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THE SILURIAN OF THE MEHAIGNE AREA (BRABANT MASSIF, BELGIUM) LITHOSTRATIGRAPHY AND FEATURES OF THE SEDIMENTARY BASIN

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During the eight years of research, published partly in this work I received the help of many people and it is impossible to thank them all personnally here.

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ABSTRACT

After a detailed study of about 140 sections of Silurian sediments from the Mehaigne area in the eastern part of the Brabant Massif, a lithostratigraphic column 2100 m thick is established and 9 informal formations and 9 members are defined. The sedimentology shows the turbiditic nature of the deposits and the sedimentation in a distal flysch facies under the bathyal conditions of a mio-geosynclinal trough. This trough is situated on the SE part of the London-Brabant microcontinent, whose edges were folded during the Caledonian orogenesis. The variation observed in the flysch shows in general the approach of the Caledonian orogenesis and furthermore consists of six megacycles, probably caused by movements of the Ardenne in full orogenesis.

RESUME

L'auteur décrit en détail 140 affleurements dans le Silurien de la région de la Mehaigne (partie orientale du Massif du Brabant). Une colonne lithostratigraphique est établie. Neuf formations informelles et neuf membres ont été définis. Les sédiments sont des turbidites et ont été déposés dans un facies de flysch distal dans des conditions bathyales d'une fosse miogéosynclinale. Cette fosse est localisée dans la partie SE du microcontinent Londres-Brabant, dont les bords ont été pliés pendant l'orogenèse caledonienne. La variation dans le flysch montre en général l'approche de cette orogenèse. En plus six megacylces sont reconnus dans le flysch; ils reflètent probablement des mouvements de l'Ardenne en pleine orogenèse.

KORTE INHOUD

Het gedetailleerde onderzoek van ongeveer 140 ontsluitingen in Silurische sedimenten van het Mehaigne gebied (oostelijk deel van het Massief van Brabant) laat toe een litostratigrafische kolom op te bouwen van 2100 m dikte. Daarin worden negen informele formaties en negen informele leden gedefiniëerd. Sedimentologisch zijn deze sedimenten turbidieten; ze werden afgezet in een distaal flysch facies onder bathyale omstandigheden in een miogeosinclinale trog. Deze trog is te situeren in het SE-deel van het Londen-Brabant microcontinent waarvan de randen geplooid werden in de Caledonische orogenese. De waargenomen vertikale variatie in de flysch toont de geleidelijke nadering van deze orogenese en bestaat bovendien uit zes megacycli vermoedelijk veroorzaakt door de vertikale bewegingen van de Ardenne dat zich dan in volle orogenese bevond.

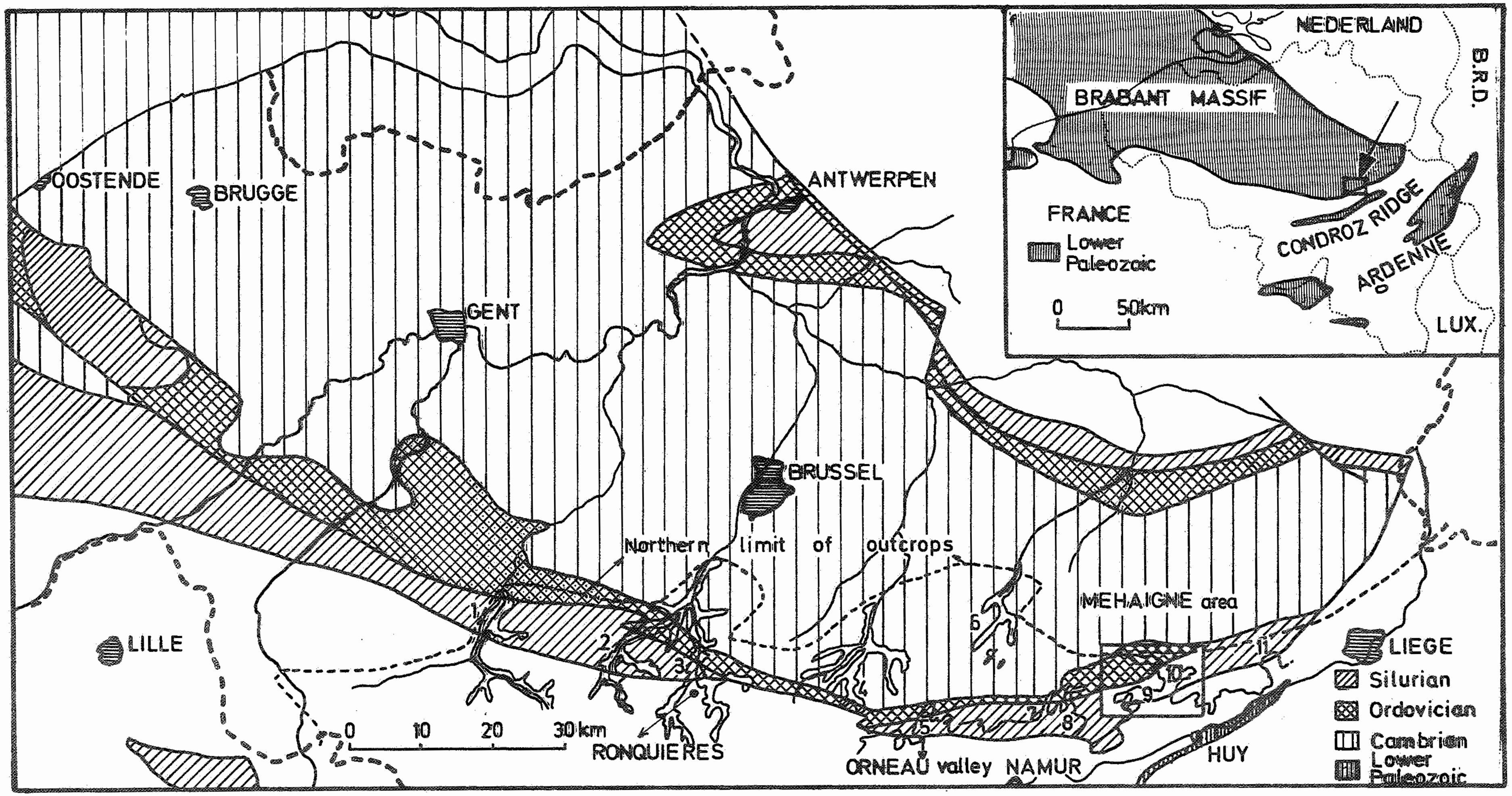

Fig. 1 : General geological map of the Brabant Massif (Lower Paleozoic) after LEGRAND (1968). The outcrop areas are only on its southern rim (1) Dender-valley, (2) Senne-valley, (3) Sennette-valley, (4) Dyle-valley, (5) Orneau-valley, (6) Demer-valley, (7) Leuze-Hanret, (8) Cortil-Wodon and Noville-les-Bois, (9) Burdinale valley, (10) Mehaigne valley (11) Horion-Hozémont. The type localities of the Silurian in the Brabant Massif are situated and the Mehaigne area is shown in the square. The inset in the right corner shows the position of the Brabant Massif and other Lower Paleozoic Massifs in Belgium and the surrounding region.

1. INTRODUCTION AND LITERATURE

1.1. Introduction

In this paper the Silurian and some Ordovician sediments from the Brabant Massif are studied in outcrops along the flancs of the Mehaigne valley between the villages of Avennes and Huccorgne, and along the flancs of a tributary, the Burdinale valley. For the sake of brevity the whole area concerned will be called "Mehaigne area".

Geographically it is situated at the transition of three natural regions : the "dry western Hesbaye" (characterized by Cretaceous chalk under a thick loam cover); the "western Hesbaye" with Cenozoic sands and clay under a loam cover, and the "Meuse Depression" where outcrops of Paleozoic rocks are found.

Geologically it is the most eastern outcrop area of the Brabant Massif, except for the small Horéon-Hozémont area 10 km to the east, where some lower Paleozoic rocks of the Brabant Massif are also exposed. To the south the Silurian is discordantly covered by sediments of the Middle Devonian transgression : the Mazy conglomerate in the western part of the Mehaigne area (Gvb on the detailed geological maps on scale 1/40.000, 1903) and a greywacke of the same age or younger in the eastern part, followed by the Late Devonian and Carboniferous deposits of the northern part of the Synclinorium of Namur. The Paleozoic is covered by subhorizontal sediments of Cretaceous age ("Hervian" or Campanian Cp2 and Cp3 chalk according to the symbols on the detailed geological map,1903), and by Oligocene sands (Tg 1). On the highest points of the topography some gravel beds of old riverterraces of the Meuse (denominated Onx gravels on the geological map) occur as well as an occasionally thick cover of later Pleistocene loesses.

1.2. Earlier studies on the Brabant Massif

The Silurian of the Mehaigne area was never the object of an elaborate study. Indeed the Silurian of the Brabant Massif has been defined lithostratigraphically 30 to 60 km more to the west in the Orneau valley and in the Sennette valley (fig. 1), where more numerous and longer sections are present than in the Mehaigne area.

The Brabant Massif has already been studied thoroughly since a long time (e.g. DUMONT, 1848). In the period between 1873 and 1914 MALAISE and other authors analysed the stratigraphy of the Silurian of the Brabant Massif in detail. After this period little has been added. Several authors revised the stratigraphy but with the scarcity of graptolite horizons to date the lithostratigraphical units and the lack of a good key to describe the turbiditic sediments (see later) these revisions were often imprecise and sometimes added confusion. For the lithostratigraphical unit "Assise de Corroy", for example, of a lower and middle Wenlockian age (VERNIERS, 1983.) three type localities have been designated, each with a different lithology. It is therefore clear that these "type areas" have to be reinvestigated.

The Silurian sediments have been more thoroughly studied in boreholes of the Brabant Massif west of the outcrop area, (i.e. west of the

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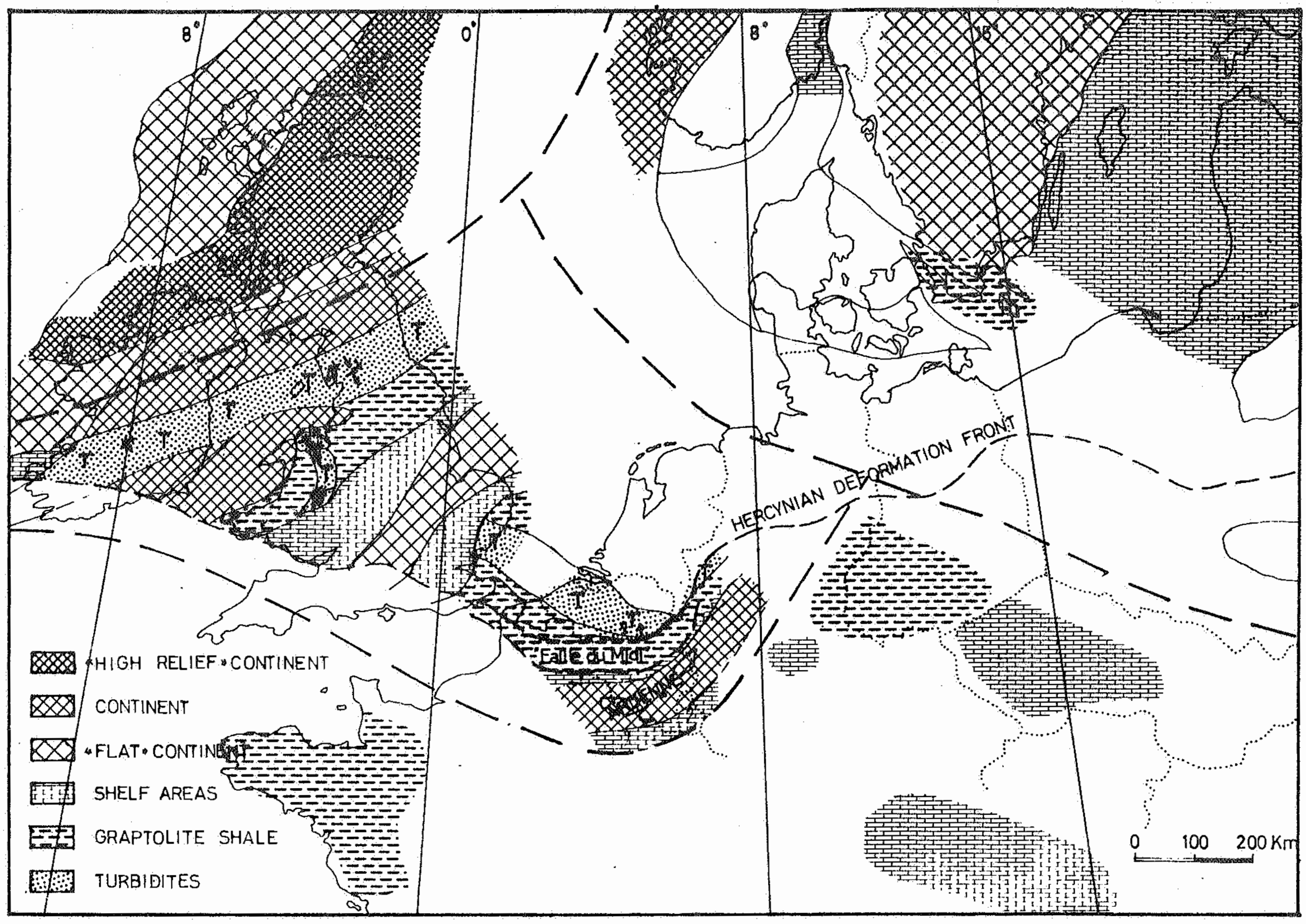

Fig. 2A : Early Ludlovian palaeogeography of a part of Europa (for Great Britain and Ireland after ZIEGLER, RICKARDS & Mc KERROW, 1974)

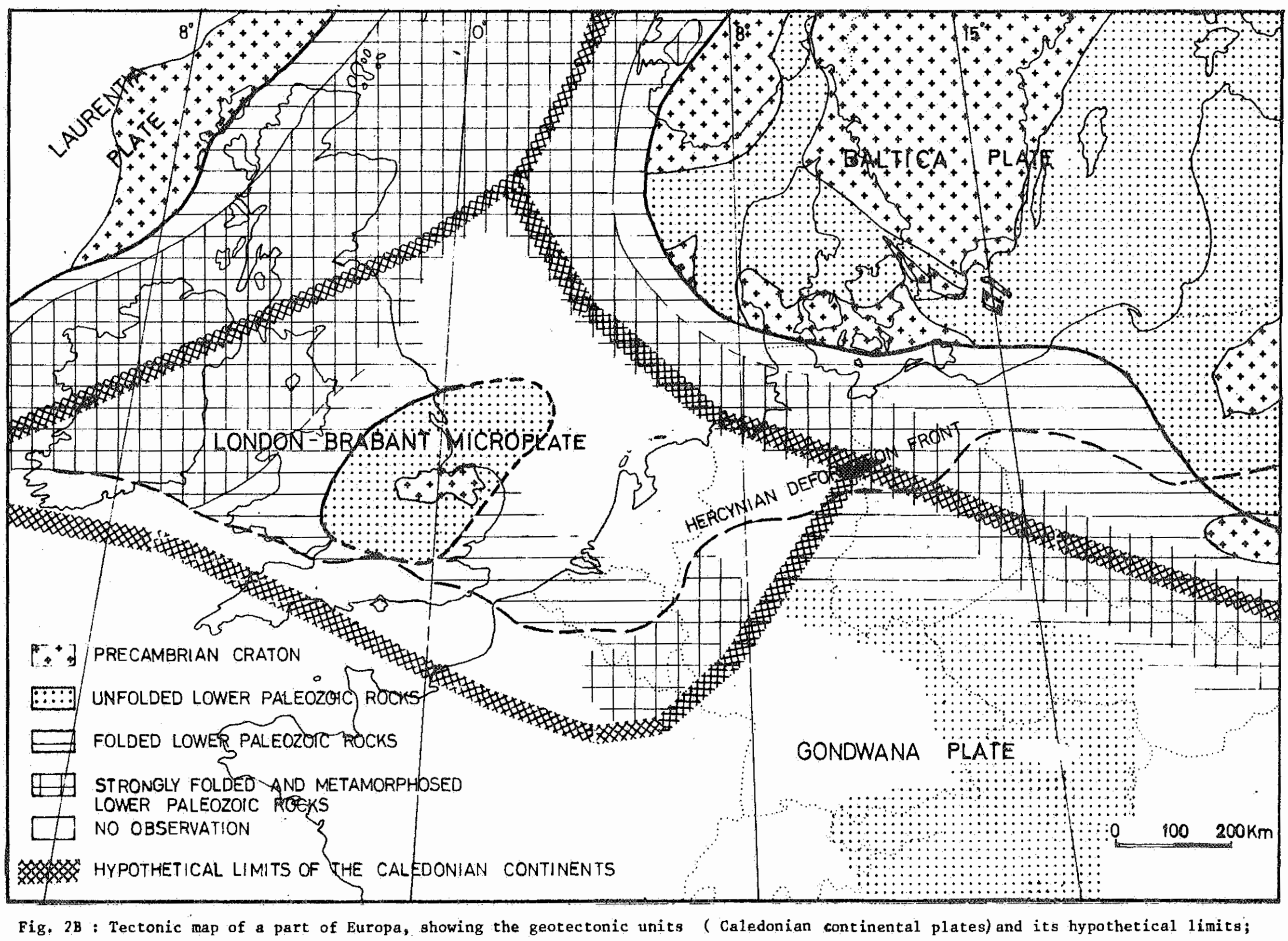

Fig. 2B : Tectonic map of a part of Europa, showing the geotectonic units (Caledonian continental plates) and its hypothetical limits; their Precambrian cratons, surrounded by areas of unfolded lower Palaeozoic rocks; the lightly folded lower Palaeozoic rocks of the "Caledonian Externides" and the strongly folded and metamorphosed rocks of the "Caledonian Internides" (after ZIEGLER, 1978, except for Belgium and surrounding areas).

Dender valley), but correlations with the outcropping area are still lacking.

The typical feature of the Silurian formations in the Brabant Massif, the marked rhytmicity, has been observed in boreholes as well as in outcrops (e.g. LEGRAND, 1967b, 1982), but the nature of the rhytmicity, its variations, and its origin have never been studied.

As interest in stratigraphical studies waned, interest in structural and tectonic studies increased. MORTELMANS (1953) described two orogenetic movements in the Silurian of one of the valleys of the Brabant Massif, and LEGRAND (1967b) proved that both movements were pre-Middle Devonian. Later MICHOT (1979) proposed, on the basis of new data, a Gedinnian age for the first, and an early Emsian age for the second orogenetic event.

In the last twenty years micropalaeontology became a new tool to unravel the stratigraphy of the lower Paleozoic of the Brabant Massif. STOCKMANS & WILLIERE (1960) established the presence of different microfossil groups (acritarchs and spores); MARTIN (1966, 1969a, 1969b, 1971) and MARTIN & RICKARDS (1979) made an inventory of acritarchs in the Cambrian, Ordovician and Silurian, and VAN GUESTAINE (1967, 1968, 1970, 1978a, b), an inventory of those in the Cambrian and Ordovician of Belgium.

Chitinozoa were described in the lower Llandoverian of a borehole at Deerlijk near Kortrijk in the Brabant Massif (MARTIN, 1971, 1974), in late Ludlovian and Pridolian rocks of Northern France (RAUSSCHER, 1970, 1973) and in a few samples of the Llandoverian and Wenlockian of the Sennette valley (Brabant Massif) (MARTIN & RICKARDS, 1979). MARTIN (1969a) mentioned organic walled microfossils for the Silurian of the Brabant Massif only in the Mehaigne area, and not in the type area (Sennette valley, Orneau valley). This is the reason that the Mehaigne area was selected to start a detailed reinvestigation of the stratigraphy of the Silurian of the Brabant Massif.

Up to now few efforts have been made to locate the Brabant Massif within the Caledonian structural framework of Western and Northern Europe. On the basis of information collected during the subsurface exploration of the North Sea, ZIEGLER (1978) is the first to consider the London-Brabant Massif as an intramontane, stable platform (microcontinent) surrounded on all sides by Caledonian fold belts (see fig. 2). The Lower Paleozoic orogenetic belt in Belgium and neighbouring areas (Northern France and Germany) would form the south-western orogenetic rim at the border of a Precambrian intramontane, stable platform (an old craton). This old craton has been postulated to exist in the southern part of the North Sea as a source area for the Cambrian sediments in Belgium (BEUGNIES et al. 1976), and it has also been discovered in boreholes in NW England, south of Hull. Unfolded areas presently exposed in the west of the Welsh Borderland and detected in the south in boreholes around London surround it. Further away from this craton, Caledonian folded geosynclinal areas are found to the south-west in the Ardenne, folded during the Caradocian, and in the Brabant Massif, folded at the end of the Silurian and in the Early Devonian. The folded belts also occur to the west and the northwest of this old craton in Wales and Northern England. There also, the orogenetic belt

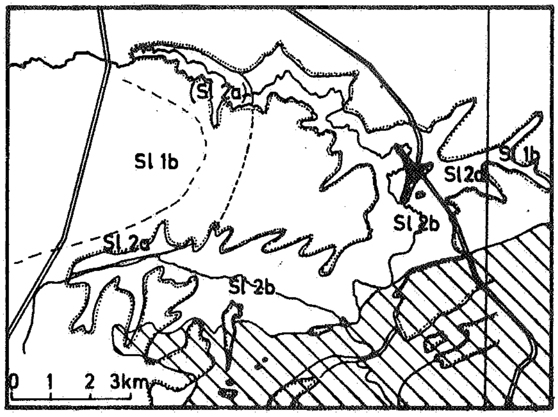

Fig. 3A Geological map 1/40.000 (1903) (reduced) Lower Paleozoicum by C. MALAISE

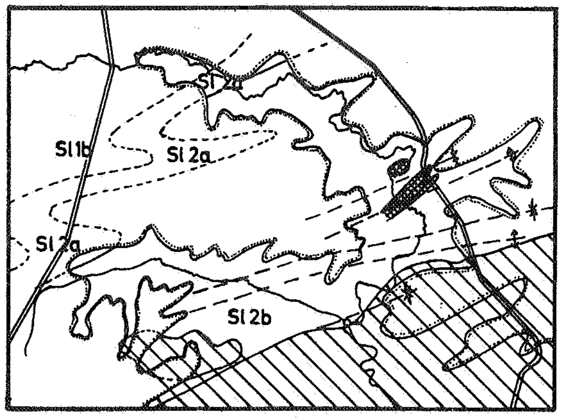

Fig. 3 B P. FOURMARIER, 1912 (1921).

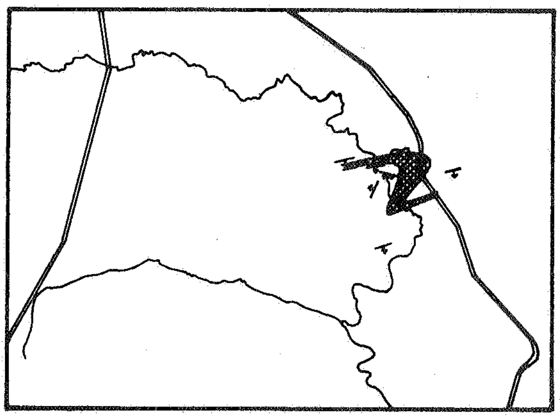

Fig. 3C P. FOURMARIER, 1920. (reduced)

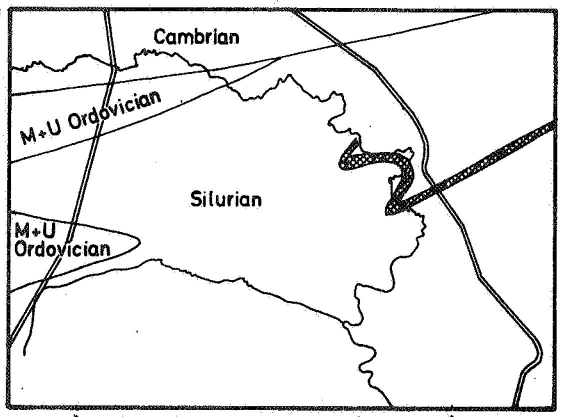

Fig. 3D G. MORTELMANS, 1955. (reduced)

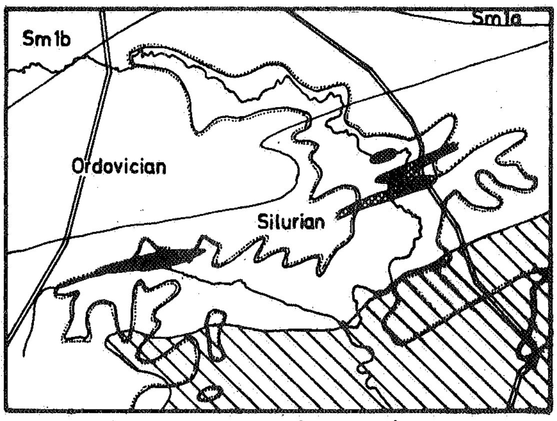

Fig. 3E R. LEGRAND, 1967. (enlarged)

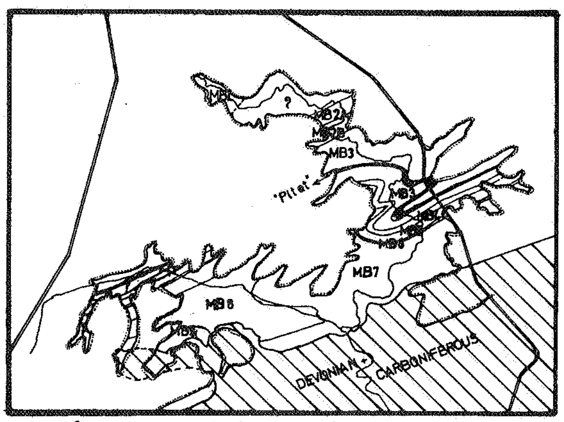

Fig. 3F This study. (reduced)

Fig. 3 : Geological maps of the Mehaigne area seen by different authors (reduced or enlarged to the same scale).

3A : Geological map (1/40.000) by MALAISE, RENARD and de la VALLEE-POUSSIN (1903). Sl1b : "Assise de Gembloux" (Ordovician), Sl2a : "Assise de Grand-Manil", Sl2b : "Assise de Corroy" and "Assise de Vichenet" (Silurian). The line doubled with a dotted line gives the limit of the Mesozoic and Cenozoic cover and the hatched area in the SE shows the extention of the Devonian-Carboniferous strata of the Synclinorium of Namur. Note the different designation of strata at both sides of the mapsheet division in the east : Sl2b (Silurian) on sheet Wasseiges-Braives (west) and Sl1b (Ordovician) on sheet Jehay-Bodegnée (east).

3B : Part of the tectonic map of the Brabant Massif (scale 1/160.000) by P. FOURMARIER (1921, but written in 1912). Symbols as in fig. 3.A. The long dashed lines give the position of anticlines and synclines. The limits of the lithostratigraphic units are drawn following the fold pattern. The nature and structure of the volcano-sedimentary layer of Pitet shown here on two separate places is unclear as in the previous fig. 3.A.

3C : Map on scale 1/40.000 with mapping of the volcano-sedimentary layer of Pitet showing its interbedded nature within the Silurian sediments according to P. FOURMARIER (1920). Some dip and strike readings are given.

3D : Part of the tectonic map of the Brabant Massif of G. MORTELMANS (1955) on scale 1/80.000. The volcano-sedimentary layer of Pitet is connected with those of the Voroux-Goreux complex. Cambrian rocks are shown in the north.

3E : Part of the geological map of the Brabant Massif by LEGRAND (1968) on scale 1/300.000. The volcano-sedimentary layer south of Lamontzée is shown and at Pitet it has a different pattern than in fig. 3C

3F : Reduction of the geological map (1/25.000) in this study with the limits of the lithostratigraphical formations (numbered 1 to 9). The crosshatched narrow patch shows the more complicated pattern of extension than suggested in the other figures.

further away from the craton has been folded before the belt near the craton. This similar tectonic history not observed in other areas in Western and Northern Europe indicates that they belonged to one large tectonic unit.

According to this hypothesis, from a tectonical viewpoint, the Lower Paleozoic of Belgium and neighbouring areas form part of the "London-Brabant microplate" that was surrounded during the Caledonian orogenetic period by much bigger plates : the Laurentia plate, the Baltica plate and the northern extension of the Gondwana plate. This hypothetical configuration could help in explaining the polyphasic orogenetic history of the "London-Brabant microplate" of which the Brabant Massif was the south-eastern part.

1.3. Earlier studies on the Mehaigne area

To our knowledge fifty two articles were published on the Mehaigne area; thirty of them appeared in the last century and 39 focused on the volcano-sedimentary layer of Pitet, which forms only·about 1% of the total volume of sediments in the Mehaigne area. No real stratigraphical division of the area has ever been published and most articles on the sedimentary rocks are extremely vague.

1.3.1. Sedimentary rocks : Earlier workers mention some outcrops (DUMONT, 1948, six outcrops; MALAISE, 1873, two sections through 16 outcrops with some dip and strike measurements; DELWALQUE, 1875, five outcrops). The detailed geological map on scale 1/40.000 (1903) was made by MALAISE and for the volcanic rocks by RENARD and de la VALLEE-POUSSIN. Most of the outcrops are placed in the "Assise de Corroy" and the "Assise de Vichenet" grouped under the label "S12b". Some outcrops between Burdinne and the old watermill of Bounia in the Burdinale valley are attributed to the (Llandoverian) "Assise de Grand-Manil" ("S12a"), possibly together with some outcrops between Villes-en-Hesbay and Avennes in the Mehaigne valley. Ordovician sediments could also be present, but no outcrops are shown on the map. MALAISE et al. (ibid.) when drawing the limit between "S12a" and "S12b" do not take into account the dip and strike readings by MALAISE (1873). The poor state of knowledge of the Silurian of the Mehaigne area is well illustrated when one compares the geological map of Jehay-Bodegnée (1895) and that of Wasseiges-Braives (1903). In the valley of the Ruisseau de Vaux the sediments are mapped "S11b" : i.e. "Assise de Gembloux" (late Ordovician) while on the map to the east (Wasseiges-Braives) the same valley is mapped as "S12b" : i.e. "Assise de Corroy" and "Assise de Vichenet" (Wenlockian); no fault is indicated in between the two maps (see fig. 3).

Later FOURMARIER (1912, published only in 1921 and summarized in FOURMARIER, 1922) describes eight outcrops and for the first time defines the structure of the beds (three syncline-anticline-couples orientated WNW-ESE). He does not draw a limit between the lithostratigraphical units ("S12a" and "S12b") in the area where he defined the folds, and only maps one unit combining the "Assise de Corroy" and the "Assise de Vichenet" ("S12b"). However, limits between the lithostratigraphical units ("S12a" and "S12b") are drawn in zones without outcrops.

Later publications become rare and very vague. MICHOT (1954) correlates the outcrops at Fumal-church (in the Mehaigne valley) with these of Vichenet (Orneau valley) which he classifies as "Assise de Ronquières", only on the basis of lithological similarities.

VANDERVEN (1967) studies the cleavage of the Mehaigne area, probably around Huccorgne-watermill, but does not give any description of outcrops. He found a normal cleavage with the presence of kinkbands indicating two orogenetic phases and calculated the direction of the forces.

LEGRAND (1968) presents a map with a very good summary of the knowledge on the Brabant Massif based mainly on subsurface data, but unfortunately for the volcano-sedimentary layer of Pitet he gives an outcrop configuration in a S-form, contrary to that in the studies by FOURMARIER (1920) and FLICK (1935).

In 1969a MARTIN studies two palynological samples (LAM-1 = CD-1 in this study, and FAL-16 = IG-1 in this study) and attributes them an early Wenlockian age by comparing them with an assemblage from a borehole at Houtem in Western Flanders dated with graptolites by LEGRAND (1968).

In his unpublished master thesis HELDERWEIRT (1971) describes for the first time some sedimentological and petrographical characters of five outcrops. Four kinds of "rhytmicities" can be distinguished, all with different lithology. In the same year VERNIERS gives in his unpublished master thesis, the palynological content of two samples (Chitinozoa and Acritarcha, from CD-1A/6 and IF-11/C1) which suggests that the volcano-sedimentary layer at Lamontzée and at Pitet probably have the same age (late Llandoverian). Furthermore, his structural map of the Mehaigne area hypothesizes that Llandoverian as well as Wenlockian and Ludlovian sediments may be present.

1.3.2. <u>The volcano-sedimentary layer of Pitet</u> : More research was conducted about the volcano-sedimentary layer of Pitet than about the pelitic sediments. Described for the first time by DUMONT (1832, 1848), it was understood as an intrusive pipe ("typhon intrusif") (cf. GOSSELET, 1860). de la VALLEE-POUSSIN (1875) and de la VALLEE-POUSSIN & RENARD (1876) describe the rock as a "porphyroide" or a microconglomerate with eruptive elements, concordant with the Silurian sediments, and metamorphosed afterwards. The layer would be 80 to 100 m thick under the little hill Butte Saint-Sauveur (JG-1 on appendix 3) and would be thinner at Bois Cornet (IF-11 on appendix 3). In 1896 the same authors call the rock a keratophyric tuff because of its albitization and the presence of tuff structures.

FOURMARIER (1920) proves its intercalation in the sediments by dip and strike measurements of the "volcanic" rock and the surrounding sediments, and by observation of the same cleavage in both the tuff and the sediments. He describes the structure of the beds as an anticline-syncline couple with inclination of the axis to the WSW, and proves that only one volcanic layer occurs in the whole area around Pitet. FLICK (1935) makes a new petrographical study of the tuff and redivides it on the basis of chemical and petrographical analyses. But he contradicts the previous authors and sees two rhyolitic masses at Saint-Sauveur and at Bois Cornet, surrounded by characteristic tuffs which pass laterally into the pelitic sediments. As origin for the volcanic rocks, he thinks of a submarine eruption with a rhyolitic dome of which the Butte Saint-Sauveur is a relic. He finds graptolites in a level above the volcanic rock, which for the first time allow the dating of part of the sediments of the Mehaigne area as Wenlockian. On the other hand he designates four outcrops as being related to the volcano-sedimentary layer of Pitet, which, according to our data, belong to a non-volcanic level about 110 m higher (member MB 3E, see later). In his survey of the magmatic rocks of Belgium CORIN (1965) gives some chemical analyses and shows some photographs of thin sections of the three important types of this volcanic rock.

DE PAUW (1971), in his unpublished master thesis, does not accept the divisions of FLICK (1935) between rhyolite and tuff, and sees only the existence of one clastic tuff, coarse at the base (up to 7 mm grain size) fining upwards, and passing higher without interruptions into a normal pelitic sediment. It is however possible to distinguish three types of rocks without clear limits. Type 1 is a cinerite or ash tuff; fine, massive and homogene, showing conchoidal fractures, with fine to microscopically fine grains; this type was called "eurite" by DUMONT (1848). Type 2 has a coarse to medium grain size (sandfraction) and, is heterogenous, with crystals of 1 mm size and crystal and glass lenses. Type 3 is a coarse to very coarse pure crystal tuff, with grain size up to 7 mm and many lenses of slate and crystals : it is the "albite phylladiphère" of DUMONT (1848) and the "porphyroïde" of de la VALLEE-POUSSIN (1875) and de la VALLEE-POUSSIN & RENARD (1876).

The grains of this rock consist of (1) poorly rounded phenocrystals suggesting transport, (2) small fragments of crystals suggesting an explosive volcanic activity, and (3) sedimentary rock fragments (slate, micaceous sandstone, devitrified glass, microlithic rocks with fluidal structure, old reworked tuffs and fragments of feldspar agglomerates). The origin of all these grains can be sedimentary, (hypo)volcanic, plutonic, or pyroclastic. DE PAUW concludes that the volcano-sedimentary layer of Pitet has a pyroclastic origin but has been transported over a short distance. Afterwards this rock was modified by diagenesis, dynamometamorphism and a weak cleavage in the fine grain parts. The granulometry observed in thin sections of samples from the little hill of Saint-Sauveur (Pitet, Fallais) permits DE PAUW to determine the dip and strike of the bed. He shows that the little hill is formed in a volcano-sedimentary layer not thicker than 40 m thick , on the top of an anticline with its axis dipping to the SW. This little hill is therefore not the remnant of the eruption centre as DUMONT (1848) and FLICK (1935) had suggested.

The detailed geological map on scale 1/40.000 (1903) also mentions magmatic rocks. DORMAL in MALAISE (1892) describes them as porphyroids and eurites. DE PAUW (ibid.) has not found this rock in the place indicated on the geological map but 250 m more to the south (CD-1, CD-3 and CD-4 of app. 3). This rock is a coarse, crystal tuff and a lithic tuff analogous to type 3 at Pitet.

The volcano-sedimentary layer of Pitet found at Pitet and Lamontzée is not the only volcanic rock encountered in the region. One also has to mention the volcano-sedimentary layers of Cortil-Wodon and Noville-les-Bois to the west of the Mehaigne area (MALAISE, 1892, 1894, 1900) which according to CORIN (1965) occurs on the same line as Pitet and Lamontzée. To the east of the Mehaigne area, magmatic and volcano-sedimentary rocks occur in the Voroux-Goreux complex at Haneffe, Donceel, Jeneffe, Roloux and Noville, on the eastern prolongation of the volcano-sedimentary rock of Pitet (CORIN, 1965). Their exact relation to the Mehaigne area has not been studied.

2. LITHOSTRATIGRAPHY

2.1. Introduction

The outcrops of Silurian rocks in the Mehaigne area are never spectacular and most sections are small. Nevertheless we were able to locate about 400 outcrops (see appendix 3) of which 114 were recorded in the archives of the Aardkundige Dienst van België (Geological Survey of Belgium; sheetmap Braives, 41/6 and Wasseiges 41/5). The outcrops were labelled, as in example CD-22E, with CD indicating the 1 x 1 km square of the Lambert coordinate grit in which the outcrop is situated, and 22, the outcrop-number within this square; E indicates a part of that outcrop. Samples in this outcrop are labelled e.g. CD-22E/36 with 36 indicating the sequence from where the sample was taken (see later p. 17). In each outcrop the following characteristics were studied : (1) dip and strike of the layers; (2) dip and strike of the slaty cleavage (fissility); (3) the general petrography. In about 100 outcrops it was possible to do a detailed logging of the section with observations on the thickness of the beds (with an accuracy of 1 mm), bedding planes, sedimentological and lithological features of each bed, their succession, color and fossil content (mainly graptolites). The granulometry was estimated with the aid of handpieces previously characterized in thin section studies. The sections represent about 1500 m of sediments of which 600 m are described in detail (see fig. 8, 9 and 10 and annexe). The localizations are shown on small maps on a scale of 1:1000 for the most important outcrops i.e. outcrops representative of formations or formation-members and for sequential patterns. Localization of the micropaleaeontological or petrographical samples and of the graptolite horizons are included (appendix 1).

2.2. Petrography of selected samples

The aim of this study was not to do a detailed petrographic analysis. But looking through the literature on the Silurian of the Mehaigne area one is struck by the vagueness of the descriptive petrographical names applied. Most authors observe "schistes" (shales) and "phyllades" (slates) and some detail them as "celluleux, chloriteux, quartzeux or psammiteux". This reflects the lack of an accurate classification for the rocks found in the study area. Most classifications will only distinguish two or three main groups. In PETTIJOHN's classification (1975) the sediments of the Mehaigne area are designated as only slates or siltstones. BLATT et al. (1972) also use a simple but more extensive classification : slates are divided into silt slates (with more than 2/3 silt) and mudslates (with between 1/3 and 2/3 silt). BOUMA (1962) uses a classification based on the Wentworth scale where the proportions of sand, silt and clay are put in a triangular graph. In his classification we can describe our rocks as silty slate (pelite), siltstone (silt), sandy slate (pelite), or very sandy slate (pelite). Between brackets we give the original name of BOUMA, but because of the oblique slaty cleavage in the rocks of the Mehaigne area we have to call them slates. The most elaborate classification is from MICHOT (1958) based on grain size, the proportion of the grains to the submicroscopical matrix, which can be quartzitic (quartz-grains touching each other), reticulate (low proportion of matrix), or empatic (a well-represented matrix with grains dispersed throughout it). This measurement or estimation is made on thin sections. With his classification we can distinguish seven different rocktypes : pelitoslate, pelitopsammite, micropsammoslate, mi-

		Lithological classification														
		author		MICHOT 1958	PETTIJOHN 1975	BOUMA 1962	Main grain size of grains (µm)	Matrix	Mineral content: Q	muscov.	chlorite	sericite	albite	calcite	
e divisions	CD-1	F. HELDERWEIRDT 1971	thin sections					E	+++	++	+		?		(2)
	CD-10	F. CORIN 1965 p. 85	"	(schiste) slate							++				
	IG-1A/29	ibi	"	pelitoslate			10-20	E	+	+	+				
	IE-1	HELDERWEIRDT 1971	"					E	++	++	++		++		(2)
	JD-5	HELDERWEIRDT 1971	"						+++	+++	++		++		(2)
	JD-5/1	ibi	"	coarse pelitoslate			30-55	E	+	+	+				
	JD-2/33	ibi	"	coarse pelitoslate				E							
	JD-2/46	ibi	"	coarse pelitoslate				E							
	JD-2/124 top	ibi	"	fine micropsammoslate to pelitoslate			15-30(150)	E(R)							
	JD-2/124 base	ibi	"	coarse micropsammoslate			30-80	E	+	+	+		+		
	JD-4/30 top	ibi	"	fine pelitoslate			ℓ-10	E	+	+	+		+		
	JD-4/30 base	ibi	"	coarse pelitoslate			chlorite 30-60								
	CD-22E/35	ibi	"	pelitopsammite			5-15	R	+	+	+				
	GH-3	HELDERWEIRDT 1971	"						++		+++		+	++	(2)
d divisions	IG-1A/29	ibi	"	coarse micropsammoslate			chlorite 40-80	E							
	CD-1	HELDERWEIRDT 1971	"				muscovite up to 150 µm	Q and R	+++	++	++		+		(2)
	IE-1	HELDERWEIRDT 1971	"						+++	++	+		?		(2)
	JD-5	HELDERWEIRDT 1971	"												
	JD-5/1	ibi	"	fine micropsammoslate											
	JD-5/2	ibi	"	fine micropsammoslate			20-40	R	+	+					
	JD-4/29	ibi	"	fine micropsammoslate			10-20	E	+	+	+				
	JD-2/38	ibi	"	coarse micropsammoslate				E							
	JD-2/46	ibi	"	fine micropsammoslate and micropsammite			50-60	E and R Q and R							
c divisions	CD-22E/36	ibi	"	coarse micropsammite and microquartzite, fine psammoquartzite and psammite.					+	+	+	+			
	GH-3	HELDERWEIRDT 1971	"						+++	+++	++		++	++	(2)
	IG-1A/23	S. GEETS pers. comm. 1972	(1)	micropsammite	very badly sorted coarse siltstone	very sandy pelite									
	CD-1A/6	ibi	thin section	micropsammite and microquartzite	medium sorted, symmetrical to positive assymmetrical, mesocurtical coarse siltstone		30-60 and 50-90 chlorite to 120µm	R + Q	+	(+)	+	+			
	JD-5	HELDERWEIRDT 1971	"	Fine psammoquartzite or Fine psammite			50-120		+++	+++	+		++		(2)

(1) Sedimentological analysis by S. GEETS (1972 pers. comm.), laboratorium voor Algemene Geologie en Petrografie, R.U.G. Gent. (sieves, sedimentation balance, heavy mineral separation) The heavy minerals form 1,7% of the sand fraction of the sample and are made of tourmaline, chlorite, zircon, rutil, anataze, plus opaque and altered minerals; the clay minerals are principally illite with some kaolinite.

(2) Results of the mineralogical composition by Röntgen diffraction analysis.

E: empatic matrix
R: reticular matrix
Q: quartzitic matrix

Fig. 4 : Results of some petrographical and granulometrical analyses of samples from the Silurian of the Mehaigne area.

cropsammite, microquartzite, psammoquartzite and psammite. Each can be specified as coarse or fine (see fig. 4).

In order to more accurately describe the lithology of the encountered rocks, a short petrographical study was undertaken on some samples covering most of the stratigraphical column. Fig. 4 lists these petrographical studies together with those of HELDERWEIRT (1971) and CORIN (1965). The samples were later used on the field to estimate the petrography of other exposed sediments. The rocks have been named according to the three last classifications described above.

Granulometric observations show that the sediments are nearly all in the siltfraction with the quartz grain size mostly between 10 and 60 µm, and rarely up to 375 µm in the c-divisions (see later p. 17); chlorite, maybe of neoformation, reaches up to 120 µm. In every bed the grain size decreases slightly towards the top, and most beddingplanes correspond to a clear change in the grain size. The minerals in the submicroscopic matrix are quartz, chlorite, muscovite, albite and some ubiquitous heavy minerals. Argillaceous minerals are illite and some kaolinite.

The petrographical changes are mostly linked to the sedimentological features of the beds. Those with a compact sedimentation commonly have a empatic structure, or more rarely, a reticular one. In MICHOT's classification, they are designated as fine to coarse pelitoslates, and sometimes pelitopsammites. In BOUMA's classification they are silty slates, and in the classification by BLATT and collaborators, they are mudslates, sometimes siltslates.

The lamellated beds consists of lamellae(1) of 0.1 to 0.5 mm thickness (0.1 to 0.3 mm for the fine, and 0.3 to 0.5 mm for the medium lamellation). They have an alternating quartzitic and reticular structure. Where the lamellations are not pronounced, the structure is alternating reticular and empatic. In these not well pronounced lamellations, fine and coarse micropsammoslates or micropsammites alternate with micropsammoslates (classification of MICHOT). In BOUMA's classification they are alternating silty and sandy slates, and in the classification of BLATT et al. they are fine and coarse siltslates or siltstones.

The current ripple beds consist of lamellae of 0.1 to 0.5 mm, with alternating quartzitic and reticular structures, and are made of a coarse silt to fine sand,poorly to very poorly sorted. In MICHOT's classification they are microquartzites alternating with micropsammites, or fine psammoquartzites with fine psammites; in BOUMA's classification they are sandy to very sandy slates, or fine or very fine sandstone. According to BLATT et al. and PETTIJOHN's classification, they are siltstones, siltshale and fine or very fine sandstone.

The beds showing compact sedimentation (no sedimentation structures at all) are all pelitic and have four different mineralogical compositions across the stratigraphical column. First there is the mineralogical distinction (easy to use on the field) between "chloritic" and "quartzic"

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(1) Lamellae are about 0.1 to 1 mm thick and therefore not called laminae but lamellae.

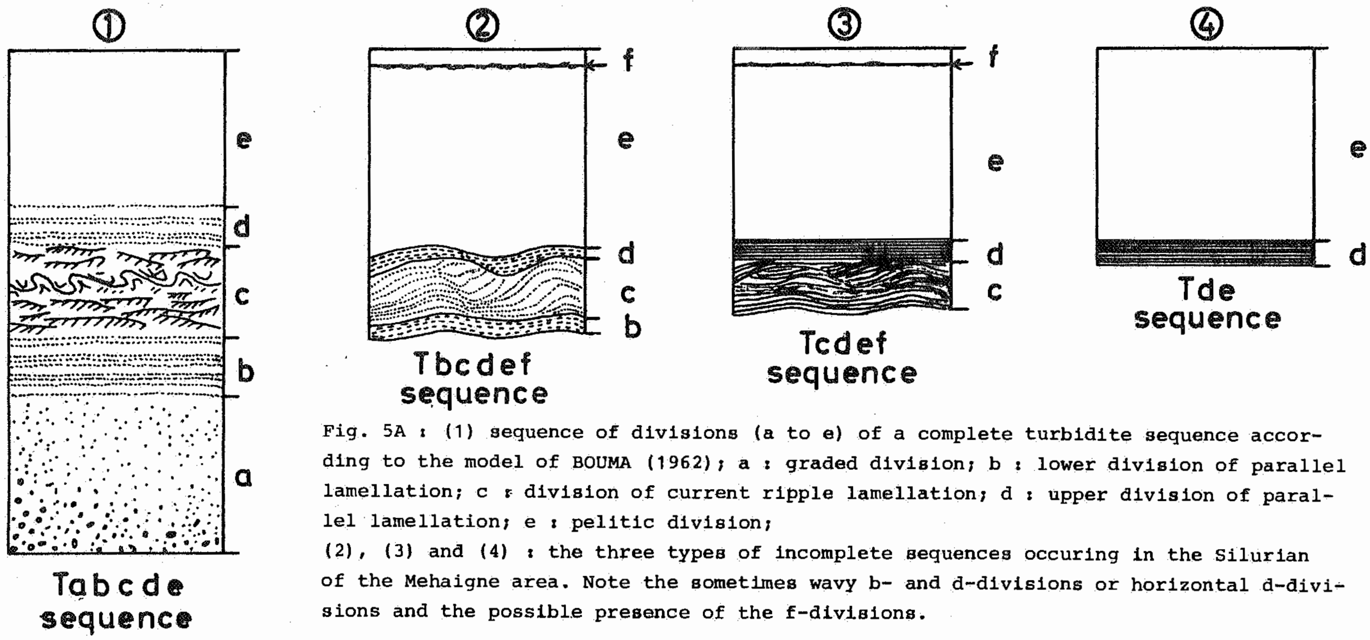


Fig. 5A : (1) sequence of divisions (a to e) of a complete turbidite sequence according to the model of BOUMA (1962); a : graded division; b : lower division of parallel lamellation; c : division of current ripple lamellation; d : upper division of parallel lamellation; e : pelitic division;
(2), (3) and (4) : the three types of incomplete sequences occuring in the Silurian of the Mehaigne area. Note the sometimes wavy b- and d-divisions or horizontal d-divisions and the possible presence of the f-divisions.

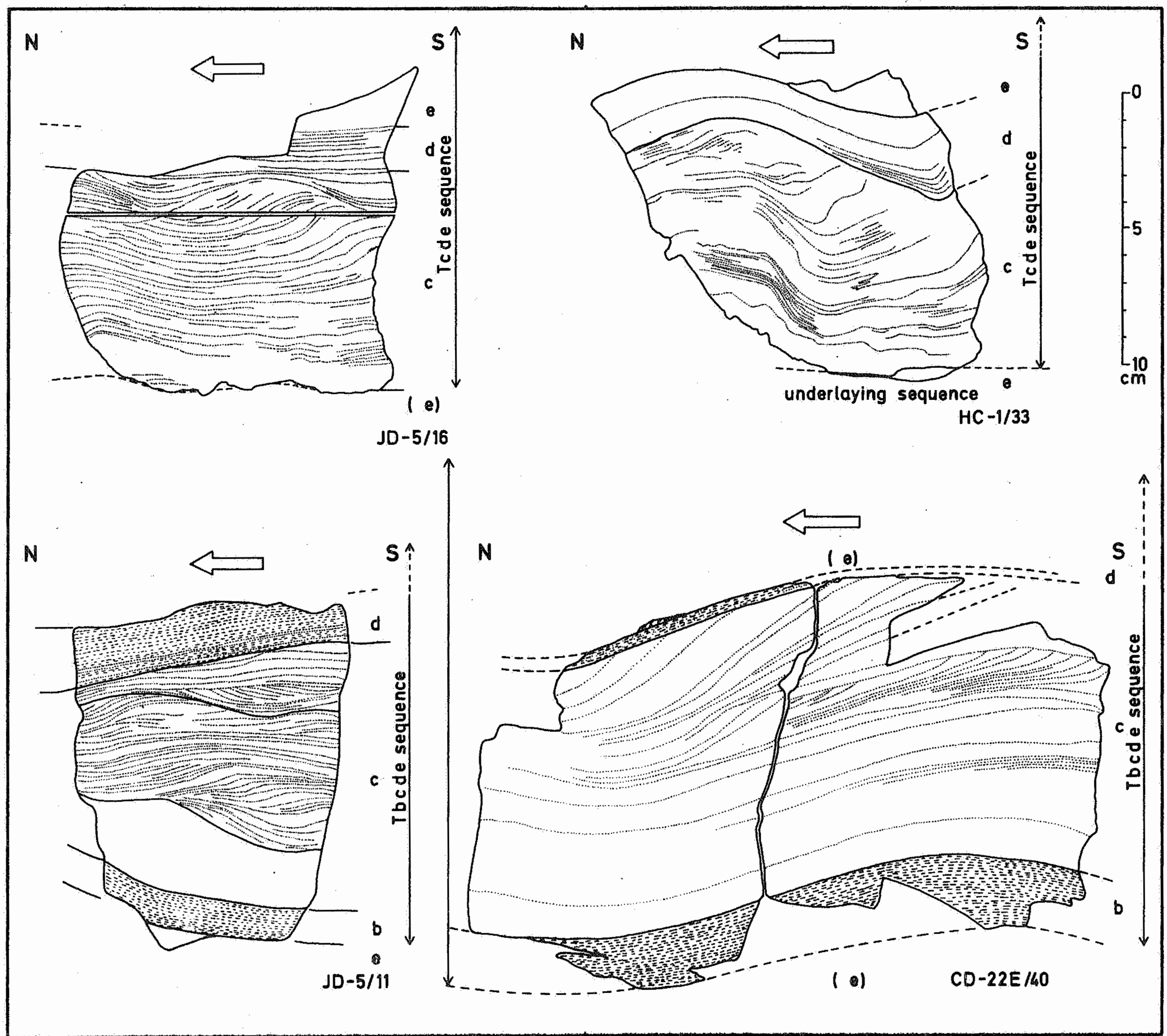


Fig. 5B : Four drawings of sawn hand pieces in the Tbcd sequences showing current ripple lamellation and the deduced direction of the turbidity current. All sections are cut normal to the long axis of the ripple marks.
Samples JD-5/16 and HC-1/33 are taken from the same turbidite at 2,3 Km distance from each other. Sample CD-22E/40 comes from formation MB4B (early Wenlockian) and the three others from formation MB7 (middle or late Wenlockian).

slates (quartzic is a translation of the french "quartzeux"). The "chloritic" slates are yellow to greenish gray, flaky and soft when scratched with a knife. In thin sections one finds that they contain mainly chlorite (in booklets) with a smaller amount of quartz; therefore we call them "chloritic". The "quartzic" slates are light to dark gray, flaggy or shaly (thickness of fissile planes 0.3-1 cm) and not easy to scratch with a knife. Thin section analysis shows that they contain mainly quartz grains accompanied by chlorite, and therefore we call them "quartzic" although this does not necessarily imply the presence of quartzitic cement.

Both groups can contain calcite cement; this doubles the number of the mineralogical groups : chloritic slates with or without calcite, and quartzic slates with or without calcite.

Pyrite is nearly always present. According to KRUMBEIN & GARRELS (1952), this points to very reducing conditions during deposition and during early diagenesis. This pyrite seems to have grown around nuclei that could be organic walled microfossils (Chitinozoa and Leiosphaeridea). In several cases pyrite crystals were found in the micropalaeontological preparations showing inner casts of Chitinozoa. In other cases pyrite crystals were seen, growing through the tegument of Chitinozoa and Leiosphaeridea. We suspect that the intensive growth of pyrite crystals can account for the absence of organic walled microfossils in several horizons. The presence of calcite cement at some levels (formations MB2, MB4 and MB8, see later) indicates, again according to KRUMBEIN & GARRELS (ibid.), alcalic conditions at least during deposition.

The pelitic sediments in the Mehaigne area all show fissility at an angle of 50° of 90° to the bedding plane. This demonstrates incipient metamorphism. The presence of chlorite, sericite, albite and the absence of epidote indicate a high diagenesis or the anchizone of the metamorphism. Measurements on the degree of carbonization of the organic material favor the second alternative (see p. 59-60).

2.3. Description of the rhytmicity of the sediments

2.3.1. The elementary sequence : The most pronounced character of the Silurian sediments in the Mehaigne is their repetitive character. It has been observed before in Silurian sediments of other areas of the Brabant Massif, but never studied in detail (LEGRAND, 1961, 1967a, b, 1982 and in the archives of the Geological Service of Belgium). Independently from the mineralogy, elementary sequences can be recognized in the sediments of the Mehaigne area. They are built up in a fixed, characteristic way, i.e. : a succession of a maximum of four beds (divisions) with different sedimentological features, always in the same order, though certain beds can be absent. We use the same lettercode for these beds (a to e) as BOUMA (1962) used for similar sediments. His a-bed (division) is absent in the Mehaigne area. The most complete elementary sequence in the Mehaigne area is composed from bottom to top of the following beds (later, we will always use the term "division" for these beds).

- b-bed (b-division) : lower parallel lamellation : lamellae of 0.1 to 0.2 mm thickness, sometimes faintly lenticular, with an alternating quartzitic and reticular structure of microquartzite and micropsammite; the lower bedding plane is always very clear and shows an erosive unconformity with the underlaying sequence; the bed as a whole can undulate, but will always have parallel lamellations; it can show slight thickening or thinning in the undulations, from which the direction of the current can be deduced by looking at the foreset lamellae (see fig. 5); graptolites are mostly found in this bed b and once a long Conularia sp. was collected in it (CD-22E/40 division a); thicknesses range from 0.3 to 12.5 cm.

- c-bed (c-division) : current ripple lamellation : lamellae of 0.1 to 0.5 mm with tangent cross bedding with sometimes a tendency towards convolute bedding ; with alternating quartzitic and reticular structure of micropsammite and microquartzite or fine psammoquartzite and fine psammite; the lower bedding plane is clear, but when a b-bed (b-division) is underlaying it may be gradual; when the b-bed (b-division) is missing, this bed can have an erosive contact with the underlaying e-bed of the lower sequence; ripplemarks are often assymetrical, convex in the through and sharp on the crest, but sometimes the reverse has been observed; in oriented sections, the direction of the current flow can be read from the position of the foresets; fig. 5 gives a few examples of such sections in bed (division) c; the upper bedding plane can be clear or gradual and is often undulating; this bed usually has the coarsest grain size of all the sediments in the sequence, and with its quartzitic cement it tends to be very hard in outcrops and easy to trace; the average thickness of this bed shows a bimodal curve with thin c-beds (c-divisions) (0.5 to 10 cm thickness, small amplitude : 0.5-1 cm, and long wavelength : 20-30 cm) and thick c-beds (c-divisions) (10-22 cm thickness, medium amplitude 1-4,5 cm and medium wavelength : 9-18 cm) (see fig. 5); some graptolites were found in this bed.

- d-bed (d-division) : upper parallel lamellation : fine lamellation (lamellae of 0.1 to 0.2 mm) or medium lamellation (lamellae of 0.3 to 0.5 mm); sometimes slightly lenticular with alternating quartzitic and reticular or reticular and empatic structure with micropsammites and microquartzite or microquartzite and micropsammoslate; the bedding planes (both lower and upper) can be clear, sometimes gradual, and at times show an undulation when there is an underlying c-bed (c-division); the thickness of the lamellae is usually laterally constant; sometimes the lamellae may increase in thickness or disappear towards the top. Graptolites are rarely found in this d-bed (d-division) and only when it directly overlies an e-bed (e-division) of an underlying sequence; the thickness is between 0.3 and 23 cm.

- e-bed (e-division) : pelitic rock with compact sedimentation; the sediments have a empatic structure, rarely reticular and are pelitoslates (i.e. : fine silty slates; mudslates or siltslates), displaying towards the top a gradual decrease in size of the grains disseminated in the matrix; the upper bedding plane is always clearly cut; the lower bedding plane is clear or gradual, and the thickness is from 1 to 149 cm.

- f-bed (f-division) : in the chloritic slates at 0.3 to 0.5 cm under the top of the e-bed (e-division), one finds a thin bed 0.2 to 0.6 cm thick with unclear, gradual bedding planes, dark gray in colour and of about the same petrography, structure and sedimentology as the rest of the e-bed (e-division). Because BOUMA (1962) did not mention this bed (division) it is labelled here as the "f"-bed (f-division), until its exact meaning is understood.

In the Mehaigne area an elementary sequence only rarely contains all of the beds (divisions) described above. Most elementary sequences consist of only d- and e-beds (divisions); other elementary sequences consist of b-, c-, d-, e- and occasionally f-beds (f-divisions); in certain combinations the d-beds (d-divisions) are absent, or are too thin to be recognized. Altogether three main "types of elementary sequences" occur in the Mehaigne area, hereafter referred to as "types of sequences" : Tbcde(f), Tcde(f) and Tde(f) (see fig. 5A). In the first two types, the d-bed (d-division) may be absent (see above). The significance of the f-bed (f-division) is unclear and also linked to a mineralogical feature (chloritic matrix). Therefore the presence or absence of this f-bed (f-division) can not be used to single out "types of sequences" other than the three main ones.

2.3.2. The elementary sequence : a turbidite. The succession of beds (divisions) in a sequence described above is analogous to the "sequence of intervals" in the Tertiary turbidites of the French Alps defined and labelled with a letter code by BOUMA (1962). In this work the same letter code is used. WALKER (1978) refers to the "intervals" as "divisions". From now on we will use the term division for the beds within a sequence. Like BOUMA (ibid.), we rarely observed complete sequences of divisions; most frequently the sequence is cut off at the top or at the base. He also observed the predominance of the silt and pelitic fraction in the sediments. However, a difference between the Silurian of the Mehaigne area and the alpine turbidites is the absence of an a-division (with coarse material up to microconglomerate). The only a-division in the Mehaigne area occurs in the volcano-sedimentary layer of Pitet which is an exceptional event (see later p. 20). True convolute lamellation has not been observed either, but some c-beds tend to show a beginning of it (see fig. 4).

BOUMA (1962) demonstrates that the "sequence of intervals", (sequence of divisions) corresponds to the deposit laid down by a turbidity current. This conclusion is based on laboratory experiments by KUENEN (1958), who showed that deposits of turbidity currents are built up in a similar way as a succession of sequences of intervals (= divisions). The presence of identical sequences in the Silurian of the Mehaigne area indicates that they are turbidites i.e. deposits of turbidity currents. Other arguments confirming this conclusion are the granulometry of the sediments predominantly belonging to the silt fraction, the constant direction of the currents deduced from ripple marks and current ripple lamellations (see later p. 45), and the laterally constant thickness and composition of the sequences and succession of sequences over long distances (more than 2,5 km).

2.3.3. The volcano-sedimentary layer of Pitet : an igniturbidite ? Earlier observations (p. 10-12) and our own observations on the volcano-sedimentary layer of Pitet, which is englobed in the thick turbiditic sequence described in the previous section, can help to elucidate its origin and mode of deposition. DE PAUW (1971) shows how the grain size decreases from very coarse to very fine from bottom to top in this 25-30 m thick layer. A lower (± 20 m) bed shows only graded bedding and no other structures; it contains slate and other rock lenses, and according to DE PAUW (1971) could be composed of pyroclastics redeposited after short transport. The

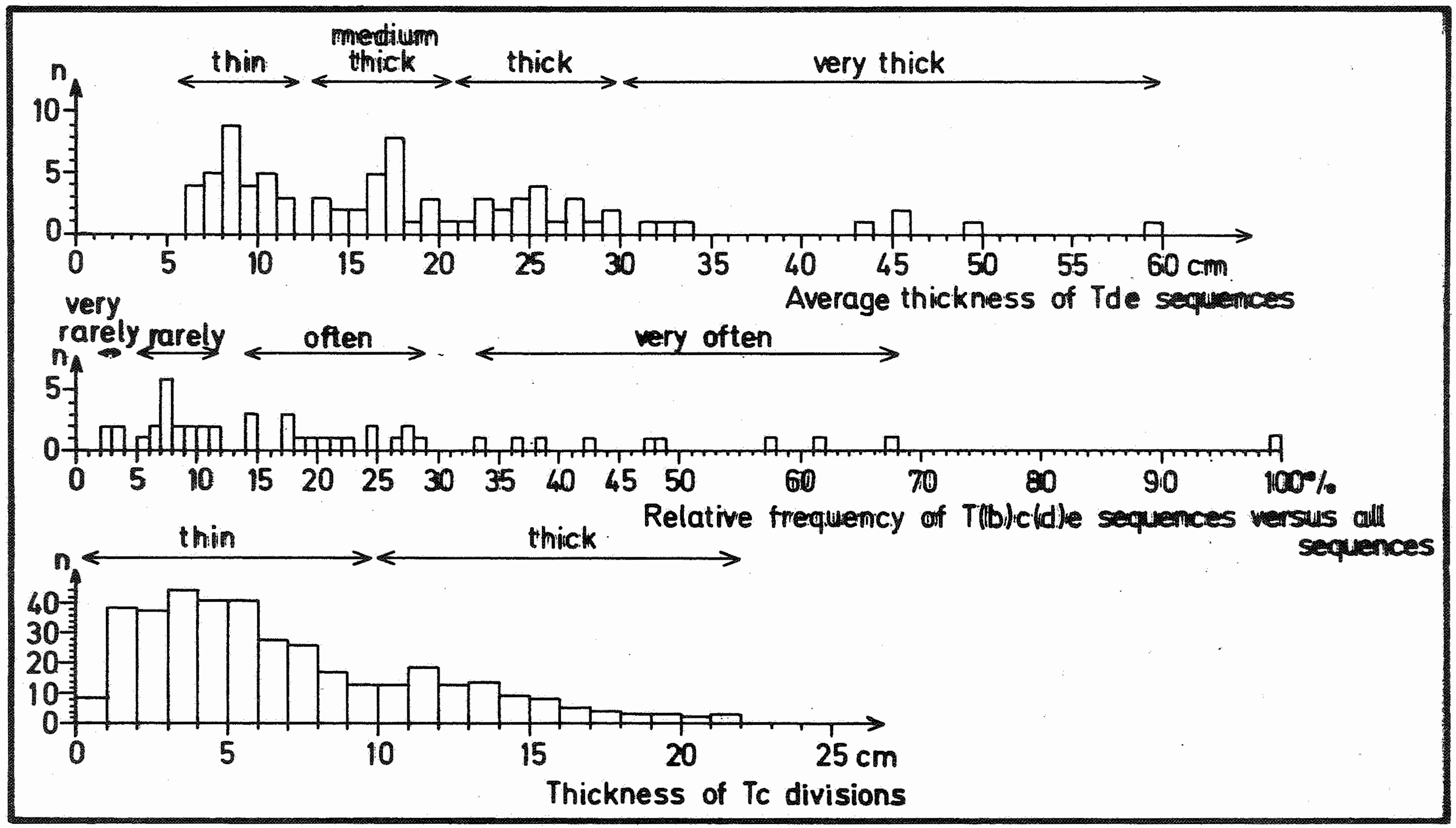


Fig. 6 : Above : Histogram of the average thickness of the Tde sequences calculated from a succession of at least 20 sequences. The four peaks in this histogram make it possible to define four classes of thicknesses.

Middle : Histogram of the relative frequency of Tbcde and Tcde sequences versus all sequences measured in a succession of at least 20 sequences.

Four groups can be defined.

Under : Histogram of the thickness of all c-divisions showing two populations, thicker or thinner than 10 cm.

overlying layer (4 m) of fine slate, still containing a substantial amount of fine volcanic and related materials, shows parallel very fine lamellation and gentle tangent cross lamellation repeated at several intervals. It is covered by fine slates (more than 2 m) still containing volcanic and related materials, showing compact bedding. These sedimentological features resemble those of a "sequence of divisions" sensu BOUMA. The lower bed could be considered as an a-division, the lamellated and cross lamellated beds as b-, c- and d-divisions, and the compact layer on top as an e-division. This implies that the volcano-sedimentary layer of Pitet was deposited by a very large turbidity current. In the literature no such thick turbidites have been described. There is an example of an Oligocene ignimbrite on Rhode Island (Greece) where, after an ignimbritic eruption at a depth of several hundred meters under water, a 7.7 m thick layer of ash flow deposits and thin bedded tuff was deposited. Near the eruption center, ash flow deposits of a fluidized magma would have been deposited, and further away, turbidite deposits formed by a watery suspension of the volcanic matter (MUTTI, 1965). Although the Pitet layer is distinctly thicker than the given example of an ignimbrite (25 m versus 7.7 m), a similar depositional mechanism is possible for the Pitet layer. An ignimbritic eruption would have provoked a very large turbidity current, a so-called igniturbidite (MUTTI, 1965), which deposited the volcano-sedimentary layer of Pitet.

2.3.4. Variations in the rhytmicity : Six features cause the variation in the rhytmicity of the sediments : the lithology; the average thickness of the Tde sequences; the relative frequencies of Tbcde and Tcde sequence; the thickness of the c-division; the ratio between the average thicknesses of the sequences Tde and the T(b)c(d)e sequences; the presence of f-divisions.

Every section or partial section (when there is an important change in the rhytmicity) can be divided on the basis of the six features described above, or by combinations of them. Some comments on them follow.

- Lithology : six different lithological compositions are observed in the e-divisions :
  - dominant chlorite (called "chloritic") without calcite;
  - dominant chlorite (called "chloritic") with calcite;
  - dominant quartz with chlorite (called "quartzic") but without calcite;
  - dominant quartz with chlorite (called "quartzic") with calcite;
  - the coarse to medium grained, massive volcano-sedimentary rock of Pitet;
  - the slate of Bois Cornet (= the very fine grain upper part of the volcano-sedimentary rock of Pitet).

- Average thickness of the Tde sequences : Fig. 6 shows a frequency diagram of the average thickness of the Tde sequences in sections with from 20 to 100 Tde sequences. This diagram shows that the Tde sequences can be divided into 4 groups :
  - thin sequences : 5-12.9 cm
  - medium thick sequences : 13-20.9 cm
  - thick sequences : 21-29.9 cm
  - very thick sequences : 30-55 cm

Sequential pattern / characteristics	Lithology						Average thickness of the Tde sequences				Frequency of T(b)c(d)e sequences					Average thickness of c-divisions		Ratio between thicknesses T(b)c(d)e and Tde sequences		Presence of f-divisions
	chloritic matrix without calcite	chloritic-quartzitic matrix in sometimes calcite	quartzic matrix without calcite	quartzic matrix with sometimes calcite	volcano-sedimentary rock of Pitet (coarse to fine grained part)	slate of Bois Cornet (very fine grained part)	thin (5-12,9 cm)	medium thick (13-20,9 cm)	thick (21-29,9 cm)	very thick (30-60 cm)	not present	very rare	rare (5-11%)	often (14-28%)	very often (33-67%)	less than 10 cm	more than 10 cm	± 20%	+50-100%	yes (+)
1	+						+			+	+	+				+	+		+	+
2	+						+							+	+	+	+		+	+
3			+					+						+	+	+	+	+		−
4			+				+	+						+		+			+	−
5			+						+	+	+									−
6			+					+	+				+	+		+	+	+		−
7			+					+			+									−
8				+			+	+							+	+		+		−
9		+							+	+	+	+	+	+	+	+	+		+	−
10					+	+														

Fig. 7 : The different features characterizing the ten different sequential patterns.

- Relative frequency of Tbc(d)e and Tc(d)e sequences : Fig. 6 gives a frequency diagram of the relative frequency of T(b)c(d)e sequences observed in sections of at least 20 sequences. Five groups can be distinguished :
  - not present : 0%
  - very rarely present : 2%- 3%
  - rarely present : 5%-11%
  - often present : 14%-18%
  - very often present : 33%-67% (to 100%).

- Average thickness of the c-divisions : The frequency distribution of the thickness of all the c-divisions (fig. 6) shows two peaks. As a result, when c-divisions are present, the sections can be divided into two groups : (1) with c-divisions only smaller than 10 cm; (2) with c-divisions both smaller and larger than 10 cm. Sections with only larger c-divisions have not been observed.

- Ratio between the average thickness of Tde sequences and the T(b)c(d)e sequences. Two groups can be distinguished : (a) successions where the main thickness of the T(b)c(d)e sequences is nearly equal to that of the Tde sequences (ratios : 1/0,8 to 1/1.2); (b) successions where the main thickness of the T(b)c(d)e sequences is 50% to 100% higher than the Tde sequences (ratios : 1/1.5 to 1/2).

- Presence of f-divisions : The occasional to common presence of f-divisions is observed in a restricted number of sections only. The presence or absence of a f-division when observed in a succession of at least 20 sequences can be used to divide the sections in two groups. However the presence of f-divisions could be linked with lithologies in which chlorite predominates (chloritic pelites cited above p. 21). As this feature is sedimentological and not lithological, we have to list it separately.

2.4. Definition of the "sequential pattern".

These six features, each divided into two to five classes, allow us to classify all sections into ten groups, here referred to as "sequential patterns". These patterns group sections or parts of sections defined by a relative similarity of sedimentological and mineralogical features discussed in the previous section. Several occur only once, others are repeated at different heights in the stratigraphical column. The reflect major variations in the regime of the turbidity currents. In practice and for statistical reasons, this sequential pattern can only be established for sections with at least 20 sequences, and if possible with 50 or more. Fig. 7 gives the different factors determining the ten sequential patterns and the following tabel shows all sections or parts of it, classified according to their sequential pattern.

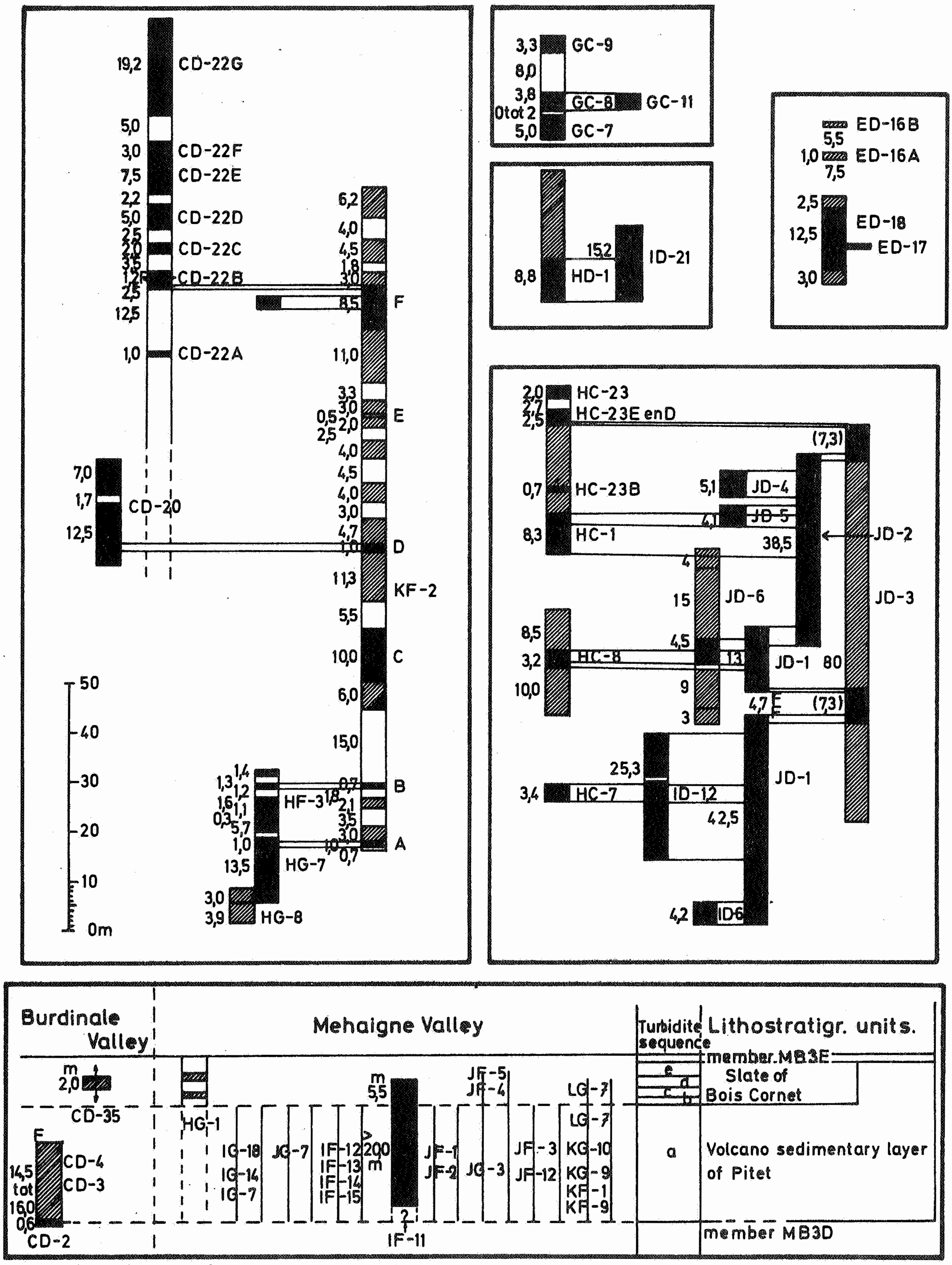


Fig. 8: Above: Stratigraphical logs of all sections where identical successions of sequences (chronosequences) are observed. The horizontal lines mark the thickness over which they were observed (for symbols see fig.9).
Under: All sections belonging to the marker bed of Pitet.

Sequential pattern	Sections
1	BD-7, (CD-19), HF-1, (HF-4), ((KF-2A)), ((KF-2B)), KF-2C, IG-1, HF-3, HG-7; (CD-12), IG-19, JG-1, IH-1.
2	CD-1, CD-20, ((HF-4)), ((KF-2D)), ((KF-2E)), ((KG-3)), ((KG-4)), ((CD-22A)), CD-22B, CD-22C, CD-22D, IF-17, IF-18, KF-2F.
3	CD-22E, (CD-22F), CD-22G, (0-7.8 m).
4	((CD-2)), (ED-2A), ED-2B, IF-9.
5	((CB-7))?, ((CB-8))?, (CC-1)?, (HC-8), (HC-23D, E and G), JD-1(30.3-40 m) JD-1(40-42 m, 50-57 m), JD-3(0-1 m), JD-3(3-13 m), JD-2(34.9-23.9 m), JD-6, ID-1+2(16.7-25.3 m).
6	(FC-8), HC-1, HD-1, HD-4, ID-21, JD-2(23.9-3.4 m), JD-3(1.4-7.4 m), JD-4, JD-5, IE-3, IE-7+9, ((HH-6A)), HH-6D. HC-25A, FD-1, (FD-6), HD-3, ID-1+2(5.2-13 m), ID-6, ID-9, JD-1(0-11.4 m), JD-1(18.4-25.9 m), IE-1, IE-2, IE-12, JE-1, JE-2, JE-3
7	(FC-6), (FC-7), GC-4, (HC-7), HC-10, (HC-23B), (HC-25C), ((HC-25B)), CD-22G(7.8-15.8 m); ID-2(0-5.9 m and 13-16 m), JD-1(11.4-18.4 m), JD-1(25.9-30.3 m), JD-2(3.4-0 m).
8	GH-3, GH-9.
9	(GC-7), (GC-8), (GC-9), GC-11, GC-4, (DD-10), ((DD-12)), DD-13, DD-14, DD-15, ((ED-6)), (ED-12), ((ED-13)), (ED-14), ED-17, ED-18, ((ED-21)).
10	CD-2, CD-3, CD-34, CD-35, IF-11, IF-13, IF-14, IF-15, JF-1, JF-2, JF-3, JF-4, JF-5, JF-7, JF-12, IG-7, IG-9, IG-10?, IG-13, IG-14, JG-3, JG-4, HG-1, HG-19?, KG-9, KG-10, LG-7.

Tabel of the different sections according to their sequential pattern. One section (EI-12) shows no rhytmicity at all, and cannot be classified in this list. (Between brackets : 10-19 sequences; double brackets : <10 sequences).

2.5. Construction of the lithostratigraphical column.

The relations between the different sections is established by four methods.

2.5.1. Chronosequences : Sections from different places can show completely identical successions of sequences in their lithology, their sedimentology, and their thickness etc. We found this case in 18 sections which were a few hundred meters to 2.5 km distant from each other, with thicknesses of 2 to 25 m (fig. 8) and about 20 to 125 sequences. The differences in total thickness between two of these sections is 1-5% and within the error of measurements. Most sequences have comparable thicknesses; only in a few cases (2%) were differences in thickness of up to

40% found.

The probability that these comparable successions were built up in exactly the same way but in different periods is very small. Therefore it can be accepted that these identical successions represent chronosequences, where every sequence forms a chronohorizon and was deposited during a very limited timespan (several hours) by the turbidity current spreading out over a large area. Fig. 8 shows the stratigraphical logs of all sections where identical successions or chronosequences were observed.

2.5.2. Geometric correlations : The relative position of different sections in adjacent outcrops (a few meters apart) can be estimated by geometric measurements in the field, e.g. in a roadcut where between two outcrops no observations are possible due to soil cover, vegetation, buildings etc. Sources of error can be little faults with a displacement in the order of a few decimeters or meters, and incorrect geometric measurements or estimations. When done with caution, no significant errors will occur with this method. In the cases where major faults (10 m, 100 m or more of displacement) do occur between outcrops, they are always accompanied by minor "satelite" faults located in the outcrops. Folds are another possible source of error. However, sharp angular folds have never been observed in the Mehaigne area and are not likely to exist. Those observed are always very gentle and with a few dip and strike measurements one can easily locate them. Hence the method, if carefully used, leads to accurate correlations of adjacent sections with possible errors in the order of maximum of a few meters.

2.5.3. Marker beds or distinctive lithologies : Two kinds of marker beds are particularly useful for stratigraphic correlation in the Mehaigne area. There is the volcano-sedimentary layer of Pitet with a thickness of about 23 m for the coarse-grained part, and some 5 m for the very fine grained upper part, called the "slate of Bois Cornet". The Pitet layer represents a single event. It is easily recognized in outcrops or on the surface of the fields because of the presence of larger rock fragments, and also in the geomorphology. This hard layer is more resistant to erosion than the normal slates and marked by narrow valley cuts. Fig. 8 lists all the outcrops belonging to this marker bed. Its mapping gives us a first idea of the fold structures of the area which clearly shows the fold axes slightly inclined to the WSW.

In some levels several thick Tde sequences occur which are very hard and massive and show a reticular matrix, especially under the microscope. These Tde sequences are only found in one part of the column, about 25 m thick; and therefore form a kind of marker zone.

A very distinctive lithology, showing no cyclicity at all, occurs in outcrop (EI-12) in the north of the Mehaigne area. It also has a lithostratigraphic significance.

2.5.4. Other correlations : The relative place in the lithostratigraphical column of all the other sections, not correlated by the three methods described above, had to be established by geometrical calculations and estimations. The presence of important faults obliges us to proceed with caution.

It was however possible to establish the succession of the different sequential patterns in the lithographical column using the major sections. When the same succession of sequential patterns was observed in two or more places, the correlation was considered as proven. Individual sections could then be placed according to their sequential pattern in some portion of the column. In some cases individual sections could not be accurately placed in the column. Sometimes even a group of sections with a certain sequential pattern could not be placed in the column. For these cases the micropalaeontological content had to be studied.

2.5.5. The construction of the lithostratigraphical column : The correlation methods, as described above, allow the construction of the lithostratigraphical column as follows (bottom to top).

One outcrop near Avennes (EI-12) shows a lithology completely different from that of the rest of the Mehaigne area, with no rhytmicity and a high amount of pyrite. It is separated by an area about 2.5 km wide with no outcrops from the outcrops at Latinne-Hosdin-Les Ruelles. Its position is probably at the base of the column because of its localisation and the general SSE dip of the strata in the Mehaigne area. This is confirmed by the microfossils (VERNIERS, 1981, 1982 ; see also p. 31).

The outcrops at Les Ruelles in Hosdin-Latinne (GH-3, GH-4, GH-9, GH-10, GH-11, GH-14, GH-15) all have the same structure : all the beds dip NNW, and belong to sequential pattern 8. According to geometric computations, about 180 m of sediments are present. To the north there are no outcrops until Avennes, and their position is probably somewhere above the section EI-12 already described. To the south a completely different structural and sedimentological group appears in the Trou du Loup, in Hosdin-Latinne. In between, a big fault or a big anticline may exist. Therefore its relative position cannot be established by geometrical methods and has to be deciphered with the aid of the microfossils (VERNIERS, 1981; see also p. 32).

The outcrops of the Latinne-Hosdin-Trou du Loup (HH-2, HH-4, HH-6, HH-7) is structurally uniform and dips SSE. It shows sequential pattern 6, which is unique in this area because it only occurs frequently 2.5 km more to the south around Fumal. On geometrical grounds, at least 150 m of sediments would be present here. There are four possible positions for this group of outcrops. The easiest explanation is that it occurs just above the outcrops of Latinne-Hosdin-Les Ruelles and that in between, there exists a large anticline; it is then followed by the outcrops of Fallais-Center. A second explanation is that it occurs under the group of Latinne-Hosdin-Les Ruelles with a large anticline separating it, and to the south a big fault orientated WSW-ENE with a few hundred meters of vertical displacement (southern block downfaulted). A third explanation is that it has a much older age and was uplifted between two major faults to the north and the south of the outcrops oriented WSW-ENE. A fourth explanation is that because of the similarities in sequential pattern, it has the same age as the sediments found around Fumal; then we have to admit that it was downfaulted more than 1000 m between two major faults, both oriented WSW-ENE. The palaeontology shows that the first alternative is correct (see p. 32).

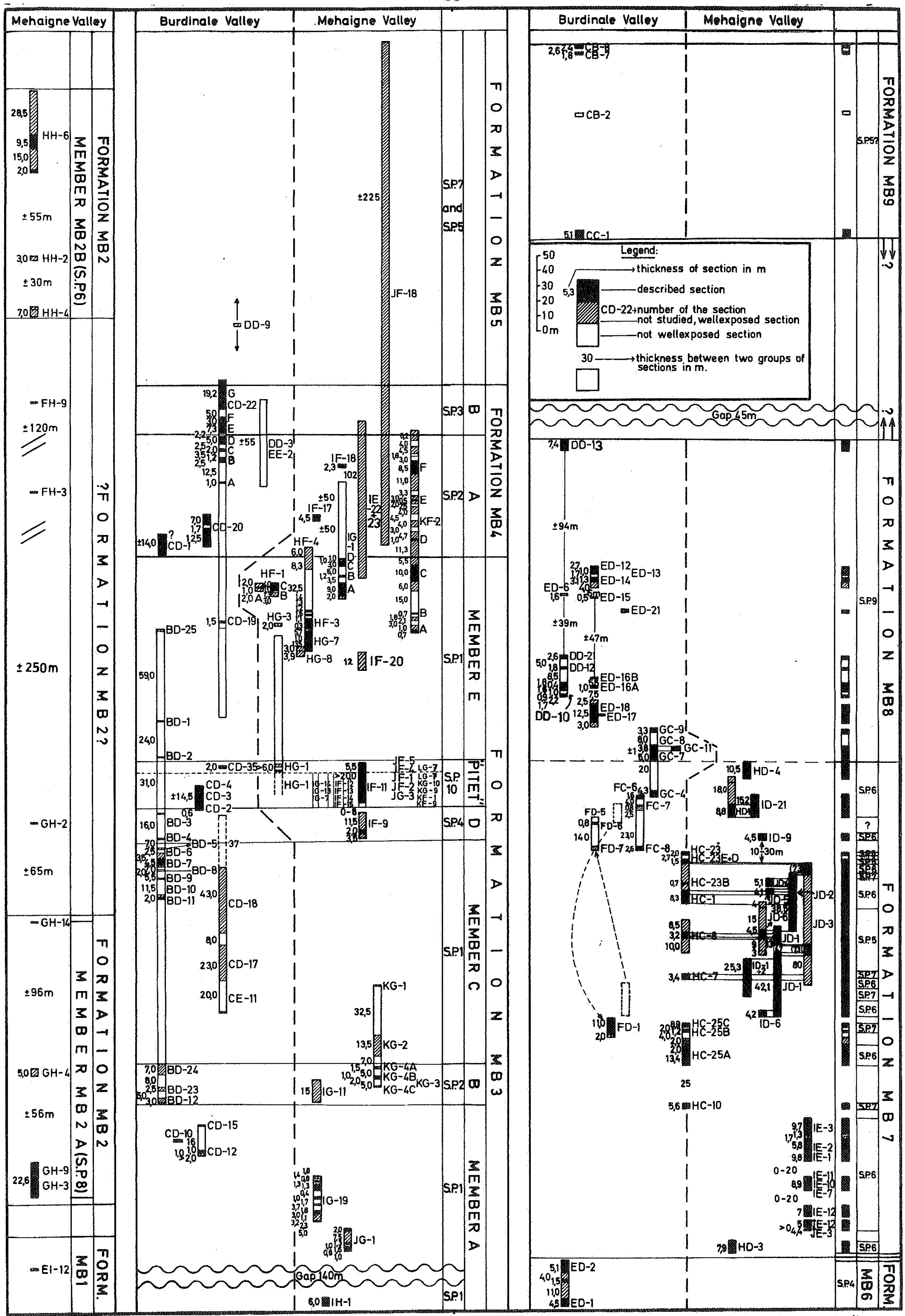


Fig.9: Construction of the lithostratigraphical column, correlation of all sections and lithostratigraphical units, (arrows indicate the position in the column after biostratigraphical evidence showed a different position than determined by lithostratigraphical correlation. S.P.: sequential pattern.)

South of this last group many outcrops occur in both the Mehaigne and the Burdinale valleys. A distinct marker bed occurs : the volcano-sedimentary layer of Pitet. The relative position of all these outcrops is calculated in both valleys by their geometric position in relation to the marker bed, and a consistent stratigraphical column, 950 m thick, is constructed. In the Mehaigne valley (from Fallais to Dreye) sequential pattern 1 was found from 100 m to 470 m under the volcano-sedimentary bed of Pitet. However, an intercalation of sequential pattern 2, at least 20 m thick, occurs at about 160 m under the marker bed; it was observed once in Warnant-Dreye-north (KG-3, KG-4) and may be present in older boreholes of Fallais-Center (IG-11, IG-12). It will palaeontologically be shown later (see p. 32) that sections BD-24 and BD-25 at Burdinne-Les Vallées in the Burdinale valley belong to the same horizon in the column (sequential pattern 2).

Around Lamontzée in the Burdinale valley the sequential pattern 1 is also observed north (below) of the marker bed; this means that if no fault occurs under the alluvia of the Burdinale, the group of outcrops at Lamontzée-Center and along the road NW of Bounia is situated at 30 m to 200 m under the marker bed. In two outcrops just under the marker bed, both in the Burdinale valley at CD-2, and in the Mehaigne valley at IF-9, sequential pattern 4 occurs at least 17 m thick. Above the marker bed about 135 m of sequential pattern 1 is found in several outcrops in the Mehaigne valley at Fallais-south (HF-3, HG-7, HG-8), Fallais railway (IG-1) and Warnant-Dreye-south (KF-2A, B, C) and in the Burdinale valley at Oteppe-Bounia (CD-19). From 135 m up to 220 m above the marker bed sequential pattern 2 occurs in many outcrops in the Mehaigne valley at the Ruisseau de Norméa, Dreye Au Châpin, Dreye-south, in a temporary trench north of "Bois du Tier à Mehaigne" and also south of Pitet on the south bank of the river; in the Burdinale valley at Oteppe-Vissoul, Oteppe-Bounia and Lamontzée-Rue de Rochée. In the Burdinale valley at Oteppe-Bounia and in the temporary trench at "Bois du Tier à Mehaigne" in the Mehaigne valley it is succeeded by a sequential pattern 4 over at least 32 m thick. In the same sections of both valleys it is overlain by sequential pattern 5 and possibly 7 at least 220 m thick. All the sections described above form a reliable column about 950 m thick.

The position of one group of outcrops along the Burdinale valley at Burdinne-Les Vallées was problematic. At the bottom 25 m or more sediments of sequential pattern 2 occur followed by 265 m of sequential pattern 1 only visible in a series small, separated outcrops. If the bottom part corresponds to the sequential pattern 2 observed at Warnant-Dreye-north (KG-3, KG-4), then somewhere between the outcrops one should find the marker bed (Pitet). However this has not been seen until now, but micropalaeontological analysis has solved this problem (see p. 32 ; VERNIERS 1982).

Sequential pattern 4 occurs in a section about 30 m thick in the Burdinale valley at Oteppe-Vissoul (ED-1, ED-2). According to the general structural framework it should occur above the sections with sequential pattern 5 (and 7?) described above.

In many sections from around Fumal and Huccorgne in the Mehaigne valley and in some parts of the Burdinale valley between Marneffe and

Assemblage zones Chitinozoa	Formations members	Microfossil samples in the Burdinale-valley	Microfossil samples in the Mehaigne-valley
C4	Formation MB5	63 DD-9A 34 CD-22G/115	
C3	Member MB4B	33 CD-22G/78 32 CD-22G/1 31 CD-22F/17 30 CD-22E/36 29 CD-22E/35	
C3	Member MB4A	28 CD-22D/1 27 CD-22B/1 26 CD-22A/2 24 CD-20/224 23 CD-20/114 21 CD-20/33	25 KF-2E/2 22 KF-2D/4
C2	Member MB4A	20 CD- 1F/198 19 CD- 1A/33 18 CD- 1A/6	
C2	Member MB3E	12 CD- 19/10 62 BD- 1A	17 KF-2C/91 16 KF-2C/0 15 I G- 1/91 14 I G- 1/8 13 KF-2B/4 11 KF-2A/2
C1	Member MB3D	10 CD- 2/5	9 I F- 9/+11,5m 8 I F- 9/- 2,5m
C1	Member MB3C	61 BD- 7/46 60 BD- 7/2	
B2	Member MB3B		KG-4B
B2	Member MB3A	CD-15A CD-10	7 I G-19/+24,8m 6 I G-19/10 I G-19/-5m J G- 1/35 I H- 1/2 FH- 9
B2	Member MB2B		59 HH-6E/51 58 HH-6D/226 57 HH-6A/5

Fig.10: Succession of Chitinozoa assemblage zones in the Burdinale valley and the Mehaigne valley. The succession is identical in both valleys.

Huccorgne, an alternation of sequential patterns 5, 6 and 7 occurs. According to the general structural framework it should be located above the section with sequential pattern 4 at Oteppe-Vissoul, described above. The relative position of these sections can be established using exact correlations of the chronosequences (fig. 8) and in same cases geometric arguments. They can be accurately grouped into four groups of sections, but their relative positions in respect to each other remain doubtful. From bottom to top we probably have the group of outcrops of Fumal-Church and Fumal-Rue Marneffe, followed by the group of Fumal-Bois aux Guisses which are correlated with the outcrops at Huccorgne-Watermill, and higher up, the group of Fumal-Les Trous and Huccorgne-Les Avaux. The small group of outcrops of the Burdinale valley seems to fall in between the last two groups. Micropalaeontological studies established the exact superposition. The total thickness of the observed,not overlapping,sections is 242 m; according to several estimations this group could be 250 to 330 m thick.

Around Oteppe and Marneffe in the Burdinale valley sections with sequential pattern 9 overlie the above mentioned sections of sequential patterns 5, 6 and 7. They represent at least 86 m of thickness, but their mutual relation is only generally established.

In the Burdinale valley much further to the south (1,5-2 km) three outcrops occur around Boin-Héron (CC-1, CB-7 and CB-8) of sequential pattern 5 (?) with some special characteristics (e.g. relative thick d-division). There are too few sections present to describe a separate sequential pattern for them. A considerable gap of observations (several hundred meters thickness) exists between these sections and the sections around Oteppe and Marneffe, but very probably they belong to the top of the Silurian in the Mehaigne area. The micropalaeontological content proves this (see p. 33 and VERNIERS 1982).

Fig. 9 shows the final result of the correlations as described above. The lithostratigraphic column approximately 2100 m thick shows the relative position of each section with indication of the correlation method used.

2.6. Biostratigraphical control

To confirm the lithostratigraphical correlations or to locate sections with an unknown position, biostratigraphical evidence is used. The biozonation, the description and the occurence of the Chitinozoa used in this chapter are given in VERNIERS (1981, 1982) if not stated otherwise. The micropalaeontological samplenumber and their corresponding outcrop-label can be found in fig. 10.

The supposedly lowest section (EI-12) in sample 1 contains Desmochitina minor (EISENACK, 1931) and Cyathochitina spp. (EISENACK, 1955). These taxa are late Ordovician forms and therefore prove that this section is the oldest of the Mehaigne area. The lithostratigraphical conclusions, made on general geometrical grounds, are hereby confirmed by the biostratigraphy.

The sections at Latinne-Hosdin-Trou du Loup have lithostratigraphically, an uncertain position in relation to the neighbouring sections at Latinne-Hosdin-Les Ruelles and around Fallais. The micropalaeontological samples 57, 58 and 59 contain Chitinozoa which extend into both neighbouring members (e.g. Conochitina sp. A (VERNIERS 1981, 1982) and Eisenackitina sp. C (VERNIERS 1981, 1982) ; they also contain Chitinozoa extending only downwards into the sections at Latinne-Hosdin-Les Ruelles as Conochitina cf. C. edjelensis elongata sensu NESTOR 1980, and Incertae Sedis sp. A. (VERNIERS 1981, 1982) extending only upwards into the sections in Fallais. Therefore its position is most probably in between its two neighbours with the sections at Les Ruelles at the bottom and the sections around Fallais at the top. The middle to late Llandoverian age of the sections at Latinne-Hosdin-Trou du Loup and at Latinne-Hosdin-Les Ruelles (VERNIERS 1982) confirms their stratigraphical position above section EI-12.

Higher up in the lithostratigraphical column there is a rather continuous group of sections, 950 m thick, correlated by the different methods described above. In both valleys an identical succession of sequential patterns occur, and an identical succession of the four assemblage zones B1, C1, C2, C3 of VERNIERS (1982) (fig. 10) also occurs, which confirms the correlations of this part of the column.

The position of a discontinuous series of sections along the Burdinale valley at Burdinne-Les Vallées is unclear on lithological and sedimentological grounds (see p. 29). Samples 60 and 61 were taken in the middle of the upper unit, and sample 62 at the top. Samples 60 and 61 clearly belong to assemblage zone C1 of VERNIERS (1982) as found in the sections just under the volcano-sedimentary layer of Pitet, and sample 62 belongs to the base of assemblage zone C2 found in the sections 65 m to 130 m above this marker bed. Thus, the lower unit (of sequential pattern 2) corresponds to member MB3B (see later p. 36) and the thick, upper unit (of sequential pattern 1), to members MB3C up to MB3E (see later p. 38). The volcano-sedimentary layer of Pitet and the sequential pattern 4 of member MB3D were not found on the field, but should be situated between outcrops BD-1 and BD-2, or between BD-2 and BD-3.

Above this thick group of sections, a section with sequential pattern 4 was found only in the Burdinale valley at Oteppe-Vissoul. The Chitinozoa of samples 38 and 39 of this section belong to the same assemblage subzone D1 as the basal part of sections around Fumal and Huccorgne. Unfortunately no micropalaeontological samples from the largest upper portion of the underlying group of sections (e.g. JF-18) have been treated. The assemblages of samples 38 and 39 are rather different from those corresponding to the base of the part of section JF-18 with sequential patterns 5 and 7. Its relation towards the upper part of section JF-18 therefore remains unknown. However the results do not contradict the lithostratigraphic conclusion.

In the group of sections of sequential patterns 5, 6 and 7, three major groups of sections from the Mehaigne valley have been described, but their relative position to each other remains doubtful. No Chitinozoa bearing samples are found from the lowest group of section (Fumal-Church and Fumal-Rue de Marneffe). The group of sections around Huccorgne-Watermill (sections HC-1 and HC-25) and the lower half of the sections in Fumal-Bois aux Guisses are rather similar in Chitinozoa assamblages and both belong to assemblage subzone D1. The highest group of sections at Fumal-Les Trous and

Huccorgne-Les Avaux is similar to the upper half of the sections in Fumal-Bois aux Guisses especially because of the presence of Conochitina sp. E. (VERNIERS, 1982) which is a typical species of the younger assemblage subzone D3, but already present in the upper part of the assemblage subzone D2, and Conochitina sp. B. (VERNIERS, 1981, 1982) which is typical to assemblage subzone D3.

In the Burdinale valley several sections of sequential pattern 5, 6 and 7 occur above the section at Oteppe-Vissoul with sequential pattern 4, and are correlated with the outcrops around Fumal and Huccorgne. The Chitinozoa assemblages from samples 72 and 73 (sections FD-6 and FC-8) all belong to assemblage subzone D2. These sections should fit between the group of sections of Fumal-Bois aux Guisses and the younger group of sections at Fumal-Les Trous and Huccorgne-Les Avaux, or between the Fumal-Bois aux Guisses sections and the lower lying group of sections at Huccorgne-Watermill (HC-10, HC-25).

Because of the presence of Conochitina aff. proboscifera (EISENACK, 1937) the Chitinozoa assemblages from samples 74 and 75 from section FD-1 (Marneffe-Bois de Briot) belong to assemblage subzone D1, and without doubt are situated lower than the section group of Fumal-Bois aux Guisses.

The Chitinozoa of the sections around Oteppe and Marneffe belong to assemblage subzone D3. Lithostratigraphically these sections form the upwards continuation of the sections around Fumal.

The assemblages from three sections near Héron-Boin are early to middle Ludlovian in age, and therefore, on biostratigraphical grounds, the youngest assemblages of the Mehaigne area. The lithostratigraphical conclusion that these three sections are the highest of the Mehaigne area is therefore also confirmed.

Several isolated sections have a doubtful or unknown place in the stratigraphical column. In an isolated outcrop near the railway station at Braives, the sedimentological structures were not observed. Sample FH-9 contains Incertae Sedis sp. A. which is only found in assemblage subzone B2 and only very rarely at the base of assemblage subzone C1. This implies that at the railway station of Braives, the rocks should be younger than those found at Latinne-Hosdin-Les Ruelles. A possible explanation is that the dip to the north, unusual for the Mehaigne area, but observed at Latinne-Hosdin-Les Ruelles, continues to the north up till the railway station of Braives. Because of the lack of any other outcrop in this area, this conclusion is very tentative.

The position of the sections with sequential pattern 1 at Lamontzée-Center is unclear. According to geometrical calculations (depth under the volcano-sedimentary layer of Pitet) these have to be placed either above the thin intercalation of sequential pattern 2 or under it (in member MB3A or possibly in MB3C, see later p. 36). Sequential pattern 2 was not observed in the Burdinale valley at this place. No Chitinozoa were found in sample CD-10 and CD-15 but Incertae Sedis sp. A. occurs, which is only found in other samples of assemblage subzone B2, and only very rarely at the base of assemblage subzone C1. Therefore the sections CD-10 and CD-15 most probably belong to member MB3A on litho- and biostratigraphical grounds. This indirectly excludes the presence of a major fault under the alluvia of the Burdinale valley at this place. Since two outcrops (BD-23 and BD-24) along the Burdinale at Burdinne-Les Vallées belong to the sequential pattern 2 intercalation (member MB3B) to occur under the alluvia just south of Lamontzée-Center.

Section CD-1 (Lamontzée-Rue de Rochée) with sequential pattern 2 also has an unclear position. From the structural and sedimentological point of view it most probably belongs to the same level as CD-20 and CD-22A.B.C. (member MB4A). But a major fault was observed just north of the outcrop, bringing the sediments in contact with the volcano-sedimentary layer of Pitet (in CD-2). Therefore, via a system of faultwedges it may also belong to the sequential pattern 2 intercalation under the volcano-sedimentary layer of Pitet (member MB3B) which crops out 500 m to the west in BD-24 and BD-25. It could also possibly be part of a thin intercalation of more than 13 m of sequential pattern 2 possibly occuring within the member MB3E near its base. Fragments were not observed of this sequential pattern 2 on the field between HG-1 (volcano-sedimentary layer of Pitet) and HG-3 (85 m higher up in the columm). But the lack of real outcrops in the lower half of formation MB3E cannot rule out this possibility. Graptolites found in this section only give a range from middle Llandoverian to late Ludlovian (VERNIERS & RICKARDS, 1979). The Chitinozoa assemblages in samples 18, 19 and 20 belong to assemblage subzone C2 which excludes a relation with member MB3B. The assemblages seem to fit between samples 13 and 16 of the section KF-2 at Warnant-Dreye-south (top of member MB3E); although the intercalation somewhere in member MB3E cannot be excluded on basis of the Chitinozoa on lithological and sedimentological grounds, it is put at the very base of member MB4A. If lateral variation in sedimentological features occurs between e.g. sequential pattern 2 in the Burdinale valley and sequential pattern 1 in the Mehaigne valley 8 km to the east, section CD-1 could correspond to the top part of member MB3E of the Mehaigne valley.

Outcrop HD-3 at Fumal-Au Doyar is isolated from other outcrops, and belongs to sequential pattern 6, and therefore could belong to either a level in the column shows in JF-18 (formation MB5, see later) or a level in the column disclosed around Fumal and Huccorgne (formation MB7). This last possibility is the most probable within the structural framework of the area. The surrounding outcrops belong to formation MB7; the sequential pattern 4, seen in Oteppe-Vissoul (formation MB6), is not observed ; maybe it is present but unseen because of the absence of outcrops around HD-3. The Chitinozoa in samples 35 and 36 from HD-3 belong to assemblage subzone D1, although <u>Cingulochitina cingulata</u> (EISENACK 1931) is not present. It resembles the assemblages of the group of sections around Huccorgne-Watermill (HC-10, HC-25), and those of Oteppe-Vissoul (ED-1, ED-2). As explained earlier (p. 32) no Chitinozoa assemblages have been studied from the upper part of section JF-18. Section HD-3 could belong to either that upper part (of formation MB5) or to the group of sections around Fumal (lower part of formation MB7). However, in earlier work (VERNIERS, 1981), I agreed with this first possibility. But difficulties occurred when drawing the geological map of this area. Because of the structural framework of the area I now consider HD-3 as most likely to belong to the lower part of formation MB7.

In the group of sections at Fumal-Les Trous, sections ID-21 and HD-1 are correlated on the basis of chronosequences. The position of the higher lying section HD-4 (Huccorgne-Les Avaux) had to be checked. Samples 70 and 71 from this section HD-4, are compared with samples 50, 51 and 69 from sections ID-21 and HD-1. The Chitinozoa assemblages in samples 70 and 71 are nearly identical to those in sample 69, with a dominance of Cingulochitina cingulata, but they are slightly dissimilar to samples 50 and 51. Thus section HD-4 must be situated at the top of HD-1 or just above it.

The micropalaeontological analysis could not indicate the position of the following sections where no Chitinozoa were found : GH-2 at Fumal-Church (IE-1, 2 and 3), and several sections around Oteppe and Marneffe.

2.7. Definition of the lithostratigraphic units

After the construction of the lithostratigraphic column, it is possible to define nine lithostratigraphic formations (fig. 10) based on the presence of one or more sequential patterns. Within these formations different sequential patterns or variations within the patterns permit the definition of members. Fig. 14 makes it easy to understand these variations in the different features and patterns when reading the formation descriptions. The formations are numbered MB1 to MB9 (MB standing for Mehaigne and Burdinale valley). The members are labelled with letters ranging from A to E : e.g. member MB3E. These formations have an informal status, because of several uncertainties and gaps in the lithostratigraphical column of the Mehaigne area, and various problems of historical priority, since the Silurian of the Brabant Massif was formally defined in other areas (Orneau valley and Sennette valley, see p. 5). Only when the whole Silurian of the Brabant Massif will have been re-analysed, can a new formal division be established, perhaps including some of the formation names used here for the Mehaigne area. The formations and members of the Mehaigne area are described from bottom to top in the following section.

- formation MB1

representative section (informal type locality) : EI-12, near "Moulin Velu Pont" (Braives-Avennes).
thickness : unknown.
lithologic description : fine mudslates with a lot of disseminated pyrite cubi (0.5-3 mm size); weathered colour : light grey (greenish-yellow).
sedimentology : no cyclicity, compact sedimentation.
boundaries : unknown; at the top (to the S) locally bounded by a fault?; at the base (to the N) under mesozoic cover.

- formation MB2

- member MB2A

representative section : GH-3, GH-9, Latinne-Hosdin-Les Ruelles.
other sections : GH-4, GH-10, GH-11, GH-14, GH-15.
thickness of recorded sections : 22.6 m.
outcropping thickness of the section : 27.6 m.

estimated thickness of the formation : at least 180 m.
sequential pattern : 8.
lithology : mudslates, siltslates and fine siltstones, quartzic sometimes calcareous.
sedimentology : Tde sequences thin to medium thick (average thickness of at least 20 cycles : 11-19 cm); Tcde sequences very often present (38-61% of all sequences) with about the same average thickness approaching that of Tde sequences (at average 20% thicker); with thin c-divisions (0.5 to 6 cm).
boundaries : lower : unknown; upper : not seen, possibly member MB2B.

- member MB2B

representative section : HH-6, Latinne-Hosdin-Trou-du-Loup.
other sections : HH-2, HH-4, HH-7.
thickness of recorded sections : 11.5 m.
thickness of outcropping sections : >55 m.
estimated thickness of member : >150 m?
sequential pattern : 6.
lithology : dark to medium grey mudslates, siltslates, siltstones and fine sandstones with quartzic pelites in the e-divisions.
sedimentology : Tde sequences are often present (74%) and medium thick (17 cm average); only one Tbcde sequence is observed (14.2 m thickness); Tcde sequences are often present (24%) and thick (26 cm average); c-divisions are mostly thin, ranging from 0.5 to 18.5 cm and averaging 6.9 cm.
boundaries : lower : possibly member MB2A; upper : unknown, possibly member MB3A.

- formation MB3

- member MB3A

representative section : IG-19, Fallais-Center.
other sections : JG-1, IH-1, CD-10, CD-12, CD-15.
thickness of recorded sections : 19.9 m.
outcropping thickness of the sections : 55.6 m.
estimated thickness of this member : at least 270 m.
sequential pattern : 1.
lithology : mudslates, siltslates, siltstones and fine sandstones with uncalcareous chloritic matrix in the e-divisions.
sedimentology : thin Tde sequences (the average thickness in at least 20 sequences : 6-9 cm); T(b)cde sequences absent or rarely present (0-11% of all sequences), generally about 60% thicker than the average Tde sequence; with c-divisions mostly between 0.5 and 9 cm and rarely (about 10%) between 11 and 16 cm thick.
boundaries : lower : unknown, possibly MB2B; upper : member MB3B.

- member MB3B

representative section : KG-4A, B, C at Warnant-Dreye-north.
other sections : KG-3, (IG-11), (IG-12), (CD-23), (CD-24).
thickness of recorded sections : 0 m.
outcropping thickness of the sections : 4 m.
minimal thickness of the member : 28 m.

sequential pattern : 2.
lithology : mudslates, siltslates, siltstones and fine sandstone and in the e-divisions non-calcareous chloritic pelites.
sedimentology : thin Tde sequences (about 10 cm); T(b)cde sequences frequent and much thicker (20-50 cm) than Tde sequences.
boundaries : lower : member MB3A; upper : in the 7 m of not observed strata between KG-4A and KG-2.

- member MB3C

representative section : KG-2, Warnant-Dreye-south.
other sections : (CD-17), (CD-18), (BD-3), (BD-4), (BD-5), (BD-6), BD-7, (BD-8), (BD-9), (BD-10), (BD-11).
thickness of recorded sections : 19 m.
estimated thickness : at least 80 m, probably about 140 m.
sequential pattern : 1.
lithology and sedimentology : cf. member MB3A.
boundaries : lower : member MB3B; upper : unknown, somewhere in a 30 m gap of unobserved strata below MB3D.

- member MB3D

representative section : IF-9, Fallais-Pitet-Les Falihottes.
other sections : CD-2.
thickness of recorded sections : 2.6 m.
thickness of outcropping sections : 17.6 m.
estimated thickness of the member : at least 22 m.
sequential pattern : 4.
lithology : mudslates, siltslates and siltstones (quartzic, non-calcareous pelites).
sedimentology : Tde sequences thin to medium thick (average of 12 cm); T(b)cde sequences frequent and generally thicker than Tde sequences; with thin c-divisions.
boundaries : lower : see member MB3C; upper : volcano-sedimentology layer of Pitet (contact observed in CD-2).

- Volcano-sedimentary layer of Pitet

representative sections : JF-2 (old quarry at the Butte Saint-Sauveur), and IF-11 (old quarry at Bois Cornet) both at Pitet, Fallais.
other sections : CD-2, CD-3, CD-34, CD-35, HG-1, HG-19?, IG-7, IG-9, IG-10?, IG-13, IG-14, JF-1, JG-3, JG-4, JF-3, JF-4, JF-5, JF-7, JF-12, IF-13, IF-14, IF-15, KG-9, KG-10, LG-7.
thickness of studied sections : 20 m (coarse to fine grained beds) 5.5 m (very fine grained beds, also called slate of Bois Cornet).
estimated thickness : about 23 m (coarse to fine grained beds); about 8 m (slate of Bois Cornet).
sequential pattern : 10.
lithology : the lower bed is a massive rock over 20 m thick, with graded bedding; at the base a coarse to very coarse pure crystal tuff with grain size up to 7 mm and many slate and crystal lenses; passing gradually upwards into a coarse to medium coarse tuff (grain size 1 mm and less), heterogenous with crystal and glass lenses; described as "albite phylladifère" by DUMONT (1848), and "porphyroïde" by de la VALLEE-POUSSIN (1875) and de la VALLEE-POUSSIN &

RENARD (1876). This passes gradually into more than 5.5 m of fine to very fine sediment, slaty with conchoidal fracturing, resistant to erosion; described as "eurite" by DUMONT (1848) and "phyllade (= slate) du Bois Cornet", and called an ash tuff or cinerite by DEPAUW (1971).

sedimentology : the lower 20 m show a graded bedding without other sedimentary structures; the very fine "slate of Bois Cornet" shows very parallel lamellation and very fine cross bedded lamellation in several intervals over 4 m thick; the above lying very fine slate of more than 1.5 m shows compact sedimentation.

boundaries : lower : member MB3D; upper : not observed, but in view of the origin of this unit a sharp contact with member MB3E should exist.

- member MB3E

representative section : KF-2C, Warnant-Dreye-south.
other sections : CD-19, HG-3, HG-7, HG-8, HF-1, HF-3, JF-4 (lower part), JG-1A to D, KF-2A, KF-2B.
thickness of recorded sections : 55 m.
thickness of outcropping sections : 64 m.
estimated thickness of the member : 135 m.
sequential pattern : 1.
lithology : mudslates, siltslates, siltstones and fine sandstones, with non-calcareous chloritic pelites in the e-divisions.
sedimentology : Tde sequences at an average of between 8 and 11 cm; T(b)cde sequences are absent or rarely present (0-7% of all sequences), generally about 75% thicker than the main Tde sequences, with c-divisions at an average of between 0.5 and 8 cm and in 1/3 of all the c-divisions between 11 and 20 cm thick.
boundaries : lower : the volcano-sedimentary layer of Pitet; upper : formation MB4 observed between KF-2C and KF-2D, in IG-1 (above D), in HF-4, and between CD-19 and CD-20.

- formation MB4

- member MB4A

This member groups members MB4A and MB4B from earlier publications (VERNIERS & RICKARDS 1979; VERNIERS, 1981).
representative section : CD-20 and CD-22A to CD-22D, Oteppe-Bounia.
other sections : CD-1, KF-2D, KF-2E, IF-17, IF-18, KF-2F.
thickness of recorded sections : 48.0 m.
thickness of outcropping sections : 57.6 m.
estimated thickness of the member : 82 $\pm$ 10 m.
sequential pattern : 2.
lithology : mudslates, siltslates, siltstones and fine sandstone with non-calcareous chloritic pelites in the e-divisions.
sedimentology : Tde sequences thin to medium thin (average between 6 and 14 cm); T(b)cde sequences frequent to very frequent (20-50%), generally twice as thick as the average Tde sequence, with c-divisions between 1 and 10 cm in 50 to 65% of all the c-divisions, and 10 to 22 cm in the rest of the cases.
boundaries : lower : member MB3E; upper : member MB4B.

remarks : CD-22D, which was put in a member called MB4C in earlier publications (see above), is placed in this member, because of the thin Tde sequences, the relatively much thicker T(b)cde sequences than the Tde sequences, and the thick c-divisions.

A general tendency is observed in this member, going from the bottom to the top. The Tde sequences are thin in the lower half (average between 6 and 10 cm) and thin to medium thick in the upper half (average between 6 and 14 cm). This tendency to thicken continues in member MB4B and formation MB-5. The T(b)cde sequences are frequent to very frequent in the lower part (20-30% of all sequences), and even more frequent in the higher part (25-60%). In 2/3 of the cases the c-divisions are smaller than 10 cm in the lower part, while in the upper part only half of them are smaller than 10 cm.

In the topmost 10 m of this member and the lower 10 m of member MB4B thick layers of siltslates to siltstones occur with a reticular to quartzitic structure, resistant to erosion, showing very few sedimentological features; these layers are probably Tde sequences. They only occur at this level of the stratigraphical column in the Burdinale valley (CD-22D, CD-22E, CD-22F) as well as in the Mehaigne valley (KF-2F).

- <u>member MB4B</u>

this member is nearly equal to member MB4C of earlier publications (<u>ibid</u>.).
representative section : in the Burdinale valley CD-22E, CD-22F, CD-22G (0-7.8 m), at Oteppe-Bounia.
other sections : (JF-18).
thickness of recorded sections : 26.1 m.
thickness of outcropping sections : 31.1 m.
estimated thickness : 32 m.
sequential pattern : 3.
lithology : mudslates, siltslates, siltstones and fine sandstones with non-calcareous quartzic pelites in the e-divisions.
sedimentology : Tde sequences are medium thick (average : 16-18 cm); T(b)cde sequences are frequent to very frequent (25-60% of all sequences) and are generally about the same thickness (about 30% difference); in 3 out of 4 cases the c-divisions are 2 to 10 cm thick, in 1 out of 4 cases between 10 and 16 cm thick, rarely more.
boundaries : lower : MB4A see above: upper : MB5, boundary fixed just above the last T(b)c(d)e sequence in CD-22G at 15.8 m where sequential pattern 3 changes into sequential pattern 7.

- <u>formation MB5</u>

representative section : in the Mehaigne valley : only briefly investigated in the temporary outcrop for a pipeline (JF-18); detailed sedimentological description is lacking but the general characteristics have been recorded.
other sections : in the Burdinale valley : DD-9, CD-22G (15.8-19.2 m).
thickness of recorded sections : 225 m.
estimated thickness : more than 225 m.
sequential pattern : 5 and 7.
lithology : grey mudslates, siltslates, siltstones and fine sandstones

with non-calcareous quartzic pelites in the e-divisions.
sedimentology : in the lower 125 m the Tde sequences are medium thick to thick (15 to 30 cm); between 125 and 185 m the Tde sequences are thick and very thick (up to 60 cm), and in the upper 35 m the Tde sequence are medium thick to very thick (30 to 60 cm) with relatively thick d-divisions. T(b)cde sequences are sometimes present but their frequency and thickness have not been recorded.
boundaries : lower : MB4B see above; upper : not observed on the field, probably formation MB-6.

- formation MB6

representative section : in the Burdinale valley : ED-1 and ED-2, Oteppe-Vissoul.
thickness of the recorded sections : 9.4 m.
thickness of the outcropping sections : 29. 4 m.
estimated thickness : more than 30 m.
sequential pattern : 4.
lithology : grey mudslates, siltslates, siltstones and fine sandstones with non-calcareous quartzic pelites in the e-divisions.
sedimentology : Tde sequences are medium thick; T(b)cde sequences are frequent (about 15% of all sequences) and normally thicker (± 50%) than the average Tde sequences; c-divisions are thin (2-8 cm).
boundaries : lower : probably formation MB5 (contact not observed); upper : probably formation MB7.

- formation MB7

representative section : in the Mehaigne valley JD-1, JD-2 and JD-3, Fumal-Bois aux Guisses.
other sections : in the Mehaigne valley HD-1, HD-2, HD-3, HD-4, ID-1, ID-2, ID-6, ID-9, ID-21, JD-4, JD-5, JD-6, IE-1, IE-2, IE-3, IE-7, IE-10, IE-11, IE-12, JE-1, JE-2, JE-3; in the Burdinale valley : FC-6, FC-7, FC-8, HC-1, HC-7, HC-8, HC-10, HC-22, HC-23, HC-25, FD-1, FD-5, FD-6, FD-7.
thickness of recorded sections : 242 m.
estimated thickness of formation : 330 m.
sequential pattern : 5, 6 and 7 alternating (see fig. 14).
lithology : grey mudslates, siltslates, siltstones and fine sandstones with quartzic pelites in the e-divisions.
sedimentology : sequential pattern 5 : thick Tde sequences (average between 24 and 28 cm) with absent or very rare T(b)cde sequences. Sequential pattern 6 : medium thick to thick Tde sequences (average between 17 and 25 cm) with rarely present to very frequent T(b)cde sequences (6 to 30% of all sequences) of about the same thickness as the Tde sequences; the c-divisions are either thicker or thinner than 10 cm but there is a higher frequency (80%) of c-divisions thinner than 10 cm. Sequential pattern 7 : medium thick to thick Tde sequences (average between 14 and 18 cm) and no T(b)cde sequences.
boundaries : lower : probably formation MB6, but contact not observed; upper : not observed, but situated in the observation gap (± 20 m) between GC-4 and GC-7 (Marneffe-Bois Dreût Tier), where sequential pattern 7 changes into sequential pattern 9 characterizing formation MB8.

- formation MB8

representative section : in the Burdinale valley : ED-12, ED-13, ED-14, Oteppe-Center in the Rue de l'Eglise.
other sections : only in the Burdinale valley : GC-4, GC-7, GC-8, GC-9, GC-11, DD-10, DD-12, DD-13, DD-14, DD-15, DD-21, ED-6, ED-16, ED-17, ED-18, ED-21.
thickness of the recorded sections : 50 m.
thickness of outcropping sections : 86 m.
estimated thickness of the formation : more than 210 m.
sequential pattern : 9.
lithology : siltslates and siltstones with quartzic-chloritic pelites, sometimes calcareous in the e-divisions.
sedimentology : thick to very thick Tde sequences (an average between 21 and 51 cm), with T(b)cde sequences (0 to 33% of all sequences), an average 50% thicker than the average Tde sequences; c-divisions range between 0.8 and 13 cm.
boundaries : lower : formation MB7 (see above); upper : unclear, possibly formation MB9 : gap of information over a strip about 2,5 km wide.

- formation MB9

representative section : only in the Burdinale valley : CB-7 and CB-8 at Héron-Boin.
other sections : CC-1.
thickness of the recorded sections : 9 m.
thickness of the formation : >125 m?
sequential pattern : 5? (see p. 31).
lithology : mudslates, siltslates and siltstones with quartzic pelites in the e-divisions.
sedimentology : thick Tde sequences with sometimes relatively thick d-divisions in the Tde sequences; T(b)cde sequences are rare.
boundaries : lower : possibly formation MB8 (see above); upper : not established because of the covering of Devonian rocks.

3. TYPE AND FEATURES OF THE SEDIMENTARY BASIN

3.1. Type of sediment : flysch

As shown above (p. 19), the Silurian sediments of the Mehaigne area are turbidites. This genetic term only points out their origin and mode of deposition i.e. by turbidity currents. However, most turbidites have been recognized in the well defined tectonic framework of flysch-facies deposits which represent the immediately pre-orogenic infillings of geosynclinal troughs. Few turbidites are found in other tectonic frameworks, e.g. in recent basins along the continental margins as deep-sea sands, in intercalations between other kinds of deposits of fluviolacustrine milieus (e.g. in the Rhône delta in Lake Geneva, FOREL, 1885) or in brackish-water molasse successions (ZEIL, 1960). To distinguish flysch deposits s.s. as observed in the Alpine and Hercynian orogeneses from turbidites in other tectonic frameworks and called flyschlike or flyschoid deposits, various essential features have been stressed.

According to DZULINSKI & SMITH (1964), flysch deposits s.s. have to be (1) marine and (2) terrigenous; (3) they have to consist of turbidites with all their characteristic structures and features (current and directional marks, sedimentary structures such as graded bedding, laminations, small scale current ripples and convolute laminations, poor sorting, lateral and vertical homogenity etc.); (4) slump deposits, pebbly mudstone and sandstones are often present; (5) fossils are scarce : redeposited fossils occur in the sandy beds, pelagic or relatively deep-water benthonic microfossils in the shaly beds, but in situ shallow-water benthonic fauna is absent; (6) scarcity of volcanic rocks other than fine tuffites; (7) virtual absence of large scale cross-stratification indicative of shallow environment; (8) absence of features suggestive of subaeral conditions such as dessication cracks, salt crystal pseudomorphs, foot prints of land animals or birds; (9) laterally they pass into non-flysch deposits via transitional facies, frequently of considerable thickness and extension, and characterized by the gradual appearance of non-flysch features, making it difficult to define other than arbitrary boundaries; (10) the pre-flysch deposits pass gradually into flysch deposits; hence a flysch never rests directly on a transgression surface; (11) the flysch is immediately pretectonic and represents the youngest deposits tectonized by the orogenesis, and all younger sediments are discordant and post-tectonic.

VASSOEVICH (1948) and RECH FROLLO (1972) point to other essential features such as:(12) the presence of the carbonates appearing at several degrees, especially in the Alpine flysch, or (13) the advanced diagenesis and incipient metamorphism (anchi-zone). The characteristic fissility of the rocks is not always visible in the field, but elongation of minerals in certain planes is frequently observed in thin sections. This characteristic brings the flysch more into the metamorphic realm than into the sedimentary realm. For both VASSOEVICH (ibid.) and RECH FROLLO (ibid.), this feature allows the separation of true flysch from other marine flysch-like or flyschoid deposits. (14) Last of all, the great thicknesses of flysch deposits (hundreds to thousands of meters) has been stressed (TERCIER 1947). Not one of these features by itself is characteristic of a flysch, but the combination of all or almost all features recorded, permits the recognition of a flysch s.s.

The Silurian sediments of the Mehaigne area show most features described as essential for a flysch. They are marine (presence of the exclusively marine fossils such as graptolites and Chitinozoa; feature 1) and terrigeneous (by their lithology, feature 2), and their turbiditic nature has been proven above (p. 19; feature 3). Macrofossils are scarce, except for redeposited graptolites and Conularia sp. in b-, c- and d-divisions, and redeposited organic microfossils (Chitinozoa, Prasinophycae and Acritarcha) in the pelitic e-division, also occuring in the other divisions (see VERNIERS 1982 ; feature 5). There is only one volcanic rock present : the volcano-sedimentary layer of Pitet, possibly of ignimbritic origin (feature 6). No large scale cross stratification occurs (feature 7) and no features suggestive of subaeral conditions (feature 8) are seen. The lateral variation to non-flysch sediments has not been observed (feature 9) and the vertical concordant continuation from pre-flysch sediments is difficult to verify. The oldest sediments (formation MB2A) are turbidites and the only older outcrop of near Avennes (EI-12, formation MB1) is only doubtfully dated and not well studied ; however it does not show the alternating rhytmical pattern of a turbidite and could represent a pre-flysch facies. In the Orneau-valley 30 km more to the west in the Brabant Massif, the oldest Silurian turbidites are of early Llandoverian age and rest on non-rhytmical sediments with graptolites, brachiopods and trilobites from the top of the Ashgillian and the base of the early Llandoverian; higher in this early Llandoverian sequence, a subaeral or shallow water ignimbrite follows (VERNIERS, 1982). These sediments represent the pre-flysch sedimentation in this area. Comparable pre-flysch deposits can be postulated for the Mehaigne area (feature 10). The regional geology of the area shows gently dipping Middle and/or Late Devonian strata discordantly covering the Silurian turbidites folded by the Caledonian orogenesis (feature 11). Calcareous cement is observed in formations MB2A, at the base of formation MB7 and in formation MB8 (feature 12). The advanced diagenesis (anchi-zone or zeolite-facies) is demonstrated later (p. 60); the fissility of the pelitic rocks oblique to the stratification is one of the most striking features in the outcrops (feature 13). The thickness of the Silurian turbidites is considerable : the middle Llandoverian to early Ludlovian sediments in the Mehaigne area are probably more than 2100 m thick, while the Wenlockian only accounts for at least 850 m (feature 14).

Feature 14 (the presence of slumpstructures, pebbly mudstones or sandstones) has not been recorded in the Mehaigne turbidites. However, as this area was situated in the distal part of the turbidite fan system (see p. 49), these slumpstructures are not likely to exist there. Except for feature 4, 9 and possibly 10, all the other features recorded provide evidence that the turbidites of the Mehaigne area belong to a flysch-facies. This implies that the turbidites were the pre-orogenic infillings of a geosynclinal trough.

The pre-flysch sediments visible in the Orneau-valley contain several originally calcareous layers with a rich macrofauna (trilobites, brachiopods, crinoids, graptolites etc.). These macrofossil bearing layers and in the Mehaigne area the calcareous cement at several horizons in the turbidites (fig. 14) point, following AUBOUIN (1965), to the presence of

Section and number of sequence	Wavelength (cm)	Amplitude (cm)	Orientation of currents	direction currents
Formation MB7				
FC-8/11-12	20	2,5		
FC-8/8-9	7-12	1-1,5		
HD-4/1	15-30	1-1,5		
HD-4/1-2	25	4,5		
HD-1/13-14	10-20			
ID-21/61	20	1,5		
ID-21/19-20			N27°W	
ID-21/12-13	24-28	1-1,5		
ID-21/7-8	18-20	1-1,5	N10°W	
JD-3/9-10	1,5	0,2		
JD-4/4	13;14;17;21;27	1;1;1;1,5;2	N27°W	
JD-2/16	14;21;30	1;1,5;2		
JD-4/5	16;21;30	1,5-3	N25°W	to the N
JD-2/17	17;18;18;21	2-2,5		
JD-4/6	18;23;28	1,5-2,5	N25°E	
JD-2/35-36	18;20;21	1-2	N20°W	
JD-4/27-28	8	0,5		
JD-4/28-29	25	2,5-4,5		
JD-4/31-31	30	2		
JD-5/23	15	1,5		
JD-2/56			N25°W	
JD-5/21	14;15;21	1,5-2,5	N23°W	to the N
JD-5/16-17	12;23	0,5-1,5	N25°W	to the N
JD-5/11	10;13;14;15;16	1,5-3,0	N23°W	
JD-5/10-11	9;16	1-1,5		
JD-5/6bis-7	4	0,5-0,7		
HC-1/33				to the N
HC-1/7-8	7-10	2		
HC-1/7	10;13;13;18	1,5-3		
HC-1/6-7	18;21	6-10	N10°E	

Section and number of sequence	Wavelength (cm)	Amplitude (cm)	Orientation of the currents	direction of the currents
Formation MB7				
JD-2/88-89	15	1,5		
JD-2/91-92	23	1,5		
JD-2/94-93	10	0,7		
JD-2/98-99	10-12,5	1,0		
JD-2/105-106	6-7	0,5		
JD-2/108-109	7-10	0,3-0,5		
ID-13			N19°W	
JD-1/98			N20°W	
HC-25c/201-202	10	0,5		
IE-3/59			N 0°E	
IE-7/19	30-40	1		
IE-7/18	30;35;36;40			
Formation MB4				
CD-22E/38			N25°W	to the N
CD-22E/36			N25°W	to the N
CD-22E/34			N25°W	to the N
CD-22E/24-25		0,5		
CD-22E/12-13	23	2		
CD-22E/11-12		2		
CD-20/35	10	1	N 7°W	
CD-1F/182	25-30	4		
Member MB3E				
IG-1/58-58bis			N65°W	
Member MB3A				
IH-1/23	20	2	N0°E	
Member MB2A				
GH-3/37			N35°W	to the N
GH-3/33			N35°W	to the N
GH-9/22bis-23	16-20	1-1,2	N37°E	
GH-9/1 en 2			N45°E	

Fig. 11 : Orientation & direction of turbidity currents as measured from current ripples and current ripple lamellations (cf. fig. 4B). Also are given the wavelengths and amplitudes of some current ripples.

a miogeosynclinal trough rather than a eugeocynclinal trough, during the Silurian in the Brabant Massif.

3.2. Depth of the basin

The microfossil content (abundance of the thick-walled *Leiosphaeridia* & *Prasinophyceae*), the absence of spores), the generic and specific composition of the Chitinozoa-assemblages and their high diversity allow us to conclude that outer deep shelf conditions (approximately 75-200 m depth) prevailed in the source area of the turbidites (VERNIERS 1982). Turbidity currents descended along a slope from this source area into the Mehaigne area which had to be bathyal from at least middle Llandoverian to early Ludlovian. This is not in contradiction with other studies on the deposital conditions of flysch. Earlier hypotheses assumed flysch to be either littoral (ZUBER, 1901; ABEL, 1927; KARNY, 1928; MANGIN, 1962), shallow or neritic, (depths less than 200 m; SONDER, 1946; ZEIL, 1960; HANZILOVA & ROTH, 1963). However, these refer to deposits later classified as flysch-like or flyschoid (see above). Experiences with turbidity currents by KUENEN & MIGLIORINI (1950) show that the deposition of most turbidites is not influenced by the surface dynamics of the sea, but basically directed by gravity forces. The hypothesis of a fairly deep environment for flysch-type turbidites is by now generally accepted (Mc BRIDE, 1962, 1964). Moreover, KELLING (1964) showed that turbidite currents occur in a deeper environment than that of the black graptolitic shales. Depths for deposition of flysch-type turbidites of at least 85 m (DILL, 1964) or more than 200 m have been proposed (DZULINSKI & WALTON, 1965).

On the other hand, the Mehaigne area did not reach into the abyssal plain, because no contourites or hemi-pelagic deposits are recognized, which are normally associated with abyssal deposits. Contourites are turbidites redeposited by other currents and show well-defined sedimentary structures. They are thin bedded (less than 5 cm), well sorted very fine sands and silts, with inverse and normal graded bedding, frequent laminations both parallel and oblique, basal structures and absence of "sequences of divisions" *sensu* BOUMA (HOLLISTER & HEEZEN, 1972; NELSON, MUTTI & RICCI LUCCHI, 1975). No such sediments are present in the Mehaigne area.

The presence of pyrite in the sediments indicates a highly reducing environment during the deposition and also during early diagenesis (KRUMBEIN & GARRELS, 1952). Pyrite has been observed in several stages growing from the inside of organic microfossils (Chitinozoa, large *Leiosphaeridia*). This pyrite growth sometimes continued until the microfossils cracked and were destroyed. It also shows that during early diagenesis a highly reducing environment prevailed in the Mehaigne area.

3.3. Direction of the currents

The orientations of the turbidity currents are measured perpendicularly to the longitudinal axis of the ripple marks which nearly always occur at the top and the base of the c-divisions of the turbidite sequence. These measurements were made in formations and member MB2A (N-S; N35°W); MB3 (N-S; N65°W); MB4 (N7°W; N25°W); MB7 (14 orientations ranging from N27°W to N25°E with an average of N15°W) (fig. 11). The results show that the actual orientation of the currents is NNW-SSE with some variations.

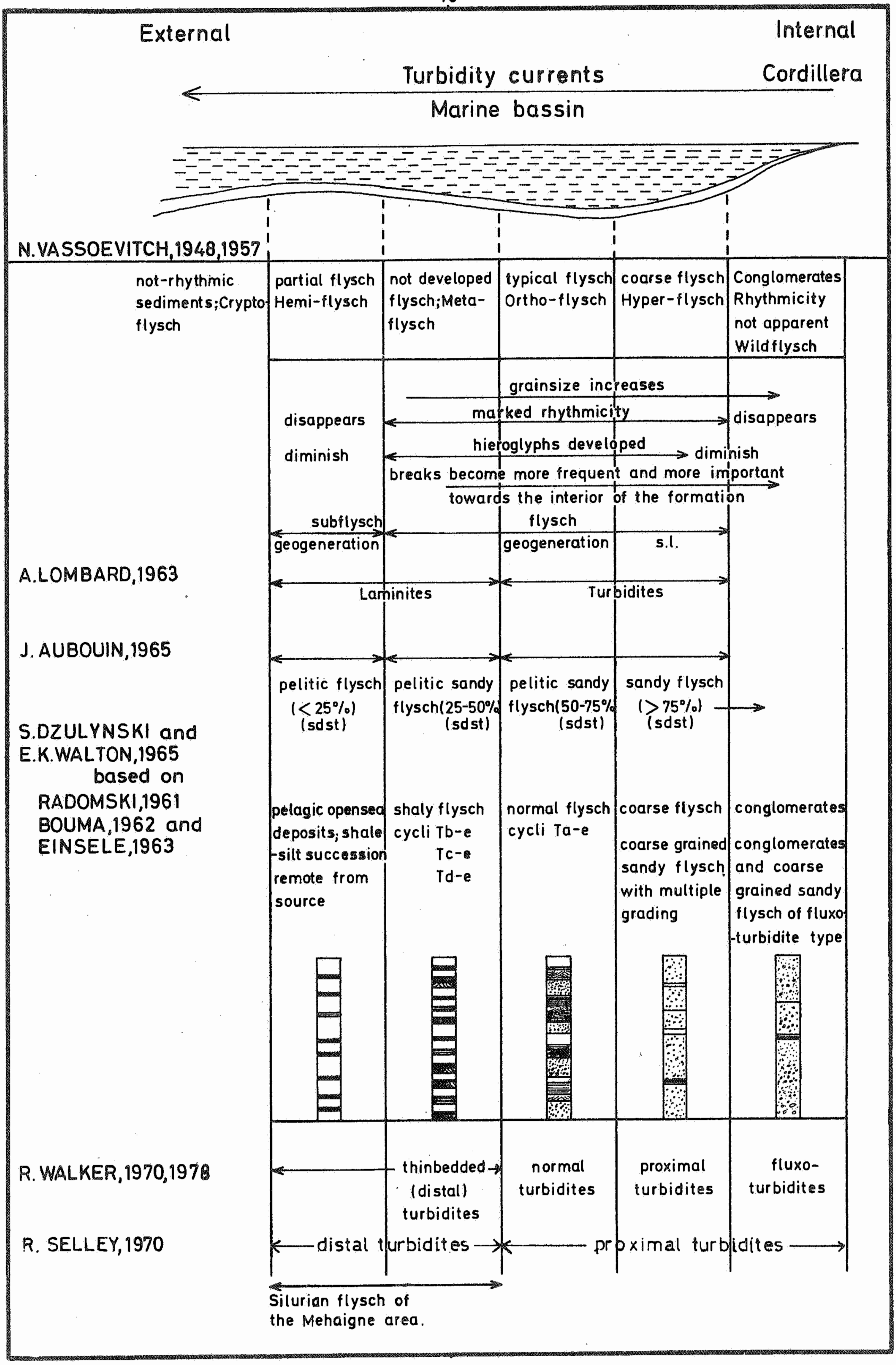


Fig.12 Divisions of a flysch in a geosynclinal trough proposed by different authors.

The direction of the currents cannot be deduced with certainty from the study of the ripple marks. It was studied through sedimentological observations in outcrops and eight oriented samples. These samples were sawn perpendicular to the longitudinal axis of the ripple marks i.e. in the orientation of the currents. Fig. 5B shows some drawings of the observed sedimentological features from which the direction of the currents was deduced. In all cases the direction is towards the north; a southern source area for the turbidity currents is therefore probable.

3.4. Provenance of the sediments

Because the sediments are turbiditic in origin, they have been transported twice : first from the primary source area towards the secondary source area from where the turbidity currents continued down the slope. The secondary source area was definitely situated on the outer deep shelf as shown by the Chitinozoa assemblages encountered (VERNIERS, 1982). The mineralogical composition (presence of quartz, chlorite, illite, a few mica, plagioclase, calcite and ubiquist heavy minerals, see p. 15) does not allow the determination of a specific petrographic origin. The most evident origin for the sediments would therefore be older sedimentary rocks. Because of a southern source area for the turbidity currents, we must look for a continent south of the Brabant Massif; therefore the Ardenne is the most likely primary source area. It mainly consists of arenaceous and pelitic sediments with some minor plutonic rocks; it was folded and uplifted in the Caradocian, eroded during the Silurian and submerged in the lowermost Devonian. Other evidence is provided by MARTIN (1969a) who found reworked Ordovician acritarchs together with spores in late Llandoverian to Ludlovian sediments of the Condroz Ridge. She suggests that the origin of these microfossils is a continental area to the south : the Ardenne. The most likely hypothesis for the origin of the Silurian sediments in the Mehaigne area is therefore that they are derived from the erosion of the Ardenne, and that they were deposited in a epicontinental sea north of the emerged Ardenne. The Condroz Ridge would form the deeper part of this sea (as already proposed in the reconstruction of MICHOT, 1980) and from there the sediments were brought by turbidity currents along a slope to the north into the Mehaigne area.

3.5. Distance to the source of the turbidity currents

For the palaeogeographical reconstruction of the region it is important to have an idea of the original distance between the source area of the turbidity currents and the Mehaigne area. If we use the models given in fig. 12, the general composition of the flysch in the Mehaigne area indicates a rather distant source. According to the authors cited, the deposits can be respectively called : a partial to non-developed flysch, or a hemi- to metaflysch (VASSOEVITCH, 1948); laminites (LOMBARD, 1963); a pelitic, pelitic-sandy or sandy-pelitic flysch (AUBOUIN, 1965); a shaly flysch or normal flysch (DZULINSKI & WALTON, 1965); a distal turbidite (SELLEY, 1970).

During the last ten years, a more detailed model has been described of a system comprising a source area of the turbidites on top of a continental slope a submarine canyon and a deposition fan of turbidites

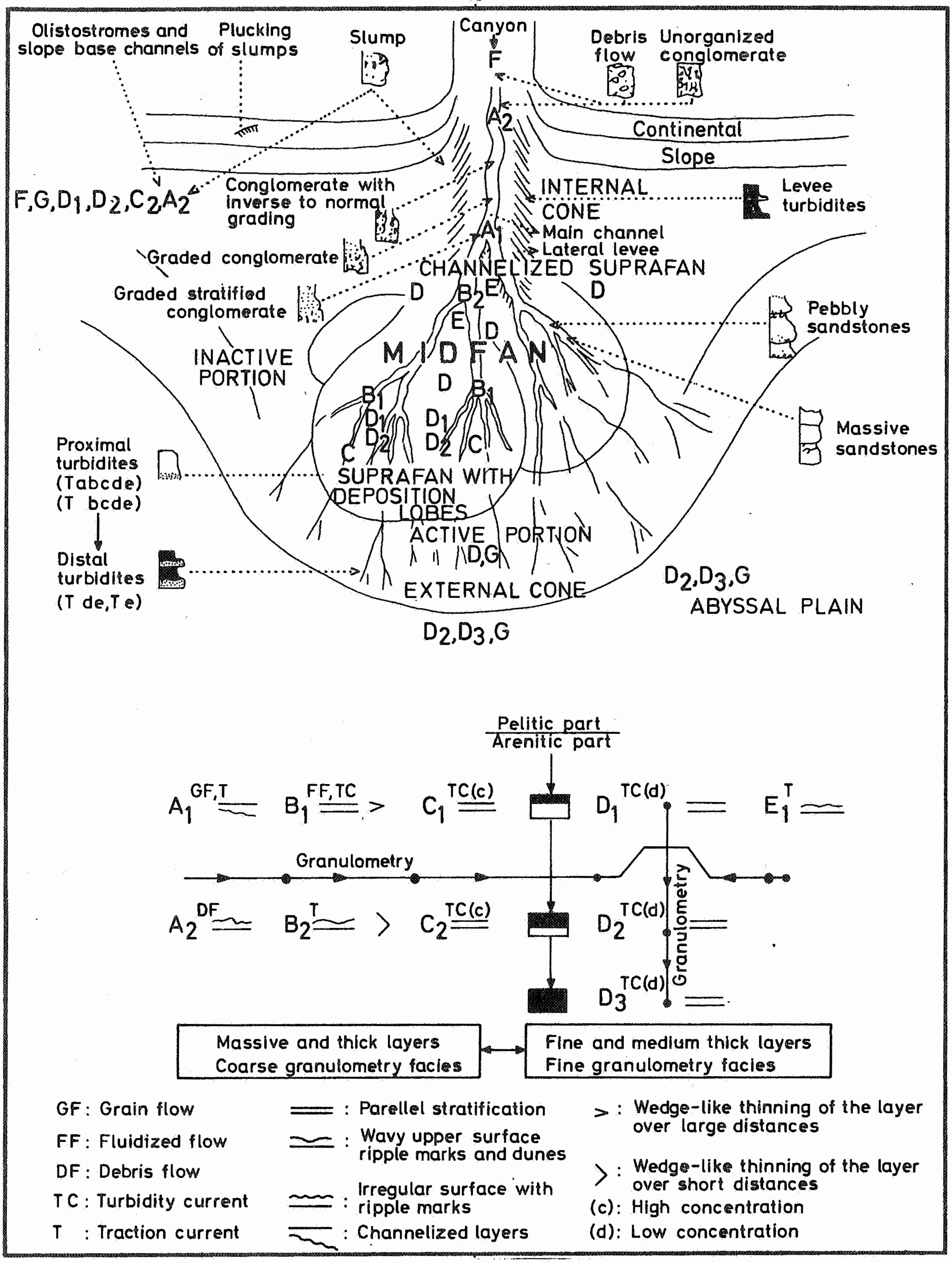


Fig.13 : Above : Model of a deep sea fan at the end of a submarine canyon along a continental slope showing the different parts and the type of turbidite facies or sedimentation pattern in each part. G is the symbol for contourites or hemi-pelagic sediments (after WALKER & MUTTI, 1973 and later; INGERSOLL, 1978 in BOIRIE & SOUQUET, 1980).

Under : Classification of turbidite facies and other resedimentated facies according to MUTTI & RICCI LUCCHI (1975). The turbidites of the Mehaigne area would belong to facies D1, D2 or D3 according to their fine granulometry and the fine to medium thickness of the layers.

and related sediments. The deposits are described separately in the different elements of the submarine fan system : along the slope, in the submarine canyon, in the channels, on the levees, in the lobes (between the distribution channels), on the external cone, and in the abyssal plain. Using these descriptions, seven facies associations (subdivided in 2 to 3 subfacies) are defined within the submarine canyon and fan system, according to various criteria as grain size, thickness of the layers, sand-pelite relation, lateral variation of the layers, structure and texture, etc. (fig. 13) (WALKER & MUTTI, 1973; MUTTI & RICCI LUCCHI, 1975; INGERSOLL, 1978).

If the Silurian turbidites of the Mehaigne area were deposited in such a submarine fan system, they would belong to the more distal D facies (see explanation in fig. 13). This facies is characterized by incomplete sequences (Tbcde, Tcde, Tde) with wide lateral extension and rather small thicknesses (max. 150 cm thick). The Mehaigne turbidites would vary from subfacies D1 (sand beds (b-, c- and d-divisions together) thicker than the pelitic e-divisions) to subfacies D2 (sandy beds thinner than the pelitic beds). These subfacies are found in the deposition lobes of the suprafan (midfan) or in the external cone of the fan (fig. 13). They vary throughout the stratigraphical column reflecting small changes in the depositional environment (WALKER, 1970; SESTINI, 1970; MUTTI & RICCI LUCCHI, 1972, 1975; WALKER & MUTTI, 1973; COUMES, 1976). The foregoing description of turbidites refers to phenomena observed on the margin of a continental slope. Therefore the model may not apply to the situation within the geosynclinal context of the Mehaigne area, but it is clear that the turbidites of the Mehaigne area are of a distant type.

Some granulometrical studies give a relation between the maximum grain size in the sandy beds (a-, b-, c- and d-) of the turbidites, and distance to the mouth of the submarine canyon from where the turbidites started. In the Mehaigne area the maximum grain size is between 0.375 and 0.500 mm. According to the values given by NELSON (1973) for the deepsea fan of Astoria in the North East Pacific, the distance from the Mehaigne area to the source would then be 100 to 130 km. This distance is probably exaggerated since we are dealing with a different kind of basin. More investigations are needed before observed grain size-distance relation can be used, but again the suggestion remains that the turbitites in the Mehaigne area are of a distant type.

3.6. Palaeogeographic reconstruction

Another problem is the position of the Mehaigne area in the global geosynclinal trough. Typical flysch troughs (the Polish trough, DZULINSKI & WALTON, 1965; the Welsh trough, WOOD & SMITH, 1959; the Appalachians, ENOS, 1969; the Apennine trough in the miocene Marnoso-arenacea, RICCI LUCCHI, 1978) are thought to have been elongated basins with transport basically parallel to the longitudinal axis of the basin from axial sources at one or both basin ends. But possibly there are lateral sources of supply, in which case the current directions would be deflected in the direction of the main basin axis (KELLING, 1962; RICCI LUCCHI, 1978). However, situations are known where a transversal filling is more likely. BOUMA (1962), for example, found that in the Alpine flysch in the French Provence, the E-W trending basin could be divided into depressions with a N-S elongation in which the turbidity currents moved longitudinally, i.e. transversally to the general E-W axis. A similar situation could be present in the Mehaigne area where the turbidity currents ran to the north while the orientation of the first order fold axes indicates the general direction of the geosyncline more or less E-W. It is clear that more information on the composition and the facies of the flysch, the direction of the turbidity currents etc. from other places in the Brabant Massif is needed before an accurate picture of the configuration and type of geogynclinal trough can be obtained.

The palaeogeographic reconstruction of the Silurian deduced from the area studied would be the following : a southern continental area, the Ardenne, from where the sediments originated,with north of it a epicontinental sea of which we only know the deeper part i.e. the Condroz Ridge, with a graptolitic facies containing spores and reworked microfossils originating in the Ardenne; to the north of the Condroz Ridge, a hypothetical, undiscovered source area for the turbidity currents on an outer, deep, epicontinental shelf, and north of it at some distance (several tens of km) the distal part of a turbidite fan system in the Mehaigne area, in a bathyal environment with highly reducing conditions in a miogeosynclinal trough.

This conclusion brings us to another, geometrical problem. About 11 km south of the Mehaigne area following the strata under the Synclinorium of Namur, the Silurian sediments of the Condroz Ridge occur, supposedly still autochtonous and not moved by the Hercynian "Faille du Midi". They show a graptolitic shale facies which is believed to occur on the deeper epicontinental shelf. The whole system of a slope with coarse flysch, typical flysch, hemi-flysch or metaflysch in between the Brabant Massif and the Condroz Ridge cannot fit into this strip only 11 km wide. A thrust fault in between these two regions, such as the Mosan fault ("Faille Mosane") proposed by MICHOT (1979) under the Synclinorium of Namur to explain other stratigraphical, petrological and structural observations, could possibly solve this contradiction.

READING (1972) proposed four different tectono-sedimentary frameworks for true flysch facies in contemporary situations. The flysch of the Mehaigne area can be classified as the Mediterranean type. This type occurs nowadays in the Eastern Mediterranean Sea, and is mostly influenced by movements and collisions of microcontinents enclosed between the two larger continental plates of Africa and Europe. That the flysch of the Mehaigne area belongs to this type is not surprising if we remember the position of the Mehaigne area and the Brabant Massif on the SE-edge of the London-Brabant microcontinent enclosed by three major continental plates (Laurentia, Baltica and Gondwana; see p. 7, 9 & fig. 2B).

3.7. Vertical variation in the flysch : general evolution and megacycles

The most obvious vertical variation in the flysch is the general increase in thickness of the Tde sequences in the stratigraphical column, as a quick glance at the detailed section descriptions (appendix 2) shows (see also fig. 14). In the lower half, the average thickness of the Tde sequences is between 6 and 12 cm while in the upper half, it is between

15 and 45 cm. However, this is only a general trend and some exceptions are found. There is another general trend, also with some exceptions, that chloritic matrices of the e-divisions occur in the lower part of the column while in the upper part quartzic matrices generally predominate. The increase in volume of sediments brought into the Mehaigne area and the increase of quartz grains in the matrix (changing from chloritic to quartzic) observed with increasing height in the column could show the approach of the Caledonian orogenesis (sensu stricto).

Besides this general evolution, one also observes a marked megacyclical variation. Throughout the stratigraphical column four and possibly six megacyclical variations occur, with each megacycle between approximately 100 and 500 m thick. They are numbered I to VI in fig. 14. The features causing this variation, as described above (p. 21) are (1) the relative frequence of each type of sequence (Tbcde, Tcde and Tde); (2) the average thickness of Tde sequences; (3) the thickness of c-divisions; (4) the mineralogy (chloritic, quartzic and calcareous) of the e-division; (5) the differences or similarities in the average thickness between the Tde sequences and the T(b)cde sequences. The presence of f-division is not considered here, because it is linked to the mineralogy (see p. 23).

We will first describe the most pronounced and well dated megacycle IV, 475 m thick and of late Llandoverian, early and middle Wenlockian age. In member MB3E there are few Tcde and very few Tbcde sequences (together 3-8% of the total number of sequences). The Tde sequences are generally thin (8-10 cm). The c-divisions are either thick or thin and the e-divisions have a chloritic matrix. At the transition with member MB4A in the lower part of the early Wenlockian, there is a marked and steady increase in the relative frequence of Tcde sequences. In member MB4A they account for 26% to 100%, but there are very few Tbcde sequences present (up to 7%). The Tde sequences are on an average, still thin (6.5-10.5 cm); c-divisions are more often thin than thick, but generally thicker than the c-divisions of the underlying MB3E member. The e-divisions still have a chloritic matrix, but at some horizons they may be calcareous. At the transition to member MB4B in the M. riccartonenesis Zone (upper part of the early Wenlockian), there is another change : the relative frequency of Tbcde and Tcde sequences in member MB4B decreases only slightly (32-73%), but the Tbcde sequences are much more frequent than in the underlying member MB4A (6-35%). The highest frequence of Tbcde sequences occurs at the transition of the early to middle Wenlockian. There is also a marked increase in the average thickness of the Tde sequences (16-17 cm). The thickness of the c-divisions decreases slightly but both thick and thin ones are present. Another important change already occurs in the top of the underlying member MB4A; there the e-divisions acquire a quartzic matrix; in member MB4B, the matrix is completely quartzic. At the transition between formations MB4 and MB5, Tbcde and Tcde sequences disappear completely, the average Tde thickness increases considerably (about 26 cm); but the mineralogy of the e-divisions remains quartzic. The whole middle Wenlockian formation MB5, more than 225 m thick, has the same features.

The second most pronounced megacycle is VI, about 400 m thick and of a middle to late Wenlockian age. In member MB7, from sections HC-10 to

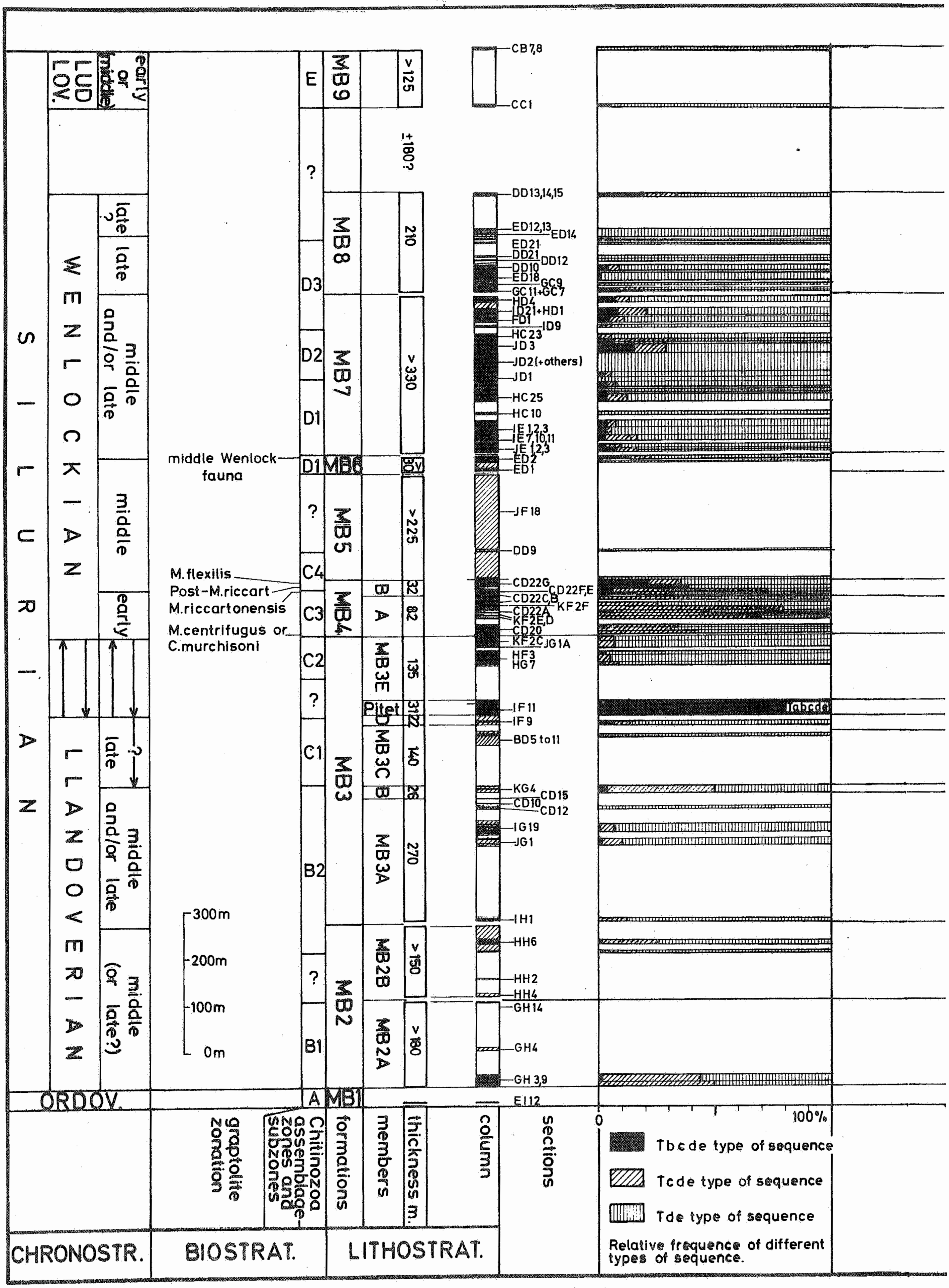
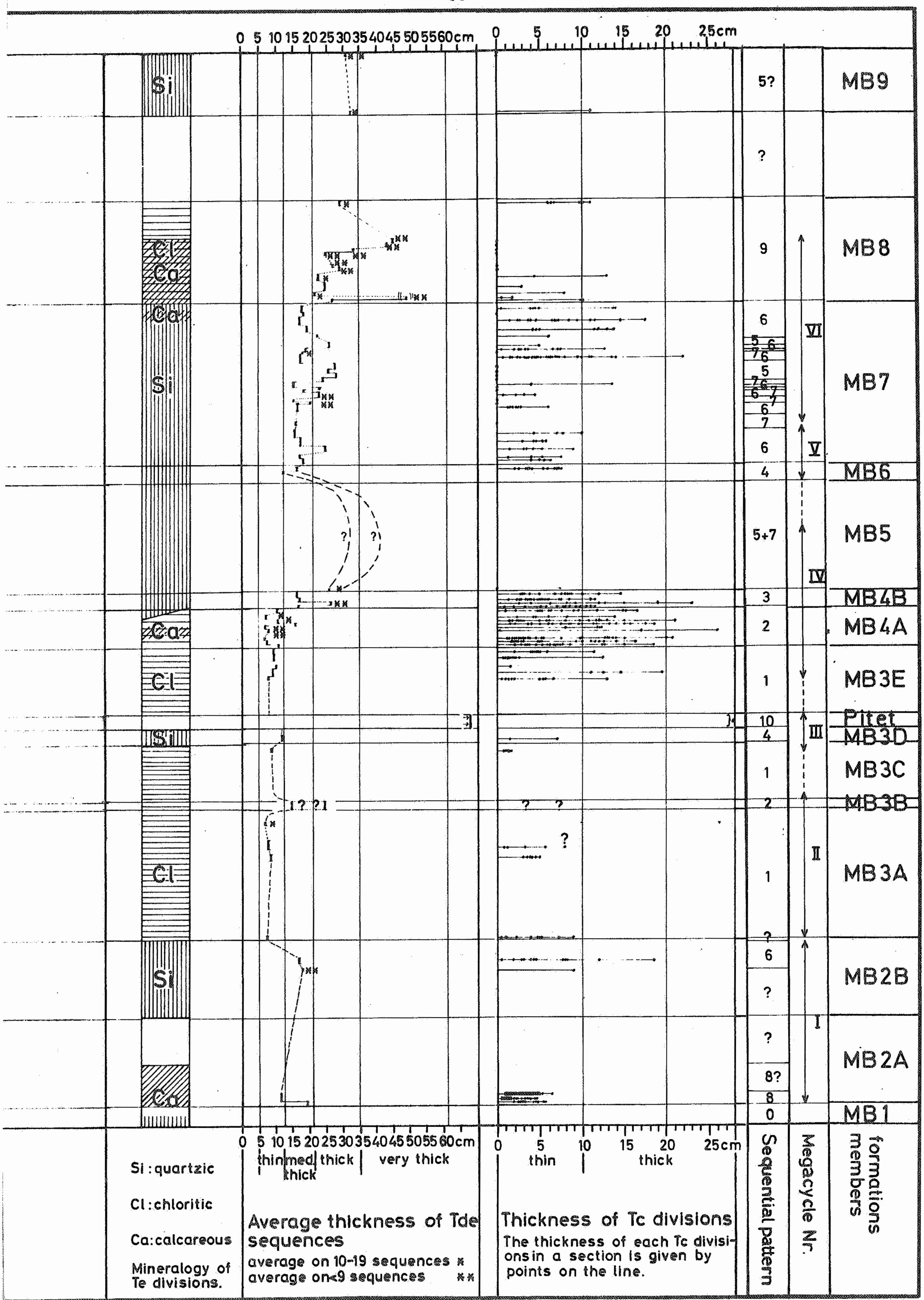


Fig. 14 : Megacyclic variations in the Silurian of the Mehaigne area.


MB9
MB8
MB7
MB6
MB5
MB4B
MB4A
MB3E
Pitet
MB3D
MB3C
MB3B
MB3A
MB2B
MB2A
MB1
Si
Cl
Ca
0 5 10 15 20 25 30 35 40 45 50 55 60cm
thin med thick thick very thick
0 5 10 15 20 25cm
thin thick
Si : quartzic
Cl : chloritic
Ca : calcareous
Mineralogy of Te divisions.
Average thickness of Tde sequences
average on 10-19 sequences ×
average on<9 sequences ××
Thickness of Tc divisions
The thickness of each Tc divisions in a section is given by points on the line.
Sequential pattern
Megacycle Nr.
formations members
I
II
III
IV
V
VI

JD-2 (23.9 m). Tbcde and Tcde sequences are rarely present (0-12%) and approximately in the same proportion. The Tde sequences are at an average, medium thick to thick (16-28 cm). The few c-divisions are rather thin (less then 6 cm except for one of 13.5 cm). The matrix of the e-divisions is quartzic. In this same part of the megacycle some minor cyclic variations were observed : in the parts of the thick sections JD-1 and JD-2 where no T(b)cde sequences occur, the Tde sequences are at average thicker than in the parts where T(b)cde sequences occur. In the rest of formation MB7, from JD-2 (23.9 m) upwards the T(b)cde sequences are more often present (0-32%). The average thickness of the Tde sequences remains the same as in the lower part with the same minor cyclic variations. The c-divisions are more often thin than thick, but they never reach the thicknesses measured in formation MB4B. The matrix of the e-division is still quartzic, but at the top several horizons are calcareous. At the transition between formations MB7 and MB8 marked changes occur. T(b)cde sequences are still present at the base of formation MB8, but higher up they become rare or disappear completely. At the same transition, a marked increase in average thickness of Tde sequences occurs (thick to very thick : 21.5-45 cm), increasing higher up in the formation. The rare c-divisions are mainly thin and the matrix of the e-divisions becomes chloritic, either calcareous or not.

Megacycle II is of a slightly different kind, more than 300 m thick and of a middle and/or late Llandoverian age. In member MB3A the T(b)cde sequences are very rare (0-12%), with Tbcde sequences nearly always absent (up to 2%). The Tde sequences are at an average thin (6.5-8 cm) and the c-divisions are always thin (maximum 9 cm thick). The matrix of the e-divisions is chloritic. In member MB3B Tcde sequences occur very often, but Tbcde sequences are still very rare. The Tde sequences are at an average medium thick and the c-divisions are either thin or thick. The matrix of the e-divisions remains chloritic. In member MB3C the same features occur as in member MB3A, with neither an increase in thickness of the Tde sequences nor a mineralogical change.

Megacycle III is about 100 m thick and probably of a late Llandoverian age. In member MB3C the same features occur as in member MB3A described above. In member MB3D the T(b)cde sequences occur slightly more often (0-13%), with both Tbcde and Tcde sequences about equally present. The Tde sequences are at an average slightly thicker (12 cm), the c-divisions are (very) thin (less than 7 cm). The matrix of the e-divisions becomes quartzic. This megacycle III is covered by the volcano-sedimentary layer of Pitet, whose position within this megacycle is unclear; higher up there is a gap in observations of about 70 m thick between the end of megacycle II and the first section of megacycle III.

The description of megacycle I is more uncertain because of gaps in observation between members MB2A, MB2B and MB3A. It could be about 330 m thick and of a middle, possibly late Llandoverian age. In formation MB2A Tcde sequences are very often present (43-50%), but the Tbcde sequences are nearly always absent. The Tde sequences are at an average thin to medium thick (11-19 cm). The frequent c-divisions are remarkably thin (less than 6.5 cm) and the matrix of the e-divisions is chloritic, sometimes calcareous. The overlying member MB2B has rather different features : it has less frequent Tcde sequences (15-25%). Tbcde sequences are nearly always absent, but the c-divisions are thicker than in member MB2A (up to 18 cm); the Tde sequences are thicker (17-18 cm). The matrix of the e-divisions changes clearly to quartzic. In the above lying member MB3A, Tcde sequences are rare again, Tde sequences in average thin, c-divisions thin (less than 9 cm) and the matrix changes again to a chloritic one.

The megacycle V cannot be clearly described due to the lack of good observations. It has a middle Wenlockian and a lower late Wenlockian age. It starts in formation MB5, without T(b)cde sequences, with thick or very thick Tde sequences, and a quartzic matrix. At the transition to formation MB6 it changes : Tbcde and Tcde sequences are rare to frequent, but present in about equal amounts (26%). Medium thick Tde sequences and thin c-divisions (less than 8 cm), are characteristic; the matrix of the e-divisions is still quartzic. The same features continue in the lower part of formation MB7 until section IE-3, where Tbcde sequences and Tcde sequences (together 6-17%) occur in about equal proportions. The c-divisions are thin (less than 10 cm) while Tde sequences are at an average medium thick to thick. Higher up in megacycle V, the amount of T(b)cde sequences and the thickness of c-divisions decreases again towards megacycle VI.

We can divide these six megacycles into two types. A first type of megacycle (IV, VI and less clearly I and III) shows in the first phase a low amount of T(b)cde sequences, with thin c-divisions, followed by a second phase with the highest amount of T(b)cde sequences (the culmination of the megacycle) and generally thicker c-divisions. In the third phase the amount of T(b)cde sequences decreases drastically and the few c-divisions are once again thin; this situation resembles that of the first phase, but the Tde sequences are in general much thicker than in that first phase. Somewhere near the top of the second phase or at the transition to the third phase, an important mineralogical change occurs. This type of megacycle shows a fundamentally different pattern before and after its culmination. This is not true for the second type of megacycle (II and V), where one sees a return to the previous conditions after the culmination i.e. the same mineralogy and the same average thickness of Tde sequences. The megacyclical variations may reflect the régime of the turbidity currents. We can describe this "régime" on the basis of four characteristics of the turbidity currents and try to explain some aspects of the depositional mechanism as reflected in them.

We assume that the ratio of (incomplete) Tde sequences, (more complete) Tcde sequences and (most complete) Tbcde sequences in a particular part of the column is indivative for the average energy of turbidity currents in that part. Indeed, several authors (see fig. 12) observed that near their source, turbidity current deposits are composed of Tabcde sequences; further away from the source Tbcde sequences occur, still further away Tcde sequences and finally Tde sequences. Apparently the lower the average energy of the turbidity current, the more incomplete the deposited sequences will be. By calculating the above mentioned ratio in different parts of the column (20 to 100 sequences), we obtain a first indication of the average energy of the turbidity currents in these parts.

A second indication of the "energy" of turbidity currents may be the thickness of the c-divisions. For example : members MB2A and MB4A have a comparable high average energy of turbidity currents (the same high rela-

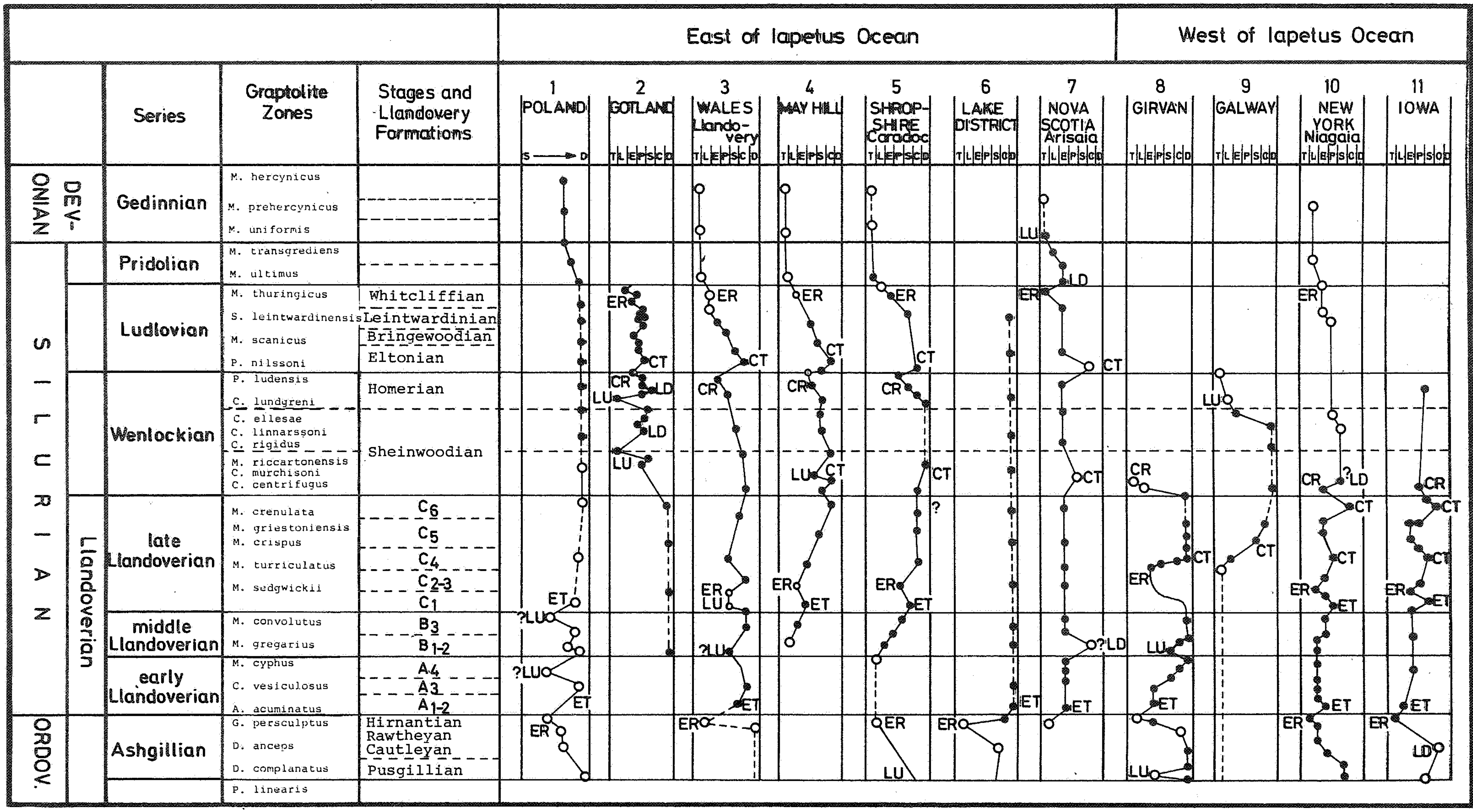


Fig. 15 : Depth changes during uppermost Ordovician, Silurian and lowermost Devonian on two contemporary continents west and east of the Iapetus ocean. Each column contains a scale from T (terrestrial) to D (deep) or the appropriate brachiopod eco-groups (Lingula, Eocoelia, Pentameras, Stricklandia and Clorinda). A solid circle indicate firm control of both ecogroup and age; an open circle indicates some uncertainty. Dashed lines indicate terrestrial, unfossiliferous or very deep environments where small depth fluctuations may not be detected. E : eustatic; C : continental; L : local; T : transgression; R : regression; U : uplift; D : deepening. (After Mc KERROW,1979, fig. 1 except for Gotland : after LAUFELD 1979)

tive frequency of Tcde sequences) but in MB2A the thickness of the c-divisions (see fig. 14; fourth column) never exceeds 6.3 cm, while it reaches 22.5 cm in MB4A. From this, one may perhaps conclude that member MB4A was deposited under a more energetic régime than member MB2A, although both have the same relative frequency of the different types of sequences.

A third characteristic of turbidity current can be expressed by the average thickness of Tde sequences, which can vary markedly (see p. 21 and fig. 6). An explanantion may be that this characteristic expresses the average amount of material transported by the turbidity currents. As mentioned in the beginning of this chapter (p. 50), the average thickness of Tde sequences gradually increases throughout the column, suggesting a steady increase in the amount of transported material.

The three above mentioned characteristics were used for study the paleoecology of the Chitinozoa in the area (VERNIERS 1982). A fourth characteristic of the "régime" of turbidity currents is the ratio between the average thickness of the Tde sequences and the T(b)cde sequences. The Tde sequences can be slightly thicker (10-35%) than the T(b)cde sequences; this occurs in formations and members MB2, MB3D, MB4B, MB6 and MB7. It can be much thicker (60 to 100%), as seen in formations and members MB3A, MB3B, MB3C, MB3E, MB4A and MB8. There exists a correlation between the occurrence of T(b)cde sequences generally much thicker than Tde sequences and a chloritic matrix in the e-divisions; on the other hand T(b)cde sequences only slightly thicker than Tde sequences are linked with a quartzic matrix in the e-divisions. From this we deduce tentatively that in the lower part of the column with a predominantly chloritic matrix, we see a quieter régime of turbidity currents with higher energy turbidites intruding. Higher in the column where a quartzic matrix prevails in the e-divisions, a more energetic and more constant regime would exist. This also would indicate the gradual approach of the Caledonian orogenesis (s.s.) throughout the column (see also p. 51).

What could be the possible general causes of these megacycli variations ? It is clear that they are linked to factors in the source area of the turbidity currents. Increased or decreased energy and variation in the amount of transported material of the turbidity currents could be provoked by uplifting or sinking of the source area, causing a steeper or flatter slope, or by movements of the source area away or towards the Mehaigne area. Indeed, according to models proposed by MUTTI & RICCI-LUCCHI (1972) and by INGERSOLL (1978) the lower part of our megacycles would correspond to a prograding submarine cone and the upper part to a retrograding cone. Eustatic sea-level changes would also provoke changes in the source area and provoke megacyclical variation in the flysch. McKERROW (1979) compiled all the eustatic sea-level oscillations and continentel or local movements in the Silurian around the North Atlantic Ocean, while LAUFELD (1979) described in detail the sea-level changes for Gotland (Sweden) (fig. 15). At the time of the two most important megacycles (IV and VI) neither eustatic nor continental movements are observed but local movements are recorded in the Anglo-Welsh basin and in Gotland. Therefore local uplift and sinking of the source area of the turbidity currents in or near the Condroz Ridge, linked with the orogenetic very active Ardenne, are the only possible causes for the megacyclic variation in the flysch of the Mehaigne area.

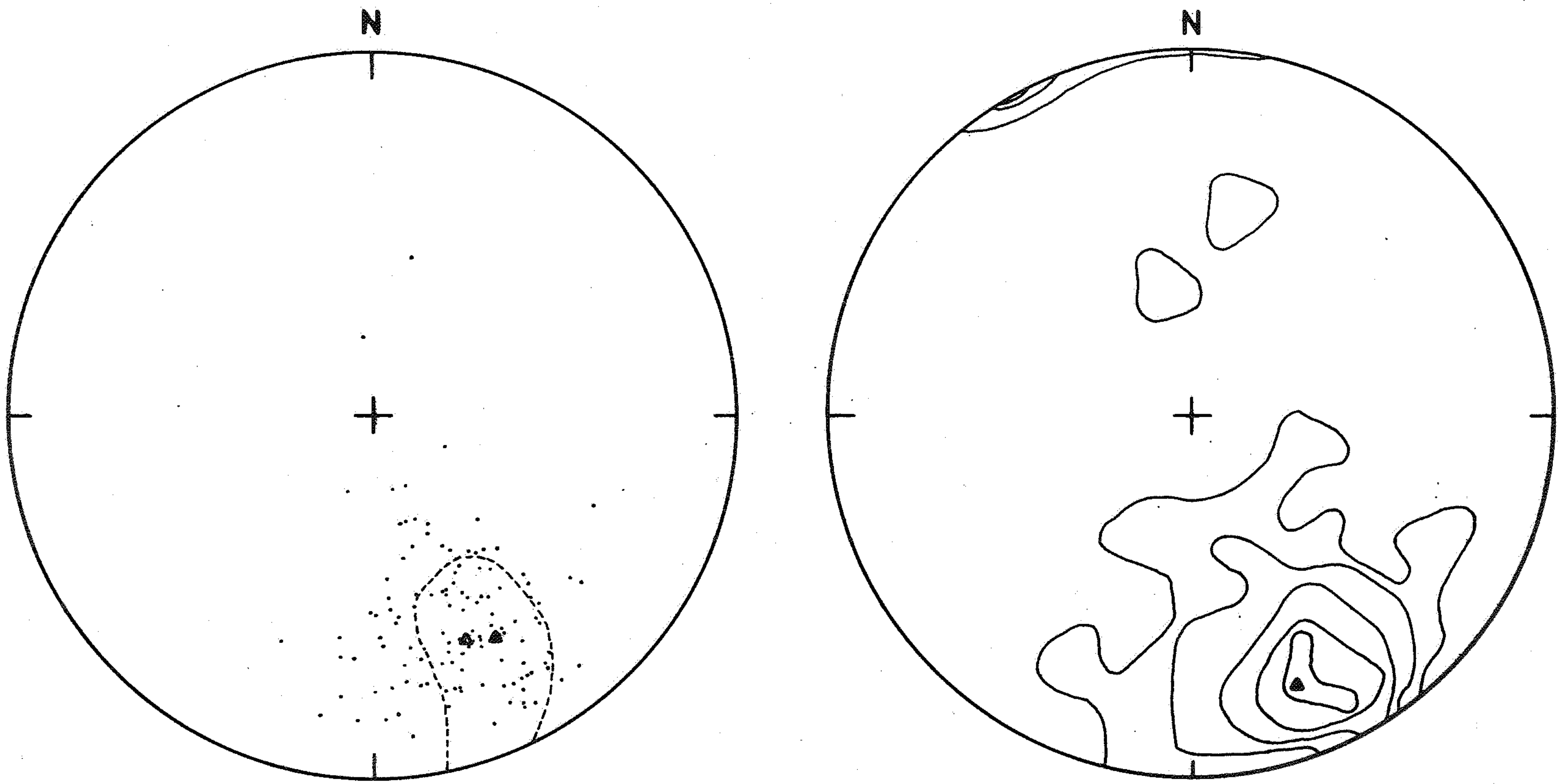


fig. 16A fig. 16B

FIG. 16A : POLES OF THE CLEAVAGE IN A WULFF NET (119 MEASUREMENTS) IN THE SILURIAN OF THE MEHAIGNE AREA (OPEN TRIANGLE : MEAN OF OUR MEASUREMENTS; BLACK TRIANGLE : MEAN AND DOTTED LINE : OUTER LIMIT OF THE POLES OF CLEAVAGE ACCORDING TO VANDERVEN 1967 IN THE SAME AREA)

FIG. 16B : CONTOURED DIAGRAM FOR THE POLES OF CLEAVAGE IN THE SILURIAN OF THE MEHAIGNE AREA ON A SCHMIDT NET AND COUNTOURED WITH A KALSBEEK COUNTING NET (CONTOURS 0.85-4.3-8.5-12.8-14.5 % PER 1% AREA, MAXIMUM 15.3 %; 119 POINTS). EXCEPT FOR SOME ABERRATIC OBSERVATIONS, THE POINTS CLUSTER AROUND A SINGLE MEAN ORIENTATION OF THE CLEAVAGE (N70°E 69°N). THE CLEAVAGE IN THE MEHAIGNE AREA IS THUS OF A AXIAL PLANE TYPE. THE CLUSTER TENDS PARTLY TOWARDS THE CENTER (DECREASING DIP), POSSIBLY DUE TO CREEP IN THE OUT-CROPS. THE OTHER TENDENCY OF THE CLUSTER IN DIRECTION OF THE STRIKE (RANGING FROM N41°E TO N70°W) REFLECTS THE MINOR ONDULATIONS IN THE MAIN CLEAVAGE DIRECTION.

On the west side of the London-Brabant microcontinent, local uplifts are observed during the early Wenlockian in the May Hill area (HURST et al., 1978), but they are at a different moment than the culmination of megacycle IV. The bathymetrical history in Gotland (Sweden) at the south-west side of the large Baltica plate, facing the east side of the London-Brabant microcontinent is quite complex. Many waterdepth changes occur and are interpreted as transgressions and regressions. A remarkable simultaneousness can be seen between the well dated megacycle IV and the "regression-transgression" cycle in the Visby Beds-Högklint Beds-Tofta Beds and basal Mulde Beds. In the late Wenlockian another marked change in depth occurs in Gotland in the Slite Beds, Halla Beds, Mulde Beds and Klinteberg Beds. In the Mehaigne area the megacylce VI is also of late Wenlockian age, but not precisely dated. Therefore their simultaneousness cannot be proved. Taking into account the distance between the two areas it is not probable that orogenetic movements in the Ardenne provoked the seadepth oscilations in Gotland. Similar Caledonian tectonic movements nearer to Gotland in the northern German-Polish Caledonides and their NW prolongation hidden under the eastern part of the North Sea (cf. ZIEGLER 1978) could be their cause.

4. DIAGENESIS

As mentioned earlier very little petrographical work was carried out; therefore we can only summarize some general observations. The sediments of the Mehaigne area were modified after their sedimentation by marked diagenesis (see above p. 17). As elsewhere in the Silurian of the Brabant Massif, they show a clear fissility oblique to the bedding planes (oblique slaty cleavage) which could indicate an advanced diagenesis or the anchizone of metamorphism. This cleavage has a general steep dip to the north, sometimes to the south. Fig. 16 gives a diagram of our measurements of the fissility projected on a Wulff net together with the diagram obtained by VANDERVEN (1967) for the same area. It shows that the poles of the cleavage planes cluster around a single average orientation (N70°E, 69°N) and that the cleavage in the Mehaigne area is thus of an axial plane type and different from e.g. that in the Orneau valley where a fan-type cleavage occurs (see MORTELMANS, 1953). Deformations of the cleavage observed in minor ondulations (fig. 16B) and the phenomenon of "kink bands" described by VANDERVEN (ibid.) indicate that two consecutive orogenetic epicodes influenced the area. Two such episodes were already observed in other places of the Brabant Massif (Orneau valley, MORTELMANS 1953 and VANDERVEN, ibid.; Sennette valley, LEGRAND, 1967b) and were attributed to two phases of the Neocaledonian orogenesis (respectively of Pridolian-Gedinnian age and of middle to late Emsian age) by LEGRAND (1967a) and MICHOT (1979). It seems possible that the two orogenetic episodes observed in the Mehaigne area are from the same age as those in the Orneau- and the Sennette valley since all three areas form part of the same tectonic unit : the Brabant Massif.

VERNIERS (1982) mentions analyses on the degree of carbonization of the organic material done by Dr. Y. SOMERS (1982, pers. comm.), from the I.N.I.E.X. at Liège (Belgium), which gives a more exact idea of the diagenesis. The reflectance on vitrinite from two samples was measured from the lower and upper part of the total column (samples IG-19/+24,8 m and CB-8/7). The measurements gave values with an average of 4% medium reflectance (between 2,5 and 7%). These high values clearly show the rank of antracites.

In petrographical classification this corresponds to the deeper part of the zeolite facies (anchi-zone) and possibly to a very low grade metamorphism. However, our few petrographical observations showing an abundance of chlorite and sericite in the slates point to the zeolite facies (anchi-zone). The typical minerals (albite and epidote) of the low metamorphism zone or greenschist facies were not found in our thin sections. From the foregoing it is evident that a very thick series of sediment covered the Mehaigne area at the end of the Silurian producing an incipient metamorphism. These sediments have all been eroded after the Caledonian orogenesis and before the Givetian (Middle Devonian), whose rocks cover the folded Silurian sediments.

5. A BRIEF STRUCTURAL DESCRIPTION OF THE AREA

Structures were observed in outcrops or were deduced directly from combined field observations. Four kinds of deformations occur : large scale folds, smalle scale folds and faults with minor or major displacements.

Generally the large folds are gradual and open with amplitudes of several hundreds of meters and only visible in large outcrops or deducible from series of outcrops. Little folds are rare and have an amplitude of several meters; they are only observed in the centre of a closed, rather small anticline at Warnant-Dreye-North (KG-3, KG-4), where three of these small symmetrical folds occur. Some very small ondulations of the beds with an amplitude in the order of 10 cm are present in formation MB4, but they are syngenetic and typical for turbidites. Several minor flexures were observed in the larger folds, and in the axes of the large folds some minor ondulations occur. For example, outcrop HC-1 at Huccorgne-Watermill is situated in the center of a large syncline, but in the outcrop itself one sees only a minor very open anticline.

The small faults with a dip slip of a few cm to a meter often occur in groups and sometimes make the detailed logging of sections difficult. No faultbreccias are observed associated with these faults, and they mostly occur as satelites of bigger faults. The larger faults with dip slips of ten to hundreds of meters are always associated with faultbreccias, of a few cm to 4 m thick (e.g. north of CD-2 at Lamontzée). The dip and strike of the beds and the major folds are shown on map 2 and the large faults are mapped on the geological map (map 3).

Generally speaking the Burdinale valley is structually less complex than the other valley studied here. The continuity of a dip of 30° to 40° S to SSE is interrupted by four syncline-anticline couples with a plunging axis of 5 to 10° WSW. In the Burdinale valley between Burdinne and Oteppe the strata dip to the south (40° to 85°), and their strike is E-W at Burdinne and ENE-WSW between Lamontzée and Oteppe. At Lamontzée a large ENE-WSW trending fault displaces a southern bloc about 140 m downwards. In Oteppe a broad syncline-anticline couple occurs with flancs dipping about 30° to 40° and a plunging axis 5° to 10° towards the WSW. Between the Ruisseau La Prâle and Petit Molû two little syncline-anticline couples are observed, also with plunging axes to the WSW. North of Huccorgne a large syncline occurs ondulating in its centre (see above), and also having a WSW-ENE plunging axis. At the same place between the watermill and the church WSW-ENE striking faults dipping steeply to the south occur. The southern blocks were thrown down tens or several tens of meters. Similar faults were observed in the Devonian-Carboniferous rocks more to the south (DAMIEAN, 1954) and are probably of Hercynian or post-Hercynian age.

In the Mehaigne valley the structure is more diversified. In the northwest the structure is not clear as outcrops are absent. South of Latinne an anticline occurs between Latinne-Hosdin-Les Ruelles and Latinne-Hosdin-Trou du Loup with the northern flanc dipping 30-35° to the NNW and the southern flanc, 30-70° to the SSE. South of this area till Fumal-Thier de Huy, five anticline-syncline couples occur, all tending ENE-WSW with axes generally plunging WSW. At the NW of Fallais (outcrop HG-12) an anticline with axis plunging WSW occurs. North of Pitet there is a very open syncline, again with a WSW plunging axis. A smaller anticline with the same WSW plunging axis is situated in the Butte Saint-Sauveur (Fallais-Pitet). A closed syncline occurs south of it, and at Fallais-Pitet-Les Falihottes. A closed anticline occurs with horizontal axis east of the Mehaigne river, west of this river it plunges WSW. The structural pattern described was originally recognized by mapping the volcano-sedimentary layer of Pitet. Between Fallais-Pitet-Les Falihottes and Fumal-Church few direct observations are possible, but no folds are expected to occur. From north to south in Fumal-Church and Fumal-Rue de Marneffe, one finds a rather small and closed syncline, an anticline followed by a more open syncline with axis plunging NE instead of WSW as elsewhere in the Mehaigne area. In the southern part of Fumal at the Fumal-Thier de Huy and at Fumal-Bois aux Guisses, the southern half of a very open anticline is seen disturbed by two smaller flexures with the same strike as the anticline. The central part of this broad anticline shows some minor anticlinal and synclinal ondulations with SW plunging axes. In conclusion, we can say that in the Mehaigne valley the strata generally dip between 30° and 60° to the SE, interrupted by many larger open and smaller closed folds with, in most cases, WSW plunging axes.

The structural correlation of both valleys is somewhat complex. From the lithological correlations, a fault can be deduced that would occur between the two valleys (between Fumal-Les Trous and Huccorgne-Watermill) with a downthrow of about 100 m for the NE block. The large syncline-anticline couple at Oteppe in the Burdinale valley could correspond to the two syncline-anticline couples at Pitet in the Mehaigne valley. The folds observed between Marneffe and Huccorgne in the Burdinale valley could correspond than to the many folds observed at Fumal in the Mehaigne valley (see appendix 4 and 5 : general structural map and geological map). Earlier correlations of some folds in both valleys by FOURMARIER (1921) do not appear thus to be probable.

CONCLUSIONS

In this study the Silurian sediments of the Mehaigne area are analysed in detail. This area (mapsheet 132 Wasseiges-Braives) is located in the eastern part of the Brabant Massif folded during the Neocaledonian orogenesis. In some 400 outcrops (for their general localisation see appendix 3) a total of 1500 m of sediments are accessible. The sedimentology and petrography of about 600 m of these are described in detail (see logs in appendix 2). For each well studied outcrop, a detailed localisation map is given in appendix 1.

The dominant rocktype is mudslate, but siltslate, sandy slate and siltstone also occur; in the field the siltstone may look like fine sandstone. From the viewpoint of diagenesis and/or metamorphism, they belong to the deeper zeolite facies and generally show an oblique slaty cleavage. A deposit of volcanic origin also occurs : the volcano-sedimentary layer of Pitet, about 27 m thick and most probably of late Llandoverian age. It is interpreted here as a deposit from a large turbidity current provoked by an ignimbritic eruption.

The most characteristic feature of the deposits is their rhytmicity. The sediments are built up as a repetitive succession of elementary sequences that contain two to five divisions, each with specific sedimentological features. These elementary sequences correspond to the sequence of intervals (divisions) described by BOUMA (1962) for deposits of turbidity currents. The divisons are denominated a, b, c, d and e. In the Mehaigne area the a-divisions are absent. On the other hand at the top of the e-divisions a fine specific layer may occur, called here f. The sequences observed are Tbcde(f), Tcde(f) and Tde(f). The general sedimentology of the Silurian sediments of the Mehaigne area therefore proves their deposition by turbidity currents.

Six different features cauce variation in the rhytmicity of the turbidites : the lithology; the average thickness of the Tde sequences; the ratio between the average thickness of the Tde sequences and the Tbcde sequences; the thickness of the c-divisions; the ratio between the average thickness of the Tde sequences and that of the T(b)cde sequences; the presence of f-divisions. Each feature allows a division into two to five classes and a subdivision of all the sections into ten groups with very well defined sedimentological and/or mineralogical characteristics referred to as "sequential patterns". They reflect the large scale variations in the regime of the turbidity currents.

A lithostratigraphical column 2100 m thick is constructed on the basis of four methods : (1) direct correlation of identical successions of sequences (chronosequences); (2) estimation of relative position of adjacent outcrops; (3) the presence of marker beds or distinctive lithologies; (4) geometrical estimations of the relative position of sections at distances exceeding fifty meters. The position of several outcrops remains doubtful because of their isolated location. To establish the position of these outcrops the micropaleontological content, mainly Chitinozoa, was studied.

Nine informal formations, MB1 to MB9, are described in detail. Several of them are subdivided into 2 to 6 members (members MB2A, MB2B, MB3A, MB3B, MB3C, MB3D, MB3E, MB4A, MB4B). Only after similar litho- and biostratigraphical research in the Silurian type-localities of the Brabant Massif (Orneau and Sennette valleys), a formal division for the Silurian in the whole massif can be proposed. Some of the units of the Mehaigne area might than be used in a formal way. The lithostratigraphical units were dated by VERNIERS & RICKARDS (1979) and VERNIERS (1981, 1982) from middle Llandoverian to early and possibly Ludlovian age. Formation MB1 may be of the late Ordovician. By these datations the large thicknesses of the Silurian sediments in the Mehaigne area become obvious : e.g. the Wenlockian by itself accounts for at least 850 m of sediments.

The turbidites from the Mehaigne area show all the features of a flysch-facies and belong to the miogeosynclinal trough type (AUBOUIN, 1965). Measurements of the direction of the current ripples and observations of polished sections show a southern source for the turbidity currents. The petrography indicates that the sediments are derived from older sedimentary rocks. The Ardenne, formed by the Caledonian orogenesis at the end of the Ordovicium and exposed to erosion during the entire Silurian, is situated to the south of the Mehaigne area and was probably the original source of the sediments in the Mehaigne area.

The microfossil content allowed VERNIERS (1982) to conclude that outer deep shelf conditions prevailed in the source area of the turbidity currents; these currents descended into the Mehaigne area, which had to be bathyal.

The granulometry and the features of the turbidites of the Mehaigne area point to a rather distant source area (several tens of kilometers), but no reliable estimate of the distance can be made.

The paleogeographic reconstruction for the Silurian, deduced from the area studied, would be the following : a southern continental area, the Ardenne, where the sediments originated; north of it an epicontinental sea, of which we know only the deeper part, i.e. the Condroz Ridge, with a graptolitic facies containing spores and reworked microfossils derived from the Ardenne; to the north a hypothetical source area for the turbidity currents on an outer deep epicontinental shelf and, some distance north of this, the deposition area of the distal turbidites of the Mehaigne area in a bathyal environment with highly reducing conditions in a miogeosynclinal trough. The foregoing spatial sequence covers several tens of kilometers and cannot be fit into the actual area comprising the Brabant Massif and the Condroz Ridge which are separated at present times by only 11 km, measured under the Synclinorium of Namur. However, it could fit in, if one accepts under the Synclinorium of Namur the presence of a thrust fault, the Mosan-fault (la faille mosane), postulated by MICHOT (1979) on the basis of stratigraphical, petrological and structural data.

The flysch in the Mehaigne area is similar to the Mediterranean flysch type (READING, 1972) in recent environments, which is influenced by movements and collisions of microcontinents between larger continental plates. A similar situation also occurs in the Brabant Massif which is situated on the SE edge of the London-Brabant microcontinent enclosed by three major continental plates (Laurentia, Baltica and Gondwana).

It is remarkable that the direction of the turbidity currents (S-N) is nearly perpendicular to the general direction of the geosynclinal trough of the Brabant Massif in the Silurian, which generally has the same direction as the folding (E-W) in the Mehaigne area. In the classic examples of geosynclines, the three directions are identical. For the Brabant Massif one has to postulate the presence of small transverse basins, directed N-S, perpendicular to the larger geosynclinal trough directed E-W, to explain the observed turbidity current directions.

There are two types of variations in the flysch of the Mehaigne area : a gradual increase of the thickness of the Tde sequences and the increasing amount of quartz grains in the e-divisions, reflecting the approach of the Caledonian orogenesis. The other variation is shown by the presence of at least four and probably six megacycles with a thickness between 100 m and 500 m (numbered I to VI on fig. 14). There are two types of megacycles : the first type shows fundamentally different patterns before and after its culmination. In its first phase it has low energy turbidites which transport low amounts of sediments. In the second (culminating) phase the energy of the turbidites is high. In the third phase there is a mineralogical change, the energy decreases again and the amount of transported material increases considerably. In the second type of megacycles one sees, after the culmination, a return to the conditions of the first phase with the same mineralogy and the same average thickness of Tde-sequences.

The megacyclinal variations are thought to be caused by local up and down movements in the source area of the turbidity currents (Condroz Ridge) which were themselves provoked by movements in the Ardenne which was in full orogenetic development. Eustatic or continental sea-level changes are another possible cause for megacyclical variations in a flysch, but have to be ruled out as a cause for these variations in the Mehaigne area. These sealevel changes, observed in other areas (fig. 15), do not occur at the levels where most megacycles are observed.

The structural features of the Mehaigne area are shown in a dip and strike map (appendix 4). The dip is generally 30-60° to the S or SE, interrupted in the Mehaigne and Burdinale valley, by respectively seven and four syncline-anticline couples, mostly with a axis plunging 5-10° WSW. Some larger faults occur with dip slips of 10 to 100 m showing fault-breccias as well as small faults with displacements of at the most a few meters.

Measurements of the poles of cleavage planes cluster around a single average orientation (strike N70°E; dip 69°N), showing that the slaty cleavage is of a axial plane type, different to that found in the Orneau valley and the Sennette valley situated more to the W in the Brabant Massif. The presence of kinkbands (VANDERVEN, 1967) and the inclined fold axes indicate two orogenetic forces which are attributed in other places of the Brabant Massif to two different phases of the Neocaledonian orogenesis (LEGRAND, 1967; MICHOT, 1978).

Finally, the geographical distribution of the lithostratigraphic units is shown on a geological map with a scale 1/25.000 (appendix 5).

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Register of outcrops in this study, classified according to their number with indication on which page the detailed localization (Det. loc.) map or description and the detailed log (Det. log) can be found. "In between brackets" (e.g. (88)) points to a detailed descriptive localization.

	Det. Loc.	Det. log		Det. Loc.	Det. log		Det. Loc.	Det. log		Det. Loc.	Det. log
CB-1	(88)	-	CD-12	77	98	JD-3	(89)	108,110	HG-1	(91)	-
CB-7	77	117	CD-13	77	-	JD-4	84	111-112	HG-3	(91)	-
CB-8	77	117	CD-15	77	-	JD-5	84	111	HG-7	85	98
CC-1	77	117	CD-17	(88)	-	JD-6	84	111	HG-8	85	-
CC-2	77	-	CD-18	(88)	-	CE-12	(90)	-	HG-19	(91)	-
FC-1	80	-	CD-19	78	99	DE-3	(90)	-	IG-1	85	99
FC-2	80	-	CD-20	78	101	EE-2	(90)	-	IG-7	(91)	-
FC-5	80	-	CD-22	78	102-103	IE-1	83	105	IG-9	(92)	-
FC-6	80	113	CD-34	(88)	-	IE-2	83	105	IG-10	(92)	-
FC-7	80	113	CD-35	(88)	-	IE-3	83	105	IG-11	(92)	-
FC-8	80	113	DD-9	78(88)	-	IE-4	83	-	IG-12	(92)	-
GC-4	80	115	DD-10	79	116	IE-6	83	-	IG-13	(92)	-
GC-7	80	115	DD-12	79	116	IE-7	83	104-105	IG-14	(92)	-
GC-8	80	115	DD-13	(88)	117	IE-8	83	-	IG-18	87	-
GC-9	80	116	DD-21	79	116-117	IE-9	83	104-105	IG-19	87	97
GC-11	(88)	115	ED-1	79	-	IE-10	83	104-105	JG-1	85	97
HC-1	81	110	ED-2	79	103	IE-11	83	104-105	JG-3	(92)	-
HC-7	81	106	ED-4	79	-	IE-12	83	114	JG-4	(92)	-
HC-8	81	106	ED-5	79	-	IE-22	(90)	-	KG-1	86	-
HC-10	81	106	ED-6	79	117	JE-1	82	104	KG-2	86	-
HC-23	81	110	ED-12	(88)	117	JE-2	82	104	KG-3	86	-
HC-24	81	-	ED-13	(88)	117	JE-3	82	104	KG-4	86	-
HC-25	81	106	ED-14	(88)	117	HF-1	86	99	KG-6	86	-
HC-27	81	-	ED-15	(88)	-	HF-3	85	98	KG-9	(92)	-
HC-28	81	-	ED-16	79	-	HF-4	85	-	KG-10	(92)	-
BD-1	76	-	ED-17	79	116	IF-9	86	98	LG-7	(92)	-
BD-2	76	-	ED-18	79	116	IF-11	(90)	98	FH-3	(92)	-
BD-3	76	-	ED-21	(89)	117	IF-12	(90)	-	FH-9	(92)	-
BD-4	76	-	FD-1	(89)	113	IF-13	(90)	-	GH-2	(92)	-
BD-5	76	-	FD-4	(89)	-	IF-14	(90)	-	GH-3	87	96
BD-6	76	-	FD-5	(89)	-	IF-15	(90)	-	GH-4	(93)	-
BD-7	76	98	FD-6	(89)	113	IF-17	86	101-102	GH-9	87	96
BD-8	76	-	FD-7	(89)	-	IF-18	86	101	GH-10	87	-
BD-9	76	-	HD-1	(89)	114	IF-20	(90)	-	GH-11	87	-
BD-10	76	-	HD-3	80	104	JF-1	(90)	-	GH-14	(93)	-
BD-11	76	-	HD-4	82	114-115	JF-2	(90)	-	HH-2	(93)	-
BD-12	76	-	ID-1	82	112	JF-3	(90)	-	HH-4	(93)	-
BD-23	76	-	ID-2	82	112	JF-4	(90)	-	HH-6	87	96-97
BD-24	76	-	ID-3	82	-	JF-5	(91)	-	HH-7	87	-
BD-25	76	-	ID-6	82	111	JF-6	(91)	-	IH-1	87	97
CD-1	77	100-101	ID-8	82	-	JF-7	(91)	-	EI-12	(93)	-
CD-2	77	98	ID-9	82	110-111	JF-12	(91)	-			
CD-3	77	-	ID-21	79	114	JF-18	(91)	-			
CD-4	77	-	ID-23	82	-	KF-1	(91)	-			
CD-9	77	-	JD-1	84	107-109	KF-2	84	99-100			
CD-10	77	-	JD-2	(89)	109-110	KF-9	(91)	-			

Register of outcrops in this study classified according to their name with indication on which page the detailed localization on maps or with description (between brackets) and the detailed log description can be found.

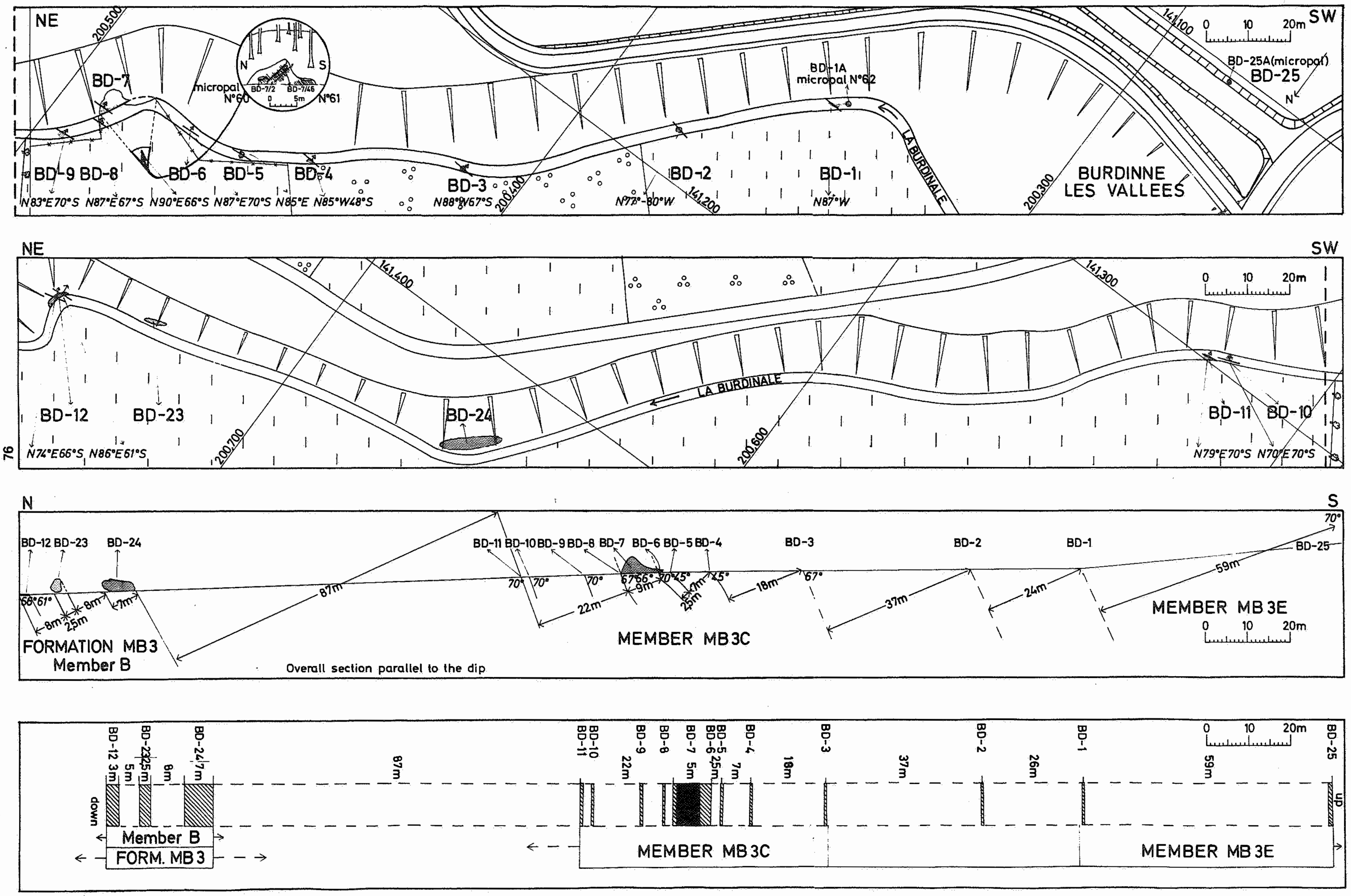
	Det. Loc. Map	Det. log description
Burdinne-Les Vallées (BD-1 to 12, 23, 35)	76	98
Fallais-Bocha (HF-1)	86	99
Fallais-Calvaire (IH-1)	87	97
Fallais-Center (IG-18, 19)	87	97
Fallais-Grande Route (JG-1)	85	97
Fallais-Pitet-Bois Cornet (IF-11)	(90)	98
Fallais-Pitet-Les Falihottes (IF-9)	86	98
Fallais-Pitet-le Point du Jour (IF-17, 18)	86	101-102
Fallais-Railway (IG-1)	85	99
Fallais-south (HF-3, 4; HG-7, 8)	85	98
Fumal-Au Doyar (HD-1, 3)	80	104,114,115
Fumal-Bois aux Guisses (JD-1, 2, 3)	(89)	107-110
Fumal-Church (IE-1 to 4, 6)	83	105
Fumal-Foncourt (JE-1 to 3)	82	104
Fumal-Les Trous (ID-21)	79	114
Fumal-Mozon (ID-9, 23)	82	110-111
Fumal-Rue Marneffe (IE-7 to 12)	83	104-105
Fumal-Thièr de Huy (JD-1, 4 to 6)	84	107-109,110-111
Fumal-Thièr de Mozon (ID-1 to 3, 6, 8)	82	111-112
Héron-Boin-Bois des Bachets (CC-1, 2)	77	117
Héron-Boin-Center (CB-7, 8)	77	117
Huccorgne-Les Avaux (HD-4)	82	114-115
Huccorgne-Watermill (HC-1, 7, 8, 10, 23 to 25, 27, 28)	81	106,110,111
Lamontzée-Center (CD-9, 10, 12, 13, 15)	77	98
Lamontzée-Rue de Rochée (CD-1 to 4)	77	98,100,101
Latinne-Hosdin-Les Ruelles (GH-3, 9 to 11)	87	96
Latinne-Hosdin-Trou du Loup (HH-6, 7)	87	96-97
Marneffe-Bois Dreût Tier (GC-4, 7 to 9)	80	115-116
Marneffe-Grande Route (FD-1, 4, 5, 6, 7)	(89)	113
Marneffe-Watermill (FC-1, 2, 5 to 8)	80	113
Oteppe-Bounia (CD-19, 20, 22)	78	99,101,102,103
Oteppe-Castle (ED-16, 17, 18)	79	116
Oteppe-Cense d'âs Trîches (DD-13)	(80)	117
Oteppe-Center (ED-12, 13, 14)	(88)	117
Oteppe-Pond (DD-10, 12, 21; ED-4, 5, 6)	79	116-117
Oteppe-Vissoul (ED-1, 2)	79	103
Warnant-Dreye-north (KG-1, 2, 4, 6)	86	-
Warnant-Dreye-south (KF-2)	84	99-100

Appendix 1 : Detailed localization maps or detailed descriptive localization of the outcrops, sampling areas and representative sections.

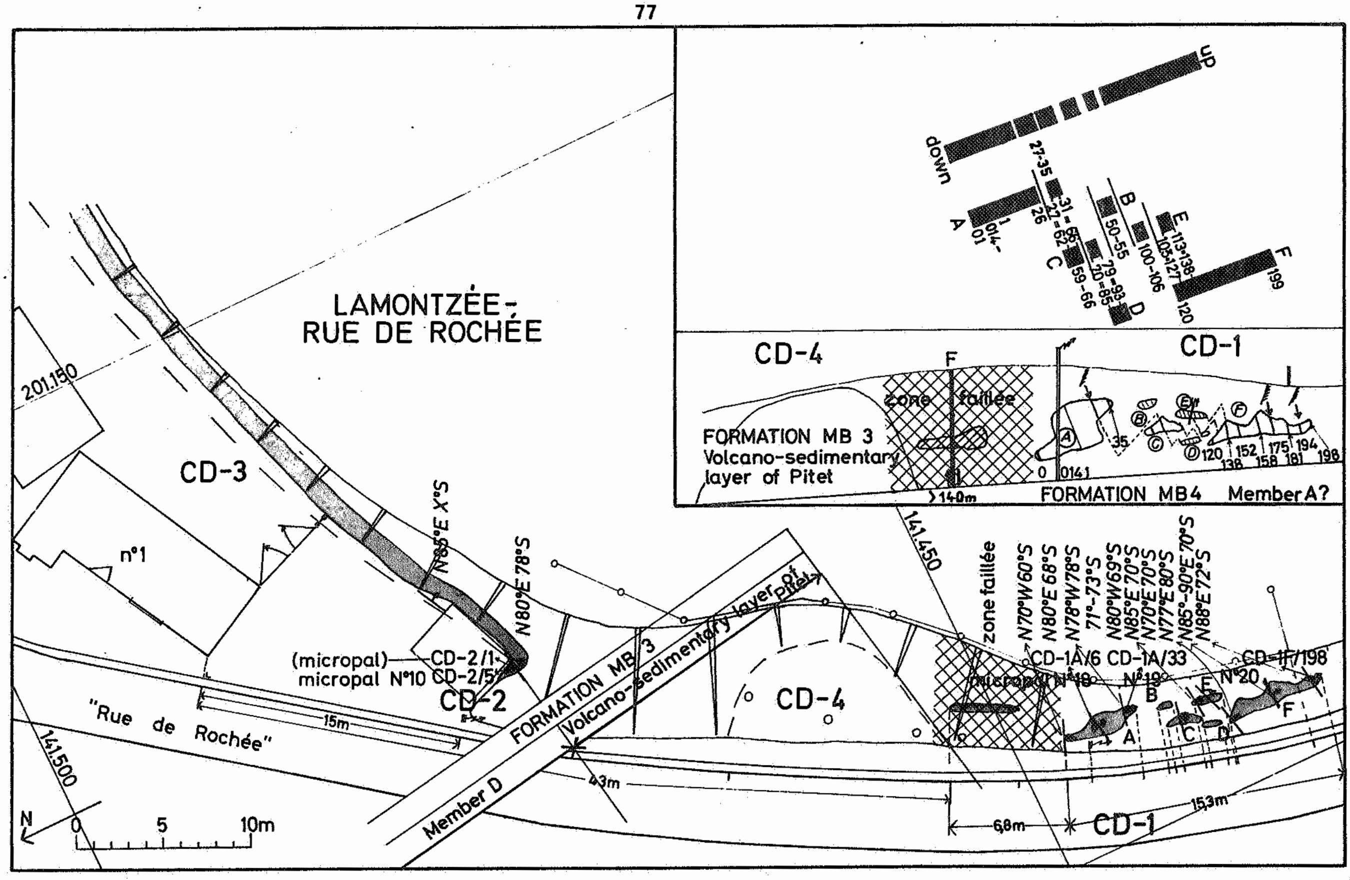
Detailed localization maps are given p. 76-87 for 33 groups of outcrops ; for the other outcrops the localization is described p. 88-93. The detailed localization maps are mostly on scale 1/1000 and the legend is given below. The place of outcrops is shown, of the sampling, of the measurements of the strike and dip, of the layers. Insets show the stratigraphical column in real thickness of the outcrops present, with their litho- and chronostratigraphical units. Maps reflect the situation between 1971 and 1974 when most fieldwork was done.

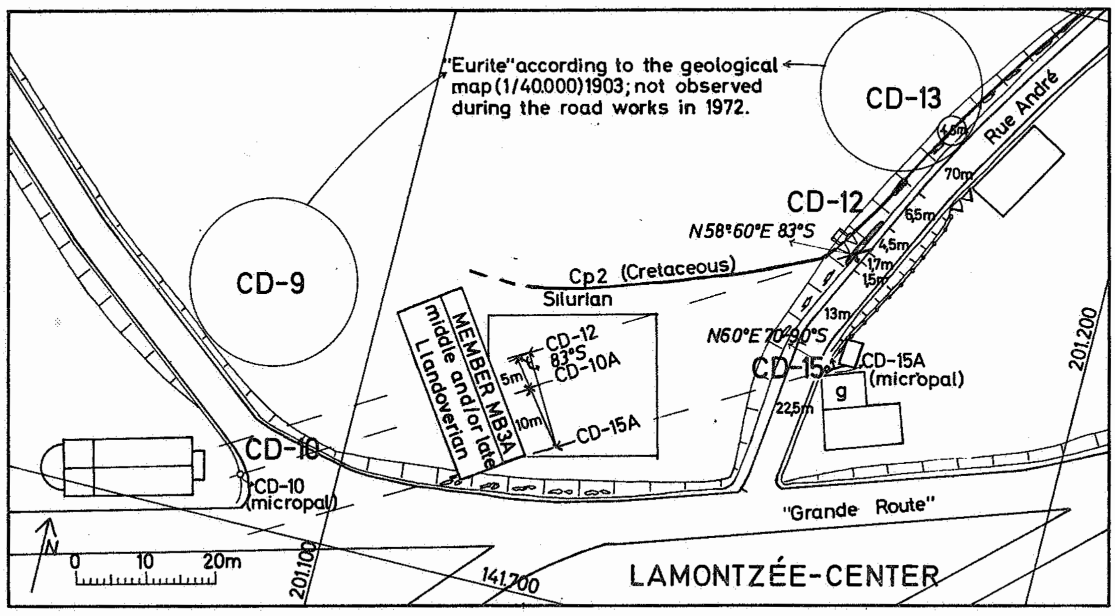
Legend :

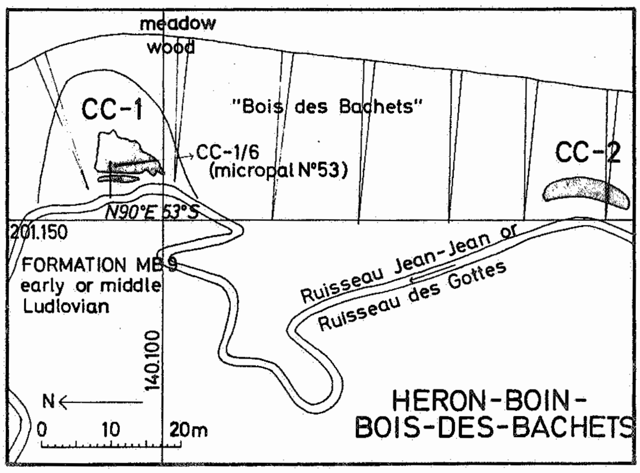
	outcrop
	place where section was recorded
	probable geological limit
	certain geological limit
	synclines
	anticlines
	syncline with axe dipping in direction of arrow
37	strike and dip of layer
F F	fault
F F	faultzone
	graptolite level
Cp2	symbol of the geological map 1903 : "Hervian" : green marl of the Campanian
Cp3a, Cp3b	Campanian chalk
	house or building
No14	house with house-number
g	garage
	stable
	electricity cabine
	pole (electricity)
	post (ilumination)
BD-24	number of outcrop
BD-24A	part (A) of outcrop (BD-24)
(A) BD-1A	place of sampling and number of sample
micropal. No13	micropaleontological sample
	number and place of sample
202.000 141.700	coordinates 100 x 100 m in the Lambert-grid (see topographic map 1/25.000)
N	geographical north
3m 5m	slope (point indicates bottom)
	indication of height of slope
	small slope
	meadow
	wood
	isolated tree
Sce	source
	electric, iron fence or hedge
	stone fence

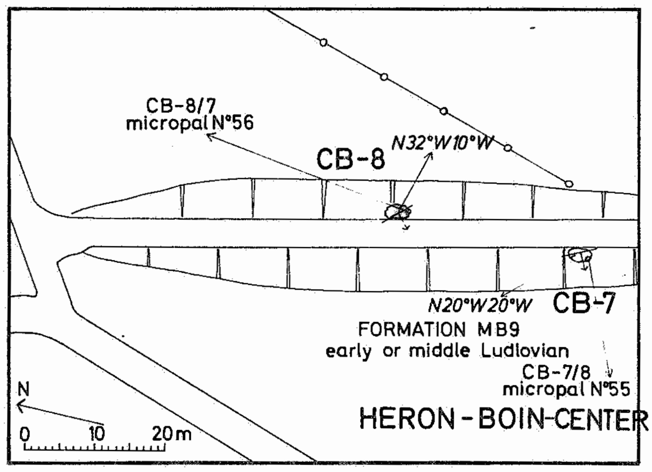


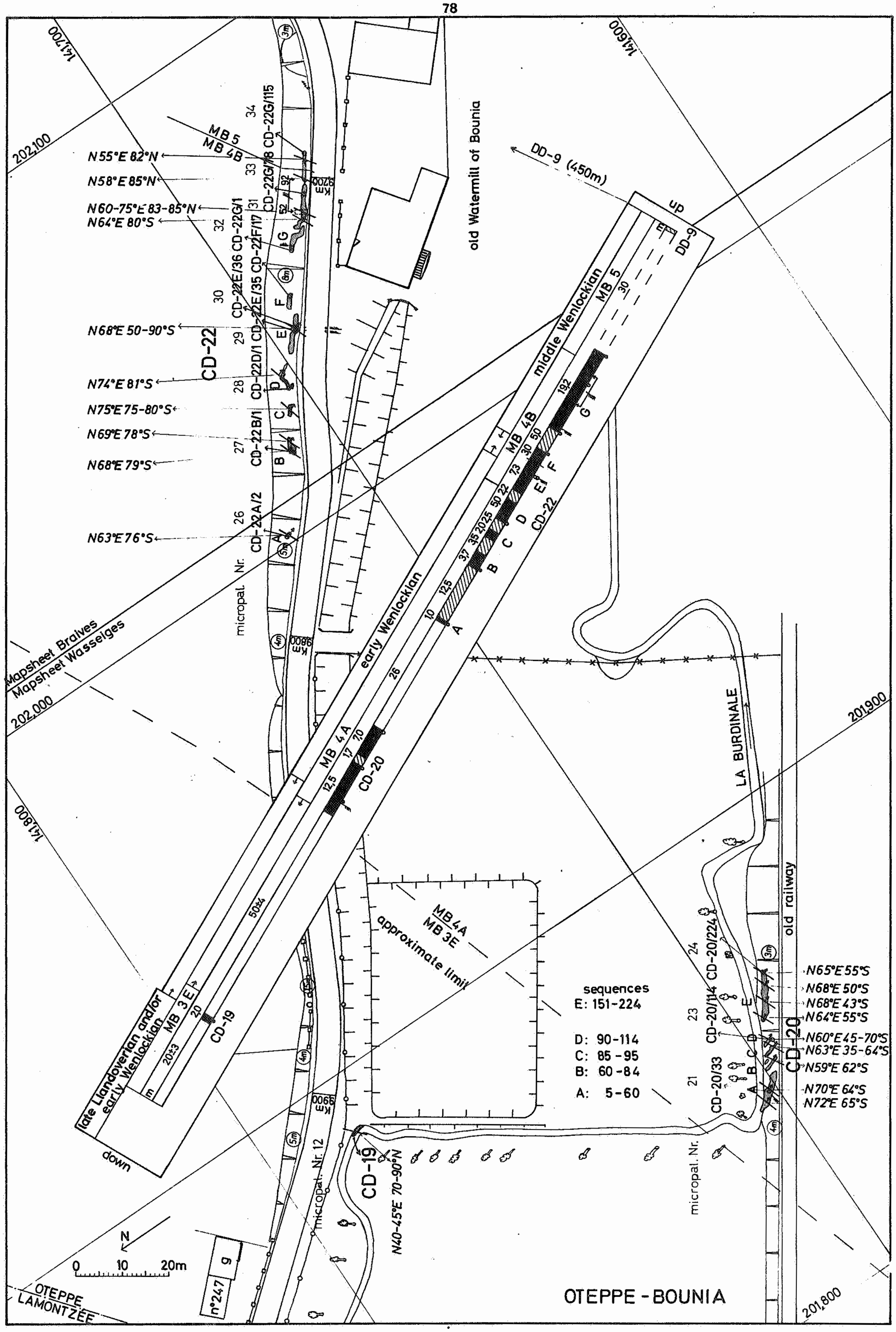
NE
SW
0 10 20m
BD-7
micropal N°60
BD-7/2
BD-7/46
0 5m
N°61
BD-1A
micropal N°62
BD-25A(micropal)
BD-25
BD-9 BD-8
BD-6
BD-5
BD-4
BD-3
BD-2
BD-1
LA BURDINALE
BURDINNE
LES VALLEES
N83°E70°S N87°E67°S N90°E66°S N87°E70°S N85°E N85°W48°S
N88°W67°S
N77°-80°W
N87°W
200.500
200.400
200.300
141.200
141.100
NE
SW
0 10 20m
141.400
141.300
BD-12
BD-23
BD-24
LA BURDINALE
BD-11 BD-10
N74°E66°S N86°E61°S
N79°E70°S N70°E70°S
200.700
200.600
N
S
70°
BD-12 BD-23 BD-24
BD-11 BD-10 BD-9 BD-8 BD-7 BD-6 BD-5 BD-4
BD-3
BD-2
BD-1
BD-25
87m
22m
9m
18m
37m
24m
59m
FORMATION MB3
Member B
MEMBER MB3C
MEMBER MB3E
0 10 20m
Overall section parallel to the dip
BD-12 3m
BD-23 5m
BD-24 8m
87m
BD-11
BD-10
BD-9
BD-8
BD-7
BD-6
BD-5
BD-4
BD-3
BD-2
BD-1
BD-25
22m
5m
7m
18m
37m
26m
59m
0 10 20m
down
up
Member B
FORM. MB3
MEMBER MB3C
MEMBER MB3E

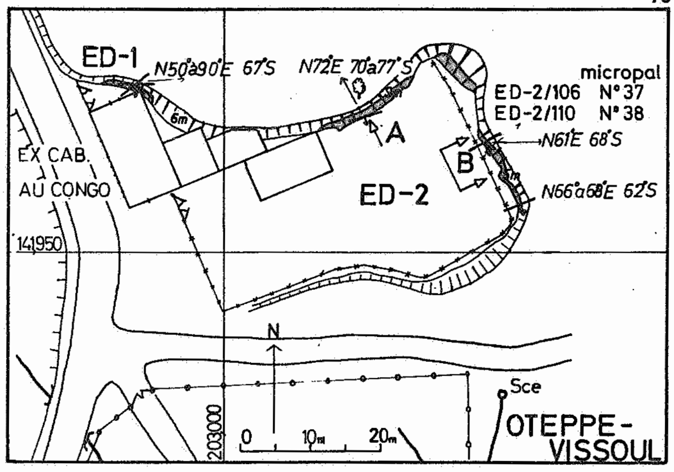

LAMONTZÉE-
RUE DE ROCHÉE
CD-3
n°1
CD-4
CD-1
(micropal) CD-2/1
micropal N°10 CD-2/5
CD-2
"Rue de Rochée"
15m
FORMATION MB 3
Volcano-sedimentary layer of Pitet
Member D
43m
68m
15,3m
zone faillée
N70°W60°S
N80°E 68°S
N80°E 78°S
CD-1A/6 CD-1A/33
micropal N°18
N°19
N°20
CD-1F/198
201.150
141.500
141.450
N
0 5 10m
FORMATION MB 3
Volcano-sedimentary
layer of Pitet
zone faillée
FORMATION MB4 Member A?
down
up

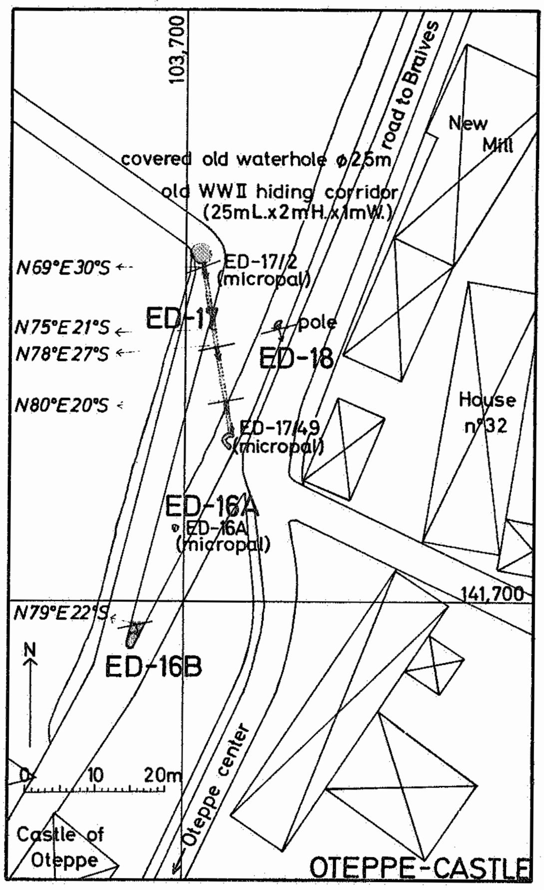

"Eurite" according to the geological map (1/40.000) 1903; not observed during the road works in 1972.
CD-13
CD-9
CD-12
Rue André
N58°60°E 83°S
Cp2 (Cretaceous)
Silurian
MEMBER MB3A
middle and/or late
Llandoverian
CD-12
83°S
CD-10A
CD-15A
N60°E 70-90°S
CD-15
CD-15A
(micropal)
CD-10
CD-10
(micropal)
"Grande Route"
LAMONTZÉE-CENTER
201.100
141.700
201.200
N
0 10 20m

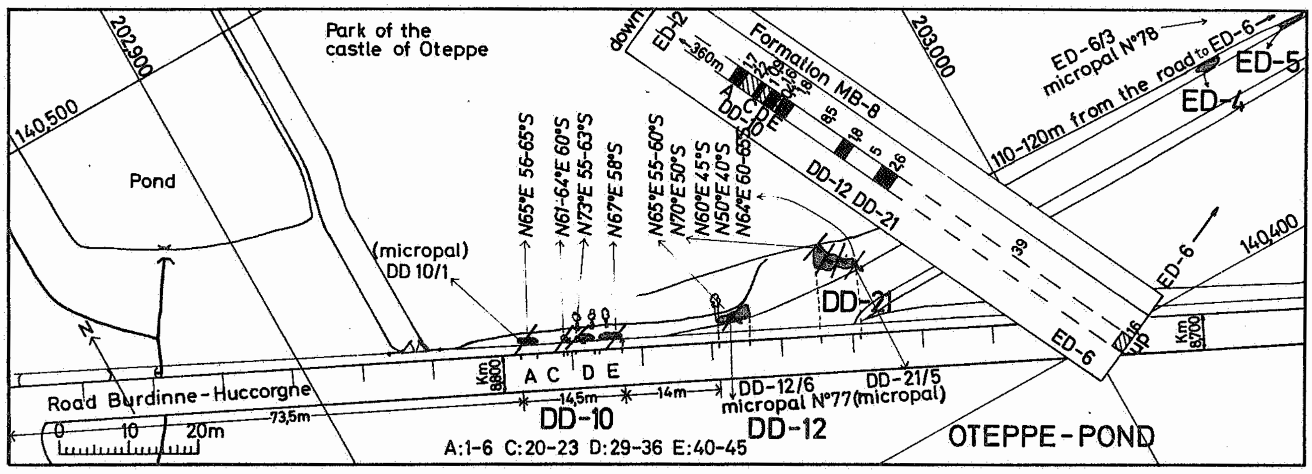

meadow
wood
CC-1
"Bois des Bachets"
CC-1/6
(micropal N°53)
CC-2
N90°E 53°S
201.150
FORMATION MB9
early or middle
Ludlovian
Ruisseau Jean-Jean or
Ruisseau des Gottes
140.100
N
0 10 20m
HERON-BOIN-
BOIS-DES-BACHETS

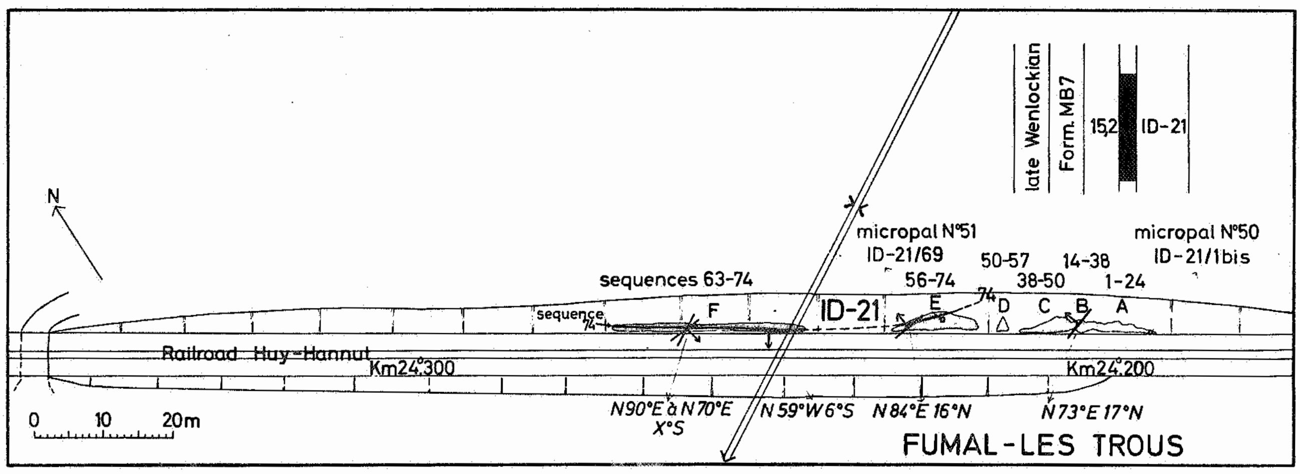

CB-8/7
micropal N°56
CB-8
N32°W10°W
N20°W20°W
CB-7
FORMATION MB9
early or middle Ludlovian
CB-7/8
micropal N°55
N
0 10 20m
HERON-BOIN-CENTER

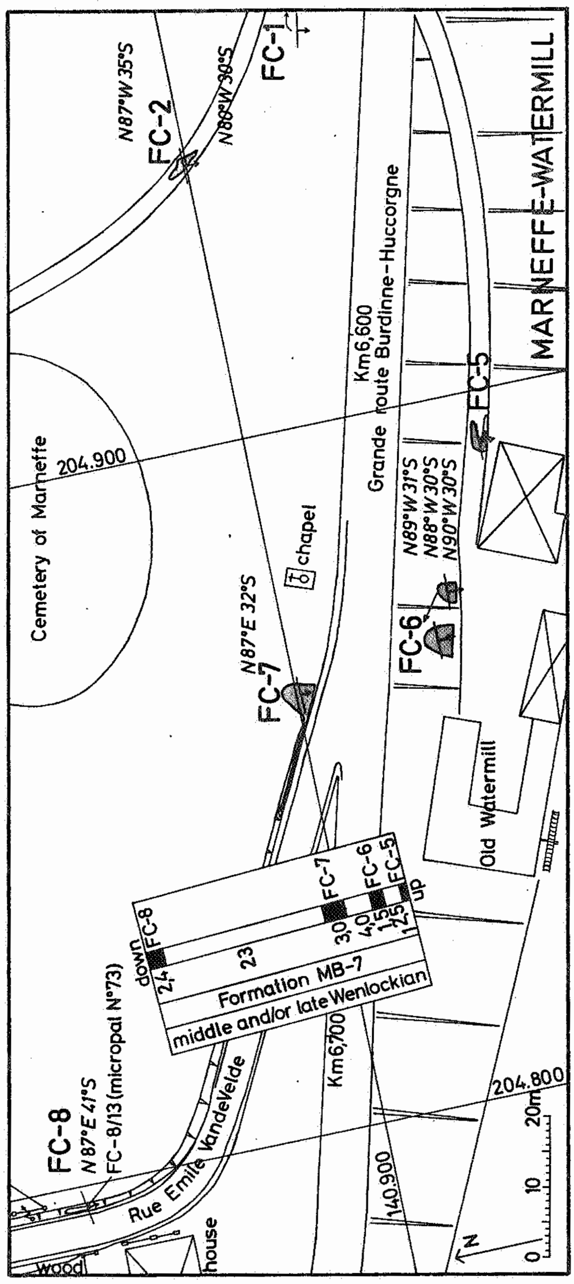

OTEPPE - BOUNIA
CD-22
CD-20
CD-19
DD-9
DD-9 (450m)
old Watermill of Bounia
LA BURDINALE
old railway
Mapsheet Braives
Mapsheet Wasseiges
OTEPPE
LAMONTZEE
n°247
early Wenlockian
middle Wenlockian
late Llandoverian and/or early Wenlockian
MB 5
MB 4B
MB 4A
MB 3E
approximate limit
up
down
micropal. Nr.
micropal. Nr. 12
N55°E 82°N
N58°E 85°N
N60-75°E 83-85°N
N64°E 80°S
N68°E 50-90°S
N74°E 81°S
N75°E 75-80°S
N69°E 78°S
N68°E 79°S
N63°E 76°S
N65°E 55°S
N68°E 50°S
N68°E 43°S
N64°E 55°S
N60°E 45-70°S
N63°E 35-64°S
N59°E 62°S
N70°E 64°S
N72°E 65°S
N40-45°E 70-90°N
CD-22G/115
CD-22G/78
CD-22G/1
CD-22F/17
CD-22E/36
CD-22E/35
CD-22D/1
CD-22B/1
CD-22A/2
CD-20/224
CD-20/114
CD-20/33
sequences
E: 151-224
D: 90-114
C: 85 - 95
B: 60 - 84
A: 5 - 60
N
0 10 20m
202,100
202,000
201,900
201,800
141,700
141,600
141,800
Km 9700
Km 9800
Km 9900


ED-1
N50°à90°E 67°S
N72°E 70à77°S
micropal
ED-2/106 N°37
ED-2/110 N°38
N61°E 68°S
A
B
EX CAB.
AU CONGO
ED-2
N66°à68°E 62°S
141950
N
Sce
203000
0 10m 20m
OTEPPE-VISSOUL

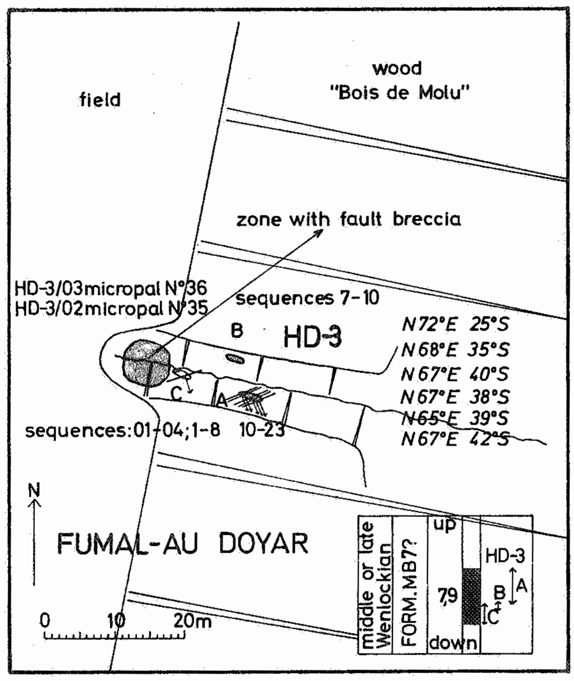

103,700
road to Braives
New Mill
covered old waterhole ø2,5m
old WWII hiding corridor
(25mL.x2mH.x1mW.)
N69°E30°S
ED-17/2 (micropal)
N75°E21°S
N78°E27°S
ED-17
pole
ED-18
N80°E20°S
ED-17/49 (micropal)
House n°32
ED-16A
ED-16A (micropal)
141,700
N79°E22°S
N
ED-16B
0 10 20m
Oteppe center
Castle of Oteppe
OTEPPE-CASTLE


202,900
Park of the castle of Oteppe
140,500
Pond
N
Formation MB-8
203,000
ED-6/3 micropal N°78
110-120m from the road to ED-6
ED-5
ED-4
ED-12
360m
DD-10
DD-12 DD-21
N65°E 56-65°S
N61-64°E 60°S
N73°E 55-63°S
N67°E 58°S
N65°E 55-60°S
N70°E 50°S
N60°E 45°S
N50°E 40°S
N64°E 60-65°S
(micropal)
DD 10/1
DD-21
ED-6
140,400
ED-6
Km 8,600
Km 8,700
A C D E
Road Burdinne-Huccorgne
73,5m
14,5m
14m
DD-10
DD-12/6 micropal N°77
DD-21/5 (micropal)
DD-12
0 10 20m
A:1-6 C:20-23 D:29-36 E:40-45
OTEPPE-POND

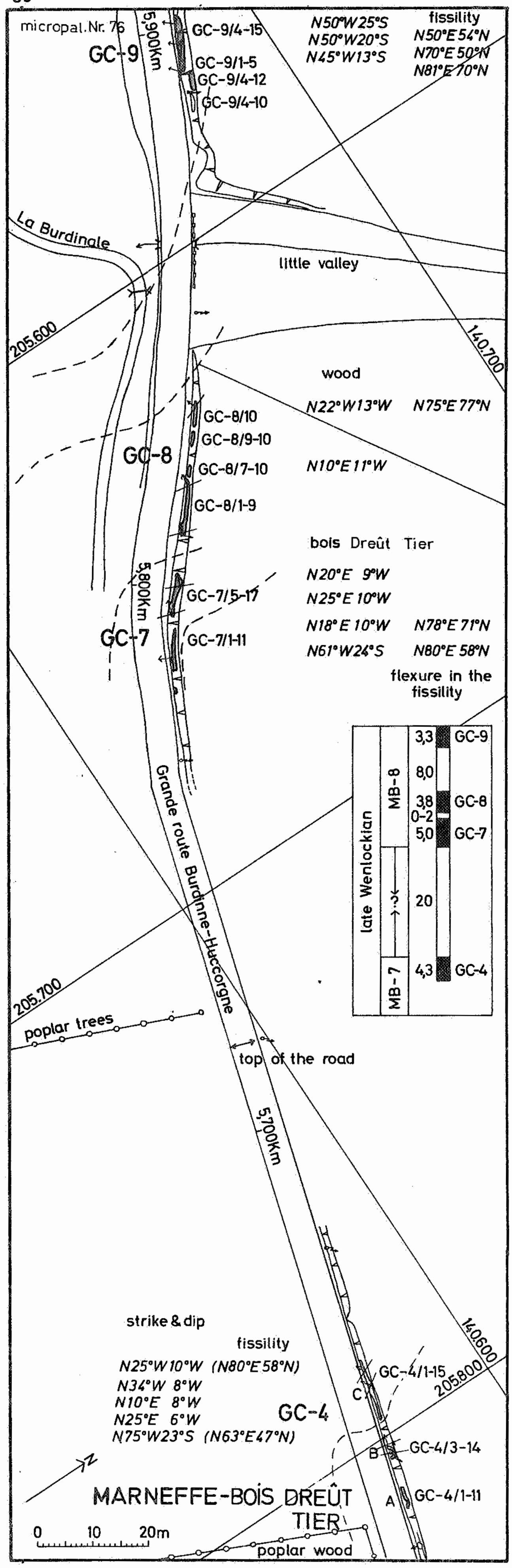

late Wenlockian
Form. MB7
15,2
ID-21
N
micropal N°51
ID-21/69
micropal N°50
ID-21/1bis
50-57
14-38
56-74
38-50
1-24
sequences 63-74
ID-21
E
D
C
B
A
F
sequence 74
Railroad Huy-Hannut
Km24,300
Km24,200
0 10 20m
N90°E à N70°E X°S
N59°W6°S
N84°E16°N
N73°E17°N
FUMAL-LES TROUS



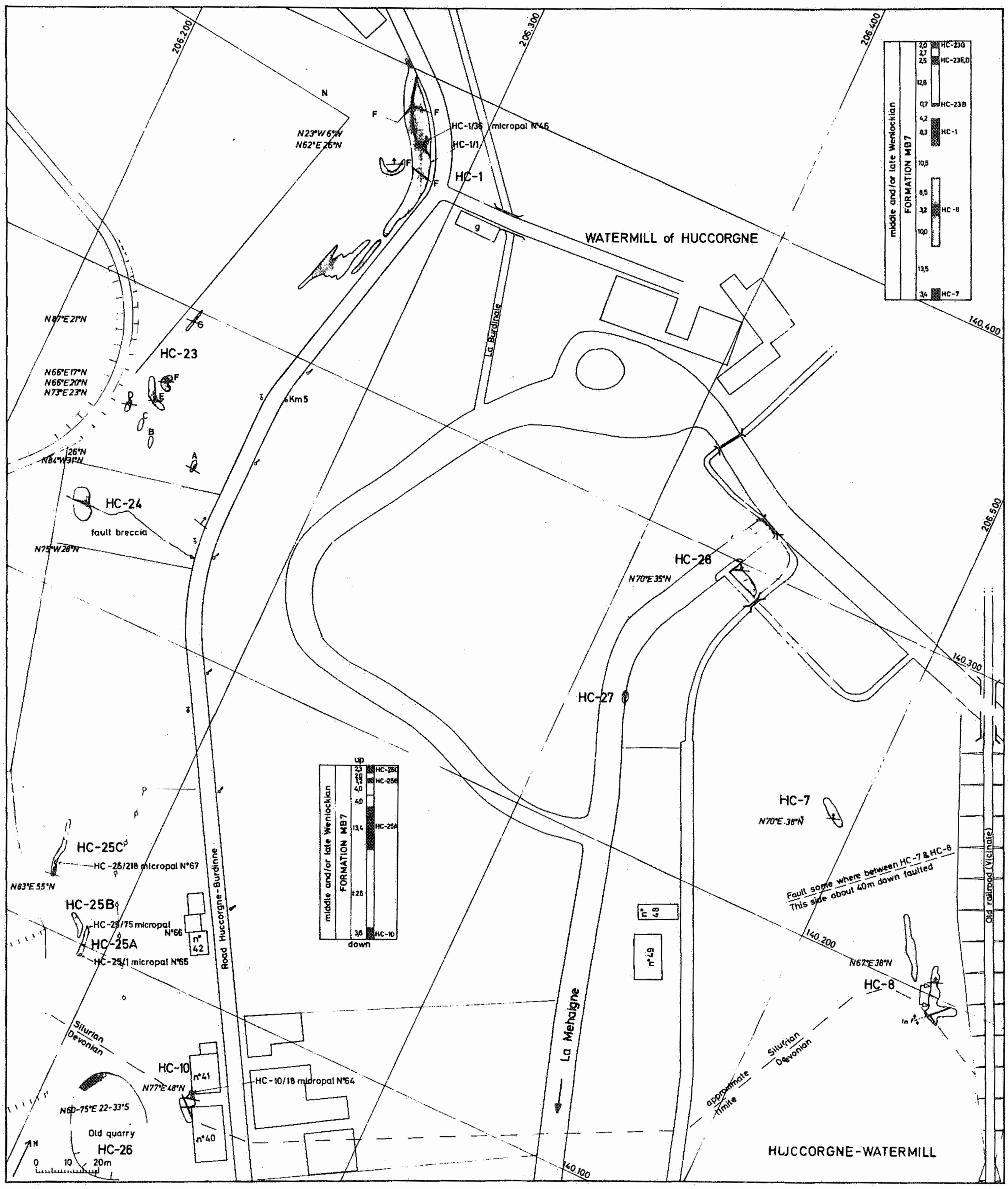
MARNEFFE-WATERMILL
FC-1
FC-2
N87°W 35°S
N86°W 30°S
Cemetery of Marneffe
204.900
Km6,600
Grande route Burdinne-Huccorgne
FC-5
N89°W31°S
N88°W30°S
N90°W30°S
chapel
FC-6
N87°E 32°S
FC-7
Old Watermill
down
FC-8
2,4
23
30
FC-7
4,0
FC-6
1,5
FC-5
12,5
up
Formation MB-7
middle and/or late Wenlockian
FC-8
N87°E 41°S
FC-8/13 (micropal N°73)
Rue Emile Vandevelde
Km6,700
140.900
204.800
house
wood
N
0
10
20m

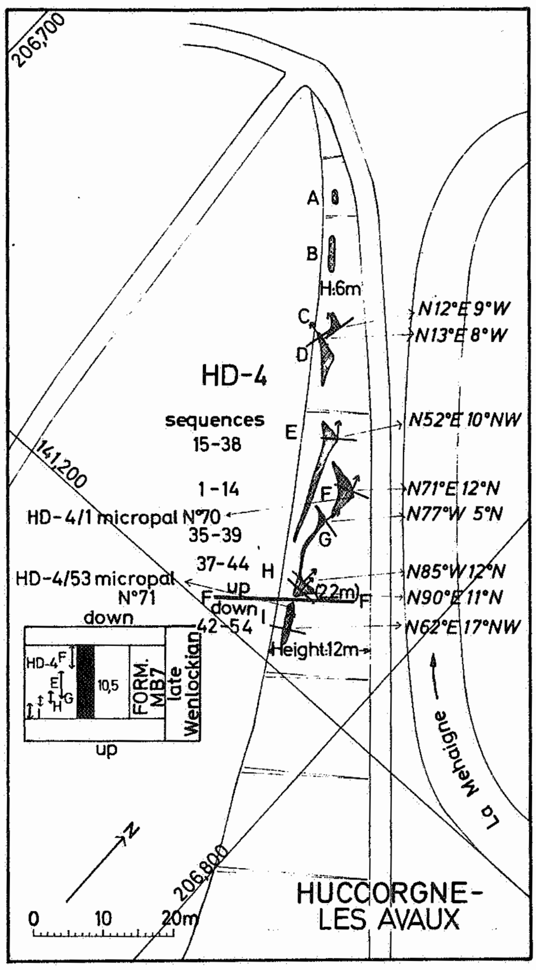


field
wood
"Bois de Molu"
zone with fault breccia
HD-3/03micropal N°36
HD-3/02micropal N°35
sequences 7-10
B
HD-3
N72°E 25°S
N68°E 35°S
N67°E 40°S
N67°E 38°S
N65°E 39°S
N67°E 42°S
C
A
sequences:01-04;1-8 10-23
N
FUMAL-AU DOYAR
0
10
20m
middle or late Wenlockian
FORM.MB7?
up
7,9
down
HD-3
B
A
C

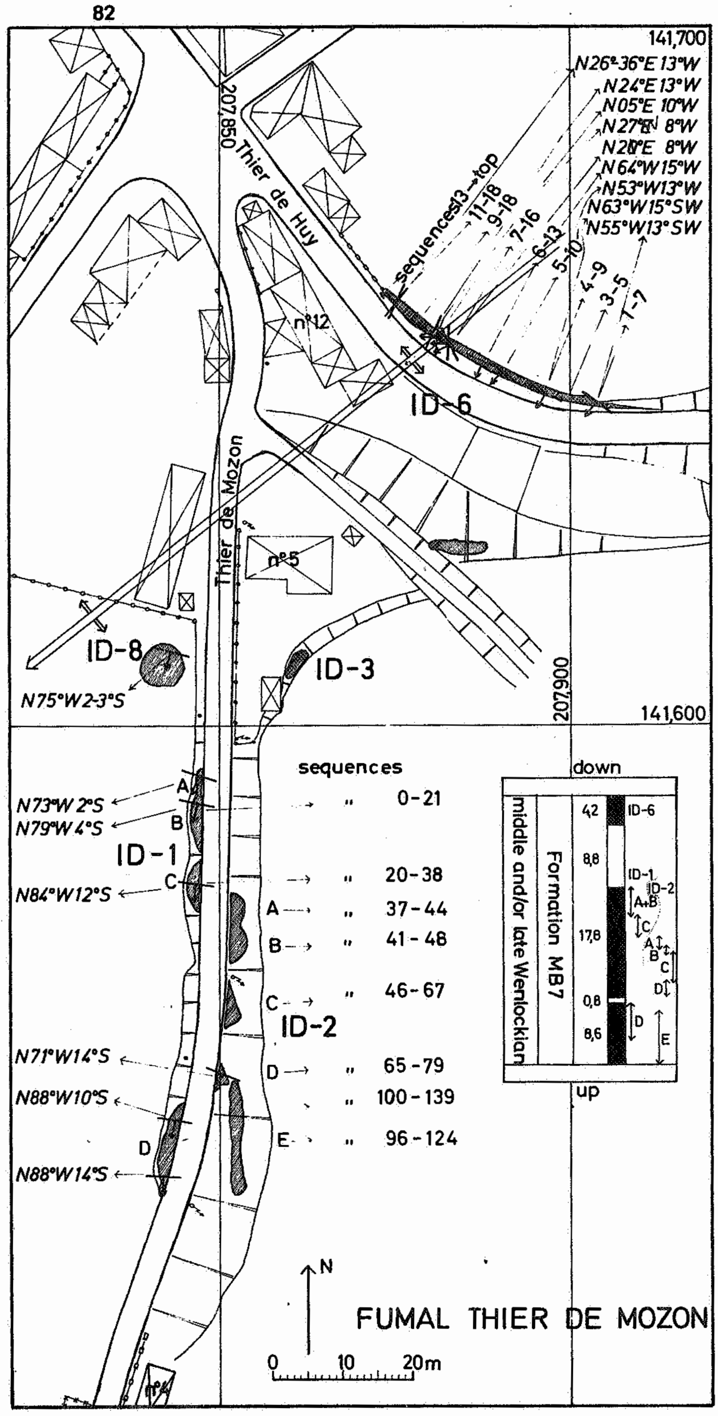


micropal.Nr. 76
GC-9
5,900Km
GC-9/4-15
GC-9/1-5
GC-9/4-12
GC-9/4-10
N50°W25°S
N50°W20°S
N45°W13°S
fissility
N50°E 54°N
N70°E 50°N
N81°E 70°N
La Burdinale
little valley
205.600
140.700
wood
N22°W13°W
N75°E 77°N
GC-8/10
GC-8/9-10
GC-8
GC-8/7-10
N10°E 11°W
GC-8/1-9
bois Dreût Tier
N20°E 9°W
N25°E 10°W
5,800Km
GC-7/5-17
GC-7
GC-7/1-11
N18°E 10°W
N78°E 71°N
N61°W24°S
N80°E 58°N
flexure in the fissility
late Wenlockian
MB-8
MB-7
3,3
GC-9
8,0
3,8
GC-8
0-2
5,0
GC-7
20
4,3
GC-4
Grande route Burdinne-Huccorgne
205.700
poplar trees
top of the road
5,700Km
strike & dip
fissility
N25°W10°W (N80°E58°N)
N34°W 8°W
N10°E 8°W
N25°E 6°W
N75°W23°S (N63°E47°N)
GC-4
GC-4/1-15
140600
205.800
C
B
GC-4/3-14
A
GC-4/1-11
N
MARNEFFE-BOIS DREÛT TIER
0
10
20m
poplar wood

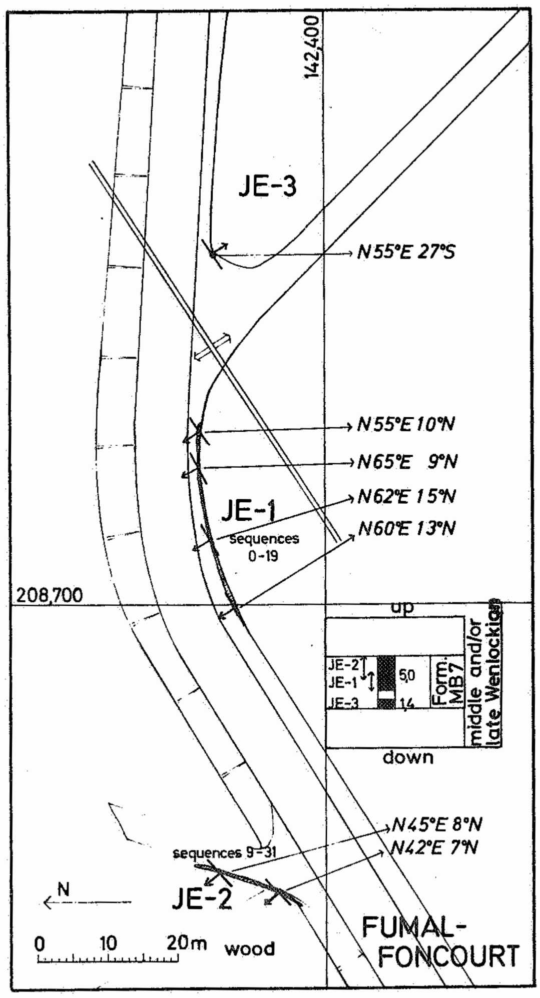

WATERMILL of HUCCORGNE
HC-1
HC-1/36 micropal N°46
HC-1/1
N23°W 6°W
N62°E 26°N
La Burdinale
HC-23
HC-24
fault breccia
Km5
HC-28
N70°E 35°N
HC-27
HC-7
N70°E 38°N
Fault some where between HC-7 & HC-8
This side about 40m down faulted
HC-8
N62°E 38°N
HC-25C
HC-25/218 micropal N°67
HC-25B
HC-25/75 micropal N°66
HC-25A
HC-25/1 micropal N°65
Road Huccorgne-Burdinne
La Mehaigne
Silurian
Devonian
approximate limite
HC-10
N77°E 48°N
HC-10/18 micropal N°64
N60-75°E 22-33°S
Old quarry
HC-26
Old railroad (Vicinale)
HUCCORGNE-WATERMILL
middle and/or late Wenlockian
FORMATION MB7
up
down
206.200
206.300
206.400
206.500
140.400
140.300
140.200
140.100
0 10 20m



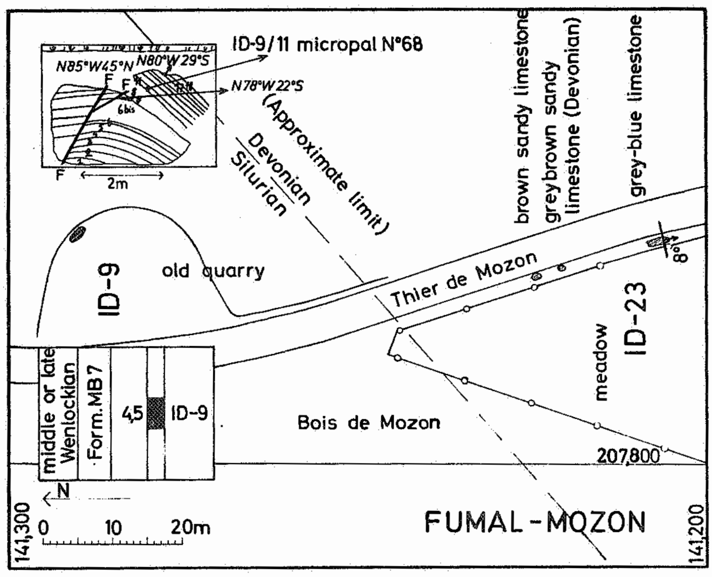
206,700
141,200
206,800
HD-4
sequences 15-38
1-14
35-39
37-44
42-54
HD-4/1 micropal N°70
HD-4/53 micropal N°71
up
down
H:6m
Height:12m
(22m)
N12°E 9°W
N13°E 8°W
N52°E 10°NW
N71°E 12°N
N77°W 5°N
N85°W 12°N
N90°E 11°N
N62°E 17°NW
La Mehaigne
FORM. MB7
late Wenlockian
10,5
N
0 10 20m
HUCCORGNE-LES AVAUX



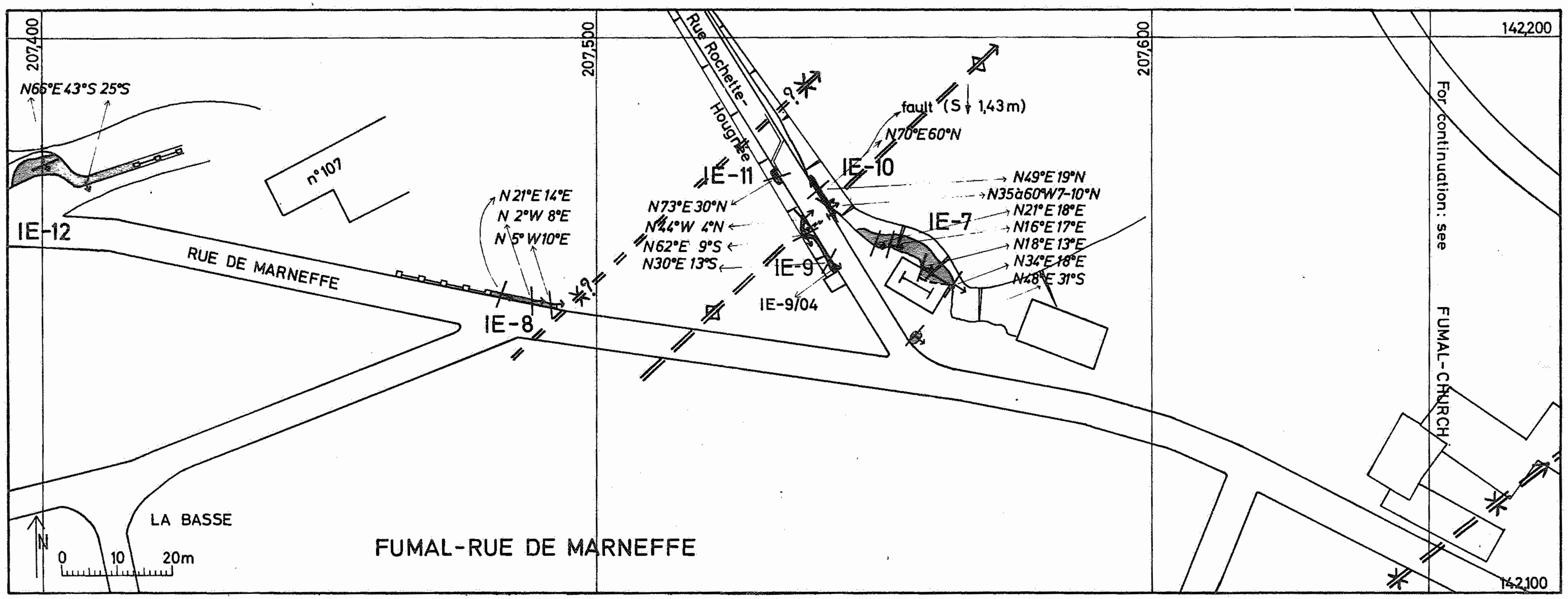
141,700
207,850
Thier de Huy
Thier de Mozon
n°12
n°5
ID-6
ID-8
ID-3
ID-1
ID-2
sequences 13→top
11-18
9-18
7-16
6-13
5-10
4-9
3-5
1-7
N26°-36°E 13°W
N24°E 13°W
N05°E 10°W
N27°E 8°W
N20°E 8°W
N64°W 15°W
N53°W 13°W
N63°W 15°SW
N55°W 13°SW
N75°W 2-3°S
N73°W 2°S
N79°W 4°S
N84°W 12°S
N71°W 14°S
N88°W 10°S
N88°W 14°S
207,900
141,600
sequences
0-21
20-38
A 37-44
B 41-48
C 46-67
D 65-79
100-139
E 96-124
down
up
middle and/or late Wenlockian
Formation MB7
42
8,8
17,8
0,8
8,6
N
0 10 20m
FUMAL THIER DE MOZON



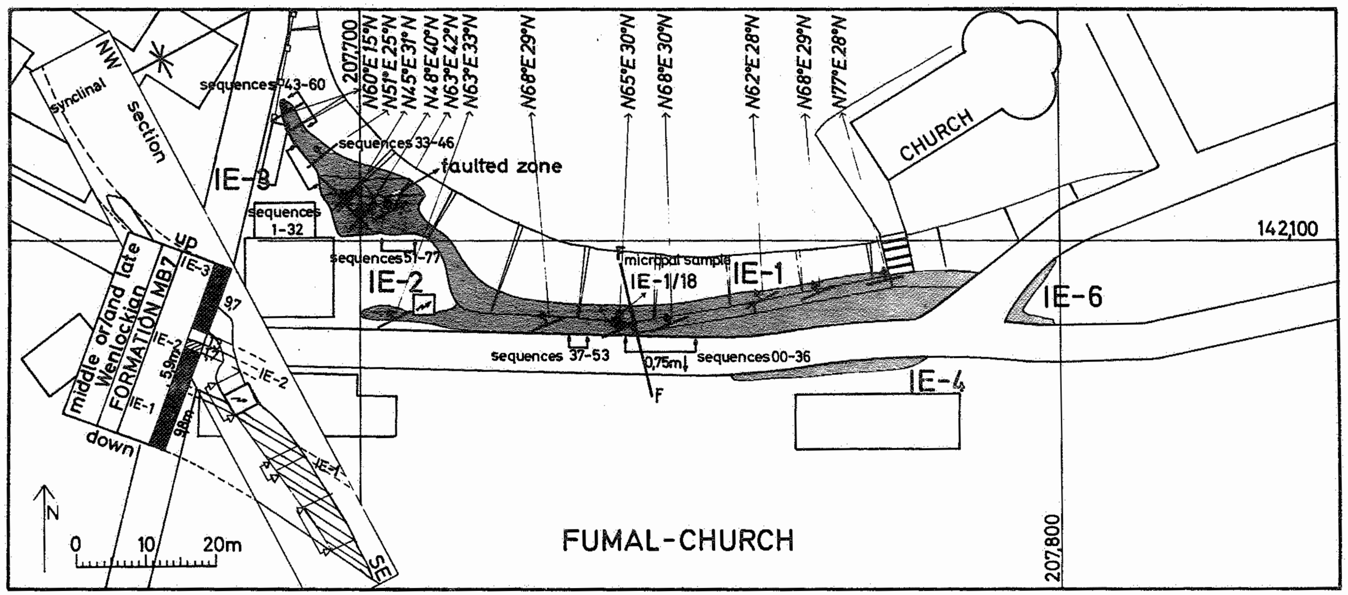
142,400
208,700
JE-3
N55°E 27°S
JE-1
sequences 0-19
N55°E 10°N
N65°E 9°N
N62°E 15°N
N60°E 13°N
up
down
JE-2
JE-1
JE-3
5,0
1,4
Form. MB7
middle and/or late Wenlockian
sequences 9-31
JE-2
N45°E 8°N
N42°E 7°N
N
0 10 20m
wood
FUMAL-FONCOURT



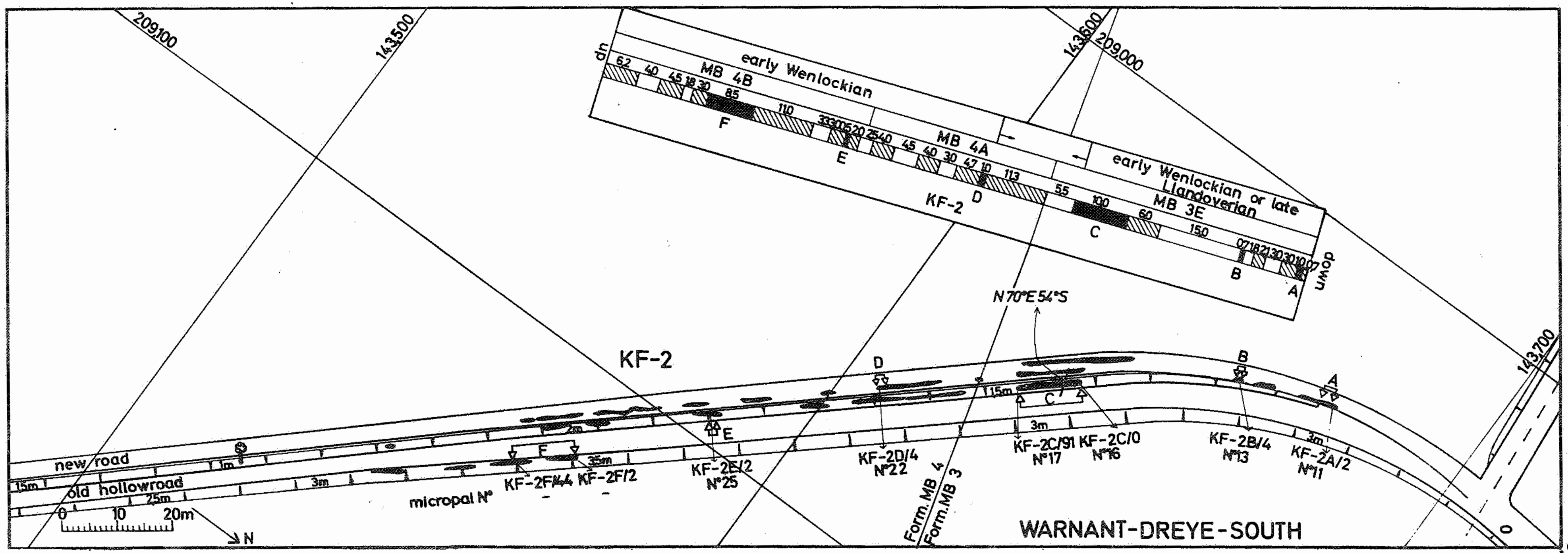
ID-9/11 micropal N°68
N85°W 45°N
N80°W 29°S
N78°W 22°S
2m
(Approximate limit)
Devonian
Silurian
brown sandy limestone
greybrown sandy limestone (Devonian)
grey-blue limestone
ID-9
old quarry
Thier de Mozon
ID-23
meadow
Bois de Mozon
middle or late Wenlockian
Form. MB7
4,5
207,800
141,300
141,200
0 10 20m
FUMAL-MOZON



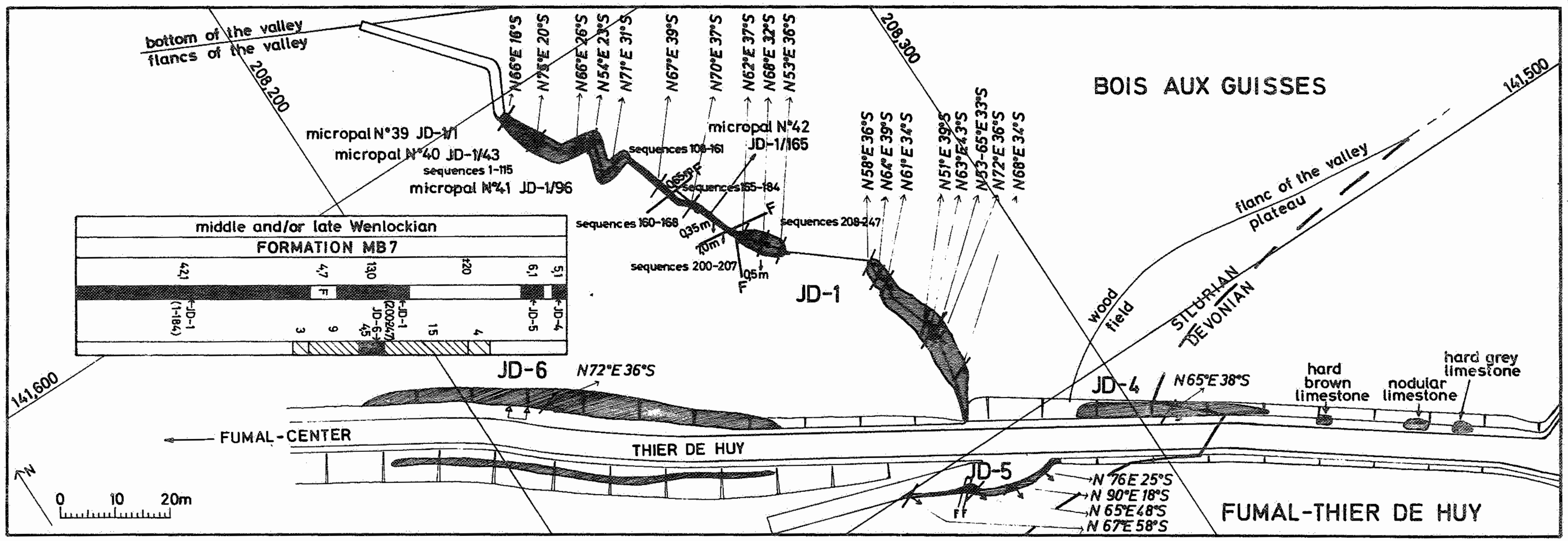
FUMAL-RUE DE MARNEFFE
207,400
207,500
207,600
142,200
142,100
N66°E 43°S 25°S
n°107
IE-12
RUE DE MARNEFFE
N 21°E 14°E
N 2°W 8°E
N 5° W10°E
IE-8
Rue Rochette-Hougnée
IE-11
N73°E 30°N
N44°W 4°N
N62°E 9°S
N30°E 13°S
IE-9
IE-9/04
fault (S 1,43m)
N70°E 60°N
IE-10
IE-7
N49°E 19°N
N35à60°W7-10°N
N21°E 18°E
N16°E 17°E
N18°E 13°E
N34°E 18°E
N48°E 31°S
For continuation: see FUMAL-CHURCH
LA BASSE
N
0 10 20m



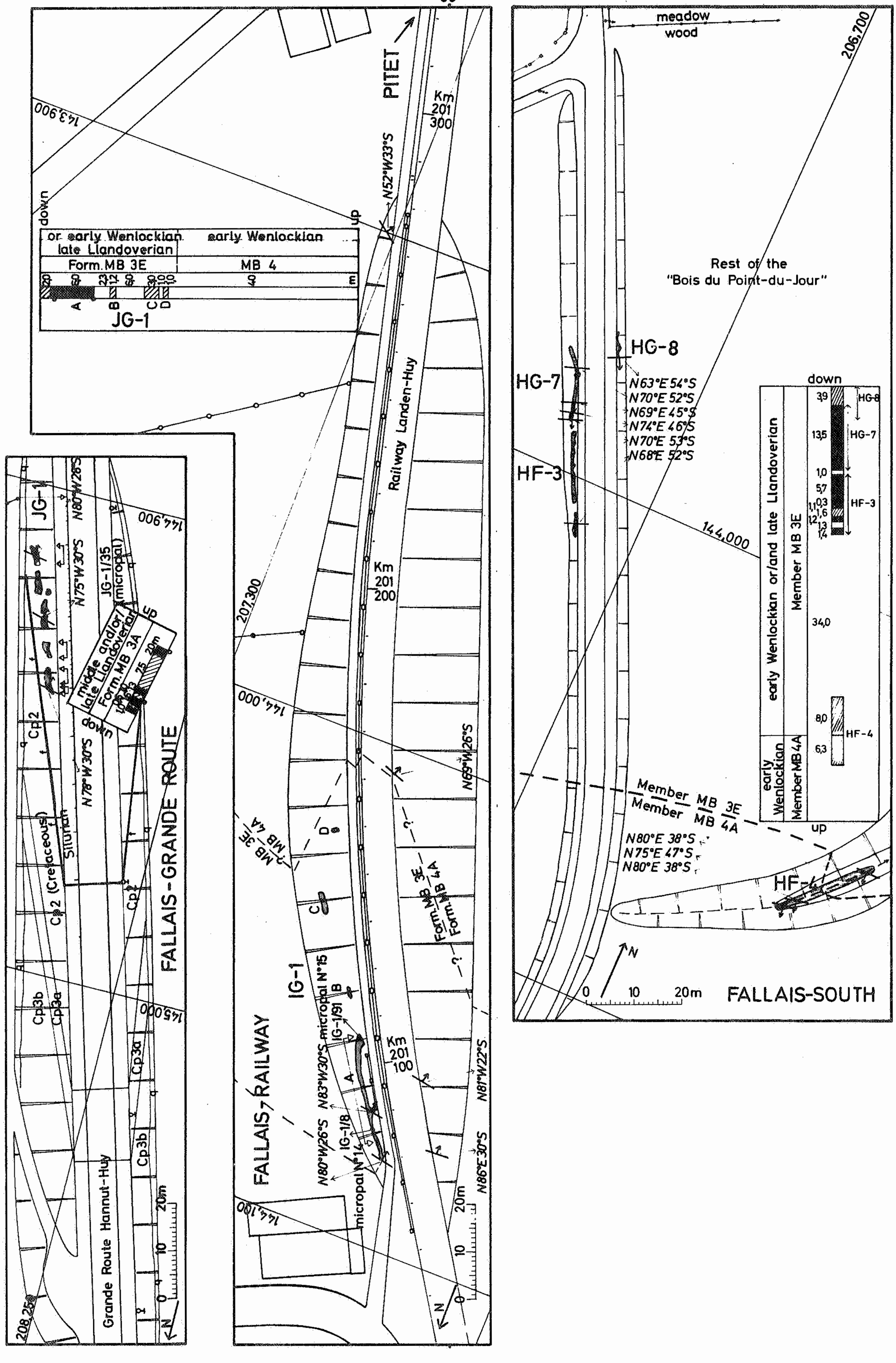
FUMAL-CHURCH
207,700
207,800
142,100
NW
section
SE
synclinal
up
down
middle orland late Wenlockian
FORMATION MB7
IE-3
IE-2
IE-1
9,7
5,9m
9,8m
sequences 43-60
sequences 33-46
faulted zone
sequences 1-32
sequences 51-77
N60°E 15°N
N51°E 25°N
N45°E 31°N
N48°E 40°N
N63°E 42°N
N63°E 33°N
N68°E 29°N
N65°E 30°N
N68°E 30°N
N62°E 28°N
N68°E 29°N
N77°E 28°N
CHURCH
micropal sample
IE-1/18
IE-1
IE-6
IE-4
F
sequences 37-53
0,75m
sequences 00-36
N
0 10 20m

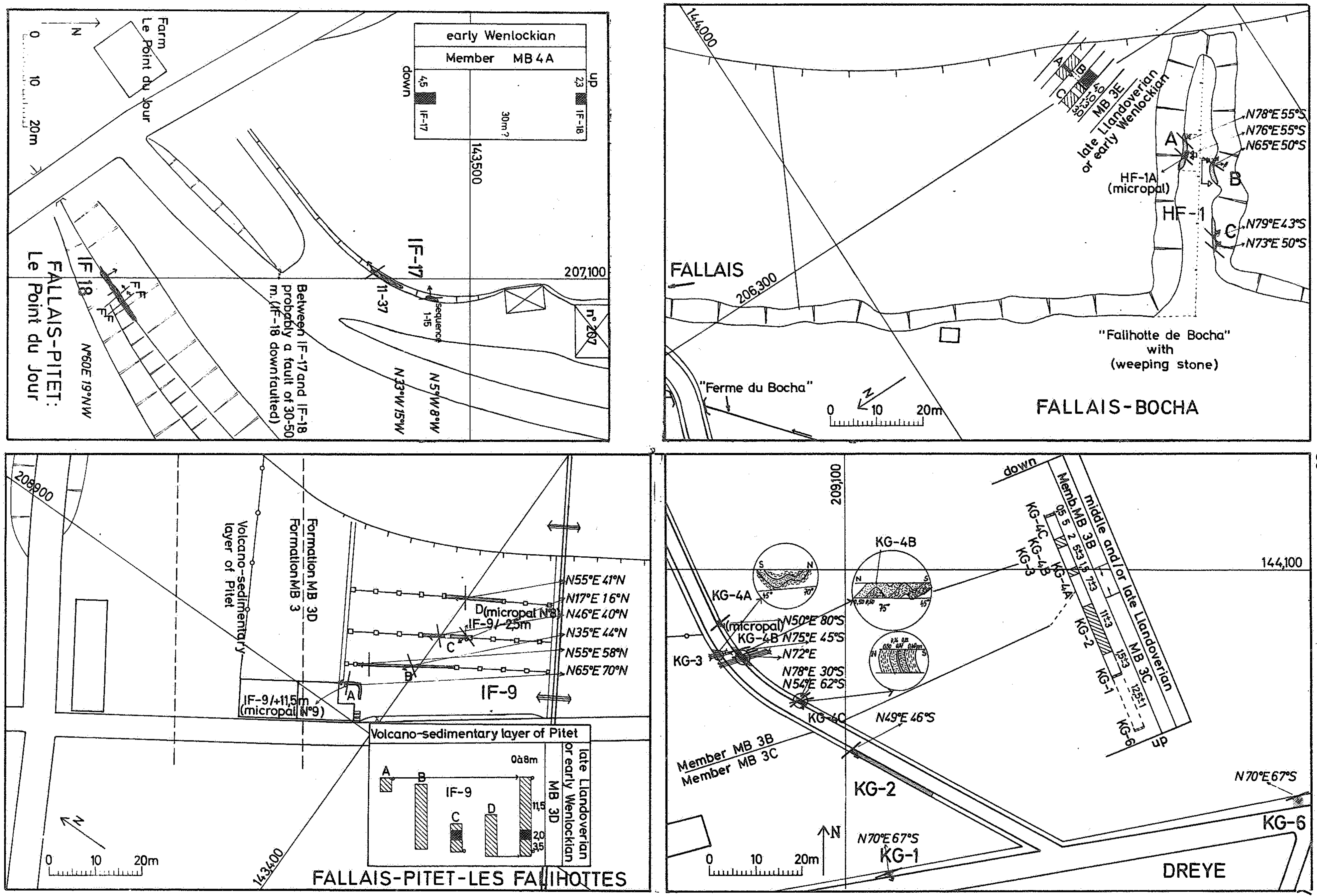


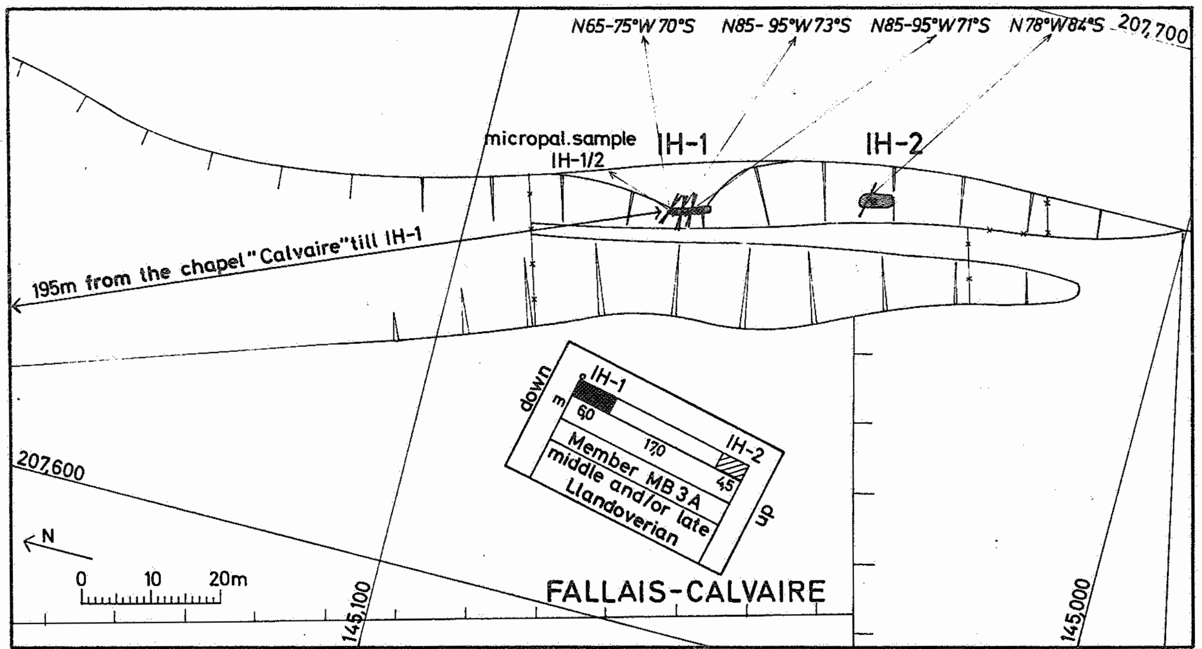
209,100
143,500
143,600
209,000
143,700
early Wenlockian
MB 4B
MB 4A
early Wenlockian or late Llandoverian
MB 3E
up
down
F
E
D
C
B
A
KF-2
N 70°E 54°S
new road
old hollowroad
micropal N°
KF-2F/44
KF-2F/2
KF-2E/2 N°25
KF-2D/4 N°22
KF-2C/91 N°17
KF-2C/0 N°16
KF-2B/4 N°13
KF-2A/2 N°11
Form. MB 4
Form. MB 3
WARNANT-DREYE-SOUTH
0 10 20m
N

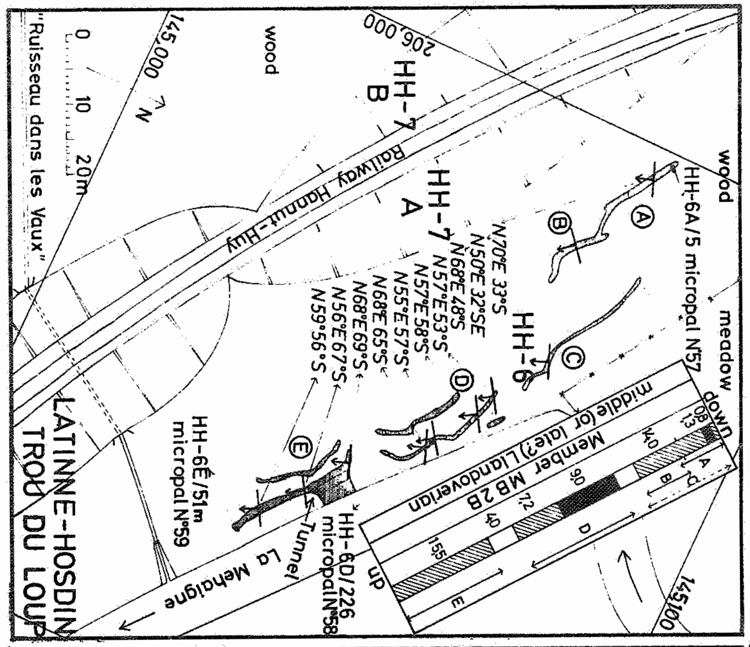


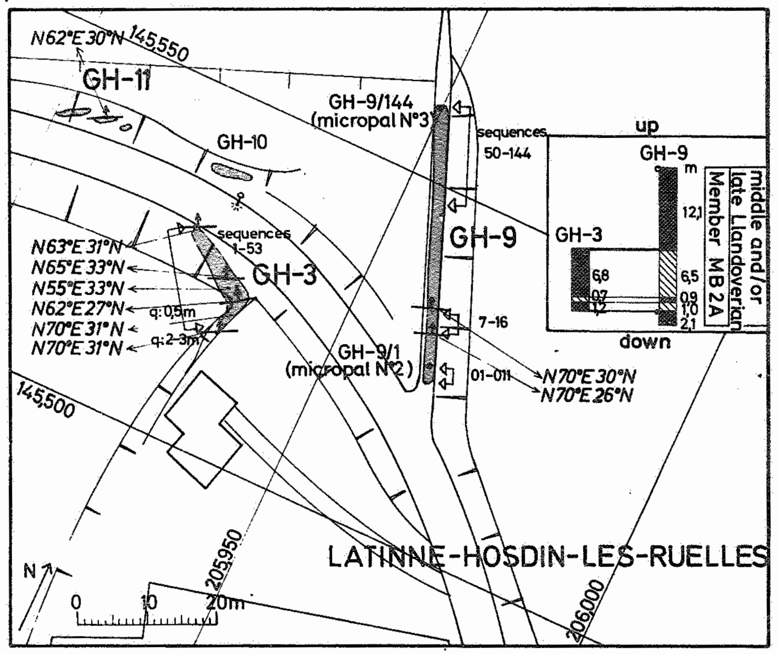
bottom of the valley
flancs of the valley
208,200
208,300
141,500
141,600
BOIS AUX GUISSES
N 66°E 16°S
N 75°E 20°S
N 66°E 26°S
N 54°E 23°S
N 71°E 31°S
N 67°E 39°S
N 70°E 37°S
N 62°E 37°S
N 68°E 32°S
N 53°E 36°S
micropal N°39 JD-1/1
micropal N°40 JD-1/43
sequences 1-115
micropal N°41 JD-1/96
micropal N°42 JD-1/165
sequences 108-161
sequences 165-184
sequences 160-168
sequences 208-247
sequences 200-207
JD-1
N 58°E 36°S
N 64°E 39°S
N 61°E 34°S
N 51°E 39°S
N 63°E 43°S
N 33-65°E 33°S
N 72°E 36°S
N 68°E 34°S
flanc of the valley
plateau
wood
field
SILURIAN
DEVONIAN
middle and/or late Wenlockian
FORMATION MB7
JD-6
N 72°E 36°S
JD-4
N 65°E 38°S
hard brown limestone
nodular limestone
hard grey limestone
FUMAL-CENTER
THIER DE HUY
JD-5
N 76E 25°S
N 90°E 18°S
N 65°E 48°S
N 67°E 58°S
FUMAL-THIER DE HUY
0 10 20m
N

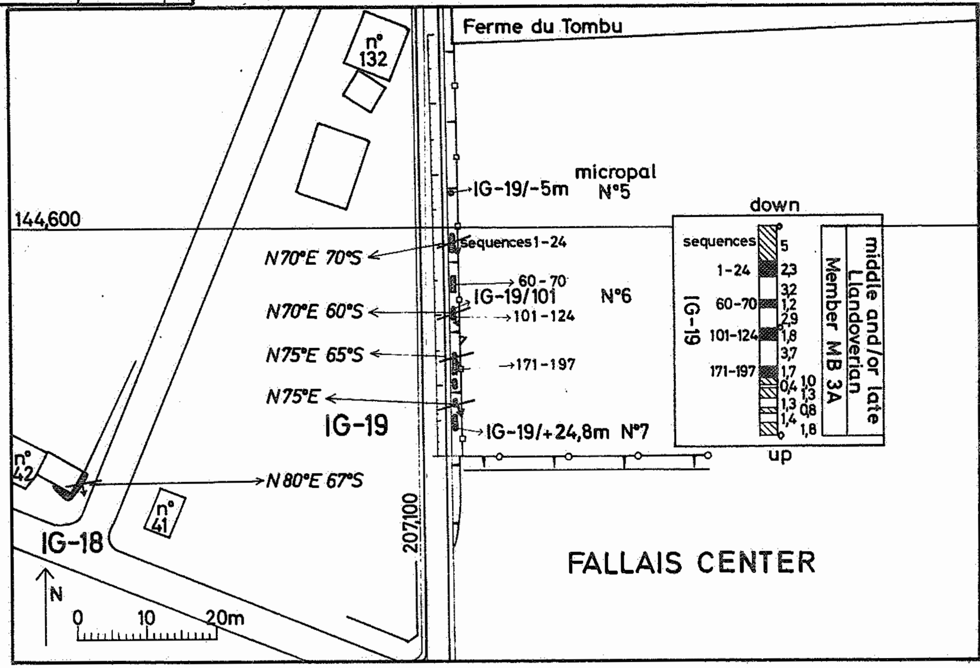

PITET
Km 201 300
N52°W33°S
down
up
or early Wenlockian late Llandoverian
early Wenlockian
Form. MB 3E
MB 4
JG-1
143,900
Railway Landen-Huy
Km 201 200
207,300
144,000
144,100
N69°W26°S
MB 3E
MB 4A
Form. MB 3E
Form. MB 4A
IG-1
micropal N°15
IG-1/91
IG-1/8
micropal N°14
N83°W30°S
N80°W26°S
N81°W22°S
N86°E30°S
Km 201 100
FALLAIS-RAILWAY
20m
10
0
N
JG-1
N80°W28°S
144,900
N75°W30°S
JG-1/35 (micropal)
middle and/or late Llandoverian
Form. MB 3A
N78°W30°S
Cp2
Cp2 (Cretaceous)
Silurian
FALLAIS-GRANDE ROUTE
Cp3b
Cp3a
145,000
Grande Route Hannut-Huy
208,250
meadow
wood
206,700
Rest of the "Bois du Point-du-Jour"
HG-8
HG-7
HF-3
N63°E54°S
N70°E52°S
N69°E45°S
N74°E46°S
N70°E53°S
N68°E52°S
144,000
down
early Wenlockian or/and late Llandoverian
Member MB 3E
early Wenlockian
Member MB4A
up
Member MB 3E
Member MB 4A
N80°E38°S
N75°E47°S
N80°E38°S
HF-4
N
0
10
20m
FALLAIS-SOUTH


FALLAIS-PITET:
Le Point du Jour
Farm
Le Point du Jour
early Wenlockian
Member MB 4A
up
down
IF-17
IF-18
30m ?
143,500
207,100
IF-17
IF 18
11-37
sequence 1-15
Between IF-17 and IF-18 probably a fault of 30-50 m. (IF-18 downfaulted)
N°60E 19°NW
N33°W 15°W
N5°W 8°W
n° 207
0 10 20m
FALLAIS-BOCHA
FALLAIS
144,000
206,300
MB 3E
late Llandoverian or early Wenlockian
HF-1A (micropal)
HF-1
N78°E 55°S
N76°E 55°S
N65°E 50°S
N79°E 43°S
N73°E 50°S
"Falihotte de Bocha" with (weeping stone)
"Ferme du Bocha"
0 10 20m
FALLAIS-PITET-LES FALIHOTTES
208900
143400
Volcano-sedimentary layer of Pitet
Formation MB 3D
Formation MB 3
N55°E 41°N
N17°E 16°N
N46°E 40°N
N35°E 44°N
N55°E 58°N
N65°E 70°N
D(micropal N°8)
IF-9/-2,5m
IF-9/+11,5m (micropal N°9)
IF-9
Volcano-sedimentary layer of Pitet
0à8m
late Llandoverian or early Wenlockian
MB 3D
0 10 20m
DREYE
209,100
144,100
down
up
middle and/or late Llandoverian
Memb.MB 3B
MB 3C
KG-4C
KG-4B
KG-4A
KG-3
KG-2
KG-1
KG-6
KG-4B
KG-4A
(micropal)
N50°E 80°S
N75°E 45°S
N72°E
N78°E 30°S
N54°E 62°S
N49°E 46°S
Member MB 3B
Member MB 3C
N70°E 67°S
N70°E 67°S
0 10 20m


N65-75°W 70°S
N85- 95°W 73°S
N85-95°W 71°S
N 78°W 84°S
207,700
micropal.sample
IH-1/2
IH-1
IH-2
195m from the chapel "Calvaire" till IH-1
207,600
IH-1
m
60
17,0
IH-2
45
down
up
Member MB 3A
middle and/or late
Llandoverian
N
0 10 20m
145,100
145,000
FALLAIS-CALVAIRE


"Ruisseau dans les Vaux"
0 10 20m
145,000
N
wood
206,000
HH-7 B
HH-7 A
Railway Hannut-Huy
HH-6
HH-6A/5 micropal N°57
wood
meadow
N 70°E 33°S
N 50°E 32°SE
N 68°E 48°S
N 57°E 53°S
N 57°E 58°S
N 55°E 57°S
N 68°E 65°S
N 68°E 69°S
N 56°E 67°S
N 59°E 56°S
HH-6E/51m
micropal N°59
HH-6D/226
micropal N°58
Tunnel
La Mehaigne
LATINNE-HOSDIN
TROU DU LOUP
middle (or late?) Llandoverian
Member MB 2B
down
up
145,100


N62°E30°N
145,550
GH-11
GH-10
GH-9/144
(micropal N°3)
sequences
50-144
sequences
1-53
GH-9
GH-3
N63°E31°N
N65°E33°N
N55°E33°N
N62°E27°N
N70°E31°N
N70°E31°N
q: 0,5m
q: 2-3m
7-16
GH-9/1
(micropal N°2)
01-011
N70°E 30°N
N70°E 26°N
145,500
up
GH-9
GH-3
m
12,1
6,8
6,5
0,7
1,2
0,9
1,0
2,1
down
middle and/or
late Llandoverian
Member MB 2A
N
0 10 20m
205,950
206,000
LATINNE-HOSDIN-LES-RUELLES


Ferme du Tombu
n° 132
IG-19/-5m
micropal
N°5
144,600
sequences 1-24
N70°E 70°S
60-70
IG-19/101
N°6
N70°E 60°S
101-124
N75°E 65°S
171-197
N75°E
IG-19
IG-19/+24,8m N°7
N 80°E 67°S
n° 42
n° 41
IG-18
207,100
N
0 10 20m
FALLAIS CENTER
down
sequences
1-24
60-70
101-124
171-197
IG-19
5
2,3
3,2
1,2
2,9
1,8
3,7
1,7
0,4
1,0
1,3
1,3
0,8
1,4
1,8
up
middle and/or late
Llandoverian
Member MB 3A

Detailed descriptive localization of outcrops mentioned in this work and not shown on the detailed localization maps.

CB-1 : Héron-Boin-Center : outcrop in small, 4 m long,road-cut (W side) and outcrop in a pit 7 m to the NW of the outcrop in the wood, at 88 m N of main road, in the southern most part of Bois de Boin; dir. & dip : N24°W 36°W ; N15°E 27°W , cleavage : N75°E, 72°N .

GC-11: Marneffe-Grande Route : outcrop in slope behind and E of house N°190, at a small side street, 85 m E from the "Grande Route" Burdinne-Huccorgne ; there is a fault in this section in the same direction as the E side of the house ; W of the fault 3 m of section are present ; E of the fault 2.1 m ; dir. & dip : N86°W 11°S ; N77°W 14°S , cleavage : N82°E 75°N.

CD-17: Lamontzée between "Ferme de la Nèffe" and Ancien Moulin de Bounia" : loose pieces of slate in slope over 60 m, in the NE road-cut of the "Grande Route", north of the side road ; this section continues in section CE-12 ; in a series of boreholes with a handdrill every 20 m, only slates are found, no volcano-sedimentary layer of Pitet.

CD-18: Lamontzée between "Ferme de la Nèffe" and Ancien Moulin de Bounia" : outcrops in 250 m long slope along sideroad in a cut along the N side : very weathered slate, sometimes reddish coloured.

CD-34: Lamontzée : 350-450 m E of church : loose pieces of rock in the slope along the S side of the Burdinale valley ; medium to coarse grained volcanic tuff : volcano-sedimentary layer of Pitet.

CD-35: Lamontzée : outcrop 450 m E of church ; in the S side of the river Burdinale itself ; very fine slate very finely lamellated, ressembling the "slate of bois Cornet" : upper part of the volcano-sedimentary layer of Pitet.

DD-9 : Oteppe-Bounia : outcrop in W side of brooklet at 240 m N of the "Grande Route", 11 m north of a waterpit along the brooklet : dark gray slates with lamellated and compact sedimentation : micropal. Nr. DD-9A.

DD-13: Oteppe-Cense d'âs Triches : outcrop behind chapel and SE of it in a curved road-cut to the farm Cense d'âs Triche ; dir. & dip in the E : N74°W 27°S , cleavage : N66°W 68°N ; in the middle of the outcrop : N77°W 28°S , cleavage : N83°W 68°N ; near the chapel : N69°W 26°S , cleavage : N79°W 64°N ; micropal. Nr. DD-13/2 and DD-13/16 : see detailed log description (p. 117).

ED-12: Oteppe-Center : outcrop in the garden behind house Nr. 55 in the "rue de l'Eglise".

ED-13: Oteppe-Center : outcrop in a E-W directed slope under the wall of a garden at 12 to 22 m W of the rue de l'Eglise facing house Nr. 48 ; dir. & dip : N82°E 31°S and N86°E 29°S, cleavage : N80°E 68°N ; micropal. Nr. ED-13/4:see detailed log description (p. 117).

ED-14: Oteppe-Center : outcrop under a N-S directed wall, 4 m W of the rue de l'Eglise, north of outcrop ED-13 ; dir. & dip : N51°W 21°S , cleavage : N70°E 57°N; micropal. Nr. ED-14/2 : see detailed log description (p. 117).

ED-15: Oteppe-Center : horizontal outcrop in the SW most corner of the place in front of the church (covered in 1972) ; dir. & dip : N86°E 21°S , cleavage : N65°E 53°W.

ED-21: Oteppe-Wérichet : outcrop in E slope of road-cut, at a height of 6 m above the road, 25 to 40 m S of house, at 370 m S of church of Oteppe ; dir. & dip, 25 m S of house : N36°E 21°W , cleavage : N81°W 76°N ; 32 m S of house : N41°E 19-24°W , cleavage : N80°E 71°N ; 40 m S of house : N64°E 20°W ; in the southern part a little fault : N30°W 75°E with uplift of E part ; micropal. Nr. ED-21/2 : see detailed log description (p. 117).

FD-1 : Marneffe-Grande Route : large outcrop at the border between Oteppe and Marneffe in the N slope of the road-cut between Km 7.490 and 7.530, in the curve NW of the brook "La Prâle" ; dir. & dip : 10 m N of curve : N24°E 30°W , cleavage : N65°E 80°N ; in the curve : N9°E 38°W , cleavage : N56°E 79°N ; 5 m S of curve : N8°E 31°W , cleavage : N54°E 73°N ; in the E most part : N22°E 32°W , cleavage : N54°E 73°N ; these data show the center of a anticline with axe dipping to the WSW ; micropal. Nr. FD-1/3 and FD-1/101 : see detailed log description (p. 113).

FD-4 : Marneffe-Grande Route : loose pieces of slate in N slope of road-cut around Km 7.400.

FD-5 : Marneffe-Grande Route : outcrop in N slope at Km 7.330, 70 m SE of side road to "Le Prâle".

FD-6 : Marneffe-Grande Route : outcrop in N slope of the road in a excavated part at Km 7.240, 130 m W of side path to Marneffe ; many small faults in this outcrop,possibly caused by creep.

FD-7 : Marneffe-Grande Route : outcrop in N slope at Km 7.175, near the highest point of the road.

HD-1 : Fumal-Au Doyar : large outcrop in a cliff and several outcrops above it in the flank of the valley, in the E part of Bois de Molû ; some 27 m of section is present, 8.8 m is described ; dir. & dip on top : N90°E 14°S ; at the base : N85°E 25°S ; micropal. Nr. HD-1/14 m : taken some 14 m above the top of described section.

JD-2 : Fumal-Bois aux Guisses : long outcrop in both sides of a deep ravine, running from the plateau 30 m deeper to halfway the flank of the valley in the Bois aux Guisses ; it starts 130 m E from the Thier de Huy along the S edge of Bois aux Guisses ; at the top of ravine the Devonian sandstone, shales and limestone are found on top of the Silurian ; dir. & dip : -7 m under the plateau : N65°E 27°S , cleavage : N59°E 74°N ; -23 m under the plateau : N74°E 30°S , cleavage : N42°E 71°N ; at the base of the outcrops : N77°E 26°S , cleavage : N68°E 71°N ; 38.6 m of section is present and described ; micropal. Nr. JD-2/1, 56, 117, 124, 152 : see detailed log description (p. 109-110).

JD-3 : Fumal-Bois aux Guisses : long outcrop in both sides of a deep ravine, with at -0.5 to -7 m under the plateau: 10 m Devonian rocks and from -7 to -50 m under the plateau Silurian rocks ; some 80 m of section is present : only the sections not described in JD-1 and JD-2 are described here ; the upper entrance is at 260 m to the E of Thier de Huy along the upper (S) edge of Bois aux Guisses ; dir. & dip : at the top : N70°E 31°S, cleavage : N75°E 65°N ; in the middle : N70°E 27°S , cleavage : N68°E 67°N ; at the base of the outcrops : N70°E 27°S , cleavage : N64°E 62°N ; micropal. Nr. JD-3/29 taken at the top of section, just under the Devonian rocks ; see detailed log description (p. 108,110).

CE-12: see CD-17.

DE-3 : Oteppe-Vissoul : loose pieces of sandstone on the field W of the road, 270 m N of "Cabaret au Congo".

EE-2 : Oteppe-Vissoul : loose pieces of sandstone on the field E of the road, 200-250 m SW of Chapel St. Donat.

IE-22: Fallais-Pitet : in a temporary trench, for the construction of a pipeline (1975) over 330 m distance, Silurian rocks were cut ; starting from the road from Point-du-Jour to Fumal eastwards : between 40 m and 120 m the limit between members MB3E and MB4A ; at 320 m still member MB4B ; about 100 m of section is present ; at 35 m N19°W 10°W ; at 120 m : 20°E dip ; at 135 m the axe of a small anticline : at 140 m : N36°E 27°W ; at 180 m N31°E 15°W ; at 230 m N31°E 23°W.

IF-11: Fallais-Pitet-Bois Cornet : old quarry at the entrance of Bois Cornet, NE of the road ; 450-500 m SE of the castle-farm of Pitet ; often studied earlier ; 25 m of section present and described ; dir. & dip : N64°E 61°S ; micropal. Nr. IF-11/C1 and IF-11/C3 : see detailed log description (p. 98).

IF-12: Fallais-Pitet : outcrop on the S side of a road-cut in the road to Fumal at 260 m SE of the bifurication near the sawmill.

IF-13: idem at about 180 m SE from bifurcation.

IF-14; idem at about 120 m SE from bifurcation.

IF-15: idem at about 60 m SE from bifurcation : IF-12 to IF-15 show all the coarse grained volcano-sedimentary layer of Pitet.

IF-20: Fallais-Pitet : temporary trench for the construction of a pipeline (1975), over 45 m length, between the road Pitet-Fumal and the railway at 340 m SE of the bifurcation near the sawmill ; dir. & dip : near railway : N43°E 58°SE ; in the middle ; N50°E 43°SE ; near the road : N67°E 67°S.

JF-1 and JF-2 : Fallais-Pitet-butte Saint-Sauveur : all around this small hill, with on top the archeological site of the chapel of Saint-Sauveur (gallo-roman, franco-merovingic), there are outcrops and old quarries, with one large quarry on the S side (JF-2) ; only the volcano-sedimentary layer of Pitet is found here ; often studied earlier (see p. 10-12) ; DE PAUW (1971) established the dip and strike by grainsize analysis and we conclude that the "butte" is formed on the center of a broad anticline with axe dipping to the SW.

JF-3 : Fallais-Pitet-Les Falihottes : Chemin de Westa : outcrop in the N slope of a road-cut 320 to 570 m W of the bridge of the Mehaigne near the castle-farm of Pitet ; from 100 to 170 m from the beginning of the road (going uphill) : fine to medium grained volcano-sedimentary layer of Pitet ; from 170 to 250 m the grainsize increased ; no contacts found; dip probably to NNW.

JF-4 : Warnant-Dreye-Bois Robert : outcrop in NE slope of road-cut of the "Grand Route" between the side road to Vaux-et-Borset and the side road to Dreye ; weathered slates of Bois Cornet, upper part of the volcano-sedimentary layer of Pitet.

JF-5 : Warnant-Dreye-Bois Robert : outcrop in S slope of road-cut of the beginning of the road to Vaux-et-Borset (via the plateau) at 0 to 20 m E of the "Grand Route" ; weathered slates of Bois Cornet, upper part of the volcano-sedimentary layer of Pitet ; dir. & dip : N73°E 27°S.

JF-6 : Warnant-Dreye-Bois Robert : loose pieces of slates in the N slope of the road-cut of the road to Dreye at 35 m from the "Grand Route" ; shales of probably member MB3E.

JF-7 : Warnant-Dreye-Bois Robert : outcrop in the N slope of the road-cut of the road to Dreye at 80 m from the "Grand Route" ; probably member MB3E.

JF-12: Fallais-Pitet-Les Falihottes : chemin de Westa : loose pieces of the volcano-sedimentary layer of Pitet on the field N of the chemin de Westa, at 160 to 200 m from the beginning of the road ; see JF-3.

JF-18: Fallais-Pitet & Fumal-Bois du Tier à Mehaigne : temporary trench, (July 75) 825 m long, for the construction of pipeline ; starting from the "Grand Route" Huy-Hannut at Km 9.770 and going westwards to the valley bottom 250 m SE of the quarry of Bois Cornet (IF-11) ; at 65 m : N60°E 49°SE ; at 80 m : curve to N79°W ; with relatively thick Td division ; at 126 m : end of Mesozoic cover : height 152 m ; dir. & dip : N55°E 55°S ; at 290 m : corner of wood : dir. & dip : N57°E 60°S : between 80 and 126 m very thick sequences with relatively thick Td divisions ; between 126 and 225 m : very thick sequences (up to 60 cm ; between 325 and 332 m (second corner of wood) thick to medium thick sequences ; around 420 m transition of formations MB5 to MB4, which continues up to 748 m (last point where Silurian rocks were seen in the trench) ; graptolites in member MB4B between 420 to 520 m ; thick quartzitic sandstones (Tb, Tc and Td divisions) between 486 and 526 m ; at 523 m : dir. & dip : N52°E 55°S.

KF-1 : Warnant-Dreye : slope in a wood about 100 m SW of the confluence of the "Ruisseau de Dreye" and "Ruisseau des Etangs" : loose pieces of the volcano-sedimentary layer of Pitet, spread out over the slope.

KF-9 : Warnant-Dreye : SW of Ferme de Chantraine, along the road to KF-2 at 75 m S of the "Ruisseau of Dreye" : small borehole (1,2 m) with Silurian chloritic shale at the bottom.

HG-1 : Fallais-South : outcrops of hard rocks in meadow 420 m E of "Ferme du Bocha", 20 to 40 m SE of the "Ruisseau de Bocha" : 5 m section of the top part of the volcano-sedimentary layer of Pitet : the so-called slate of Bois Cornet ; the coarse grained part was not seen in outcrop but loose pieces of it were found in the meadow ; dir. & dip : N70°E 53°S.

HG-3 : Fallais-South : outcrop in W slope in the curve of the road Fallais to Marneffe at the intersection to the "Ferme du Bocha", near the houses called "Les Vieilles Mohones"; dir. & dip : N66°E 36°S , cleavage : N80°W 68°N.

HG-19: Fallais-South : place of an old outcrop in both slopes of a hollow road about 250 m SW of the castle of Fallais, at 30 to 100 m NW of the crossing with the road Fallais to Marneffe ; in these slopes earlier authors might have found the volcano-sedimentary layer of Pitet.

IG-7 : Fallais : place of old outcrops in the SE slopes behind the house along the road Fallais-Pitet described by DE LA VALLEE-POUSSIN & RENARD, 1896,

p. 7-10 ; the volcano-sedimentary layer of Pitet with upper and lower contact was observed in these times.

IG-8 : idem, about 100 m more to the E.

IG-10: idem, about 400 m W of the "Grande Route" at Km 11.000.

IG-11: Fallais-center : old borehole (1927) for water, described by HALET (1936) in the dossier of the Geological Survey of Belgium (Nr. 341) : 2 m of quartzitic rocks are described in between shales.

IG-12: idem, old borehole more near the station : in the dossier of the Geological Survey of Belgium (Nr. 429) : description of some quartzitic rocks in the borehole.

IG-13: Fallais-Pitet : outcrop in a slope behind chapel at 150 to 200 m ENE of the watermill of Pitet, described by previous authors : DUMONT, 1848, p. 309 ; DE LA VALLEE-POUSSIN & RENARD, 1890, p. 7-10 ; Nr. 242 in the dossier of the Geological Survey of Belgium.

IG-14: idem, an outcrop in a N-S directed slope more to the NE ; Nr. 243 in the dossier of the Geological Survey of Belgium.

JG-3 : Warnant-Dreye-Bois Robert : outcrop in the NE slope along main road Huy-Hannut between Km 10.730 and 10.795 in front of the houses Nr. 182 and 183 ; to the NW the coarse and medium grained volcano-sedimentary layer of Pitet ; to the SE the fine grained part ; the lower limit is situated just between the houses Nr. 182 and 183, or a little to the SE of it.

JG-4 : Warnant-Dreye-Bois Robert : outcrop in the N slope of the small side road to Vaux-et-Borset ; east of a stone wall over 10 m : fine grained volcano-sedimentary layer of Pitet.

KG-9 : Warnant-Dreye : at the confluence of the "Ruisseau de Dreye" and the "Ruisseau des étangs" : loose pieces of the volcano-sedimentary layer of Pitet.

KG-10: Warnant-Dreye : slope at 40 m SW of the confluence of the "Ruisseau de Dreye" and the "Ruisseau des étangs" : loose pieces of the volcano-sedimentary layer of Pitet.

LG-7 : Warnant-Dreye-Au Châpin : temporary trench for the construction of pipeline (1973), directed N60°W, parallel and 100-150 m SW of the "Ruisseau de Narmea" ; north of the road from Dreye to Vaux : fine and coarse grained volcano-sedimentary layer of Pitet ; SE of the road : fragments of the very fine volcano-sedimentary layer of Pitet (slate of Bois Cornet) ; than for 300 m to the SE : chloritic slate pieces, with at the end (SE) quartzitic rocks (formation MB4).

FH-3 : Braives-Au-Tombu : site of an old quarry, 150 m S of railroad Km 16.600, described by MALAISE, 1873, p. 39 : "coarse, gray-blue slates with a earthen aspect, easily destroyed, with colour turning greyish or yellowish when weathered".

FH-9 : Braives-Au-Tombu : N slope of railroad-cut around Km 16.600 ; described earlier by the dossier of the Geological Survey of Belgium (Nr. 225) and FOURMARIER, 1920, p. 47 ; our micropal. sample Nr. FH-9 comes from 37 m W of the road crossing near the station.

GH-2 : Latinne : loose pieces of slate in both slopes of railroad-cut between

Km 18.360 and 18.470 ; outcrops described earlier in the dossier of the Geological Survey of Belgium (Nr. 227) ; our micropal. sample Nr. GH-2 comes from Km 17.430.

GH-4 : Latinne-Hosdin : west of Les Ruelles : outcrop in W slope of a curved road-cut, near Km 17.750 of the railway ; more than 5 m section is present ; dir. & dip : N70°E 31°N.

GH-14: Latinne : loose pieces in slope of meadow, 80 m E of bridge over the Mehaigne (road Latinne-center to Les Ruelles), at a few meter from the valley bottom ; micropal. Nr. GH-14.

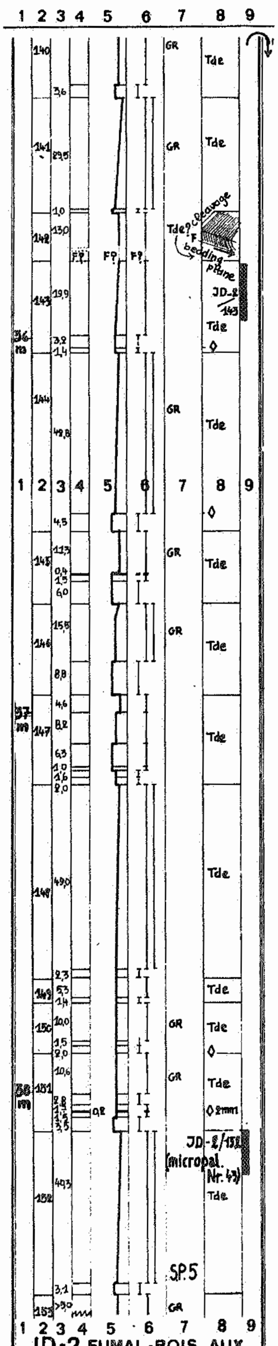
HH-2 : Latinne-Hosdin : outcrop in SE slope of road-cut about 100 m E of watermill ; dir. & dip : N51°E 55°S.

HH-4 : Latinne-Hosdin : outcrop between the two roads of a bifurcation, 100 m SW of the watermill ; dir. & dip : N57°E 65°S.

EI-12: Braives, near Moulin Velu Pont (Avennes) : loose pieces of slate found next to an uprooted tree in a small wood, 15 m NW of the SE most corner of the wood and 3 m NE of the meadow in the valley bottom ; about 310 m SE of the watermill of Velu Pont ; micropal. sample Nr. EI-12A.

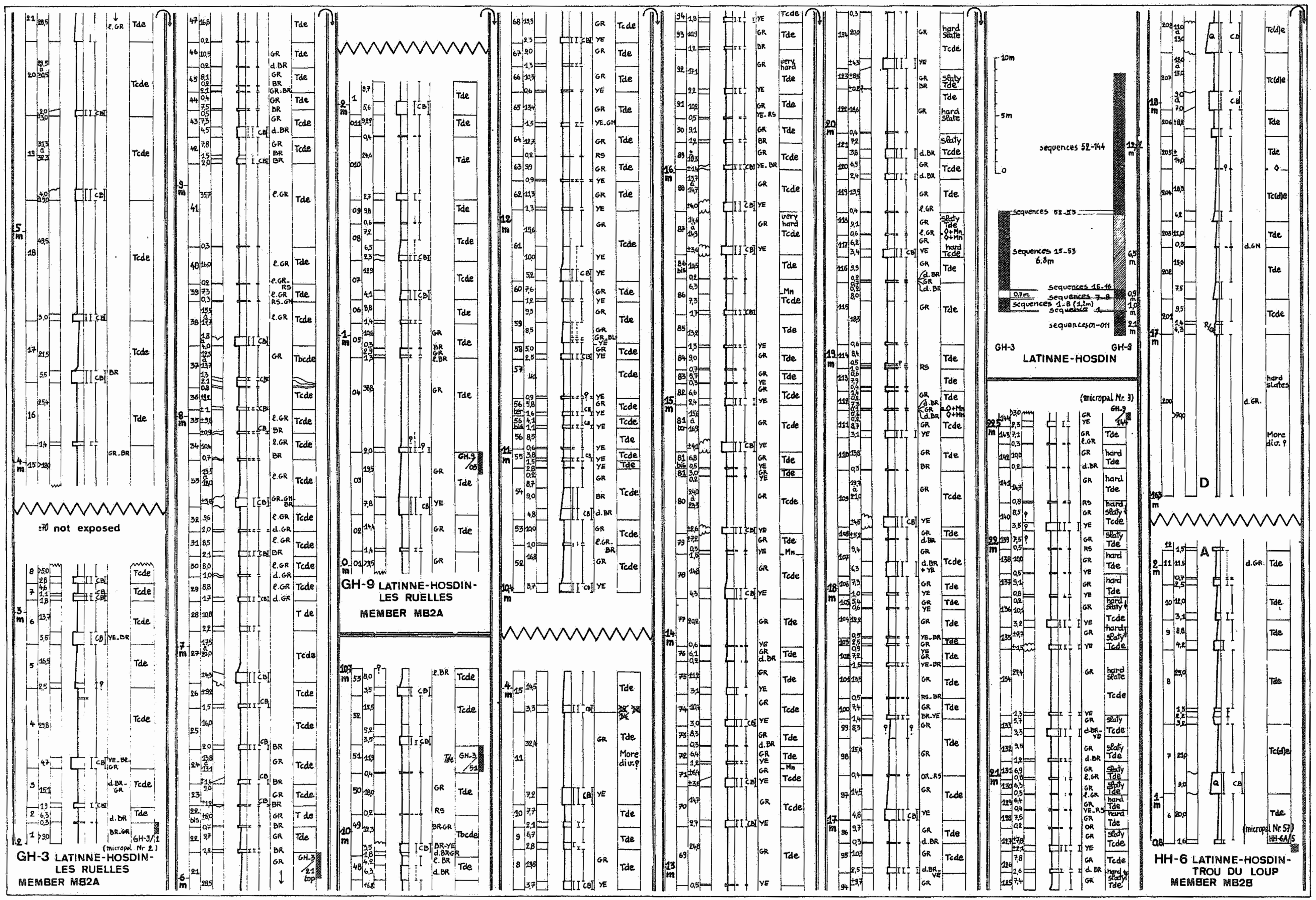
Appendix 2 : Detailed log descriptions

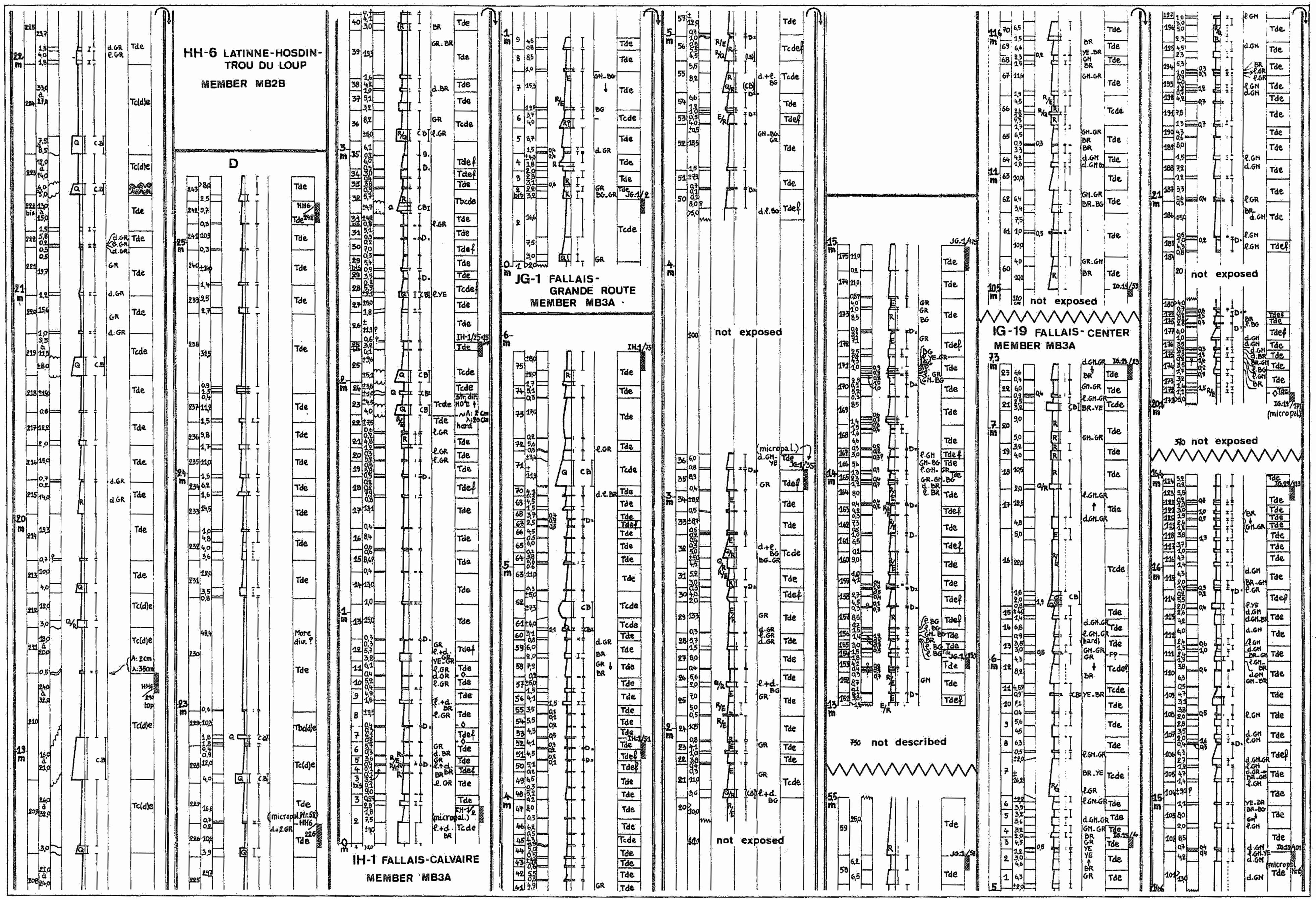
In the following 22 pages (p. 96-117) the sedimentological and petrographical features of some 600 m of sections are described in detail. Each column reads from bottom to top and from left to right. At the base of each section the number of outcrop and section is given, the name of the commune from before the 1978 fusion of communes, plus the local name(s), the lithostratigraphic unit and sometimes the sequential pattern.
The description is given in nine subcolumns and on scale 1/20. When unclear the features is put between brackets : e.g. : (C.B.) ( ); when doubtful, a question mark is used.

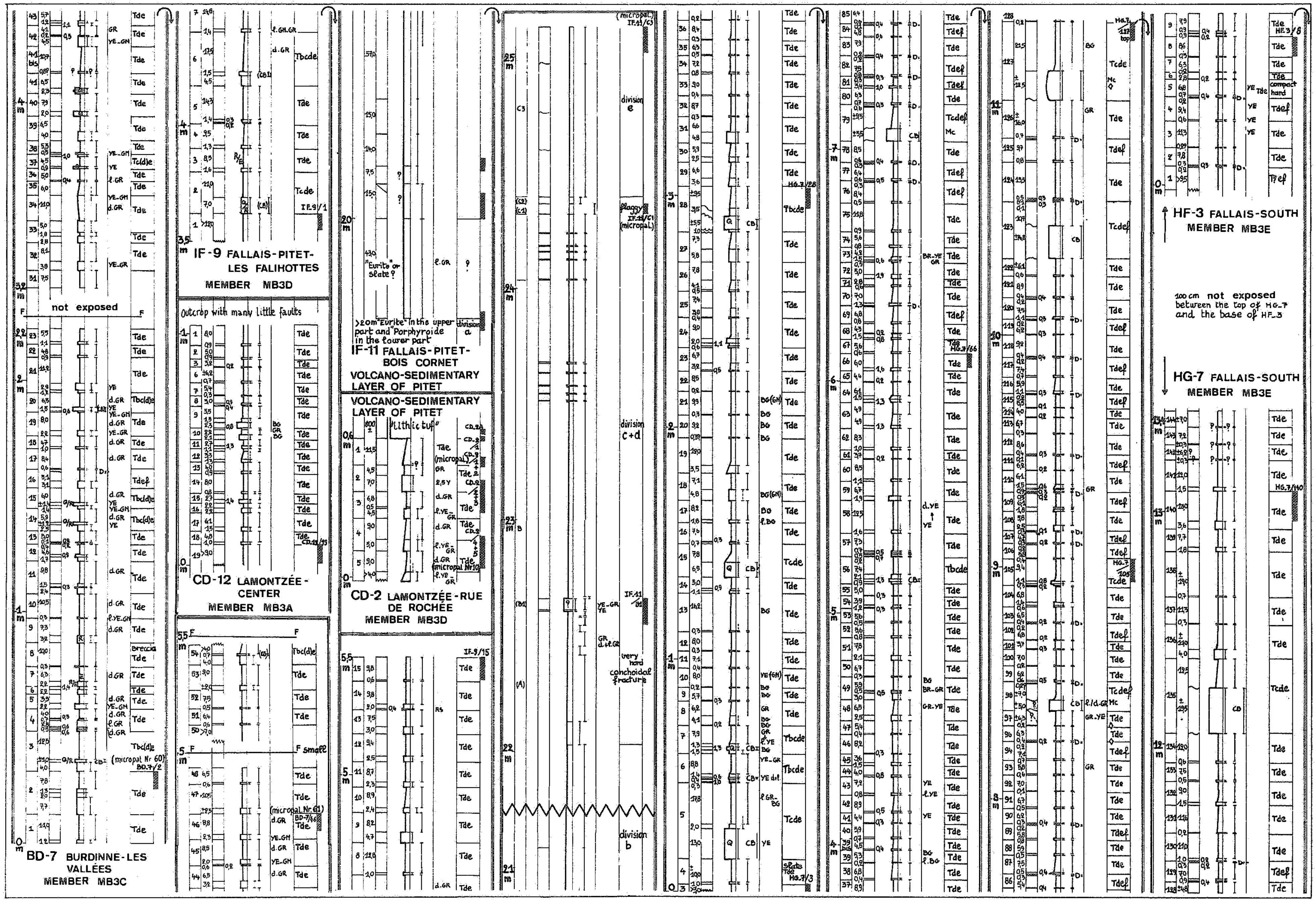


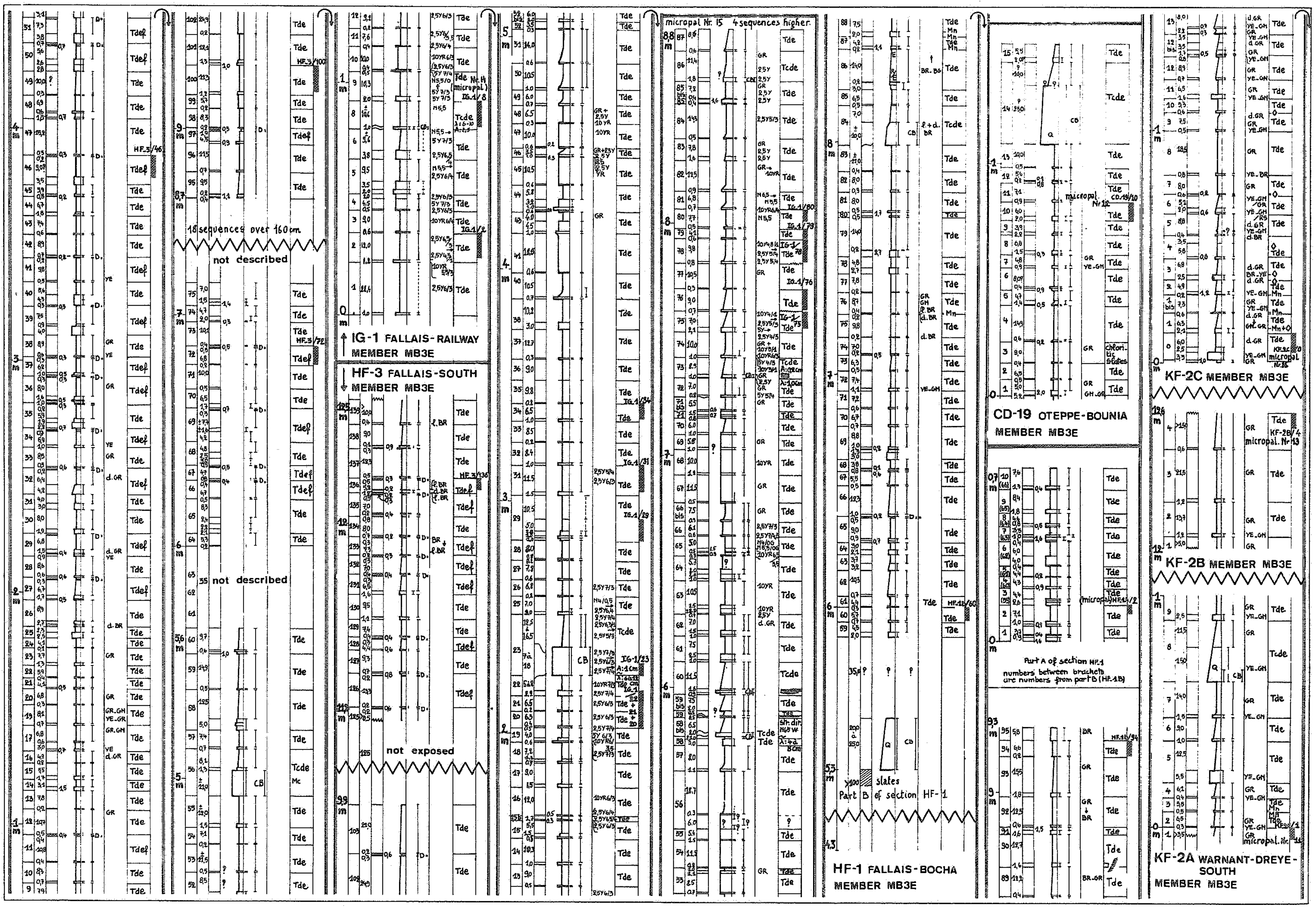
JD-2 FUMAL-BOIS AUX GUISSES
FORMATION MB7
sequential patterns 5,6,7

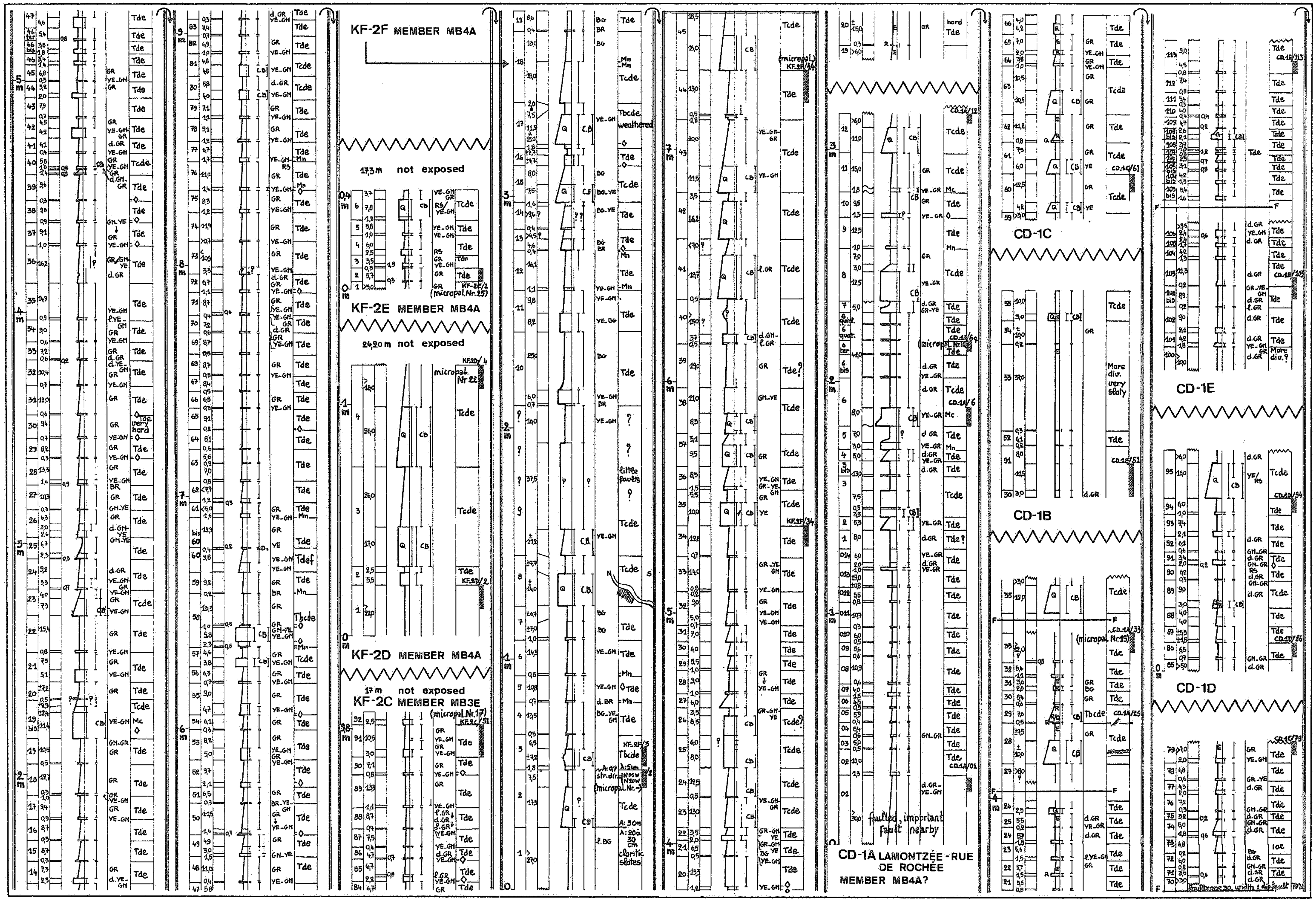
1) cumulative thickness in meters, with every meter marked.
2) number of each (turbidite) sequence.
3) thickness of each division or subdivision of a sequence in centimeter (cm).
4) representation of the different layers in the column, with indication of thinning or wavy layers.
5) relative estimation of the granulometry of the rock: far left : fine sandstone ; middle left : very sandy slate ; middle : sandy slate ; middle right : silty slate ; right : clayey slate. Sometimes the proportion of the grains to the matrix is given : E : empatic ; R : reticulate ; Q : quartzitic (see MICHOT, 1958; p. 13-15).
6) sedimentological features of each layer : far left (▦) very fine lamellation (4-10 lamellae per mm) ; middle left : (≣) fine lamellation (1-3 lamellae per mm) ; middle : (☐) compact sedimentation ; middle right : (⋯) obvious graded bedding ; far right : (C.B.) convolute lamellation, current ripple lamellation, finely crossbedded lamellation (⋘) ; far right : (D) dark layer (f-division, see p. 18).
7) colour of the unweathered rock :
   GR : gray RS : rusty
   GN : green OR : orange
   YE : yellow YE-GR : yellowish-gray
   BR : brown d. : dark
   BG : beige l. : light
   Sometimes the colour are given according to the International Soil colour chart used for colourdescription in pedology; e.g. : 2,5Y or 2,5Y 7/5
8) Tbcde(f), Tcde(f), Tde(f) : type of (turbidite) sequence
   - ◊◊ : level with pyrite cubi (not always marked)
   - Mn : level with Manganese oxides
   - Mc : level with mica
   - λ : dimensions of current riple : longitude (wave-length) in cm
   - A : dimensions of current riple : amplitude in cm
   - dir. N60°E : direction of turbidity current, deduced from ripple mark direction (see p. 45, 47)
   - S.P. 5 : sequential pattern 5
   - indication of slaty or hard appearance ; or, if doubt exists that more sequences might occur : (more div.?).
9) localization in column of the samples taken to the lab, with sample number and mentioning if used for micropaleontology (e.g. : micropal. Nr. 43).
- Contination upwards of a section is always at the bottom of next column to the right.

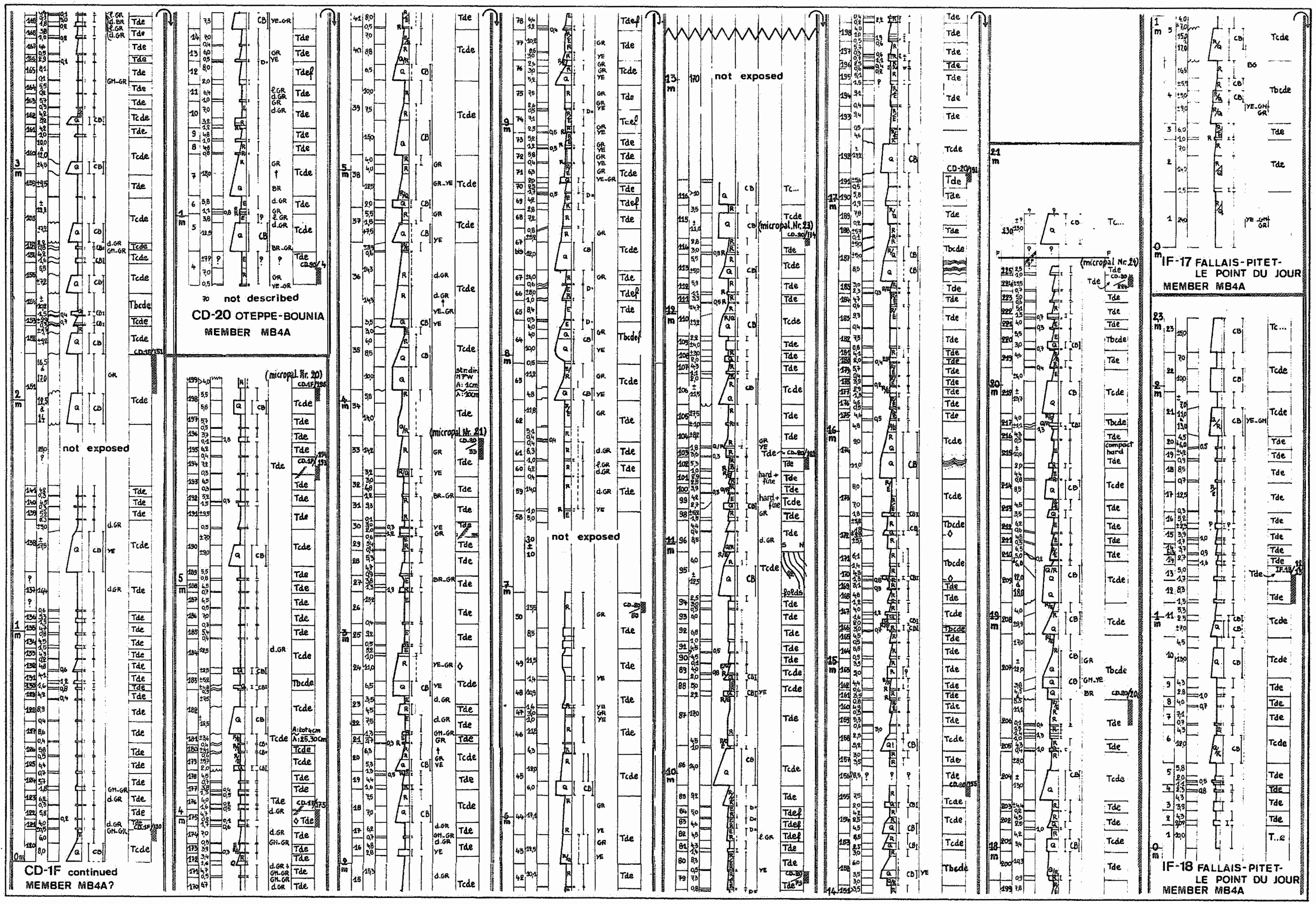

GH-3 LATINNE-HOSDIN-LES RUELLES
MEMBER MB2A
GH-9 LATINNE-HOSDIN-LES RUELLES
MEMBER MB2A
HH-6 LATINNE-HOSDIN-TROU DU LOUP
MEMBER MB2B
GH-3 GH-8
LATINNE-HOSDIN
sequences 52-144
sequences 52-53
sequences 15-53
6.8m
sequences 15-16
sequences 7-8
sequences 1-8 (1.1m)
sequences 4
sequences 01-011
10m
5m
0
not exposed
(micropal Nr. 3)
(micropal Nr 2)
(micropal Nr 57)

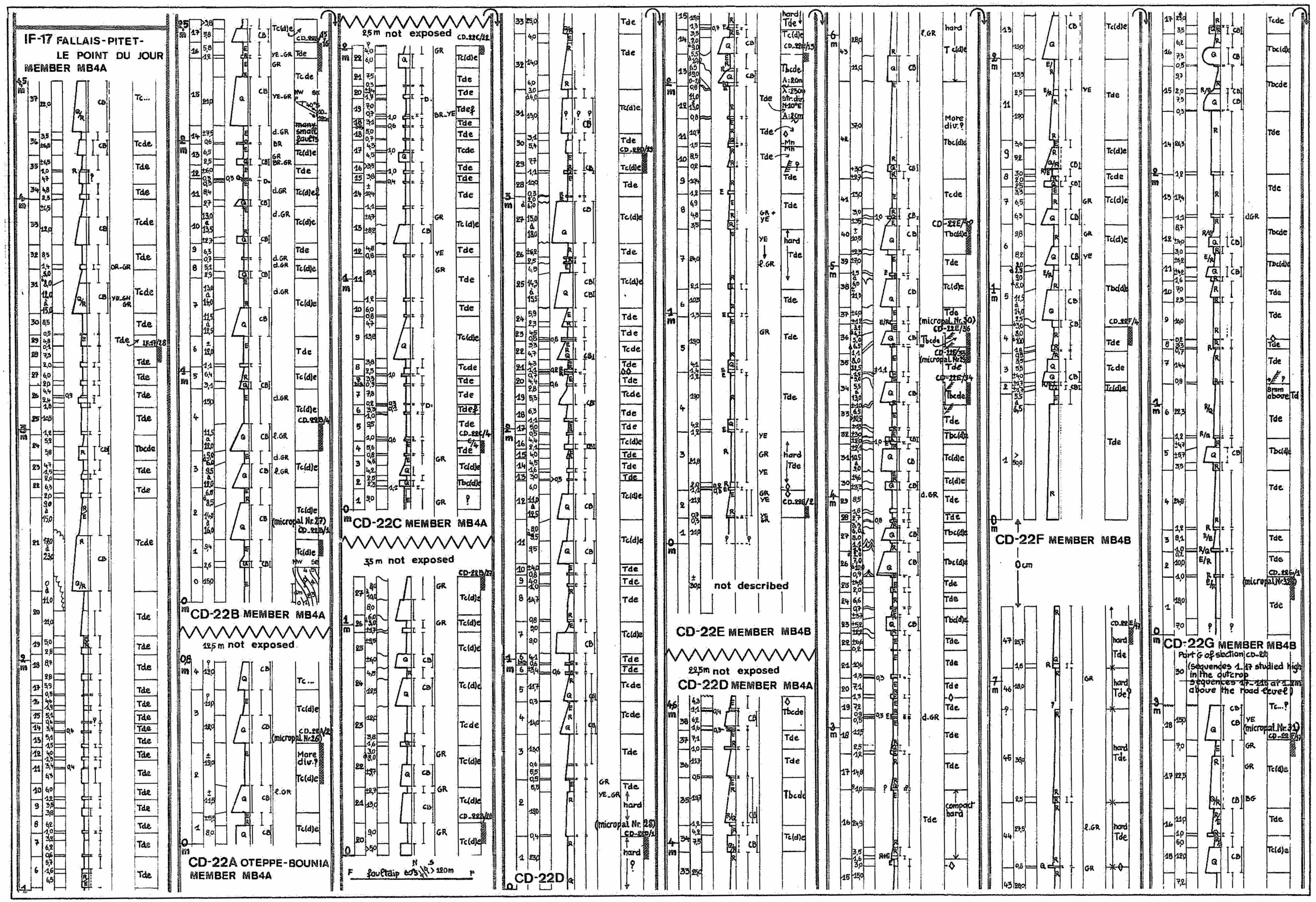

HH-6 LATINNE-HOSDIN-TROU DU LOUP
MEMBER MB2B
D
JG-1 FALLAIS-GRANDE ROUTE
MEMBER MB3A
IH-1 FALLAIS-CALVAIRE
MEMBER MB3A
IG-19 FALLAIS-CENTER
MEMBER MB3A
not exposed
not described

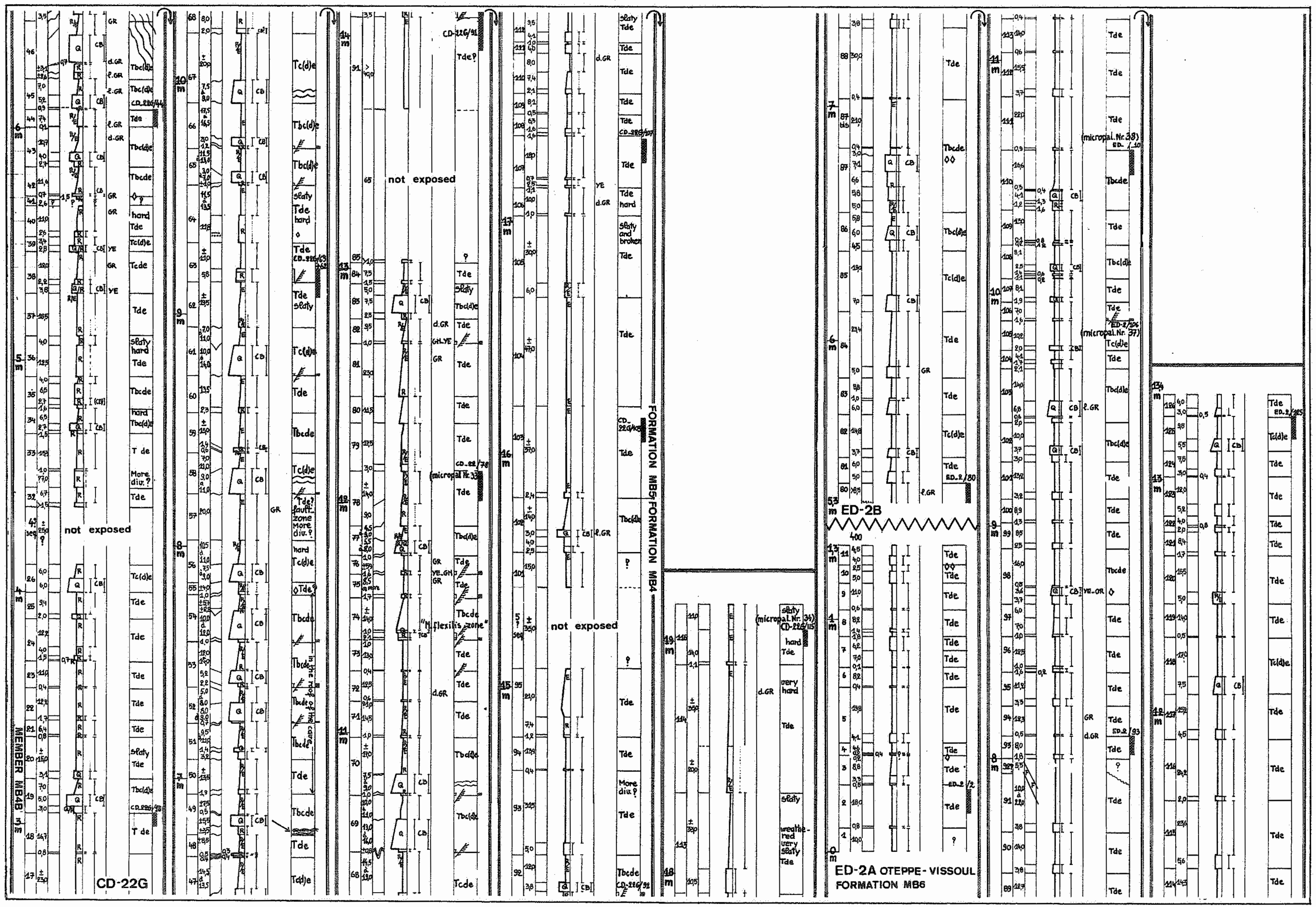

BD-7 BURDINNE-LES VALLÉES
MEMBER MB3C
not exposed
IF-9 FALLAIS-PITET-LES FALIHOTTES
MEMBER MB3D
Outcrop with many little faults
CD-12 LAMONTZÉE-CENTER
MEMBER MB3A
>20m "Eurite" in the upper part and "Porphyroide" in the lower part
IF-11 FALLAIS-PITET-BOIS CORNET
VOLCANO-SEDIMENTARY LAYER OF PITET
VOLCANO-SEDIMENTARY LAYER OF PITET
"Lithic tuf"
CD-2 LAMONTZÉE-RUE DE ROCHÉE
MEMBER MB3D
division e
division c+d
division a
division b
very hard conchoidal fracture
HF-3 FALLAIS-SOUTH
MEMBER MB3E
100 cm not exposed between the top of HG-7 and the base of HF-3
HG-7 FALLAIS-SOUTH
MEMBER MB3E


IG-1 FALLAIS-RAILWAY
MEMBER MB3E
HF-3 FALLAIS-SOUTH
MEMBER MB3E
18 sequences over 160 cm
not described
not described
not exposed
micropal Nr. 15 4 sequences higher
HF-1 FALLAIS-BOCHA
MEMBER MB3E
Part B of section HF-1
slates
CD-19 OTEPPE-BOUNIA
MEMBER MB3E
Part A of section HF-1
numbers between brackets
are numbers from part B (HF-1B)
KF-2C MEMBER MB3E
KF-2B MEMBER MB3E
KF-2A WARNANT-DREYE-
SOUTH
MEMBER MB3E

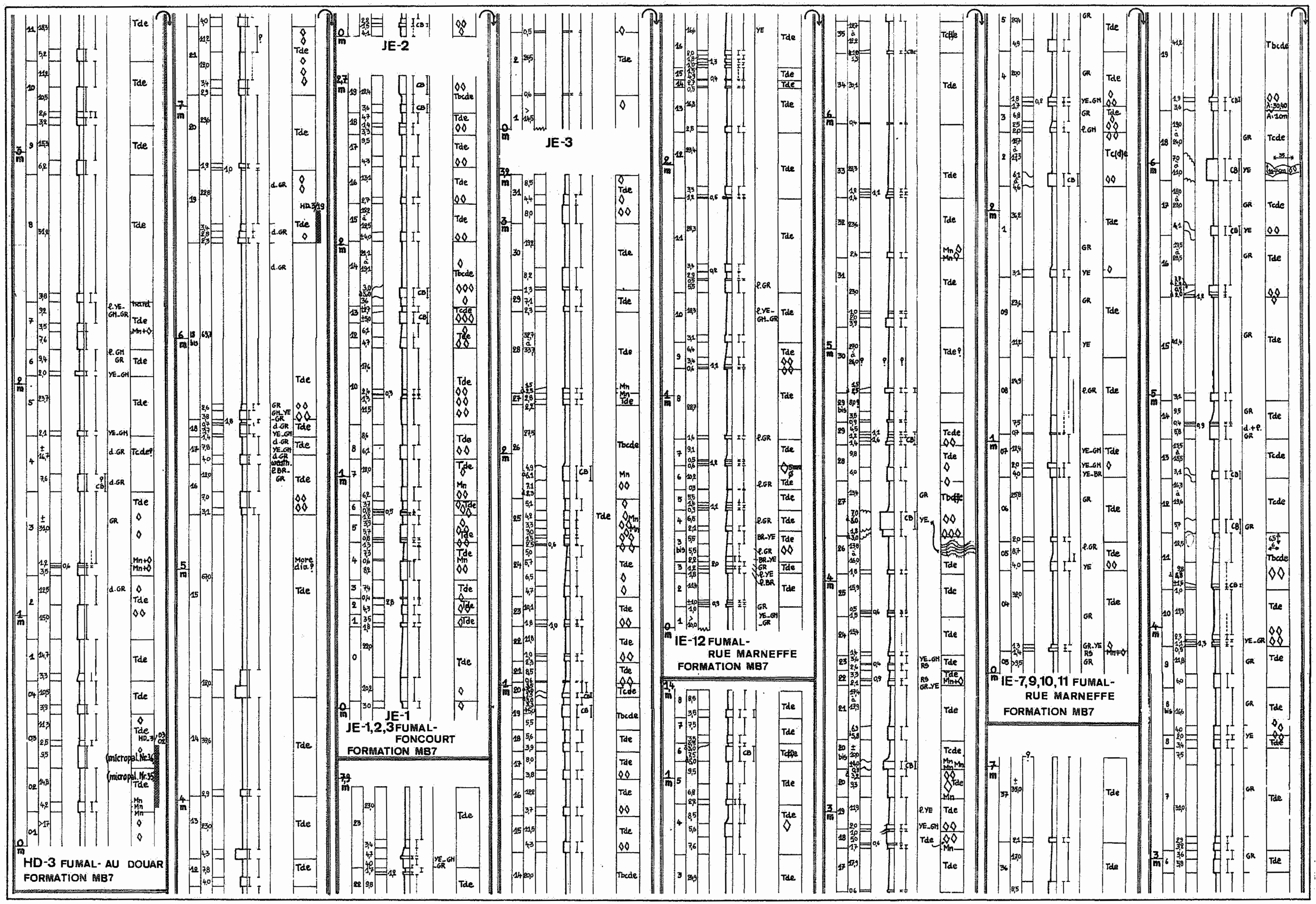

KF-2F MEMBER MB4A
17,3 m not exposed
KF-2E MEMBER MB4A
24,20 m not exposed
KF-2D MEMBER MB4A
17 m not exposed
KF-2C MEMBER MB3E
CD-1A LAMONTZÉE - RUE DE ROCHÉE MEMBER MB4A?
faulted, important fault nearby
CD-1C
CD-1B
CD-1E
CD-1D


CD-1F continued
MEMBER MB4A?
not exposed
not described
CD-20 OTEPPE-BOUNIA
MEMBER MB4A
(micropal. Nr. 20)
(micropal. Nr. 21)
not exposed
not exposed
(micropal. Nr. 23)
(micropal. Nr. 24)
IF-17 FALLAIS-PITET-
LE POINT DU JOUR
MEMBER MB4A
IF-18 FALLAIS-PITET-
LE POINT DU JOUR
MEMBER MB4A

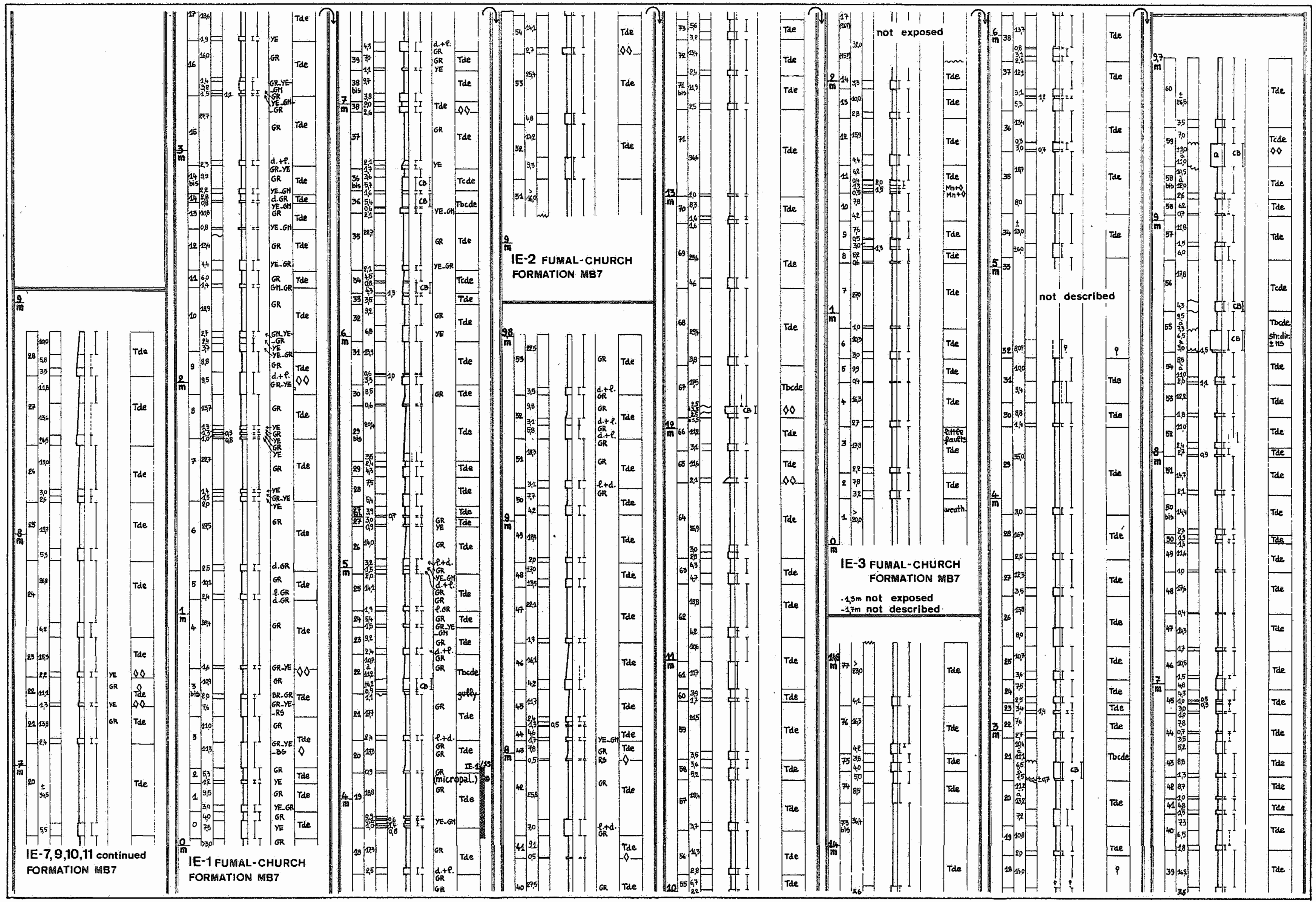

IF-17 FALLAIS-PITET-LE POINT DU JOUR MEMBER MB4A
CD-22B MEMBER MB4A
12,5 m not exposed
CD-22A OTEPPE-BOUNIA MEMBER MB4A
25 m not exposed
CD-22C MEMBER MB4A
35 m not exposed
fault dip
CD-22D
CD-22E MEMBER MB4B
22,5 m not exposed
CD-22D MEMBER MB4A
not described
CD-22F MEMBER MB4B
CD-22G MEMBER MB4B
Part G of section CD-22
(sequences 1-17 studied high in the outcrop
sequences 17-21 at 1-2 m above the road level)

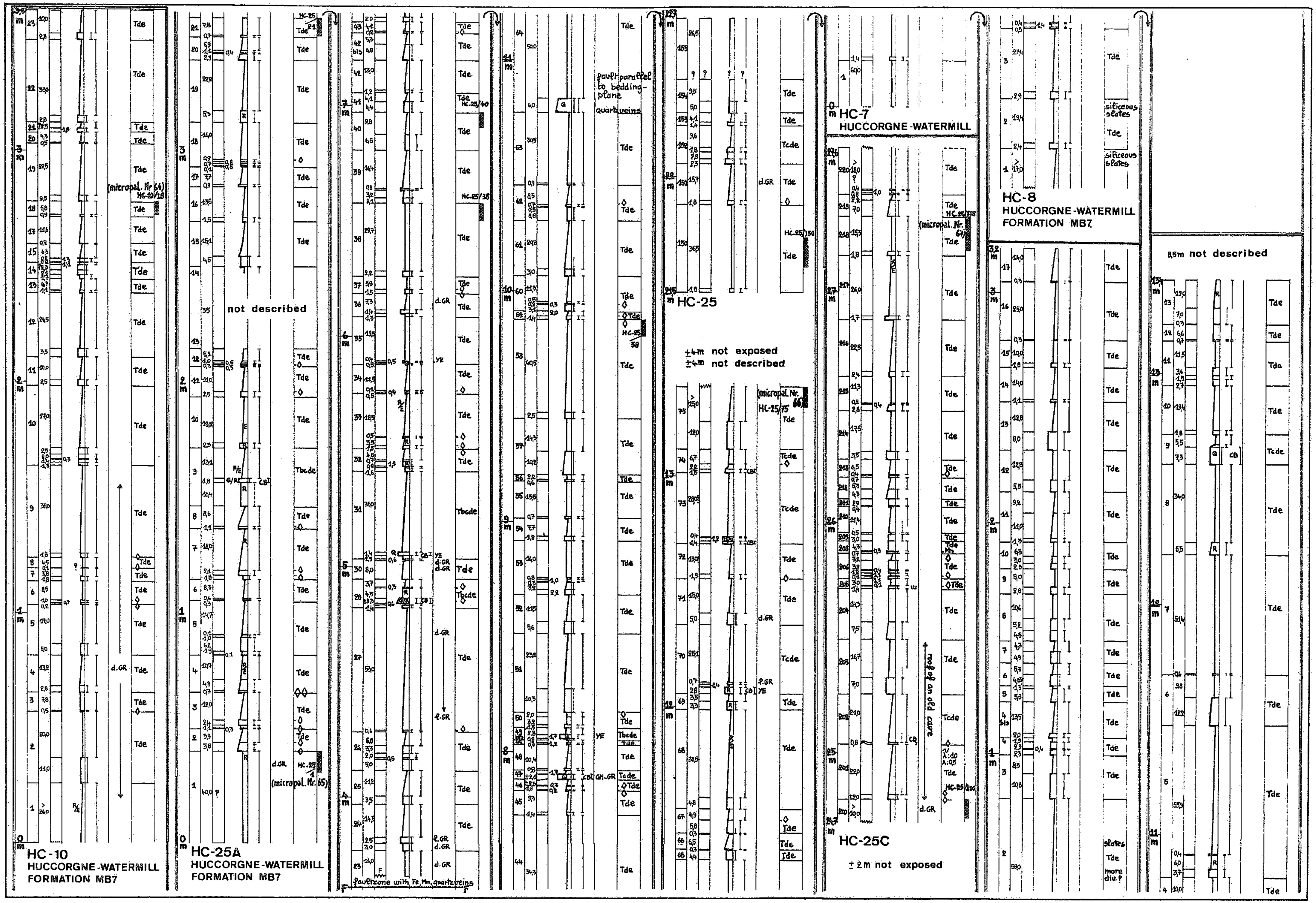


CD-22G
MEMBER MB4B
not exposed
not exposed
"N. flexilis zone"
not exposed
FORMATION MB5/FORMATION MB4
ED-2B
ED-2A OTEPPE-VISSOUL
FORMATION MB6

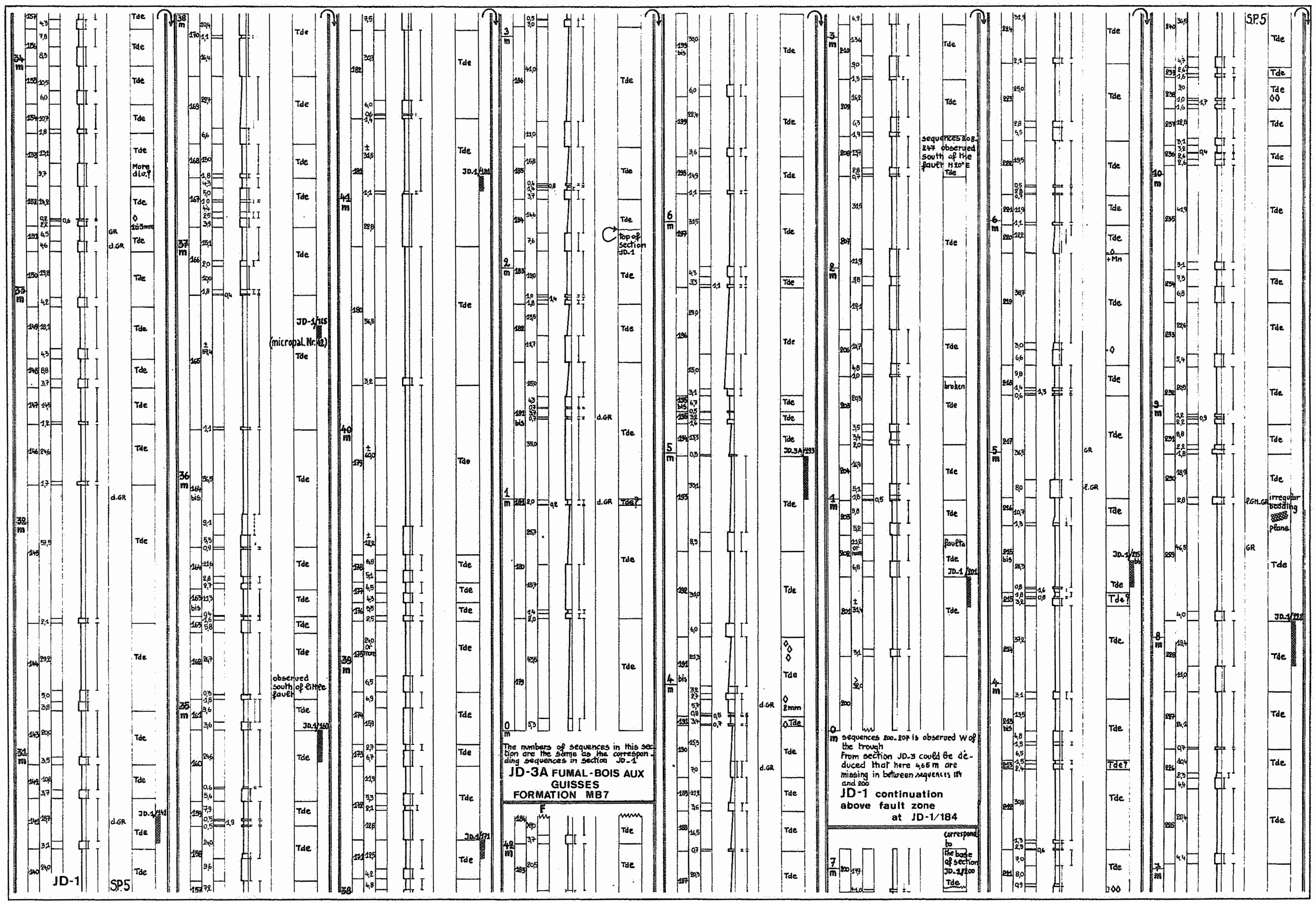


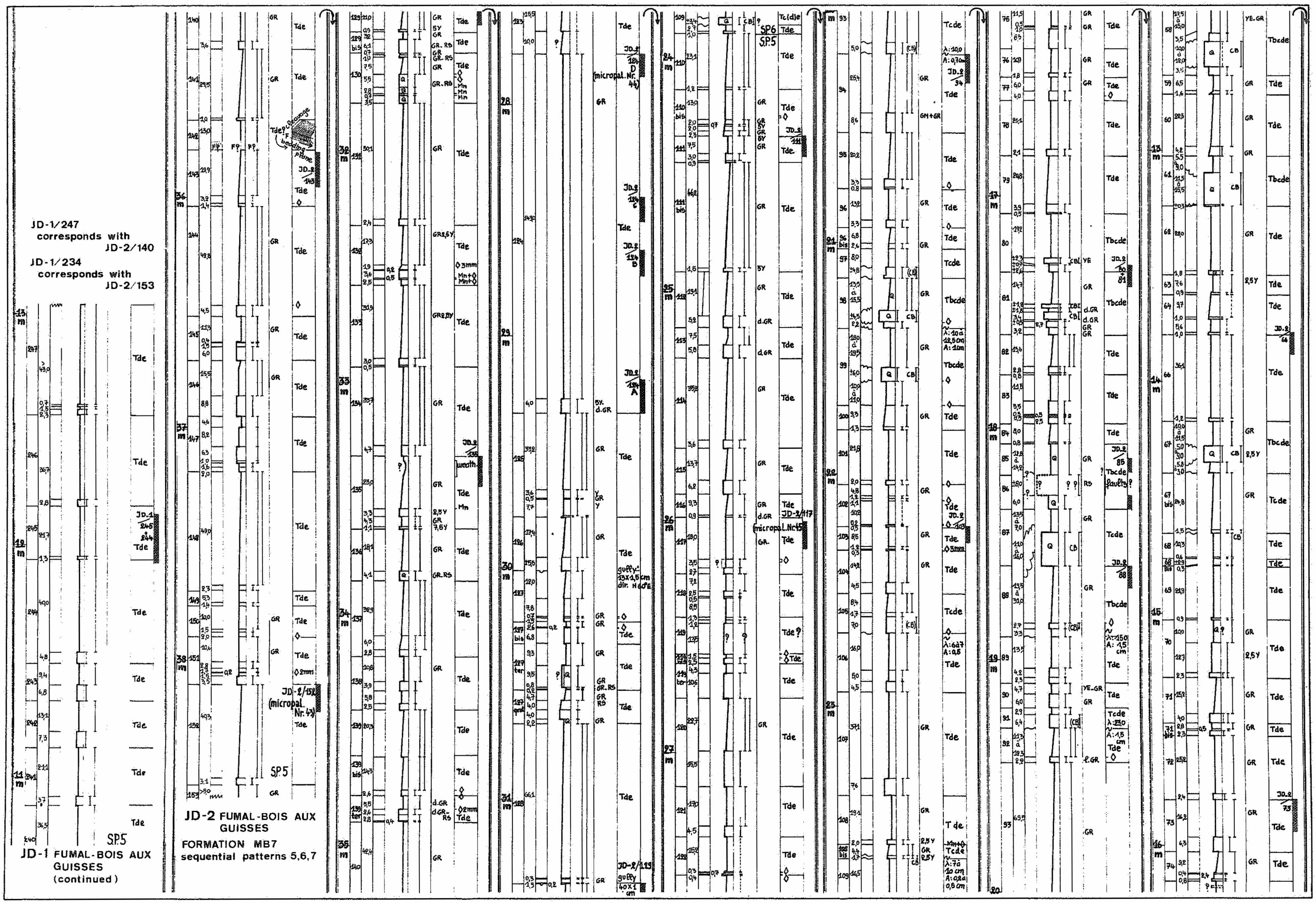
HD-3 FUMAL- AU DOUAR
FORMATION MB7
JE-2
JE-3
JE-1
JE-1,2,3 FUMAL-FONCOURT
FORMATION MB7
IE-12 FUMAL-
RUE MARNEFFE
FORMATION MB7
IE-7,9,10,11 FUMAL-
RUE MARNEFFE
FORMATION MB7

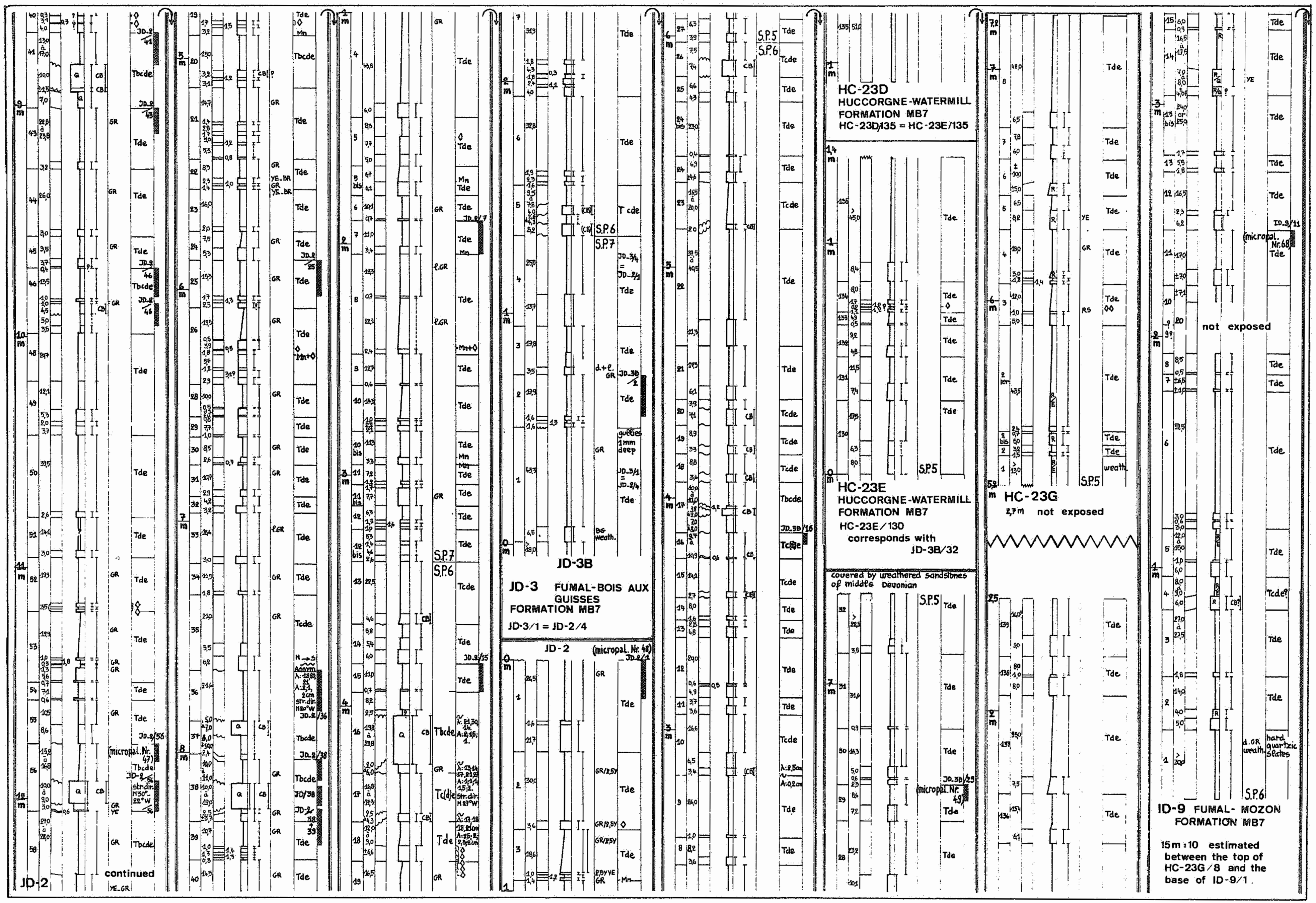

IE-7, 9, 10, 11 continued
FORMATION MB7
IE-1 FUMAL-CHURCH
FORMATION MB7
IE-2 FUMAL-CHURCH
FORMATION MB7
IE-3 FUMAL-CHURCH
FORMATION MB7
-1,3m not exposed
-1,7m not described
not exposed
not described

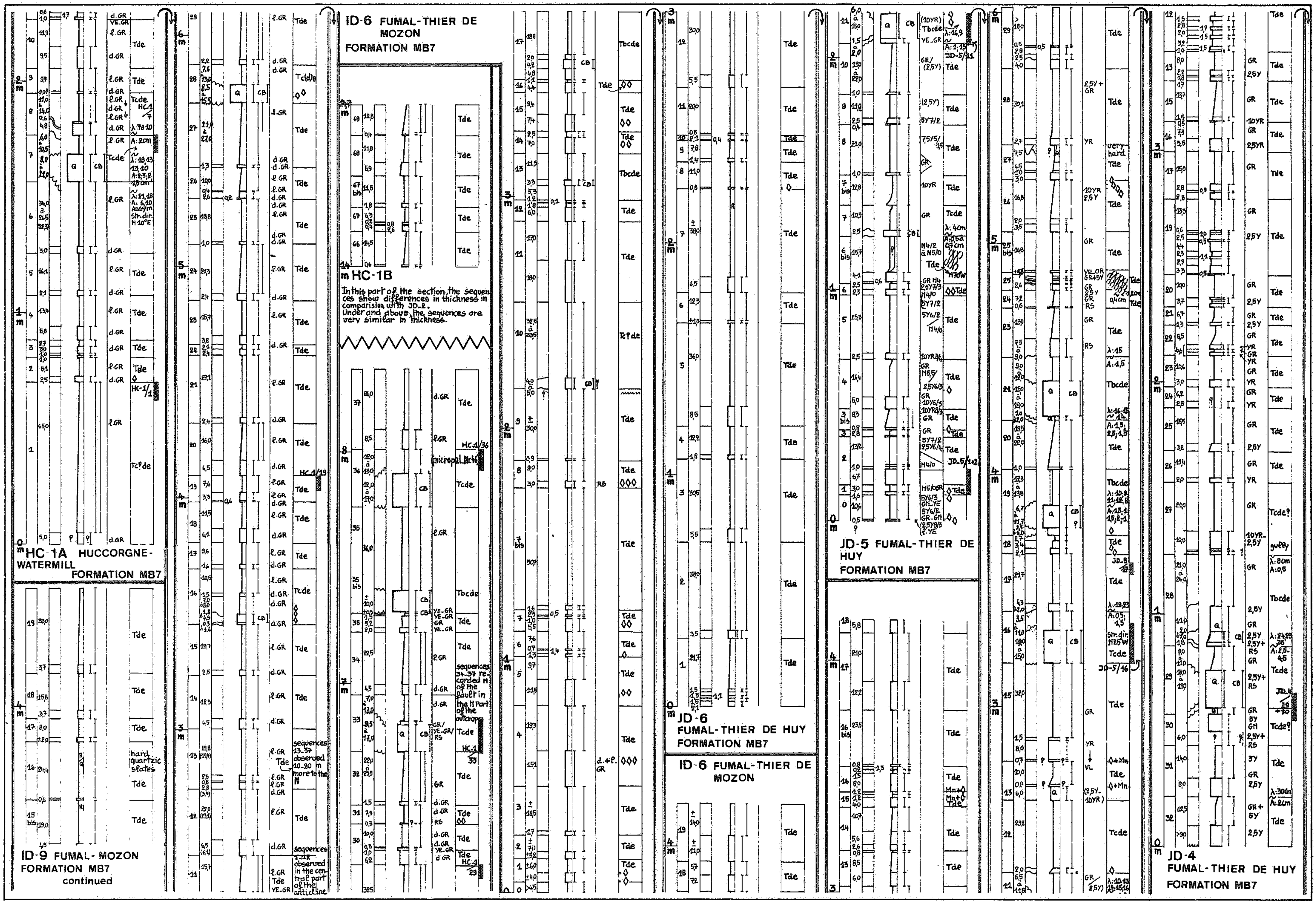

HC-10
HUCCORGNE-WATERMILL
FORMATION MB7
HC-25A
HUCCORGNE-WATERMILL
FORMATION MB7
not described
faultzone with Fe, Mn, quartzveins
fault parallel to bedding-plane
quartzveins
HC-25
±4m not exposed
±4m not described
HC-7
HUCCORGNE-WATERMILL
HC-25C
±2m not exposed
roof of an old cave
HC-8
HUCCORGNE-WATERMILL
FORMATION MB7
8,5m not described


JD-1 FUMAL-BOIS AUX GUISSES
FORMATION MB7

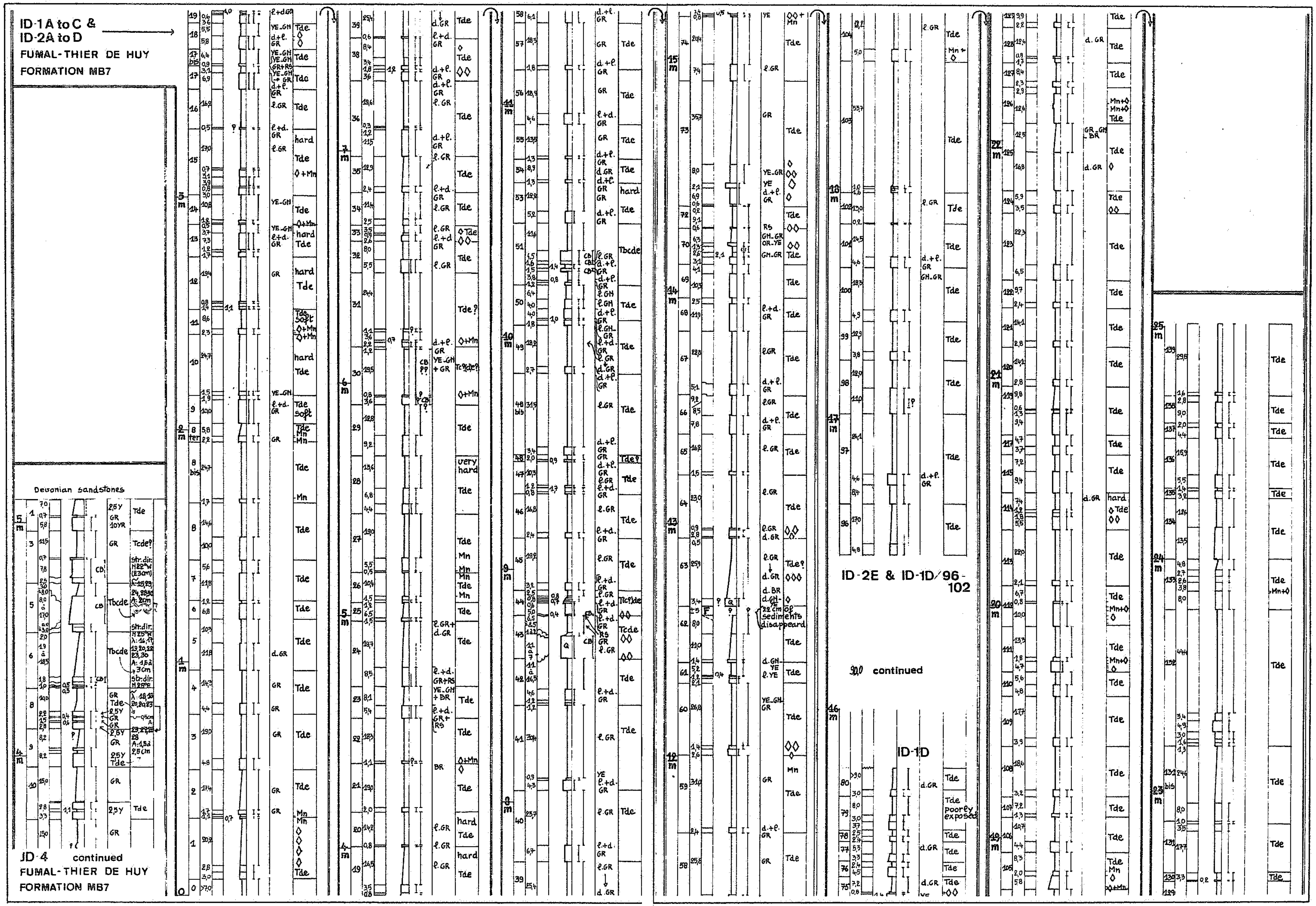

JD-1
SP5
The numbers of sequences in this section are the same as the corresponding sequences in section JD-1
JD-3A FUMAL-BOIS AUX GUISSES
FORMATION MB7
Top of section JD-1
sequences 200-207 is observed W of the trough
From section JD-3 could be deduced that here 4,65 m are missing in between sequences 184 and 200
JD-1 continuation above fault zone at JD-1/184
sequences 208-247 observed south of the fault N 20° E
observed south of the little fault
(micropal. Nr. 42)
JD-1/115
JD-1/160
JD-1/201
irregular bedding plane

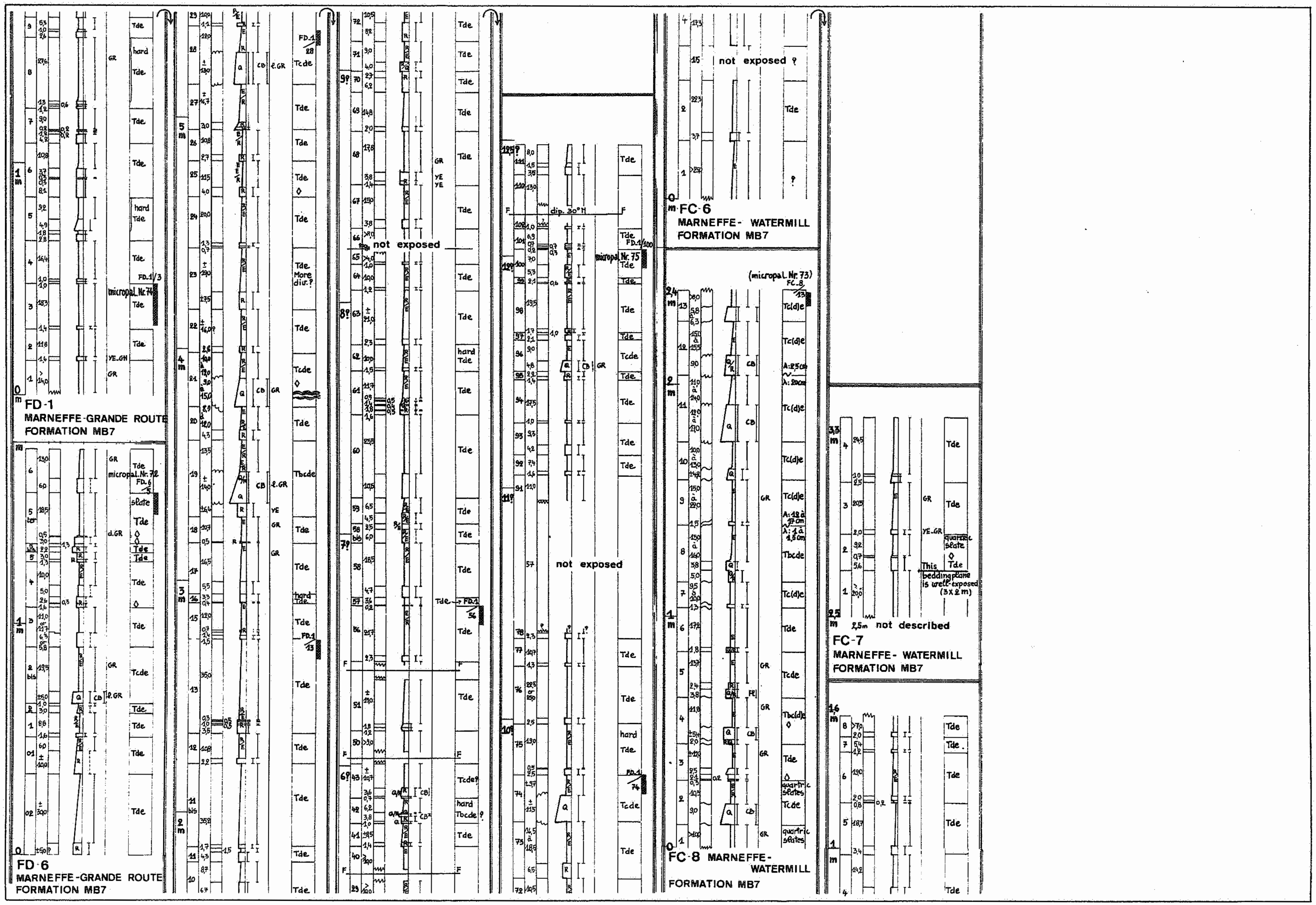

JD-1/247
corresponds with
JD-2/140
JD-1/234
corresponds with
JD-2/153
JD-1 FUMAL-BOIS AUX GUISSES (continued)
JD-2 FUMAL-BOIS AUX GUISSES
FORMATION MB7
sequential patterns 5,6,7
SP5
SP6

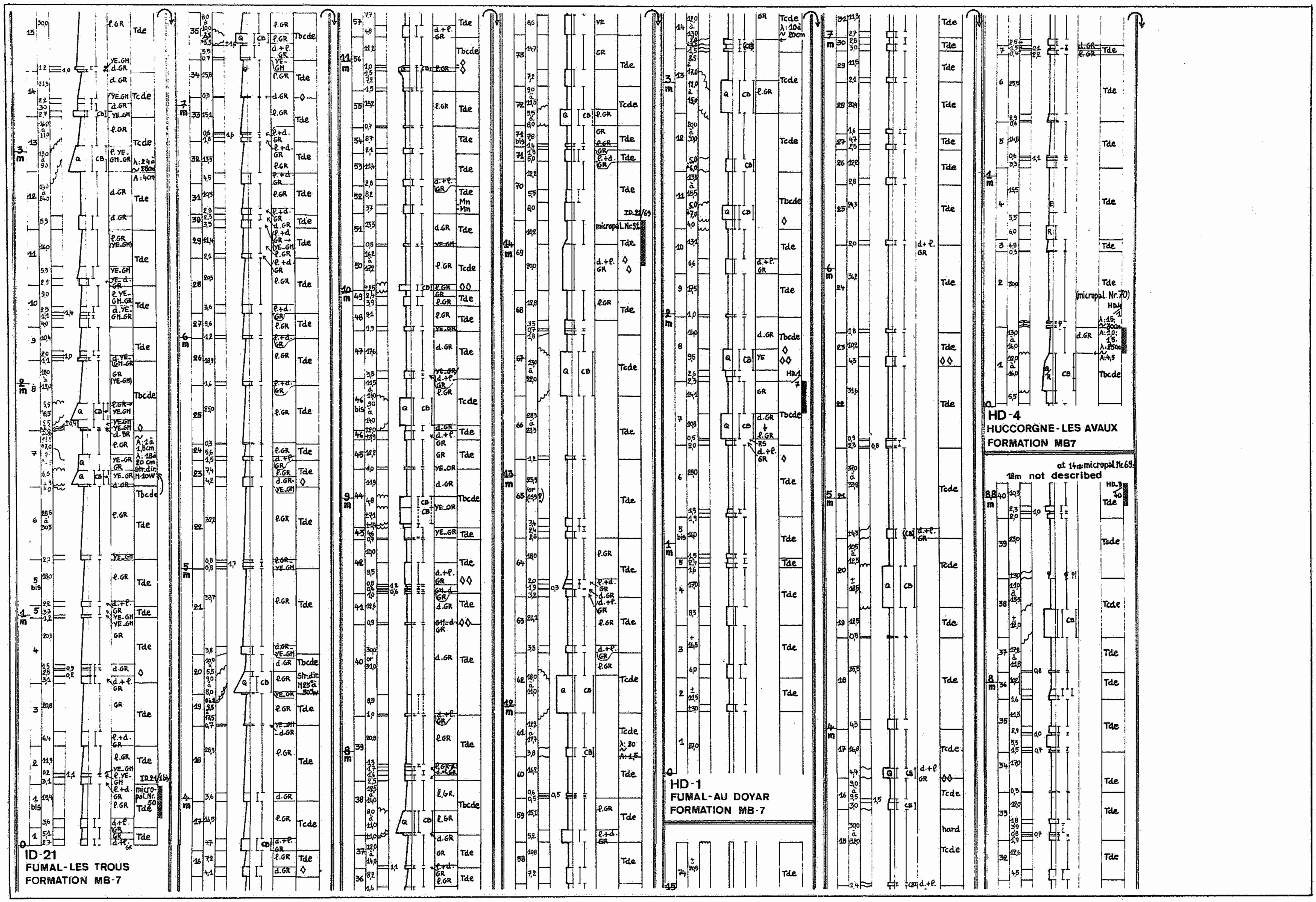

JD-2
continued
JD-3B
JD-3 FUMAL-BOIS AUX GUISSES FORMATION MB7
JD-3/1 = JD-2/4
JD-2
(micropal. Nr. 48)
HC-23D
HUCCORGNE-WATERMILL FORMATION MB7
HC-23D/135 = HC-23E/135
HC-23E
HUCCORGNE-WATERMILL FORMATION MB7
HC-23E/130 corresponds with JD-3B/32
covered by weathered sandstones of middle Devonian
HC-23G
2,7 m not exposed
not exposed
ID-9 FUMAL- MOZON FORMATION MB7
15m ± 10 estimated between the top of HC-23G/8 and the base of ID-9/1.

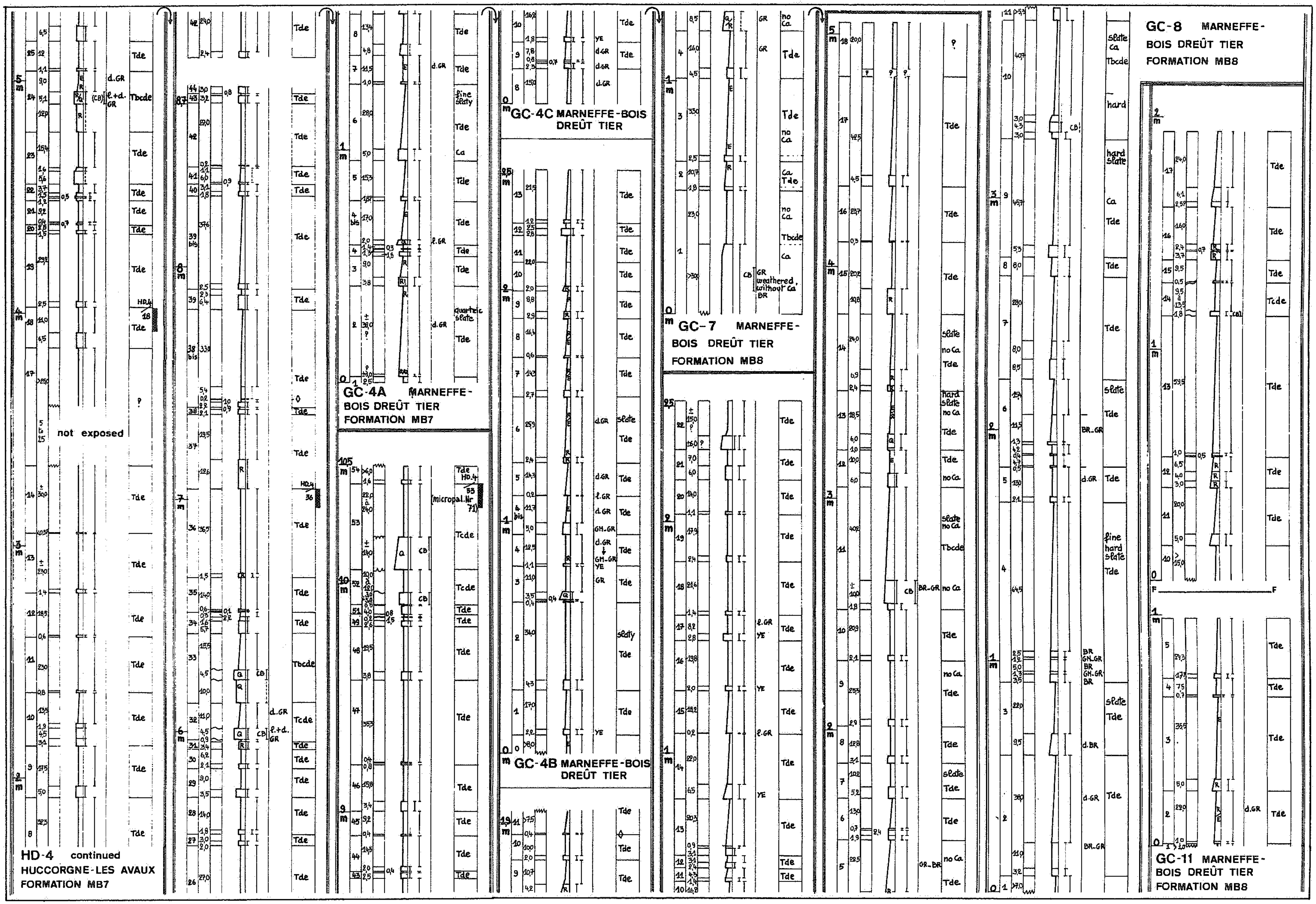


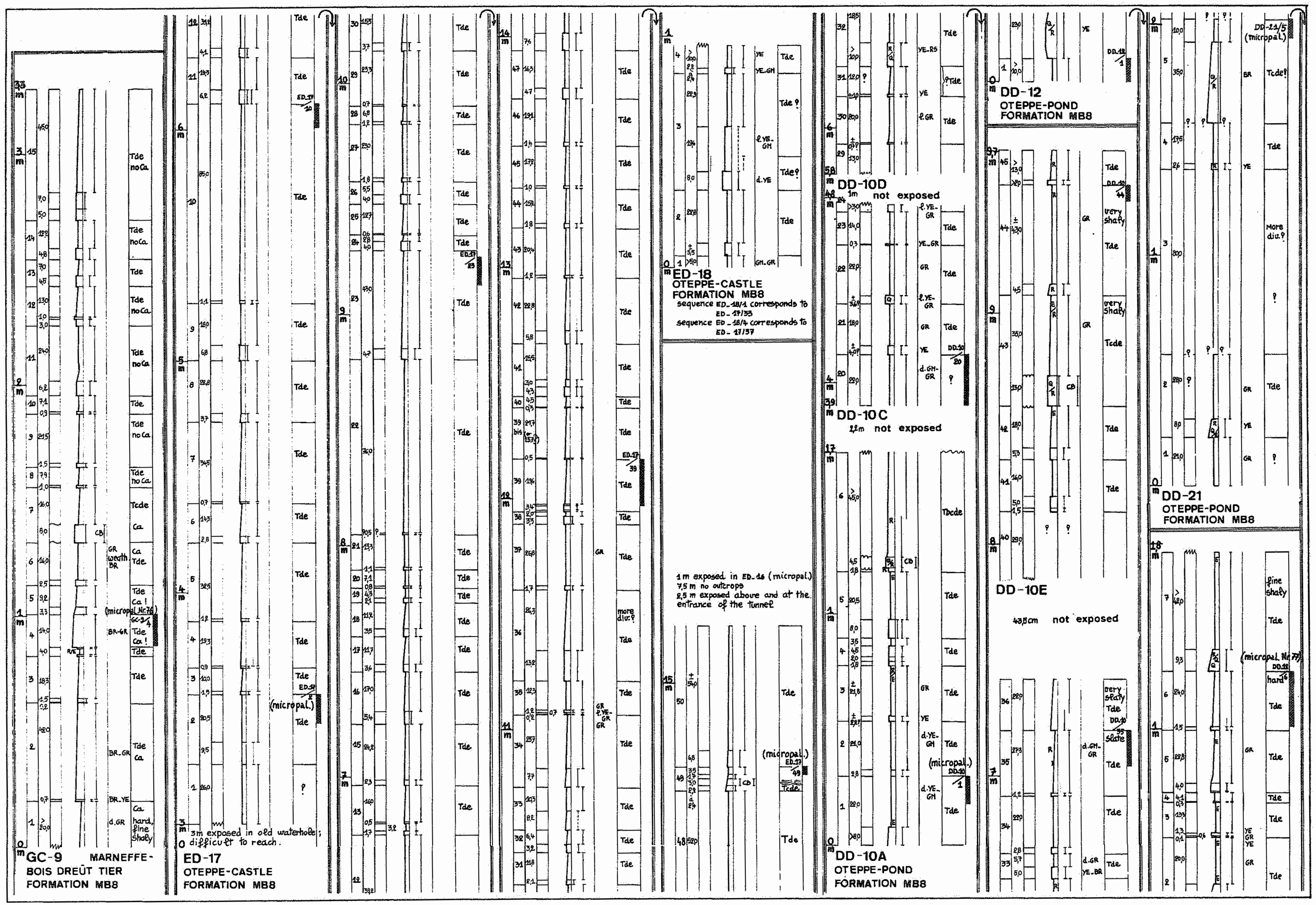
HC-1A HUCCORGNE-WATERMILL
FORMATION MB7
ID-9 FUMAL-MOZON
FORMATION MB7
continued
ID-6 FUMAL-THIER DE MOZON
FORMATION MB7
HC-1B
In this part of the section the sequences show differences in thickness in comparision with JD-2. Under and above the sequences are very similar in thickness.
sequences 34-37 recorded N of the fault in the N part of the outcrop
sequences 13-37 observed 10-20 m more to the N
sequences 1-12 observed in the central part of the anticline
JD-6
FUMAL-THIER DE HUY
FORMATION MB7
ID-6 FUMAL-THIER DE MOZON
JD-5 FUMAL-THIER DE HUY
FORMATION MB7
JD-4
FUMAL-THIER DE HUY
FORMATION MB7

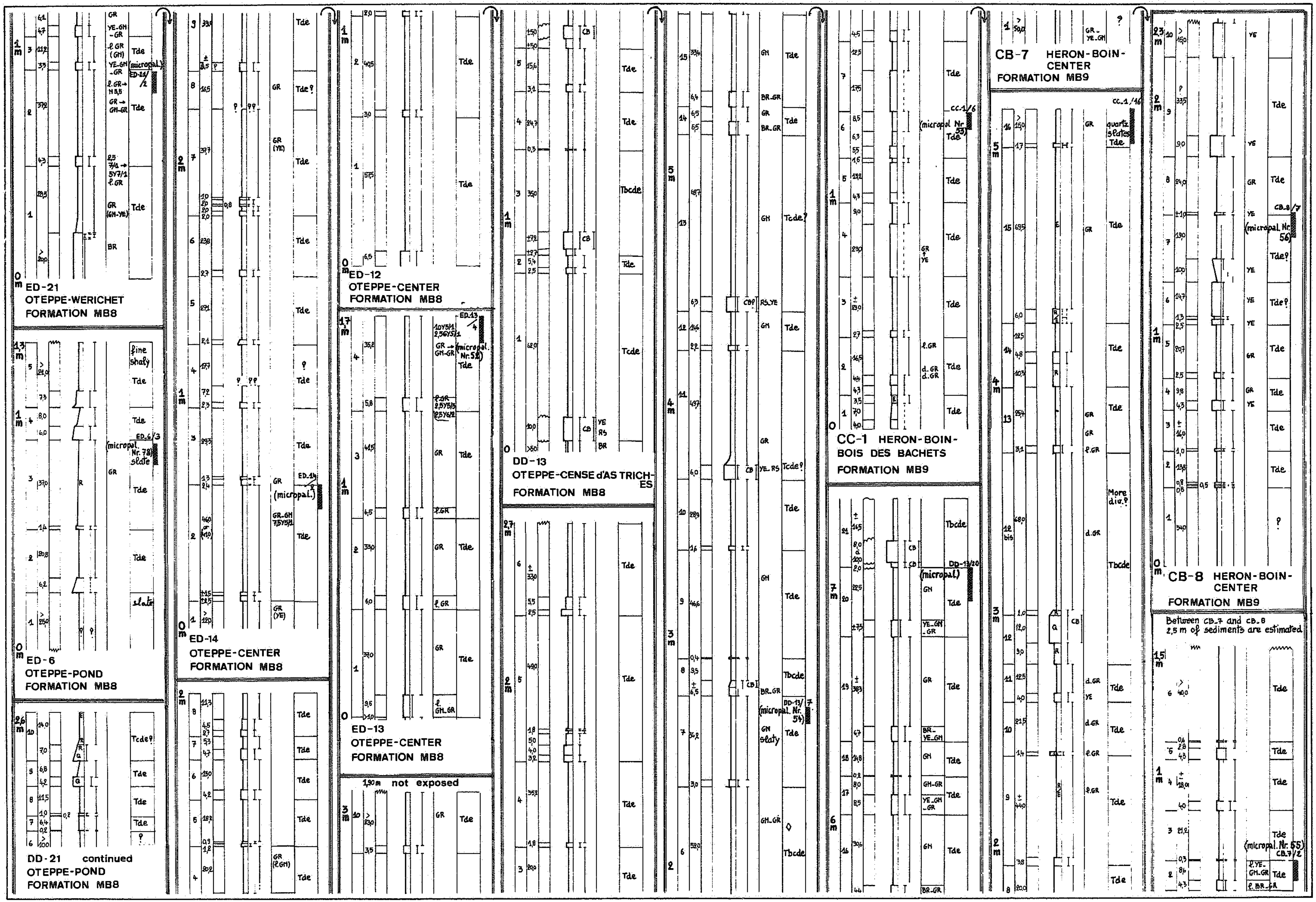

ID-1A to C &
ID-2A to D
FUMAL-THIER DE HUY
FORMATION MB7
Devonian sandstones
JD-4 continued
FUMAL-THIER DE HUY
FORMATION MB7
ID-2E & ID-1D/96-102
90,0 continued
ID-1D


FD-1
MARNEFFE-GRANDE ROUTE
FORMATION MB7
FD 6
MARNEFFE-GRANDE ROUTE
FORMATION MB7
not exposed
not exposed
dip. 30° N
FC 6
MARNEFFE- WATERMILL
FORMATION MB7
not exposed ?
(micropal. Nr. 73)
FC 8 MARNEFFE-
WATERMILL
FORMATION MB7
FC-7
MARNEFFE- WATERMILL
FORMATION MB7
2,5m not described
This beddingplane is well-exposed (3x2m)
micropal. Nr. 74
micropal. Nr. 72
micropal. Nr. 75


ID-21
FUMAL-LES TROUS
FORMATION MB-7
HD-1
FUMAL-AU DOYAR
FORMATION MB-7
HD-4
HUCCORGNE-LES AVAUX
FORMATION MB7
18m not described


HD-4 continued
HUCCORGNE-LES AVAUX
FORMATION MB7
not exposed
GC-4A MARNEFFE-BOIS DREÛT TIER
FORMATION MB7
GC-4C MARNEFFE-BOIS DREÛT TIER
GC-4B MARNEFFE-BOIS DREÛT TIER
GC-7 MARNEFFE-BOIS DREÛT TIER
FORMATION MB8
GC-8 MARNEFFE-BOIS DREÛT TIER
FORMATION MB8
GC-11 MARNEFFE-BOIS DREÛT TIER
FORMATION MB8


GC-9 MARNEFFE-BOIS DREÛT TIER
FORMATION MB8
ED-17
OTEPPE-CASTLE
FORMATION MB8
3m exposed in old waterhole; difficult to reach.
ED-18
OTEPPE-CASTLE
FORMATION MB8
sequence ED-18/1 corresponds to ED-17/33
sequence ED-18/4 corresponds to ED-17/37
1m exposed in ED-16 (micropal.)
7,5m no outcrops
2,5m exposed above and at the entrance of the tunnel
DD-10D
1m not exposed
DD-10C
2,2m not exposed
DD-10A
OTEPPE-POND
FORMATION MB8
DD-12
OTEPPE-POND
FORMATION MB8
DD-10E
43,8cm not exposed
DD-21
OTEPPE-POND
FORMATION MB8


ED-21 OTEPPE-WERICHET FORMATION MB8
ED-6 OTEPPE-POND FORMATION MB8
DD-21 continued OTEPPE-POND FORMATION MB8
ED-14 OTEPPE-CENTER FORMATION MB8
ED-12 OTEPPE-CENTER FORMATION MB8
ED-13 OTEPPE-CENTER FORMATION MB8
1,90 m not exposed
DD-13 OTEPPE-CENSE d'AS TRICHES FORMATION MB8
CC-1 HERON-BOIN-BOIS DES BACHETS FORMATION MB9
CB-7 HERON-BOIN-CENTER FORMATION MB9
CB-8 HERON-BOIN-CENTER FORMATION MB9
Between CB-7 and CB-8 2,5 m of sediments are estimated