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THE PRESUMED UPPER ORDOVICIAN GREEN ROCKS AT REBECQ RE-INTERPRETED AS A RESURFACING OF THE CAMBRIAN OISQUERCQ FORMATION (SENNE VALLEY, ANGLO-BRABANT DEFORMATION BELT, BELGIUM)

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(8 figures, 1 table, 1 plate)

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ABSTRACT. Lithological, magnetic and geochemical data do not allow distinguishing the homogenous, green cleaved mudstone at Rebecq (Senne Valley), defined as the Upper Ordovician Hospice de Rebecq Formation by Herbosch (2005), from those of the Asquempont Member of the Lower to lower Middle Cambrian Oisquercq Formation. Moreover, structural geological considerations and new mapping show that the geology of the Rebecq area is better explained by re-considering the homogenous, green cleaved mudstone at Rebecq as a local resurfacing of the Asquempont Member of the Oisquercq Formation in the footwall of the Asquempont Detachment System. Using this idea, a new geological map is presented of the Rebecq area.
As the rocks at Rebecq, in the type locality of the Hospice de Rebecq Formation, are better re-considered as belonging to the Asquempont Member of the Oisquercq Formation, the name Hospice de Rebecq Formation should be abandoned. This, in turn, implies that also the green rocks of the Grand-Manil area (Orneau Valley), previously considered as belonging to the Hospice de Rebecq Formation, should be renamed. For the latter, we propose the name Cimetière de Grand-Manil Formation.

KEYWORDS: Asquempont Detachment System, Asquempont Member, geochemistry, Lower Palaeozoic, magnetic properties, Oisquercq Formation, stratigraphy

1. Introduction

On the basis of detailed mapping and lithological and sedimentological observations in the Rebecq area (Senne Valley) and in the Grand-Manil area (Orneau Valley) (Fig. 1), Herbosch (2005) introduced a new Ordovician formation. This formation consists of a green, slightly to very homogenous, cleaved mudstone and Herbosch

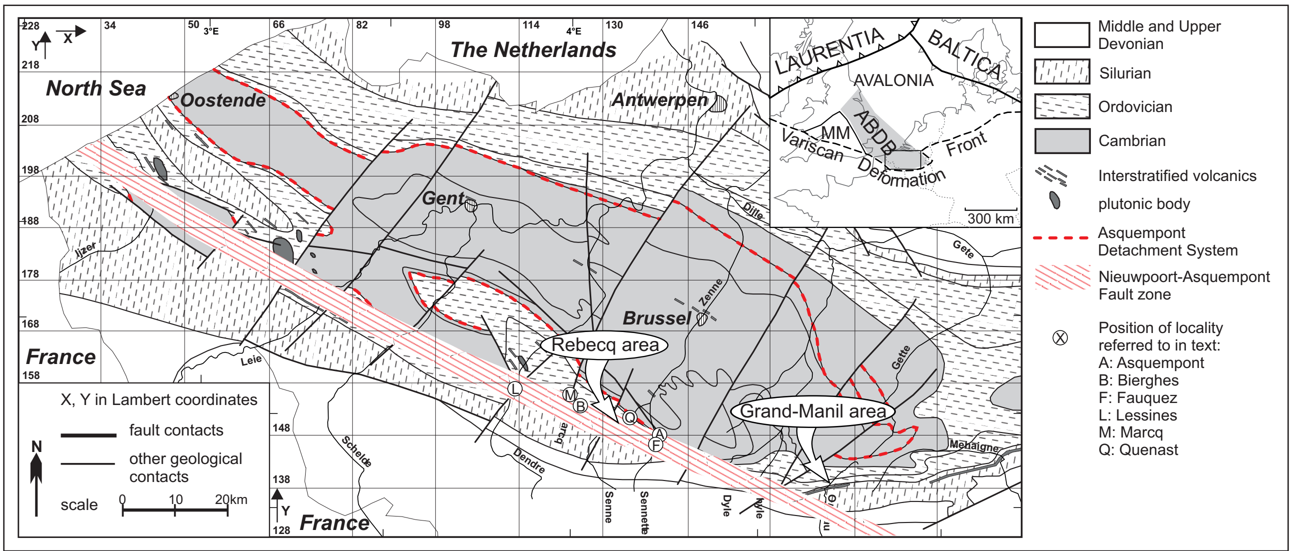

Figure 1. Geological subcrop map of the Brabant Massif (after De Vos et al., 1993 and Van Grootel et al., 1997) showing the position of the two main outcrop areas of the Hospice de Rebecq Formation described by Herbosch (2005): the Rebecq area in the Senne Valley and the Grand-Manil area in the Orneau Valley. Also the position of localities referred to in the text is indicated. The upper right inset shows the position of the Brabant Massif within the Anglo-Brabant Deformation Belt (ABDB) along the NE-side of the Midlands Microcraton (MM) in the context of Avalonia, Baltica and Laurentia.

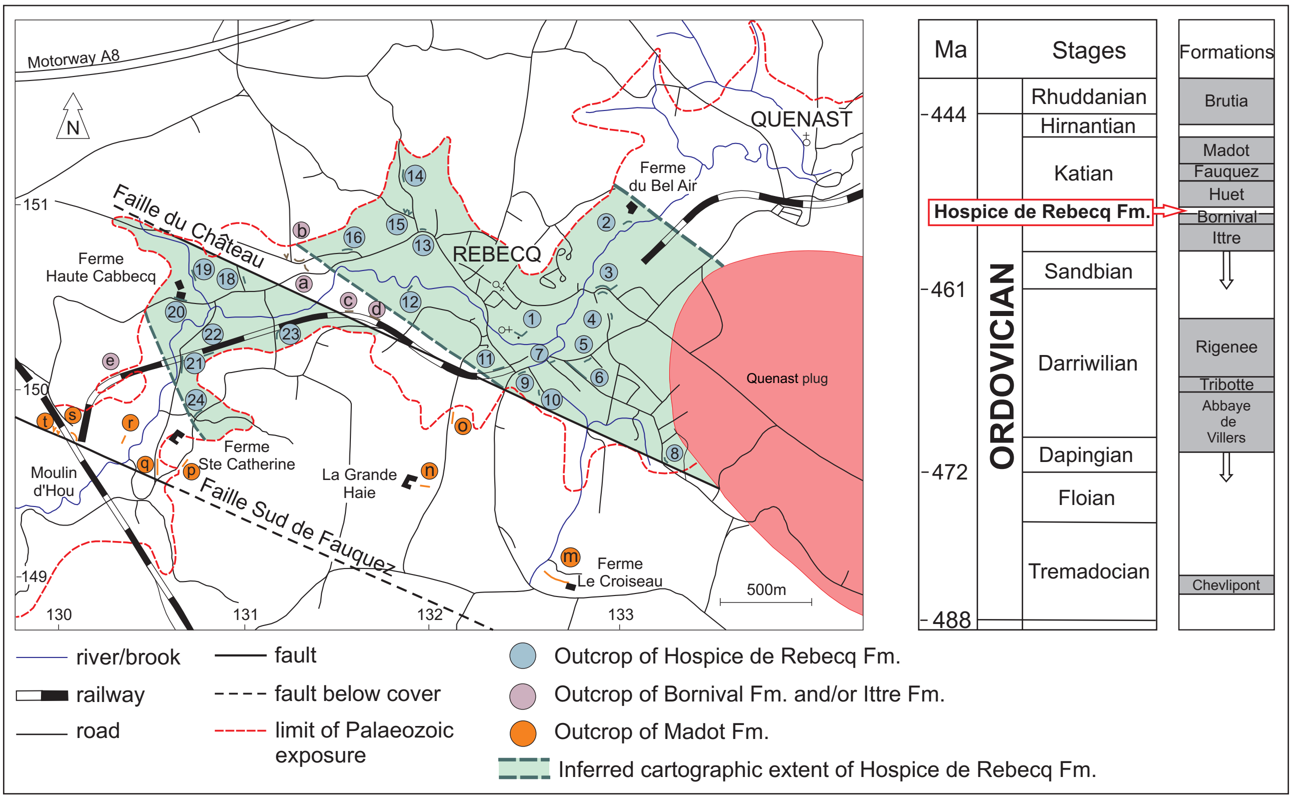

Figure 2. The Hospice de Rebecq Formation in the Senne Valley after Herbosch (2005). Left: Outcrop map of the Hospice de Rebecq Formation, of the Bornival Formation and of the Madot Formation in the Rebecq area between Quenast and Moulin d'Hou. Right: Stratigraphic column of the Ordovician in the Senne Valley. Observation hiatus zones are in white and the stratigraphic position of the Hospice de Rebecq Formation is indicated by an arrow.

(2005) called this formation the Hospice de Rebecq Formation, after a well-preserved outcrop in the garden of the hospice at Rebecq (Senne Valley). Stratigraphically, this formation was placed in the Upper Ordovician, overlying the Bornival Formation and underlying the Huet Formation (see also Verniers et al., 2001) (Fig. 2). Although there is no fossil evidence, this stratigraphic position seems a logical choice, considering the cartographic occurrence and the existing stratigraphy of the Brabant Massif. Indeed, cartographically, the Quenast plug at Rebecq (Senne Valley) is flanked towards its southern and western parts by this homogenous, green mudstone of the Hospice de Rebecq Formation of Herbosch (2005), and both are completely surrounded by

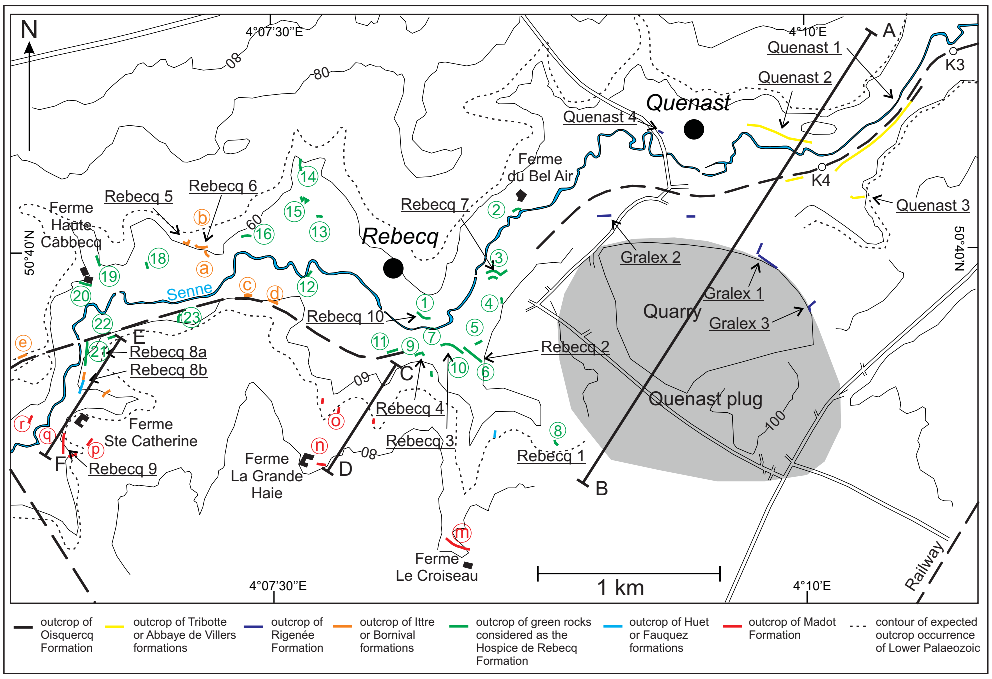

Figure 3. Simplified topographic map of the Quenast-Rebecq area, showing the outcrop distribution of the different lithostratigraphic units, based on mapping by Debacker (2001), Herbosch (2005), Lammertyn (2005), Herbosch et al. (in press) and new observations. Outcrop numbers of Herbosch (2005) are circled, and outcrop names of Debacker & Sintubin (2008) are underlined. Also shown are three section lines, showing the position of the three subsections of the composite section of Fig. 7.

Ordovician formations (Figs 2 & 3). Especially towards the southern parts of the area, Upper Ordovician formations abound (e.g. Bornival Formation, Madot Formation, Herbosch et al., in press) (Figs 2 & 3). Moreover, in the Grand-Manil area (Orneau Valley), a very similar, green mudstone is flanked by the Bornival Formation towards the North and the Huet Formation towards the South (fig. 4 of Herbosch, 2005). In addition, according to the stratigraphy of the Brabant Massif shown in Verniers et al. (2001) and later confirmed by Vanmeirhaeghe et al. (2005), a biostratigraphical hiatus exists between the Bornival Formation and the Huet Formation (Fig. 2). Hence, the positioning of the Hospice de Rebecq Formation by Herbosch (2005) within this hiatus, this being compatible also with the cartographic distribution of the different formations, was accepted by most people involved with the Belgian Lower Palaeozoic and was also formally taken into consideration by the Belgian Palaeozoic stratigraphic committee.

However, within the last two years, new data caused the first author of this paper to start questioning the actual stratigraphic position of the green rocks at Rebecq (e.g. Debacker et al., 2010). In this paper we give an overview of new and existing data that plead a case for re-considering the stratigraphic position of the green rocks at Rebecq, considered by Herbosch (2005) as the Hospice de Rebecq Formation, and provide a new geological map of the Rebecq area that is compatible with this revised stratigraphy. Throughout this paper the name Hospice de Rebecq Formation refers to the Hospice de Rebecq Formation as defined by Herbosch (2005).

2. Geological setting

Both outcrop areas of the Hospice de Rebecq Formation, defined by Herbosch (2005), are situated within the southern part of the Brabant Massif (Fig. 1; De Vos et al., 1993). The Brabant Massif consists of deformed, anchizonal to shallow epizonal, lowermost Cambrian to upper Silurian, mainly fine-grained deposits. It forms the southeasternmost, Belgian part of the Anglo-Brabant Deformation Belt, one of the deformation belts of eastern Avalonia (Van Grootel et al., 1997; Verniers et al., 2002). There is only evidence for one single progressive deformation event, now called the Brabantian deformation event (Debacker et al., 2005a). This deformation event was already happening during the late Llandovery, and continued until the Emsian, possibly even Eifelian (Verniers et al., 2002; Debacker et al., 2005a). This event involved the inversion of a pre-existing basin (the Brabant Basin), and mainly resulted in the development of a regional cleavage and cogenetic folding (Debacker et al., 2005a). There is no evidence of wide-spread reverse faulting at the present-day erosion level (Giese et al., 1997; Debacker et al., 2004a), and thus far only one significant reverse shear zone has been documented, this being at Marcq in the Marcq Valley (Debacker, 1999).

The Rebecq area is situated in the Senne Valley and is regarded as one of the classical outcrop areas of the Brabant Massif, mainly because of the presence of the Quenast plug (Figs 2 & 3). The Quenast plug is a quartz microdiorite, interpreted as a feeder pipe or volcano neck (André & Deutsch, 1984; André, 1991) and intrudes predominantly fine-grained, homogenous Middle to Upper Ordovician siliciclastic deposits (Herbosch *et al.*, in press). At Rebecq, to the South and West of the plug, homogenous, fine-grained mudstone of the Hospice de Rebecq Formation is encountered. Further to the southwest (outcrops Rebecq 5 and 6), the Ittre or Bornival formation occurs, consisting of micaceous, dark blue-grey mudstone with intercalated thin, silty layers (Figs 2, 3 & 4). To the WNW to ENE of the plug (outcrops Gralex 1 to 3, Quenast 4) homogeneous, fine-grained, dark bluish grey to grey mudstone of the Rigenée Formation occurs. To the NE of the plug, the Abbaye de Villers Formation occurs (outcrops Quenast 2 and 3 and southern part Quenast 1), consisting of a centimetric alternation of bioturbated, micaceous creme-coloured to pale-grey fine sandstone and siltstone and dark blue-grey to black mudstone. Further to the NE,

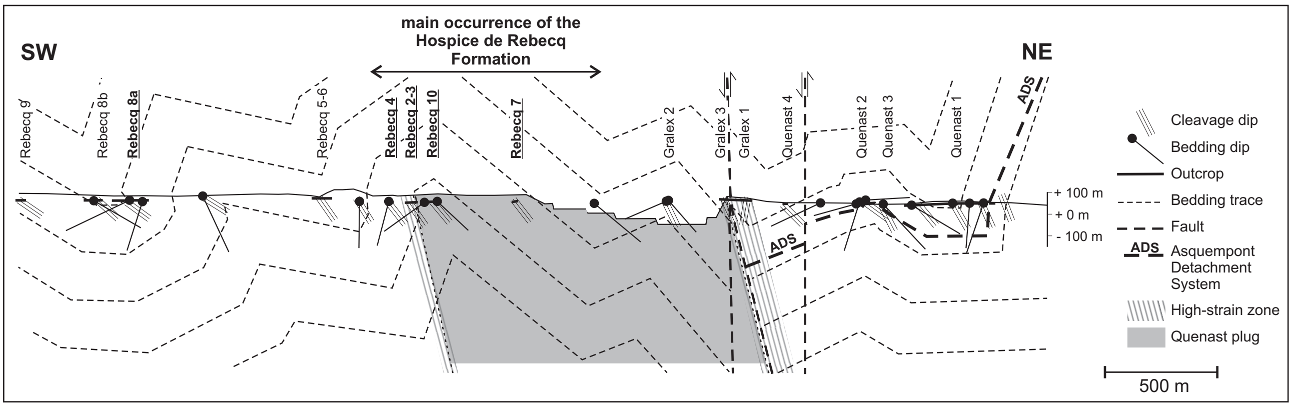

Figure 4. Section across the Rebecq area, showing cleavage and inferred bedding and fold geometry (adapted after Debacker & Sintubin, 2008, in turn partly based on Debacker, 2001, Lammertyn, 2005, Herbosch, 2005 and Herbosch et al., in press). Bedding traces should be regarded merely as guides and do not have any stratigraphic significance. Outcrops of the Hospice de Rebecq Formation are in bold and underlined. Note that the southern part of the section (between outcrops Rebecq 5 and 6 and outcrop Rebecq 9) is geometrically rather poorly constrained, and in the case of outcrop Rebecq 8b, also the lithostratigraphy is uncertain (Upper Ordovician, but still doubt about the formation; see also Lammertyn, 2005 and Herbosch, 2005).

extremely homogenous, greenish grey (S) and dark blue-grey (N) mudstone of the Lower to lower Middle Cambrian Oisquercq Formation occur (outcrop Ripain 1 and northern part of outcrop Quenast 1) (Figs 3 & 4).

Partly due to the relative position to the Quenast plug, the degree of cleavage development strongly varies across the Rebecq area. Because of this, the green cleaved mudstone of the Hospice de Rebecq Formation ranges from mudstone with an embryonic cleavage towards a true slate (Debacker & Sintubin, 2008).

The Quenast – Rebecq area is also renowned for its many fault contacts. The limit between the Oisquercq Formation and the Lower Ordovician to the North of the Quenast plug is formed by the Asquempont Detachment System, a pre-cleavage and pre-folding low-angle extensional detachment, visible in outcrop Quenast 1 (Fig. 4) (Debacker et al., 2003, 2004b; Herbosch et al., in press), and forming part of a detachment system that can be traced all around the core of the Brabant Massif (Debacker et al., 2004b, 2005b; Piessens et al., 2005; Herbosch et al., 2008) (Fig. 1). The Rebecq area is cross-cut also by a large number of steep normal faults, formed after folding and cleavage development. Some of these faults have throws of several hundred meters, and all are thought to form part of the Nieuwpoort-Asquempont fault zone (Debacker et al., 2003, 2004b) (Fig. 1). This fault zone is essentially a WNW-ESE-trending normal fault zone, consisting of N(NE)- and S(SW)-dipping normal faults, of which individual faults are visible in outcrop in the Sennette Valley (Asquempont and Fauquez areas), the Senne Valley (Quenast and Rebecq areas), at Bierghes quarry and in the Dendre Valley (Lessines) (Debacker et al., 2003, 2004b; cf. Legrand, 1968; André & Deutsch, 1985; De Vos et al., 1993) (see Fig. 1 for position).

In the Grand-Manil area in the Orneau Valley, the cartographic distribution of the different lithostratigraphic units is much more straightforward than in the Rebecq area. Across the Grand-Manil area, lithostratigraphic units are dipping gently to steeply to the SSE (see Fig. 4 of Herbosch, 2005) and fault contacts are rare. From North to South, the Ittre and Bornival formations are encountered, followed by the Hospice de Rebecq Formation and the Huet Formation (see also Fig. 2). The Huet Formation is bounded to the South by a more or less strike-parallel, steeply dipping fault, separating this formation from the Madot Formation and hereby removing the Fauquez Formation (see also Verniers et al., 2001 and Fig. 2). To the South of the Madot Formation, the Brutia Formation occurs, representing the basal formation of the Silurian in the Brabant Massif.

3. Analysis of new and existing data

3.1. Lithology

3.1.1. Analysis of pre-existing data

Herbosch (2005) describes the Hospice de Rebecq Formation as: "*….constituée de schistes plus ou moins silteux, le plus généralement massifs, de teinte grise avec une nette nuance verte à l'état frais. Ce qui frappe de prime abord, c'est la nature massive de la roche, c'est-à-dire l'absence de stratification bien visible. En cherchant bien, on finit par trouver de fines laminations millimétriques ou des lits se marquant par des variations de nuances, soit dans les gris clairs, soit dans les verts plus foncés*".

According to the same author, the Hospice de Rebecq Formation in the Rebecq area (Senne Valley) is slightly different from the same formation in the Grand-Manil area (Orneau Valley, see Fig. 1 for position). For the Rebecq area, Herbosch (2005) continues the general description quoted above with: "*Dans la région de Rebecq, ces laminations se marquent très bien sous forme de linéations d'intersection sur les plans de schistosité. La pyrite en fins cristaux cubiques est assez fréquente et explique l'enduit rouille qui couvre la surface des affleurements.*". For the Grand-Manil area, Herbosch (2005) writes: "*Dans la région de Grand-Manil, ces roches montrent globalement le même aspect massif et la même couleur bien qu'elles soient souvent beaucoup plus altérées. Ceci leur donne alors une couleur plus foncée, gris olive à gris-vert foncé. L'altération croissante provoque l'apparition de fines linéoles vert foncé qui deviennent de plus en plus épaisses (cm). Dans cette région, on observe également des niveaux de l'ordre du cm plus silteux à laminations planes-parallèles, obliques ou même convolutes qui forment des séquences granodécroissantes à base nette. Ceci suggère fortement des dépôts formés par des courants de turbidité de forte densité très distaux. La pyrite est plus abondante dans les niveaux silteux.*"

Hence, the original description of the Hospice de Rebecq Formation by Herbosch (2005) clearly mentions a slight difference in colour and overall lithology between the Rebecq and the Grand-Manil areas. In the Rebecq area, a massive, greenish-grey, very homogeneous silty mudstone occurs (photo C in Herbosch, 2005), whereas in the Grand-Manil area the same formation is characterised by a slightly darker greenish-grey to often olive-coloured silty mudstone, in which often more silty beds can be recognised, suggestive of a turbiditic origin (photos D-G in Herbosch, 2005).

3.1.2. New outcrop observations

In the framework of the present study, we re-visited both outcrop areas of the Hospice de Rebecq Formation. Our new observations confirm the original description of Herbosch (2005), but also allow emphasising three clear differences between the green rocks in both outcrop areas. Firstly, although the outcrops in the Grand-Manil area are in a poor condition, and the rocks appear often weathered, bedding can generally be recognised. By contrast, although in the Rebecq area several outcrops are in a much better condition than the best outcrops of the Grand-Manil area, bedding is always extremely difficult to observe in outcrop. Secondly, although not mentioned in Herbosch (2005), we have observed weathered, oxidised, bedding-parallel nodules in the majority of the outcrops in the Grand-Manil area (e.g. photo D on Plate 1). However, such nodules have never been observed in the Rebecq area. Thirdly, the colour of these mudstones to fine-grained siltstones is clearly different between both outcrop areas, with a clear olive-coloured touch in the Grand-Manil area that is not observed in the Rebecq area (compare photo C with photos D-H on Plate 1).

Rocks with the same facies as that of the Hospice de Rebecq Formation at Grand-Manil, have only been encountered at one other outcrop locality of the Brabant Massif. This facies, with similar nodules, has been observed in the upper part of the hill below the former ruins of the Fauquez castle, at Fauquez in the Sennette Valley (outcrops NN6E-I in Verniers et al., 2005). Verniers et al. (2005) tentatively attributed these rocks at Fauquez to the Huet Formation, hereby considering the nodules as alveoli of decalcified fossil fragments.

The facies of the Hospice de Rebecq Formation at Rebecq (see above and Herbosch, 2005) (photo C on Plate 1) fully matches that of the Asquempont Member of the Lower to lower Middle Cambrian Oisquercq Formation. Verniers et al. (2001) describe the Asquempont Member as "greenish grey to green slate and frequently laminated siltstone". The laminated aspect, however, is only found in the upper part of this member (Herbosch et al., in press). Debacker et al. (2004a) add that at Asquempont (Senne Valley), this member consists of greenish grey, porous mudstones, characterised by an extreme lithological homogeneity in which previously only a few bedding planes were ever observed (see photos A and B on Plate 1). In the course of the present study, we re-examined the lithology within the main outcrops of the Hospice de Rebecq Formation in the Rebecq area, and compared this with the lithology of the Asquempont Member. In none of the cases a clear distinction could be made (compare photos A and B with photo C on Plate 1).

3.2. Overall bedding and fold geometry in the Quenast - Rebecq area

Debacker & Sintubin (2008) constructed a cross-section of the Rebecq area in order to illustrate the attitude of the Quenast plug relative to the folded host rocks. On this section (Fig. 4), the deposits are folded into a fold train of hectometre-scale, open, SW-verging folds characterised by relatively long straight limbs and rather narrow hinges. To the North of the Quenast plug, a synform is present, whereas along the southern parts of the plug a large antiform becomes apparent. It is exactly within the zone occupied by this antiform that the majority of the outcrops of the Hospice de Rebecq Formation occur (Fig. 4). Towards the North, this zone is flanked by the Rigenée Formation, the Ittre Formation or the Bornival Formation, whereas towards the South this zone appears to be flanked by the Bornival Formation (Figs 2, 3 & 4). According to Herbosch (2005), all these formations are older than the Hospice de Rebecq Formation (Fig. 2). If indeed the younger formation, like suggested by Herbosch (2005), the occurrence of the Hospice de Rebecq Formation within this antiform would imply a synclinal antiform. Such a structure requires a polyphase deformation history for which there is no evidence (Sintubin, 1999; Debacker et al., 2005; Debacker & Sintubin, 2008). In the case of an anticlinal antiform, however, the Hospice de Rebecq Formation should be older than the surrounding formations, this being incompatible with its stratigraphic position (Fig. 2).

3.3. Magnetic properties

Debacker et al. (2010) investigated the magnetic properties of a variety of lithostratigraphic units of the Brabant Massif. Magnetic techniques employed are the determination (a) of magnetic susceptibility (MS, for methodology, see Ellwood et al., 2000 and references therein), (b) of the temperature-dependent variation in MS within the "room temperature interval" (for methodology, see Herbosch et al., 2008 and Debacker et al., 2009, 2010), (c) of the anisotropy of magnetic susceptibility (AMS) at room temperature (for methodology, see Jelinek & Pokorny, 1997), (d) of the AMS at low temperatures (77°K; for methodology, see Lüneburg et al., 1999 and references therein), (e) of the AMS at high magnetic fields (torque magnetometry; for methodology, see Martín-Hernández & Hirt, 2001 and references therein), (f) of the anisotropy of the anhysteretic remanent magnetism (AARM; for methodology, see McCabe et al., 1985 and Jackson, 1991) and (g) of the magnetic mineralogy by means of a stepwise thermal demagnetisation of a three-axis isothermal remanent magnetism (for methodology, see Lowrie, 1990).

Even when combined, none of these techniques allow distinguishing the green mudstone in the Rebecq area, placed in the Hospice de Rebecq Formation by Herbosch (2005), from the Asquempont Member of the Oisquercq Formation. This is quite surprising, as even the stepwise thermal demagnetisation of a three-axis isothermal remanent magnetism on its own allows distinguishing and characterising all twelve other of the fourteen lithostratigraphic units investigated (Fig. 5). The latter results, combined with the lithological similarities (see above, Plate 1) and the structural architecture of the Rebecq area (see above, Fig. 4), led Debacker et al. (2010) to suggest that the green rocks at Rebecq, attributed to the Hospice de Rebecq Formation by Herbosch (2005), might in fact belong to the Asquempont Member of the Oisquercq Formation.

3.4. Geochemistry

Geochemical analyses of different lithostratigraphic units of the Brabant Massif have been performed at the *Centre de Recherches Petrographiques et Géochimique, Spectrochimie - Service d'Analyses des Roches et des Mineraux*, at *SARM*, Vandoeuvre (France). Sample preparation involves impregnation with $LiBO_2$ and dissolution with HNO_3. The analysis of the major element composition was done by means of ICP-AES and quality control was done by means of international geostandards. The uncertainties on the major element concentrations are: SiO_2 and Al_2O_3 < 1%; Fe_2O_3 < 2%; MnO 5 to 10 %; MgO < 5%; CaO < 10%; Na_2O < 15%; K_2O < 2%; TiO_2 < 10%; P_2O_5 < 10%.

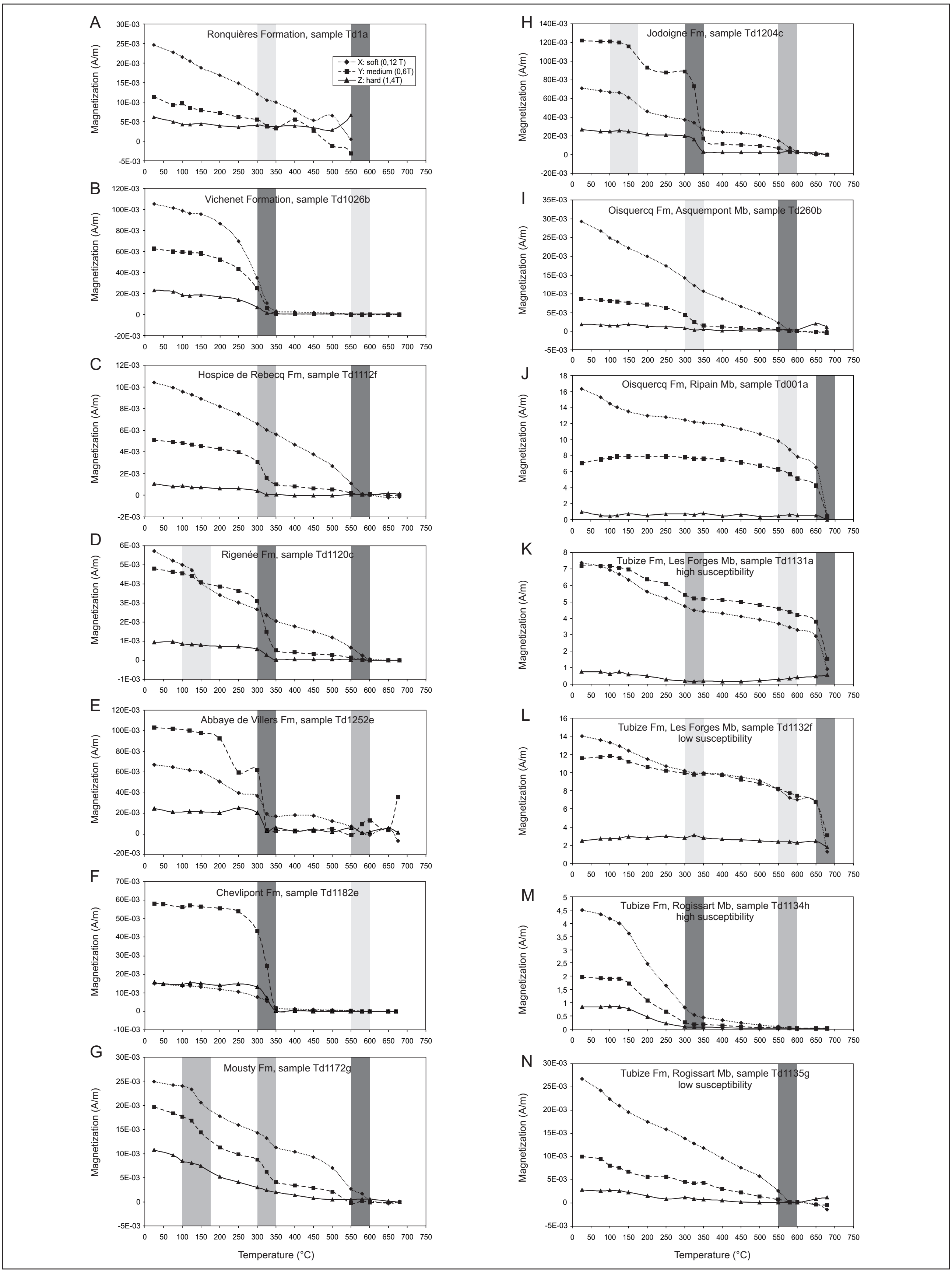

Figure 5. Thermal demagnetisation curves of 12 lithostratigraphic units of the Brabant Massif, taken from Debacker et al. (2010). For the Les-Forges Member and the Rogissart Member of the Tubize Formation both high-susceptibility and low-susceptibility samples are shown. The curves represent the stepwise demagnetisation of a “three axis” isothermal remanent magnetisation. The three successive saturation fields applied are 1.4 T, 0.6 T and 0.12 T. The three curves respectively reflect hard, medium and soft components, or carriers with high, medium and low coercivities, respectively. Significant drops, corresponding to blocking temperatures of specific carriers, are marked in grey, with the grey values reflecting their relative importance (dark grey > pale grey).

Sample	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	TiO_2 %	P_2O_5 %	L.O.I. %	Total %
BLM	57.71	20.48	7.34	0.09	2.28	0.22	0.90	5.15	1.03	0.12	4.88	100.20
TUBmsg	55.67	22.28	7.45	0.08	2.49	0.22	0.78	5.65	1.00	0.15	4.48	100.25
TUBrog	52.82	19.65	10.88	0.09	3.49	1.06	1.55	4.51	0.91	0.17	5.03	100.14
OIS1	62.14	19.52	7.54	0.13	2.02	0.10	0.45	3.47	1.00	0.10	4.43	100.90
OIS388	59.92	18.46	8.16	0.19	2.08	0.29	0.98	3.89	0.94	0.25	3.87	99.03
OIS432	59.12	18.31	9.25	0.26	2.40	0.22	1.16	3.37	0.93	0.22	3.95	99.19
OIS2	60.79	19.23	7.88	0.12	1.95	0.10	0.44	3.59	0.97	0.19	4.53	99.79
JODorb	64.25	21.88	1.07	0.00	0.55	0.04	0.24	5.84	1.06	< L.D.	5.43	100.36
JODjod	50.47	30.54	2.57	0.02	0.73	0.10	0.99	6.88	1.33	0.07	5.99	99.67
MSTmil	57.25	22.67	4.57	0.13	1.67	0.16	0.62	4.21	1.02	0.11	7.26	99.67
MSTsup	59.06	20.92	6.87	0.38	1.97	0.07	0.15	4.75	0.95	0.08	4.79	100.00
ABV	56.81	20.59	9.29	0.14	1.87	0.28	0.67	3.70	1.01	0.23	5.41	99.99
RIG	58.21	21.58	7.66	0.08	1.73	< L.D.	0.76	3.64	1.14	0.10	5.10	99.97
ITT	71.42	11.47	7.83	0.24	1.70	0.92	1.32	1.35	0.64	0.40	3.52	100.83
HOR	61.32	19.42	7.59	0.15	2.06	0.09	0.72	3.66	0.98	0.08	4.22	100.29
FAU	68.73	16.58	2.19	0.03	1.20	0.25	0.33	4.06	0.80	0.16	6.17	100.51
BRU	65.04	19.12	3.75	0.02	1.38	0.03	0.09	5.09	0.57	0.07	5.26	100.41
BGP	56.24	21.48	9.81	0.38	1.93	< L.D.	0.50	3.49	1.04	0.09	5.06	100.01
FAL	57.66	19.18	9.45	0.17	2.25	0.26	0.35	3.55	0.91	0.11	5.84	99.72

Table 1. Major element composition of samples of different lithostratigraphic units of the Brabant Massif. Sample localities are shown in appendix. The detection limit (L.D.) is 0.02 % for CaO and 0.03 % for P_2O_5. < L.D.: below detection limit.

The major element composition of the Asquempont Member of the Oisquercq Formation (samples OIS1, OIS2, OIS388, OIS432) is remarkably similar to that of the green mudstone in the Rebecq area (sample HOR), considered as the Hospice de Rebecq Formation by Herbosch (2005) (see Table 1). For all elements analysed, the composition of the sample of the green mudstone in the Rebecq area, considered as the Hospice de Rebecq Formation, is well within the range of the four samples of the Asquempont Member.

In order to verify the significance of this similarity, we have compared the geochemical composition of these 5 samples with those of 14 other pelitic lithostratigraphic units (mudstone, claystone, siltstone, shales and slates), ranging from the Lower Cambrian up to the Silurian (Table 1). As can be seen on Fig. 6 the four samples of the Oisquercq Formation (samples OIS*) and the one sample of the green mudstone attributed to the Hospice de Rebecq Formation (Rebecq area; sample HOR) are always well grouped. On a Fe_2O_3 – Al_2O_3 graph (Fig. 6A) the four

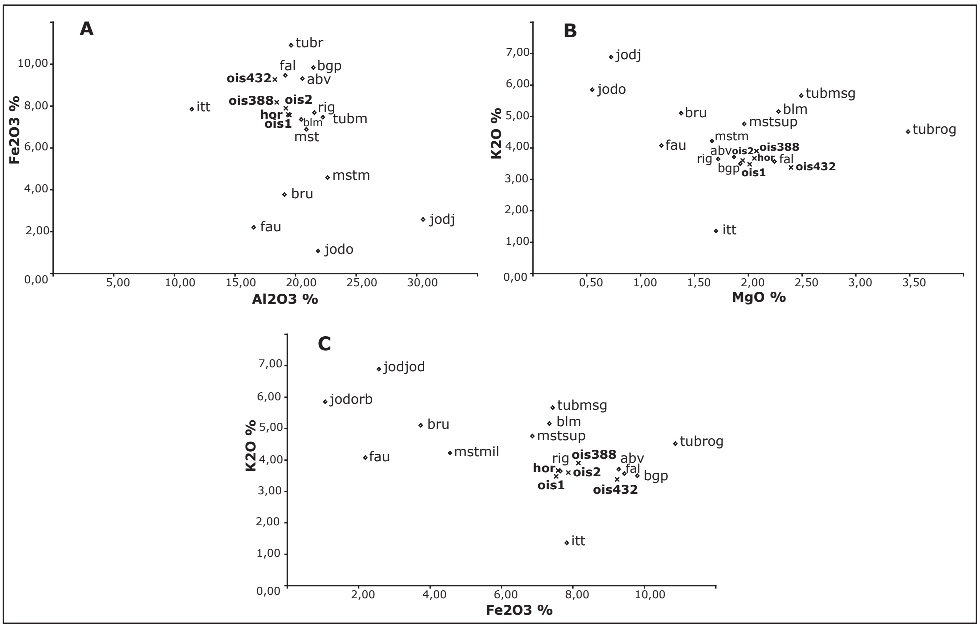

Figure 6. Major element composition graphs of investigated lithostratigraphic units of the Brabant Massif. A) Fe_2O_3-Al_2O_3; B) K_2O-MgO; C) K_2O-Fe_2O_3. HOR: Hospice de Rebecq Formation at Rebecq; OIS*: Asquempont Member of the Oisquercq Formation. See also table 1, and see appendix for sample position and lithology.

samples OIS* and the sample HOR are separated from the other pelitic lithostratigraphic units investigated, and sample HOR is situated within the cluster of samples OIS*. On a K_2O – MgO graph (Fig. 6B) the four samples OIS* and the sample HOR are separated from thirteen of the fourteen other samples investigated. Again, sample HOR is situated within the cluster of samples OIS*. This cluster also includes a sample of the Silurian Fallais Formation, which is a green slate, lithologically quite comparable to the Asquempont Member and the Hospice de Rebecq Formation (Rebecq area), but which, because of its turbiditic origin, lacks the extreme lithological homogeneity (cf. Verniers et al., 2001). Also on a K_2O – Fe_2O_3 graph (Fig. 6C) the four samples OIS* and the sample HOR are well grouped, and separated from thirteen of the fourteen samples of the other pelitic lithostratigraphic units investigated. The cluster also includes a sample of the Ordovician Rigenée Formation, which is a dark grey, homogenous slate.

Despite their lithological resemblances, the analysed pelitic lithostratigraphic units of the Brabant Massif often show quite a large spread in composition. However, the major element composition of the Asquempont Member of the Oisquercq Formation does not vary much and the green mudstone in the Rebecq area, attributed to the Hospice de Rebecq Formation by Herbosch (2005), has a virtually identical major element composition as the Asquempont Member.

4. Discussion

4.1. Are there sufficient arguments for re-considering the stratigraphic position of the green rocks in the Rebecq area?

When taken together, the lithological, magnetic and geochemical similarities do demonstrate an uncannily strong similarity between the green mudstone in the Rebecq area attributed to the Hospice de Rebecq Formation on the one hand and the Asquempont Member of the Oisquercq Formation on the other hand. In addition, the occurrence of these green rocks within an antiform core in the Rebecq area, surrounded by rocks of the Ittre and Bornival formations, is much more compatible with an age older than that of these surrounding rocks, rather than with a younger age as in the case of the Hospice de Rebecq Formation. Hence, there are sound arguments for suggesting that at Rebecq, the green rocks attributed to the Hospice de Rebecq Formation by Herbosch (2005) may in fact belong to the much older Asquempont Member of the Oisquercq Formation.

4.2. Can the occurrence of the different units be explained by means of this revised stratigraphic position?

In order to test the hypothesis presented above, we made an attempt to explain the occurrence of the different lithostratigraphic units within the Rebecq area. The map of Fig. 3 shows the outcrop distribution of the different lithostratigraphic units in the Rebecq area, based on the works of Debacker (2001), Lammertyn (2005), Herbosch (2005), Herbosch et al. (in press) and new observations. Taking into account the overall bedding geometry and observed cleavage/bedding relationships (Debacker & Sintubin, 2008; see also Fig. 4), we constructed a cross-section across this map (Fig. 7). The construction of this section is based on three main assumptions. Firstly, the green rocks at Rebecq belong to the Asquempont Member of the Cambrian Oisquercq Formation. Secondly, the pre-cleavage and pre-folding Asquempont Detachment System, separating the Ordovician units from the Asquempont Member in the Senne-Sennette outcrop area (see Debacker et al., 2003, 2004b), is an originally gently N-dipping feature. The original (pre-folding) N-dipping nature of this low-angle normal fault system was first proposed by Piessens et al. (2005), and was later confirmed by field observations (e.g. Debacker et al., 2005b, Herbosch et al., 2008). Thirdly, any stratigraphical mismatch observed on section is explained by means of steeply dipping post-cleavage normal faults of the

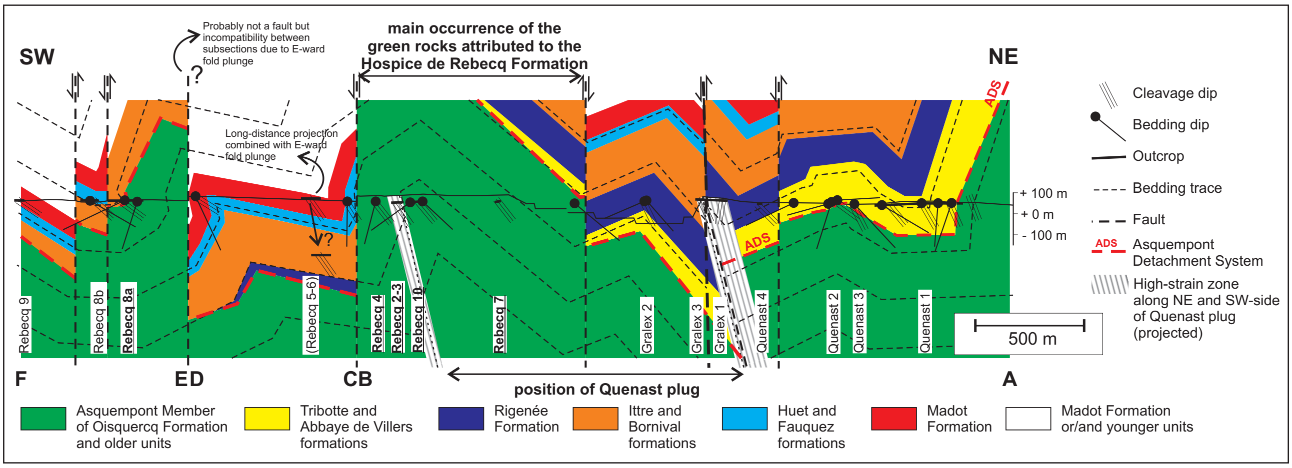

Figure 7. Composite section across the Quenast-Rebecq area, consisting of three subsections (A-B, C-D and E-F). Bedding traces should be regarded merely as guides and do not have any stratigraphic significance. See Fig. 3 for section lines, and compare with Fig. 4 for geometry. See text for discussion.

Nieuwpoort-Asquempont fault zone (see Debacker et al., 2003, 2004b; Herbosch et al., in press and Debacker & Sintubin, 2008). As most of these faults have not been observed in outcrop, they are marked by vertical dashed lines on the section. For section construction we also took into account published thickness estimates of the different lithostratigraphic units (e.g. Verniers et al., 2001), as well as a number of basic principles of section construction (constant bedding thickness, plane strain…).

Several features complicate section construction across this area. Firstly, the Senne river Valley is not oriented perpendicular to regional strike. This implies that some observation points have to be projected a relatively long distance, thus resulting in a much higher uncertainty. Secondly, lithostratigraphy changes also laterally, in particular within the WSW-part of the area (e.g. between outcrops Rebecq 8a and Rebecq 1; Figs 2 & 3). This is mainly a result of the presence of a significant fold plunge. In outcrops Rebecq 8a and 8b, for instance, the cleavage/bedding intersection plunges 15 to 30°SE, implying a SE-ward fold plunge and hence an along-strike, SE-ward younging of the beds in these parts. There are two main ways of compensating these complications. One way is to take into account the fold plunge when projecting distant outcrop observations onto the section. However, fold hinges have rarely been observed and the plunge of the cleavage/bedding intersection is not constant across the area and suggests the presence of periclinal folds. This implies that each data point may have to be projected with another, often poorly constrained, plunge. Hence, there is too much uncertainty to employ this method. The other way, which we use herein, is to make a composite section consisting of several subsections. On each of these subsections, only nearby lithostratigraphic data are projected. Positions of beginning and end points of the different subsections (Fig. 3) are a result of a best-fit trial-and-error method.

On the final composite section (Fig. 7), the junctions of the different subsections are depicted as post-cleavage normal faults. The junction of subsections A-B and C-D corresponds to the fault "*Faille du Château*" of Hennebert & Eggermont (2002) on the map of Herbosch (2005) and Herbosch *et al.* (in press) (see Figs 2 & 8; faults F1 and F3 in Verniers *et al.*, 2005). The stratigraphic mismatch across the junction of subsections C-D and E-F, however, may simply be a result of the SE-ward fold plunge in these parts and does not need to correspond to an important normal fault. The fault "*Faille Sud de Fauquez*" of Hennebert & Eggermont (2002; F2 in Verniers et al., 2005) is shown on the map of Herbosch (2005) and Herbosch et al. (in press) to the South of the southwesternmost outcrop (Fig. 2), which is at the southern extremity of our section. The position of this fault is very uncertain, as it is merely traced as a

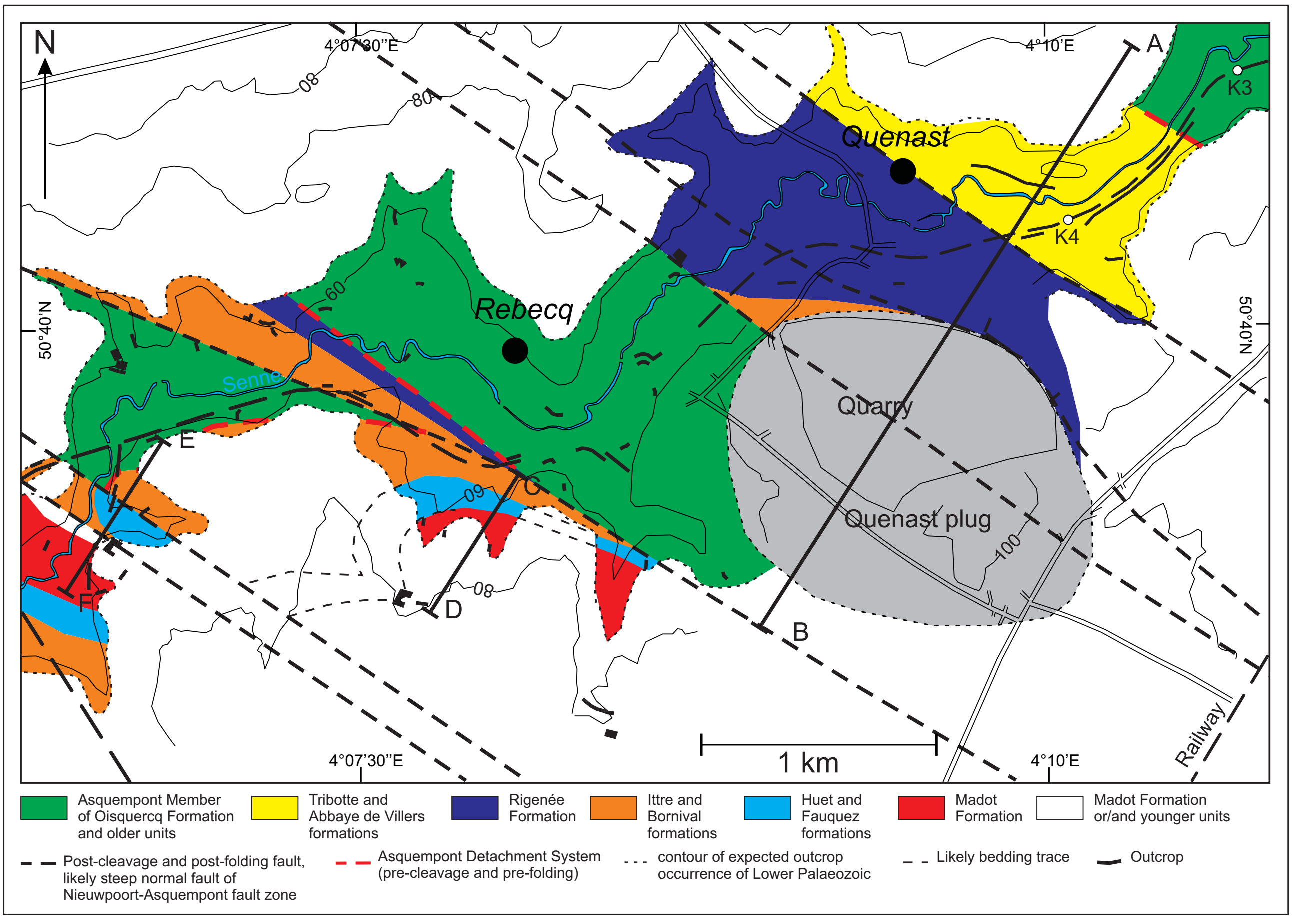

Figure 8. Newly proposed map of the Quenast-Rebecq area, using the assumption that the green rocks at Rebecq represent a resurfacing of the Asquempont Member of the Oisquercq Formation (see text and compare with Figs 2, 3 and 7).

continuation of the "*Faille Sud de Fauquez*" of Hennebert & Eggermont (2002) from the adjacent map sheet, and it is possible that the two faults in subsection E-F actually correspond to this fault. Even with this composite section procedure, some local uncertainties still exist. For instance, although geometrically there appears to be no problem, outcrops Rebecq 5 and Rebecq 6 (Bornival Formation) are projected in the Madot Formation. This is a result of the fold plunge, combined with a projection across the fault forming the junction between subsections A-B and C-D.

As shown on the composite section (Fig. 7) and on the map (Fig. 8), the distribution of the different lithostratigraphic units can be explained by considering the green rocks at Rebecq as a resurfacing of the Asquempont Member of the Oisquercq Formation in the footwall of the Asquempont Detachment System. The post-cleavage normal faults do have apparent displacements well within the range of those of the Nieuwpoort-Asquempont fault zone (e.g. Debacker et al., 2003, 2004b). These apparent displacements are a function of fold plunge, stratigraphic thickness of the different units, and cut-off angle of the Asquempont Detachment System and any change of these three parameters will result in different apparent post-cleavage normal fault displacements.

In summary, combined with the lithological, magnetic and geochemical observations, the section and accompanying map do demonstrate that there is no need for a separate formation for the green rocks at Rebecq and that these rocks may well represent a resurfacing of the Asquempont Member of the Oisquercq Formation in the footwall of the Asquempont Detachment System.

4.3. Suggested future studies in the Rebecq area

Further detailed field work should be performed in the Rebecq area, in particular in the outcrop section of outcrop 21 of Herbosch (2005) (i.e. outcrops Rebecq 8a and Rebecq 8b in Debacker & Sintubin, 2008), informally called the Ferme St.-Catherine outcrop section. The main interest of this ~300 m long outcrop section lies in the fact that it contains both the green mudstone considered as the Hospice de Rebecq Formation by Herbosch (2005) and herein re-interpreted as the Asquempont Member of the Oisquercq Formation, and one or two other, probably Upper Ordovician, lithostratigraphic units (Lammertyn, 2005; Herbosch et al., in press). According to Lammertyn (2005), the northern part of this outcrop section (outcrop 21 of Herbosch, 2005; outcrop Rebecq 8a of Debacker & Sintubin, 2008) contains both the green mudstone and bluish grey, either dark or pale coloured (depending on amount of weathering), rather homogenous cleaved mudstone, with occasional intercalated siltstone beds, possibly belonging to the Bornival Formation (see Fig. 3). Our new observations confirm this, and we can now narrow down the gap between this green mudstone (Asquempont Member of the Oisquercq Formation), and what we think is the Bornival Formation, to a ~7.5 m-wide unexposed zone, between 118.2 m and 125.7 m South of the railway bridge. As we observed in these outcrop parts, bedding is gently S-dipping, seemingly suggesting that the green mudstone is older than what we think is the Bornival Formation. It is within this ~7.5 m-wide gap that we would expect the Asquempont Detachment System. However, several important post-cleavage normal faults occur in this outcrop area, forming part of the Nieuwpoort-Asquempont fault zone (cf. Debacker et al., 2004b, Debacker & Sintubin, 2008 and Herbosch et al., in press). In addition, our recent observations point to the presence of a syn-cleavage high-strain zone within these parts of the outcrop section, possibly representing a low-angle reverse shear zone, such as in the nearby Marcq area (e.g. Debacker, 1999). Hence, there is no guarantee that within this ~7.5 m-wide gap the Asquempont Detachment System will actually be observed, as it may be displaced by later, syn- or post-cleavage shear zone or fault activity.

4.4. What about the Hospice de Rebecq Formation in the Grand-Manil area?

In the Rebecq area (Senne Valley), we re-interpret the green mudstone considered as the Hospice de Rebecq Formation by Herbosch (2005), as the Asquempont Member of the Oisquercq Formation. This also holds true for the green mudstone in the garden of the hospice at Rebecq, considered by Herbosch (2005) as type locality of the Hospice de Rebecq Formation. However, for the green mudstone in the Grand-Manil area (Orneau Valley) things are different. There, the green rocks are lithologically quite different from both the green rocks at Rebecq and from the Asquempont Member of the Oisquercq Formation, and also their stratigraphic position seems, on the basis of cartographic grounds, rather well constrained. Hence, in the Grand-Manil area, there are no reasons to doubt the presence of the Hospice de Rebecq Formation as defined by Herbosch (2005).

This results in the peculiar and very confusion situation in which a lithostratigraphic unit in the Orneau Valley is named after an outcrop in the Senne Valley (~40 km to the WNW) in which this lithostratigraphic unit (the Hospice de Rebecq Formation) has not been observed. In order to avoid future confusion, we suggest to abandon the name Hospice de Rebecq Formation (Herbosch, 2005) altogether, and to propose a new name for the green rocks at Grand-Manil, formerly considered as the Hospice de Rebecq Formation. For the green rocks at Grand-Manil, we suggest the name Cimetière de Grand-Manil Formation. The name is chosen from the "*Notice explicative*" of the geological map of Delcambre & Pingot (2002, p.26) which distinguished two informal units in these green rocks: the "*Unité de la Chapelle Ste Adèle*" and the "*Unité du cimetière de Grand-Manil*". Herbosch (2005) joined them in his now obsolete Hospice de Rebecq Formation. As the best outcrops occur near the cemetery of Grand-Manil, the name Cimetière de Grand-Manil Formation seems the most logical choice for the green rocks at Grand-Manil.

5. Conclusions

The strong lithological, magnetic and geochemical similarities between the Hospice de Rebecq Formation at Rebecq (Senne Valley) and the Asquempont Member of the Oisquercq Formation do not allow distinguishing both lithostratigraphic units. Moreover, the occurrence of the green rocks supposedly belonging to the Hospice de Rebecq Formation within the core of an antiform surrounded by rocks of the Ittre and Bornival Formation, suggests an age older than these surrounding formations, which is not compatible with the proposed stratigraphic position of the Hospice de Rebecq Formation (see Herbosch, 2005). Finally, the cartographic occurrence of the different lithostratigraphic units in the Rebecq area can be explained also by reconsidering the green rocks attributed to the Hospice de Rebecq Formation as belonging to the Asquempont Member of the Oisquercq Formation.

Hence, in the absence of further evidence, we reconsider the green rocks at Rebecq, previously attributed to the Hospice de Rebecq Formation by Herbosch (2005), as being a resurfacing of the Asquempont Member of the Cambrian Oisquercq Formation in the footwall of the Asquempont Detachment System. In order to avoid future confusion, we suggest to abandon the name Hospice de Rebecq Formation (Herbosch, 2005) altogether, and propose the new name Cimetière de Grand-Manil Formation for the green rocks at Grand-Manil (former Hospice de Rebecq Formation of Herbosch, 2005).

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7. References

ANDRÉ, L., 1991. Caledonian magmatism. *Annales de la Société Géologique de Belgique*, 114: 315-323.

ANDRÉ, L. & DEUTSCH, S., 1984. Les porphyres de Quenast et de Lessines: geochronologie, geochimie isotopique et contribution au problème de l'age du socle Precambrien du Massif du Brabant (Belgique). *Bulletin de la Société belge de Géologie*, 93: 375-384.

ANDRÉ, L. & DEUTSCH, S., 1985. Very low-grade metamorphic Sr isotopic resettings of magmatic rocks and minerals: Evidence for a late Givetian strike-slip division of the Brabant Massif, Belgium. *Journal of the Geological Society, London*, 142: 911-923.

DEBACKER, T.N., 1999. Folds trending at various angles to the transport direction in the Marcq area, Brabant Massif, Belgium. *Geologica Belgica,* 2: 159-172.

DEBACKER, T.N., 2001. *Palaeozoic deformation of the Brabant Massif within eastern Avalonia: how, when and why?* Unpublished Ph.D.-thesis, Laboratorium voor Paleontologie, Universiteit Gent.

DEBACKER, T.N., DEWAELE, S., SINTUBIN, M., VERNIERS, J., MUCHEZ, PH. & BOVEN, A., 2005a. Timing and duration of the progressive deformation of the Brabant Massif, Belgium. *Geologica Belgica*, 8: 20-34.

DEBACKER, T.N., HERBOSCH, A., SINTUBIN, M., & VERNIERS, J., 2003. Palaeozoic deformation history of the Asquempont-Virginal area (Brabant Massif, Belgium): large-scale slumping, low-angle extensional detachment development (the Asquempont fault redefined) and normal faulting (the Nieuwpoort-Asquempont fault zone). *Memoirs of the Geological Survey of Belgium*, 49: 1-30.

DEBACKER, T.N., HERBOSCH, A., VERNIERS, J. & SINTUBIN, M., 2004b. Faults in the Asquempont area, southern Brabant Massif, Belgium. *Netherlands Journal of Geosciences/Geologie en Mijnbouw*, 83: 49-65.

DEBACKER, T.N., HERBOSCH, A. & SINTUBIN, M., 2005b. The supposed thrust fault in the Dyle-Thyle outcrop area (southern Brabant Massif, Belgium) re-interpreted as a folded low-angle extensional detachment. *Geologica Belgica*, 8: 53-69.

DEBACKER, T.N., HIRT, A.M., ROBION, P. & SINTUBIN, M., 2009. Differences between magnetic and mineral fabrics in low-grade, cleaved siliciclastic pelites: A case study from the Anglo-Brabant Deformation Belt (Belgium). *Tectonophysics*, 466: 32-46.

DEBACKER, T.N. & SINTUBIN, M., 2008. The Quenast plug: a mega-porphyroclast during the Brabantian Orogeny (Senne Valley, Brabant Massif). *Geologica Belgica*, 11: 199-216.

DEBACKER, T.N., SINTUBIN, M. & ROBION, P., 2010. On the use of magnetic techniques for stratigraphic purposes: examples from the Lower Palaeozoic Anglo-Brabant Deformation Belt (Belgium). *Geologica Belgica*, 13: 333-350.

DEBACKER, T.N., SINTUBIN, M. & VERNIERS, J., 2004a. Transitional geometries between gently plunging and steeply plunging folds: an example from the Lower Palaeozoic Brabant Massif, Anglo-Brabant deformation belt, Belgium. *Journal of the Geological Society, London*, 161: 641-652.

DELCAMBRE, B., PINGOT, J. L., 2002. *Notice explicative de la Carte Chastre-Gembloux n°40/5-6*, *Carte Géologique de Wallonie*. Namur, Ministère de la Région Wallonne. 72 p.

DE VOS, W., VERNIERS, J., HERBOSCH, A. & VANGUESTAINE, M., 1993. A new geological map of the Brabant Massif, Belgium. *Geological Magazine*, 130: 605-611.

ELLWOOD, B.B., CRICK, R.E., EL HASSANI, A., BENOIST, S.L. & YOUNG, R.H., 2000. Magnetosusceptibility event and cyclostratigraphy method applied to marine rocks: Detrital input versus carbonate productivity. *Geology*, 28: 1135-1138.

GIESE, U., KATZUNG, G., WALTER, R. & WEBER, J., 1997. The Caledonian deformation of the Brabant Massif and the Early Palaeozoic in northeast Germany: compared. *Geological Magazine*, 134: 637-652.

HENNEBERT, M. & EGGERMONT, B., 2002. *Carte Braine-le-Comte - Feluy n° 39/5-6, Carte géologique de Wallonie, échelle 1/25000.* Namur, Ministère de la Région Wallonne.

HERBOSCH, A., 2005. Hospice de Rebecq: une nouvelle Formation dans l'Ordovicien supérieur du Massif du Brabant (Belgique). *Geologica Belgica*, 8: 35-47.

HERBOSCH, A., DEBACKER, T.N. & PIESSENS, K., 2008. The stratigraphic position of the Cambrian Jodoigne Formation redefined (Brabant Massif, Belgium). *Geologica Belgica*, 11: 133-150.

HERBOSCH, A., DUMOULIN, V., BLOCKMANS, S. & DEBACKER, T. (in press). *Carte Rebecq-Ittre n° 39/1-2, Carte géologique de Wallonie, échelle 1/25000.* Namur, Ministère de la Région Wallonne.

JACKSON, M., 1991. Anisotropy of magnetic remanence: a brief review of mineralogical sources, physical origins, and geological applications, and comparison with susceptibility anisotropy. *Pure and Applied Geophysics*, 136: 1-28.

JELINEK, V. & POKORNY, J., 1997. Some new concepts in technology of transformer bridges for measuring susceptibility anisotropy of rocks. *Physics and Chemistry of the Earth*, 22: 179-181.

LAMMERTYN, D., 2005. *Lithostratigrafie, biostratigrafie met Chitonozoa en kartering van de Formatie Hospice de Rebecq en aangrenzende formaties (Boven-Ordovicium, Massief van Brabant).* Unpublished M.Sc.-thesis UGent.

LEGRAND, R., 1968. Le Massif du Brabant. *Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique*, 9: 1-148.

LOWRIE, W., 1990. Identification of ferromagnetic minerals in a rock by coercivity and unblocking temperature properties. *Geophysical Research Letters*, 17: 159-162.

LÜNEBURG, C. M., LAMPERT, S.A., LEBIT, H.D., HIRT, A.M., CASEY, M. & LOWRIE, W., 1999. Magnetic anisotropy, rock fabrics and finite strain in deformed sediments of SW Sardinia (Italy). *Tectonophysics*, 307: 51-74.

MARTÍN-HERNANDEZ, F. & HIRT, A.M., 2001. Separation of ferrimagnetic and paramagnetic anisotropies using a high-field torsion magnetometer. *Tectonophysics*, 337: 209-221.

MCCABE, C., JACKSON, M. & ELLWOOD, B.B., 1985. Magnetic anisotropy in the Trenton Limestone: results of a new technique, anisotropy of anhysteretic susceptibility. *Geophysical Research Letters*, 12: 333-336.

PIESSENS, K., DE VOS, W., BECKERS, R., VANCAMPENHOUT, P. & DE CEUKELAIRE, M., 2005. *Project VLA03-1.1: Opmaak van de pre-Krijt subcropkaart van het Massief van Brabant voor invoering in de Databank Ondergrond Vlaanderen.* Unpublished end-report, Koninklijk Belgisch Instituut voor Natuurwetenschappen, Belgische Geologische Dienst, 90 p.

SINTUBIN, M., 1999. Arcuate fold and cleavage patterns in the southeastern part of the Anglo-Brabant Fold Belt (Belgium): tectonic implications. *Tectonophysics*, 309: 81-97.

VAN GROOTEL, G., VERNIERS, J., GEERKENS, B., LADURON, D., VERHAEREN, M., HERTOGEN, J. & DE VOS, W., 1997. Timing of magmatism, foreland basin development, metamorphism and inversion in the Anglo-Brabant fold belt. *Geological Magazine*, 134: 607-616.

VANMEIRHAEGHE, J., STORME, A., VAN NOTEN, K., VAN GROOTEL, G., & VERNIERS, J. 2005. Chitinozoan biozonation and new lithostratigraphical data in the Upper Ordovician of the Fauquez and Asquempont areas (Brabant Massif, Belgium) *Geologica Belgica*, 8: 145-159.

VERNIERS, J., HERBOSCH, A., VANGUESTAINE, M., GEUKENS, F., DELCAMBRE, B. PINGOT, J.L., BELANGER, I., HENNEBERT, DEBACKER, T., SINTUBIN, M. & DE VOS, W. 2001. Cambrian-Ordovician-Silurian lithostratigraphical units (Belgium). *Geologica Belgica*, 4: 5-38.

VERNIERS, J., PHARAOH, T., ANDRÉ, L., DEBACKER, T., DE VOS, W., EVERAERTS, M., HERBOSCH, A., SAMUELSSON, J., SINTUBIN, M. & VECOLI, M., 2002. The Cambrian to mid Devonian basin development and deformation history of Eastern Avalonia, east of the Midlands Microcraton: new data and a review. *In*: Winchester, J., Verniers, J. & Pharaoh, T. (eds) *Palaeozoic Amalgamation of Central Europe.* Geological Society, London, Special Publications, 201: 47-93.

VERNIERS, J., VAN GROOTEL, G. & DEBACKER, T.N., 2005. The Upper Ordovician lithostratigraphy and structure of the Fauquez area (Brabant Massif, Belgium). *Geologica Belgica*, 8: 160-175.

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Appendix: position and lithology of samples used for geochemical analyses.

BLM: Biotite slate from the Blanmont Formation, Opprebais quarry, Gette outcrop area.

TUBmsg: Grey-green slate from turbiditic succession (Te-interval) of the Tubize Formation, lower part of Mont-St-Guibert Member, church of Mont-St-Guibert, Orne Valley, Dyle-Thyle outcrop area.

TUBrog: Green slate from turbiditic succession (Te-interval) from the Rogissart Member of the Tubize Formation, Rogissart, Haine Valley, Senne-Sennette outcrop area.

OIS1: Green massive slate from the Asquempont Member of the Oisquercq Formation, Km 40.950 of the channel trench near Asquempont Bridge, Sennette Valley, Senne-Sennette outcrop area.

OIS388: Green slate from the Asquempont Member of the Oisquercq Formation, Lessines borehole 388 m, Lessines, Dender subcrop area.

OIS432: Green slate from the Asquempont Member of the Oisquercq Formation, Lessines borehole 432 m, Lessines, Dender subcrop area.

OIS2: Green massive slate from the Asquempont Member of the Oisquercq Formation, E side of the channel trench about 100 m to the N of Asquempont bridge, Sennette Valley, Senne-Sennette outcrop area.

JODorb: Black pyritic slate from the Jodoigne Formation, Orbais Unit, Orbais, Gette outcrop area.

JODjod: Black slate of the Jodoigne Formation, Jodoigne Unit, Jodoigne (Grand Moulin), Gette outcrop area.

MSTmil: Black pyritic slate from the Mousty Formation (middle part?), Noirha borehole 32.9 m, Noirha, Thyle Valley, Dyle-Thyle outcrop area.

MSTsup: Dark grey slate from the upper part of the Mousty Formation, Tangissart borehole, 15 m, Km 38.9 of the railway trench, Tangissart, Thyle Valley, Dyle-Thyle outcrop area.

ABV: Argillaceous siltstone from the Abbaye de Villers Formation, near the abbey of Villers, Thyle Valley, Dyle-Thyle outcrop area.

RIG: Dark grey slate from the upper part of the Rigenée Formation, Cocriamont Castle Park, Thyle Valley, Dyle-Thyle outcrop area.

ITT: Black slate from the Ittre Formation, Lessines borehole 214 m, Lessines, Dender subcrop area.

HOR: Green massive slate from the Hospice de Rebecq Formation, old quarry in the Hospice property, Rebecq, Senne Valley, Senne-Sennette outcrop area.

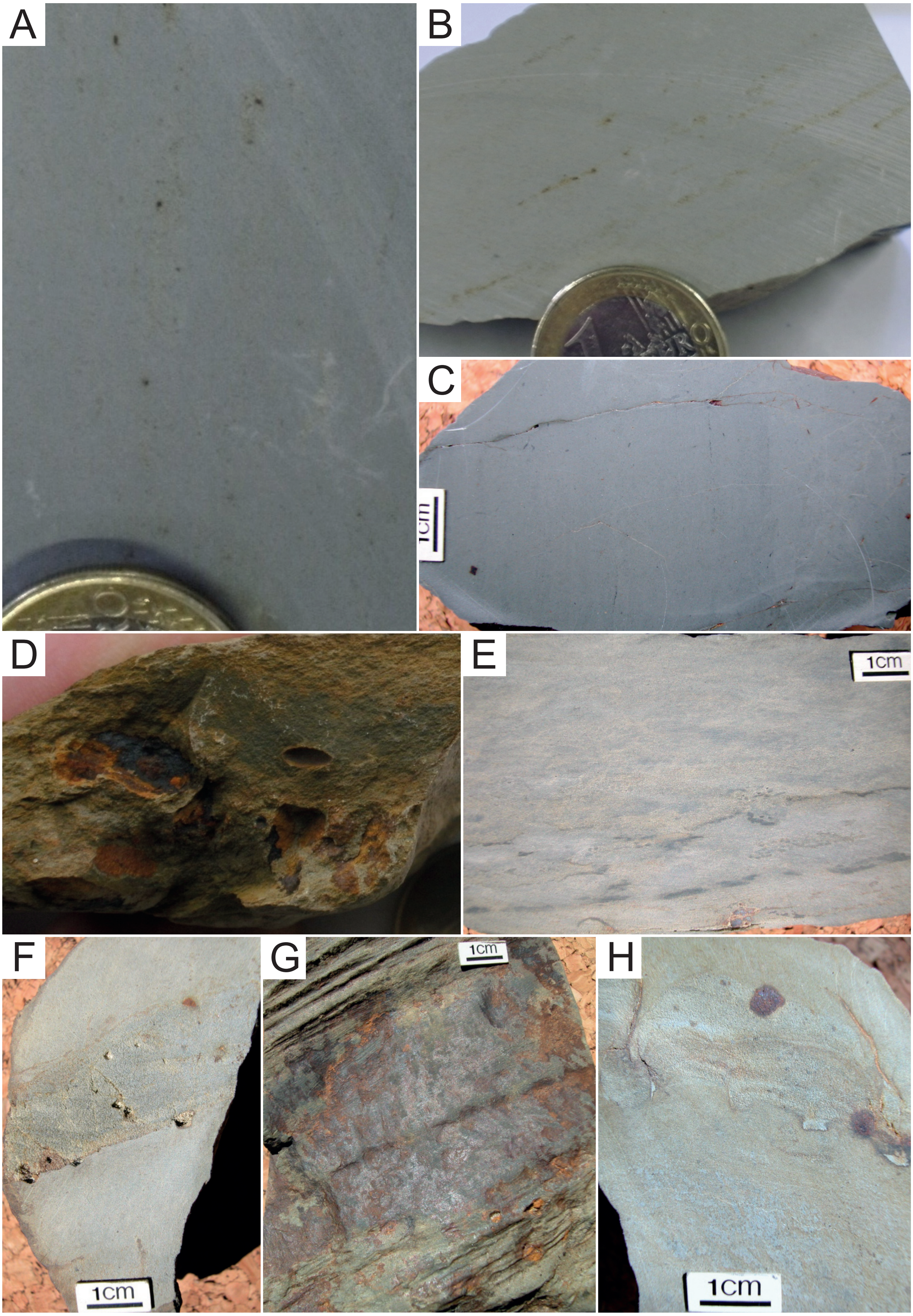
FAU: Pyritic black slate from the Fauquez Formation, Lessines borehole 357.3 m, Dender subcrop area.

BRU: Black slate from the Brutia Formation, upper part of the lower member, old quarry at Tri à la Vigne, Grand-Manil, Orneau outcrop area.

BGP: Grey slate from the Bois Grand-Père Formation, Grand-Manil, Orneau outcrop area.

FAL: Green slate from the upper part of the Fallais Formation, Km 2.810 of the railway trench near old quarry “Poudrière de Corroy”, Orneau outcrop area.

Plate 1. Photographs of cut or broken samples: A and B: Asquempont Member of the Oisquercq Formation at the railway section at Virginal (Sennette Valley): greenish claystone with vague bedding lamination. C: Green mudstone at the hospice of Rebecq (Senne Valley) (obsolete Hospice de Rebecq Formation, herein re-interpreted as Asquemont Member of Oisquercq Formation): very vague stratification, marked by small variations in hue; left a pyrite crystal; D: Olive-green mudstone at Grand-Manil (Orneau Valley): typical altered facies with bedding-parallel nodules; E: Green mudstone at Grand-Manil, 3 Rue de la Vôte, East of the Chapelle Sainte Adèle (Orneau Valley): greenish grey slate, slightly altered; stratification is visible at the bottom of the sample. F: same as E. In the middle of the sample a 2 cm thick silty bed; above the sharp base oblique lamination is followed by planar lamination disappearing progressively upwards. Holes are due to the oxidation of pyrite. G: Green mudstone in the sunken road West of the cemetery of Grand-Manil (Orneau Valley): at the bottom planar to oblique lamination gradually grades into massive shale. At the top a sharp contact with overlying coarser bed. H: Green mudstone in a temporary excavation South of the cemetery of Grand-Manil. In the upper part a thick silty bed shows oblique lamination; at its base load and flame structures are present; two purplish spots correspond to oxidised pyrite.
The green mudstone at Grand-Manil, depicted in photos D to H, was attributed to the Hospice de Rebecq Formation by Herbosch (2005) but is renamed herein as the Cimetière de Grand-Manil Formation.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