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DETAILED MAPPING AT THE NORTHWEST SIDE OF THE STAVELOT MASSIF

COMMENTS ON THE XHORIS, THE OE AND THE GILEPPE SUD FAULTS

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(16 pages, 7 figures)

Cover illustration: Geology of the Gileppe area and the area to the west of the lake

Content

Foreword

As Fernand Geukens expressed in 2010 in an interview published in the Information Letter of the Sciences Faculty of Leuven University, a geological map bears a datum which reflects the scientific knowledge of that time. Furthermore, a geological map represents the personal interpretations of the author. Therefore, geological maps of the same region may differ in time due to the level of outcrops, of scientific knowledge and different interpretations of various authors. However, if substantially documented, each geological interpretation is worth attention.

This is the case for the Limbourg-Eupen mapsheet on the complex northwest border of the Stavelot Massif, formally mapped and described in 1996 by Laloux et al., for which F. Geukens presents his own interpretation. We draw attention to a major conceptual difference on the presence or absence of transversal faults between the map by Laloux et al. and the map extracts presented by F. Geukens in this paper. Observations in the area can either be explained by a combination of transversal and longitudinal faults or by only longitudinal faults; the latter concept has traditionally been advocated by F. Geukens and is used also in this publication whilst the former concept is used by Laloux et al., which represents the accepted concept for the geological map of Wallonia. Geology is a natural science, extrapolating conceptual models from limited observations, for which it is likely dangerous to express “definitive” statements.

Most of Geukens’ career has been devoted to the understanding of the Stavelot Massif and its border. Nobody will ever come within reach of the amount of geological observations made by him of this most complex territory. His invaluable contribution to the Belgian geology has to be emphasized. This paper of regional interest, which perfectly corresponds to the scope of the Professional Papers is likely one of his last messages to the geological community, for which we sincerely thank him.

Leon Dejonghe and Michiel Dusar

on behalf of the editorial board of the Professional Papers

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Abstract. Detailed observations have allowed to present additional and alternative geological mapping results in the area between Eupen and west of the Gilleppe Lake till the Jalhay Massif, and in the area between Houssonloge and Lorcé in the north and Werbomont, Grimbièmont and Chevron in the south. In the Eupen area the Stadtgraben fault has been identified. Between Eupen and the Gileppe an alternative tract of the Oe Fault has been mapped. The geology of the Gileppe Lake area, in front of the Jalhay Massif, has been mapped as consisting of several small nappes thrusted northwards and occurring just beneath the major Eupen thrust sheet. In the area between Houssonloge and Grimbièmont the tract of the Xhoris Fault has been mapped. The Xhoris fault trace is complicated by the existence of the Bru nappe. This nappe is considered to be the detached southern part of the north-plunging Paradis syncline and it overlies in part the Xhoris Fault.

Key-words: cartography, Stavelot Massif, Oe Fault, Stadtgraben Fault, Bru nappe, Paradis Syncline, Xhoris Fault, Mormont Fault.

Introduction

The Limbourg-Eupen (43/5-6) geological map sheet at scale 1:25.000, mapped and described by Laloux et al. (1996) is dealing with the complex northwest border of the Stavelot Massif between Eupen and the Gileppe. The mapping has revealed a structural framework that contributed substantially to the understanding of the regional tectonic deformation history as developed in a coherent model by Hance et al. (1999).

At the geological map scale, establishing the continuity between the different outcrops is a serious challenge the outcome of which is seldom final leaving no room for alternative solutions. Admitting the excellent overall quality of the geological map sheet Limbourg-Eupen, in the present short note two small areas, one between Eupen and the Gileppe and one around and to the west of the Gileppe Lake are discussed based on a series of new observations; in particular the Oe Fault near Eupen and the Gileppe Fault around the reservoir lake are discussed. Also recent detailed mapping results are presented on the Xhoris Fault to the northeast of Werbomont, also in the northwest area of the Stavelot Massif on the still to be published map sheet 49. The mapped areas are shown on the location map in Fig. 1.

For the ease of the reader, the topographic localities referred to in the text are highlighted on the maps and important geological localities have been labelled with a number between brackets in the text and also each time indicated on the maps.

1. The Xhoris Fault between Werbomont and Chevron (Figs. 2 and 3)

The Xhoris Fault has already been represented on the 1:40 000 maps around the turn of the 19th to 20th century. The fault was most clearly identified at the Xhoris locality, in the northeast of the Hamoir-Ferrières 1:40 000 map where a southwest plunging fold train of the Dinant synclinorium is thrusted northwards bringing east of Xhoris Lower Devonian over Middle and Upper Devonian. Towards the Dinant synclinorium in the West the fault has been traced in detail by Dusar (1989). To the east the Xhoris fault could be traced rather easily till Harzé and from there southwards till the northeast of Werbomont, following the faulted contact between Lower Devonian and Middle-Upper Devonian (Harzé, Houssonloge, Ruisseau du Paradis) and between two series of Lower Devonian displaying different strike and stratigraphy (Grand Bois de Berleur and Bois Royal de Règnière).

However to the northeast of Werbomont different formations of the Salm Group rocks appear and also the Lower Devonian in contact with the Caledonian Stavelot Massif displays a different structure in the form of the northeast-southwest trending Bru syncline. The tracing of the Xhoris Fault in this area becomes more complicated. Lhoest (1935) e.g. has proposed that in the Werbomont area the fault systematically follows the contact between the Salm Group and the Lower Devonian, leading to a westwards dipping and undulating fault plane (see Cambier & Dejonghe, 2010).

Geukens (1984a) has proposed that in the Werbomont area the eastern boundary of the Ordovician Salm Group rocks, thrusted eastwards over the Lower Devonian, marks the trace of the Xhoris Fault to the south (fig.1 in Geukens, 1984a). The Lower Devonian north of La Platte and La Neuville has a subhorizontal dip, but south of the sources of the Ruisseau du Pouhon, the Lower Devonian is reduced to a narrow very steeply dipping conglomerate tract of north-south direction, approximately analogous to the steeply dipping Xhoris fault recognised south of Harzé. This narrow continuous Lower Devonian trace on the map ends in the south at the Ruisseau de Bergival where a fault breccia allows to recognise the Xhoris Fault tract. Geukens (1984a) discusses in detail the eastwards continuation of the Xhoris Fault into the Stavelot Massif where the fault trace is cut in several short tracts by the post-Variscan faults of the northern part of the Malmédy pull-apart basin (Geukens, 1995).

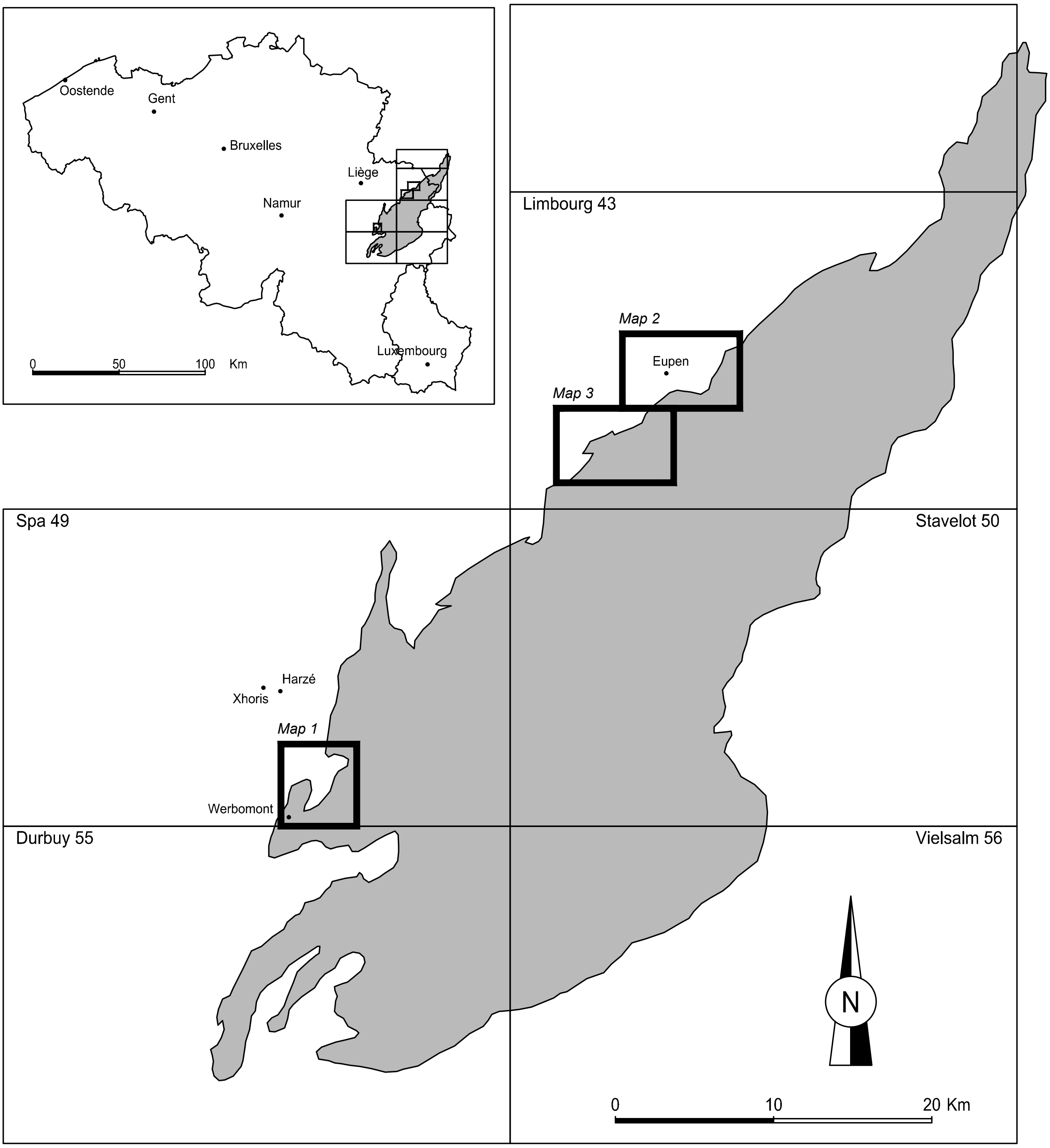

Figure 1. Position of the maps discussed in the text bordering the northwest side of the Stavelot Massif coloured grey.

The discussion by Geukens (1984a.) was also a reply to the reflections of Graulich (1983) who proposed the connection of the Xhoris Fault with the Bras Fault, occurring south of the pull-apart basin, and even extending the fault to the southwest into the Lamsoul Fault, forming the basal plane of a regional gravitational nappe.

A revision of all existing field data, complemented with recent observations in the area of Werbomont, Chevron, Houssonloge has allowed to map in detail the trace of the Xhoris fault in the complicated and much discussed zone to the east of Werbomont (Fig. 2).

New observations have allowed to map the Eifelian syncline along the Ruisseau du Paradis **(1)** , further called the Paradis syncline, ending abruptly in the west where it is overthrusted by the Gedinnian (Lockhovian). In the Grand Bois de Berleur, dispersed red Marteau Formation rocks and grey quartzite blocks of Siegenian (Pragian) age, but no basal Lower Devonian conglomerate, allow to trace the Xhoris Fault and to link it with an observed clay fault gouge during the construction works along the new motorway at about 3400 m south of the Harzé bridge **(2)**. Under the high tension line, just to the south, appear the first Salm Group rocks covered by N30°E striking Lower Devonian basal conglomerates **(3)**, a typical situation for the western boundary of the Stavelot Massif as mapped e.g. west of Lorcé. This strike direction and the stratigraphic succession makes that the Lower Devonian, in eastern direction, belongs to the Paradis synclinal structure and contrasts with the north-south trending Lower Devonian , also overlying Salm Group rocks, near Règnière under the high tension line in western direction. Apparently two different structural blocks are present and the contact between both structural elements logically is the prolongation of the Xhoris Fault to the south. This is supported by the occurrence of a 400 m long very narrow Lower Devonian basal conglomerate sliver quenched in the contact between the two structural Lower Salm Group blocs **(4)**: this conglomerate sliver is marking the trace of the Xhoris Fault curving slightly to the southeast.

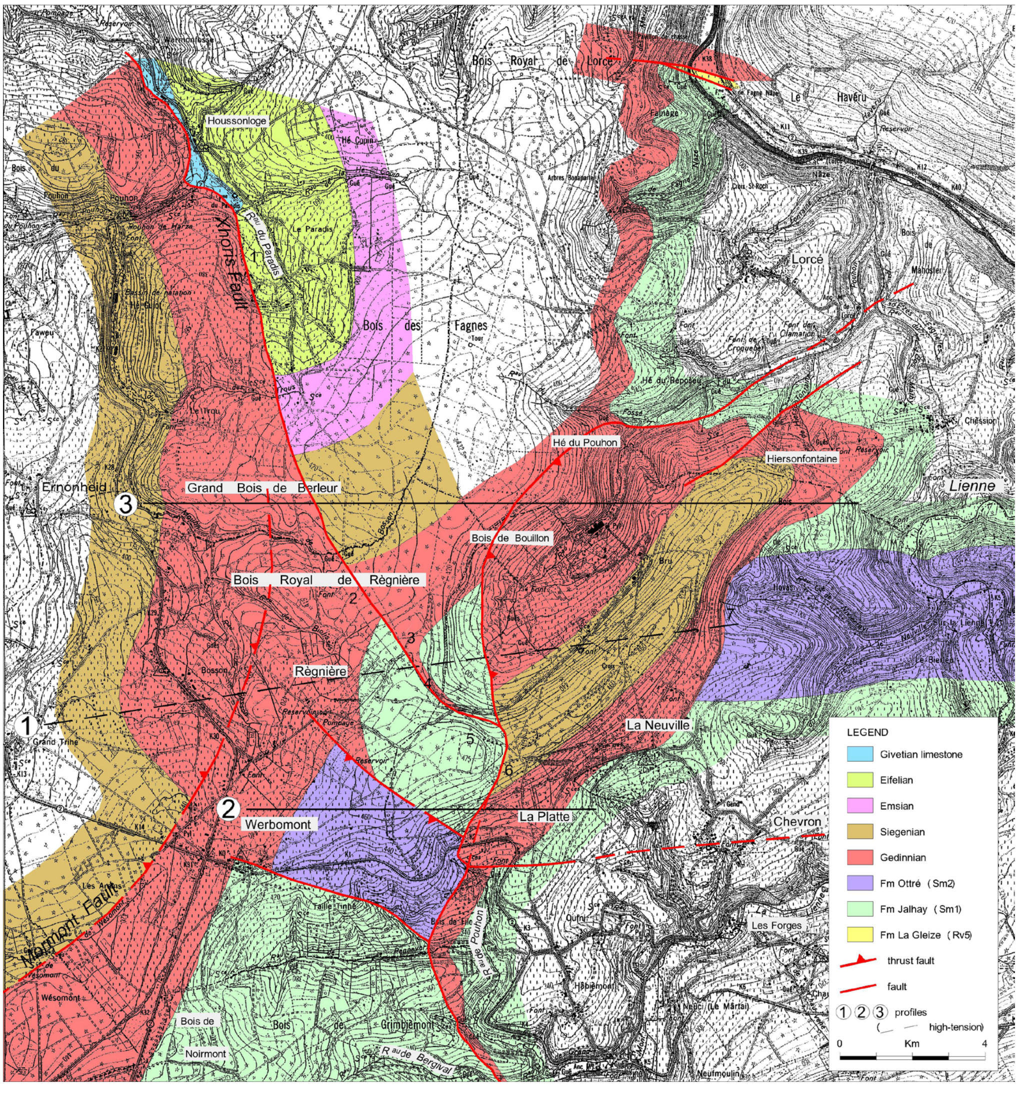

Figure 2. The Xhoris fault mapped along the Paradis Syncline in the north, along the Bru nappe, and along the Ruisseau de Pouhon and Ruisseau de Bergival in the south. The 3 east-west profile lines shown in Figure 3 are indicated on the map. Note the existence of the Xhoris Fault, marked with a dashed line, below the southwestern tip of the Bru nappe.

The narrow conglomerate fault trace can be followed till a small topographic high at 475m **(5)**. Here the fault trace can not simply be extended anymore. Still the contact between the lower Salm Group rocks at the hill and the topographically lower northeast trending quartzites of the Siegenian (Pragian) to the east, is an obviously faulted contact, but compared to the narrow conglomerate sliver this fault must be mapped with an abrupt change in direction following now a north-south to slightly southwest trend **(6)**. These Siegenian quartzites are part of the larger Bru syncline as mapped by Asselberghs (1946) who also interpreted the southwest trending fault trace as the Xhoris fault.

The mapping allows to trace this new north-south fault further northwards following the contact between the lower Salm Group rocks and Gedinnian rocks. As the Gedinnian takes an unusual thickness in the Bois de Bouillon, it is reasonable to assume the fault to continue across this Bois de Bouillon where it then logically is linked with the major east-west fault at Hé de Pouhon, displacing the contact between the Salm Group rocks and the Lower Devonian conglomerates; this major fault can probably be linked wit a fault mapped south of Lorcé. A smaller parallel companion fault is mapped west of Hiersonfontaine, which could explain some of the suspected stratigraphic and structural complexities in the Bru nappe that are difficult to map in detail as almost no outcrops occur in the area and dispersed rocks at the surface have to be used for mapping. Anyway, this fault from west of La Platte, across the Bois de Bouillon till Hé du Pouhon and probably south of Lorcé, makes the Bru syncline to look like part of a nappe overlying the regular west border of the Stavelot Massif; this border is defined in the area of the Lienne syncline, in the east of the map, by the contact between folded Salm Group rocks and the unconformably overlying Lower Devonian conglomerates, shales and sandstones. Such contact is present in the Bru nappe **(7)** but shifted eastwards with respect to the area of Lorcé in the north and the area of Bois de Noirmont in the south. Within the Bru nappe, the Lower Devonian contact with the Salm Group strata can easily be mapped east of the road between La Platte and La Neuville. In the south, the nappe is bordered by an east-west fault in the source area of the Ruisseau du Pouhon. This fault can be recognised as it not only displaces the basal conglomerate of the Lower Devonian but also causes an abrupt change in strike direction of the conglomerate, almost east-west north of the fault and almost north-south south of the fault. The trace of this east-west fault to the east is lost in the Salm Group rocks in the direction of Chevron and Les Forges. Remains also the location of the eastern border of the Bru nappe; it has to be sought for in the area of Chevron, but as it has to occur within Salm Group rocks it has not been possible to locate it for the time being. Note that the south-western tip of the Bru Nappe is mapped to have overthrusted the Xhoris Fault (Fig.2 and geological section 2 in Fig.3) rendering the exact southern extension of the Xhoris Fault more difficult to recognize.

South of the east-west border of the Bru nappe at the sources of the Ruiseau du Pouhon, the Lower Devonian is reduced to a narrow very steeply dipping conglomerate tract of north-south direction. The contact with the Salm Group to the east is the normal unconformable contact whilst the fault contact with the Salm Group to the west is a faulted contact, approximately analogous to the steeply dipping Xhoris fault recognised south of Harzé, and interpreted here as its southern extension. However here in the south the Xhoris fault enters the Caledonian Stavelot Massif. This trace of the Xhoris fault ends in the south at the Ruisseau de Bergival where a fault breccia allows to recognise the Xhoris Fault tract.

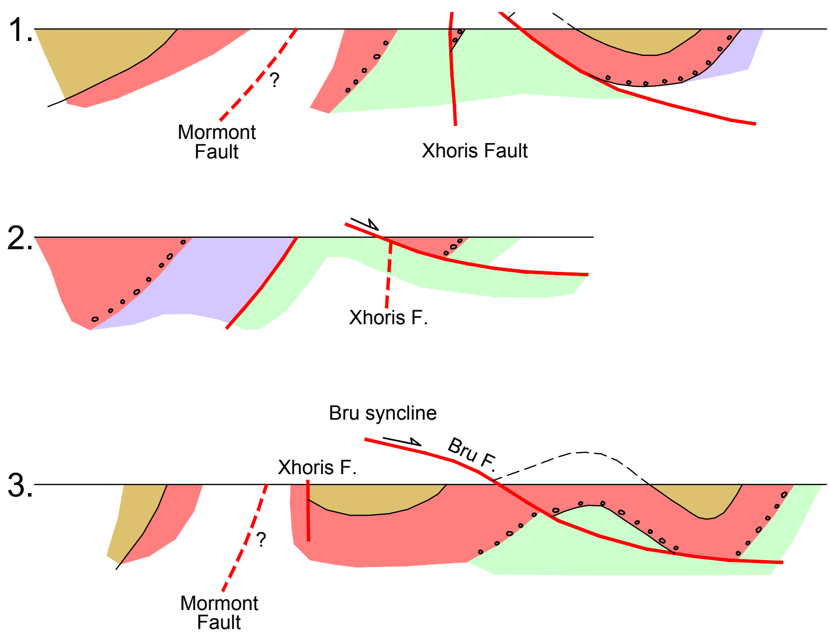

Figure 3. Three east-west profiles (see map Fig.2) across the Xhoris fault , also illustrating the Bru nappe structure.

It is important to note that in this interpretation the short north-south to slightly southwest fault trace curved around the eastern side of the 475 m topographic high **(5)**, and bringing Lower Salm Group strata to the west in contact with Siegenian quartzites and Gedinnian to the east, turning east at the Sources du Ruisseau du Pouhon, and considered as the Xhoris Fault by Asselberghs (op. cit), is in fact part of the bordering fault of the Bru nappe in the southwest. This Bru nappe therefore must hide the Xhoris Fault below it as shown in profile 2 of Fig.3.

The tectonic origin of this Bru nappe can be explained by a relative north to north-eastwards movement of the Dinant Basin with respect to the Caledonian Stavelot Massif. Such relative movement is generally acknowledged and expressed e.g. by the Ourthe Zone (see Hance et al., 1999). The main faults allowing this differential north to north-eastern movement are the Xhoris fault and the Mormont Fault.

The Mormont Fault could be mapped in detail using the motorway reconnaissance drillings. North of the village of Mormont the fault brings the Siegenian of the Dinant Synclinorium in contact with the Siegenian bordering the west side of the Stavelot Massif. To the northwest of Werbomont, the Mormont Fault enters the Gedinnian rocks; towards the Xhoris Fault in the Bois Royal de Règnière the fault trace is lost, due to the lack of outcrops, but it probably joins the Xhoris Fault in this forest explaining also the apparent thickening of the Gedinnian on the map in the area of Bosson-Règnière. The mechanically weak Marteau Formation shales have acted as the detachment zone explaining why no conglomerates are found in this major tract of the Xhoris fault.

The Dinant Synclinorium structures are pushed along the Mormont and Xhoris Faults and overthrust the west side of the Paradis syncline. The Paradis syncline was a fold probably determined by the existence of a bend in the west border of the Stavelot Massif judging from the geometry of the present border of the Massif. The southern part of this north-plunging syncline is detached where the Mormont and Xhoris Faults join, and thrusted, might be even slightly rotated north-eastwards over the west border of the Stavelot Massif, forming now the Bru nappe. The northwards plunging of the Paradis syncline explains the stratigraphy in the Bru nappe, limited to Gedinnian and lower Siegenian rocks. The formation of this nappe formed in a later stage of the tectonic process, explaining it is overlying part of the Xhoris Fault.

The existence of this complex structure precisely in this area is thought to be related to the original bend in the Caledonian Massif border, having allowed in the first place the formation of the plunging Paradis syncline and causing afterwards the detachment of its southern part when the Dinant fold belt was thrusted to the north along the Caledonian Massif.

This model is illustrated by three east-west profiles across the Bru nappe (Fig.3). The profiles imply that the Salm Group rocks of the original western border of the Massif are to be found below the Bru nappe.

2. The Oe fault near Eupen (Figs. 4 and 5)

2.1. Stratigraphic units used in the mapping.

Our mapping in the Eupen area is using basically four lithological units: a mostly red coloured thick conglomerate at the base underlain by red shales, a shaly interval characterised by the intercalation of fossiliferous greywacke, and on top occur limestones followed by homogeneous soft shales.

In the Devonian stratigraphy inspired by Asselberghs (1946) these four lithostratigraphic units belonged in chronostratigraphic terms to respectively the Emsian namely Burnot conglomerate with underlying red Winenne shales, the Couvinian with the Grauwacke de Rouillon and crinoidal limestone beds, the Givetian limestones and the Frasnian shales.

Since the revision of the Devonian stratigraphy (Dejonghe et al., 1991a,b; Hance et al., 1992) and the 1:25 000 mapping in the area (Laloux et al., 1996) , the chronostratigraphic interpretation has been modified.

The conglomerate is now interpreted as upper Eifelian to lowest Givetian based on the recognition in shaly intercalations in the conglomerate of palynological zonation AD in Eupen and AD-Lem in Heusy. The practice of distinguishing a pale coloured basal Middle Devonian conglomerate from a red coloured Emsian conglomerate was certainly inspired by the classical section exposed at Tailfer along the Meuse.

The Grauwacke de Rouillon, now apparently an obsolete subdivision in the Devonian stratigraphy (Bultynck et al., 1991; Bultynck & Dejonghe, 2001) has been incorporated in the Pepinster Formation (Dejonghe et al., 1991b) and it is suggested in Hance et al.(1989) that the fossiliferous middle part of the grauwacke as decribed by Asselberghs (1954) corresponds to the Heusy Member of the Pepinster Formation. As the Vicht conglomerate straddles the Eifel-Givetian boundary and the Heusy Member is younger, it is difficult to maintain a Couvinian age for the grauwacke containing shales.

The limestones in the mapped area are of an accepted Givetian age. The soft shales on top the limestones are either belonging to the Givetian Roux Formation or to the Nismes Formation of Frasnian age.

For the mapping exercise discussed in this paper, the chronostratigraphy is not essential and therefore, when referring to the mapping results, the informal units conglomerate, strata with grauwacke (including also reddish shales and sandstones), limestone and soft shales are used to describe the geology of the Eupen – Membach area and to discuss the position of the Oe fault.

2.2. The Oe Fault on the 1:25000 Geological map

The 1:25 000 map Limbourg-Eupen 43 / 5-6 (Laloux et al.,1996) shows south of Eupen the traces of the north-dipping Oe Fault and more to the south the south-dipping traces of the Helle and the Eupen Faults. The south dipping Walhorn-Pepinster Fault is mapped to the north of Eupen and south of Baelen. All these faults are mapped more or less parallel to each other. On the profiles accompanying the geological map, the Walhorn-Pepinster and the Oe Faults are linked to form the Goé unit above the concave shaped fault plane, and the Oe and Helle Faults are linked to define the Gileppe unit underlying the convex shaped fault plane. The dominantly Lower Devonian between the Helle and the Eupen Faults is part of the Goé unit. The structural concept and its tectonic origin are well illustrated and explained in Laloux et al. (1997) and Hance et al. (1999).

2.3. Mapping results and the trace of the Oe Fault

On the geological map the Oe Fault south of Eupen is tentatively linked up beneath the Vesdre alluvium with the fault bordered to the north by conglomerates (Vicht) exposed south of the Chapelle St. Quirin. Our new field data suggest that both exposed fault traces do not link up (Fig. 4).

Just to the northeast of Eupen, east of the railway station near Nispert, exists the contact between the strata with grauwacke to the west and the conglomerate to the east **.** The same conglomerate has been observed during the rebuilding in 2000 of the Hallenbad swimming pool of Eupen **(1)**. Furthermore this conglomerate can be followed as a pronounced geomorphological ridge along the Eupen-Limbourg road till, just north of the Camping Hertogenwald in the bend of the road, the conglomerates are apparently cut by a fault and replaced by Givetian limestones in the west, as shown by the presence of dolines **(2)**, and by the strata with grauwacke in the east. While strata with grauwacke can also be mapped northwest of the conglomerate band, the same strata also occur to the southeast of the conglomerates. This is proven by the several crinoid levels in excavations along the road from Eupen center to the sports center. In fact both bands have also been mapped by Laloux et al. (1996) as Pepinster Formation. The southeastern grauwacke bearing strata band is wedging out to the northeast where it disappears to the east of Nispert in the Haasbach south of Katharinenbusch, between a red shale facies in the west, mapped as Lower Devonian Bois d'Ausse by Laloux et al. (1996) or Lower Devonian Winnenne shales in Asselbergh (1946) terminology, and in fault contact in the east with Lower Devonian red and green shales and sandstones of the Acoz Formation as mapped by Laloux et al. (1996).

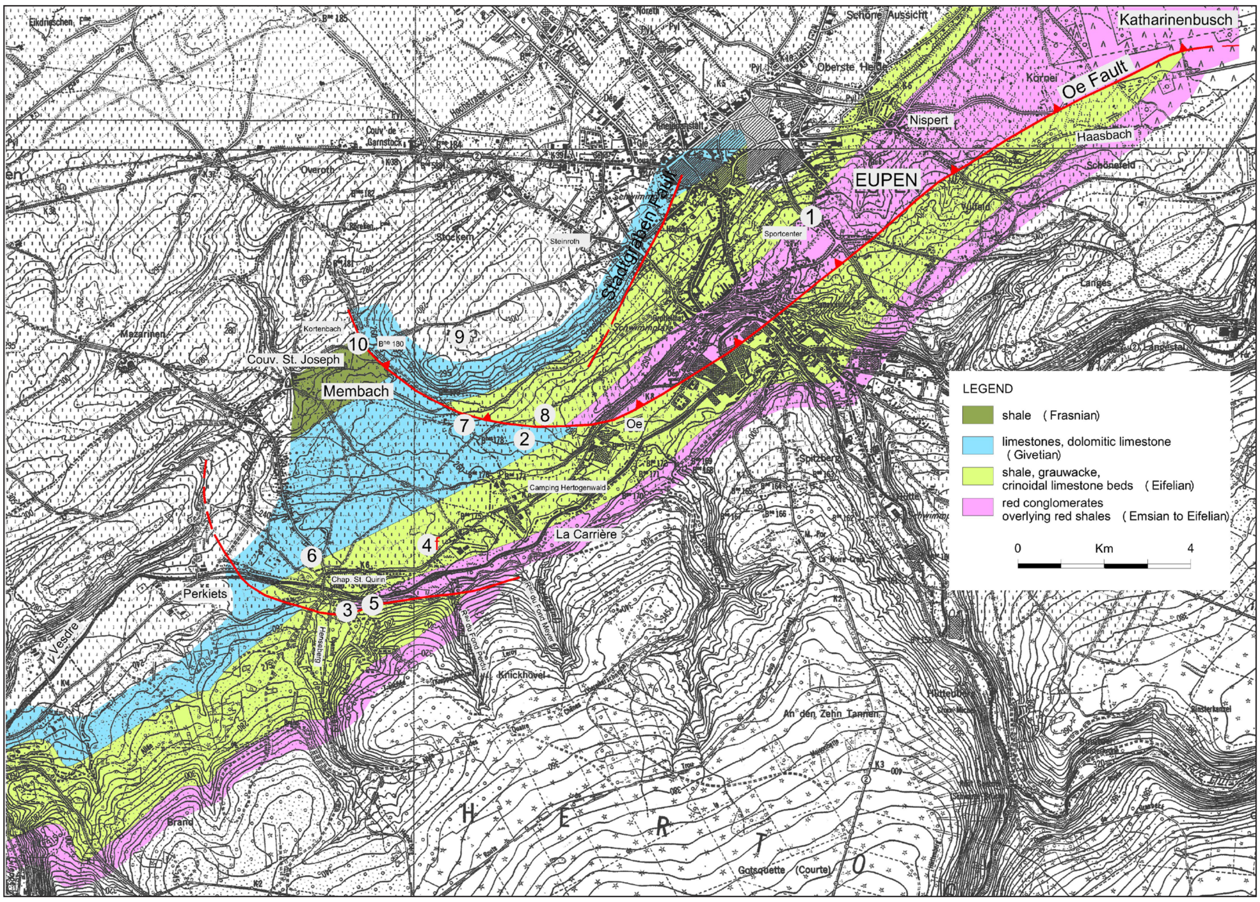

Figure 4. Oe fault trace between Eupen and Membach and position of the Stadtgraben fault.

Seen the repetition of the sequence grauwacke-strata-in-contact-with-the-conglomerate, it is logical to link this fault south of Katharinenbusch with the fault to the north of the Camping Hertogenwald, as is also represented by Laloux et al. (1996) on the map as the Oe Fault.

The conglomerates at Haasbach can be traced to the southwest almost parallel with the Oe fault, e.g.crossing the Eupen-Helle valley road where the Vicht parastratotype outcrop has been described in Dejonghe et al. (1991a), passing south of the Camping Hertogenwald (La Carrière), till the bridge of the road over the Vesdre near the Chapelle St. Quirin. The conglomerates still exist in a forest road which starts to the east from the Chemin de Henseberg at about 200 m from the bridge over the Vesdre **(3)**; the conglomerates occur in normal to steeply reversed, stratigraphic contact with the grauwacke bearing strata north of the conglomerate. The presence of these grauwacke bearing strata north of the conglomerate is proven by several fossil localities **(4)**. However, in western direction, the conglomerate band is rapidly wedging out, already directly to the east of the Chemin de Henseberg, and it can be mapped in fault contact with grauwacke strata occurring south of the conglomerates. The faulted nature of this contact is also indicated by a broad zone of red clay **(5)**. In 1950 a deep water pipeline trench from the Eupen Lake to Verviers has exposed the characteristic white coarse quartzites forming the base of the Givetian, underlying the limestones, just to the north of the bridge over the Vesdre and the Chapelle St. Quirin **(6)**. The mapping of the position of the limestones is further helped by the pedological map of the area (Pahaut & Oldenhove de Guertechin, 1961). This base of the Givetian occurs in normal stratigraphic contact with the grauwacke bearing strata south of the conglomerates.

Logically the conglomerates, wedging out near the Chemin de Henseberg south of the bridge over the Vesdre, are displaced to the east by the fault; the grauwacke bearing strata south of the conglomerate band is wedging out in the same direction and the last traces of it are found in the Ruisseau du Fond Perdu. The fault itself ends close to the Fond Meyer based on the mapping of the conglomerates below and to the east of the grauwacke. From there, in opposite direction towards the Gilleppe valley, the conglomerate and grauwacke bearing strata can be mapped in several side valleys of the Vesdre as continuing regularly till the Gileppe valley where a fold is mapped, bending the contact between both layers in northwest direction.

In this interpretation the Oe Fault observed at Haasbach, south of Katharinenbusch northeast of Eupen, can be linked with the fault north of the Camping Hertogenwald but this fault can not be linked with the east-west trending fault south of the Chapelle St. Quirin as it is interpreted on the map by Laloux et al. (1996).

Northwest of Camping Hertogenwald, the trace of the Oe Fault can be further mapped based on the presence of a doline surrounded with limestone blocs near ‘borne 177’ on the topographic map **(2)**, and of an east-west trending limestone breccia in construction works on an old farm house directly west of ‘borne 178’ **(7)**. The limestones are Givetian and mostly covered by terrace deposits. The position of the doline close to and in the direction of the conglomerates, and the breccia, both point to the presence of a fault. North of the doline limestones and north of the wedging-out conglomerates, occur disperse blocs of sandstones and red shales belonging to the grauwacke bearing strata **(8)**, trending regularly towards Eupen and linking up with the strata west of Nispert discussed earlier.

In our mapping, these fault indications are part of the Oe Fault, turning westwards north of Camping Hertogenwald.

East of Membach, the extension of the Couvent St.Joseph was built on Frasnian grey-greenish sandy shales. The exact position of the Givetian-Frasnian boundary could not be observed. At the base of the slope of the large limestone hill **(9)** that extends till Eupen, thick Givetian limestone beds outcrop along the north-south trending road just south of borne 180 (Kortenbach). Along the road to the south these limestone beds can be seen cut by a fault. This faulted zone can be traced to about 100 m west of borne 180 (Kortenbach) in the bending of the road from Membach to Eupen, where important reddish broken-up rocks were exposed over a few meters in the foundations of new houses **(10)**. This disturbance in the rock succession is also recognised on the Eupen-Limbourg geological map but attributed to the effect of a northwest-southeast trending steep fault (Laloux et al., 1996). The position of the Givetian limestones in the area can also be deduced from the calcareous soils mapped by Pahaut and Oldenhove de Guertechin (1961).

Linking up all these indications of faulting in the area between Camping Hertogenwald and Kortenbach leads to a fully curved fault trace of the Oe Fault defining a small nappe as is figured in the profile (Fig.5). This nappe might have been detached by gravity from the rising front zone of the Caledonian Stavelot Massif (profile Fig.5). The geomorphology between Membach and Eupen therefore is determined by the structural geology.

Recent outcrops in foundations of large constructions on the hill west of Steinroth have shown a bending of dolomitic rocks parallel to the curved trace of the Oe Fault as mapped in this study **(9)**.

The fault displacing the conglomerates south of the Chapelle St. Quirin could have a similar shape as the Oe Fault, as suggested on the map by tracing the fault between the Chapel and Perkiets.

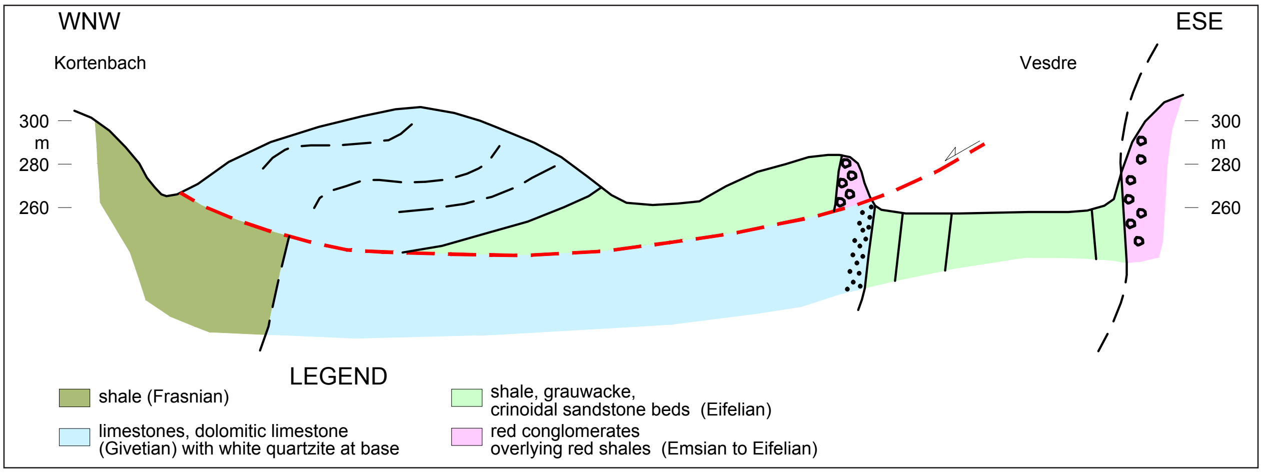

Figure 5. Schematic profile from Kortenbach to the Vesdre Valley in the southeast (see map Fig.4) illustrating the nature of the Oe fault.

2.4. The Stadtgraben fault.

The town of Eupen is located inside the nappe defined by the Oe fault. Its geology has been investigated already in an early stage in search for water, leading finally to the construction of the Eupen Dam near the major thrust bringing the Caledonian of the Stavelot Massif over the Lower Devonian (Holzapfel, 1899, 1910; Loup, 1973; Schimpke, 1899; Geukens, 1983, 1984b). Several elements point to the existence of a fault in the south-western part of the town. An observation during the recent (2003-2004) construction works at the St. Nicolas Hospital has confirmed the presence of a 25 m clay-loamy zone in Givetian limestones striking N40-45°E. A trench for evacuating the water from the construction site to the Stadtgraben river, perpendicular to the strike of the strata, shows the reddish shales and sandstones belonging to the grauwacke strata in normal contact with red shales at the base of the Givetian. The basal Givetian limestones show a 'pli en chaise' fold. In the clay-loamy zone occur dark horizons (photo Fig.7) striking N30°E and dipping 50°W, possibly the original strike of the Givetian limestones suggesting an intense in situ chemical weathering of the limestones. To the north the clay can be followed over about 30 m (photo Fig.6) in the same direction till it disappears below a chapel. The almost pure illite composition of the clay similar to the insoluble residu composition of the Givetian limestones at the site suggests extensive dissolution of the limestone by water circulation along a faulted zone rather than the sedimentary filling of a pre-existing large karst hole; besides the grain-size of the clay is very fine with modal sizes between 2.6 and 40 µm and 10% coarse percentiles below 65 µm and even as low as 22,5 µm (laser diffraction analysis). A borehole at the construction site has proven the clay to occur at least to 10 m depth. About 400 m to the southwest of the Hospital at the left bank of the Stadtgraben river cone penetration testing till 15 m depth, by Geologica N.V. in 1985, has not reached hard rock and remained in loamy and clayey soil with altered rock fragments. Extending the fault zone in north-eastern direction leads to the centre of Eupen where Fe, Pb and Zn mineralisation has been reported by Dejonghe et al. (1993).

Already in 1893 a borehole was made in the search for water starting in limestones on the right bank of the Stadtgraben at the locality 'in den Ettersten' (Loup, 1973). The 83m borehole depth was unsuccessful but at its bottom a 60m long gallery was excavated to the southeast following the limestones but ending in a broken and jointed zone, already drafted by Holzappel (fig 10 in 1910) as a south dipping thrust fault, bringing the grauwacke bearing strata over the limestones. It seems logical to link this zone in the gallery with the fault zone with clay observed at the hospital construction site. The origin of the voids collecting the clays and loams are not simply karst dolines but represent a continuous dissolution band along a fractured fault zone; the intense dissolution is helped by the acidity of the water draining from the Caledonian Stavelot Massif and the Lower Devonian strata in front of it.

Figure 6. The occurrence in the excavations near the Hôpital Saint-Nicolas in Eupen of a 25 to 30 m wide clay zone within Givetian limestones, marking the passing of the Stadtgraben Fault (see Fig. 4). Note in the left part the steeply dipping black layers, possibly representing the geometry of the original limestones.

It is proposed to name this fault the Stadtgraben fault. Such a fault zone can be associated with the sliding northwards of the Oe Fault as discussed before.

3. The Gileppe Sud fault and the structure between the Theux window and the Gileppe Lake (Fig. 7)

In this part detailed mapping results are presented along the Gileppe Sud Fault tract and a model is proposed for the structural make up of this area between the Cambrian quartzite dominated thrust nappe east of the Gileppe Lake and the Theux Window in the west.

3.1. The Gileppe Sud fault on the Limbourg-Eupen 43 / 5-6 map.

On the 1:25 000 map Limbourg-Eupen 43 / 5-6 (Laloux et al. 1996) the Gileppe unit is bordered in the south by the north-dipping Gileppe Fault delimiting the Jalhay Massif in the south (see also Hance et al., 1999). The Jalhay Massif is situated between this Gileppe_Fault on top and the Theux-Tunnel Fault at depth. On the geological map the trace of this Gileppe Fault can be followed from south of the Hé des Morts hill, northeast of the Gileppe Lake, in eastern direction and ending where it is cut by, and joins, the major Eupen Fault which is thrusting the main mass of Cambrian La Venne-Coo Formation rocks of the border of the Stavelot Massif. Where the Gileppe Fault is crossing the Gileppe lake, it is supposed on the map to splay in two parts; especially the main trace in the south is markedly displaced southwards by a supposed northwest-southeast fault. This southern main trace of the Gileppe Fault is continuing from Hobôster in western direction towards the northeast edge of the Theux window near Jehanster.

In the Hobôster-Le Chêneu-Louviépré tract, the north-dipping fault is mapped north of the Cambrian La Gleize (Rv5) Fm, occurring in an anticlinal core of the Salm Group. Southwest of Le Chêneu, a narrow Lower Devonian sliver is mapped over a short distance along the fault. More westwards, between Louvriépré and Jehanster, the fault separates two Lower Devonian blocs.

In the area discussed, Fourmarier and Aderca (1958) have mapped and discussed a Gileppe Sud and a Gileppe North fault as main longitudinal structural elements, displaced by numerous post Variscan NW-SE transversal faults.

3.2. Detailed structural mapping of the Gileppe-Louviépré-Foyir area

Geukens (fig 5, 1999) has presented a map of the Gileppe-Louviépré area based on his observations around and in the Gileppe Lake when it was emptied in 1959 for repair works on the dam. Since that time new field data have been obtained resulting in the detailed map presented here (Fig. 7). The discussion of this new detailed map, starts from the east side of the Gileppe Lake, and continues westwards till the Louviépré –Foyir zone.

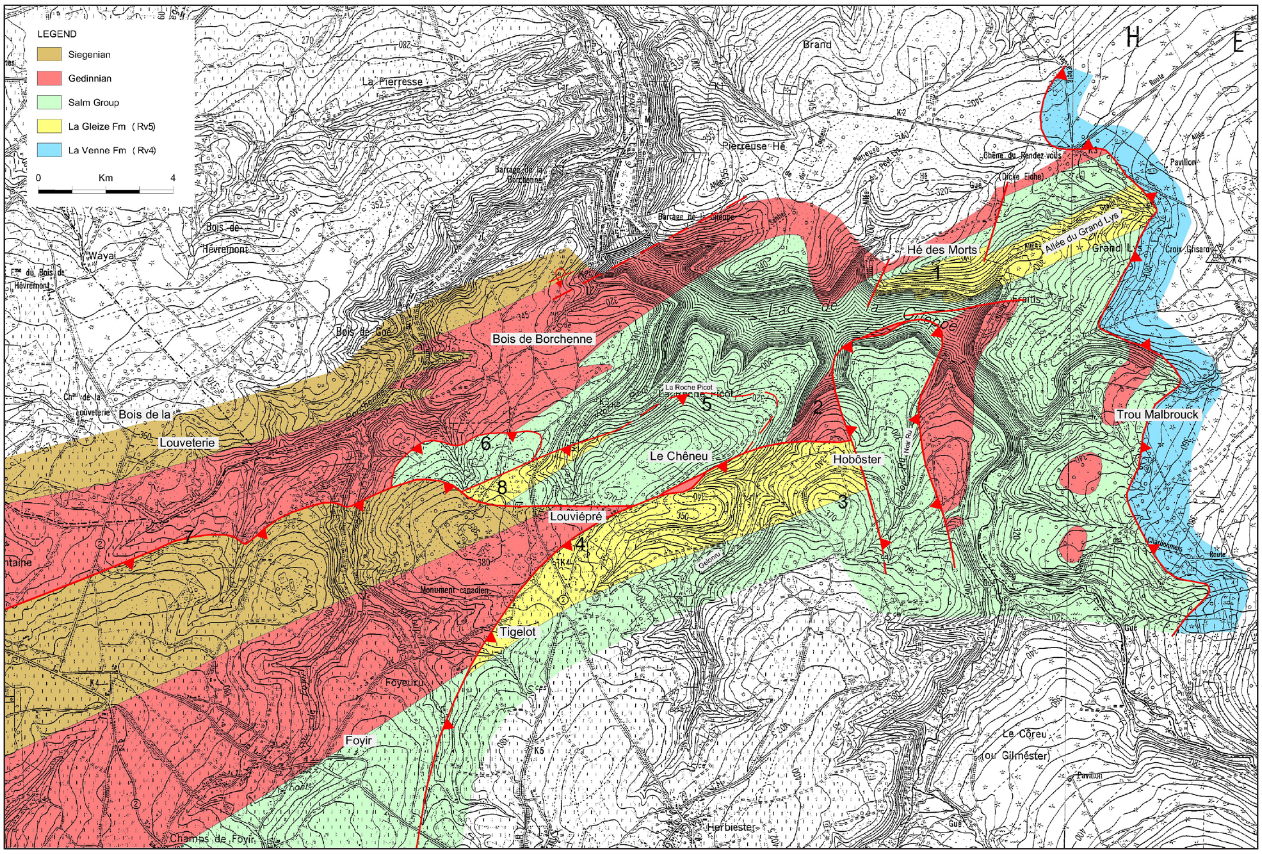

Figure 7. Geology of the Gileppe area and the area to the west of the lake illustrating the many thrust faults defining individual nappes.

Detailed mapping south of Hé des Morts has not observed Salm Group rocks between La Gleize (Rv5) rocks **(1)** ; therefore an important northeast-southwest fault as shown on the map of Laloux et al. (1996) is improbable. The outcrops of these La Gleize black shales along the Allee du Grand Lys are all part of a single narrow anticlinal core in lower Salm Group rocks, similar to other narrow anticlinal cores which occurs south of the Gileppe Lake in the Jalhay Massif.

The map south of the Gileppe Lake, in the area of Hobôster and the Ruisseau Noir Ru, is based on the outcrops of conglomerates observed when the Lake was empty. Conglomerates could be observed almost completely surrounding a north-south trending patch of Salm Group rocks, rich in graptolites (Dictyonema) and cone-in-cone nodules, forming the hill between the Ruisseau Noir Ru and the next western subsidiary valley of the Lake (Ruisseau de Gelonru). It also allowed the observation of a faulted eastern contact of the Salm Group rocks with the Gedinnian: the fault has a strike N20-30°E and a dip of 30°W measured in the Noir Ru embayment. These observations, and the distribution of the Lower Salm Group facies rich in graptolites and cone-in-cone structures, are most easily explained by a shallow Salm Group nappe overlying Lower Devonian as already discussed by Geukens (1999). The eastern trace of this Lower Salm Group nappe corresponds to the northwest-southeast trending major splay of the Gileppe fault mapped by Laloux et al. (1996), from the middle of the Lake into the Ruisseau Noir Ru to the south.

During the tunnel construction from the Soor to the Gileppe, an important fault could be observed in the Salm rocks near Trou Malbrouck, close to the faulted contact with the Cambrium Revin Group; its orientation was difficult to estimate and no obvious link with other known faults at the surface could be made.

Part of the approximately north-south fault mapped by Laloux et al.(1996), from the middle of the Lake southwards towards Hobôster, corresponds in our mapping interpretation to the western map trace of the concave shaped nappe fault occurring at relative shallow depth below the small lower Salm Group nappe described above.

Northwest of Hobôster, the Gedinnian reappears from below the Salm Group nappe, followed to the west, in unconformable contact, by the Salm Group rocks, which is the normal stratigraphic sequence at the border of the Stavelot Massif **(2)**.

South of Le Chêneu, the structure of this Lower Devonian-Salm Group succession is cut by the La Gleize Formation rocks in a faulted contact, shown by the opposite strikes of the strata in both units. The black shales of the La Gleize Fm form a slightly southwest-northeast trending narrow anticlinal core; to the south of Hobôster these black shales are in normal contact with the Salm Group strata which constitute the southern limb of the anticline **(3)**.

To the west between Louvriépré and Tigelot, the La Gleize anticlinal strata are in fault contact with the Lower Devonian. Detailed mapping of the contact between the La Gleize anticlinal core between Tigelot and Louvriépré shows that the black shales cover both the basal conglomerates and the overlying Marteau Fm red shales in the Devonian band, pointing to thrust faulting driven from the south and implying a south dipping fault plane **(4)**.

This fault between Louvriépré and Tigelot logically links up with the northern border of the La Gleize Formation till Hobôster; this northern border is also a faulted contact as the black shales are in contact successively with conglomerates and Marteau red shales in the west, Lower Salm Group strata south of Le Chêneu, and in the east again Lower Devonian rocks exposed northwest of Hobôster **(2)**. The fault north of the La Gleize Formation, from Tigelot till Hobôster, delineates the front of a medium-sized thrust unit. This thrust unit is cut and overlain in the east by the small Lower Salm Group nappe discussed earlier.

The Lower Devonian band west of the La Gleize Formation, with Foyir located in its southern border, is considered part of the Jalhay Massif (Geukens, 1986; Laloux et al.,1996) or occurring just north of this Massif (Geukens, 1999). This last difference in interpretation can be understood as the Foyir Lower Devonian band can be seen in some instances in normal unconformable contact with Salm Group rocks to its south and in other instances it can be seen overthrusted by the Salm Group rocks. In fact the Foyir Lower Devonian occupies a similar map position with respect to the Early Paleozoic Jalhay Massif as does the Lower Devonian in the Theux Window (see e.g. Geukens, 2008). This relatively regular band of Lower Devonian north of Foyir, is bordered to the north by a major approximately east-west fault **(7)** north of which a repetition of Lower Devonian is found in the Borchenne valley and the Bois de la Louveterie; this fault is considered by Laloux et al. (1996) as a major part of the Gileppe fault. It also undoubtedly corresponds to a short fault tract mapped by Asselberghs (1956) between Foyir and the Bois de Borchenne. The Devonian in the Bois de Borchenne, north of this east-west fault, is part of the regular Lower Devonian bordering the Stavelot Massif more to the northeast and crossing also the northern part of the Gileppe Lake. A schematic structural evolution model of its origin, thrusted over the Jalhay Massif in front of the main Eupen thrust can be found on the map of Geukens (1986).

The Salm Group strata, which normally border the northeast Stavelot Massif in front of the major Eupen-

Venn thrust fault (see maps in Geukens 1986 & 1999) can be observed south of the Bois de Borchenne Lower Devonian, covering the area across La Roche Picot till Le Chêneu. Importantly in these Salm rocks clear indications of thrust tectonics can be observed.

There is for instance north of Louvriépré and west of Le Chêneu an additional smaller La Gleize black shale anticlinal core **(8)** with a faulted northern boundary, analogous to the larger La Gleize Formation band between Louvriépré and Hobôster. On the map this northern boundary fault is tentatively extended eastwards through a zone of very intensively deformed Salm rocks having also many slickensides, observed on the slope to the Gelonru valley near La Roche Picot **(5)**. The small La Gleize core is cut in the west by the fault separating the Foyir Lower Devonian from the regular Borchenne valley Lower Devonian which is bordering the Stavelot Massif and belonging to the Gileppe unit sensu Geukens (1986). Another small thrust nappe could be mapped, entirely in Lower Salm Group rocks, lying partly in front of the western part of the small La Gleize anticlinal core and partly north of the fault bordering the Foyir Lower Devonian band in the north. The contact of the Salm Group rocks in this nappe with the Bois de Borchenne Lower Devonian to the north, has been observed in detail in the 1971 extensive construction works for 2 m deep water conducts **(6)** and the Salm Group strata have been seen tightly folded with subhorizontal fold planes, sometimes slightly (10°) dipping to the west, fragmented and thrusted over the Gedinnian conglomerates to the north.

3.3. The regional structural style

What is considered in a regional scale mapping as a continuous fault, the Gileppe Fault, becomes much more complex when mapped on a more detailed scale. In fact, in the interpretation presented in this paper, the whole area north of the Early Paleozoic Jalhay Massif consists of several small northwards thrusted nappes.

The major thrust block is the core of the Jalhay Massif itself, bound in the north by the Foyir Lower Devonian strata. Also the contact between the southern Early Paleozoic core of the Jalhay Massif and its northern Foyir Devonian rim is itself often in thrust contact. This Foyir Devonian rim overthrusts the Gedinnian and Siegenian of the Bois de Borchenne. This latter Lower Devonian is the regular Lower Devonian with Salm Group strata to its south, bordering the Massif of Stavelot and overthrusted by the Cambrian along the major Eupen Fault. East of the Lower Devonian between Foyir and Bois de Borchenne, several other small nappes have been identified. A small Salm Group nappe **(6)** is wedged in between the Foyir and the Bois de Borchenne Lower Devonian structural units. A somewhat larger La Gleize- Salm Group thrust nappe front is identified between Hobôster-Louvriépré and Tigelot, thrusting northwestwards over the Foyir Devonian rim and northwards over the Gileppe unit Salm group rocks. In fact it is not excluded that a southern part of this Salm Group rocks around Le Chêneu still forms another small nappe including the small fault bounded La Gleize anticlinal core to its northwest. Another small Salm Group nappe definitely occurs in the Noir Ruisseau zone overlying Lower Devonian.

This amalgamation of several small northwards thrusted nappes precludes the recognition of one single Gileppe Fault plane in the area. The general thrust direction is northwards with south dipping fault planes although fault planes can easily become undulating producing also north dipping fault planes. The complexity of this structural make-up illustrates the effect of the major northwards Eupen thrust; indeed the whole area discussed has been directly underlying this major thrust plane. Notwithstanding these intense thrusting, the distance over which the nappes have been thrusted northwards can not have been large as the narrow La Gleize anticlinal structures in the Theux window, the Jalhay Massif and the Gileppe area are structures so similar that they are considered to have originally been one single structure (see map Geukens, 1986; Geukens, 2008).

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