

LOWER LLANVIRN (ORDOVICIAN) GRAPTOLITES AND ACRITARCHS FROM THE «ASSISE DE HUY», BANDE DE SAMBRE-ET-MEUSE, BELGIUM¹

Th. SERVAIS² & J. MALETZ³

(6 figures and 3 plates)

ABSTRACT.- The Huy formation («assise de Huy») is the oldest unit present in outcrops in the Belgian «Bande de Sambre-et-Meuse». Graptolites and acritarchs show that the beds are of early Llanvirn *Didymograptus artus* Biozone age. The localities of Huy and of Sart-Bernard and the Wépion borehole are reinvestigated and the collection of Maillieux, 1939 is restudied.

RESUME.- La formation de Huy («assise de Huy») est l'unité la plus ancienne qui affleure dans la Bande de Sambre-et-Meuse. Des graptolites et des acritarches indiquent un âge Llanvirn inférieur, Biozone de *Didymograptus artus*. Les localités de Huy et de Sart-Bernard, ainsi que le sondage de Wépion sont réétudiés et la collection de Maillieux, 1939 est réexaminée.

1.- INTRODUCTION

1.1.- The «Bande de Sambre-et-Meuse»

The Lower Palaeozoic rocks of Belgium have been subdivided geographically, on the basis of «massifs» («Massif du Brabant», «Massifs de la Haute Ardenne») and «bandes» («Bande de Sambre-et-Meuse»).

The «Bande de Sambre-et-Meuse» area, also called the «Bande condrusienne», is a strip, 65 km long and 0,5 to 3 km wide, parallel to the Sambre and Meuse rivers (fig.1). It consists of sedimentary rocks of Ordovician and Silurian age. Lithologically it is mainly composed of shales and siltstones, partially calcareous in the upper Ordovician.

The first researches on the numerous discontinuous outcrops by geologists at the end of the last century were followed by the general overview of Malaise (1909a,b-1910) and by the important field work of Michot (1928-1934). Since then, other general geological investigations in this area have not been undertaken.

Within the Bande de Sambre-et-Meuse different units, called «assises», have been recognized, based on both lithological and palaeontological features. In this text, we use the informal term «formation» for the Belgian expression «assise».

Fig.2 gives an overview of the names of the Ordovician formations of the Sambre-et-Meuse area. They have been used inconsistently. The first terms were introduced by Malaise (1909a,b) who recognized three formations: the «assise de Huy» of Arenig, the «assise d'Oxhe» of Llandeilo and the «assise de Fosse» of Caradoc age. This concept of the stratigraphy of the Bande de Sambre-et-Meuse was generally accepted, and was used for the Legend to the Geological Map of Belgium, published in 1929.

Maillieux (1926) introduced the term «assise de Vitriaval-Bruyère» and subdivided (Maillieux, 1939) the oldest formation into the «assise de Huy» and the new «assise de Sart-Bernard». The oldest lithological unit, present in the borehole of Wépion, but not in outcrops, was called the «assise de Wépion» by Martin (1969).

1.- Manuscript received in March 1992.

2.- Grant-holder I.R.S.I.A. Université de Liège, Services Associés de Paléontologie; 7, place du XX Août - B-4000 LIEGE (Belgium).

3.- Technische Universität Berlin, Institut für Geologie und Paläontologie; Sekr. EB 10, Ernst-Reuter Platz 1 - D-1000 BERLIN 10 (Germany).

The Huy, Sart-Bernard, Vitrival-Bruyère and Oxhe formations all consist of grey to black mudstones and siltstones. They have been described from different areas in the Bande de Sambre-et-Meuse (fig. 1). The lithological differentiation of these four units in the field is difficult. Until now, none of these formations has been formally defined and generally their bases and their tops are unknown.

Most of the original age attributions are no longer justified. Recent publications clarified the ages of some parts of the Ordovician sequence of the Bande de Sambre-et-Meuse. The youngest formation, the «assise de Fosse», is of Ashgill age

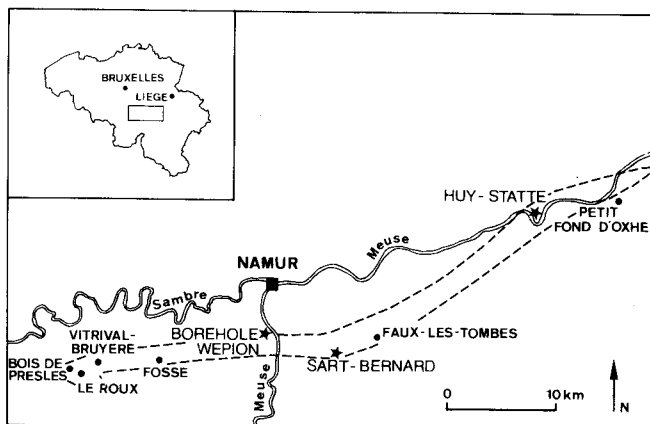


Fig. 1.- Location of investigated localities in this work and of the different type-localities of all Ordovician formations of the Sambre-et-Meuse Band (after Martin, 1969, fig. 5).

(Sheehan, 1988; Lesperance & Sheehan, 1988). A part of the Oxhe formation, at its type locality, belongs to the Longvillian Stage of the Caradoc Series (Dean, 1991). The ages of the fossil bearing horizons of the Vitrival-Bruyère and Sart-Bernard formations have yet to be reconsidered. The age of the Huy formation is clarified in this paper.

1.2.- The Huy formation, «Assise de Huy»

As a locality name, Huy has been used for four different geological units. Dumont (1832) introduced the term «Calcaire de Huy» for Upper Devonian limestones. Murlon (1876) named the «Psammities rouges de Huy», another Upper Devonian lithological unit. The «Poudingue de Huy» of Middle Devonian age was introduced by Fourmarier & Lespineux (1908). We use in this text the informal name of Huy formation for the Ordovician «assise de Huy» of Malaise (1909a,b).

Lecrenier (1887) collected 500 samples, containing 30 graptolite species, from the same localities of the railway section at Huy and Statte at which Malaise (1873) found a specimen of «*Climacograptus scalaris*». Malaise (1887, 1888a) continued studies on the graptolites from these «schistes siluriens de Huy», and from other localities, including the section of the «schistes noirs de Sart-Bernard» at Sart-Bernard (Malaise, 1888b, 1888c). He compared the fossil content of the Huy, Statte and Sart-Bernard sections and attributed all horizons to the Arenig (Malaise, 1890, 1900), later

Malaise 1909a Malaise 1909b	Malaise 1910 Carte géol. de la Belg. 1929	Maillieux 1926	Maillieux 1939	Michot 1954, 1980	Martin 1969
SI2c : Assise de Fosse	SI1b : Assise de Fosse	+ Horizon de Le Roux Assise de Fosse		Assise de Fosse	+ Sous-Assise Faulx-les- Tombes Assise de Fosse + Sous-Assise Bois de Presles
----- SI2b : Assise d' Oxhe	----- SI1a' : Assise d' Oxhe	+ Horizon d'Oxhe		-----	----- Assise d'Oxhe
-----	-----	Assise de Vitrival - Bruyère		Assise de Vitri- val - Bruyère	----- Assise de Vitrival - Bruyère
SI 2a : Assise de Huy	SI 1a : Assise de Huy	Assise de Huy	Ass. de Sart - Bernard Assise de Huy	Assise de Sart - Bernard	----- Assise de Sart-Bernard ----- Assise de Huy ----- Assise de Wépion

Fig. 2.- Different stratigraphical concepts of the Ordovician of the Sambre-et-Meuse Band in the literature. All existing formation names are included in the diagram. Our investigations concern the «Assise de Huy» in the concept of Maillieux 1939.

placing all these outcrops in the «assise de Huy» (Malaise, 1909a,b).

Maillieux (1913) first subdivided this formation into a lower and an upper part, and later into two formations of different ages (Maillieux, 1938, 1939). In these studies of the Ordovician of Sart-Bernard, the lower unit, also present at Huy and Statte, yielded graptolites of the «*Didymograptus bifidus*» Biozone and was called the Huy formation. The overlying Sart-Bernard formation provided a macrofauna containing various fossil groups of Llandeilo age.

Michot (1954, 1980) placed both units in his «assise de Sart-Bernard». This view has generally been adopted (e.g. fig. 9 in Robaszynski & Dupuis, 1983). Graulich (1961) followed this concept, when he discovered the graptolitic shales in the Wépion borehole.

We use the Huy and Sart-Bernard formations in the sense of Maillieux (1939) who indicated the lithological and especially the biostratigraphical differences between the units.

2.- FOSSIL LOCALITIES

The «assise de Huy» (sensu Maillieux, 1939) was described from Huy, Statte and Sart-Bernard and was recorded at other localities. The fossil content is not sufficient to prove the attribution to the Huy formation of outcrops in the western part of the Bande de Sambre-et-Meuse (e.g. in the «pointe de Puagne»; Michot, 1928) and of the graptolite bearing shales at Marlagne and at Dave (Maillieux, 1939, p. 50, 51).

In this work we investigate the Huy formation at the classical localities of Huy and Sart-Bernard and in the Wépion borehole.

2.1.- Huy - Statte

Malaise (between 1873 and 1910) and Lecrenier (1887) mentioned important collections of graptolites from these localities (fig.3). Outcrops were present near the stations of Huy and Statte, separated by a tunnel. Graptolite bearing horizons were reported from both the western and eastern ends of the tunnel, but their exact location is not known. Michot (1932b) mapped the area using the «Arenigian-Llandeilian» as the oldest unit.

These outcrops have disappeared because the route of the railway line and the position of the station in Huy have changed since that time. At the present time, no more outcrops are present at Statte. At Huy, at the eastern end of the new tunnel, near the station «Gare du Nord», very small discontinuous outcrops are present only at the

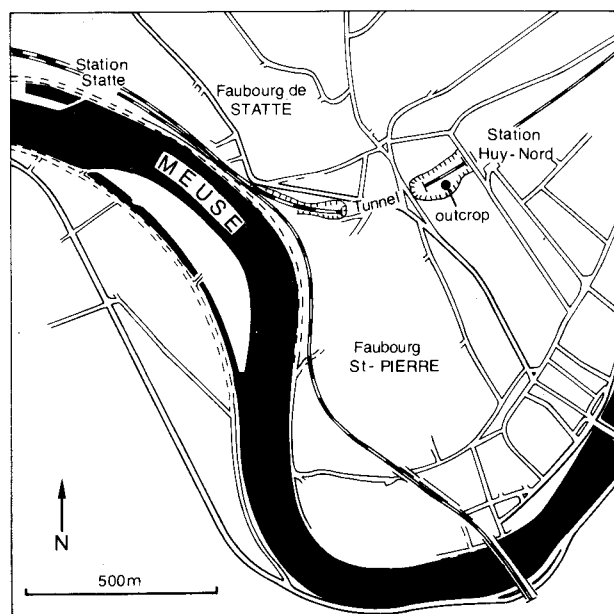


Fig. 3.- Location of the investigated outcrop at the type-locality of the Huy formation near the station Huy-Nord.

southern slope of the railway section, at about km 30,850. The greyish-black mudstones yield several fossil bearing horizons. These outcrops are isolated and the geological setting is unknown.

Our acritarch samples from this locality (Huy 1 and Huy 2) are located between the graptolite bearing horizons.

Faunal list

Huy, Gare du Nord

Graptolites:

- Didymograptus* sp. of *D. artus* Elles & Wood type
- Janograptus* sp. cf. *J. petilus* Berry
- Aulograptus cucullus* (Bulman)
- Glyptograptus* sp. (*G. brevis* Elles & Wood group)
- Glyptograptus* sp. (*G. euglyphus* Lapworth group)
- Undulograptus camptochilus* (Skevington)

Crinoids.

Phyllocarids.

Brachiopods.

Acritarchs: two samples at km 30,850; Huy 1 and Huy 2.

Remarks

The macrofauna is dominated by graptolites. They are usually flattened and poorly preserved. Little detail can be seen and specific determinations are often impossible. The graptolites are commonly associated with fragments of phyllocarids.

Michot (1934, p. 68) recorded *Didymograptus bifidus*, *Dichograptus octobrachiatus*, *Glyptograptus dentatus*, *Phyllograptus angustifolius* and *Aeglina binodosa*, determined by Maillieux. The fauna was restudied by Bulman (1950), who indicated *Climacograptus scharenbergi* and *Amploxograptus* cf. *confertus* as further biserials. *D. protobifidus* (Bulman, 1950) certainly belongs to the Llanvirn group of pendent didymograptids; the material is indeterminable at the specific level.

Our material includes well preserved specimens of *Aulograptus cucullus*, some in low relief and common in one layer. Only a few poorly preserved biserials were discovered, indicating *Undulograptus camptochilus* and two different glyptograptids. One poorly preserved specimen of *Janograptus* cf. *J. petilus* is present.

Brachiopods, crinoids and phyllocarids have not been cited at this locality before. Of these three groups, only phyllocarids are found in greater numbers. Specimens of crinoids are common on one slab, showing different sizes. They are usually poorly preserved as moulds, sometimes showing a pentagonal outline.

The determination of a specimen of the trilobite «*Aeglina binodosa*» (in: Michot, 1934) is interesting. Trilobites have not been discovered in recent collections.

2.2.- Sart-Bernard

The two sections on the Brussels-Luxembourg railway line at Sart-Bernard (fig.4), about 10 km South-East of Namur, have been studied several times. Maillieux (1939, p. 3) reviewed previous studies and figured the macrofossils of the Huy and Sart-Bernard formations.

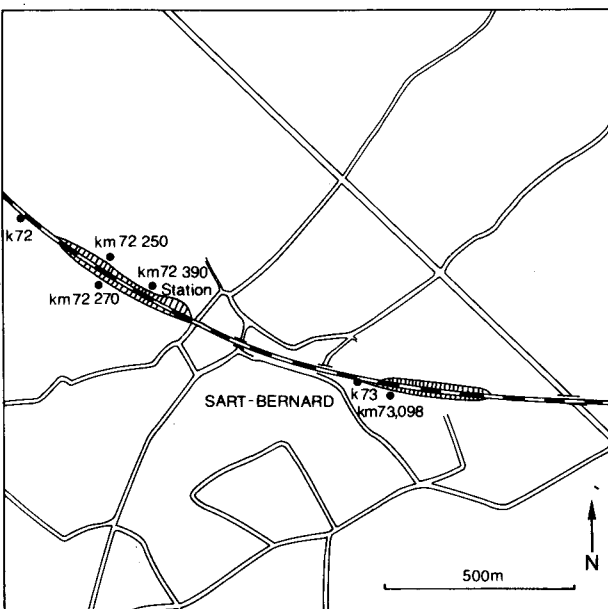


Fig. 4.- Location of investigated fossil horizons in the Huy formation at Sart-Bernard.

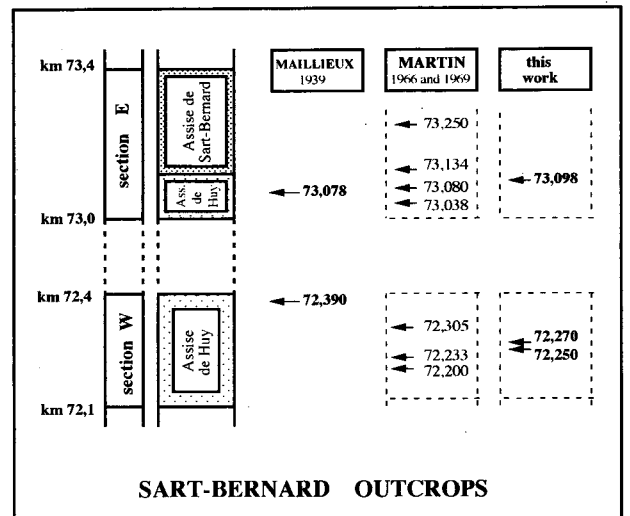


Fig. 5.- Position of investigated fossil horizons and palynological samples in the Huy and Sart-Bernard formation at Sart-Bernard.

The first section, between km 72,1 and km 72,4, exposes the Huy formation and the second, to the East between km 73,0 and km 73,4, the Huy and Sart-Bernard formations (fig.5). Both sections are now overgrown by the vegetation. The detailed geological setting is problematical and the nature of the contact between the formations is not clear.

The position of the graptolite horizons investigated in this work and of the palynological samples at Sart-Bernard is given in fig.5. Maillieux (1939) indicated three fossil bearing levels. Only one of them was located exactly. In the western section, one level at km 72,390 (Nanine 1) yielded graptolites, trilobites and phyllocarids and was attributed to the «*D. bifidus*» Biozone. The exact location of the other two fossil horizons in the eastern section was not given. The first (Nanine 2a) was also placed in the «*D. bifidus*» Biozone. The second (Nanine 2) yielded a macrofauna of Llandeilo age.

Bulman (1950) revised the graptolites of Naninne 1 and Naninne 2a and located the latter horizon at km 73,078. He indicated (p.7) that «the fauna of Huy and Sart-Bernard is in all probability slightly earlier than the zone of *D. bifidus*» and mentioned an «undoubted *D. bifidus* zone age» for the higher horizon (Nanine 2a).

In this work only the graptolite material figured by Maillieux (1939) is revised. New material was discovered at km 72,250 and at km 72,270 in the western section. Another horizon with indeterminable remains of graptolites was found in the eastern section at km 73,098.

Our acritarch samples at km 72,250 and km 72,270 were taken from between the graptolitic horizons. The exact age of the sample from km 73,098 is not known.

Faunal lists

Remarks

Sart-Bernard 72250

Graptolites:

- Holmograpthus callotheca* (Bulman)
Acrograptus acutidens (Elles & Wood)
Glyptograptus sp.

Tomaculum problematicum Groom

Acritarchs: one sample, SB 72250.

Sart-Bernard 72270 a

Graptolites:

- Didymograptus* sp. of *D. artus* Elles & Wood
 type
Diplograptus ? *decoratus* (Harris & Thomas)

Trilobites:

- Pricyclopyge binodosa* ssp. (Pl. II, fig. 2,4,5)
Placoparia sp. (Pl. II, fig. 7)
Novakella sp. (Pl. II, fig. 10)

Crinoids.

Lingulid brachiopods.

Phyllocarids.

Tomaculum problematicum Groom.

Acritarchs: one sample, SB 72270 S 1.

Sart-Bernard 72270 b

Graptolites:

- Tetragraptus headi* (Hall)
Didymograptus sp. of *D. artus* Elles & Wood
 type
Acrograptus acutidens (Elles & Wood)
Glyptograptus sp.

Trilobites:

- Pricyclopyge binodosa* ssp.
Cyclopyge sp. (Pl. II, fig. 9)

Phyllocarids.

Acritarchs: one sample, SB 72270 S 2.

Sart-Bernard 72390 (Maillieux, 1939)

Graptolites:

- Dichograptus octobrachiatus* (Hall)
Phyllograptus sp.
Didymograptus sp. of *D. artus* Elles & Wood
 type
Holmograpthus callotheca (Bulman)
Acrograptus acutidens (Elles & Wood)
Cryptograptus antennarius (Hall)
Diplograptus ? *decoratus* (Harris & Thomas)

Sart-Bernard 73098

Acritarchs: one sample, SB 73098.

The graptolite specimens figured by Maillieux (1939) have been revised by Bulman (1950). Some determinations have had to be changed since Bulman's list, and new determinations are given here. Bulman's record of *Climacograptus scharenbergi* is based on an unidentifiable biserial specimen. *Phyllograptus angustifolius* Hall is indicated here as *Phyllograptus* sp. Due to the poor preservation and taxonomic problems, specific determinations of phyllograptids are difficult at the present time. The specimen of *Didymograptus acutidens* Lapworth (*in* Maillieux, 1939) was determined by Bulman as belonging to *Holmograpthus callotheca*. *Didymograptus bifidus* (Hall) and *Didymograptus stabilis* Elles & Wood belong to the Llanvirn group of pendent didymograptids, which are included here as *Didymograptus* sp. of *D. artus* type. The long proximal spines present in the *Cryptograptus tricornis* specimen show that it belongs to *C. antennarius*.

A few trilobites are found at Sart-Bernard. Maillieux (1939) reported ? *Asaphellus* sp., *Cyclopyge prisca longicephala* (Kloucek) and *Placoparia* sp. He only figured a specimen of *C. prisca longicephala*, which may better be included in *Pricyclopyge binodosa* ssp. A few more specimens of this species were discovered in this investigation along with specimens of *Cyclopyge* sp., *Placoparia* sp. and *Novakella* sp.

Indeterminable fragments of phyllocarids are present at Sart-Bernard. They were identified by Maillieux (1939) as *Lamprocaris micans* Novak.

2.3.- Wépion Borehole

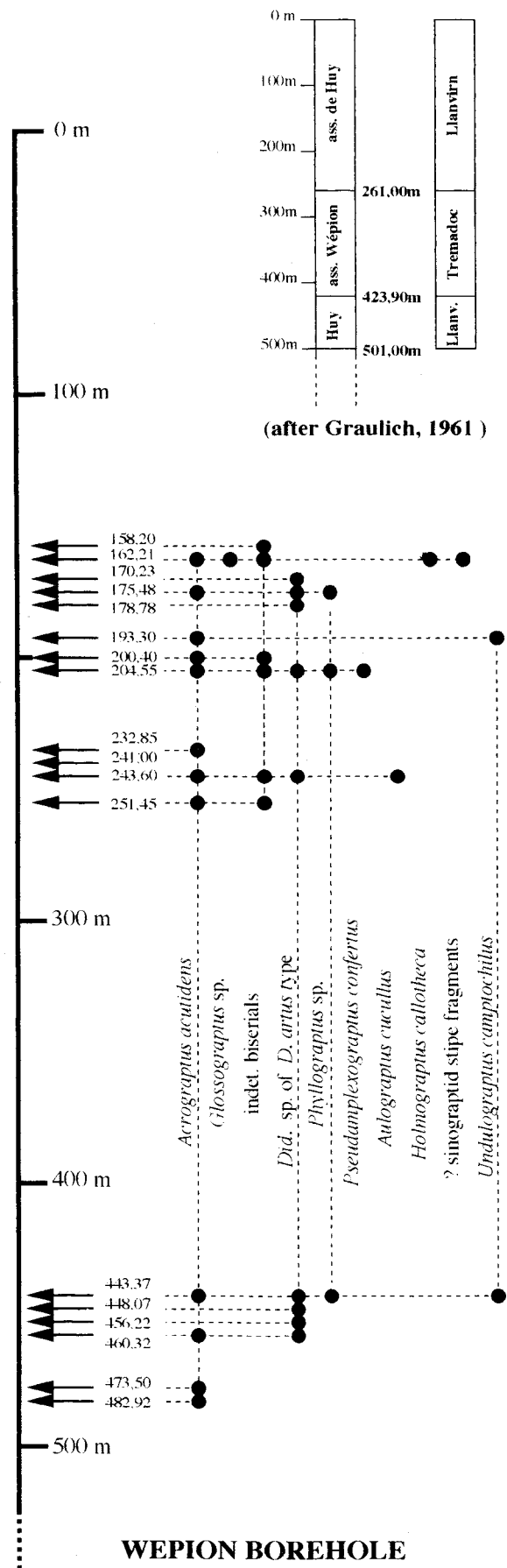
Graulich (1961) published a description of the Wépion borehole. In its uppermost part, Ordovician rocks are present (fig. 6). He placed the Llanvirnian graptolite bearing mudstones, present between Om and 261,00m and between 423,90m and 501,00m, in the «assise de Sart-Bernard» (Sla) following the stratigraphical concept of Michot (1954). These rocks belong in fact to the Huy formation (*sensu* Maillieux, 1939).

The graptolite levels investigated in this work are parts of the collections of the Belgian Geological Survey (Brussels). Graptolites seem to be more common between 150m and 250m and between 440m and 480m.

Faunal list

Graptolites:

- Acrograptus acutidens* (Elles & Wood)
Didymograptus cf. *D.(E.) hirundo* (Salter)
Didymograptus sp. of *D. artus* Elles & Wood
 type



- Aulograptus cucullus* (Bulman)
- Phyllograptus* sp.
- Holmograptus callothecca* (Bulman)
- Glossograptus* sp.
- Pseudamplexograptus confertus* (Lapworth)
- Undulograptus camptochilus* (Skevington)
- Undulograptus* sp. 1
- dichograptid fragments
- ? sinograptid fragments

Trilobites:
Pricyclopyge binodosa ssp.
 Acritachs: five samples; 158,20m; 182,65m;
 218,45m; 259,33m; 496,00m.

Remarks

The distribution of graptolites investigated in this work is summarised in fig. 6. Graulich (1961) provided a preliminary faunal list but some determinations have had to be changed. The specimens determined as *Didymograptus artus* and *D. bifidus* belong to the pendent didymograptids of *D. artus* type. They are not determined here to specific level as preservation is usually poor. *D. nicholsoni* was not found and the basis for this determination of Graulich (1961) is unknown, as he did not figure any specimen. The specimen of *Climacograptus scharenbergi* (Graulich, 1961, pl. 1, fig. 2) belongs to *Undulograptus* sp. 1. The structure of the rhabdosome differs strongly from typical *P. scharenbergi* (Lapworth). *Clyptograptus dentatus* may be misprinted for *Glyptograptus dentatus*. Glyptograptids are common in the borehole, but cannot be specifically determined. Two specimens, that may have been included in *G. dentatus* by Graulich, are described here under *Undulograptus camptochilus*. Newly discovered species are *Aulograptus cucullus* and *Holmograptus callothecca*. The former may have been mistaken for a *Didymograptus artus* specimen, the latter possibly was the basis for the determination of *D. nicholsoni*.

Unfortunately the preservation of many graptolite specimens is too poor for specific determination. This is especially important for biserial graptolites. They are often preserved in scalariform view, showing no detail of thecal structure and proximal developments. Pendent didymograptids are collectively reported under *Didymograptus* sp. of *D. artus* type. None of them shows the proximal development. All are, however, comparable in possessing a long and slender sicula, unlike the mid-Arenig *Didymograptellus bifidus*. A poorly preserved proximal part of a horizontal didymograptid is here attributed to *D. cf. D. (E.) hirundo*, due to the wide stipes and the comparatively short supradorsal part of the sicula.

Fig. 6. - Distribution of selected graptolites in the Huy formation of the Wépion borehole.

3.- AGE OF THE HUY FORMATION

3.1.- Graptolites

The presence of graptolite bearing horizons proves the attribution of the dark mudstones to the «assise de Huy», the oldest formation of the Bande de Sambre-et-Meuse. Graptolite horizons are very common in the Wépion borehole. More continuous graptolite occurrences may also be found at Huy and Sart-Bernard, but the poor quality of the outcrops does not allow a complete documentation.

All faunas from the three localities are virtually identical in age. Differences in faunal lists may be due to limited outcrops and poor preservation. Furthermore, the strata yielded few graptolites compared with graptolitic shales of other areas.

In all the investigated localities the fauna includes a great proportion of pendent didymograptids. Pendent didymograptids are indicators for the Llanvirn. They first occur above the Arenig-Llanvirn boundary (Fortey & Owens, 1987) and die out prior to the base of the Llandeilo. The best indication of the age of the fauna is given by the occurrence of *Holmograptus callotheca* and *Aulograptus cucullus*. Both species are well known from Scandinavia, where they are restricted to the uppermost Arenig and the lower part of the Llanvirn (Ekström, 1937; Berry, 1964; Skevington, 1965). The biserials indicate an early Llanvirn age, as species such as *Pseudamplexograptus confertus*, *Diplograptus? decoratus* and the glyptograptids of the *G. brevis* and *G. euglyphus* groups are not present in the upper Arenig. The discovery of specimens which can be attributed to *Undulograptus camptochilus* is interesting. This species was formerly known only from the *Didymograptus hirundo* Zone of the Holen Limestone of Öland, Sweden. The presence of *Cryptograptus antennarius* at Sart-Bernard is another indication for the lower Llanvirn. The species appears first in the upper Arenig and is replaced by *Cryptograptus schäferi* in the upper Llanvirn (Fortey, Beckly & Rushton, 1990).

3.2.- Acritarchs

Acritarchs have often been used to date outcrops devoid of other fossils, but their exact stratigraphic ranges are not always known. Confusion between lithostratigraphy and biostratigraphy has commonly introduced errors in the dating of palynological samples. Well documented taxonomic studies of precisely dated levels of Llanvirn and especially Llandeilo age are rare.

Palynological investigations in the Huy formation started with the studies by Martin (1966, 1969). Martin (1966) attributed the three samples of the western section at Sart-Bernard to the «assise de Huy» of upper Arenig («*D. bifidus*») age and subdivided the eastern section into the Arenig of «*D. bifidus*» age and the Llandeilo («assise de Sart-Bernard») providing the samples 73,134 and 73,250. It is not clear from Martin's (1966) discussion that she attributed the two *bifidus* Zone samples from the eastern section at Sart-Bernard (73,038 and 73,080) to the «assise de Huy».

In 1969, she placed (p. 32-33) the same samples differently. The three samples from the western section were attributed to the upper Arenig («*D. hirundo*» and not «*D. bifidus*») Huy formation, and the four samples from the eastern section to the Llanvirn («*D. bifidus*») Sart-Bernard formation, following Bulman (1950).

The attributions of these and of all other samples to the Huy and Sart-Bernard formations in Martin (1966, 1969) are not clear or cannot be proven.

In the present work, 11 palynological samples from the different outcrops and from the borehole have been analysed. The age of most of our samples is exactly known; some of them were collected between graptolite levels indicating an early Llanvirn age. They all contain acritarchs in variable amounts, but also chitinozoa and graptolite fragments. The preservation of the material is moderate to poor. All our samples were subjected to standard palynological techniques including oxidation with Schulze solution, and were sieved at 12 µm.

The acritarch assemblage of the Huy formation is very rich. In this work only preliminary results of our studies are given. The assemblage is typical of the Mediterranean palaeoplankton province (Vavrdo-va, 1974), which has been described principally from other areas (e.g. Bohemia, North Africa, France etc.).

Martin (1966, 1969) investigated a part of the assemblage and described some new taxa. Some of these have to be reviewed because the taxonomy of Ordovician acritarchs fairly advanced since that time. At the present time, part of the material is indeterminable at the specific level, due to taxonomic problems in the literature.

At least 10 species of *Michrystidium* and several species of the genera *Acanthodiacrodium*, *Baltisphaeridium*, *Goniosphaeridium*, *Leiofusa*, *Leiosphaeridia* and *Multiplacisphaeridium* are present. Their determination at the specific level is difficult. Other genera more typical for the Ordovician, such as *Arkonina*, *Coryphidium*, *Stellechinatum* and *Striatotheca* are also well represented.

The genus *Veryhachium* is represented by trispinose and rectangular forms of different sizes. The trispinose specimens have either a smooth or a granulate vesicle wall (e.g. «*Veryhachium piliferum*» Martin 1966, p. 10). The latter may be included in a separate genus.

Other specimens have a smooth central body, but ornamented appendices, like ?*Veryhachium* sp. 1 (Pl. III, fig. 11). Rectangular forms of different size-ranges may be attributed to *Veryhachium minutum* Downie 1958 (Pl. III, fig. 8) and to the informal *Veryhachium lairdii-valiente* group.

Spinose specimens of ?*Veryhachium* are attributed here to ?*Veryhachium fakirum* Martin 1969 (Pl. III, fig. 9). Specimens very similar to ?*Veryhachium horridum* Paris & Deunff 1970 are also present.

Different species of *Stellechinatum* are found. *S. celestum* (Martin) Turner 1984 (Pl. III, fig. 7) is considered to appear in Great Britain above the Arenig-Llanvirn boundary (Molyneux 1990).

In our assemblage the genus *Arkonia* includes different species. *A. tenuata* Burmann 1970 and *A. virgata* Burmann 1970 (Pl. III, fig. 12) are indicators for Llanvirn or younger strata. *A. triangulata* (Cramer *et al.*) Vavrdova 1978 and ?*A. scabrata* (Cramer 1964) are also found in the Huy formation.

The genus *Frankea* seems to be represented by one species only: *F. sartbernardensis* (Martin) Colbath 1986 (Pl. III, fig. 5). All specimens of the Huy formation and of the type locality at Sart-Bernard have a striate vesicle wall. The genus appears in the upper Arenig and is common in the Llanvirn (Servais, 1992).

Further species present in the Huy formation are *Marrocanium simplex* Cramer *et al.* 1974 (Pl. III, fig. 6) and *Aureotesta clathrata* Vavrdova 1972. Both were first described from levels of probable Arenig age, but they are also present in the Llanvirn.

Other readily determinable species found in our assemblage are *Baltisphaera ternata* Burmann 1970 (Pl. III, fig. 4) and *Dicrodiacrodium normale* Burmann 1970.

Specimens of the genus *Pireia* are found and they may be referred to *Pireia dubia* Vavrdova 1972, *Pireia lagenaria* (Burmann) Eisenack *et al.*, 1976 and *Pireia ornata* (Burmann) Eisenack *et al.*, 1976 (Pl. III, fig. 10).

Comparison with other assemblages

The material of the Huy formation is typical of the Ordovician palaeogeographic temperate to cold Mediterranean province. Data from precisely dated levels of Llanvirn age are poor. The

stratigraphical coverage is at the present time insufficient for a standard biozonation for the Llanvirn.

Parts of the acritarch assemblage of the Rigenée formation in the Belgian Brabant Massif (Servais, 1991) are very similar to the material from the Huy formation.

The acritarch content of the samples of the Huy formation shows greatest similarities to the material described by Vavrdova (e.g. 1977) from the Sarka formation in Bohemia, which is generally attributed to the Llanvirn, and to the assemblages assigned to the upper Llanvirn described from Eastern Germany (e.g. Burmann 1970). Some other similar assemblages attributed to the Llanvirn are described from France (Paris & Deunff, 1970; Rauscher, 1974) and from England and Wales, where Booth (1979), Lister & Holliday (1970) and Lister *in* Arthurton & Wadge (1981) recorded acritarchs from different localities of possible early Llanvirn age.

3.3.- Other fossils

Trilobites

A few trilobites were found at Sart-Bernard and in the Wépion borehole. They are poorly and incompletely preserved. The most common species is *Pricyclopyge binodosa* ssp. (Pl. II, fig. 2, 4 and 5), represented by several pygidia and thoracic segments. No cephalon was, however, discovered and determinations remain tentative. The hollow nodes on the third axial ring of the thorax, characteristic for all *Pricyclopyginae* (Fortey & Owens, 1987) are well preserved in some specimens. *P. binodosa* is well known from the upper Arenig and the Llanvirn. Several biostratigraphically important subspecies can be distinguished.

One cranium with attached parts of the first two thoracic segments of a *Cyclopyge* species are present in the collection from Sart-Bernard (Pl. II, fig. 9).

A very poor, complete specimen of *Placoparia* sp. (Pl. II, fig. 7) was found at Sart-Bernard. Unfortunately the specimen is weathered and many details are no longer visible. No details of the cephalon are visible except for the general outline. The thorax includes about 11 segments. The axis is more or less parallel sided in the frontal part, but tapers slightly distally. The pygidium is triangulate, but the number of segments cannot be discerned due to the poor preservation. The axis terminates shortly before the end of the pygidium. *Placoparia* is known from the Arenig to the Llandeilo (Fortey & Owens, 1987).

Tomaculum problematicum Groom
(Pl. II, fig. 12, 13)

Groom (1902, p. 127-128) called a trace fossil consisting of aggregates of «egg-like bodies» from the Tremadoc in Malvern, England, *Tomaculum problematicum*. This fossil, consisting of strings of fecal pellets, has been described from different parts of the Ordovician in Europe. It is similar to the «Oeufs d'origine indéterminée» mentioned by Barrande (1872) from Bohemia and the «Coproli-thes (?)» described by Thorol (1935) from the Ordovician of the Montagne Noire, Southern France. It has been described also by R. & E. Richter (1939, 1941) and cited from western France by Peneau (1941), from Thuringia by Volk (1941), from western Germany by Beyer (1941, 1943), from Spain by Radig (1964), from the Vosges Mountains by Ross (1964) and from the Ordovician of Rügen (northern Germany) by Jaeger (1967). *Tomaculum problematicum* has not been recorded from the Bande de Sambre-et-Meuse until now, but Boscheinen (1983) observed the trace fossil sporadically in the Salm of the eastern part of the Stavelot-Venn Massif.

The occurrence of *Tomaculum problematicum* in the Huy formation at Sart-Bernard is especially interesting because these strings of fecal pellet material are very widespread in the Ordovician of the Ebbe-Anticline in the Rheinisches Schiefergebirge where they have a local stratigraphic importance (Beyer, 1941, 1943; Eiserhardt *et al.*, 1980). In this area, less than 200 km East of the Bande de Sambre-et-Meuse, *Tomaculum problematicum* is typical of the Llanvirn «Unterer Tonschieferhorizont».

4.- DISCUSSION

The Huy formation is the lowest unit of four formations built up by a series of grey to black mudstones and siltstones. Graptolites and acritarchs show that the beds are of early Llanvirn, *Didymograptus artus* Biozone age. The quality of the outcrops at Huy and Sart-Bernard is poor and the geological setting is problematical. In the field, the base and the top of the formation cannot be observed.

The base of the formation may be present in the Wépion borehole, where the Wépion formation of Tremadoc age underlies the graptolitic shale of the Huy formation.

The top of the formation is not known. Dean (1991) observed an unnamed formation, which lithologically resembles the Huy formation, in the Oxhe inlier (Petit Fond d'Oxhe), to the East of Huy (fig. 1). He attributed a Llandeilo age to this formation, which is possibly identical to the Huy formation or a younger part of it. In this area of the Bande de Sambre-et-Meuse, the overlying unit is

the Caradocian Oxhe formation, but parts of the sequence are missing (Dean, 1991).

At Sart-Bernard, the Sart-Bernard formation overlies the Huy formation, and in the eastern part of the Bande de Sambre-et-Meuse, outcrops which lithologically resemble the Huy formation are overlain by the Vitruval-Bruyère formation (Michot, 1934).

Because of the scarcity of outcrops and the complicated tectonic structure, only detailed lithostratigraphical and structural tectonic studies of the complete Bande de Sambre-et-Meuse will lead to an improved understanding of the stratigraphy of this area.

Correlation of the Huy formation.

The formational names have been used inconsistently in the Belgian Brabant Massif. In its eastern part the Rigenée formation has been described. This formation, lithologically similar to the Huy formation, yields no graptolites, but the poorly preserved acritarchs indicate a late Arenig/Llanvirn and/or Llandeilo age (Servais, 1991). In the western part of the Brabant Massif, in the Sennette valley, the La Tourette formation (André *et al.*, 1991, fig. 14), also called unit D by Martin & Rickards (1979), and possibly the equivalent of the Rigenée formation (André *et al.*, 1991, fig. 17), resembles the Huy formation. It yields graptolites of Llanvirn age. The Huy formation can probably be correlated with parts of the Rigenée formation and of the La Tourette formation in the Sennette valley because of the lithological and biostratigraphical similarities.

The Ordovician of the Ebbe-Anticline in the Rheinisches Schiefergebirge (Germany) is subdivided into four lithological units (e.g. Eiserhardt *et al.*, 1980). All the units comprise dark shales and siltstones. Only the age of parts of the two lowermost formations is known because they have both yielded Llanvirn graptolites (Beyer, 1941; Jentsch & Stein, 1961). Future studies may help to correlate exactly these lithological units with parts of the Ordovician of the Bande de Sambre-et-Meuse in Belgium.

5.- PALAEOONTOLOGICAL NOTES ON GRAPTOLITES

Tetragraptus headi (J. Hall)

Pl. I, fig. 13

Material: Sart-Bernard 72250: 1 specimen.

Remarks: One single specimen was found at Sart-Bernard, but stipe fragments supposedly belonging to this species are common. The species is

clearly defined by its size and characterized by the well developed proximal membrane. The species was first described by J. Hall (1865) from the Lévis shale at Point Lévis, Quebec. The species is common in the *P. confertus* Zone at the Côte Fréchette section (Maletz, 1992).

Aulograptus cucullus (Bulman)

Pl. I, fig. 22, 23; Pl. II, fig. 3

Material: Huy: 10 specimens; Wépion borehole: 1 specimen in relief at 243,60 m.

Description: The sicula is long and slender, measuring 2.2-2.3 mm. The origin of th 1¹ is about 1.7-1.8 mm below the apex of the sicula. The proximal development is isograptid, dextral. The thecae are climacograptid with deep apertural excavations. The stipes are slender, widening slightly to distal values of 0.6-0.7 mm. There are about 5.5-6.0 thecae in the first 5 mm, giving a thecal spacing of 11-12 thecae in 10 mm.

Occurrence: The biostratigraphic range of *A. cucullus* is known to be from the upper part of the *Didymograptus hirundo* Zone in Scandinavia (Skevington, 1965) to the early Llanvirn *Didymograptus artus* and lower part of *D. murchisoni* Zones (Ekström, 1937; Berry, 1964). The species is widely known around the Gondwana margin. It occurs in Britain (Rushton & Molyneux, 1989), Bohemia (Boucek, 1973), South America (Bulman, 1931), Spain (Gutierrez Marco, 1986) and Southwest China (Mu *et al.*, 1979). One specimen of *Aulograptus cf. cucullus* was figured by Lenz & Jackson (1986) from the *Paraglossograptus tentaculatus* Zone of the Canadian Cordillera.

Janograptus sp. cf. J. petilus Berry

Pl. I, fig. 14.

Material: Huy: 1 flattened specimen.

Description: Slender rhabdosome measuring 0.2-0.25 mm across the thecal apertures. The thecal inclination is about 10-12°. The thecal apertures are simple. There are 10 thecae in 10 mm. The stipes are long and flexuous building up a subhorizontal rhabdosome.

Remarks: The specimen is poorly preserved and shows no details. No trace of a sicula is seen, however, indicating that it must belong to *Janograptus*. The type material of *J. petilus* Berry comes from the *Didymograptus murchisoni* Zone

of Norway (Berry, 1964) and is known from few specimens. *Janograptus* occurs from the middle Arenig to the Llanvirn, but is a rare genus. The genus cannot be taken as a time indicator.

dichograptid stipe fragments

Slender stipe fragments are very common at many levels in the Wépion borehole and are also found in all outcrops. Unfortunately, no proximal parts have been found. Therefore, a specific determination is not possible and the fragments are here assembled as dichograptid fragments. Some belong to specimens of *Acrograptus acutidens*. Wider stipe fragments may partly belong to the pendent didymograptids and to *Tetragraptus headi*. Other fragments show an undulating dorsal line of the stipe (Pl. I, fig. 12) and may belong to yet undescribed sinograptines. No proximal parts have been found associated with these fragments.

Holmograptus callothea (Bulman)

Pl. I, fig. 7-10; Pl. II, fig. 11

Material: 1 specimen, Maillieux (1939, pl. 1, fig. 7), Sart-Bernard; 1 specimen, Sart-Bernard 72250; several specimens from the Wépion borehole.

Description: The sicula is typically parallel-sided, about 0.7-0.9 mm long and bears two conspicuous elaborations on the dorsal and ventral side of the aperture. A short nema is sometimes present. As all specimens are flattened, the proximal development and other internal structures of the thecae are not clearly visible. There is a conspicuous dorsal fold at the place of every thecal origin. The stipes are subhorizontal to declined. They have a width of 0.3-0.4 mm initially and slowly widen to about 1.0-1.1 mm at a distance of 3 cm from the sicula in the longest specimen. There is no increase of thecal overlap as was described for *Holmograptus lentus* (Skevington, 1965). *H. callothea* is known from proximal parts only (Bulman, 1936). Distal stipe development is not clear from the types, therefore.

Remarks: The identity of *Holmograptus callothea* with *H. lentus* (Skevington, 1965, p. 41) is not proven and therefore an age relation based on this species may be somewhat tentative at the moment. *Holmograptus* species without dorsal spines on the prothecal folds and without distally increasing thecal overlap are present in the Darrwillian 2 of Australia (Maletz, unpublished) in

the *Pseudamplexograptus confertus* Zone of Quebec (Maletz, 1992) and in the *P. confertus* Zone of China (Mu, 1957, *Tylograptus geniculiformis*, *T. regularis*). Spined species are common in younger strata. They have been found in the Darriwillian 3 of Australia (*Didymograptus nodosus* Harris, 1924), or the upper part of the *Glyptograptus dentatus* Zone (Ruedemann, 1947, Mount Merino, New York = ?*D. ? decoratus* Zone).

Glyptograptus sp. (*G. brevis* Elles & Wood group)
Pl. I, fig. 5

Material: Huy: 1 specimen.

Description: Slender biserial nearly parallel sided rhabdosome reaching a width of 1.2 mm distally. The width at the aperture of th¹¹ is about 0.9 mm. The proximal part bears one spine, the virgella. It is broken and does not show the complete length. The first thecae grow strongly upwards as in *Glyptograptus brevis*.

The rhabdosome is flattened and shows no internal details. The thecae are glyptograptid with a rounded geniculum. The supragenicular walls are slightly outward inclined. The apertures are horizontal to slightly introverted. Their exact structure is not seen. There are 6 thecae in the first 5 mm.

Remarks: The species is known only from one flattened specimen. It cannot be related with certainty to other glyptograptids of this type, which usually appear somewhat later in the Llandeilo. It may be compared with *Undulograptus paradoxus* (Boucek) (= *Climacograptus pauperatus* Bulman), but differs in less geniculated thecae with more strongly outward inclined supragenicular walls. The specimen differs from *Glyptograptus shellvensis* Bulman in being more slender. It also shows no subapertural spines on the first two thecae.

Glyptograptus sp. (*G. euglyphus* Lapworth group)
Pl. I, fig. 17

Material: Huy: 1 flattened specimen.

Description: The specimen is flattened and shows only the rhabdosome outline. It is slender with long (6.5 mm) virgella and nema (20 mm). The rhabdosome widens from 0.9 mm initially to 1.5-1.6 mm distally. The first thecae are poorly preserved and the presence of apertural spines on the first thecal pairs cannot be excluded. The thecae are glyptograptid with strongly outward

inclined supragenicular portions. The apertures seem to possess low lateral lappets. The nema is prominent through the whole rhabdosome, reaching a width of 0.18 mm. It is slightly tapering distally and bears in its distal portion small bulbous extensions.

Remarks: The specimen resembles *Glyptograptus euglyphus* in the rhabdosome outline. A safe identification is not possible, as the proximal part is poorly preserved. The thecae are more densely spaced than the types of Elles & Wood, having 13 thecae/10 mm proximally and 12 thecae/10 mm distally compared with 9-10 thecae/10 mm proximally and 8-9 thecae/10 mm distally.

Glyptograptus sp.

Pl. I, fig. 6, 20

Material: Sart-Bernard 72250, 72270.

Description: Slender biserial rhabdosome with glyptograptid thecae. The specimens are flattened and do not show many details. It widens from initially 0.7 mm to 1.5 mm distally. The virgella is about 3.5 mm long in the longer specimen. No thecal spines are visible at the first thecal pair. The first thecae grow outward upward with the aperture slightly introverted. The thecae are glyptograptid with outward inclined supragenicular walls. The form of the thecal apertures is not seen. There are 7-7.5 thecae in the first 5 mm. The rhabdosome length reaches 15 mm.

Remarks: Due to the poor preservation a specific determination is not possible. The specimens occur together with uniserial (dichograptid) stipe fragments of unknown affinities. They may be related to *Undulograptus camptochilus* from the Wépion borehole, due to the rhabdosome form and the failure of developing apertural spines on the first thecal pair, but are much more slender.

Undulograptus camptochilus (Skevington)

Pl. I, fig. 2, 15, 19 ?; Pl. II, fig. 8; Pl. III, fig. 1,3

Material: Wépion, 193,30 m, one specimen in partial relief; one questionable flattened specimen at 443,37 m; Huy, one poorly preserved, flattened specimen.

Description: The description is based on the relief specimen. The specimen is 32 mm long without virgella and nema. The nema alone measures at

least 22 mm. Indications of a float-structure are present, but poorly preserved at its distal end. The virgella is at least 3 mm long, but incomplete.

The rhabdosome is 0.9 mm wide at the first thecal pair and slowly widens to a final width of 2.0 mm in the first 8 mm. There are 7 thecae in the first 5 mm. Distally 5 thecae can be measured in 5 mm.

The proximal 6-7 thecal pairs are more or less pseudoclimacograptid. Their style changes slowly to a glyptograptid type with nearly horizontal supragenicular walls. The apertures are straight, slightly to strongly introverted, depending on the position on the rhabdosome. Distal thecae seem to have more strongly introverted thecal apertures. A geniculation may be present at the first thecal pair, but is inconspicuous. The proximal development is not clearly seen as the proximal part shows only low relief and parts are obscured. The median septum seems to be complete. It forms a zig-zag line. The thecae are strongly undulating, with a long and slender prothecal part and high overlap. The proximal development type is not clearly seen, but may belong to the type C of Mitchell (1987). This type is clearly seen in another similar specimen preserved in reverse view, differing in more glyptograptid thecae and more slender form of the rhabdosome. Also the thecae are somewhat shorter and less undulating proximally.

Discussion: The proximal part shows no difference to *U. camptochilus* Skevington. Distally the thecae have a quite different aspect, and no longer resemble the climacograptid type. This change is not seen in any isolated specimens from the Hølen Limestone of Öland, figured by Skevington (1965) and Mitchell (in press), showing only 6-7 thecal pairs. It is suggested here, that *U. camptochilus* always shows this thecal change in longer rhabdosomes, and that the Scandinavian material, as well as the Belgian specimens, belongs to one single species.

The specimen from Huy is somewhat wider in the distal part, reaching 2.5 mm in width. In all other characters it is similar to the specimens from the Wépion borehole and is included in this form. The differences in width may be caused by tectonic stretching.

The material is similar also to *Pseudoclimacograptus cumbrensis* Bulman. Differences can be seen in the more strongly upward growing first thecal pair and less closely spaced thecae, being glyptograptid instead of pseudoclimacograptid. There is no apertural spine on the 1st in *U. camptochilus*.

Distribution: The species is known from the Hølen limestone of Öland, where it is found in the upper part of the *Didymograptus hirundo* Zone. Possibly many specimens of this form have formerly been

attributed to *Glyptograptus teretiusculus*, a species typical of younger strata. In Belgium, it occurs in the *Didymograptus artus* Biozone in the lower Llanvirn.

Undulograptus sp. 1

Pl. I, fig. 3, 4; Pl. III, fig. 2

Material: 2 specimens from the Wépion borehole, one is flattened, the other preserved in relief.

Description: The most complete rhabdosome is 12 mm long. It is preserved in full relief. A short virgella is indicated. The rhabdosome widens from 0.9 mm proximally to 1.75 mm distally. There are 5.5 thecae in 5 mm distally, but 6.5 thecae in the first 5 mm. The thecae show an extreme form of the double sigmoidal curvature characteristic of members of the *Undulograptus austrodentatus* group (Mitchell, in press). The geniculum is clearly developed, but is rounded. The excavations at the thecal apertures are deep and inclined toward the rhabdosome mid-line. The thecal apertures are simple. The proximal development is seen in reverse view. It belongs to the pattern C of Mitchell (1987). The median septum is complete. It is strongly zig-zag-shaped through the whole rhabdosome. The first two thecae show a strong upward growth component in their distal parts. No indication of apertural spines is present.

Discussion: The specimens are similar to *U. formosus* in their proximal structure, but differ strongly in thecal characters. The thecae are more strongly geniculate and the median septum is zig-zag-shaped in contrast to the slightly undulate median septum in *U. formosus*. Similar rhabdosome form is found in specimens described as *Climacograptus scharenbergi* from the Upper *Didymograptus* Shale of Norway by Bulman (1953) and referred to *Pseudoclimacograptus oliveri* by Bouček (1973). These specimens differ, however, in possessing more complexly curved thecae and a wider rhabdosome distally.

Diplograptus ? decoratus (Harris & Thomas)

Pl. I, fig. 16

Material: 1 complete, flattened specimen figured by Maillieux (1939); 1 distal rhabdosome fragment, Sart-Bernard 72270.

Remarks: The single specimen preserved in the Natural Museum of Belgium at Brussels shows climacograptid proximal thecae and glyptograptid distal thecae. In its dimensions it does not differ

from the type material of *P. ?decoratus* as redescribed by Hughes (1989). The typical heart-shaped vesicle is not present, however. The types of *D. ?decoratus* are from the higher part of the Darriwillian (Da 2-3) and the occurrence of the species in the Lower Llanvirn of Belgium may indicate a correlation of this interval with the Darriwillian of Australia. The specimen is the only indication for the possible presence of higher parts of the Llanvirn in Belgium. The stratigraphic range of *decoratus*-type diplograptids, however, needs to be studied in more detail. The earliest form of this group, *Diplograptus ellesi* Bulman is known from the *D. bifidus* zone of Ellergill (Bulman, 1963).

ACKNOWLEDGEMENTS

The authors are grateful to Dr. S.G. Molyneux and Dr. A.W.A Rushton (British Geological Survey) for reviewing the manuscript. Prof. M. Vanguetaine (Université de Liège) gave much appreciated informations and provided the palynological samples of the Wépion borehole.

Thanks are due to Dr. A. Dhondt (Institut Royal des Sciences Naturelles) and to Prof. J. Bouckaert (Geological Survey of Belgium) for supplying us the samples of the collection of Maillieux and of the Wépion borehole.

A part of the financial support was provided by the NATO Collaborative Research Grant Programme («Ordovician acritarch/graptolite stratigraphy and correlation between Belgium and Germany», Grant n° SA. 5 - 2 -05 between the TU Berlin, Prof. B. D. Erdtmann and the University of Liège, Prof. M. Vanguetaine).

BIBLIOGRAPHIE

ANDRE, L., HERBOSCH, A., LOUWYE, S., SERVAIS, T., VAN GROOTEL, G., VANGUESTAINE, M. & VERNIERS, J., 1991.- Guidebook to the excursion on the stratigraphy and magmatic rocks of the Brabant Massif, Belgium. In: L. André, A. Herbosch, M. Vanguetaine & J. Verniers (eds.), Proceedings of the International Meeting on the Caledonides of the Midlands and the Brabant Massif, Brussels 20 to 23 septembre 1989. *Ann. Soc. géol. Belg.*, 114 (2): 283-323.

ARTHURTON, R.S. & WADGE, A.J., 1981.- Geology of the country around Penrith. Memoir of the Geological Survey of Great Britain, Sheet 24 (England and Wales).

BARRANDE, J., 1872.- Système silurien du centre de la Bohême. I. Partie: Recherches paléontologiques. Supplément au vol. I. Trilobites, Crustacés divers et Poissons. Prague - Paris.

BERRY, W.B.N., 1964.- Graptolites of the *Ogygiocaris* Series. *Norsk Geologisk Tidsskrift*, 44: 61-170.

BEYER, K., 1941.- Zur Kenntnis des Silurs im Rheinischen Schiefergebirge I. Das Auftreten von *Tomaculum problematicum* Groom im Ebbe-Sattel und die Bedeutung der Kotpillen-Schnur für die Gliederung des sauerländischen Ordoviciums. *Jb. Reichsstelle f. Bodenforschung* 1940, 61: 198-221.

BEYER, K., 1943.- Neue Fundpunkte von *Tomaculum problematicum* Groom im Ordoviciem des Sauerlandes. *Ibid.* 1942, 63: 124-133.

BOOTH, G.A., 1979.- Lower Ordovician acritarchs from successions in England and North Wales. Unpublished Ph. D. thesis, University of Sheffield.

BOSCHENIN, J., 1983.- Neue Beobachtungen im Ordovizium des nordöstlichen Vennsattels. *Aufschluss*, 34: 181-188.

BOUCEK, B., 1973.- Lower Ordovician graptolites of Bohemia. Publishing House of the Czechoslovak Academy of Sciences, Prague.

BULMAN, O.M.B., 1931.- South American Graptolites with special reference to the Nordenskjöld collection. *Arkiv för Zoologi*, 22A(3): 1-11.

BULMAN, O.M.B., 1936.- On the graptolites prepared by Holm. Part 7. *Arkiv för Zoologi*, 28: 1-107.

BULMAN, O.M.B., 1950.- On some Ordovician graptolite assemblages of Belgium. *Bull. Inst. Roy. des Sc. nat. de Belg.*, 26(5): 1-8.

BULMAN, O.M.B., 1953.- Some graptolites from the *Ogygiocaris* Series (4a) of the Oslo district. *Arkiv för Mineralogi och Geologi*, 1(17): 509-518.

BULMAN, O.M.B., 1963.- On *Glyptograptus dentatus* (Brongniart) and some allied species. *Palaeontology*, 6: 665-689.

BURMANN, G., 1970.- Weitere organische Mikrofossilien aus dem unteren Ordovizium. *Paläontologische Abhandlungen, Abt. B.*, 3: 289-332.

COLBATH, K., 1986.- The lower Paleozoic organic-walled phytoplankton («acritarch») genus *Frankea* Burmann 1970. *Micropaleontology*, 32: 72-73.

CRAMER, F.H., 1964.- Microplankton from three Palaeozoic formations in the Province of Léon, NW Spain. *Leidse Geologische Mededelingen*, 30: 253-361.

CRAMER, F.H., KANES, W.H., DIEZ, M. del C.R. & CHRISTOPHER, R.A., 1974.- Early Ordovician acritarchs from the Tadla Basin of Morocco. *Palaeontographica Abt. B.* 146: 57-64.

DEAN, W.T., 1991.- Ordovician trilobites from the inlier at Le Petit Fond d'Oxhe, Belgium. *Bull. Inst. Roy. des Sc. nat. de Belg., Sc. de la Terre*, 61: 135-155.

DOWNIE, C., 1958.- An assemblage of microplankton from the Shineton Shales (Tremadocian). *Proceedings of the Yorkshire Geological Society*, 31: 331-349.

DUMONT, H.A., 1832.- Mémoire sur la constitution géologique de la province de Liège. *Mém. couronnés Acad. roy. Belg. in: 4°*, 8: 1-73.

EISENACK, A., CRAMER, F.H. & DIEZ, M. del C.R., 1976. Katalog der fossilen Dinoflagellaten, Hystriosphären und verwandten Mikrofossilien. *Acritarcha* 2. Band IV. Teil. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart: 1-863.

EISERHARDT, K.-H., HEYCKENDORFF, K. & THOMBANSEN, E., 1980. Zur Stratigraphie und Tektonik des nördlichen Ebbe-Teilsattels (Sauerland, Rheinisches Schiefergebirge). In: E.T. Degens, J. Timm & H.K. Wong (eds.), Rheinisches Schiefergebirge: Ebbe-Antiklinorium. Fazies, Stratigraphie, Tektonik. *Mitt. Geol.-Paläont. Inst. Univ. Hamburg*, 50: 199-238.

EKSTRÖM, G., 1937.- Upper *Didymograptus* Shale in Scania. *Sveriges Geologiska Undersökning, Serie C*, n° 403: 1-53.

FORTEY, R.A., BECKLY, A.J. & RUSHTON, A.W.A., 1990.- International correlation of the base of the Llanvirn Series Ordovician System. *Newsl. Stratigr.*, 22(2/3): 119-142.

FORTEY, R.A. & OWENS, R.M., 1987.- The Arenig Series in South Wales. *Bulletin of the British Museum of Natural History. Geology Series*, 41(3): 69-307.

FOURMARIER, P. & LESPINEUX, G., 1908.- Compte rendu de l'Excursion du 28 juin 1908 aux environs de Huy. *Ann. Soc. géol. Belg.*, 35: B 303.

GRAULICH, J.-M., 1961.- Le sondage de Wépion. *Mém. Expl. Cartes Géol. et Min. de la Belgique.*, 2: 1-102.

GROOM, T., 1902.- The sequence of the Cambrian and associated beds of the Malvern Hills. *Quart. J. Geol. Soc. London*, 58.

- GUTIERREZ-MARCO, J.C., 1986.- Graptolitos del Ordovico espanol. Thesis doctoral. Universidad complutense de Madrid: 1-701.
- HALL, J., 1865.- Graptolites of the Quebec Group. *Geological Survey of Canada*: 1-151.
- HARRIS, W.J., 1924.- Victorian graptolites (New Series), Part 1. *Proceedings of the Royal Society of Victoria*, 36 (New Series): 92-106.
- HUGHES, R.A., 1989.- Llandeilo and Caradoc graptolites of the Bultih and Shelve Inliers. *Palaeontographical Society Monograph*: 1-89.
- JAEGER, H., 1967.- Ordoviz auf Rügen. Datierung und Vergleich mit anderen Gebieten. (Vorläufige Mitteilung). *Ber. deutsch. Ges. geol. Wiss. A. Geol. Paläont.*, 12: 165-176.
- JENTSCH, S. & STEIN, V., 1961.- Neue Fossilfunde im Ordovizium des Ebbe-Sattels. *Paläont. Z.*, 35: 200-208.
- LECRENIER, A., 1887.- Communication *Ann. Soc. géol. Belg.*, 14: 182-183.
- LENZ, A.C. & JACKSON, D.E., 1986.- Arenig and Llanvirn graptolite biostratigraphy, Canadian Cordillera. In: C.P. Hughes & R.B. Rickards (eds.). *Palaeoecology and Biostratigraphy of graptolites*. Geological Society Special Publication: 27-45.
- LESPERANCE, P.J. & SHEEHAN, P.M., 1988.- Trilobites et Brachiopodes ashgilliens (Ordovicien supérieur) de l'«Assise» de Fosse, Bande Sambre-Meuse (Belgique). *Bull. Inst. Roy. des Sc. nat. de Belg., Sc. de la Terre*, 57: 91-123 (dated 1987).
- LISTER, T.R. & HOLLIDAY, D.W., 1970.- Phytoplankton (acritarchs) from a small Ordovician inlier in Teesdale (County Durham), England. *Proceedings of the Yorkshire Geological Society*, 37: 449-460.
- MAILLIEUX, E., 1913.- Quelques mots sur l'état actuel des connaissances relatives au terrain silurien de la Belgique. *Bull. Soc. belge Géol.*, 27: 76-83.
- MAILLIEUX, E., 1926.- Remarques sur l'Ordovicien de la Belgique. *Ibid.*, 36: 67-85.
- MAILLIEUX, E., 1938.- Observations nouvelles sur l'Ordovicien de la Belgique. *Ibid.*, 48: 22-23.
- MAILLIEUX, E., 1939.- L'Ordovicien de Sart-Bernard. *Mém. Musée Royal d'Hist. nat. Belg.*, 86: 1-59.
- MALAISE, C., 1873.- Description du terrain silurien du centre de la Belgique. *Acad. roy. de Belg. Mém. couronnés*, 37: 1-122.
- MALAISE, C., 1887.- Observations sur quelques Graptolithes de la bande silurienne de Sambre-et-Meuse. *Ann. Soc. géol. Belg.*, 14: 183-184.
- MALAISE, C., 1888a.- Les schistes siluriens de Huy et leur signification géologique. *Ibid.*, 15: 39-45.
- MALAISE, C., 1888b.- Découverte de la faune de la base du silurien en Belgique. *Bull. Ac. Roy. Sc. nat. 5ème série*, 15: 365-367.
- MALAISE, C., 1888c.- Sur les schistes noirs de Sart-Bernard. *Ann. Soc. géol. Belg.*, 15: 74-75.
- MALAISE, C., 1890.- Sur les graptolithes de Belgique. *Bull. Acad. roy. Belg., 3ème série*, 20: 440-452.
- MALAISE, C., 1900.- Etat actuel de nos connaissances sur le Silurien de la Belgique. *Ann. Soc. géol. Belg.*, 25 bis: 179-212.
- MALAISE, C., 1909a.- Modifications de l'échelle stratigraphique du Silurien de Belgique. *Bull. Soc. belge Géol.*, 23: 6-8.
- MALAISE, C., 1909b.- Echelle stratigraphique du Silurien de la Belgique et âge géologique des Schistes noirs de Mousty. *Ann. Soc. géol. Belg.*, 36: 31-39.
- MALAISE, C., 1910.- Sur l'évolution de l'échelle stratigraphique du Siluro-Cambrien de la Belgique. (in Texte explicatif de la planchette de Genappe). *Ibid.*, 38: 7-28.
- MALETZ, J., 1992.- Biostratigraphie und Paläogeographie von unterordovizischen Graptolithenfaunen des östlichen Kanadas und Skandinaviens. Unveröff. Doktorarbeit, Technische Universität Berlin. 1-253.
- MARTIN, F., 1966.- Les acritarches de Sart-Bernard (Ordovicien belge). *Bull. Soc. belge Géol.*, 74: 423-444 (dated 1965).
- MARTIN, F., 1969.- Les acritarches de L'Ordovicien et du Silurien belges. *Bull. Inst. Roy. des Sc. nat. de Belg., Mém.*, 10: 1-175 (dated 1968).
- MARTIN, F. & RICKARDS, B., 1979.- Acritarches, chitinozoaires et graptolithes Ordoviens et Siluriens de la vallée de la Sennette (Massif du Brabant, Belgique). *Ann. Soc. géol. Belg.*, 102: 189-197.
- MICHOT, P., 1928.- La Bande Silurienne de Sambre et Meuse entre Fosse et Bouffiuoux. *Ibid.*, 51: 57-103.
- MICHOT, P., 1932a.- La tectonique de la bande silurienne de Sambre-et-Meuse entre Dave et le Samson. *Ibid.*, 55: B 129-144.
- MICHOT, P., 1932b.- La tectonique de la bande silurienne de Sambre et Meuse entre Huy et Ombret. *Ibid.*, 55: M 73-94.
- MICHOT, P., 1934.- La stratigraphie du silurien de la Bande de Sambre-et-Meuse. *Acad. roy. de Belg. mém. cl. des Sc. in: 8° - 2ème série*, 13: 1-108.
- MICHOT, P., 1954.- Le Silurien in: Prodrôme d'une description géologique de la Belgique (dir. P. Fourmarier). *Ann. Soc. géol. Belg.*, Liège 1954: 39-82.
- MICHOT, P., 1980.- Le segment tectonique calédonien belge. *Acad. roy. de Belg. mém. cl. des Sc. in: 8° - 2ème série*, 43: 1-61.
- MITCHELL, C.E., 1987.- Evolution and phylogenetic classification of the Diplograptacea. *Palaeontology*, 30(2): 353-405.
- MITCHELL, C.E. (in press). Evolution of the Diplograptacea and the international correlation of the Arenig-Llanvirn boundary. *Proc. 6th Int. Symp. on the Ordovician System*.
- MOURLON, M., 1876.- Sur l'étage dévonien des psammites du Condrez dans la vallée de la Meuse. *Bull. Acad. roy. Belg.*, (2), 42: 855.
- MOLYNEUX, S.G., 1990.- Advances and problems in Ordovician palynology of England and Wales. *Journal of the Geol. Soc. London*, 147: 615-618.
- MU, A.T., 1957.- Some new or little known graptolites from the Ningkuo Shale (Lower Ordovician) of Changshan, Western Chekiang. *Acta Palaeontologica Sinica*, 5(3): 369-438.
- MU, E.Z., GE, M.Y., CHEN, X., NI, Y.N. & LIN, Y.K., 1979.- Lower Ordovician graptolites of Southwest China. *Palaeontologia Sinica* (new Ser. B, 13), 156: 1-192.
- PARIS, F. & DEUNFF, J., 1970.- Le Paléoplancton Llanvirnien de La Roche-au-Merle. *Bull. Soc. géol. minéral Bratagne*, (C), 11, 1: 25-43.
- PENEAU, J., 1941.- Die Anwesenheit von *Tomaculum problematicum* im Ordovicien West-Frankreichs. *Senckenbergiana*, 23: 127-132.
- RADIG, F., 1964.- Die Lebensspur *Tomaculum problematicum* Groom 1902 im Llandeilo der Iberischen Halbinsel. *N. Jb. Geol. Pal. Abh.* 119: 12-18.
- RAUSCHER, R., 1974.- Les Acritarches de l'Ordovicien en France. *Review of Palaeobotany and Palynology*, 18: 83-98.
- RICHTER, R. & RICHTER, E., 1939.- Die Kot-Schnur *Tomaculum Groom* (= *Syncoprulus* R. & E. Richter), ähnliche Scheitel-Platten und beider stratigraphische Bedeutung. *Senckenbergiana*, 21: 278-291.
- RICHTER, R. & RICHTER, E., 1941.- Das stratigraphische Verhalten von *Tomaculum* als Beispiel für die Bedeutung von Lebensspuren. *Senckenbergiana*, 23: 133-135.
- ROBASZYNSKI, F. & DUPUIS, C., 1983.- Guides géologiques régionaux. Belgique. Masson, Paris.
- ROSS, H.P., 1964.- Fossilpunkte in den Steiger und Weiler Schiefer (Vogesen). *Nachr. Akad. Wiss. Göttingen II. Math. - phys. Kl.*, 3: 37-43.
- RUDEMANN, R., 1947.- Graptolites of North America. *Geological Society of America, Memoir*, 19: 1-652.
- RUSHTON, A.W.A. & MOLYNEUX, S.G., 1989.- The biostratigraphic age of the Ordovician Skiddaw Group in the Black Combe Inlier, English Lake District. *Proceedings of the Yorkshire Geological Society*, 47: 267-276.

- SERVAIS, T., 1991.- Contribution to the stratigraphy of the Ordovician Rigenée formation (Brabant Massif, Belgium) with a preliminary study on acritarchs. *In*: L. André, A. Herbosch, M. Vanguetaine & J. Verniers (eds.). Proceedings of the International Meeting on the Caledonides of the Midlands and the Brabant Massif. *Ann. Soc. géol. Belg.*, 114(1): 233-245.
- SERVAIS, T., 1992.- The Ordovician acritarch genus *Frankea* Burmann 1970. Proc. Int. Symp. on Acritarchs and Chitinozoa, Keyworth-Nottingham 1991. *Special Papers in Palaeontology (in preparation)*.
- SHEEHAN, P.M., 1988.- Late Ordovician (Ashgillian) Brachiopods from the region of the Sambre and Meuse Rivers, Belgium. *Bull. Inst. Roy. des Sc. nat. de Belg., Sc. de la Terre*, 57: 5-81 (dated 1987).
- SKEVINGTON, D., 1965.- Graptolites from the Ontikan limestones (Ordovician) of Oland, Sweden. 2. Graptoloidea and Gratovermida. *Bull. Geol. Inst. of the University of Uppsala*, 43: 1-74.
- THORAL, M., 1935.- Contribution à l'étude paléontologique de l'Ordovicien inférieur de la Montagne Noire. Imp. d. I. Charité. Montpellier 1935, 1-362.
- TURNER, R.E., 1984.- Acritarchs from the type area of the Ordovician Caradoc Series, Shropshire, England. *Palaeontographica Abt. B.*, 190: 87-157.
- VAVRDOVA, M., 1972.- Acritarchs from Klabava Shales (Arenig). *Vestník Ustredniho Ustavu Geologickeho*, 47: 79-86.
- VAVRDOVA, M., 1974.- Geographical differentiation of Ordovician acritarch assemblages in Europe. *Review of Palaeobotany and Palynology*, 18: 171-175.
- VAVRDOVA, M., 1977.- Acritarchs from the Sarka Formation (Llanvirnian). *Vestník Ustavu Geologickeho*, 52: 109-118.
- VAVRDOVA, M., 1978.- Nethromorphitae and some other acritarchs from the Bohemian Lower Ordovician. *In*: V. Pokorný (ed.). *Paleontologická Konference Katedry Paleontologie na Přírodovědecké Fakultě Univerzity Karlovy, Praha*: 61-74.
- VOLK, M., 1941.- Die Lebensspur *Tomaculum problematicum* Groom auch im Griffelschiefer des Thüringer Ordoviciums. *Senckenbergiana*, 23.

PLATE I

1. *Glyptograptid* indet, Wépion, 178,78 m; IRScNB A3364.
2. *Undulograptus camptochilus* (Skevington), Wépion, 443,37 m; IRScNB A3365
reverse view of specimen, showing proximal structure.
- 3,4. *Undulograptus* sp. 1, Wépion, 204,55 m; IRScNB A3366,
relief specimen, drawing based on both counterparts.
5. *Glyptograptus* sp. (*G. brevis* group), Huy; IRScNB A3367, flattened.
6. *Glyptograptus* sp., Sart-Bernard 72250; IRScNB A3368
7. *Holmograptus callothea* Bulman, Wépion, 162,21 m; IRScNB A3369,
the left stipe may be based on two superimposed fragments.
8. *Holmograptus callothea* Bulman, Wépion, 162,21 m; IRScNB A3370.
9. *Holmograptus callothea* Bulman, Sart-Bernard, Maillieux, 1939, pl. 1, fig. 7;
IRScNB A1615.
10. *Holmograptus callothea* Bulman, Sart-Bernard, 72250; IRScNB A3371.
11. *Acrograptus acutidens* (Elles & Wood), Sart-Bernard 72250; IRScNB A3372.
12. sinograptid fragment, Wépion, 162,21 m; IRScNB A3373.
13. *Tetragraptus headi* (Hall), Sart-Bernard 72250; IRScNB A3374.
14. *Janograptus* sp. cf. *J. petilus* Berry, Huy; IRScNB A3375.
15. *Undulograptus camptochilus* (Skevington), Wépion, 193,30 m; IRScNB A3376,
relief specimen.
16. *Diplograptus? decoratus* (Harris & Thomas), Sart-Bernard, Maillieux, 1939, pl. 1,
fig. 4; IRScNB A1619.
17. *Glyptograptus* sp. (*G. euglyphus* group), Huy; IRScNB A3377.
18. *Pseudamplexograptus confertus* (Lapworth), Wépion, 162,21 m; IRScNB A3378,
juvenile.
19. ?*Undulograptus camptochilus* (Skevington), Huy; IRScNB A3379.
20. *Glyptograptus* sp., Sart-Bernard 72270; IRScNB A3380.
21. *Didymograptus* sp. cf. *D. hirundo* (Salter), Wépion, 221,35 m; IRScNB A3381.
22. *Aulograptus cucullus* (Bulman), Wépion, 243,60 m; IRScNB A3382,
relief specimen in reverse view.
23. *Aulograptus cucullus* (Bulman), Huy; IRScNB A3383,
observe view, low relief.
24. *Didymograptus* sp. *D. artus* group, Wépion, 204, 55 m; IRScNB A3384.

The magnification of all specimens is x 5, except for fig. 13: x 2,5.

All specimens are registered and curated in the collections of the Institut Royal des Sciences Naturelles de Belgique (IRScNB), Brussels.

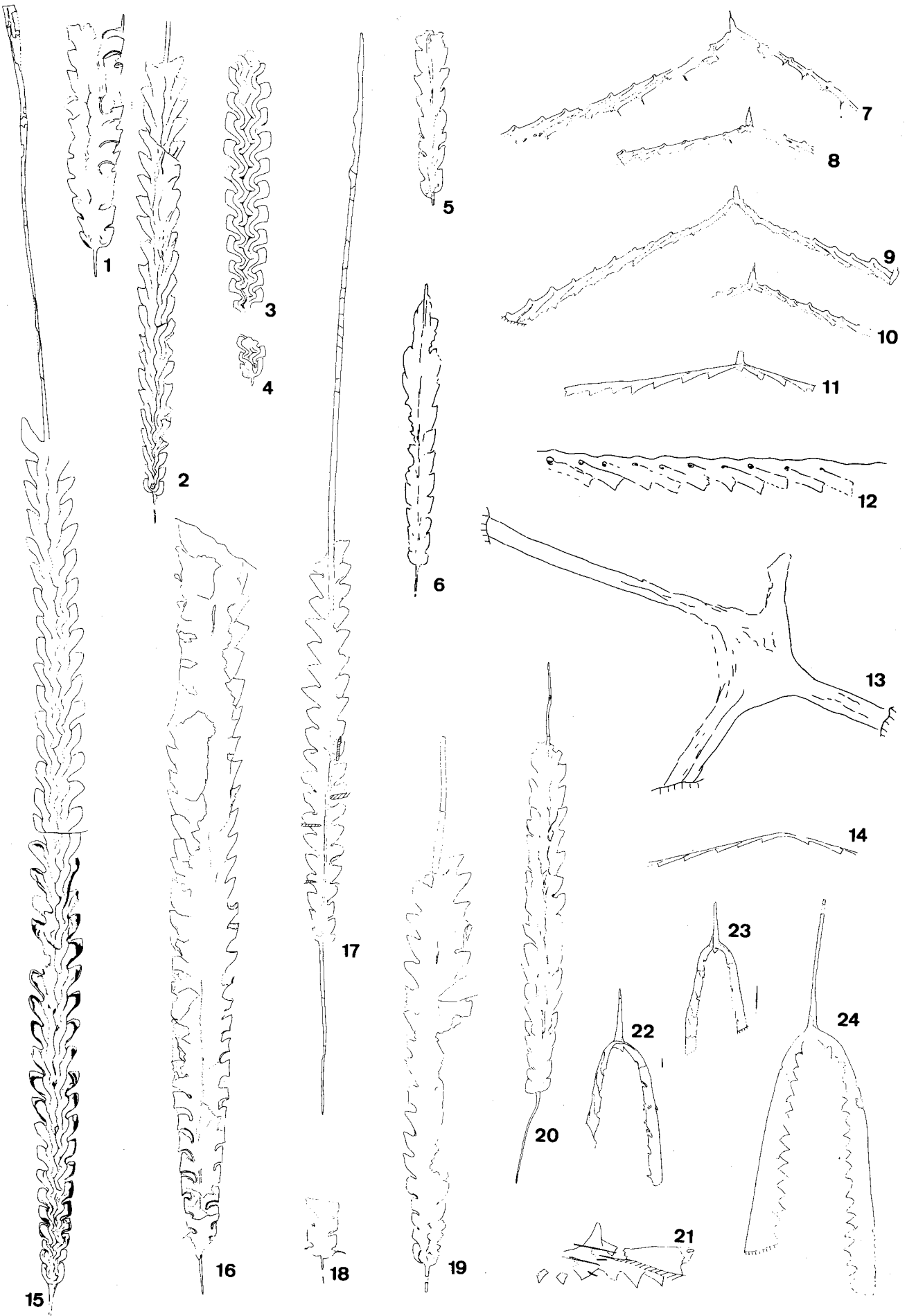


PLATE II

1. Crinoid and brachiopod fragments, Sart-Bernard 72270; IRScNB A3385.
2. *Priscyclopyge binodosa* ssp., Sart-Bernard 72270; IRScNB A3386.
3. *Aulograptus cucullus*, Wépion, 243,60 m, relief specimen in reverse view; IRScNB A3382.
4. *P. binodosa* ssp. Sart-Bernard 72270, Latex, incomplete thorax; IRScNB A3387.
5. *P. binodosa* ssp. Sart-Bernard 72270, Pygidium; IRScNB A3388.
6. meraspid trilobite indet, Sart-Bernard 72270; IRScNB A3389.
7. *Placoparia* sp., Sart-Bernard 72270, complete specimen; IRScNB A3390.
8. *Undulograptus camptochilus* (Skevington), Wépion, 443,37 m; IRScNB A3365.
9. *Cyclopyge* sp. Sart-Bernard 72270, cranidium; IRScNB A3391.
10. *Novakella* sp., Sart-Bernard 72270, incomplete pygidium; IRScNB A3392.
11. *Holmograptus callotheca* (Bulman), Sart-Bernard, distal part of stipe, specimen of Maillieux (1939), IRScNB A1615.
12. *Tomaculum problematicum* Groom, Sart-Bernard 72250; IRScNB A3393.
13. *Tomaculum problematicum* Groom, Sart-Bernard 72250; IRScNB A3394.

The magnification of all specimens is x 5, except for fig. 1,3 and 11 : x 10.

All specimens are registered and curated in the collections of the Institut Royal des Sciences Naturelles de Belgique (IRScNB), Brussels.

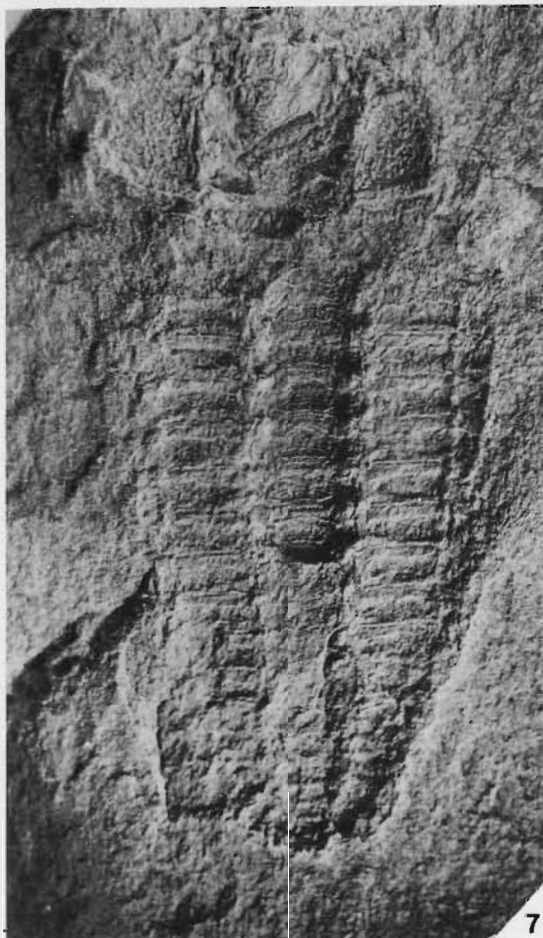
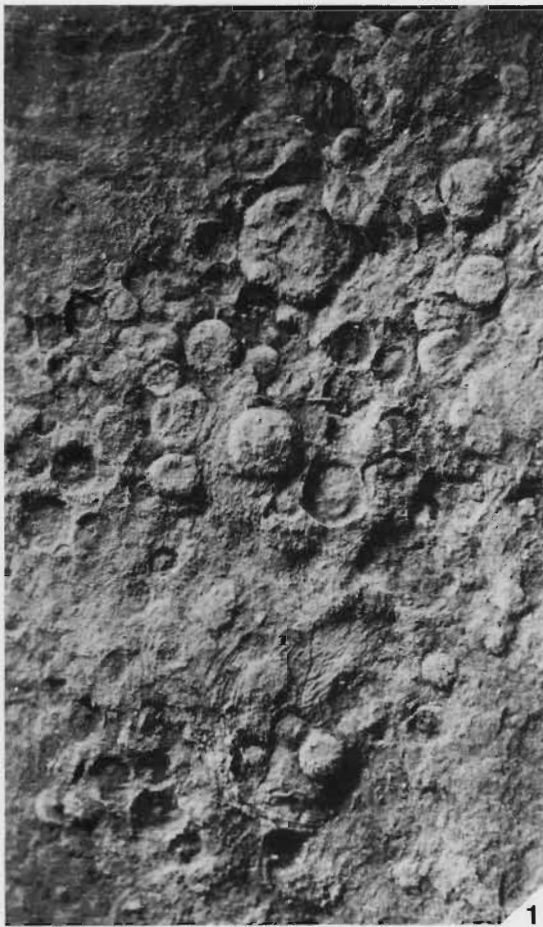


PLATE III

1. *Undulograptus camptochilus* (Skevington), Wépion, 193,30 m; IRScNB A3376, relief specimen in reverse view showing the growth paths of the thecae, proximal structure somewhat unclear.
2. *Undulograptus* sp. 1, Wépion, 204,55 m; IRScNB A3366, latex cast of the mould of the specimen, reverse view, showing the proximal structure.
3. *Undulograptus camptochilus* (Skevington), Wépion, 443,37 m; IRScNB A3365, reverse view of specimen, showing proximal structure.
4. *Baltisphaera ternata* Burmann 1970, ULg slide 22666 (England Finder graticule coordinates), U36-V37.
5. *Frankea sartbernardensis* (Martin) Colbath 1986, ULg slide 22666, F35/3-4.
6. *Marrocanium simplex* Cramer *et al.* 1974, ULg. slide 22666, N34/3-O34/1.
7. *Stellechinatum celestum* (Martin) Turner 1984, ULg. slide 22666, O42/1-3.
8. ? *Veryhachium minutum* Downie 1958, ULg. slide 22665, L33-34.
9. ? *Veryhachium fakirum* Martin 1969, ULg. slide 22665, J45/2-4.
10. *Pirea ornata* (Burmann) Eisenack *et al.*, 1976, ULg. slide 22666, E43-F44.
11. ? *Veryhachium* sp. 1, ULg. slide 22666, M 43.
12. *Arkonion virgata* Burmann 1970, ULg. slide 22666, G36/4-G37/3.

The magnification of the graptolite specimens (fig. 1-3) is x 20. All specimens are registered and curated in the collections of the Institut Royal des Sciences Naturelles (IRScNB), Brussels.

The magnification of the acritarch specimens is x 1000 (fig. 5-12) except for fig. 4: x 400. All figured specimens are from SB 72250 and are housed in the collections of the Services Associés de Paléontologie de l'Université de Liège (ULg).

