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UPPER ORDOVICIAN LITHOSTRATIGRAPHY AND STRUCTURAL ARCHITECTURE OF THE FAUQUEZ AREA (BRABANT MASSIF, BELGIUM)

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(11 figures)

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ABSTRACT. The Fauquez area along the Sennette Valley in the Brabant Massif is known for its Upper Ordovician graptolite and shelly macrofossil bearing sediments. Renewed fieldwork and a detailed overview of the geological studies in the area allowed the proposition of a new lithostratigraphy of the Upper Ordovician rocks with a detailed description of four formations (Bornival, Huet, Fauquez and Madot), the construction of a detailed lithostratigraphical column, a geological section and a geological map. On the basis of a detailed structural analysis, we interpret the Fauquez area as a large-scale, non-cylindrical antiform, being cogenetic with cleavage development, which is cut by relatively important post-cleavage normal faults. The antiform and cleavage development are attributed to the Brabantian deformation phase. The non-cylindrical shape of the large-scale antiform, as well as the non-cylindrical nature of many of the smaller, parasitic folds, is compatible with a local, syn-cleavage and syn-folding dextral shear. Possibly, this local dextral shear is a result of the unequal distribution of the more competent volcanic bodies of the Madot Formation, being significantly thicker in the western part of the area. In contrast to previous views, there is no evidence for important reverse faulting.

KEYWORDS. Ordovician, Sennette, lithostratigraphy, geological map, geological section, cleavage transection, Brabant Massif, Belgium

1. Introduction

The Fauquez area, our study area, is one of the most extensive outcrop areas of the Upper Ordovician in the Brabant Massif. It is situated in the Sennette valley around Fauquez, a hamlet on the territory of both Ittre (Province of Walloon Brabant) and Braine-le-Comte/Ronquières (Province of Hainaut) (Fig. 1). This paper provides the results of a detailed field campaign (between 1994 and 1997) and a literature review of this area in order to establish the lithostratigraphy. The study area is bordered to the East and West by Cenozoic sediments present in the higher parts of the valley flanks of the Sennette River. The southern limit coincides with the fault F2 (= Fauquez fault of Coustry, 1930 and Legrand, 1967; or the *Faille Sud de Fauquez* of Hennebert & Eggermont 2002), juxtaposing Upper Ordovician volcanoclastic rocks and upper Llandovery silt, mudstone and claystone. To the North we limit the study area to a 400 m wide E-W strip devoid of outcrops, north of the hill in the middle of the valley where the Huet quarry is situated (Fig. 1). The Fauquez area has been known by geologists for a long time (Leriche, 1931), because of the presence of three important outcrops: the impressive outcrops of volcanic rocks in the Bois des Rocs, the fossiliferous greywacke of the Huet quarry and the graptolitic black mudstone of the sunken road section near the ruins of the Fauquez castle ("*Chemin creux de Fauquez*", N°128E75 on Figs 1 & 3). However, in the stratigraphical discussion leading to the general legend for the detailed geological map of Belgium in the beginning of this century (Malaise, 1900, 1908, 1910, 1911, 1913, 1914), the outcrops around Fauquez played only a minor role, contrary to those of the Gembloux area, 33 km more to the East, where the lithostratigraphy was established. For the larger geological context as the tectonic setting and evolution of the sedimentary basin we refer to Verniers *et al*. (2002).

2. Historical overview

The location of outcrops is given in Fig. 1. The outcrop numbers used herein, are those of the archives of the Geological Survey of Belgium (*e.g*.: 128E75) and when not described in the archives new numbers are given (*e.g*.: NN10).

The oldest reference to an outcrop in the Fauquez area is given by Omalius d'Halloy (1808, 1828) when he mentioned porphyroids in the vicinity of Ronquières.

Dumont (1848) deduced the following stratigraphical succession of the rocks outcropping in the Fauquez area, from base to top: black irregular slate, pyrite-bearing slate in bands of different shades of grey, fossiliferous slate sometimes sandy and a schistoid chlorophyre (the volcanic rock of the Bois des Rocs, see below). He also mentioned the presence of fossils (corals, crinoids and shells) probably from Huet in a coarse, heterogeneous mudstone in the vicinity of La Motte and near the castle of Fauquez. At that time there was still no railway in the Sennette valley. The locality "La Motte" probably refers to the small hill in which the Huet quarry was excavated. We do not know if the quarry was already in use then, but when Malaise (1873) collected his fossils (see below), the railway track had just been cut and the quarry had already been abandoned.

Gosselet (1860) described a fauna in the Orneau valley at Grand-Manil (33 km to the East of the study area), which was attributed to the second Silurian fauna of Barrande (pers. comm. *in* Gosselet, 1860). This was the proof that the general stratigraphy of Dumont (1848) was not applicable for the rocks of the Brabant Massif. He had classified all rocks below the Middle Devonian limestone series, including the whole Brabant Massif, into his Lower Devonian units as is the case for the succession in the Dinant Synclinorium and to the South in the Anticlinorium of the Ardennes. The determination of fossils by Barrande (*ibid*.) proved the presence of much older rocks (Ordovician-Silurian) in the Brabant Massif. On the cross-section of the Sennette valley by Gosselet (*ibid*., Pl. II, Fig. 9) six lithological units are shown, uniformly dipping to the North: "6: *schistes noirs subluissants*, 7: *schistes argileux pyritifères*, 8: *schistes noirs subluissants*, 9: *schistes passant à l'ardoise*, 10: *schistes grisâtres très fissiles (siluriens?)*, 11: *porphyre*".

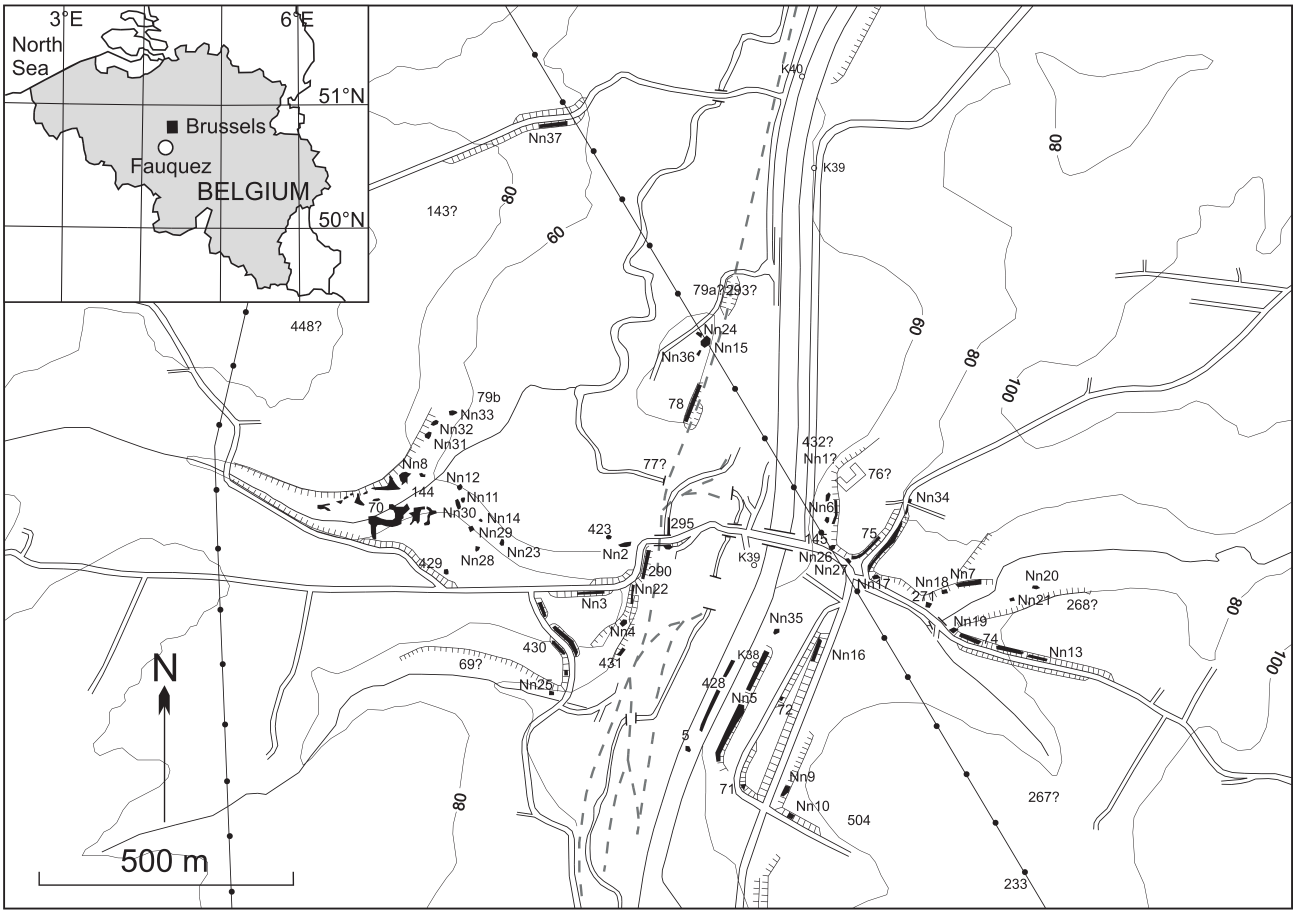

Fig. 1. Location map with all outcrops of the Fauquez study area on background of the topographical map 1/10.000. The numbers refer to the outcrops or boreholes described in the archives of the BGD/SGB; the numbers preceded by NN are numbers for not previously described outcrops; numbers with a question mark indicate that the location is only shown approximately. The inset shows the position of the study area within Belgium.

Malaise (1865) listed the outcrops in the Brabant Massif where he observed a fauna similar to that of Grand-Manil. In the Fauquez area one outcrop is situated North of the Fauquez castle ruins. We are tempted to accept that this outcrop is the Huet quarry but Malaise stated (footnote 1, p. 7) that the fossiliferous rock are dipping to the NNE, while later he measured for the bedding in the Huet quarry N50°E, 68°S (GSB archive: 128E28, Malaise, 1 October 1879) or 70°SE (Malaise *in* Faly, 1876). In a second outcrop, without any further precision, situated South of the ruins, Malaise found one valve of an *Orthis* sp. Based on numerous brachiopods belonging to several species of *Orthis*, he correlated this faunal assemblage with that described by Murchison (1859) from the Caradoc sandstone in the Welsh Borderland (U.K.).

In the first detailed stratigraphical study of the Brabant Massif, Malaise (1873) defined his 'Assise de Gembloux' as quartzitic mudstone with *Calymene incerta* and several plutonic rocks. He described the different rock types of the Fauquez area, but did not explicitly subdivide his Assise de Gembloux. He pointed out (Malaise, 1873, footnote. p. 71) that the schistoid chlorophyre of Dumont (1848) could be of an eruptive origin. Malaise (1873) is also the first author to give a species list of the fossils found in the Huet quarry and he mentioned the presence of the graptolite *Climacograptus scalaris* in the Fauquez Formation type section. This determination is probably wrong and was never confirmed by later researchers. This fossil was however used for correlation with the Gembloux area where Malaise concluded that the Fauquez Formation was a correlative of the "Assise de Grand-Manil", the latter having a Llandovery age based on graptolites. In his comments on the palaeogeography he pointed out that the fauna of Grand-Manil, in which he incorporated the fossil assemblages from the Huet and the Madot Formations, belongs to the "*système des mers de la zone du nord*" of Barrande (1863).

Vallée-Poussin & Renard (1876) are the first to study in detail the volcanic rocks from three outcrops in the Fauquez area. The first, which they called 'le vallon de Fauquez', is now known as 'Bois des Rocs' (128E70). The second one was a quarry at some 900 m distance from the Bois des Rocs, NE of lock n°40 on the canal Brussels-Charleroi. This outcrop has now disappeared but in 1889 it was indicated as 128E29 by Mourlon (GSB archive). Observations in this last outcrop allow Vallée-Poussin & Renard (*ibid.*) to contradict the opinion of Dumont (1848) who put forward an intrusive origin. The outcrop 128E29 clearly shows the mixture of ordinary clastic sediments with volcanic elements. The original stratification in 128E29 was still visible at that time. In the Bois des Rocs, Vallée-Poussin & Renard (*ibid.*) saw the volcanic complex as well stratified, with a dip between 35° and 45° to the NE and a direction between E15° to E40°S. Some 250 m North of 128E29, along the present day rue Madot, they observed a third outcrop of porphyroids. This outcrop has disappeared since. It is important to note that Vallée-Poussin & Renard (*ibid.*) show the existence of more than one level of volcanic rocks on the East side of the canal, which is confirmed by this study.

Gosselet (1880) is the first author to use in Belgium the chronostratigraphical term Caradoc, in which he included the Schistes de Gembloux (Brabant Massif) and the Schistes de Fosses (Condroz Ridge) with similar faunal assemblages. He repeated the description and arguments on the deposition of the sequence in outcrop N° 128E29 by Vallée-Poussin &

Renard (1876) but seemed to cite the strike of the strata erroneously.

The geological map Braine-le-Comte/Feluy (Malaise *et al.*, 1902) showed sixteen Lower Palaeozoic observation points in the study area, belonging to three different stratigraphical units: Sl1b: mudstone or quartz-bearing slate (*schistes ou phyllades quartzeux*) with *Calymene incerta*, *Trinucleus seticornis*, *Orthis actoniae*, etc...; Sl2a: mudstone or dark grey slate (*schistes ou phyllades gris noirâtre*) with *Climacograptus scalaris*; Sl2b: Quartzoslate, dark grey mudstone and micaceous sandstone (*quartzophyllades et schistes gris noirâtre et psammite*) with *Monograptus colonus*; additionally stratified quartzite, sandstone or micaceous sandstone (*quartzite stratoïde, grès ou psammite feuilleté*); a fourth unit contains porphyroids (□). The limits between the different units have a NW-SE direction. Although Vallée-Poussin & Renard (1876) demonstrated the existence of at least two different levels of volcanoclastic rocks, only one volcanic level, placed within the Sl2b, is indicated on the detailed geological map. The strange position of the Sl1b unit between two NW-SE trending faults is explained by the fact that Malaise (1873) placed the graptolites from outcrop 128E75 in the *Monograptus scalaris* biozone (Llandovery). The erroneous determination of the latter graptolite (see above) is repeated later (Simoens, 1907, 1908; Malaise, 1908) until Leriche (1920) corrected it and assigned a Caradoc age to this graptolite fauna.

Mathieu (1907, 1908) studied under the microscope fragments of the volcanic rock from outcrop 128E143 collected by Malaise. In the GSB archive Malaise stated that the latter locality was already indicated by Dumont (1848). Unfortunately we could not find in the publication of Dumont (*ibid.*) the mentioning of "the presence of volcanic rocks several hundred metres North of the Bois des Rocs to the East of the Farm la Vollée". Mathieu (1908) stated that these rocks differ completely from those of the Bois des Rocs (128E70). He called it a clastic porphyroid and accepted the presence of two different levels of volcanic rocks on the left bank of the Sennette valley. We think that some caution is needed here, because the precise location of the outcrop is not clear, and the reference of Malaise in the GSB archive to Dumont (1848) is possibly erroneous. In spite of these remarks it remains an interesting element that 130 years ago Vallée-Poussin & Renard observed already on the West side of the canal two different levels of volcanic rocks: the lavas and volcanic breccias of Bois des Rocs and the volcanosedimentary rocks of the "la Vollée" type.

In the first structural analysis of the area, Fourmarier (1921) put forward a synclinal fold structure with, in its core, the graptolitic black mudstone, situated below the ruins of the Fauquez castle. This solution does not require the graptolitic mudstone to be bordered by faults as indicated on the geological map of Malaise (Malaise *et al.*, 1902). In this concept the porphyroids (indicated as P on Fig. 5 of Fourmarier, 1921) are still placed within the Assise de Grand-Manil but now more substantiated with field evidence from the Orneau valley. There Malaise (1908) saw a porphyroid interstratified in Llandovery strata. Again the structural model of Fourmarier (1921) is not very satisfying, due to erroneous determination of the graptolites and the resulting wrong age for the sunken road (128E75) section.

Leriche (1920) restudied the type section of the Fauquez Formation and the graptolites from the sunken road section (128E75). To him they have a larger affinity with the *Diplograptus (Orthograptus) truncatus* (Lapworth) than with the *Climacograptus scalaris* biozone. Based on these determinations Leriche (*ibid.*) correlated the black graptolitic mudstone with the Caradoc Hartfell Shale in the Southern Uplands, U.K., a section dated now from the middle Caradoc to Ashgill (Williams *et al.*, 1972). The trilobites and brachiopods collected at the southernmost part of the talus of the canal section (Fig. 1. n° 3 *in* Leriche, 1920) were erroneously considered to be identical to those from the Huet quarry. In order to explain the presence of the fossiliferous greywacke in the two places Leriche (*ibid.*) argued that the graptolitic mudstone was interbedded within greywacke. He argued that the presence of fossiliferous greywacke South and North of the graptolitic black mudstone is easier to explain by the appearance of episodes of black mudstone deposition within a sedimentation of greywacke than the structural solution of Fourmarier (1921) who invoked the presence of a syncline to have the fossiliferous greywacke appear North and South of the black mudstone. This view is not corroborated by the present study.

Maillieux (1926) divided the Assise de Gembloux, into a lower level with "*Trinucleus seticornis*" and an upper level with "*Pleurograptus linearis*". The *Pleurograptus linearis* biozone is represented in the Fauquez area by black mudstone, present in the sunken road of Fauquez and in the sections close to the old railway station of Fauquez where he listed the following graptolites: *Pleurograptus linearis* (Carruthers), *Orthograptus basilicus* Lapworth var *basilicus* Lapworth, *Orthograptus* cf. *truncatus* Lapworth, *Climacograptus* cf. *tubuliferus* Lapworth, *Leptograptus flaccidus* (Hall). He placed these rocks in the upper Caradoc by the presence of *Pleurograptus linearis*. He provided a longer list of fossils of the Huet quarry, which probably need revision: corals: *Heliolites barrandei* Penecke; cystoids: *Sphaeronites stelluliferus* Salter; *Echinosphaerites minutus* (Forbes); crinoids; bryozoans: *Ptilodictya* sp.; brachiopods: *Nicolella (Orthis) actoniae* Sowerby, *Harknessella (Orthis) vespertilio* Sowerby, *Plathystrophea biforata* (Schlotheim), *Dalmanella testudinaria* (Dalman), *Leptaena rhomboidalis* (Wilckens), *Plectambonites sericeus* (Sowerby), *Atrypa marginalis* Dalman; gastropods: *Bellerophon bilobatus* Sowerby, *Raphistoma lenticularis* Sowerby; cephalopods: *Orthoceras belgicum* Malaise; trilobites: *Calymene incerta* Barrande, *Tretaspis (Trinucleus) seticornis* Hisinger, *Cybele verrucosa* (Pander), *Lichas laxatus* M'Coy. Maillieux (*ibid.*) also compiled a list of fossils from five outcrops of fossiliferous greywacke in the Brabant Massif: two in the Sennette valley around Fauquez (Huet quarry and Madot canal section), two in the Senne valley (Chenois-Hennuyères and Rebecq-Rognon), and one in the Orneau valley at Grand-Manil (Lefèvre quarry). He considered these faunas to be the same, although the first four outcrops contain only minor and different subsets of the assemblage from Grand-Manil. He put the rocks from these five outcrops in his "Zone à *Tretaspis seticornis*", and suggests a late Caradoc age.

A list of graptolite species is given in a revision of older and additional new determinations by Elles *in* Maillieux (1930): *Pleurograptus linearis* (Carruthers), *Dicellograptus forchammeri* Geinitz, *Orthograptus basilicus* Lapworth, *O. rugosus* Hall, *O. truncatus* var. *intermedius* Elles & Wood, *O. truncatus* var. *pauperatus* Elles & Wood, *Climacograptus styloides* Lapworth, *C. caudatus* Lapworth, *C. cf tubuliferus* Lapworth, *Leptograptus flaccidus* (Hall) (determinations by Elles except for the last two). Elles (*ibid.*) partly confirmed the late Caradoc age given by Maillieux in earlier studies (see above), but the graptolite assemblages point to the presence of both the *clingani* and *linearis* biozones. Maillieux (1930) by consequence divided the upper Caradoc in the Brabant Massif in a lower part that belongs to the *clingani* biozone (the base of the Fauquez Formation) and an upper part that belongs to the *linearis* biozone, the upper part of the "schistes de Fauquez" with *P. linearis*, followed by the "Schistes de Gembloux" with *Nicolella actoniae*. In the newly proposed division of the Caradoc in Belgium, Maillieux (*ibid.*) reversed the stratigraphical order of the fossiliferous greywacke (Schistes de Gembloux à *N. Actionae* [sic]) and the graptolitic mudstone of Fauquez. The reasons for this reversal are not given by Maillieux. In 1933 the latter author maintained his opinion on the superposition. This proposed superposition does not take into account the field evidence, already known since a long time, where the "grauwacke fossilifères de Fauquez", correlated by Maillieux (*ibid.*) with the "Schistes de Gembloux à *N. actoniae*", occupies a lower stratigraphical level than the base of the "Schistes de Fauquez". Malaise (GSB 128E75: 30 September 1879) observed, in the company of Vallée-Poussin, that the mudstone of the Fauquez Formation were underlain by the "phyllades à *Orthis*", which is confirmed by our observations.

Coustry (1930) drew a rudimentary geological map of the Fauquez area based on 13 outcrops. In his cross-section (Fig. 4 *in* Coustry, *ibid.*) he placed the porphyroids within the Assise of Gembloux, but the overall image is very similar to that of Fourmarier (1921). This author ignored the solution proposed by Leriche (1920) and the fact that more than one level of volcanic rocks is mentioned on both side of the canal. Coustry defined the Fauquez Fault (= F2) as a reversed fault which forms the southern delimitation of the Upper Ordovician in the Sennette valley.

Mortelmans (1955), in his tectonic study of the Brabant Massif, placed the outcrops in the Fauquez area within his "*Massif de Fauquez et de Villers-la-Ville*". The southern delimitation of this structural unit is formed by the Fauquez Fault (=F2). He saw the outcrops from the Fauquez area structurally belonging to the southern limb of a large SSW-verging, detached anticlinal structure, positioned according to him in a thrust.

Between 1961 and 1966 the canal was enlarged to its present-day size. Legrand (1967) saw in the newly exposed section along the East side of the canal South of the Fauquez bridge a confusing mixture of sedimentary and volcanic rocks, dipping between 60° and 70°S, with two levels of macrofossils in the southern part of the large outcrop. The southern extremity of the section consists of a volcanic breccia and conglomeratic tuff. Here he observed several large blocks, up to 1 m in diameter, of volcanic origin within the black mudstone. The complete section, characterised by the ubiquity of elements of volcanic origin is placed in the Ashgill by Legrand (*ibid.*). This is based on the (erroneous) opinion of Legrand (1961) that all volcanic rocks in the Brabant Massif, even without fossil evidence, are of Ashgill age and on the observation that the volcanic rocks are stratigraphically higher than the fossiliferous greywacke from the Huet quarry, which are dated as Caradoc, so that the volcanic rocks of the Upper Ordovician should be of an Ashgill age. Seemingly his interpretation is not based on fossil evidence but solely on his reading of Marr (1905) who introduced the Ashgill "for a series including volcanic rocks". He did, however, not take into account his own observations of macrofossil-bearing levels in the southern part of the canal section on which he agreed with Maillieux (1926, 1930) that the faunas are similar to those of the Huet quarry. These fossiliferous greywacke levels are situated in between the two levels of volcanic rocks in the canal section. To the NE of the canal bridge a large outcrop of black graptolitic mudstone was temporarily accessible (in 1968 it was already covered by debris according to Legrand, 1969). The graptolite assemblages from this outcrop were attributed to the *linearis* graptolite biozone (Legrand, 1967). He designated the sunken road section (128E75) as the *locus typicus* of the Caradoc and the volcanic rocks of the outcrop behind the house "Maison des roches" (128E430) as the *locus typicus* for the Ashgill in the Brabant Massif. He favoured the opinion that the latter outcrop was closer to the eruption centre than the volcanoclastic rocks of the canal section, confirmed by this study.

Waterlot *et al.* (1973) described five different localities in the study area, following a transect along the Sennette valley from Tubize to Feluy. They distinguished four major lithostratigraphical units. The micaceous sandstone (*psammite*) of the railway section at the Huet quarry, the "*psammophyllades*" at the railway bridge in Fauquez, the black mudstone in the "rue de Fauquez" and the rocks outcropping along the Madot canal section (East side of the canal, South of the Fauquez bridge). The Madot canal section is subdivided in three units, from North to South: 70 m of bluish, micaceous mudstone with halfway a few metres of tuffite; 60 m of black, psammitic mudstone with about 20 m of compact tuffite at the base and finally 80 to 90 m of dark mudstone with blocks of limestone, tuffite and arkose. The latter unit of the canal section is interpreted as a fault breccia, associated with the Fauquez Fault (=F2). This is the first attempt to decipher the lithostratigraphical relationships in the Fauquez area. The arguments for the stratigraphical order of the observed units are based on the older palaeontological data (e.g. the graptolite lists of Maillieux, 1926, 1930), the opinion of Legrand (1961, 1967) on the age of the volcanism, in combination with the spatial relationship of the outcrops. The rocks from the Huet quarry form the oldest unit, followed by the black mudstone of the "rue de Fauquez" and the mudstone of the railway bridge. The outcrops along the canal are considered the youngest units, which is corroborated by our study. The porphyroid of the Bois des Rocs is correlated with the volcanoclastic rocks of the canal section. As mentioned above Legrand (1967) placed the mixture of volcanic and sedimentary rocks of the Brabant Massif, often rich in fossils, in the Ashgill. Illustrative for this reasoning is the use of the trilobite *Tretaspis seticornis* in the rocks of the Huet quarry as an indication for a Caradoc age. The same fossil is, however, present in the southern part of the Madot canal section, but because the latter rocks are situated stratigraphically higher than the Caradoc black mudstone with *Pleurograptus linearis* of the "rue de Fauquez" section, he attributed the latter to the Ashgill.

Corin (1965), Van den haute (1975) and Parijs (1977) studied the petrography of the volcanic rocks in the Fauquez area. Van den haute (*ibid.*) gave a detailed description of the lithologies present in the canal section, proving for the first time the presence of fining upwards sequences within the volcanoclastic rocks, between km 37.980 and km 37.930. Parijs (*ibid.*) made a detailed topographic study of the outcrops in the Bois des Rocs. He saw two different types of volcanic rocks: lavas and resedimented volcanic material and stated that all the volcanic rocks in the Fauquez area are interstratified within the Upper Ordovician sediments. Parijs (*ibid.*) and Van den haute (*ibid.*) stressed that these volcanic rocks have been subjected to pronounced alteration. Parijs (*ibid.*) placed all the volcanic rocks stratigraphically above the fossiliferous greywacke of the Huet quarry and the graptolitic black mudstone. He did not attribute a precise age for the units except a probable Late Ordovician age.

Martin & Rickards (1979) studied the palynology of the sections opened by the widening of the canal and amongst other also four samples from the Madot canal section. The sample 77-8-3 at km 37.936 is located within the volcanosedimentary member 2 of the Madot Formation. The acritarch assemblage from this sample only gave a broad Caradoc to Llandovery age. The presence of microfossils within the member 2 supports the hypothesis of a marine resedimented volcanoclastic origin of the member. No organic microfossils were found by them in the type section of the Fauquez Formation.

In an excursion guide André (1991) discussed the Fauquez volcanic complex in two outcrops: the Bois des Rocs and the Madot canal section and described dacitic lavas, breccias and tuffs interbedded in the Upper Ordovician slate. According to him, the volcanic activity began by dacitic tuffs and mud-flow breccias composed of poorly sorted volcanic clasts supported within mudstone matrices, overlain by porphyritic dacitic lavas and graded-bedded coarse-grained tuffs and ending by a series of fine-grained tuff horizons interbedded in the Ordovician slate. From NW to SE the complex becomes along strike gradually thinner and the lithologies change from predominant lavas to predominant coarse-grained tuffs. According to the geochemical data, the volcanic products are likely to derive from the Quenast vent located 6 km to the NW. The changes in lithology and thickness of the complex are interpreted as the consequence of a decreasing distance from the eruption site. He puts the Madot canal section on the eastern end of the volcanic complex, where a 20 m-thick volcanoclastic unit contains, in its central parts, unsorted tuff with lithic volcanic and mudstone fragments in a sandy matrix and towards the top and bottom white, strongly cleaved, fine-grained tuffs. In the Bois des Rocs he described the 100 m-thick dacitic lavas characterising the western part of the Fauquez complex with various types of phenocrysts: plagioclase altered in albite and pyroxene altered in chlorite and quartz. They are incorporated in a quartzo-feldspathic sugary mesostasis or in a very fine-grained microlithic groundmass that locally exhibits a trachytic texture. The lava includes many slate xenoliths (up to 30 cm) and small (< 5 cm) comagmatic inclusions. He measured a 40°NNE dip of the lava flow and saw two main facies: a foliated (N70°W 55°N) dacitic lava North of the brook and a homogeneous dacitic lava South of the brook.

Herbosch *et al.* (1991, Fig. 6), Servais (1993) and Servais *et al.* (1993) introduced the term Fauquez Formation and Greywacke of Fauquez for respectively the graptolitic black mudstone and the fossiliferous greywacke. The volcanic rocks were incorporated into a third unit: the Fauquez volcanic complex. However, no attempt was made to decipher the stratigraphical relationship between these lithostratigraphical units.

Van Grootel *et al.* (1997) present preliminary results of their detailed study on the lithostratigraphy of the Fauquez area, with a short description of two new formations (Madot and Bornival). They dated preliminary with chitinozoans the four Upper Ordovician formations of the study area after correlation with the area around the Baltic Sea called Baltoscandia, on the palaeocontinent Baltica.

Rickards (*in* Geys & Marquet, 1988) determined one graptolite from the sunken road of Fauquez as a *Climacograptus tubuliferus*, while Erdtmann (1991) collected and determined graptolites from the same outcrop as *Dicellograptus cf. patulosus* and an *Orthograptus sp.* with large rhabdosomes. Maletz & Servais (1998) resampled graptolites of the same section (their number f3) and in the railway section (their number f4) and restudied the graptolite collections housed in the Royal Belgian Institute of Natural Sciences (Brussels) and some other collections. For the type section of the Fauquez Formation they showed a 17 m thick section with 4 graptolite levels, taken from an unpublished excursion guide book by Van Grootel *et al.* (1996). The graptolite assemblages recorded from four distinct levels contain the following species: *Orthograptus calcaratus basilicus*, *Normalograptus* sp. 1 (both can be very common), and *Dicellograptus* sp. (rare). In the railway section (f4) they describe only 2 species: *Orthograptus calcaratus basilicus* (rare) and an uncertain *Pseudoclimacograptus scharenbergi* (common). The sunken road of Fauquez locality (f3) did not contain the species that could be positively attributed to *Pleurograptus linearis*. Other elements in the assemblage indicate that the fauna may belong to the *linearis* biozone, but possibly also to the upper *clingani* biozone. The graptolite fauna from the railway section (f4) does not contain elements that allow a precise relative dating.

An overview of the Ordovician chitinozoans biostratigraphy of Belgium was presented preliminarily in Verniers *et al.* (1999) and Samuelsson & Verniers (2000).

One can conclude from the overview of about two centuries of research in the Fauquez area, that the volcanic rocks have been studied rather well, their composition and origin is known, but their lithostratigraphical position and cartographic distribution needs more detail. At least two other lithostratigraphical units have been described: the graptolitic black mudstone (the Fauquez Formation) and the fossiliferous greywacke unit (at the Huet quarry). All authors are unanimous about their Late Ordovician age, possibly from late Caradoc to early Ashgill but few data are known on the stratigraphical relation between the units, their thickness, environment of deposition, relative age, spatial distribution (geological map) and tectonic relationship.

This study tries to answer these questions in four ways: (1) detailed and prolonged field campaign with prospection for previously undescribed outcrops and thoroughly cleaning of the existing outcrops, detailed stratigraphical logging and outcrop location, lithological and sedimentological descriptions, definition, description and mapping of the lithostratigraphical units; (2) critical study of the literature to use that information in our study; (3) structural fieldwork and interpretation of the geometry and chronology of the deformation, and (4) a biostratigraphical study with chitinozoans to obtain accurate ages of the lithostratigraphical units. A preliminary study by Van Grootel & Verniers (1998) was followed by a study with more samples and more in detail by Vanmeirhaeghe *et al.* (this volume).

Van Grootel & Verniers (1998) evaluate critically all descriptions of the outcrops in the BGS/SGB archives and in the literature. A list is provided with the correlation of double or triple numbers referring to the same outcrop and of all later descriptions in the literature. In many cases wrongly located outcrops in archives or literature could be relocated. New observations on selected outcrops are also given: i.e., detailed location maps, lithostratigraphical logs and structural data (Van Grootel & Verniers, 1998).

3. Lithostratigraphy

3.1. Introduction

In the Upper Ordovician strata of the Fauquez area we have distinguished four formations (from bottom to top): the Bornival, Huet, Fauquez and Madot formations. A formal, detailed lithostratigraphical description is given below, even if they were already defined or shortly described earlier (Van Grootel et al. 1997; Verniers *et al.* 2001). The historically known outcrops and lithologies belong to the Huet, Fauquez and Madot formations. The Bornival Formation is a recently discovered lithostratigraphical unit for previously undescribed outcrops and is divided into three members. The silty mudstone (called historically greywacke), containing an abundant macrofauna of brachiopods, trilobites, bryozoans, etc., belongs to two formations: the Huet Formation and the Madot Formation (member 4 and parts of member 5). The graptolitic black or dark grey mudstone belongs to the Fauquez Formation. All the volcanic rocks of the Fauquez area belong to the Madot Formation. In Fig. 2 we show a composite lithostratigraphical column based on twelve large or otherwise important sections in the Fauquez area. A schematic section (Fig. 8) along the western side of the Sennette valley shows the superposition of the four units.

3.2. Bornival Formation

3.2.1. Type section

Right bank of the “Ri de Fauquez”, between 20 m and 68 m NNE of the small farm, rue de Bornival, n° 2 (GSB number 128E271). The formation is named after Bornival, a hamlet 1.5 km to the East of the type section. Other representative outcrops: NN21, NN20, and 128E78.

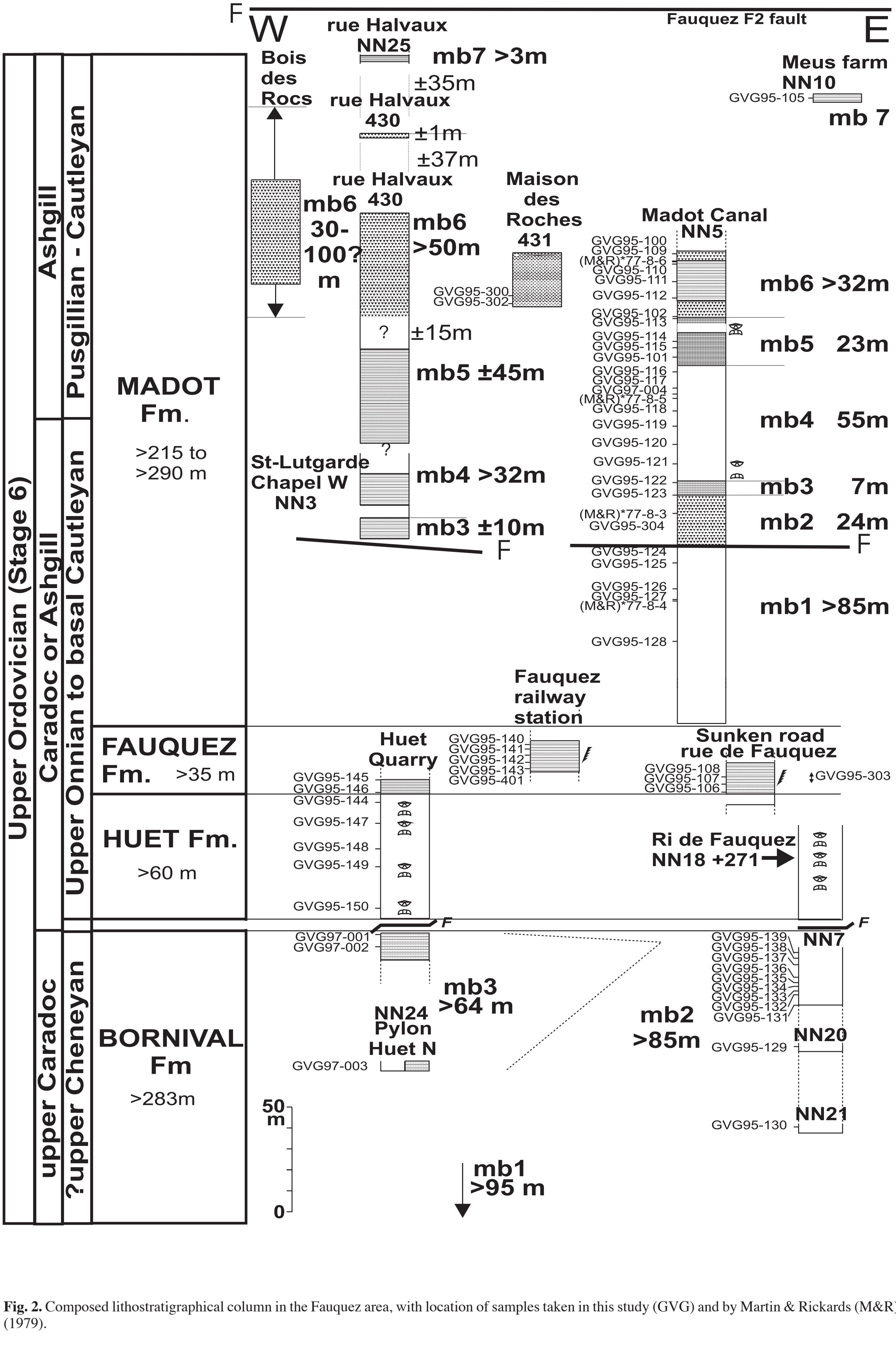

Fig. 2. Composed lithostratigraphical column in the Fauquez area, with location of samples taken in this study (GVG) and by Martin & Rickards (M&R) (1979).

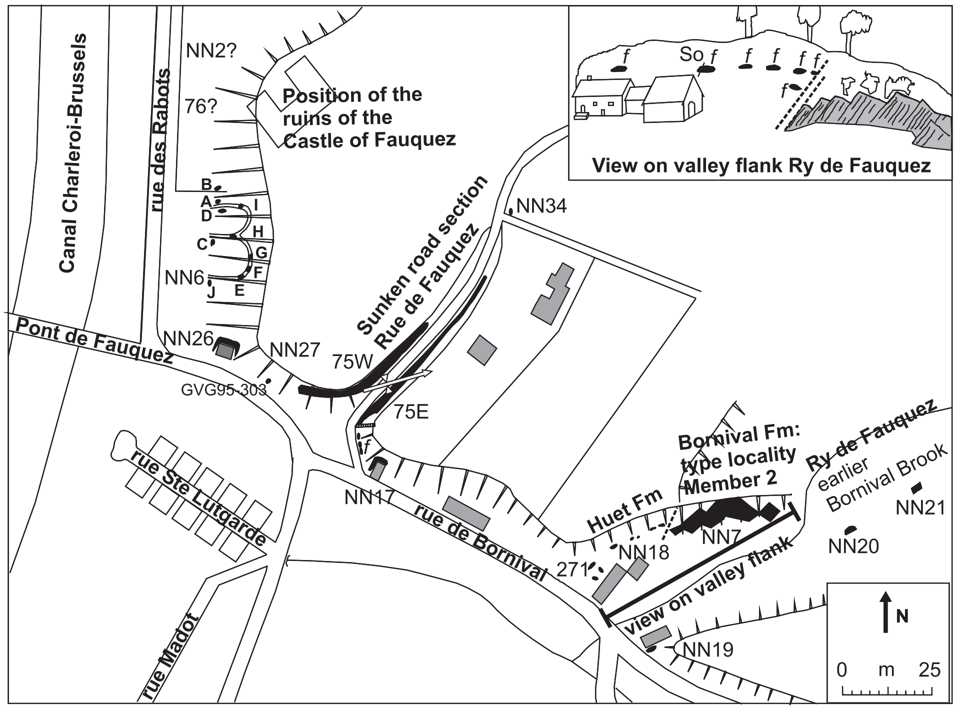

Fig. 3 Detailed location map of the outcrops around the sunken road section (rue de Fauquez), type locality of the Fauquez Formation and the outcrops along the rue de Bornival and the Ri de Fauquez brook, type locality of the Bornival Formation (member 2). Inset shows a drawing of the NW-flank of the Ri de Fauquez valley.

3.2.2. Historical record

The unit was informally mentioned for the first time as "laminated siltstone and mudstone" by Van Grootel *et al.* (1997) and briefly described in Verniers *et al.* (2001). The formation and Members 2 and 3 are described in more detail in this paper, while Member 1 is described in Vanmeirhaeghe *et al.* (this volume).

3.2.3. Limits

The upper limit, supposedly with the overlying Huet Formation, is inferred only by fault contact in four places (F1 observed in outcrop 128E78, F1 between outcrops NN7 and NN18; F1 inferred between outcrops 128E75 and NN34. Also a fault contact of F1 was observed with the Fauquez Formation in outcrop 128E74. The lower contact with the Ittre Formation, probably fault related, is visible outside the study area along the Asquempont canal section, 1.2 km N of the Fauquez canal bridge (Debacker *et al.*, 2001). As a consequence neither the top nor the base of the formation has been observed. The upper part of the formation is visible in the Senne Valley (Herbosch, this volume).

3.2.4. Subdivisions

The Bornival Formation is divided in three members.

3.2.5. Lithology

The Bornival Formation consists of a centimetric alternation of dark grey mudstone and dark grey to blackish claystone with gradual transitions. In the clayey part abundant coarse silt grains are distributed throughout. Occasional sandstone beds are not thicker than ten cm.

a) Member 1 (also called informally the laminites member) is described by Debacker *et al.* (2001), Verniers *et al.* (2001), and more in detail by Van Noten (2004 ms; see Vanmeirhaeghe *et al.* this volume), about one km North of the study area in the Asquempont canal section, as centimetric alternations of light to medium grey fine-grained sandstone, siltstone to mudstone with dark grey to black mudstone. The member contains centimetric to millimetric light grey mudstone "lenses", irregularly distributed in the dark grey mudstone. The beds appear to have a fine-grained distal turbiditic nature, with individual sequences of 1 to 4 cm, which is less apparent for the two other members of the formation.

b) Member 2, the middle member, is characterised by a centimetric alternation of black to dark grey mudstone and claystone with apparent quartz silt grains. Some of the bedding planes show small-scale ripples which are crenulated by a cleavage. Some isolated patches do occur of millimetric to sub-millimetric pyrite crystals, parallel to the bedding. This member differs from member 1 by consisting of less distinct alternations of dark grey mudstone to dark grey or black claystone. No fragments of macrofossils have so far been observed. The outcrops in the Ri de Fauquez (outcrop NN7) are the type section for this unit. Fig. 3 shows a schematic section of the type section and surrounding outcrops. The minimum thickness of the member 2 is estimated at 85 m based on the distance, direction and dips in the outcrops NN7, NN20 and NN21 and assuming a constant dip between NN7 and NN20.

c) Member 3, the upper member, consists of very dark grey to black slate with a very faint centimetric alternation caused by changing concentrations of fine silt grains in the black clayey matrix. This member is present in the northern part of the railway section at the Huet quarry and in the small outcrop NW (NN15, NN24) of the high tension pylon. The upper limit of this member with the Huet Formation in 128E78 is formed by a 30 cm wide moderately to steeply South-dipping normal fault (F1). The contact with the underlying member 2 has not been observed. The thickness of this member is estimated cartographically at 64 m. In the northern railway cut of 128E78 only about 15 m of this member can be observed but it is also present in the small outcrop NN24 to NW of the pylon, North of 128E78. At the base of the pylon three debris piles are visible with rock fragment from the holes dug for the concrete foundations. The southern and western debris piles consist of fragments of the member 3 while the pile around the northern foundation shows a mixture of member 2 and member 3 lithologies. Our estimation of the thickness of the member 2 is based on the assumption that the limit between the two members of the Bornival Formation is somewhere around the northern pylon foundation.

3.2.6. Thickness

The thickness of the formation is estimated at minimum 283 m; > 134 m for member 1, >85 m for member 2, and about 64 m for member 3.

3.2.7. Bio- and chronostratigraphy
Rare specimens of brachiopods and ichnofossils have recently been found in member 1 by one of us (TDB). The only other fossil groups so far found are chitinozoans recovered during this study. There is a significant break in composition of the chitinozoan assemblages in comparison with the three covering formations: the assemblages are much poorer and contain no *Lagenochitina baltica* or *L. prussica* (in contrast to the three covering formations). The observed contact between the Huet and the Bornival formations is a fault contact (F1 and F3). The nature of the hiatus has not yet been determined (Van Grootel *et al.*, 1997; Van Grootel & Verniers, 1998; Verniers *et al.* 2001). The restudy with chitinozoans by Vanmeirhaeghe *et al.* (this volume) indicates a probable mid Oandu (early "Stage 6", mid to late Caradoc **add new British substages**) age for the formation.

3.3. Huet Formation

3.3.1. Origin of the name
After the Huet quarry called after the name of its owner at the end of the nineteenth century; an abandoned excavation, now on private grounds on the East side of a small hill in the Sennette valley, 250 m North of the bridge at the location of the former Fauquez railway station.

3.3.2. Historical record
Previously described as "fossiliferous grauwacke of Fauquez" (see above in chapter 2). The name Huet for the unit was informally mentioned for the first time in Van Grootel *et al.* (1997) and described in Verniers *et al.* (2001). It is formally described in the present study.

3.3.3. Type section
The Huet quarry and the talus of the abandoned railway track, between 230 m and 300 m North of the railway bridge of Fauquez (outcrop 128E78; Fig. 7). Other representative outcrops: 'Ri de Fauquez' section, slope on the left bank between the 'rue de Bornival' and South of the fault contact (F1) with the southernmost outcrop of the Bornival Formation (outcrops 128E271 and NN18).

3.3.4. Limits
The base of the Huet Formation is not observed. In the type section the Huet Formation is separated from the member 2 of the Bornival Formation by a moderately to steeply South-dipping normal fault (F1) as it is also the case in the Ri de Fauquez section were a fault (F1) separates the Huet Formation from the member 2 of the underlying Bornival Formation. The upper limit is quite abrupt with the Fauquez Formation (observed in 128E75 and in 128E7; inferred between 128E74 and NN19). There are also other fault contacts with F4 (NN27, NN6).

3.3.5. Subdivisions
The Huet Formation has no subdivisions.

3.3.6. Lithology
The formation consists of heterogeneous metric beds, often with a slightly undulating base, of poorly sorted greenish to grey mudstone and fine sandstone. Characteristic is the presence of orange-yellow alveoli of decalcified fossil fragment. At some levels very faint cross-bedding can be observed. Each bed shows a fining upward tendency. A turbiditic origin can be excluded because of the absence of characteristic Bouma sequences. The macrofossils indicate a shallow shelf environment (P. Sartenaer, pers. comm. 2000), and are often fragmented and concentrated mostly at the bases of the beds, but sometimes concentrated at certain levels within a sequence. A tempestite environment of deposition, above storm wave base, is postulated.

3.3.7. Thickness
The observed thickness of the Huet Formation in the type locality is minimum 45 m. In the outcrops in the 'Ri de Fauquez' valley at the right bank of the Sennette about 43 m of Huet Formation can be observed.

3.3.8. Bio- and chronostratigraphy
Macrofossil evidence from literature (see above) suggests a Caradoc or Ashgill age for the formation. Regnell (1951) described from the Huet Quarry at least two cystoid species: *Echinospaerites barrandei belgicus* and *Haplosphaeronis proiciens*, indicating the upper Caradoc. On the field we only found the following poorly preserved groups (in decreasing order of frequency): crinoids, bryozoans, brachiopods and trilobites. In the preliminary study with chitinozoans an uppermost Oandu and lower Vormsi (Baltoscandian) stage was concluded by Van Grootel *et al.* (1997) and Van Grootel & Verniers (1998) and repeated in Verniers *et al.* (2001). The redeterminations of the latter chitinozoans and study of new samples by Vanmeirhaeghe *et al.* (this volume) indicate an Onnian (latest Caradoc, Late Ordovician) age, but a Pusgillian to earliest Cautleyan age cannot be excluded for the Huet Formation.

3.4. Fauquez Formation

3.4.1. Origin of the name
The hamlet Fauquez is located on both sides of the Sennette river, on the boundary between Ittre and Ronquières. The (old) spelling 'Fauquez' is used for this unit as by the administration and in the literature, although another spelling, Fauqué, has been used recently on topographical maps (Fig. 1).

3.4.2. Historical record
This unit, already known in literature since Malaise (1873), was previously described as "schistes noirs de Fauquez" or "fossiliferous grauwacke of Fauquez" (Maillieux, 1926) (see above in chapter 2), or "Formation de Fauquez" (Herbosch *et al.* (1991, Fig. 6) and more formally by Van Grootel *et al.* (1997).

3.4.3. Type section
The type section of the Fauquez Formation is in the rue de Fauquez, known as the 'sunken road section of Fauquez', 128E75 (see Figs 3 & 4). Other representative outcrops: 128E270, 128E295, 128E-NN6 and the southernmost part of the railway cut 128E78.

3.4.4. Limits
The base of the Fauquez Formation is present in three outcrops: the West side of the 'sunken road section of Fauquez' section (128E75) also in the East side at the location of a stone stairway and in the southern part of the railway cut at the Huet quarry (128E78). The transition in both outcrops is quite abrupt, with a clear change in granulometry, colour and thickness of the beds which changes from decimetric in the Huet Formation to centimetric and even millimetric in the Fauquez Formation. The upper limit of the Fauquez Formation was not observed directly (see below).

3.4.5. Thickness
The maximal thickness of the formation can be observed in the railway cut South and North of the railway bridge at the location of the former Fauquez railway station. At least 35 m of the formation is observed through the syncline and

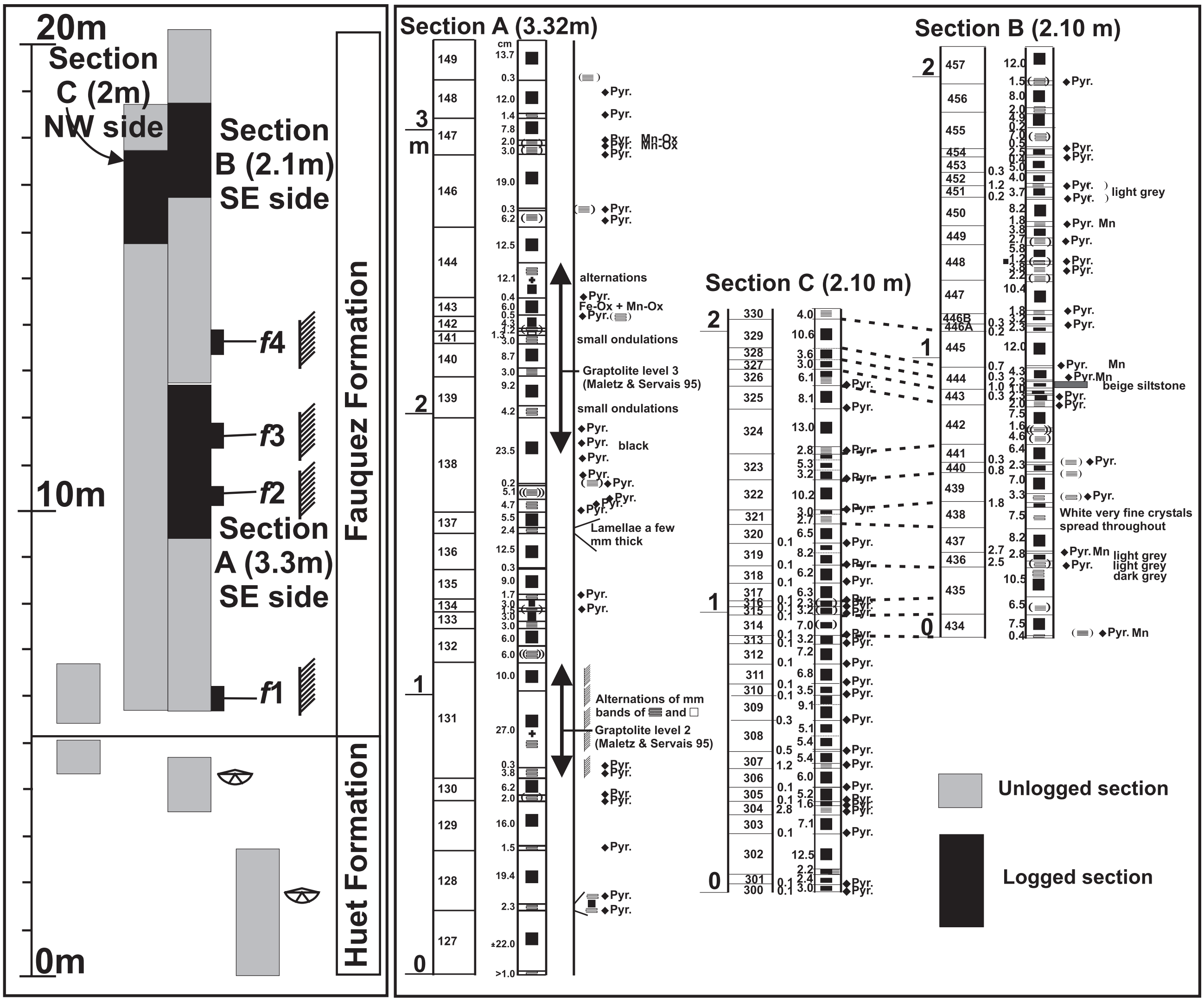

Fig. 4. (left) General lithostratigraphical column of the outcrops in the sunken road of rue de Fauquez through the Huet and Fauquez formations, with location of the detailed logged sections A, B and C; *f*1 to *f*4: graptolite levels collected and determined by Maletz & Servais (1998); (right) Detailed logged sections: Section A: SE-side of sunken road, just North of the flight of steps in stone and under an overhanging cliff and North of a fault; Section B: SE-side of sunken road, more to the North in the centre of the syncline; Section C: NW-side of sunken road in the centre of the syncline; correlation between B and C: top bed 445 = top bed 329, top bed 438 = top bed 321, basis 434 = 314. Black squares: compact stratification; black diamond: pyrite rich level; parallel lines: laminated stratification; between brackets: only slightly present; between two pair of brackets: vaguely present.

anticline couple and the several small faults South of the railway bridge, but the formation is probably thicker. This is confirmed by the Lessines borehole where this unit shows a thickness of at least 60 m (fault contact)(Herbosch *et al.* 1991).

3.4.6. Lithology

The characteristic elements of the Fauquez Formation are the fine and vague rhythmicity, enhanced by the numerous pyrite levels, the dark colour and the presence of graptolite rich levels. The lithology consists of centimetric to subcentimetric alternations of black slate with dark grey to blackish fine silty levels. Very rarely a thin layer can contain a volcanosedimentary ash or volcanic cryst admixture (see Fig. 4). The stratification is very well discernible by the abundant levels of millimetric to sub-millimetric pyrite crystals, indicating the base of each sedimentary sequence. From about 4 m above the base, both in the type section and in the Huet quarry, graptolites are or were found and particularly abundant in the W-talus of the Fauquez station section (128E270), in outcrop 128E75 (non-hammering site), in the South part of outcrop NN6 (J) and behind the electric power building (F. Martin, pers. comm., 1976) now covered (NN26). Fig. 4 illustrates the typical lithology of the Fauquez Formation with two detailed logs from the type section. The sedimentary sequences of this formation were interpreted as clayey-silty low density turbidites in an anoxic environment by Herbosch *et al.* (1991).

3.4.7. Bio- and chronostratigraphy

At first the graptolites in the formation were thought to indicate the Llandovery *scalaris* biozone (Malaise, 1873). Leriche (1920) placed the graptolites from the type section in the upper Caradoc. Elles *in* Maillieux (1926, 1930) attributed the graptolite fauna to the *linearis* or the *clingani* biozones. In spite of the reservations made by Maillieux (*ibid.*) the rocks became known as the black mudstone of Fauquez with *Pleurograptus linearis*. Bulman (1950) confirms the statement of the latter author that the Fauquez fauna probably belongs to the *Pleurograptus linearis* biozone, with a possible fragment of the index fossil. He mentions, however, that the graptolites of the same formation in the Lessines quarry are probably to be referred to the *Dicranograptus clingani* biozone, which would imply that the formation starts earlier in Lessines than in the study area (see also Verniers *et al.*, 2000). Erdtmann (1991) noted an early Caradoc age for the sunken road outcrop (128E75). Maletz & Servais (1998) attribute the rocks to the *clingani* or *linearis* biozone on the

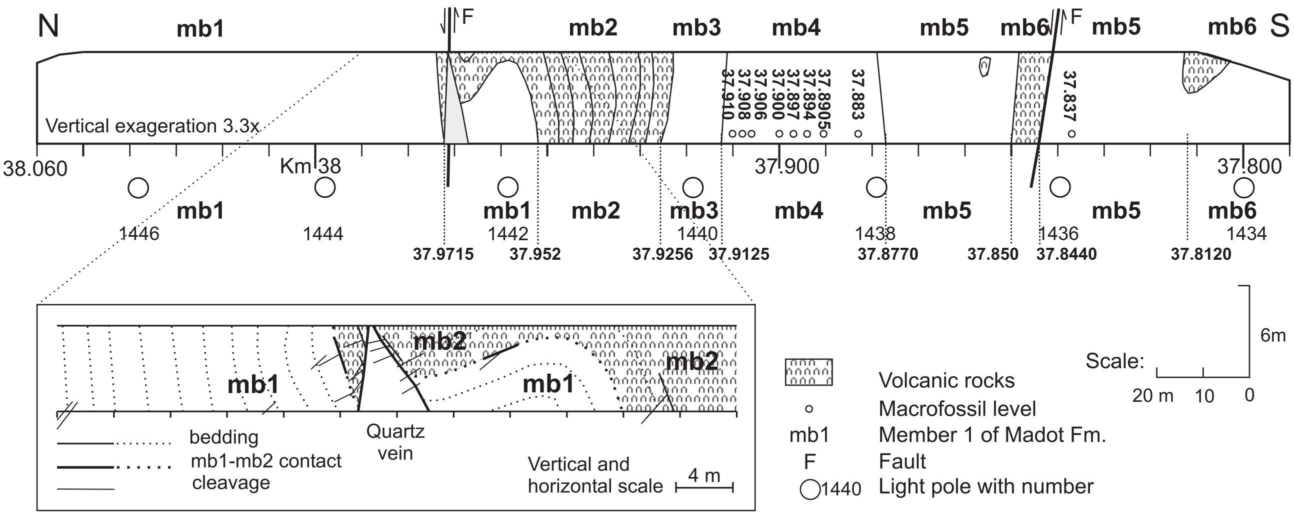

Fig. 5. Schematic section along the Madot canal section, the type locality of the Madot Formation, with members 1 to 6. The distances are measured from to milestone Km 38 along eastern side of the canal. Two relatively small normal faults are shown. The northern one corresponds to the quartz vein, and has a true dip-slip displacement. The southern fault, only observed by one of the authors (GVG), has unknown kinematics. However, judging from the fault dip, and the repetition of members 5 and 6, a normal movement with a down-throw towards the north seems likely.

base of the assemblage, however, without the presence of the nominal species. This corresponds in the Ordovician chronostratigraphy (Fortey *et al.*, 1995, 2000; Webby, 1998) with the uppermost Burrellian to lowermost Pusgillian (upper Caradoc to lowermost Ashgill). The preliminary study with chitinozoans indicated an upper Vormsi to lower Pirgu in terms of Baltoscandian stages, uppermost Caradoc to lowermost Ashgill (Van Grootel *et al.*, 1997; Van Grootel & Verniers, 1998; Verniers *et al.*, 2001). The redeterminations of the latter chitinozoans and study of new samples by Vanmeirhaeghe *et al.* (this volume) indicate an Onnian (latest Caradoc, Late Ordovician) age, but a Pusgillian to earliest Cautleyan age cannot be excluded for the Fauquez Formation.

3.5. Madot Formation

3.5.1. Origin of the name

The Madot hill East of the canal, SE of the Fauquez canal bridge.

3.5.2. Type sections

Madot canal section between km 37.980 and km 38.080, South of the Fauquez canal bridge, for the members 1 to 6, Bois des Rocs, SW of the Madot Hill for member 6 and outcrop NN10, along the road leading to the Meus Farm, and outcrop NN25, SSW of Fauquez, for member 7.

3.5.3. Historical record

The name Madot for the unit was informally mentioned for the first time in Van Grootel *et al.* (1997) and described in the overview of the Lower Palaeozoic formations of Belgium in Verniers *et al.* (2001). It is described for the first time in detail in the present study.

3.5.4. Limits

The base and top of the formation are not observed: in the Sennette valley to the South or to its top the Madot Formation is limited by the Fauquez fault (=F2), not observed but located in a depression. The base is located in the horizontal observation gap of about 55 m between the northernmost outcrop of the Madot Formation (NN5) and the southernmost outcrop of the Fauquez Formation in a bike trail leading to the canal at the SE-side of the Fauquez canal bridge NN35.

3.5.5. Subdivisions

The Madot Formation is subdivided in 7 members. The members 1 to 6 form the continuous outcrop along the canal section, the member 7 is present in two outcrops (NN10 and NN25) South of the volcanic rocks on both sides of the canal.

3.5.6. Lithology

a) Member 1 is present over a distance of 90 m in the canal section, between km 38.060 and 37.9725. It consists of dark grey to bluish mudstone and fine siltstone. So far we have not been able to distinguish the stratification in this unit. Typical is the omnipresence of coarse sandy grains or patches of it up to 25 cm length giving the rock a very heterogeneous aspect. We interpret these grains and patches as volcanoclastic material incorporated in the mud matrix. Because no stratification is observed, but the contact between member 1 and member 2 is quite sharp and subvertical, an estimation of the thickness by extrapolation of its dip to the whole of member 1 gives a tentative thickness of about 85 m.

b) Member 2 consist of at least 7 fining upward sequences (numbered V1 to V7) of poorly sorted grey greenish mudstone, sandstone and conglomeratic levels of volcanoclastic origin (see Fig. 6), of 26 m total thickness, between km 37.9715 and 37.9256. The erosive bases of the sequences V2, V3 and V4 are good indicators for the polarity of the sediments. None of the sequences show the typical Bouma pattern of a turbidite. The top of sequence V6 consist of 12.5 cm black mudstone in which Martin *in* Martin & Rickards (1979) described acritarchs. A large quartz vein is present just above the base of this member in outcrop NN5. This vein is very steeply dipping to the South and experienced a small down throw to the South (see Fig. 5). Within the conglomeratic parts of this member e.g. V3 and V7, centimetric to sub-centimetric mudstone casts occur. To the top of V7 the rock becomes gradually finer, but with its volcanosedimentary aspects still discernible.

c) Member 3 is present between km 37.9256 and 37.9125 and consists of homogenous black to dark grey slate. The overturned contact with the underlying member 2 is distinct and dips 72°NE. It has a thickness of about 7 m.

d) Member 4: at km 37.125 the lithology changes abruptly with a 10 cm thick coarse, breccias-like interval with casts of slate or of probable volcanoclastic origin in a green- greyish heterogeneous coarse siltstone and mudstone.

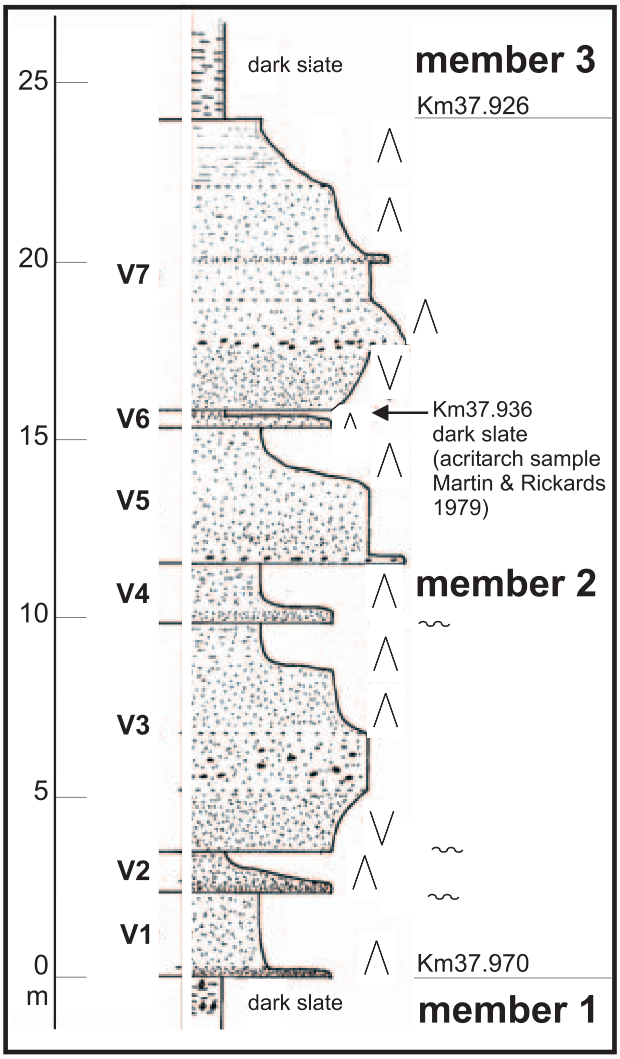

Fig. 6. Detail of lithostratigraphical column of the top of member 1, member 2 (the coarse-grained and fining upward volcanoclastic sequence) and base of member 3 of the Madot Formation in the Madot Canal section. 37.936 km is the sample locality for acritarchs by Martin & Rickards (1979). Numbers like 37.926 km give the location of the boundaries at the level of the road along the canal. Abbreviations: V1 to V7: numbers of successive cycles with fining upward volcanosedimentary sequences.

As in members 1 and 3, no bedding is observable. Distributed throughout the rocks there are levels with numerous macrofossils as bryozoans, brachiopods, crinoids, trilobites, etc. at km 37.910, 37.908, 37.906, 37.900, 37.897, 37.894, 37.8905, 37.883 and 37.837. This unit continues till km 37.877, with an estimated thickness of 45 m where it gradually passes into the overlying member over a thickness of about 10 m. It is also present West of the St-Ludgarde Chapel (outcrop NN3; Fig. 9).

e) The base of the member 5 is placed at km 37.850 where the rocks consist of a dark grey to black mudstone dotted with clusters of light grey grains. In the upper part of the member a coarse sandy bed is present. Within this unit one large boulder of volcanic origin can be observed, near the top of the slope at km 37.855. Legrand (1967) mentioned these boulders in the southernmost part of the canal section. The unit is present till km 37.850 and has an estimated thickness of about 23 m.

f) Member 6 incorporates volcanosedimentary rocks (present between km 37.850-37.844), black mudstone (South of km 37.844) and volcanic rocks of the Bois des Rocs (128E70), the Maison des Roches (128E431), rue Halvaux (128E430) (Fig. 9) and the outcrops 128E71 and 128E504. Parijs (1977) estimated a thickness of at least 100 m for the volcanic rocks of member 6 in the Bois des Rocs itself, while we estimate more than 32m along the Madot canal section.

g) Member 7 occurs South of member 6 on both sides of the canal in two small outcrops (NN10 and NN25) and consists of dark grey to black silty mudstone dotted with brownish to orange alveoli, which are either caused by the dissolution of calcareous fossil fragments or the alteration of volcanoclastic grains or minerals. A very tentative thickness estimate amounts to more than 38 m.

3.5.7. Thickness

As outlined above the apparent thickness of the formation changes over short distances according to the locality. Along the canal the bedding is often not observable. From the available observations we assume that in most of the section the rocks are steeply dipping to overturned. In this assumption the total thickness of the Madot Formation amounts to about 215 m in the Madot canal section and to about 290 m West of the canal.

3.5.8. Bio- and chronostratigraphy

The macrofauna of the Fauquez area, determined earlier by Maillieux (see above) could have been collected in this formation but also in the Huet Formation, because the author did not indicate the exact provenance of the fossil collection. No graptolites were found yet and our recent collections only proved the presence of the following poorly preserved groups in decreasing order of apparent frequency: crinoids, bryozoans, brachiopods, trilobites, corals and pelmatozoans. The macrofossils indicate a shallow shelf environment (P.

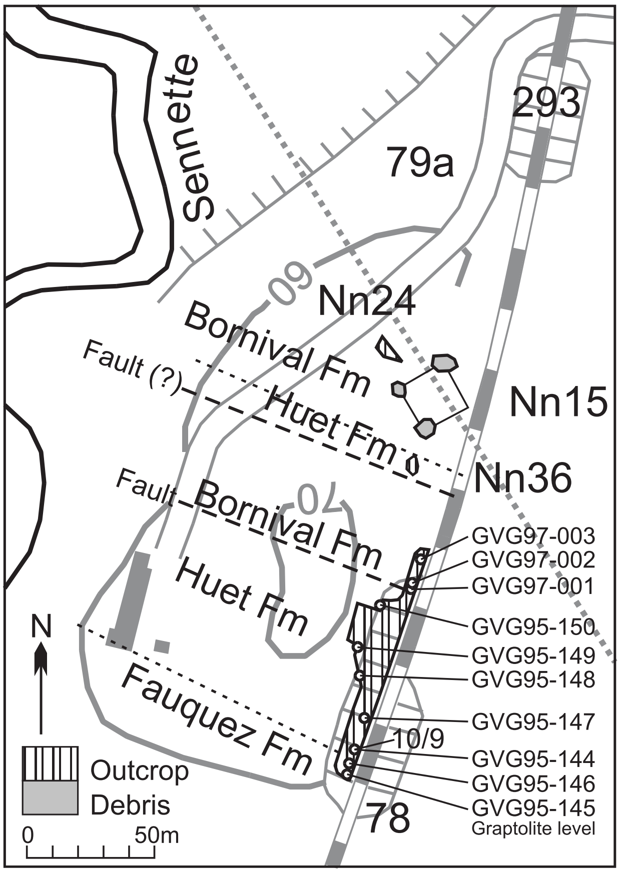

Fig. 7. Detailed location map of the Huet quarry and surroundings, with indication of sampling localities (10/9 is a sign on the outcrop wall taken as a base point, meaning Km 10.900 from the old railway line; *f*: level with macrofauna of bryozoans, brachiopods, crinoids etc.)

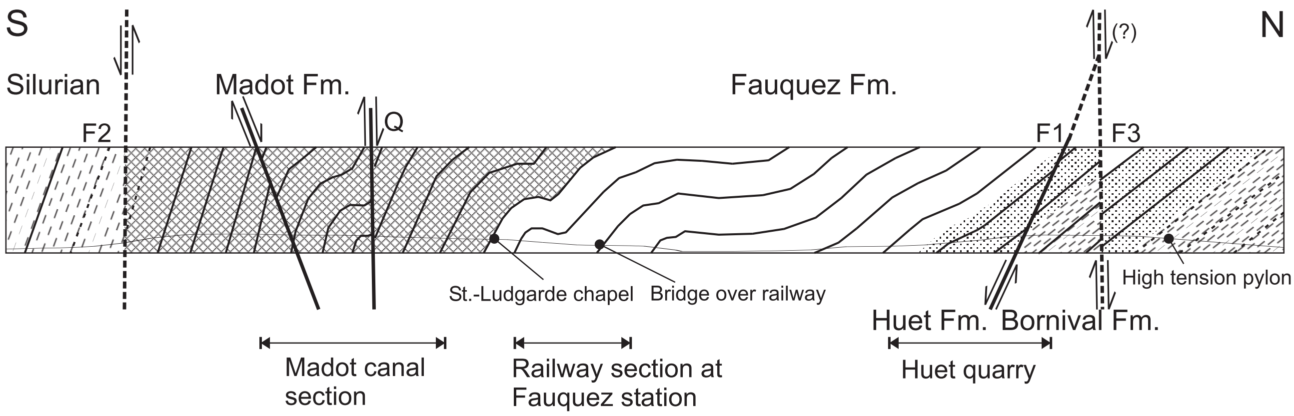

Fig. 8. Generalised section across the Fauquez area, on the western flank of the Sennette valley, along the old railway track, from South of the Maison des Roches till North of the Huet quarry, incorporating the projected Madot section (see Fig. 5). Fault F2 corresponds to the Fauquez fault of Coustry (1930) and Legrand (1967) or the *Faille sud de Fauquez* of Hennebert & Eggermont (2002). The faults F1 and F3 are not separated by Hennebert & Eggermont (2002) and are called the *Faille du Château*. Q: quartz vein within the Madot section.

Sartenaer, pers. comm., 2000). The few acritarchs in four samples recovered from the formation by Martin & Rickards (1979) indicate the broad interval Caradoc to Llandovery. The preliminary study with chitinozoans indicated possibly an uppermost Caradoc but more probably a lower Ashgill, Upper Vormsi or lower Pirgu (Baltoscandian) stage (Van Grootel *et al*., 1997; Van Grootel & Verniers, 1998; Verniers *et al*. 2001). Redeterminations of the latter chitinozoans and study of new samples by Vanmeirhaeghe *et al*. (this volume) indicate for the lower part of the Madot Formation (members 1 to 4 *pro parte*) an Onnian age (latest Caradoc, Late Ordovician), but also a Pusgillian to earliest Cautleyan age cannot be excluded. For the upper part of the formation (members 4 *pro parte* to 6) an early to middle Ashgill age is proposed (Pusgillian to Cautleyan). Member 7, palaeontologically unstudied yet, remains undated. The new data of the chitinozoan imply that part of the volcanic activity in the Madot Formation happened in the Onnian (latest Caradoc) and partly in the early or middle Ashgill, which is slightly earlier than postulated previously (*e.g*. Van Grootel et al., 1997).

4. Geological map and structural architecture

Van Grootel & Verniers (1998) presented a preliminary geological map of the area mainly based on lithostratigraphical mapping. This was corrected using the structural data by Debacker (2001). The geological map (Fig. 10) presented here is an improvement of the earlier versions. It is based on the lithostratigraphy described above and on our measurements of bedding and structural elements (cleavage, cleavage/bedding intersection, fold hinge lines, faults). The Upper Ordovician rocks of the Fauquez area are deformed into a kilometre-scale, open, S-verging, subhorizontal to gently plunging, non-cylindrical antiformal stepfold, which is defined as the Fauquez antiform (Debacker, 2001; compare with Hennebert & Eggermont, 2002). The hinge zone of this stepfold contains numerous small (metre to decametre-scale) gentle to close parasitic folds (e.g.: outcrops 128E270, 128E295, southern part of 128E75 and northern part of NN5). Cleavage/fold relationships in the open to close folds point to a cogenetic relationship with cleavage development (Debacker, 2001; compare with Sintubin, 1997, 1999). However, apart from the rather unusual gentle E-plunge of the small-scale open to close folds (e.g.: NN6, 128E270, 128E295, southern part of 128E75) and of some gentle folds (undulations in middle part of 128E75 and in 128E74), many open to close folds have a distinct non-cylindrical shape (very pronounced in outcrop NN6).

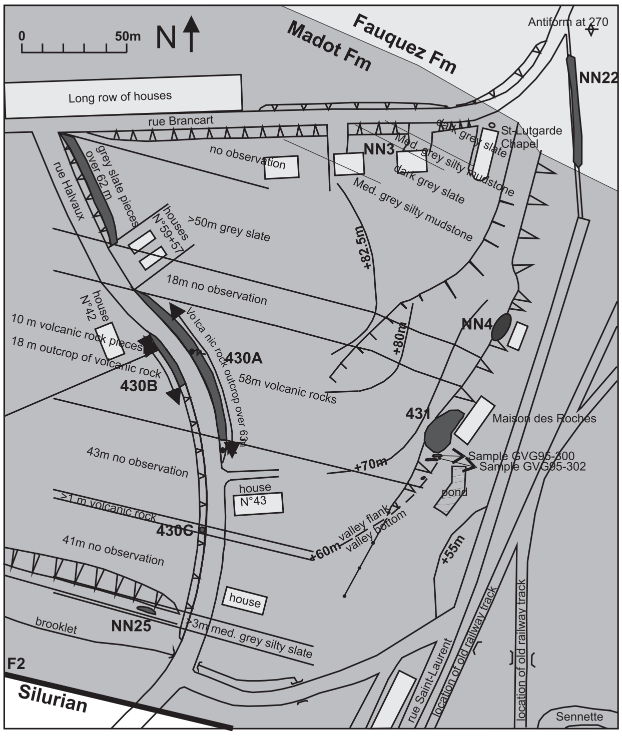

Fig. 9. Detailed location map of the outcrops W of Saint Ludgarde Chapel, and in the rue Brancart, rue Alvaux, around Maison des Roches and surroundings. Grey shading indicates the probable extent of the Madot Formation.

In contrast to Sintubin (1999), we see no evidence for more than one tectonic cleavage in the Fauquez area. There is no regionally consistent cleavage transection across the Fauquez antiform. Instead, the sense of cleavage transection seems to be influenced by the non-cylindricity of the smaller folds: often, cleavage transection changes from fold to fold, due to the changing orientation of the fold hinge lines. Although much more pronounced in the Fauquez area, this particular disposition is somewhat comparable to the Ronquières synform (Debacker *et al*., 1999). However, whereas in the Ronquières synform there is no evidence for a non-coaxial, lateral deformation, the pronounced non-cylindricity of some of the smaller, E-plunging folds in the Fauquez antiform (e.g. outcrop NN6) is compatible with a syn-cleavage and syn-folding dextral shear (Debacker, 2001). Such a dextral movement might result from the unequal

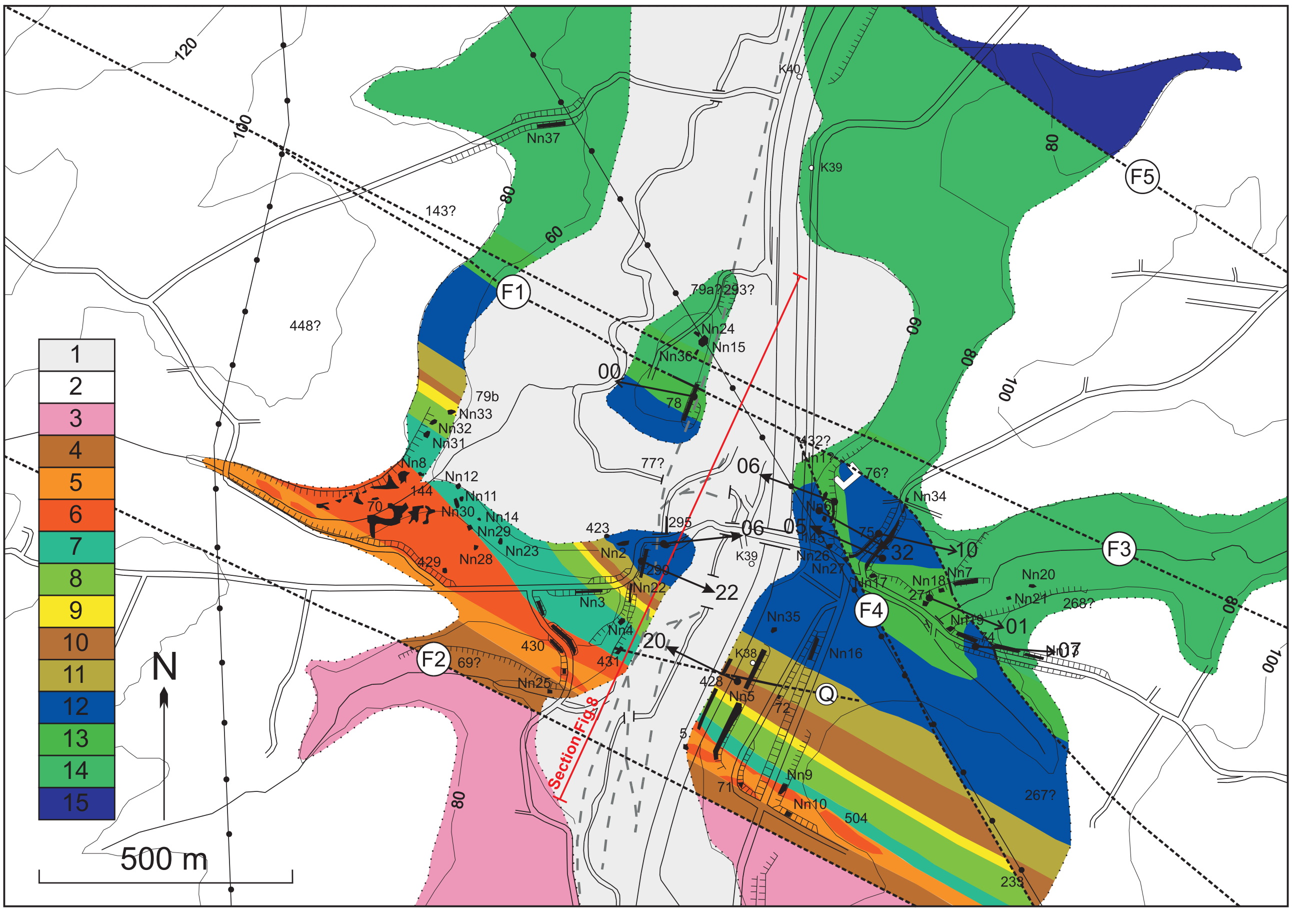

Fig. 10. Geological map of the Fauquez area on scale 1/10.000. Symbols: 1: Holocene alluvia; 2: Cenozoic deposits; 3: Silurian units; 4-11: different members in the Madot Formation; 4: member 7; 5: member 6; 6: volcanic rocks in member 6; 7: member 5; 8: member 4; 9: member 3; 10: member 2; 11: member 1; 12: Fauquez Formation; 13: Huet Formation; 14: Bornival Formation; 15: Ittre Formation.

distribution of the volcanic bodies of the Madot Formation. The presence of a thicker volcanic body in member 7 in the Bois des Rocs, West of the Sennette valley, in comparison to the East of the valley, may have resulted in a ductile dextral movement in the eastern part of the area.

Several large faults cut the Fauquez antiform (Figs 10 & 11). The moderately to steeply S-dipping fault F1,(with a dip-slip movement) brings the Bornival Formation in contact with two younger formations. The trace of this post-cleavage, normal fault is well constrained (observed in 128E78 and between NN18 and NN7, 128E74, deduced between 128E75 and NN34). Its displacement can be estimated at minimum 100 m. The southernmost fault F2 (Fauquez fault of Coustry, 1930 and Legrand, 1967; the *Faille Sud de Fauquez* of Hennebert & Eggermont, 2002) cannot be observed in outcrop but forms the limit between middle Ashgill (Madot Fm, member 7) and upper Telychian rocks (Verniers, unpublished data). Although representing a large stratigraphical gap, its throw remains unknown. If we presume a subvertical to steeply S-dipping orientation, with a down-throw towards the South (normal), this fault should have a throw of several hundred metres up to one kilometre. On the basis of a small outcrop of the Huet Formation to the SW of the high-tension pylon to the north of Huet quarry (outcrop NN36), a third fault is proposed, F3, with a down-throw to the North and a displacement comparable to that of F1. The *Faille du Château* of Hennebert & Eggermont (2002) approximately coincides with our faults F1 and F3. The contact between the Huet Formation (E) and the Fauquez Formation (W) along the E-side of the valley is formed locally by a NW-SE-trending normal fault, F4, dipping moderately to the SW, as observed by one of the authors (GVG). Its maximum displacement is several tens of meters. Possibly this fault forms a splay of F1, being parallel to its south-eastern part. In the north-eastern part of the map, another fault is shown, F5, which forms the limit between the Bornival Formation to the South and the Ittre Formation to the North. This steeply N-dipping fault, with a down-throw to the North of minimum 100 metres, was taken from Debacker *et al.* (2001; F6 *in* Debacker, 2001). We have not found indications for the *Faille nord de Fauquez* of Hennebert & Eggermont (2002).

The wide-spread post-cleavage normal faulting in the Fauquez area is compatible with the small-scale, down-dip displacement along cleavage planes. Also the thick quartz vein in outcrop NN5 (Fig. 5; Q on Fig. 10) testifies of a (small) post-cleavage extension, with a down-throw to the North (in the order of two metres). The demonstrated importance of both N and S-dipping normal faults within the Fauquez area contradicts previous views in which the faults in this area have generally been regarded as reverse faults (e.g. Mortelmans, 1955). Also the new geological map of Braine-Le-Comte – Feluy (Hennebert & Eggermont, 2002) still depicts the Fauquez area as an antiform-shaped structure being cut by reverse faults (*Faille du Château* ~ F1 & F3; *Faille Sud de Fauquez* = F2; *Faille nord de Fauquez*), supposedly with an oblique slip displacement, which is incompatible with the outcrop evidence (e.g. see F1).

Recent structural observations have pointed out the importance of post-cleavage, moderate to steep, N- and S-dipping normal faults along the Sennette valley between the Fauquez area in the South and the Asquempont area in the North (Debacker, 2001; Debacker *et al.*, 2003, 2004). These normal faults occur in a NW-SE to WNW-ESE-trending zone, which extends from the Sennette valley, over Quenast (Senne valley) towards Bierghes, and likely represents the

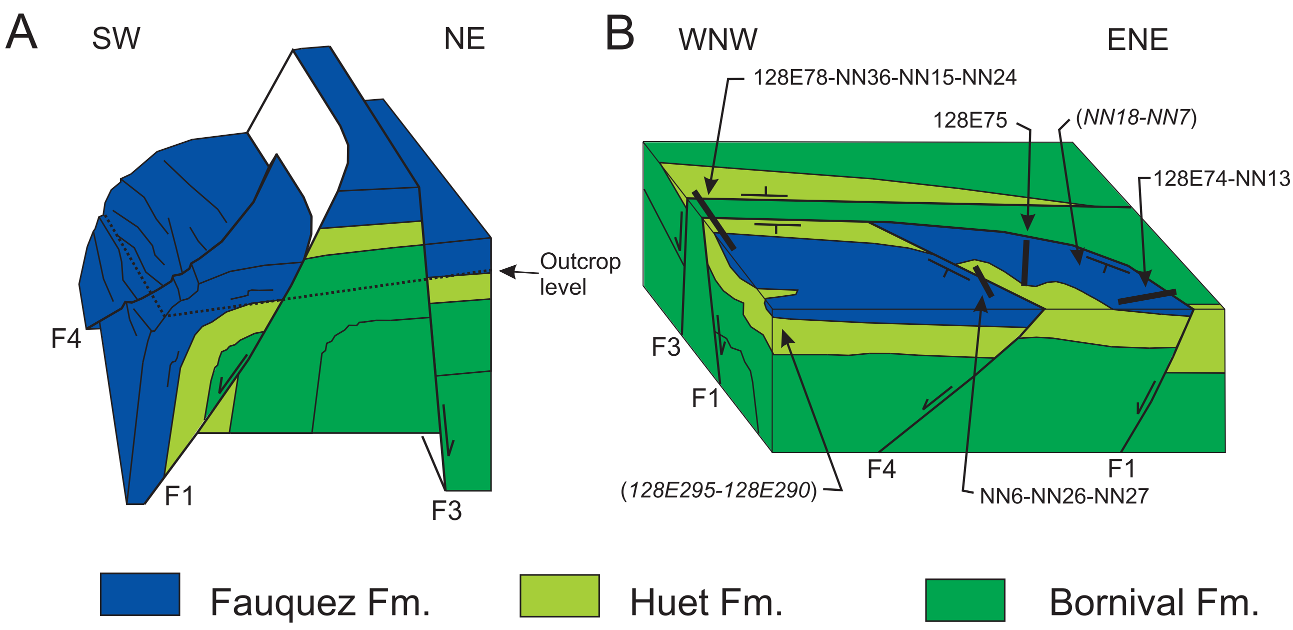

Fig. 11: Schematic block diagrams of the Fauquez antiform (not to scale). A) NW-looking view, showing the position of the smaller-scale parasitic folds in the hinge zone, and the position and relative importance of the different normal faults. B) N-looking view of the Fauquez antiform at the outcrop level marked in A. The approximate position of several outcrops is added for better orientation. Note that for the outcrops written in italic and between brackets, the exact position could not be shown, because of topographic effects or because of being situated just outside of the area.

eastern part of the Nieuwpoort-Asquempont fault zone (Debacker, 2001; see also De Vos *et al.*, 1993; André & Deutsch, 1985; Legrand, 1968). Like in the Asquempont area, also the observations in the Fauquez area suggest that this fault zone is essentially a post-cleavage, normal fault zone, deforming the Lower Palaeozoic basement into a horst-and-graben-like geometry.

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