally very continuous turbidites of the MB7 formation of middle to late Wenlock age in the Mehaigne area (Verniers, 1963; Verniers & Van Grootel, 1991), much more variation is observed here, to the point that in the top part of the Ronquières Formation, sections can no longer be correlated bed by bed if separated by several hundred meters. Three bed by bed correlated sections are oriented more or less E-W and three other pairs of sections more or less N-S (fig. 8). The three N-S pairs of sections show distinct changes in thicknesses and sedimentology: a general decrease in thickness of the beds going northwards and a decrease in number of sequences, possibly due to eroding of the above lying turbidites into the underlying ones. This trend is moderate in the lower part of the Ronquières Formation but very accentuated in the upper part, where the bed by bed correlation between two sections 10 m apart becomes tentative (Plan Incliné section and the Synclinal section). A bed by bed correlation over longer distances (several tens of meters and more) in the top 150 m of the formation is hence virtually impossible. E.g., according to the geometry, the Railway Section should correlate with a part of the upper 50 m of the Plan Incliné section situated 750 m more to the east. Only a general sedimentological trend relates it to unit M, at the proposed position, but no bed by bed correlation can confirm this. A possible correlation with a part above the Plan Incliné section, now eroded, is also possible (see fig. 9).

On the other hand, the variation is smaller in the three E-W directed pairs of sections: a less than 5 % decrease in thickness over 100 m in an eastward direction and also a decrease in number of sequences in the same direction.

cumm. thickn.	m	no. seq.	thickn.	total no. seq.	dist. betw. two seq.	m	no. seq.	thickn.	total no. seq.	relative change in thickness
RONQUIERES FORMATION										
	Plan Incliné Section					Plan Incliné Synclinal Section				
524.7	204.66	1744	1.99	17	10 m NS	1.7	14	1.70	14	14.5 % over 10 m N-S
522.7	202.67	1728				0	1			
	Plan Incliné Section					Plan Incliné Porte Aval Porte Section				
497.6	177.62	1477	3.68	45	50 m NS	2.63	33	2.63	33	28.5 % over 50 m S-N
493.9	173.94	1433				0	1			
	Plan Incliné Section					Railroad Section				
509.5	possibly related to unit N				750m EW	0	186	9.6	189	unknown E-W
489						9.6	01			
	Old Canal Section					Plan Incliné Section				
429.9	5.05	33	5.05	33	500m EW	109.94	950	5.06	42	<0.1 % over 100m E-W
424.8	0	1				104.78	909			
	Plan Incliné Belvedere Section					Plan Incliné Section				
347.1	14.41	98	14.41	98	450m NS	27.1	245	11.28	80	14.5 % over 100m S-N
336.2	0	1				16.2	166			
	Mont Godart Road Section					Ronquières Church				
135.0	135.0	539	4.59	16	300m EW	5.3	22	5.3	21	4.5 % over 100m E-W
130.5	130.5	523				0	1			
MONT GODART FORMATION										
	Mont Godart Chapel Section					Mont Godart Road Section				
52.2	3.40	272	3.40	20	100m EW	52.2	272	3.62	22	2.2 % over 100m E-W
48.6	0	253				48.6	253			

Fig. 8.- Lateral variation within the turbidites of the Mont Godart and the Ronquières Formations. The cumulative thicknesses and sequence numbers of the base and top of the correlated sections are given and their E-W or N-S direction, followed by the measured differences in thickness.

Only tentative conclusions are possible with the limited number of established correlations, but they all indicate the same trend: a clear decrease in thickness and in number of sequences in a northward direction and a similar but less pronounced decrease in an eastward direction.

It is tempting to conclude that the main apparent current direction was northwards with an eastward component, but this should be nuanced. Verniers & Van Grootel (1991) observed two current directions at right angles of each other in the Wenlockian of the Orneau Valley. Recent studies in the turbidites of the Austwick Formation (Sheinwoodian, Wenlock) in the Craven Inliers (NW Yorkshire, U.K.) show also two perpendicular palaeoflow directions. The first direction was measured on sole structures at the base of turbidites and the second on ripple laminations in the turbidites. It was interpreted that the sole structures indicated the main turbidity current direction, which follows the main axis of the basin, and that the direction normal to it was caused by internal solitary waves reflecting obliquely on the basin margin (Kneller *et al.,* 1990). A similar situation is maybe found in the Silurian of the Brabant Massif. In the Ronquières area, it would imply an E-W directed basin with mainly eastward directed currents and an apparent direction of the currents to the north.

5.2.- VERTICAL CYCLICAL VARIATIONS

A vertical variation is present throughout the column of the Mont Godart and the Ronquières Formations. It is not caused by the mineralogy, which is apparently constant throughout the column, but by sedimentological factors: (1) the frequency in a certain part of the column of each elementary sequences (Tabcde, Tbcde, Tcde, Tde, Te, Bouma, 1962) and of laminated hemipelagites, and (2) the thicknesses of each layer (Ta, Tb, etc.) within these sequences. This gradual change in sedimentological pattern is made more obvious in fig. 34 in the excursion guidebook (André *et al.,* 1989, 1991), by eight sections of five meters selected from the 180 m thick column present in the Mont Godart Section (Verniers *et al.,* in press). One can observe from bottom to top that the Mont Godart Formation (unit A) has many Tbcde (with a relative thick Tb division) and Tcde sequences (35%). These are the most energetic turbidites in the Mont Godart section. They pass gradually into the less energetic unit B of the Ronquières Formation with rare Tbcde or Tcde sequences (6%). On its turn laminated hemipelagites come into the column, they increase in thickness and rapidly dominate the turbidites (unit C). In unit D, while the laminated hemipelagites rapidly become thinner, only two Tbcde sequences occur over a total of 65 sequences (3%), in unit E 10 on 92

(11 %), in unit F 17 on 74 (23 %) and in unit G 29 on 66 sequences (44 %). This large cyclical trend is illustrated in fig. 37 of André *et al.* (1989, 1991).

The minor metric and decametric oscillations are interpreted as the result of the dynamics of the fan system or of the continental shelf supply area, or as small scale oscillations or other local factors.

However, the large deepening-shallowing cycle in the Mont Godart Section is so well marked that not a local but a regional mechanism has to be suggested. The cycle of decreasing-increasing energy of the turbidites is sedimentologically well documented, together with the thick unit C with dominant laminated hemipelagite which contains also the metabentonites. Laminated hemipelagites in mid-Silurian basinal facies, correlated with water depth maxima levels in the U.K. (Kemp, 1991), corroborate this interpretation.

Small scale oscillations are more pronounced in the Plan Incliné section, but a larger trend is also discernable in the detailed logs (Verniers *et al.*, in press). Thick fine sandstone beds occur low in the section (subunit K2), indicating either shallower but still basinal conditions or the presence of a turbidity current gully. The energy decreases gradually in subunits K3 and K4. The laminated hemipelagites dominate in subunits K5 and K7 with the presence of calcareous nodules in subunit K7. Higher up, the energy of the turbidites increases and oscillates over a large thickness through the remainder of the unit K and in unit L, where the energy of the turbidites increases drastically. In unit M, the most energetic turbidites are present with the presence of complete Bouma sequence (Tabcde). The energy decreases slightly in the uppermost unit N.

The Mont Godart and Ronquières sections can be seen as one large megacycle, starting in shallow but basinal conditions of unit A (Mont Godart Formation), with a pronounced and long deeper phase in unit C, followed by a gradual shallowing in units D, E and F. After the gap of information between both large outcrops the same conditions continue in the Plan Incliné section with an interruption by the more energetic thick sandstone beds of subunit K2 or the very low energy laminated hemipelagites of subunit K5, K7 and K10. This culminates at the top of the section, with the very energetic unit M, more energetic than the turbidites from the Mont Godart Formation (unit A).

The observed deepening-shallowing cycle is a regional phenomenon. It is also observed in strata of the same age on the other side of the Midlands Microcraton, the Welsh Borderland, and in Gotland on the nearby situated Baltica plate. A regional deepening-shallowing cycle is present in the Welsh Borderland from the top of the shallow deposits of the Wenlock Limestone Formation through the deep shelf deposits of the Elton Beds, which are part of the type section of the Gorstian, Ludlow (Bassett, 1989). A large deepening-shallowing cycle is present in Gotland from the top of the Klinteberg Beds (latest Wenlock/earliest Ludlow) to the top of the Hemse Beds (Gorstian) (Laufeld, 1974, 1979). Until this cycle in waterdepth is observed on other plates, it is considered as a regional and not as an eustatic phenomenon.

6.- SOME ELEMENTS ON THE DIAGENESIS

In outcrops, the slaty cleavage is clearly at oblique angles with the stratification, indicating anchizonal or incipient metamorphism. The finer sediments have been designated earlier slaty shales (*schistes phylladeux*) or more accurately slates. The colour of the organic fossils and the reflectivity of vitrinite are used to determine the degree of diagenesis/metamorphism.

The colour of the acritarchs (dark grey, dark brownish grey), the Chitinozoa (mostly opaque, rarely dark grey on the finer parts) and the other organic matter, places all samples into group 3 of Correia (1967), pointing to temperatures higher than 180°C.

Dr. Y. Somers (INIEX, 1984, pers. comm.) measured on two samples from the Mont Godart section (samples N° M.G. 596e = INIEX N° ED 1658; N° M.G. 685e = INIEX N° ED 1659) a reflectivity of the organic matter, in this case on Chitinozoa fragments, of respectively 4.50% (n=60, s=.90%) and 4.68% (n=75, s=1.14). If one excludes the discontinuous measurements in the very high value range of the reflectogram (5-8.5%) the results are 4.09% (n=46, s=.37%) and 4.11% (n=57, s=.25%). The maximum reflectivity on the selection of measurements, calculated from these main values, is 4.36% and 4.38%. As discussed in André & Deutsch (1985), a value around 4% main reflectance characterizes the lower and middle parts of the anchizone, but if the duration of the metamorphism is significantly long this value of thermal maturation can be indicative of higher temperatures (up to 300°C).

Recent studies on illite crystallinity in samples from the main formations of the lower Palaeozoic of the Brabant Massif, demonstrate clearly the presence of an epizonal metamorphism (greenschist facies) in all samples (Geerkens, 1992, this volume). This is the first evidence of epizonal metamorphism in the Silurian of the Brabant Massif. Hence, the methods for determining the degree of diagenesis or

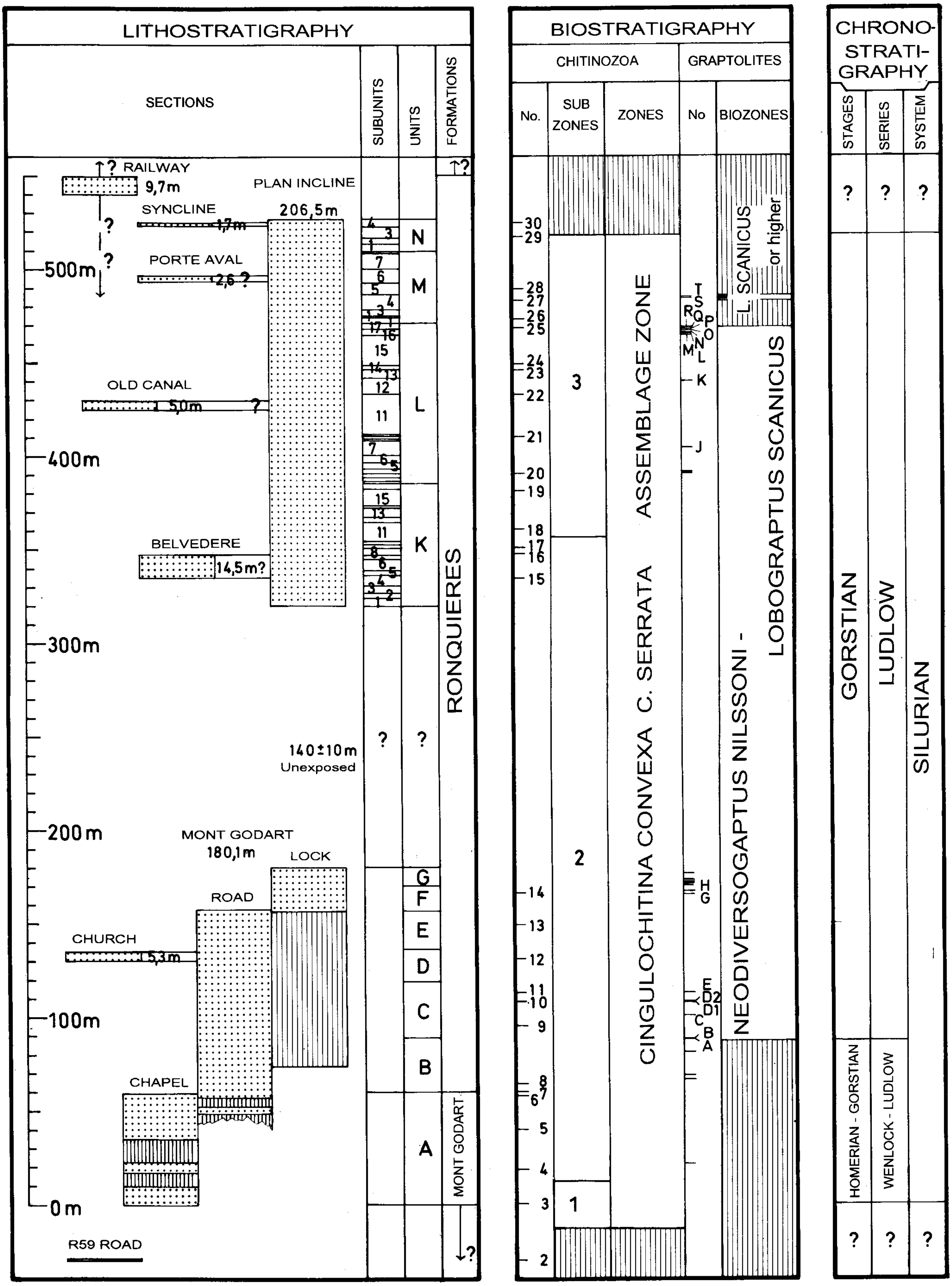


Fig. 9.- General overview of the Mont Godart and the Ronquières Formations, the relative position of the different measured sections, the units and subunits, the Chitinozoa and graptolites biozonation and the chronostratigraphy.

anchizonal metamorphism by palynomorphs or organic matter reflectivity are well established in the lower degrees of diagenesis, but are, up to now, not accurately calibrated in the deeper anchizone or epizone.

7.- LITHOSTRATIGRAPHY OF THE RONQUIERES AREA

We refer for the description of the lithostratigraphy to figure 9, where a generalized stratigraphical column is given of the Ronquières area, with the location of the different sections, the samples, the formations, the units and subunits, the biozonation with graptolites and Chitinozoa and the chronostratigraphy. The detailed logs are published separately in Verniers *et al.* (in press).

The Ronquières Formation is divided into informal units and subunits, and not in members, because it is yet unknown if they can be mapped cartographically. It could not be checked due to the lack of another outcrop area. The division in units and subunits is intended for easy reference to a certain level in the formation. Units might later be changed to the rank of members, the subunits probably not, because they are mostly too thin.

It is estimated pragmatically in the turbidites of the Silurian of the Brabant Massif that the sequential pattern, a semi-quantitative expression of the sedimentological composition (see Verniers, 1983), can be described in a part of the column whenever at least 20 turbidite sequences or turbidite/laminated hemipelagites couples are measured.

7.1.- MONT GODART FORMATION

7.1.1.- References in the literature : preliminary versions of the detailed logs were published in excursion guides without formal descriptions (Louwye, 1984 ms, Van Grootel, 1984 ms, 1990 ms, Louwye *et al.*, 1986, André *et al.*, 1987, 1989, 1991; Meilliez *et al.*, 1988); the outcrop and the formation are described herein for the first time.

7.1.2.- Kind and rank of the unit : Formation.

7.1.3.- Historical background : see above (chapter 2.2.).

7.1.4.- Stratotype : Chapel section, Rue Godart, on the Mont Godart, Ronquières, from 8.5 m to 85 m NE of the old chapel (figs. 1 & 6). Total thickness of the recorded sections: 40.5, two hiati over 12.6 and 7.4 m; minimal estimated thickness of the formation: 60.5 m. Other sections: road section, Mont Godart, from 143.5 to 137.5 m and around 128 m north of the bridge; thickness of the measured sections: 59.7 m, 3.3 m and 3.0 m.

7.1.5.- Description of the formation at the type locality :

Detailed log see above (7.1.1.) and Verniers *et al.* (in press). The formation is also named Unit A in the logs.

Lithology : Medium grey mudstone and dark grey laminated mudshale and clayshale, less frequently light grey laminated siltstone.

Sedimentology : Mostly typical Bouma mudgrade turbidites, interbedded in laminated hemipelagites. 54 % in thickness is a compact division Te, 36 % is a Td or Tb division or a laminated hemipelagite interval and 10 % is a current ripple Tc division. The thickness of the Te divisions ranges from 0,7 cm to 29.3 cm, with an average of 10.4 cm, and a slight increase in thickness from bottom to top. Four poorly exposed layers are interpreted as thick Te divisions, but possibly contain more divisions. One sequence, no. 318, is an exceptional thick turbidite marking the top of the formation. The relative frequency in numbers of Tc divisions is 37 % and they are present after at least 8 Tde or laminated hemipelagite/Te couples. In a succession of 20 sequences, there occur between 3 and 11 T(b)cde sequences. The Tc divisions range in thickness between 0.3 and 10.5 cm, with one 18.5 cm and another 33 cm thick layer forming the top of the formation. Their average thickness, without the two thick ones, is 4.6 cm. 24 % of the Tc divisions are underlain by a compact Te division, the remaining by a relatively thick (1.5 to 17 cm) laminated Tb division or hemipelagite.

Characteristics : Differences from other Silurian formations in the Brabant Massif: Formations MB2, MB3 and MB4 in the Mehaigne area are different by their light greenish or olive colours and chloritic composition. Formations MB5, MB6 and MB7 have the same colours and composition but lack the typical high frequency of Tbcde sequences, with rather thick Tb divisions and thin Tc division. Formation MB8 has much thicker Tde divisions. Formation MB9 is poorly exposed but resembles both the Mont Godart and the Ronquières Formation.

Boundaries : upper : the top of the unusual thick (98 cm) Tcde sequence (no. 318), marking the top of an energetic turbidite sedimentation;
lower : continuation downwards unknown by lack of outcrops.

7.1.6.- Regional aspects : present in part of the Road Section of the Mont Godart. No similar units are found at present in the Brabant Massif.

7.1.7.- Genesis : basinal mud-grade turbidites of medium intensity.

7.1.8.- Correlation with other units : The MB8 formation of the Mehaigne area is possibly of the same or probably of a slightly older age. The sedimentology of the latter however is very different with thick-bedded low energy, slightly calcareous mud-grade turbidites.

7.1.9.- Geological age : One graptolite level with poorly preserved specimens is not studied yet. The Chitinozoa have a lowermost Ludlow and/or possibly a latest Wenlock affinity. Lack of knowledge on the ranges of the deep water facies Chitinozoa in well-dated sections of the Wenlock-Ludlow boundary handicaps the comparison of the ranges of deep water Chitinozoa from the Mont Godart Formation (Van Grootel, 1990 ms; Van Grootel *in* André *et al.,* 1989, 1991; Van Grootel *et al.,* in prep.).

7.2.- RONQUIERES FORMATION

7.2.1.- References in the literature : re-erected by Michot (1954, 1957) and enlarged by Legrand, 1967; preliminary versions of the detailed logs were published in several excursion guides without formal descriptions (Louwye, 1984 ms, Van Grootel, 1984 ms, 1990 ms, Louwye *et al.,* 1986; André *et al.,* 1987, 1989, 1991; Meilliez *et al.,* 1988); described in detail herein.

7.2.2.- Kind and rank of the unit : Formation.

7.2.3.- Historical background : see above (chapter 2.2.).

7.2.4.- Stratotypes : Three sections at Ronquières : two at the Mont Godart : the Road Section, from the bridge till around 125 m to the north, the Lock Section, and the complete Plan Incliné Section (figs. 1 & 6).

7.2.5.- Description of the units in the formation at the type locality :

Detailed log see above (7.1.1.) and Verniers *et al.* (in press).

Lithology : Medium grey mudstone and dark grey laminated mudshale and clayshale, less frequently light grey laminated siltstone, or medium grey coarse siltstone or fine sandstone.

Sedimentology : Alternating Bouma mud-grade turbidites, interbedded in laminated hemipelagites. Changes in relative frequency of the different Bouma turbidite sequences and laminated hemipelagites and of the thickness of each of the divisions of the turbidite sequences allow the distinction of 10 units, numbered B to G and K to N, divided into subunits, named with the letter of the unit followed by a number.

UNIT B

Mont Godart sections, detailed log (Verniers *et al.,* in press) from 60.36 to 89.36 m; thickness of the unit: 29.00 m; sequence numbers 319 to 460; 142 Bouma sequences or laminated hemipelagite / Bouma sequence couples. 69% in thickness is a compact division Te, 29% is a laminated Td, Tb or laminated hemipelagite interval and 1.4% is a current ripple Tc division. The thickness of Te divisions ranges from 0.7 cm to 71 cm, with an average of 14.1 cm. The relative frequency in numbers of sequences with a Tc division is 6% and they are present after at least 48 Tde or laminated hemipelagite / Te couples. In a succession of 20 sequences, there occur between 0 and 3 T(b)cde sequences. The Tc divisions range in thickness between 2.5 and 8.6 cm. Their average thickness is 4.6 cm. 11% of the Tc divisions are underlain by a compact Te division, 89% by a laminated Tb division or hemipelagite.

UNIT C

Mont Godart sections, detailed log (Verniers *et al.,* in press) from 89.36 to 119.60 m, thickness of the unit: 30.24 m, sequence numbers 461 to 480, mostly laminated hemipelagites with some turbiditic Te divisions. 87% in thickness is a laminated hemipelagite interval, 12% is a compact Te division. No cross-bedded Tc division occurs. The thickness of 24 Te divisions ranges from 1.0 cm to 83.2 cm, with an average of 9.9 cm. Seven metabentonites are present between 2 and 6.5 cm thick and numbered MB1 to MB6. They are mainly observed in this unit and described in detail by Van den Haute (see above).

UNIT D

Mont Godart sections, detailed log (Verniers *et al.,* in press) from 119.60 to 136.30 m; thickness of the unit: 16.70 m; sequence numbers 481 to 544; 63 Bouma sequences or laminated hemipelagite / Bouma sequence couples. 75% in thickness is a compact division Te, 25% is a laminated Td, Tb or laminated hemipelagite interval and 0.3% is a current ripple Tc division. The thickness of Te divisions ranges from 4.3 cm to 59 cm, with an average of 19.9 cm. Two Tc divisions occur (relative frequency 1.2%) and they are present after at least 28 Tde or laminated hemipelagite / Te couples. In a succession of 20 sequences, between 0 and 1 T(b)cde sequences are present. The Tc divisions are 1.3 and 3.0 cm thick, with an average of 2.2 cm. They are both underlain by a laminated Tb division or hemipelagite.

UNIT E

Mont Godart sections, detailed log (Verniers *et al.,* in press) from 136.30 to 157.04 m; thickness of the unit 20.74 m; sequence numbers 545 to 631; 90 Bouma sequences or laminated hemipelagite / Bouma sequence couples. 67% in thickness is a compact division Te, 31% is a Td, Tb or laminated hemipelagite interval and 2.2% is a cross-bedded Tc division. The thickness of Te divisions ranges from 2.5 cm to 47.5 cm, with an average of 16.5 cm. The relative frequency in numbers of sequences with a Tc division is 10% and they are present after at least 28 Tde or laminated hemipelagite / Te couples. In a succession of 20 sequences, there occur between 0 and 4 T(b)cde sequences. The Tc divisions range in thickness between 1.7 and 6.0 cm. Their average thickness is 4.6 cm. All Tc divisions are underlain by a laminated Tb division or hemipelagite.

UNIT F

Mont Godart sections, detailed log (Verniers *et al.,* in press) from 157.04 to 170.14 m; thickness of the unit: 13.1 m; sequence numbers 632 to 710; 81 Bouma sequences or laminated hemipelagite / Bouma sequence couples. 63% in thickness is a compact division Te, 31 % is a Td, Tb or laminated hemipelagite interval and 6 % is a current ripple Tc division. The thickness of Te divisions ranges from 2.0 cm to 39.5 cm, with an average of 10.1 cm. The relative frequency in numbers of sequences with a Tc division is 21 % and they are present after at least 16 Tde or laminated hemipelagite / Te couples. In a succession of 20 sequences, there occur between 2 and 8 T(b)cde sequences. The Tc divisions range in thickness between 1.2 and 9.8 cm. Their average thickness without the two thick ones is 4.6 cm. 6 % of the Tc divisions are underlain by a compact Te division, 94% by a laminated Tb division or hemipelagite.

UNIT G

Mont Godart sections, detailed log (Verniers *et al.,* in press) from 170.14 to 180.1 m (top of the section); thickness of the unit: > 9.96 m; sequence numbers 711 to 781; 68 Bouma sequences or laminated hemipelagite / Bouma sequence couples. 68 % in thickness is a compact division Te, 24 % is a Td, Tb or laminated hemipelagite interval and 8 % is a cross-bedded Tc division. The thickness of the Te divisions ranges from 0,7 cm to 26.3 cm, with an average of 9.4 cm. The relative frequency in numbers of sequences with a Tc division is 43 % and they are present after at least 11 Tde or laminated hemipelagite / Te couples. In a succession of 20 sequences, there occur between 3 and 12 T(b)cde sequences. The Tc divisions range in thickness between 0.4 and 7.7 cm. Their average thickness is 2.5 cm. 24% of the Tc divisions are underlain by a compact Te division, 76% by a laminated Tb division or hemipelagite. This unit and the next 10-20 m above it, now excavated, are the beds visible and studied between 1848 and 1962. They correspond to the previous stratotype of the Assise of Ronquières *sensu* Michot (1954).

There is a gap in observation between the Mont Godart sections and the Plan Incliné sections, estimated on geometrical arguments at 140 m± 10 m.

UNIT K

Plan Incliné section, detailed log (Verniers *et al.,* in press) from 0 to 65.77 m; thickness of the unit: > 65.77 m; sequence numbers 101 to 534; 434 Bouma sequences or laminated hemipelagite / Bouma sequence couples. 73.2 % in thickness is a compact division Te, 17.9% is a Td, Tb or laminated hemipelagite interval, 8.3 % is a cross-bedded Tc division and 0.4 % a Ta division. The thickness of Te divisions ranges from 0.1 to 59 cm (one of 104 cm), with an average of 11.1 cm. The relative frequency in numbers of Tc divisions is 13.1 % and they are present after 2 to 46 Tde or laminated hemipelagite / Te couples. In a succession of 20 sequences there occur between 0 to 7 T(b)cde sequences. The Tc divisions range in thickness between 0.4 and 22.8 cm (exceptions in subunits K2 and K3 of 55 and 96 cm). Their average thickness is 9.6 cm. 48.2 % of the Tc divisions are underlain by a compact Te division, the remaining by a laminated Tb division or hemipelagite.

This unit is characterised by the absence of Ta divisions and a low frequency of Tc divisions (0 to 6 Tc divisions in a series of 20 sequences, and a maximum of 45 sequences between two Tc divisions), with an exception in the thin subunits K2 and K3. Five subunits contain dominantly laminated beds: K5 (16.73-19.70 m), K7 (25.41-27.25 m) with cigar shaped calcareous nodules, K10 (33.30-34.90 m), K12 (44.60-47.50 m), K14 (52.37-53.50 m). They alternate with subunits containing mostly relatively thick Te divisions, thin Td divisions or laminated hemipelagites and a very rare T(b)cde division: K1 (0-4.25 m), K4 (10.23-16.73 m), K6 (19.70-25.41 m), K8 (27.25-31.32 m), K11 (34.90-44.60 m), K13 (47.50-52.37 m), K16 (62.64-65.77 m). Four subunits contain more Tc divisions. There is a subunit consisting of much and thick Tc divisions with current ripple laminated, coarse siltstone and fine sandstone, K2 (4.25-7.23 m). In the level above it, K3 (7.23-10.32 m), two Ta divisions occur, and a 55 cm thick Tc division. Subunits K9 (31.32-33.30 m) and K15 (53.50-62.64 m) contain more frequently Tc divisions, but not as frequently as in the above laying units (L, M, N).

UNIT L

Plan Incliné section, detailed log (Verniers *et al.,* in press) from 65.77 to 151.23 m; thickness of the unit: 85.46 m; sequence numbers 535 to 1266; 732 Bouma sequences or laminated hemipelagite / Bouma sequence couples. 59.8 % in thickness is a compact division Te, 24.1% is a Td, Tb or laminated hemipelagite interval, 16.3 % is a current ripple Tc division and there is no Ta division. The thickness of Te divisions ranges from 0.5 cm to 47.5 cm, with an average of 7.0 cm. The relative frequency in numbers of Tc divisions is 24.9% and they are present after 2 to 15 Tde or laminated hemipelagite / Te couples. In a succession of 20 sequences, there occur between 2 and 10 T(b)cde sequences. The Tc divisions range in thickness between 0.5 and 31 cm. Their average thickness is 7.6 cm. 70.3% of the Tc divisions are underlain by a compact Te division, the remaining by a laminated Tb division or hemipelagite.

This unit is characterised by a high frequency of Tc divisions and absence of Ta divisions. Eight subunits contain frequent Tc divisions: L1 (65.77-66.62 m), L5 (73.37-76.64 m), L7 (80.28-88.25 m), L9 (89.37-90.83 m), L11 (91.95-113.30 m), L13 (122.00-126.10 m), L15 (128.70-144.44 m), L16 (144.44-148.00 m). Four thin subunits contain dominantly laminated beds: L4 (69.90-73.37 m), L10 (90.83-91.95 m), L14 (126.10-128.70 m) and L17 (148.00-151.23 m). Three thin subunits contain mostly relatively thick Te divisions, thin Td divisions or laminated hemipelagites and rarely T(b)cde divisions: L3 (68.68-69.90 m), L6 (76.64-80.28 m), L8 (88.25-89.37 m), L12 (113.30-122.00 m). One thin subunit contains several very thick Tc divisions above each other: L2 (66.62-68.68 m).

UNIT M

Plan Incliné section, detailed log (Verniers *et al.,* in press) from 151.23 to 189.54 m; thickness of the unit: 38.31 m; sequence numbers 1267 to 1584; 318 Bouma sequences or laminated hemipelagite / Bouma sequence couples. 54.5 % in thickness is a compact division Te, 14.5% is a Td, Tb or laminated hemipelagite interval, 18.0% is a current ripple Tc division and 12.1 % is a Ta division. The thickness of Te divisions ranges from 0.1 cm to 20.5 cm, with an average of 6.6 cm. The relative frequency in numbers of Tc divisions is 34.3% and they are present after 0 to 27 Tde or laminated hemipelagite / Te couples. In a succession of 20 sequences, there occur between 0 and 10 T(b)cde sequences and between 0 to 9 sequences with a Ta division. The Tc divisions range in thickness between 0.7 and 52 cm. Their average thickness is 6.4 cm. 53 % of the Tc divisions are underlain by a compact Te division, the remaining by a laminated Tb division or hemipelagite.

This unit is characterised by a high frequency of Tc divisions and frequent Ta divisions. Eight subunits are present. Three subunits contain very frequently Ta divisions: M5 (166.20-172.65 m), M7 (180.15-188.28 m), M8 (188.28-189.54 m). Two subunits contain frequently Ta divisions: M1 (151.23-154.12 m) and the thick M6 (172.65-180.15 m). One subunit contains dominantly laminated beds M3 (154.90-158-38 m). Another subunit contains very frequently thick Tc divisions, M4 (158.38-166.20 m). The thin subunit M2 contains one relatively thick Te division in a Tbcde sequence (154.12-154.90 m).

UNIT N

Plan Incliné section, detailed log (Verniers *et al.*, in press) from 189.54 to 206.52 m; thickness of the unit: 16.98 m; sequence numbers 1585 to 1755; 171 Bouma sequences or laminated hemipelagite intervals, 21.9 % is a current ripple Tc division and there is no Ta division. The thickness of Te divisions ranges from 0.5 cm to 26.5 cm, with an average of 5.6 cm. The relative frequency in numbers of Tc divisions is 31.6 % and they are present after 3 to 9 Tde or laminated hemipelagite / Te couples. In a succession of 20 sequences, there occur between 2 and 10 T(b)cde sequences. The Tc divisions range in thickness between 0.9 and 35.0 cm. Their average thickness is 6.9 cm. 40.7 % of the Tc divisions are underlain by a compact Te division, the remaining by a laminated Tb division or hemipelagite.

This unit is characterised by a high frequency of Tc divisions and the absence of Ta divisions. Two subunits contain very frequently thick Tc divisions: N1 (189.54-193.80 m) and N4 (202.50-205.52 m). One subunit is dominated by laminated beds, with some very fine Tc divisions: N2 (193.80-196.53 m). One subunit contains mostly relatively thick Te divisions, thin Td divisions or laminated hemipelagites and frequently T(b)cde divisions: N3 (196.53-202.50 m).

Characteristics : Differences with the other Silurian formation in the Brabant Massif: Formations MB2, MB3 and MB4 in the Mehaigne area are different by their light greenish or olive colours and the chloritic composition. Formations MB5, MB6 and MB7 have the same colours and composition but lack the typical high frequency of Tcde sequences, rather thick Tb divisions and thin Tc divisions. Formation MB8 has much thicker Tde sequences. Formation MB9 is poorly exposed and resembles both the Mont Godart and the Ronquières Formations.

Boundaries : upper: unknown, upwards continuation unobservable by lack of outcrops; lower: base of the sequence N° 319 above the unusual thick (98 cm) Tcde sequence N° 318, marking the top of the Mont Godart Formation (see above).

7.2.6.- Regional aspects : The same facies is observed in every studied section in the study area (Samme and Sennette valleys).

7.2.7.- Genesis : Basinal mud-grade turbidites of low to high intensity, intercalated between mostly thin-bedded laminated hemipelagites, sometimes thick (unit C : 30.24 m).

7.2.8.- Correlation with other units : The three small outcrops in the MB9 formation of the Mehaigne area, which on the basis of Chitinozoa are of a similar age, do not allow a detailed facies comparison.

7.2.9.- Geological age : Graptolites determined by Rickards in 1984 (Rickards, pers. comm. *in* Louwye, 1984 ms and Van Grootel, 1984 ms) indicate the presence of the *Neodiversograptus nilssoni* and *Lobograptus scanicus* zones and possibly the *Pristiograptus tumescens* zone, all three forming the lower Ludlow Gorstian stage. The Chitinozoa assemblages belong to the *Cingulochitina convexa- C. serrata* assemblage zone and confirm that age (Van Grootel, 1990 ms; Van Grootel *in* André *et al.*, 1989, 1991; Van Grootel *et al.*, in prep.).

8.- CONCLUSIONS

Detailed analysis of the literature and the archives of the Belgian Geological Survey, own mapping and detailed logging of the large outcrops in the Ronquières area (Verniers *et al.*, in press) allow the lithostratigraphical definition of a new formation, the Mont Godart Formation and the redefinition of the previously poorly described Ronquières Formation.

Chitinozoa (Van Grootel, 1990 ms; Van Grootel *in* André *et al.*, 1989, 1991; Van Grootel *et al.*, in prep.) and graptolites (Rickards, pers. comm. *in* Louwye, 1984 ms and Van Grootel, 1984 ms) justify a possible latest Homerian (Wenlock) or earliest Gorstian (Ludlow) estimated age for the Mont Godart Formation and a Gorstian (Ludlow) age for the Ronquières Formation.

Four different sedimentological facies occur in the sections. The most frequent are the turbidites, mostly claystone or mudstone, with some siltstone and rarely fine sandstone. They are interbedded between darker grey, anoxic laminated hemipelagites. Calcareous nodules occur in some levels, some are formed before and others after the slaty cleavage formation. The two other facies occur very rarely: oxic hemipelagites, bioturbated by either subhorizontal tubes or by pyritospheres and very fine light coloured tuffites (metabentonites).

The turbidity currents, deduced from the current ripple lamination in the Tc divisions, were apparently directed northwards. The observed lateral variation between different outcrops containing the same part of the column, show a clear decrease in thickness and in number of sequences in a northward direction with a similar but less pronounced decrease in a eastward direction. Tentatively, a main apparently northward directed current is concluded with an eastward component. However, the palaeoenvironment of the sedimentary basin is interpreted as an eastward directed turbiditic fan system in a E-W trending trough, but with apparently northward directed currents. A major megacycle is observed in both formations. Higher energy sediments, evidenced by more complete turbidite sequences and coarser grain-size, reveal overall shallower conditions low in the Mont Godart Formation and in the units M and N in the top of the Ronquières Formation. Deeper conditions prevailed in between. The observed deepening-shallowing cycle is a regional phenomenon, observed in the Welsh Borderland on the other side of the Midlands Microcraton, from the shallow deposited Wenlock Limestone Formation (latest Wenlock) through the deep shelf deposits of the Elton Beds (Gorstian, Ludlow) (Bassett, 1989). It is also observed in Gotland on the nearby situated Baltica plate, from the Klinteberg Beds (latest Wenlock/basal Ludlow) to the top of the Hemse Beds (Gorstian) (Laufeld, 1974, 1979).

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