

A new representative of the lichid genus *Ohleum* (Trilobita) from the Eifelian (Middle Devonian) of southern Belgium

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ABSTRACT. Trilobites of the family Lichidae are relatively poorly diversified within the Eifelian mixed siliciclastic-carbonate succession of the southern margin of the Dinant Synclinorium (Belgium). Until now, they were only represented by species belonging to the genera *Ceratarges* and *Eifliarges*. The recent discovery of a well-preserved specimen within the Eifelian-aged Jemelle Formation in the Couvin area led us to propose the first detailed description of a representative of the genus *Ohleum* (*O. magreani* sp. nov.) in the Ardennes.

KEYWORDS: trilobites, Lichida, Devonian, Ardennes.

RESUME. Un nouveau représentant du genre lichidé *Ohleum* (Trilobita) de l'Eifelien (Dévonien moyen) du Sud de la Belgique. Les trilobites de la famille des Lichidae sont relativement peu diversifiés au sein de la succession eifélienne du bord sud du Synclinorium de Dinant (Belgique) qui est caractérisée par une sédimentation mixte silicoclastique à carbonatée. Jusqu'à présent, ils étaient seulement représentés par des espèces appartenant aux genres *Ceratarges* et *Eifliarges*. La découverte récente d'un spécimen bien conservé au sein de la Formation de Jemelle d'âge eifélien dans la région couvinoise nous amène à proposer la première description détaillée d'un représentant ardennais du genre *Ohleum* (*O. magreani* sp. nov.).

MOTS-CLES: trilobites, Lichida, Dévonien, Ardennes.

1. Introduction

Trilobites rank among the first invertebrates which were reported and illustrated in the Devonian of southern Belgium (e.g. Davreux, 1833; de Koninck, 1841). Several authors cited and/or described trilobites from the Middle Devonian (Eifelian and Givetian) succession exposed in this area, notably Gosselet (e.g. 1860, 1880, 1888), Stainier (1887), Kayser (1895), Fournier (1897), Maillieux (1904, 1908, 1919, 1922, 1933, 1938), Richter & Richter (1919), Asselberghs (1923), van Tuijn (1927), Monseur (1958), Lessuisse (1979), and Struve (1985). After a long period during which the trilobite faunas from the considered stratigraphic interval have received scant attention from specialists, the beginning of the 21st century is marked by a renewed interest in these emblematic fossils (e.g. Magrean, 2006; van Viersen & Prescher, 2010 and references herein).

Within the Devonian succession of southern Belgium, the diversity of the trilobites reached a peak during the Eifelian (Crônier & van Viersen, 2007), which is part of major transgressive sequence starting in the late Emsian (Bultynck et al., 2000). The latter permitted the development of mixed siliciclastic-carbonate environments favourable to the emergence of new taxa belonging to the Corynexochida, Lichida, Phacopida and Proetida (Crônier & van Viersen, 2007; Bignon, 2011).

The purpose of this paper is to describe a new species of the rare lichid genus *Ohleum* Basse, 1998 from the Eifelian of the southern margin of the Dinant Synclinorium (Fig. 1) and to discuss briefly the presence of lichid trilobites within the Lower

and Middle Devonian of Belgium (Dinant and Neufchâteau synclinoria). Lichid trilobites, which are characterized by their peculiar glabellar lobation, relatively large hypostome, and tuberculate and spinose exoskeleton (Thomas & Holloway, 1988), appeared, depending on the systematic applied, in the middle Cambrian (Thomas & Holloway, 1988) or in the Ordovician (early Tremadoc) (e.g. Whittington, 2002) and became extinct in the course of the middle Givetian (Feist, 1991). In Belgium, the oldest occurrences of lichids are recorded in the Upper Ordovician of the Brabant Massif and the Sambre-Meuse strip (e.g. Richter & Richter, 1951; Lespérance & Sheehan, 1987).

2. Geological setting

The material (a single specimen!) described in this paper comes from the Couvin area (see below for more details), which is located on the southern margin of the Dinant Synclinorium (Fig. 1). This Variscan structural unit was part of the Namur-Dinant Basin, which was located on the south-eastern margin of Laurussia during Devonian time (e.a. Torsvik & Cocks, 2004).

The specimen was recovered from the Eifelian-aged Jemelle Formation (Fig. 2). In the Jemelle area, where the latter was defined originally by Godefroid (1991a), three members can be distinguished (from bottom to top): La Station, Cimetière and Chavées members. However, in the Couvin area, which is located about 55 km west of Jemelle, only the Chavées Member can be recognized above the underlying limestones of the Couvin

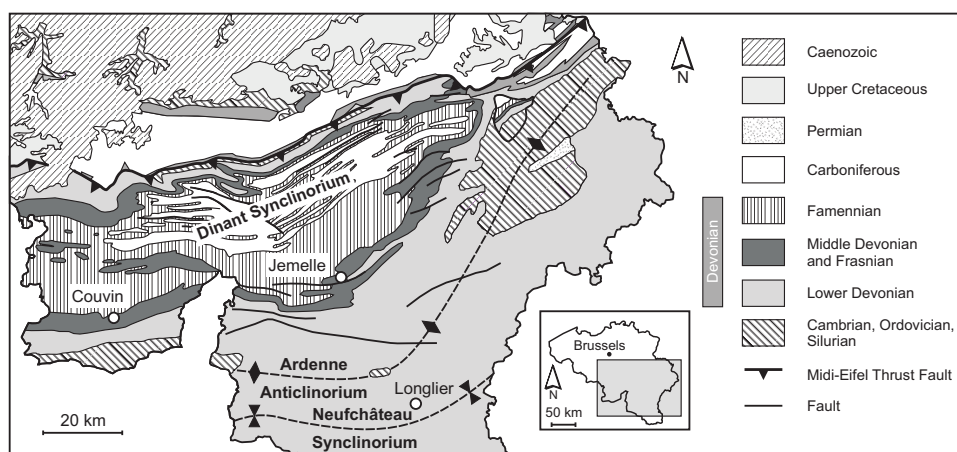


Figure 1. Schematic geological map of southern Belgium (modified from de Béthune, 1954) with location of the localities that yielded Lower and Middle Devonian lichid trilobites.

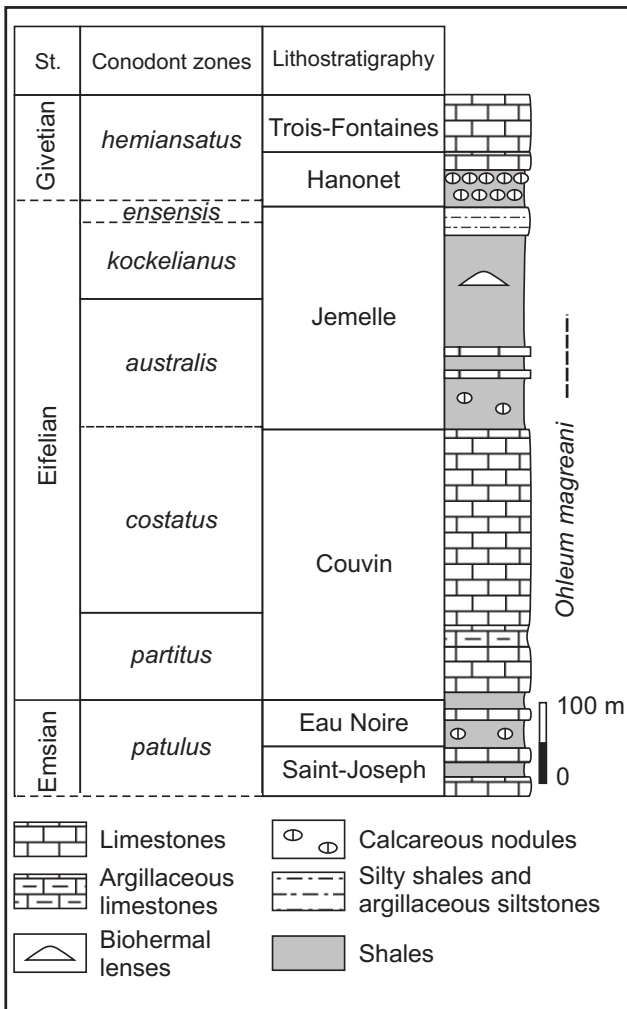


Figure 2. Eifelian lithostratigraphy of the Couvin area (modified from Bultynck et al., 2000). Abbreviation: St., stratigraphy.

Formation (Godefroid, 1991a; Dumoulin & Blockmans, 2008); the La Station and Cimeti re members are not developed. In Couvin, the Jemelle Formation is about 250 m thick (Bultynck, 1970) and is characterized by thick shale beds with carbonate nodules and limestone lenses with intercalations of thin-bedded or nodular, argillaceous or crinoidal limestone (Godefroid, 1991a). This lithostratigraphic unit contains an abundant and diversified macrofauna: bivalves (e.g. Maillieux, 1938), brachiopods (e.g. Vandercammen, 1963; Godefroid, 1972, 1995), solitary rugose corals (e.g. Tsien, 1969), tabulates (e.g. Lecompte, 1939), and trilobites (e.g. Struve, 1985; Magrean, 2007; van Viersen & Prescher, 2010). In terms of conodont zones (Fig. 2), the base of the Jemelle Formation in the Couvin area belongs to the *Polygnathus costatus costatus* Zone or to the *Tortodus kockelianus australis* Zone, whereas the biohermal lenses present within the upper part of the formation yielded conodont fauna characteristic of the *T. kockelianus kockelianus* Zone (Bultynck, 1970; Bultynck & Godefroid, 1974). According to Godefroid (1991b) and Bultynck & Dejonghe (2002), the top of the Jemelle Formation in Couvin (Co2cV *sensu* Bultynck [1970]; *T. kockelianus kockelianus* and *Polygnathus ensensis* conodont zones), which includes silty shales alternating with argillaceous, calcareous, micaceous siltstones, may correspond to a lateral equivalent of the Lomme Formation. On the basis of the conodont data, the age of the Jemelle Formation in the Couvin area is middle to late Eifelian (*P. costatus costatus*–*P. ensensis* zones) (Bultynck & Dejonghe, 2002). As noted by Marshall (2011), Eifelian substages have not been formally defined yet.

3. Systematic palaeontology

Order Lichida Moore, 1959

Superfamily Lichoidea Hawle & Corda, 1847 (*sensu* Fortey, 1997)

Family Lichidae Hawle & Corda, 1847

Subfamily Trochurinae Phleger, 1936

Genus *Ohleum* Basse, 1998

Type species. *Ohleum eurydice* Basse, 1998 (= gen. nov. ex Trochurinae *eurydice* sp. n. [nom. nud.] in Basse [1996]), from the Ohle Formation, middle Eifelian, Gummersbach, Oberbergisches Land, Germany.

Diagnosis. As the holotype of *Ohleum magreani* sp. nov. includes the first comprehensive evidence of the librigenae of *Ohleum* since those of the only previously known cranidium are damaged and the genal and metafixigenal spines broken off [M. Basse, pers. com. 2011]), it permits us to emend the generic diagnosis given by Basse (1998, p. 71) (see also Basse [in Basse & M ller, 2004, p. 111]): small-sized Trochurinae with posterolateral cranial lobe markedly larger than the bullar lobes; palpebral lobes directed externally, smaller than the bullar lobes; librigena small, triangular and with large genal spine curved posteriorly; holochroal eye on a stalk-like socle; posterior border of cranidium prolonged by prominent metafixigenal spine; pygidium sharply differentiated; number of marginal spines seeming to increase in postlarval stage; rachis limited by almost parallel margins, with pronounced thorn posteromedianly located; posterior part of rachis well-developed; pleural fields very narrow; 2 x 5 lateral projections mainly developed as long spines; both elements of the median attachment either merged (then relatively long) or separated (then short) and not dorsally erected.

Discussion. Until now, the genus *Ohleum* included, besides the type species, a second species left in open synonymy, i.e. *O. sp. n.* A *sensu* Basse (1998) (= gen. nov. ex Trochurinae sp. n. A in Basse [1996]). Both taxa were recovered from the Eifelian-aged Ohle Formation in the Rhenish Massif, east of the river Rhine, and represented by a limited number of disarticulated specimens.

Although the Eifelian trilobite fauna from the Oberbergisches Land (e.g. Basse, 1996, 1998) is very similar to that discovered within the Ahrdorf Formation at Hillesheim (Gees) (e.g. Basse & M ller, 2004), not a single occurrence of *Ohleum* is reported in the Eifel Synclines until now. A possible explanation for this situation may be the tiny size of the representatives of this genus, their rarity and their probable confusion with species of *Ceratarges* G rich, 1901, though the pygidium of the representatives of the latter are devoid of the typical median terminal projection present in *Ohleum*.

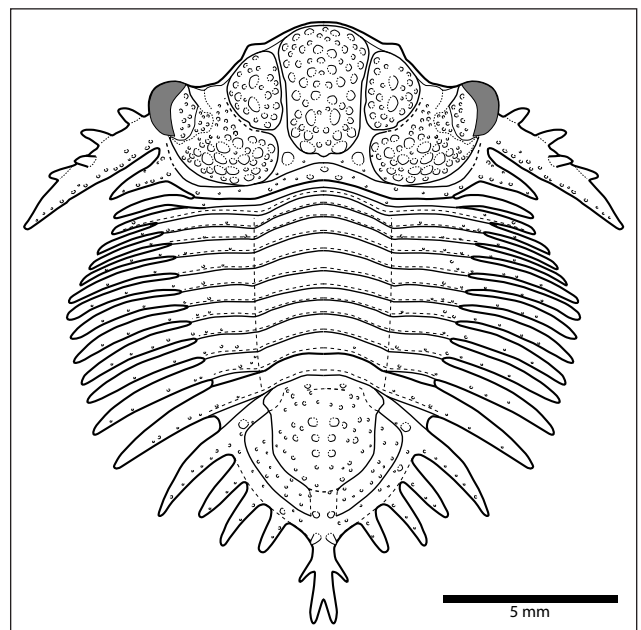


Figure 3. Reconstruction of *Ohleum magreani* sp. nov. based on the holotype (ULg-2011-11-16) and assuming the presence of 11 thoracic segments.

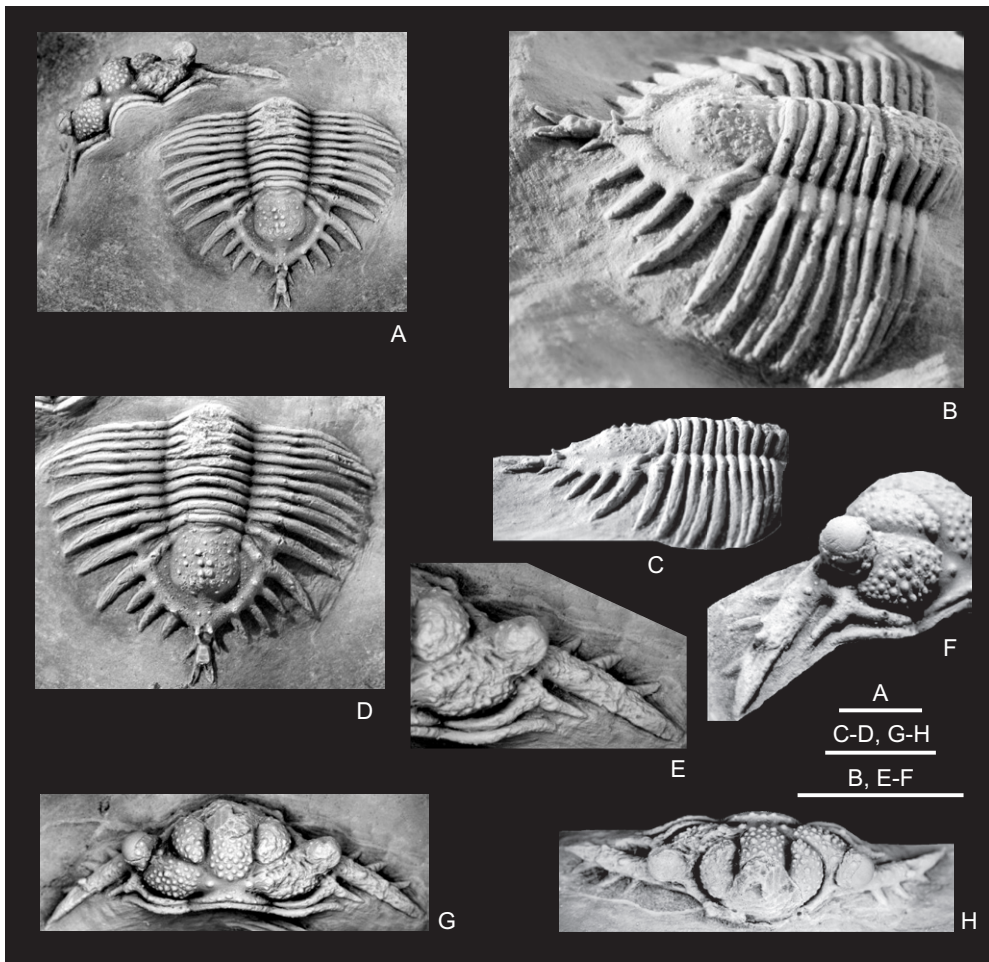


Figure 4. *Ohleum magreani* sp. nov. from Couvin (Jemelle Formation), holotype (ULg-2011-11-16). A, oblique posterior view; B, thoracopygidium, oblique lateral view; C, thoracopygidium, lateral view; D, thoracopygidium, dorsal view; E, close-up of the right librigena, dorsal view; F, close-up of the left librigena, posterolateral view; G, cephalon, dorsal view; H, cephalon, anterior view. Scale bars are 5 mm.

Ohleum magreani sp. nov.

Figs 2-4

2010 *Ohleum* cf. *eurydice* (Basse, 1998) (*sic*); Bonino & Kier: p. 426, fig. a.

2011 *Ohleum* cf. *eurydice* (Basse, 1998) (*sic*); Magrean & Taghon: pp. 88-89, fig. 7.

Derivation of name. Named after Benedikt Magrean, who discovered the holotype during fieldwork in 2006 and kindly put it at our disposal for description.

Holotype. An articulated exoskeleton, broken in two parts, probably lacking one thoracic segment. It is deposited in the collections of the Geology Department of the Liège University and registered as ULg 2011-11-16.

Type locality and horizon. A temporary outcrop (Magrean, 2007), open in 2006 during the foundation works for a new house, along of the road from Couvin to Petigny (road N99) (southern border of the Dinant Synclinorium, see Marion & Barchy [1999] for geological setting); grid references (Belgian Lambert system) (East-North): 160.803-82.763 (IGN map 57/7-8). Chavées Member of the Jemelle Formation, Eifelian (see Bultynck [1970] and Godefroid [1995] for correlations between the southern margin of the Dinant Synclinorium and the Eifel). In the absence of conodont data for the type locality and on the basis of its geological context, we can reasonably admit that the holotype is most probably from the *Tortodus kockelianus australis* conodont Zone (Fig. 2), but this needs confirmation.

Material. Only the holotype.

Diagnosis. Cephalon with genal and metafixigenal spines; genal spines bearing secondary spines; pleural ribs and terminal spines of thorax with some sparse and irregular granulations; only the first two axial rings of the pygidium developed; no further rings or pleurae on the posterior part of the pygidium; two parallel sagittal

rows of four pustules and smaller pustules randomly dispersed on posterior part of the rachis: elements of the long median 'thorn' merged and distally forked into two spines.

Description. Cranium with strongly convex glabella overhanging the very narrow and convex anterior border; glabella consisting of an elongate middle lobe and a pair of rounded, subtriangular bullar lobes; presence of an inflated and rounded posterolateral cranial lobe behind each bullar lobe, extending towards the palpebral lobes; posterolateral cranial lobes two times wider than the bullar ones; central part of the cranium (glabella, bullar lobes and posterolateral cranial lobes) ornamented with prominent pustules of varying size distributed randomly; palpebral lobes elevated, directed externally, only slightly granulated and 0.8 times smaller than the bullar lobes; holochroal eye raised above the rest of the librigena on a stalk-like socle bearing small pustules; occipital ring broad but short, granulated and ornamented with five tiny pustules; no trace of an occipital spine; pair of tiny, rounded, and slightly inflated preoccipital glabellar lobes lying between the occipital ring and the middle glabellar lobe; longitudinal glabellar and occipital furrows firmly impressed; librigena consisting of a tiny subtriangular portion merging with the eye socle, the large genal spine and the posterior border; genal spine curved posteriorly, covered with granulation and small pustules and bearing at least four smaller anteriorly directed secondary spines; posterior border continuing into a prominent metafixigenal spine approximately as long as, but coarser than the first pleural spines of the thorax.

Thorax composed of ten visible segments (most probably 11, see discussion below), all ending in long terminal pleural spines; no trace of granulation or ornamentation on the convex axial rings; pleural ribs and terminal spines showing some sparse and irregular granulation; anterior axial thoracic ring almost as broad as the posterior one, resulting in almost parallel axial furrows; pleura slightly convex with posterior band inflated; no trace of a pleural furrow; pleural spines slightly curved posteriorly, as wide as and 2.5 times as long as the pleura; pleural

spines situated in the middle of the thorax only slightly longer than those situated anteriorly and posteriorly.

Pygidium without spines or terminal thorn, 1.2 times wider than long, and with large border (c. half of the rachis width) consisting of an outer, elevated and semi-cylindrical ring and an inner flat one; rachis equidimensional with length and width corresponding to 65 per cent and to 50 per cent of those of the pygidium, respectively; only the first axial ring clearly visible and extended by a posterior pleural band ending in a long marginal spine; posterior pleural band slightly orientated posteriorly and differentiated from the axial ring by a sharper angle; posterior margin of the rachis separated from the posterior border of the pygidium by a postrachial elevation running across that portion of the pleural field; pleural furrows sharp; anterior pleural band of the first pleural segment short and almost flat; second axial ring seeming faded away (only the base of the ring on the rachis flanks are retained and extended by a posterior pleural band and a marginal spine); second marginal spine as long as the first one; second posterior pleural band more sharply directed posteriorly and flatter than the first one; posterior pleural band bearing a pustule; no further rings or pleurae on the posterior part of the pygidium, but 2 x 3 spines on the posterolateral border (the length of these spines decreases towards the terminal thorn and corresponds to c. 60 per cent of the length of the two first pygidial spines); posterior part of the rachis characterized by two parallel sagittal rows of four pustules and smaller pustules randomly dispersed on a granulated bottom; both elements of the median attachment merged and end in a fork; attachment shorter (x 0.75) than the two first marginal spines; two small spines projecting posteriorly at mid-length of the attachment extending towards the rachis by a convex elevation; two sharp pustules present where the thorn meets the pygidial border; two short but sharp thorns just posterior to the pygidial border.

Discussion. Although the thorax of the holotype of *Ohleum magreani* sp. nov. is broken in two parts, and only ten segments were preserved, we see no reason to doubt of the number of thoracic segments (11) proposed by Basse (1998) for *Ohleum*. The eleventh segment may lie hidden somewhere within the calcareous matrix. There are some records of lichids with only ten segments (Basse 1998, p.74; Kowalski 1992, fig. 151) but as stressed by Whittington (2002), these are all small specimens. They may not be holaspids or the anterior segment may be concealed beneath the posterior edge of the cephalon.

O. magreani shows some similarities with other lichids. Characteristic for *O. magreani* seem its prominent metafixigenal spines. Only very few species like *Akantharges* sp. (Thomas & Holloway, 1988: pl. 14, figs 300, 303), and *Mephiarges mephisto* (Richter & Richter, 1918) (see Basse & Müller, 2004: figs 704-705) possess such spines.

The general outline of *O. magreani* resembles that of the type species of the genus *Ohleum* (*O. eurydice* Basse, 1998). Typical for the new species are the genal spines with secondary and metafixigenal ones. The presence (or otherwise) of a metafixigenal spine in *O. eurydice* is unknown as related parts of the solely known cranidium are broken off (M. Basse, pers. com. 2011). Further comparison is difficult, because for the type species only a small holaspis is available. The pygidium, on the contrary, differentiates both species. The axial rings of *O. magreani* do not bear pustules or nodes but its second pleural band bears a node whereas *O. eurydice* bears a pair of nodes on its axial rings and a sharp node on its pleural ribs. Furthermore, the rachis of *O. magreani* is equidimensional contrary to that of *O. eurydice*, which is longer than wide. The ornamentation of the central part of the pygidium is also markedly different. The new species bears two parallel rows of four pustules whereas the pustules in the type species are not in rows but form a circle. The border of the pygidium also shows differences: *O. magreani* has a broader border than *O. eurydice*. The border of *O. magreani* consists of two equally broad rings: the outer one elevated and semi-cylindrical, the inner one flat. In *O. eurydice* the outer ring is broader. Both species bear five lateral spines on the border of the pygidium. Basse (1998) noted differences comparing the terminal spines and their position in the type species and concluded that they are slightly heteromorphic. As only the holotype is available

for *O. magreani*, no comparisons were possible. The position of the terminal spines of the new species shows a perfect bilateral symmetry and that is not always the case for *O. eurydice*. Both species have a bicomposite median complex thorn bearing spines and nodes, but the position of the ornaments differs. *O. magreani* has two sharp pustules at the attachment with the pygidial border, two short but sharp spines just posterior to the pygidial border, and two small spines outwardly directed at the distal extremity.

Comparison with *O. sp. n. A sensu* Basse (1998) is only possible for the pygidium, which has a similar general outline. Nonetheless, the spines in *O. magreani* are longer and coarser. Moreover, *O. sp. n. A* does not bear a posteromedian complex thorn but two short spines.

O. magreani shows similarities with representatives of the genus *Jasperia* Thomas & Holloway, 1988. The general outline of *J. bifida* (Edgell, 1955) from the Emsian of New South Wales (Australia) (see also Chatterton, 1971 and Campbell & Chatterton, 2009) somewhat resembles that of *O. magreani* but the ornamentation of its cephalon, thorax and pygidium is clearly distinct. *J. bifida* bears small spines on the axial ring whereas *O. magreani* has no pustules or spines on its thorax. Pygidia of both species are similar as they bear two large spines and three short terminal ones, but those of *O. magreani* are longer, especially the last three. Furthermore, the pygidium of *J. bifida* has a stronger ornamentation. Both species also share a posteromedian projection, but in *J. bifida*, it is not merged but forked. The posterolateral cranial lobes of *J. bifida* are hardly bigger than the bullar lobes. *J. duplicispinata* (Kaneko, 1984) from the Middle Devonian of the Kitakami Mountains (north-east Japan) resembles *O. magreani* in its general outline, but there are also clear differences between these species. *J. duplicispinata* has prominent spine pairs on the median glabellar lobe and a prominent spine pair on the posterolateral cranial lobe; the ornamentation on the cephalon of *O. magreani* consists of a combination of small and more prominent pustules. *J. duplicispinata* has more or less well-developed occipital spines contrary to *O. magreani*. The pygidium of *J. duplicispinata* has two prominent marginal spines, five small irregularly sized spines on its posterolateral margin and a prominent, upturned marginal spine at the posterior end; *O. magreani* has only five marginal spines and a bicomposite median attachment bearing thorns and knots.

Associated trilobite fauna. In its *locus typicus*, *Ohleum magreani* was part of a rich trilobite association where *Phacops* sp. and *Pedinopariops* sp. represented the dominant taxa. The specimens assigned to *Phacops* sp. are clearly members of the *P. latifrons* (Bronn, 1825) group and have 15 x 4 lenses. Furthermore, no specimen of *Phacops sartenaeri* Struve, 1985 was recovered. This suggests that the trilobite material examined by Struve (1985) from sections located in the vicinity of the type locality of *O. magreani* came from different levels of the Jemelle Formation (see also Basse, 2006). Additional trilobite taxa recovered with *O. magreani* are *Ceratarges* sp., *Goldius* sp., *Harpes* sp., *Gerastos dhondtae* Magrean, 2007 (nom. corr., van Viersen et al., 2009) and *Cornuproetus* (*Cornuproetus*) *cornutus cornutus* (Goldfuss, 1843) (= possibly *Cornuproetus* sp. 2 *sensu* van Viersen & Prescher [2010]). Last two species were represented by articulated specimens (B. Magrean, pers. com. 2011).

4. Lichid trilobites from the Devonian of Belgium

In the Devonian of Belgium, the oldest representatives of the family Lichidae are known from the upper part of the Pragian-aged Longlier Formation in the Neufchâteau Synclinorium (e.g. Godefroid, 1994; Bultynck et al., 2000), where they were firstly reported as a rather common species of *Lichas* by Maillieux (1914) and subsequently assigned to an unidentified species of the genus *Belenopyge* Pek & Vaněk, 1991 by van Viersen & Prescher (2009). The occurrence of the latter in the Pragian is considerably earlier than its generally accepted first appearance (in the latest Emsian) in the Ardennes and the Rhenish Massif, west of the river Rhine (Van Viersen & Prescher, 2009 and references herein).

Lichids became more abundant in the Middle Devonian (Eifelian), where they were frequently reported on the southern

border of the Dinant Synclinorium. Maillieux (1904) was the first to report their occurrence by recording *Acidaspis* cf. *vesiculosa* Beyrich, 1845 from Eifelian rocks in the Couvin area. Later, Maillieux (1919, 1933, 1938) corrected his identification to *Ceratarges armatus* (Goldfuss, 1839), and his lists of trilobites did not any longer record *A. cf. vesiculosa*, which is assumed to not occur in the Ardennes. Maillieux (1938) mentioned the presence of *C. armatus* in the old stratigraphic units Co2a and Co2c (Maillieux & Demanet, 1929), which are both included now in the Jemelle Formation (Godefroid, 1991a). As the concept of *C. armatus* has been restricted by Basse (in Basse & Müller 2004) and van Viersen (2006), a revision of Maillieux's material would be necessary to assess its conspecificity (van Viersen, 2007), but this is well beyond the scope of this work. Van Viersen (2006) described *C. cognatus* from the famous 'Mur des douaniers' (Crônier & van Viersen, 2008) in Vireux-Molhain (Ardennes, France), near the Belgian border, where it occurs within the Vieux Moulin Member of the Jemelle Formation (Eifelian). Van Viersen (2007) also described *C. cf. armatus*, from the Jemelle Formation near the railway station in Jemelle.

Basse & Müller (2004) reported the presence of the genus *Eifliarges* within the Jemelle Formation in the Couvin area on the basis of a single specimen. They noted that the latter, left in open nomenclature, shows similarities with *E. caudimirus* (Richter & Richter, 1917). Furthermore, Magrean (2006) subsequently reported this species within the Jemelle Formation in Jemelle.

5. Conclusions

In the Eifelian succession of southern Belgium (Dinant Synclinorium), the Lichidae are represented by the genera *Ceratarges*, *Eifliarges* and *Ohleum* (van Viersen, 2007; Magrean, 2006; Basse, 2006; Basse & Müller, 2004; this paper) which are only known from the essentially shaly Jemelle Formation.

In his study of the late Emsian and Eifelian mixed siliciclastic-carbonate succession exposed on the southern margin of the Dinant Synclinorium, east of the river Meuse, Godefroid (1968) underlined the role that may be played by trilobites in biostratigraphy although he noticed that they were generally poorly represented in the sections that he studied. Nevertheless, after the last decade, which was rich in descriptions of new Eifelian trilobite taxa (see references above), we believe that new collects of material by the bed-by-bed method, in conjunction with conodont analyses complemented by brachiopods and rugose corals data, will bring worthwhile biostratigraphic results in the future.

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7. References

Asselberghs, E., 1923. La faune de la Grauwacke de Rouillon (base du Dévonien moyen). Mémoires du Musée royal d'Histoire naturelle de Belgique, 33, 1-76.

Basse, M., 1996. Trilobiten aus mittlerem Devon des Rhenohercynikum: Teil I. Corynexochida und Proetida (1). Palaeontographica, Abteilung A, 239, 89-182.

Basse, M., 1998. Trilobiten aus mittlerem Devon des Rhenohercynikum: Teil III. Proetida (3), Phacopida (2), Lichida (Lichoidea, Odontopleuroidea) und ergänzende Daten. Palaeontographica, Abteilung A, 249, 1-162.

Basse, M. & Müller, P., 2004. Eifel-Trilobiten, III. Corynexochida, Proetida (2), Harpetida, Phacopida (2), Lichida. Goldschneck in Quelle & Meyer Verlag, Wiebelsheim, 260 pp.

Basse, M., 2006. Eifel-Trilobiten, IV. Proetida (3), Phacopida (3). Goldschneck in Quelle & Meyer Verlag, Wiebelsheim, 306 pp.

Béthune, P. de, 1954. Carte géologique de Belgique (échelle 1/500.000). Académie royale de Belgique, Atlas de Belgique, planche 8.

Beyrich, E., 1845. Über einige böhmische Trilobiten. Reimer, Berlin, 47 pp.

Bignon, A., 2011. Evolution morphologique et associative des trilobites sous contrainte environnementale, au Dévonien moyen et supérieur, en Ardenne Occidentale (bord sud du Synclinorium de Dinant). Unpublished PhD thesis, Lille University, 263 pp.

Bonino, E. & Kier, C., 2010. The Back to the Past Museum Guide to Trilobites. Casa Editrice Marna, Lecco, 495 pp.

Bronn, H., 1825. Ueber zwei neue Trilobiten-Arten zum *Calymene*-Geschlechte gehörig. Zeitschrift für Mineralogie, Taschenbuch, 1, 317-321.

Bultynck, P., 1970. Révision stratigraphique et paléontologique (brachiopodes et conodontes) de la coupe type du Couvinien. Mémoires de l'Institut Géologique de l'Université de Louvain, 26, 1-152.

Bultynck, P. & Dejonghe, L., 2002. Devonian lithostratigraphic units (Belgium). Geologica Belgica, 4, 36-69.

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

Bultynck, P., Coen-Aubert, M. & Godefroid, J., 2000. Summary of the state of correlation in the Devonian of the Ardennes (Belgium – NE France) resulting from the decisions of the SDS. Courier Forschungsinstitut Senckenberg, 225, 91-114.

Campbell, M.J. & Chatterton, B.D.E., 2009. Silurian lichid trilobites from Northwestern Canada: ontogeny and phylogeny of lichids. Journal of Paleontology, 83, 263-279.

Chatterton, B.D.E., 1971. Taxonomy and ontogeny of Siluro-Devonian trilobites from near Yass, New South Wales. Palaeontographica, Abteilung A, 137, 1-108.

Crônier, C. & Viersen, A.P. van, 2007. Trilobite palaeobiodiversity during the Devonian in the Ardennes Massif. Bulletin de la Société géologique de France, 178, 473-483.

Crônier, C. & Viersen, A.P. van, 2008. The 'Mur des douaniers', an exceptionally well-preserved Early Eifelian fossil site. Bulletin de la Société géologique de France, 179, 89-95.

Davreux, C.J., 1833. Essai sur la composition géognostique de la province de Liège. Mémoires couronnés de l'Académie royale des Sciences et Belles-Lettres de Bruxelles, 9, 1-297.

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

Edgell, H.S., 1955. A Middle Devonian lichid trilobite from south-eastern Australia. Palaeontologische Zeitschrift, 29, 136-145.

Feist, R., 1991. The late Devonian trilobite crisis. Historical Biology, 5, 197-214.

Fortey, R.A., 1997. Classification. In: Kaesler, R.L.(ed.), Treatise on Invertebrate Paleontology, Part O, Arthropoda 1, Trilobita (revised). Volume 1: Introduction, Order Agnostida, Order Redlichiida. Geological Society of America, Boulder, Colorado and University of Kansas Press, Lawrence, Kansas, 289-302.

Fournier, G., 1897. Un nouveau trilobite de l'étage Couvinien. Annales de la Société géologique de Belgique, Bulletin, 24, 52.

Godefroid, J., 1968. Contribution à l'étude du Couvinien entre Wellin et Jemelle (bord sud du bassin de Dinant). Académie royale de Belgique, Classe des sciences, mémoires, 2^{ème} série, 17, 1-87.

Godefroid, J., 1972. *Pseudosieberella* (Pentameridae), nouveau genre couvinien, et genres apparentés. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 48 (5), 1-41.

Godefroid, J., 1991a. Formation de Jemelle. Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique, 30, 31-39.

Godefroid, J., 1991b. Formation de la Lomme. Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique, 30, 33-40.

Godefroid, J., 1994. Le genre *Euryspirifer* Wedekind, 1926 (Brachiopoda, Spiriferida) dans le Dévonien inférieur de la Belgique. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 64, 57-83.

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

Goldfuss, A., 1839. Beiträge zur Familie der fossilen Crustaceen. In: Beiträge zur Petrefactenkunde. Nova Acta Physico-Medica Academiae Caesareae Leopoldina-Carolinae Naturae Curiosorum, 19, Abt. I, 353-364.

- Goldfuss, A., 1843. Systematische Übersicht der Trilobiten und Beschreibung einiger neuen Arten derselben. Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefakten-Kunde, 1843, 537-567.
- Gosselet, J., 1860. Mémoire sur les terrains primaires de la Belgique, des environs d'Avesnes et du Boulonnais. Imprimerie de L. Martinet, Paris, 164 pp.
- Gosselet, J., 1880. Esquisse géologique du Nord de la France et des contrées voisines. 1^{er} fascicule : Terrains primaires (textes et planches). Société géologique du Nord, Lille, 167 pp.
- Gosselet, J., 1888. L'Ardenne. Mémoires pour servir à l'explication de la carte géologique détaillée de la France. Baudry et cie, Paris, 889 pp.
- Gürich, G., 1901. Über eine neue *Lichas*-Art aus dem Devon von Neu Süd-Wales und über die Gattung *Lichas* überhaupt. Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilagebände, 14, 519-539.
- Hawle, I. & Corda, A.J.C., 1847. Prodrum einer Monographie der böhmischen Trilobiten. Calve, Prague, 176 pp.
- Kaneko A., 1984. A Middle Devonian trilobite fauna from the Kitakami Mountains, Northeast Japan, I, The Lichidae. Transactions and Proceedings of the Palaeontological Society of Japan, new series, 136, 474-491.
- Kayser, E., 1895. Sur une faune du sommet de la série rhénane à Pepinster, Goé et Tilff. Annales de la Société géologique de Belgique, Mémoires, 22, 175-216.
- Koninck, L.G. de, 1841. Mémoire sur les crustacés fossiles de Belgique. Nouveaux mémoires de l'Académie royale des Sciences et Belles-Lettres de Bruxelles, 14, 1-20.
- Kowalski, H., 1992. Trilobiten, Verwandlungskünstler des Paläozoikums. Korb, Goldschneck-Verlag, 157 pp.
- Lecompte, M., 1939. Les tabulés du Dévonien moyen et supérieur du bord sud du bassin de Dinant. Mémoires du Musée d'Histoire naturelle de Belgique, 90, 1-227.
- Lespérance, P.J. & Sheehan, P.M., 1987. Trilobites et brachiopodes ashgilliens (Ordovicien supérieur) de l'« Assise » de Fosse, Bande de Sambre-Meuse (Belgique). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 57, 91-123.
- Lessuisse, A., 1979. Contribution à l'étude paléontologique et stratigraphique du Couvinien du bord oriental du Synclinorium de Dinant. Unpublished Master thesis, Liège University, 251 pp.
- Magrean, B., 2006. Revision of some Devonian trilobites from Belgium. The genera *Astycoryphe*, *Tropidocoryphe*, *Eifliarges* and *Koneprusia*. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 76, 67-77.
- Magrean, B., 2007. A revision of Devonian trilobites from Belgium, Part 2: The genera *Gerastos* and *Cornuproetus*. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 77, 31-40.
- Magrean, B. & Taghon, P., 2011. Trilobiten aus dem Mitteldevon der Ardennen, Teil 1: Lichiden und Odontopleuriden. Fossilien, Zeitschrift für Hobbypaläontologen, 2/2011, 86-90.
- Maillieux, E., 1904. Quelques mots sur les trilobites du Couvinien des environs de Couvin. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, Procès-verbaux, 17, 579-582.
- Maillieux, E., 1908. Sur deux pygidiums aberrants du «*Bronteus flabellifer*» Goldf. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, Procès-verbaux, 21, 255-257.
- Maillieux, E., 1914. Quelques remarques sur la faune du Hundsrückien inférieur du bassin du Luxembourg. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, Procès-verbaux, 28, 77-79.
- Maillieux, E., 1919. Remarques sur la faune trilobitique de l'assise des schistes et calcaires à *Calceola sandalina* du bord sud du bassin de Dinant. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, Procès-verbaux, 29, 52-55.
- Maillieux, E., 1922. Présence du *Tropidocoryphe Barroisi* dans le Couvinien supérieur des environs de Hotton. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, Procès-verbaux, 31, 22-23.
- Maillieux, E., 1933. Terrains, roches et fossiles de la Belgique. Musée royal d'Histoire naturelle de Belgique, Bruxelles, 217 pp.
- Maillieux, E., 1938. Le Couvinien de l'Ardenne et ses faunes. Mémoires du Musée royal d'Histoire naturelle de Belgique, 83, 1-57.
- Maillieux, E. & Demanet, F., 1929. L'échelle des terrains primaires de la Belgique. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie, Procès-verbaux, 38, 124-131.
- Marion, J.-M. & Barchy, L., 1999. Carte géologique de Wallonie 1: 25 000 Chimay-Couvin 57/7-8 (+ notice explicative). Ministère de la Région Wallonne. Direction générale des Ressources naturelles et de l'Environnement, Namur.
- Marshall, J.E., 2011. Minutes of London Business Meeting. Newsletter of the Subcommittee on Devonian stratigraphy, 26, 13-18.
- Monseur, G., 1958. Sur un trilobite déterminé comme *Asteroptyge punctata* (Steininger). Annales de la Société géologique de Belgique, 82, B89-B96.
- Pek, I. & Vaněk, J., 1991. On some Silurian and Devonian trilobites of Bolivia. Acta Universitatis Palackianae Olomucensis, Facultas rerum naturalium, geographica-geologica, 103: 75-104.
- Phleger, F., 1936. Lichadian trilobites. Journal of Paleontology, 10, 593-615.
- Richter, R. & Richter, E., 1917. Die Lichadiden des Eifler Devons. Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, 1917, 50-72.
- Richter, R. & Richter, E., 1918. Paläontologische Beobachtungen im Rheinischen Devon. I. Über einzelne Arten von *Acidaspis*, *Lichas*, *Cheirusus*, *Aristozoë*, *Prosocoelus*, *Terebratula* und *Spirophyton* aus der Eifel. Jahrbücher des Nassauischen Vereins für Naturkunde, 70 (für 1917), 143-161.
- Richter, R. & Richter, E., 1919. Der Proetidenzweig *Astycoryphe*, *Tropidocoryphe*, *Pteroparia*. Senckenbergiana, 1, 1-17, 25-51.
- Richter, R. & Richter, E., 1951. Trilobiten von Ashgill-Alter aus dem Massif du Brabant (Grand-Manil). Bulletin de l'Institut royal des Sciences naturelles de Belgique, 27 (16), 1-6.
- Stainier, X., 1887. Note sur un trilobite nouveau et sur les *Pentamerus* des calcaires d'Humerée. Annales de la Société géologique de Belgique, Mémoires, 14, 75-85.
- Struve, W., 1985. Beiträge zur Kenntnis der Phacopina (Trilobita), 13): *Phacops sartenaeri* aus der Eifelium der Ardennen, Belgien. Senckenbergiana lethaea, 65, 465-469.
- Thomas, A.T. & Holloway, D.J., 1988. Classification and Phylogeny of the Trilobite Order Lichida. Philosophical Transactions of the Royal Society of London, Series B, 321, 179-262.
- Torsvik T.H. & Cocks, R.M., 2004. Earth geography from 400 to 250 Ma: a palaeomagnetic, faunal and facies review. Journal of the Geological Society of London, 16, 555-572.
- Tsien, H.-H., 1969. Contribution à l'étude des Rugosa du Couvinien dans la région de Couvin. Mémoires de l'Institut géologique de l'Université de Couvin, 25, 1-174.
- Tuijn, J. van, 1927. Le Couvinien et la partie supérieure de l'Eodévonien du bord oriental du Synclinorium de Dinant entre l'Ourthe et Ferrières. Mémoires de l'Institut géologique de l'Université de Louvain, 4, 105-262.
- Vandercammen, A., 1963. Spiriferidae du Dévonien de la Belgique. Mémoires de l'Institut royal des Sciences naturelles de Belgique, 150, 1-179.
- Viersen, A.P. van, 2006. New Middle Devonian trilobites from Vireux-Molhain (Ardennes, northern France). Senckenbergiana lethaea, 86, 63-75.
- Viersen, A.P. van, 2007. *Kettneraspis*, *Radiaspis* and *Ceratarges* (Trilobita) from the Middle Devonian of the Rochefort area (Ardennes, Belgium). Scripta Geologica, 134, 1-18.
- Viersen, A.P. van & Prescher, H., 2009. Trilobites from the Longlier Formation (Lower Devonian; Neufchâteau Synclinorium, southeast Belgium): first record of Pragian associated "Rhenish" and "Bohemian" assemblages from the Ardennes. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 79, 5-26.
- Viersen, A.P. van, Prescher, H. & Savelsbergh, J., 2009. Description of two new trilobites from the Ahrdorf Formation (Middle Devonian) at the "Trilobitenfelder" of Gees, Eifel, Rhenish Mountains. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 79, 43-53.
- Viersen, A.P. van & Prescher, H., 2010. Taxonomy and biostratigraphy of some proetid trilobites in the Middle Devonian of the Ardennes and Eifel (Rhenohercynian Zone). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, 80, 5-45.
- Whittington, H. B., 2002. Lichidae (Trilobita): morphology and classification. Journal of Paleontology, 76, 306-320.