Causes of uncertainty in geomodelling inputs: data review of Paleozoic geology of the Euregion Meuse-Rhine

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Table of contents:

1. Outcrop data

1.1 Bedding measurements

XRD	YRD	Strata	Strike (˚)	Dip (˚)	Dip direction
184125	301238	Famennian	079	20	NNW
184287	301285	Famennian			
184213	300841	Namurian			
184178	300794	Namurian	040	45	SE
183044	301670	Namurian	038	71	SE
182987	301807	Namurian	029	65	SE
182776	302249	Namurian			
184521	300889	Namurian			
184615	300801	Namurian			
184824	300820	Namurian	047	8	S
183288	301743	Namurian	030	63	SE
183175	300385	Namurian			
183086	300069	Famennian	057	20	SE
182979	299806	Namurian			
185387	300305	Namurian	051	49	SE
194206	306941	Namurian	046	18	SSE
184133	301383	Famennian	043	40	NW
180821	302626	Namurian			
180199	302874	Westphalian	342	38	SSW
179754	302580	Westphalian	332	39	SW
197647	302467	Westphalian	351	10	SW
176039	301855	Namurian	080	90	S
176125	301552	Namurian	046	18	SSE
178805	302377	Namurian	329	31	
177062	304255	Frasnian			
176342	302763	Dinantian			
176110	302320	Dinantian	018	10	SSE
176599	303495	Dinantian	041	90	
193353	308236	Namurian	030	12	SE
193863	307794	Namurian	074	26	S
195565	305449	Namurian	046	18	SE
195734	305367	Namurian	007	28	E
198526	302279	Dinantian	012	71	W
197966	303476	Famennian	072	35	S
178666	299639	Westphalian			
180784	301552	Namurian	047	28	SE
178460	304311	Frasnian			
195911	305311	Namurian	053	19	NW
195092	306072	Namurian	321	11	NE
196927	303752	Dinantian	060	40	SE
199697	302148	Dinantian	071	9	SE
197165	303217	Famennian	056	27	SE
200431	299983	Famennian	028	17	SE

211188	301864	Frasnian	058	65	SE
199386	299097	Famennian	076	30	SE
198782	299250	Dinantian	038	40	SE
196111	305659	Namurian			
205618	313816	Westphalian	059	58	SSE
205633	314642	Westphalian	344	38	E
206044	315267	Westphalian	080	90	NNW
204388	318209	Westphalian	339	14	E
204919	309659	Famennian	032	40	SE
199333	302278	Finantian	035	40	SE
199115	302432	Dinantian	039	65	SE
183086	300069	Namurian	094	49	N

Table S1.1 Bedding measurements and outcrop coordinates used to create Figure 5 in the main text. XRD and YRD correspond to the coordinate system: Amersfoort RD new. The bedding attitude in the Cottessen quarry (74, 26°) is similar to the borehole image logs of the Cottessen borehole.

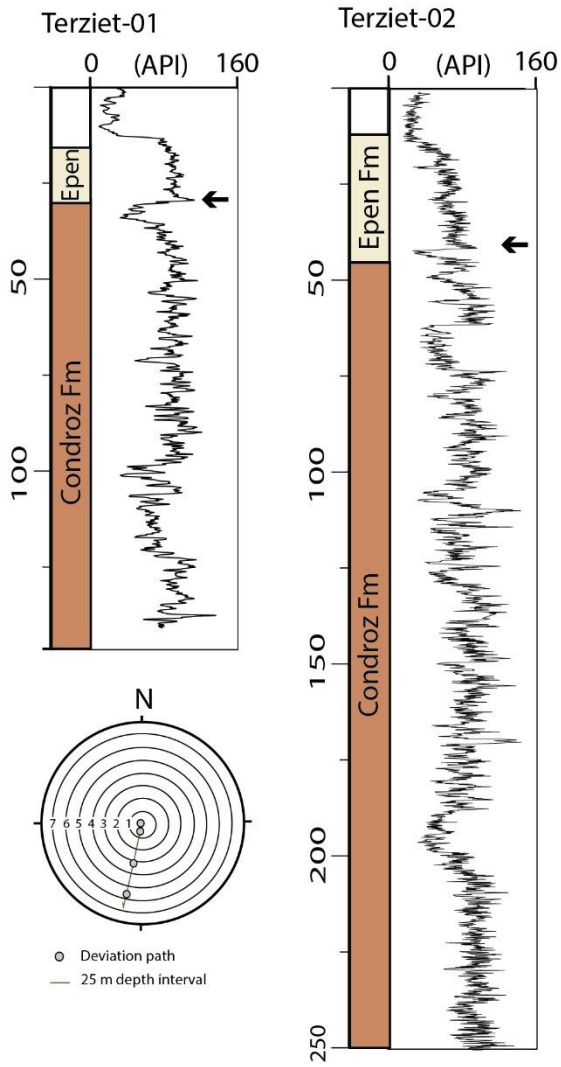
1.2 Slickensides measurements

XRD	**YRD**	**Trend/Plunge**	**kinematics**	**bedding**
193863	307794	148°/35°	-	074, 26° SSE
193863	307794	142°/30°	-	074, 26° SSE
193863	307794	155°/45°	Und. SS	074, 26° SSE
193863	307794	122°/25°	-	074, 26° SSE
194048	307834	132°/00° NW	Sinistral SS	080, 30° SSE
195734	305367	137°/15° NW	Sinistral SS	053, 40° SE
195565	305449	122°/02° NW	Sinistral SS	055, 28° SE
198526	302279	008°/30°	-	095, 54° SW
196642	304082	025°/90°	ESE-WNW	026, 90° ESE
183247	301493	031°/02°SSW	Sinistral SS	031, 70° ESE

Table S1.2 Slickensides measurements. XRD and YRD correspond to the coordinate system: Amersfoort RD new.

2. Borehole data

2.1 Terziet-01 (ETB-01)

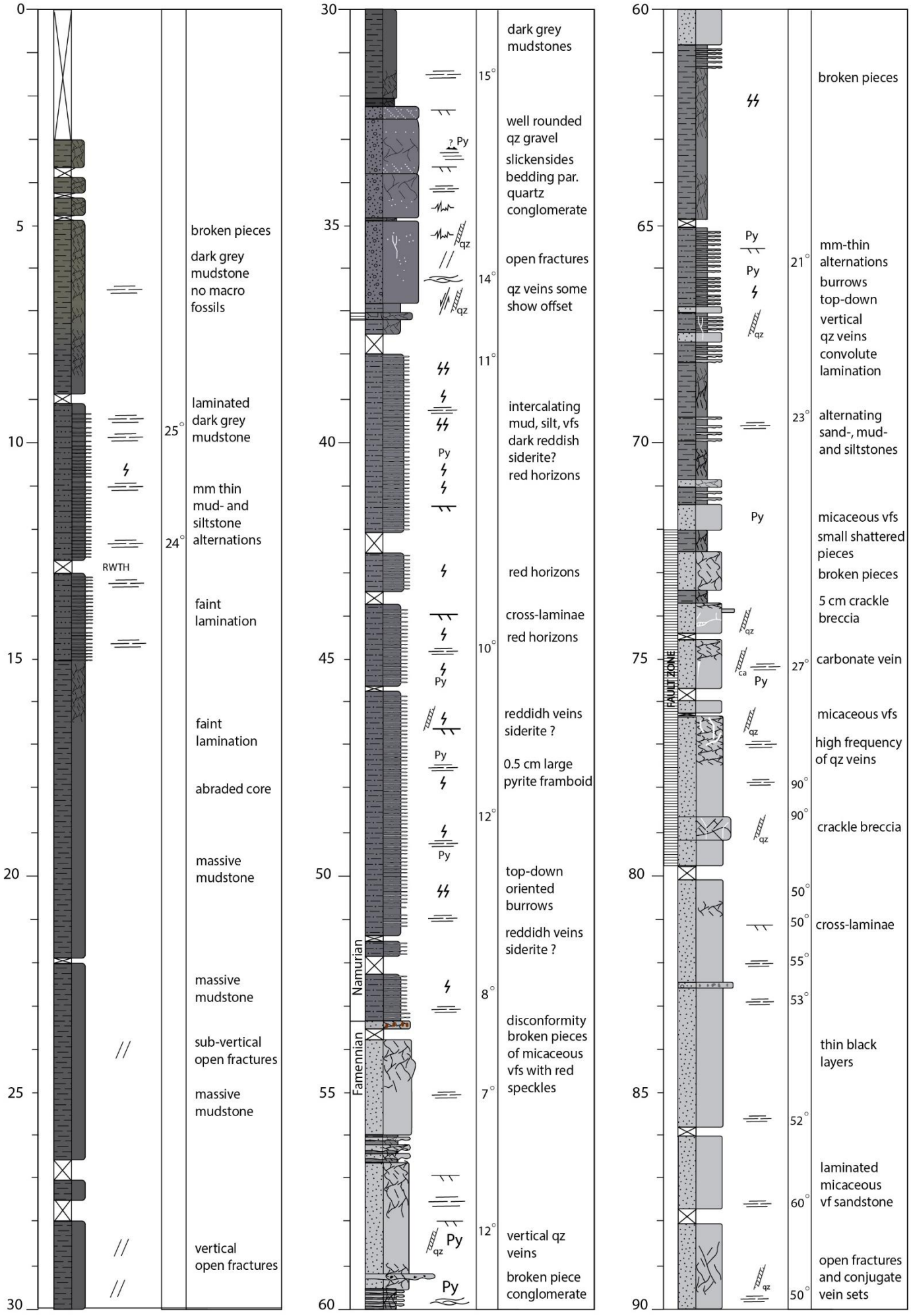


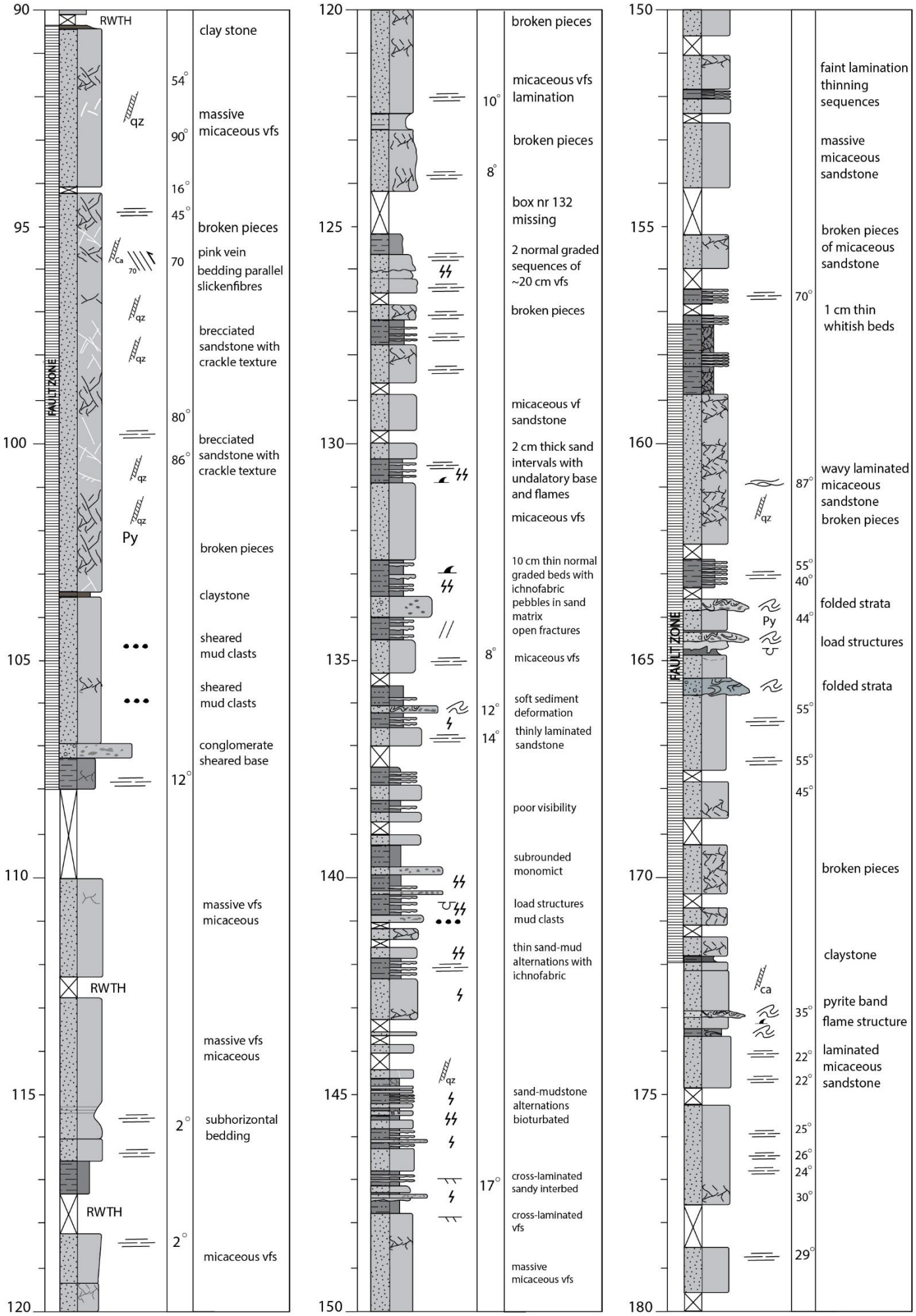
The Terziet-01 borehole was drilled at an accidental inclination towards the south (Fig. S1). The lithofacies observed in cutting samples changes from dark grey mudstone to micaceous fine sandstones at 28 m depth. The acquired gamma-ray log differs from Terziet-02 despite their nearby locations. Fault zones were not identified due to a lack of core material and borehole image logs.

Figure S2.1 Stratigraphic borehole profile of the Terziet-01 with its gamma-ray log. The arrow indicates a shift in the gamma-ray log that is also recognisable in Terziet-02. The deviation plot indicates a southward inclination of the Terziet-01 borehole.

2.2 Cottessen (ETB-03)

The Cottessen borehole encountered a 53.6 m thick succession of dark coloured shales with faint lamination and thinly alternating fine-grained sands- and mudstones (Fig. S2.2). We interpret this succession as Epen Fm. Underlying this succession are micaceous fine- to very fine grained sandstones and thinly alternating fine grained sand- and mudstones with frequent burrows. The micaceous sandstones are either massive, planar laminated, wavy laminated, or cross-laminated. Moreover, soft-sediment deformation such as slumps and loading structures, occurs. This succession from 53.6-250.1 m is interpreted as the Condroz Fm.


0
5
10
15
20
25
30
broken pieces
dark grey mudstone no macro fossils
laminated dark grey mudstone
25°
mm thin mud- and siltstone alternations
24°
RWTH
faint lamination
faint lamination
abraded core
massive mudstone
massive mudstone
sub-vertical open fractures
massive mudstone
vertical open fractures
30
35
40
45
50
55
60
dark grey mudstones
15°
well rounded qz gravel
slickensides bedding par. quartz conglomerate
? Py
qz
open fractures
14°
qz veins some show offset
qz
11°
intercalating mud, silt, vfs dark reddish siderite? red horizons
Py
red horizons
cross-laminae
red horizons
10°
Py
reddidh veins siderite ?
Py
0.5 cm large pyrite framboid
12°
Py
top-down oriented burrows
reddidh veins siderite ?
Namurian
8°
disconformity
Famennian
broken pieces of micaceous vfs with red speckles
7°
12°
qz
Py
vertical qz veins
Py
broken piece conglomerate
60
65
70
75
80
85
90
broken pieces
Py
mm-thin alternations
21°
Py
burrows top-down
qz
vertical qz veins convolute lamination
23°
alternating sand-, mud- and siltstones
Py
micaceous vfs
small shattered pieces
broken pieces
5 cm crackle breccia
qz
FAULT ZONE
ca
Py
27°
carbonate vein
micaceous vfs
qz
high frequency of qz veins
90°
90°
qz
crackle breccia
50°
50°
cross-laminae
55°
53°
thin black layers
52°
laminated micaceous vf sandstone
60°
open fractures and conjugate vein sets
50°
qz


90
95
100
105
110
115
120
RWTH
qz
Ca
70
FAULT ZONE
Py
RWTH
RWTH
clay stone
54°
massive micaceous vfs
90°
16°
45°
broken pieces
pink vein
70
bedding parallel slickenfibres
brecciated sandstone with crackle texture
80°
brecciated sandstone with crackle texture
86°
broken pieces
claystone
sheared mud clasts
sheared mud clasts
conglomerate sheared base
12°
massive vfs micaceous
massive vfs micaceous
2°
subhorizontal bedding
2°
micaceous vfs
120
125
130
135
140
145
150
broken pieces
micaceous vfs lamination
10°
broken pieces
8°
box nr 132 missing
2 normal graded sequences of ~20 cm vfs
broken pieces
micaceous vf sandstone
2 cm thick sand intervals with undalatory base and flames
micaceous vfs
10 cm thin normal graded beds with ichnofabric pebbles in sand matrix
open fractures
8°
micaceous vfs
soft sediment deformation
12°
14°
thinly laminated sandstone
poor visibility
subrounded monomict
load structures
mud clasts
thin sand-mud alternations with ichnofabric
qz
sand-mudstone alternations bioturbated
17°
cross-laminated sandy interbed
cross-laminated vfs
massive micaceous vfs
150
155
160
165
170
175
180
faint lamination thinning sequences
massive micaceous sandstone
broken pieces of micaceous sandstone
70°
1 cm thin whitish beds
wavy laminated micaceous sandstone
87°
broken pieces
qz
55°
40°
folded strata
Py
44°
load structures
FAULT ZONE
folded strata
55°
55°
45°
broken pieces
claystone
ca
pyrite band
35°
flame structure
22°
laminated micaceous sandstone
22°
25°
26°
24°
30°
29°

Supplementary Materials

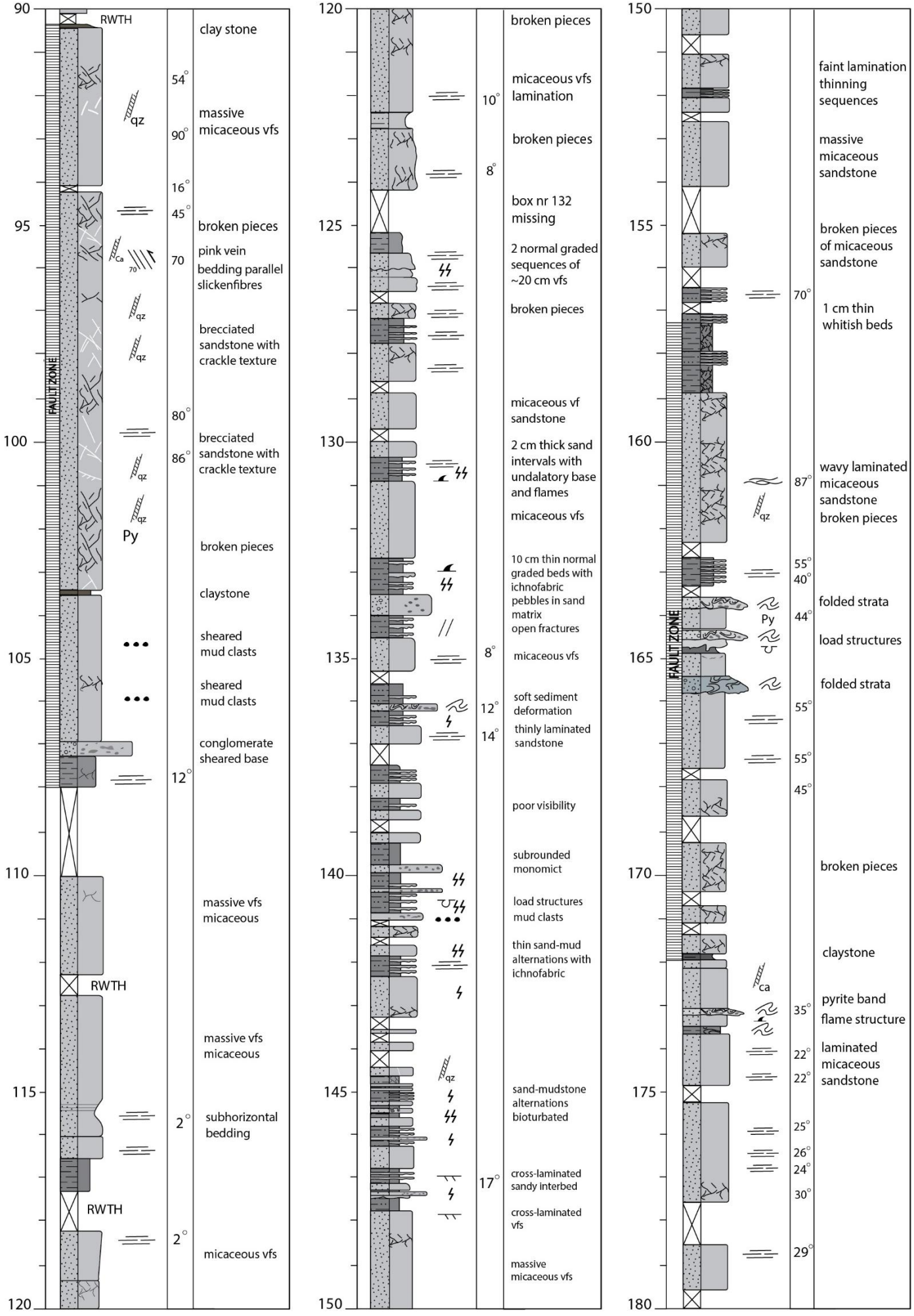


Figure S2.2. Sedimentary log of the Cottessen core (ETB-03) on previous pages.

2.2 Banholt (ETB-04)

In 2017 a 252.8 m deep borehole was drilled near Banholt (the Netherlands). The 142-230 m interval was cored and a gamma ray log and acoustic borehole images were acquired. Strata in the core consistently dip 20-45° with a gradual increase downcore. Strata consist of grey to dark grey mud- and siltstones and coaly intervals of up to 70 cm (Fig. S2.2). These coaly intervals are typically found in Westphalian strata but also occur in Namurian strata of the Baarlo Fm (NLOG, 2025). The borehole encounters no marine marker bed, as Maurenbecker (1945) described, limiting the lithostratigraphic interpretation. Yet, we interpreted the strata as Baarlo Fm based on what is drawn on the geologic map (RGD, 1995). However, as palynomorphs were all indiscernible the stratigraphic interpretation is inconclusive and comes with uncertainty.

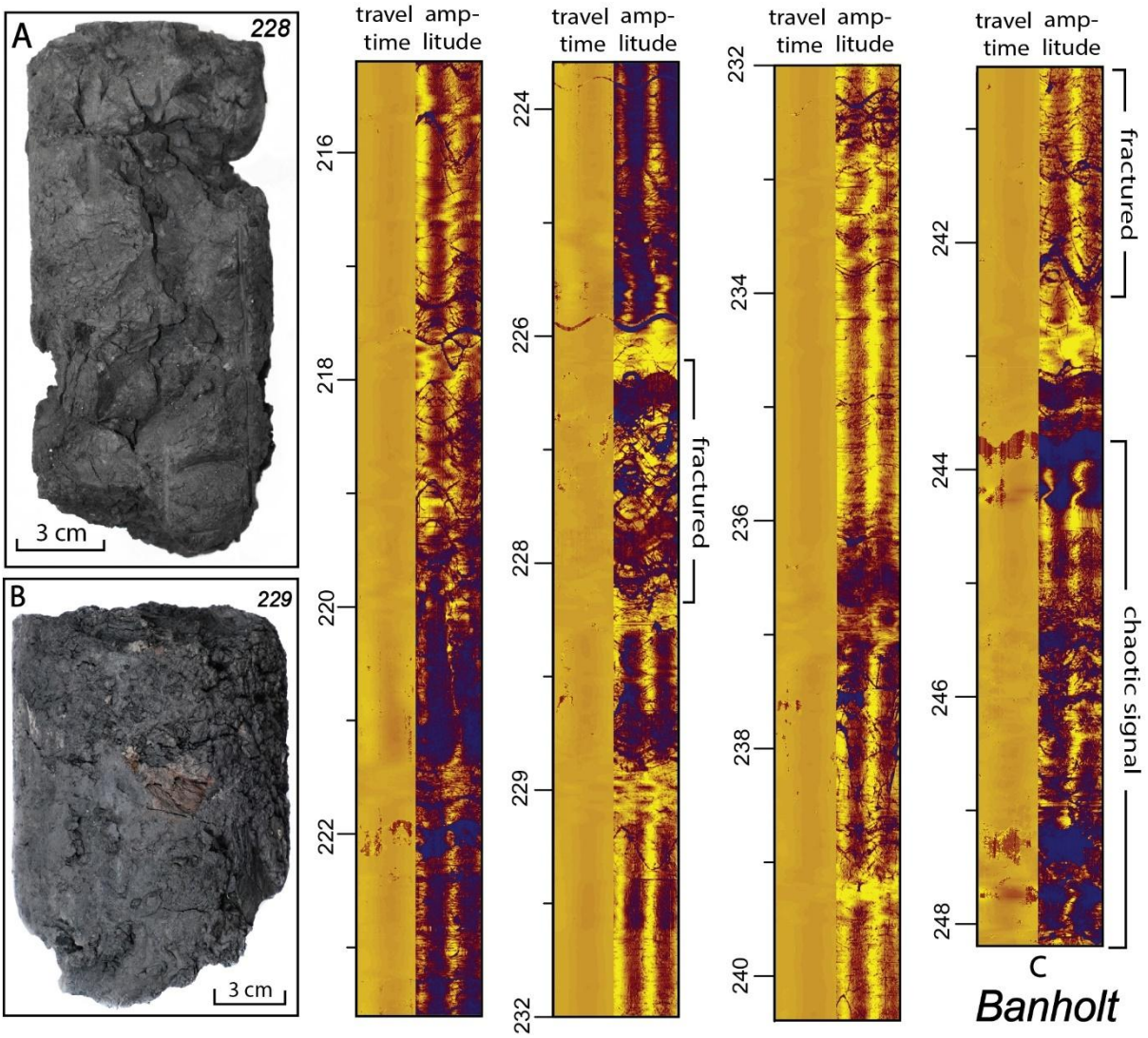


Figure S2.3 A) clayey gouge at 228 m in Banholt core. B) Fine-grained chaotic breccia at 229 m. C) Acoustic borehole images showing heavily fractured intervals and a chaotic signal at the base. The basal 25 m of the Banholt borehole is interpreted as a fault zone.

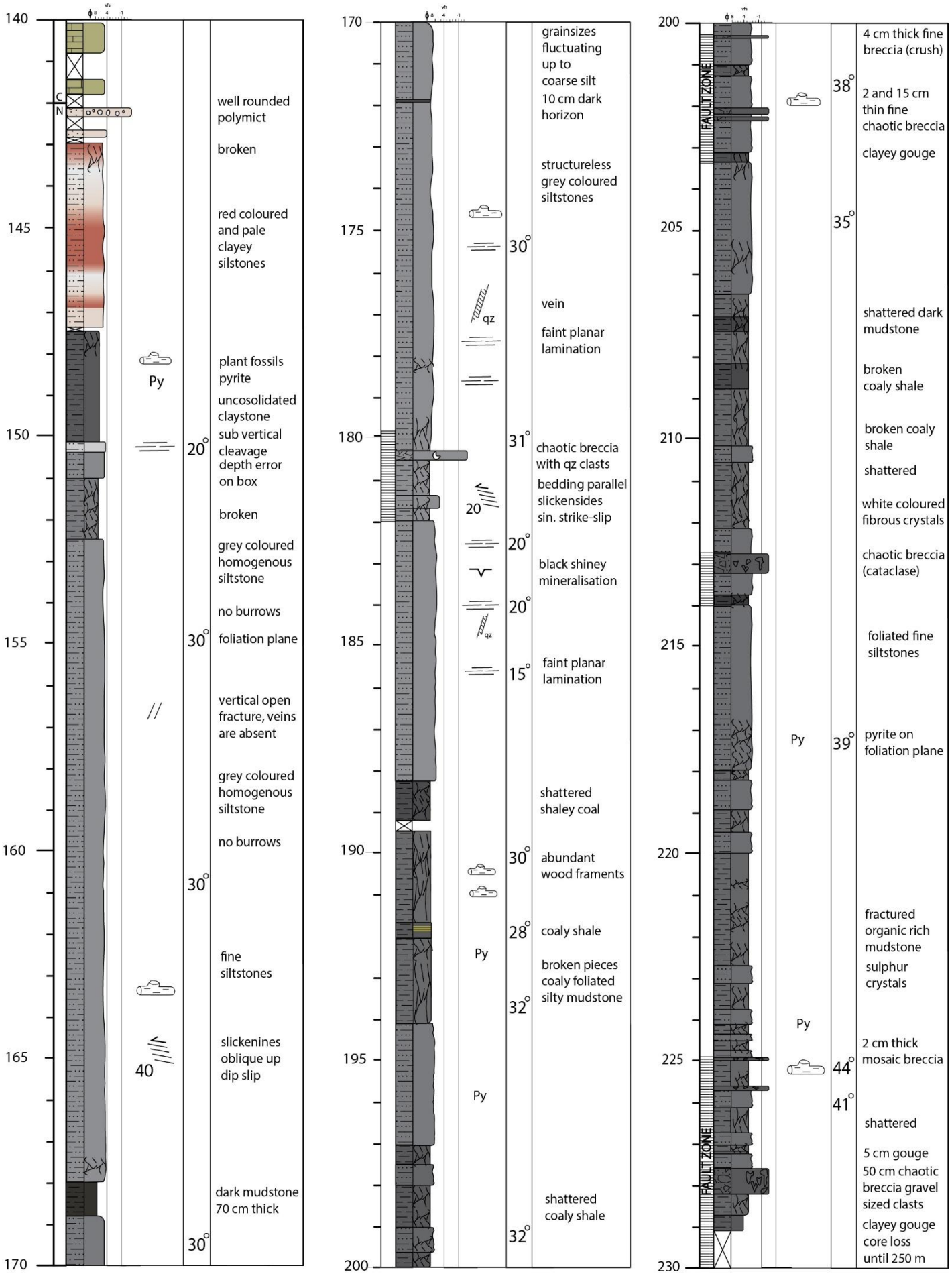

140
145
150
155
160
165
170
well rounded polymict
broken
red coloured and pale clayey silstones
Py
plant fossils
pyrite
uncosolidated claystone
sub vertical cleavage
depth error on box
20°
broken
grey coloured homogenous siltstone
no burrows
30°
foliation plane
vertical open fracture, veins are absent
grey coloured homogenous siltstone
no burrows
30°
fine siltstones
40
slickenines oblique up dip slip
dark mudstone 70 cm thick
30°
170
175
180
185
190
195
200
grainsizes fluctuating up to coarse silt
10 cm dark horizon
structureless grey coloured siltstones
30°
qz
vein
faint planar lamination
31°
chaotic breccia with qz clasts
bedding parallel slickensides sin. strike-slip
20
20°
black shiney mineralisation
20°
qz
faint planar lamination
15°
shattered shaley coal
30°
abundant wood framents
28°
coaly shale
Py
broken pieces coaly foliated silty mudstone
32°
Py
shattered coaly shale
32°
200
205
210
215
220
225
230
FAULT ZONE
4 cm thick fine breccia (crush)
38°
2 and 15 cm thin fine chaotic breccia
clayey gouge
35°
shattered dark mudstone
broken coaly shale
broken coaly shale
shattered
white coloured fibrous crystals
chaotic breccia (cataclase)
foliated fine siltstones
Py
39°
pyrite on foliation plane
fractured organic rich mudstone
sulphur crystals
Py
2 cm thick mosaic breccia
44°
41°
shattered
5 cm gouge
50 cm chaotic breccia gravel sized clasts
clayey gouge
core loss until 250 m
FAULT ZONE

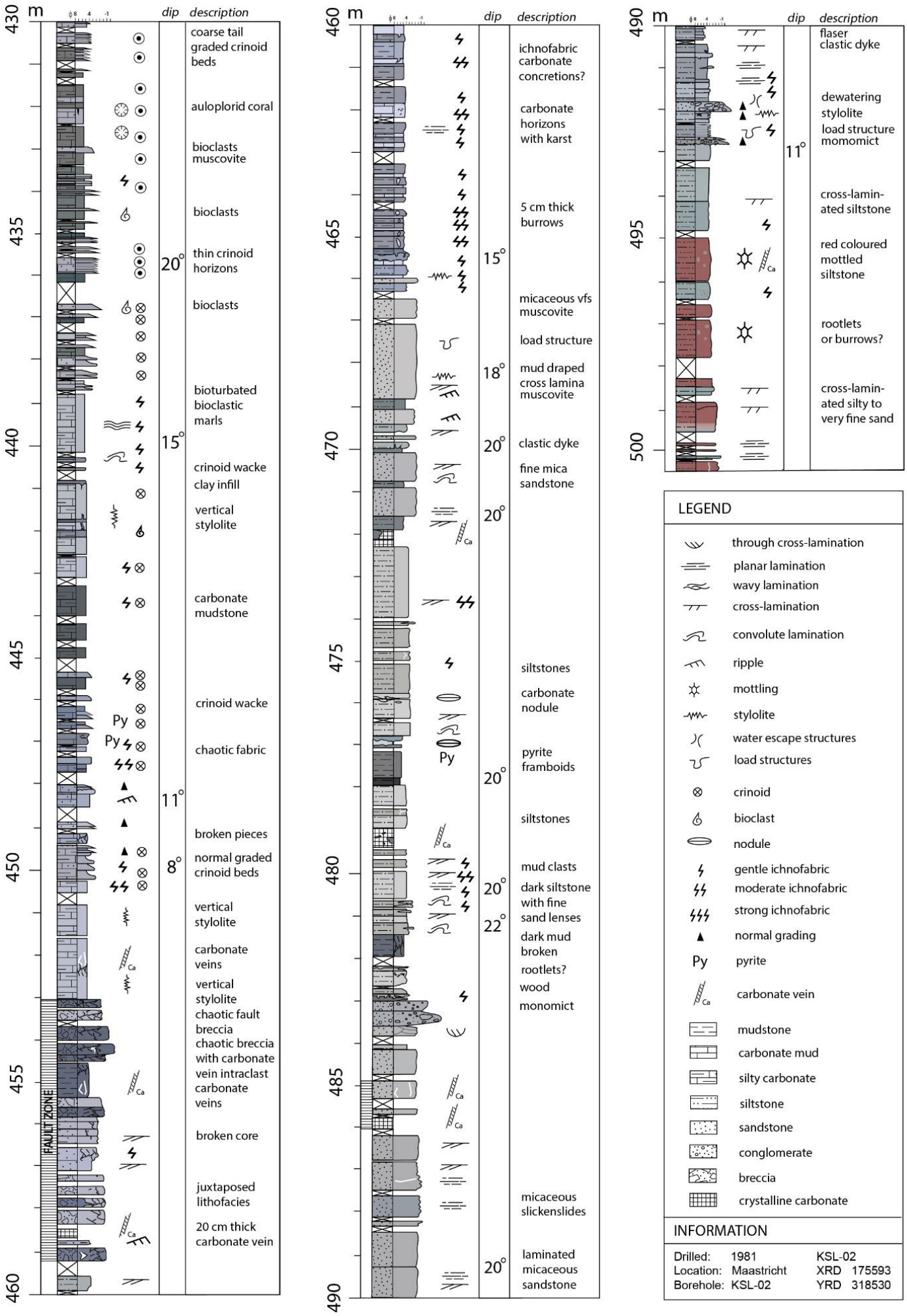
Figure S2.4 Sedimentary log of the Banholt core (ETB-04) on previous page.

2.3 Kastanjelaan-02 (KSL-02)

Famennian strata in the KLS-02 core are characterised by micaceous siliciclastics with various sedimentary structures (Bless et al., 1981a). Additionally, burrowed horizons and conglomerate intercalations are present (Fig. S2.5). The Famennian lithofacies change near a paleokarst horizon at 465.4 m from dominantly micaceous sandstones to burrowed carbonate-mudstone alternations. The top of this burrowed interval is cut by an interpreted normal fault (459.3-452.3 m) containing chaotic breccias and shear fractures. The strata above this fault comprise crinoidal-rich carbonates (Fig. S2.5) and a ~2 m thick interval of dark-coloured carbonate mudstones at 446.30-444 m. Based on the sharp contrast in lithofacies above and below the fault zone (459.3-452.3 m), we interpret the centre of the fault as the lithostratigraphic contact between Condroz Fmand Hastière Fm.

Figure S2.5 Sedimentary log of the KSL-02 core on the next page.

Supplementary Materials



3. Palynostratigraphy

3.1 Approach and Sampling

To obtain age constraints, we conducted palynologic analyses on cuttings, cores, and outcrops (Table S3.1). Rock samples were processed at CGG Laboratories, Conwy, United Kingdom. Samples were first treated with dilute hydrochloric acid to remove calcium carbonate and subsequently macerated by leaving the sample in 75% hydrofluoric acid overnight. The organic residue was sieved over a 53 µm and subsequently a 10 µm mesh. The resultant kerogens of these size classes were visually examined for their degree of brown colouration and the presence of dark macerals, upon which a specific oxidation step was applied. This involves the addition of Schulze reagents, fuming nitric acid and/or warm nitric acid. Both the unoxidised kerogens and the oxidised kerogens were transferred to a glass slide in epoxy resin and covered by a cover slip. The slides with oxidised kerogen were microscopically examined using a transmissive light Leica DM-LB2 microscope fitted with a Leica MC170 digital camera on 787.5× magnification. Each slide was fully scanned and the presence of palynomorph taxa and palynodebris clasts was scored qualitatively. The palynological slides and macerated residues are in the Geological Survey of the Netherlands sample archive.

The palynological study relies on two landmark zonation schemes for the Late Devonian (Streel et al., 1987 and later modifications) and Carboniferous (Clayton et al., 1978). Later, more detailed schemes were made, particularly in light of hydrocarbon exploration in the North Sea (McLean et al., 2005). However, we here refrain from adopting these zones because they are of a level of detail that cannot be achieved with the quality of available material. We do consider the specific events, such as originations and extinctions, that are the foundations of these zonal schemes.

Well/Section	Depth (m)	Type	Productive
KSL-02	381	Core	
KSL-02	386.6	Core	
KSL-02	391.6	Core	Yes
KSL-02	391.8	Core	Yes
KSL-02	395.1	Core	Yes
KSL-02	424.6	Core	Yes
KSL-02	430.3	Core	Yes
KSL-02	447.55	Core	Yes
KSL-02	447.8	Core	Yes
KSL-02	462.85	Core	Yes
KSL-02	465.2	Core	Yes
KSL-02	477.4	Core	Yes
Cottessen	28.5	Core	Yes
Cottessen	39	Core	
Cottessen	45.5	Core	
Cottessen	53.2	Core	Yes
Cottessen	63.2	Core	
Cottessen	64.9	Core	Yes
Cottessen	116	Core	
Cottessen	162.65	Core	Yes
Cottessen	182.6	Core	
Cottessen	213.3	Core	
Cottessen	235	Core	

Cottessen	241	Core	Yes
Terziet-2	34	Cutting	Yes
Terziet-2	102	Cutting	Yes
Terziet-2	139	Cutting	Yes
Terziet-2	172	Cutting	Yes
Terziet-2	200	Cutting	
Terziet-2	203	Cutting	
RWTH-01	20	Cutting	Yes
RWTH-01	40	Cutting	Yes
RWTH-01	50	Cutting	
RWTH-01	60	Cutting	
RWTH-01	70	Cutting	Yes
RWTH-01	100	Cutting	Yes
RWTH-01	150	Cutting	Yes
RWTH-01	200	Cutting	Yes
RWTH-01	250	Cutting	Yes
RWTH-01	300	Cutting	Yes
RWTH-01	400	Cutting	Yes
RWTH-01	500	Cutting	
RWTH-01	580	Cutting	Yes
RWTH-01	660	Cutting	
RWTH-01	700	Cutting	
RWTH-01	780	Cutting	
Banholt	147.5	Core	
Banholt	160.5	Core	
Banholt	190.5	Core	
Banholt	228.7	Core	
Dalhem-1	-	Outcrop	Yes
Dalhem-2	-	Outcrop	Yes

***Table S3.1*.** Samples analysed or evaluated in this study. Productive means whether processing yielded a sufficient palynomorph concentration for further interpretation.

3.2 Cottessen (ETB-03)

From the cored section of the Cottessen Borehole twelve samples were processed and analysed for palynology. Only five of these yielded discernible palynomorphs (Figure S3.1). For these, the preservation and richness were quite poor, yet the maturity as indicated by the spore colouration index of Fisher (1981) was substantially lower than at KSL-02 (i.e., 7.5 corresponding to a $\%R_0$ of 0.8).

Sample 28.5 m (CO)
Interpreted age: Carboniferous, not further differentiated.
Confidence of age-interpretation: low

This sample only yields long-ranging Carboniferous spores such *Densosporites pseudoannulatus* and *Lycospora pusilla*. The samples at 39 and 45.5 m were barren of palynomorphs.

Sample 53.2 m (CO)
Interpreted age: Namurian, Arnsbergian-Kinderscoutian

Confidence of age-interpretation: high

This sample contains several taxa that have a range-base in the early Namurian (Pendleian, NC-Zone of Clayton et al., 1977). These include *Savitrisporites nux* and *Crassispora kosankei.* The latter taxon is more abundant and characterized by consistent presence since the middle Namurian (Kinderscoutian). Both taxa range well into the Westphalian. However, reliable younger stratigraphic occurrences such as those of *Raistrickia fulva* and/or the presence of monosaccate pollen (*Florenites, Potoneisporites*) are not recorded. Based on the consistent presence of *C. kosankei* and the absence of taxa with an Arnsbergian or older extinction (e.g., *Rotaspora fracta*, *Cingulizonates* cf. *capistratus*) a late early to middle Namurian (Chokierian to Kinderscoutian) age is most plausible (McLean et al., 2005). Perhaps remarkably, the long-ranging and typically abundant spore *Lycospora pusilla* which originates in the early Visean is not recorded. This can be due to a specific depositional environment in which a climax vegetation comprising large *Lycospora*-producing arborescent lycopsids were not developed.

Sample 64.9 m (CO)
Provisional lithostratigraphy: Condroz Fm.
Interpreted age: late Late Famennian
Confidence of age-interpretation: high

This sample constitutes a completely different assemblage compared to the overlying sample. Typical middle to late Late Famennian (e.g., the lower part of the VCo-Zone of Streel et al., 1987 and references therein) taxa are recorded; *Grandispora famennensis*, *Retusotriletes phillipsii* and *Rugospora flexuosa*. A younger (Latest Famennian, or Strunian) age is refuted based on the absence of the marker *Retispora lepidophyta*.

Samples 162.65 and 241 m (CO)
Provisional lithostratigraphy: Condroz fm.
Interpreted age: early-middle Late Famennian
Confidence of age-interpretation: high

The assemblage from this sample is characterized by elements of the early-middle Late Famennian GF-Zone. The few spinose cavate forms that are recorded at this level more closely resemble *Grandispora gracilis.* The *Rugospora flexuosa – versabilis* complex is absent. Instead, trilete spores fit within the genus *Retusotriletes* (e.g., *R. planus*, *R. incohatus* and *R. maculatus*). A comparable, yet even more poorly preserved assemblage is encountered at 241 m depth.

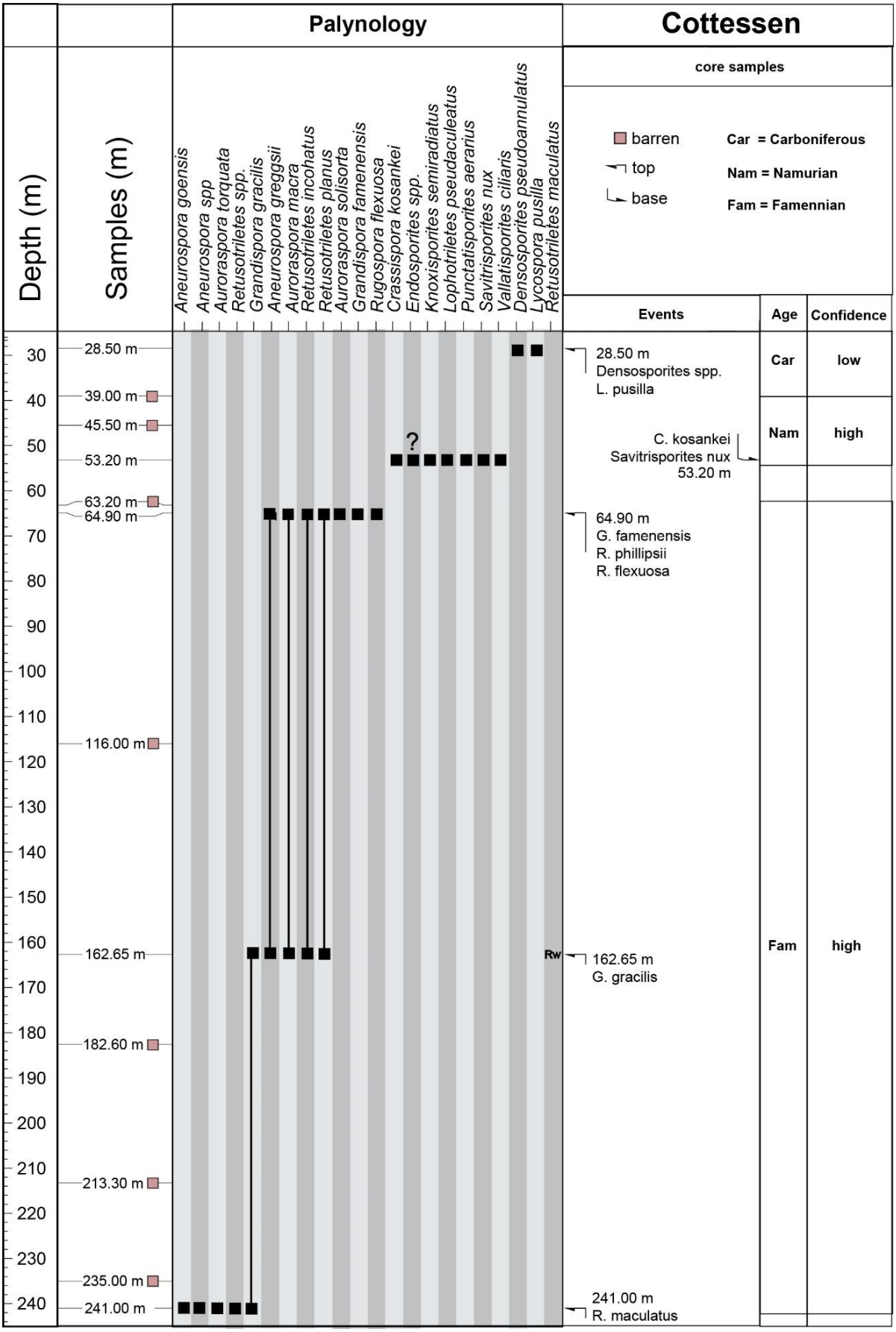


Figure S3.1. Range chart for the Cottessen borehole showing the presence of miospore taxa.

3.3 Terziet-02 (ETB-02)

From the Terziet-2 borehole 7 cuttings samples were palynologically processed and analysed. Of these only the lowermost two (200 and 203 m MD) turned out barren. The samples have a brown-coloration that is comparable to well Cottessen.

Sample 34 m
Interpreted age: mid-Carboniferous, Namurian-A, Chokierian (SO-Zone of Clayton et al., 1978)
Confidence of age-interpretation: high

This interpretation is based on:

- FOD of *Bellispores nitidus*
- FOD of *Crassispora kosankei*
- FOD of *Kraeuselisporites ornatus*
- FOD of *Savitrisporites nux*

Remark: This sample also contains the Latest Devonian (Strunian) marker *Retispora lepidophyta*. This implies that Strunian strata were eroded and subsequently reworked during early Namurian times.

Samples 102 and 139 m
Interpreted age: late Late Famennian (VCo-Zone of Streel et al., 1987)
Confidence of age-interpretation: high

At 139 m an assemblage comprising the *Rugospora-flexuosa/versabilis* complex is encountered. It is also characterized by a more diversified representation of the genus *Grandispora*, including *G. cornuta*. This is characteristic for the late Late Famennian VCo-Zone of Streel et al. (1987). Although poorly preserved and lean, a similar assemblage is encountered at 102 m.

Sample 172 m
Interpreted age: early-middle Late Famennian (GF-Zone; Streel et al. 1987)
Confidence of interpretation: high

At 172 m a poorly preserved and scarce assemblage was recovered, only comprising a handful of specimens; including *Retusotriletes incohatus*, *Retusotriles planus* and *Grandispora microseta*. This assemblage is quite comparable to the one recovered at Cottessen at 162.25 and 241 m depth, and which corresponds to the early-middle Late Famennian GF-Zone of Streel et al., 1987.

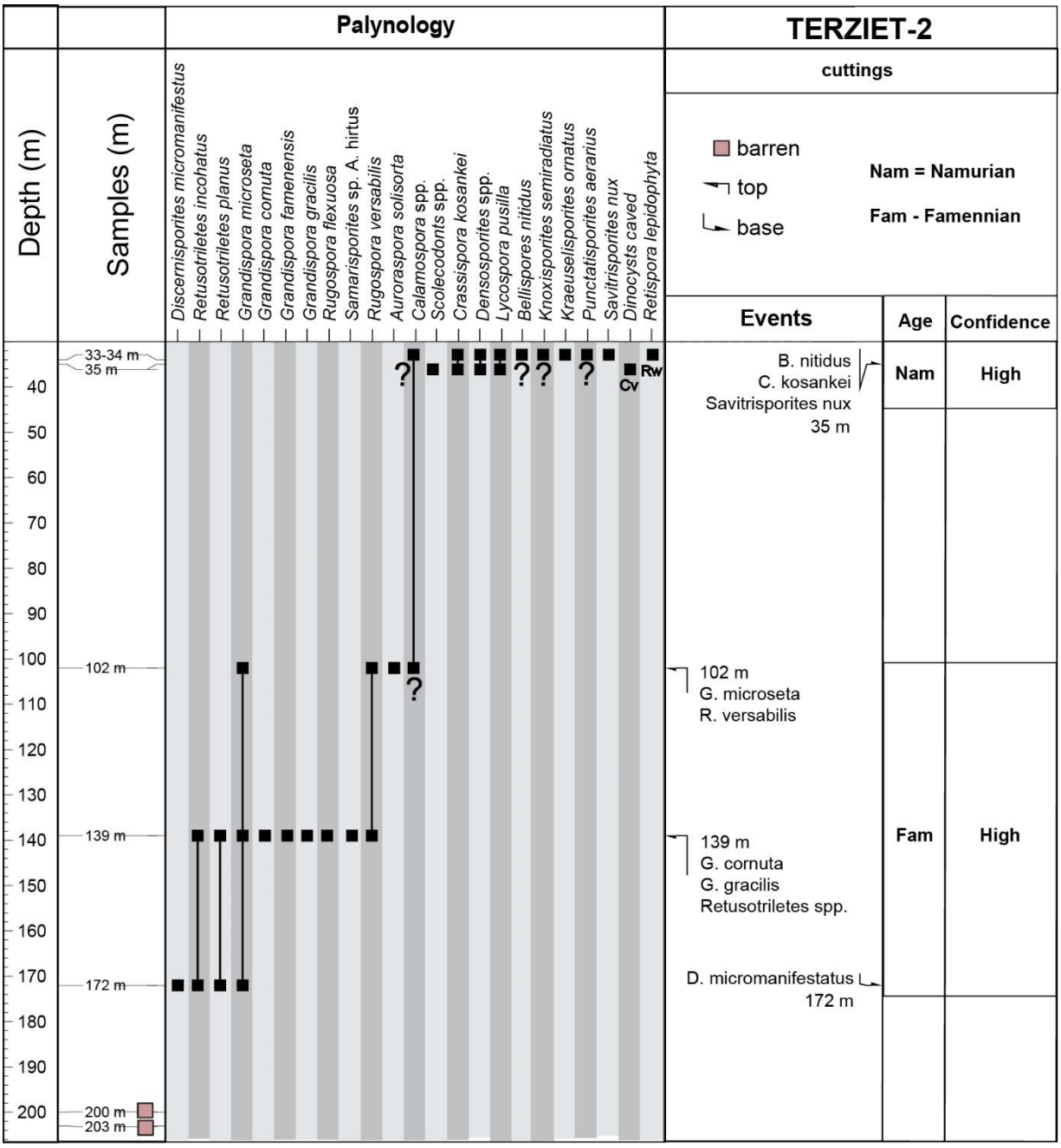


Figure S3.2. Range chart for the Terziet-02 borehole (ETB-02) showing the presence of miospore taxa.

3.4 Banholt – ETB-04

Four samples were processed from the Banholt well. None of them yielded discernible palynomorphs. The three deeper samples (228.7, 190.5 and 160.5 m) constitute a kerogen that looks very dark-colored and degraded, possibly related to intense weathering. The sample at 147.5 m is distinct, it is dominated by far lighter colored wood remains comprising sheets, cuticles and tracheids (Fig. S3.5). However, it does not contain any discernible palynomorphs. This material is likely derived from a coaly source.

3.5 RWTH-01

Based on cuttings and well-log profile, the upper 1025 m are interpreted as Carboniferous, with interpretations diverging as to whether these represent the Westphalian or Namurian. The Dinantian is not present in the well. The Carboniferous strata overly Upper Devonian strata above a thick Lower Devonian succession (Fig. 3.3).To obtain ages for the Carboniferous succession 12 cutting samples between 50 and 780 m depth were palynologically processed and analysed. Seven of these turned out to be palynologically productive. Although both the preservation and abundance of the encountered miospores were poor the encountered assemblages provide stratigraphic insights. The spore colouration is very dark, comparable to the specimens encountered in well KSL-02.

Interval 20 – 40 m (2 cutting samples)
Interpreted age: late Carboniferous - Pennsylvanian, Westphalian-A (SL-Zone of Clayton et al., 1978)
Confidence of age-interpretation: medium, due to poor preservation and scarce assemblages

This interpretation is based on:
- FOD of *Vestispora fenestrata* at 20 m
- FOD of *Triquitrites sculptulis* at 20 m
- FOD of *Westphalenisporites irregularis* at 20 m
- FOD of *Punctatisporites rotundus* at 40 m
- FOD of *Dictyotriletes bireticulatus* at 40 m
- LOD of *Bellispores nitidus* at 40 m

Remarks: *Lycospora pusilla* is commonly present indicating a Carboniferous age. The sample at 20 m MD does not contain the long-ranging Namurian-Westphalian spore *Crassispora kosankei*. This is possibly related to a change in vegetation. The samples at 50 and 60 m are barren of discernable palynomorphs.

Samples 70, 100, 150 and 200 m
Interpreted age: likely Namurian
Confidence of age-interpretation: low

Remark: The preservation of these two productive is very poor. The association comprises *Lycospora pusilla*, *Savitrisporites nux, Bellispores nitidus* and *Crassispora kosankei*, suggesting an early Westphalian or older age. The absence of definite Westphalian markers (e.g., *Radiizonates aligerens* and/or *Dictyotriletes bireticulatus*) suggests this interval is Namurian in age.

Samples 300, 400 and 580 m
Interpreted age: mid-Carboniferous, Namurian-A, Chokierian - Alportian (TK-Zone of Clayton et al., 1978)
Confidence of age-interpretation: high, except for position of base

This interpretation is based on:
- LOD of *Rotaspora fracta* at 300 m
- FOD of *Savitrisporites nux* at 400 m
- FOD of *Bellispores nitidus* at 400 m
- LOD of *Grandispora spinosa* at 400 m
- FOD of *Crassispora kosankei* at 580 m

Remark: The sample at 500 m is barren of discernible palynomorphs. Possibly the Namurian miospores occurring at 580 m are the consequence of downhole contamination into an otherwise sterile residue. The distinctive and otherwise typically abundant early Namurian taxon *Tripartites vetustus* is not recorded. It has a reported extinction in the Arnsbergian (early Namurian-A, see Dusar, 2006). Therefore it seems plausible that the interval 580 – 200 m is Chokierian to Alportian in age. The lowermost three samples (780, 700 and 660 m) are barren of palynomorphs.

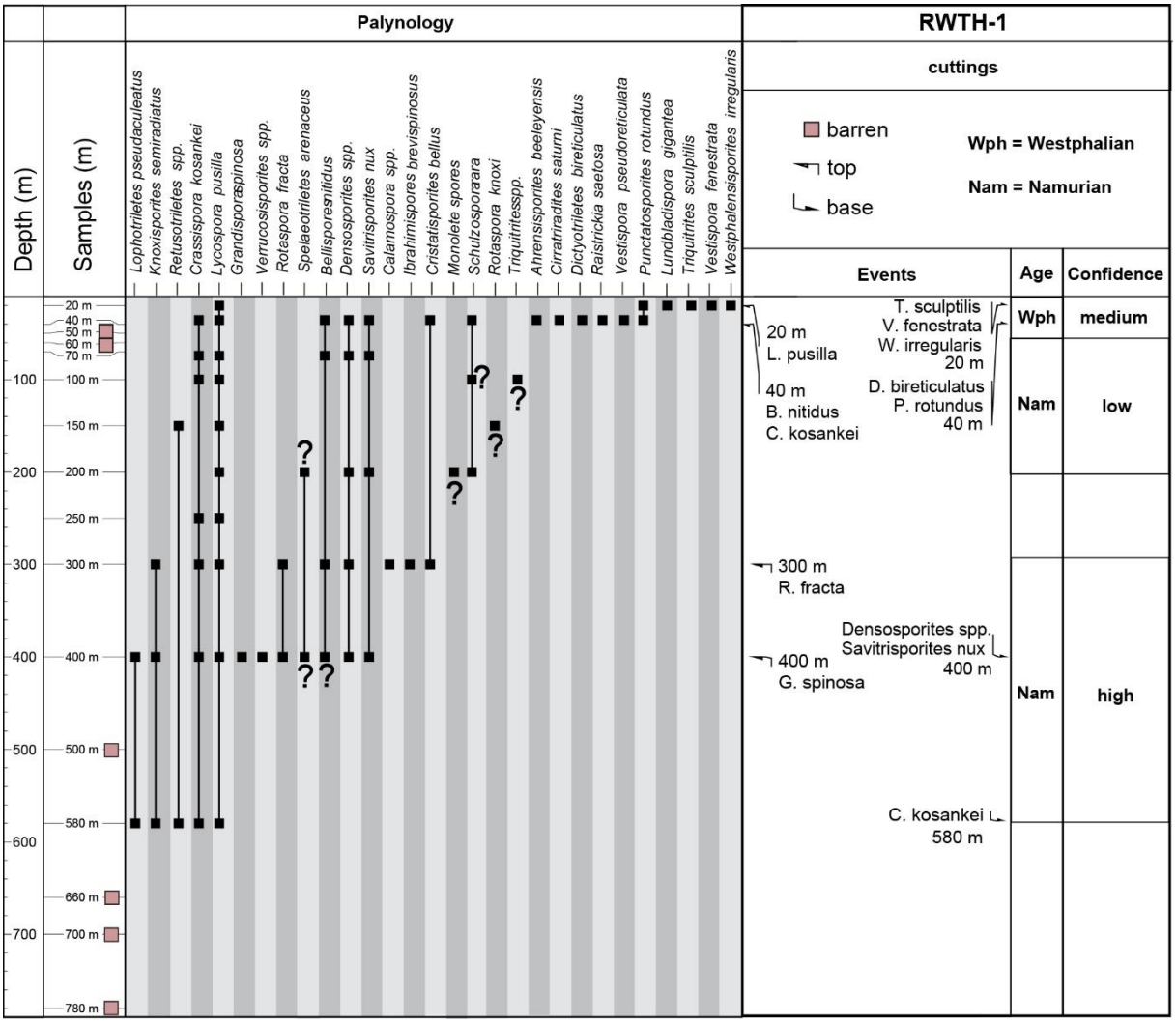


Figure S3.3. Range chart for the RWTH-1 borehole showing the presence of miospore taxa.

3.6 Kastanjelaan-02 (KSL-02)

The cored section from well Kastanjelaan-2 (KSL-02) was studied initially by Bless et al. (1981). These authors recognised three palynological distinct intervals. Their observations are summarised below.

1. The interval between 391.6 – 395.1 m (2 samples) corresponds to dark shales of the Pont d'Arcole fm. It yielded the miospores *Retusotriletes incohatus*, *Auroraspora macra*, *Hymenozonotriletes* (now *Indotriraditus*) *explanatus*, *Corbulispora* sp., *Aneurospora greggsii*, *Acanthotriltes* spp. and *Verrucosisporites* spp. The interval also comprises acritarchs; *Solisphaeridium astrum*, *Michrystridium* sp., *Gorgonisphaeridium* sp. and *Cymatiosphaera* sp.
2. The interval between 447.55 m and 462.85 m (3 samples) corresponds to a bioclastic limestone-lithology (here referred to as the Hastiere Fm.) It yields the miospores *Spelaeaotriletes* (now *Retispora*) *lepidophyta*, *Spelaeotriletes arenaceus*, *Hystricosporites multifurcatus*, *Rugospora flexuosa*, *Rugospora versabilis* and *Archaeozonotriletes* (now *Grandispora*) *fammenensis.*
3. At 465.2 m an association with *Aneurospora greggsii*, *Dictyotriletes* sp. and *Raistrickia variabilis* is recovered. This interval also yields abundant occurrences of the acritarch *Lophosphaeridium* sp. These have been recorded from the Upper Famennian of the Ourthe Valley (Becker et al., 1974).

To validate and further refine the abovementioned observations, five additional samples were analysed in this study. The samples at 381 and 386.6 m are taken from the Pont d'Arcole fm. and do not yield recognizable palynomorphs. The kerogen is dominated by dark angular phytoclasts and tracheids.

The samples at 426.6 and 430.3 m are taken from mudstone intercalations in a bioclastic limestone, provisionally assigned to the Hastiere fm. The kerogen is characterized by a high degree of thermal maturity. The preservation is poor and the palynofacies associations comprise tracheids, phytoclasts and cuticulae. Identified miospores are *Spelaeotriletes arenaceus*, *Raistrickia variabilis*, *Rugospora versabilis* and *Retusotrites incohatus*. The sample at 477.4 m from mudstone intercalations in the heterolithic basal part of the core, provisionally assigned to the Condroz fm. is overwhelmingly dominated by the miospore taxon *Retispora lepidophyta*. Other recorded taxa include *Grandispora echinata*, *Retusotriletes incohatus* and *Raistrickia variabilis*.

The following section provides a stratigraphic re-interpretation based on the observations of Bless et al. (1981) and the new analyses, from base to top (Figure 3.4). This is required because the Devono-Carboniferous palynological zonations and their calibration have changed substantially (see e.g., Maziane et al., 1999; Higgs et al., 2013 and Marshall et al., 2018; Denayer et al., 2021) since 1981.
A relevant observation that applies to all samples is the dark coloration of the palynomorphs, all are deeply dark-colored (8.5 on Fisher et al. 1981 coloration scale), which corresponds to an vitrinite-equivalent $\%R_0$-value of 1.5 or a Thermal Alteration Index (TAI) of 3.5 (Suárez-Ruiz et al. 2012).

Samples 462.8, 465.2 and 477.4 m
Interpreted age: early Latest Famennian (early Strunian)
Confidence of age-interpretation: high

This interpretation is based on:
- The FOD of *Retispora lepidophyta* (large) at basal sample 477.4 m
- The FOD of *Grandispora echinata* at basal sample 477.4 m
- Absence of *Indotradites explanatus* in interval

Remark: Bless et al. (1981) note that in the deepest sample they analyzed (465.2 m), *Retispora lepidophyta* and *Rugospora versabilis* are absent. This observation was corroborated by our analysis. This subsequently led them to interpret this sample to correspond the middle-late Late Famennian VU-zone of Paproth and Streel (1971). This zone was later renamed as the much more often used VCo-Zone (Paproth et al., 1983; Streel et al., 1987) age. However, the recording of *R. lepidophyta* and *G. echinata* at 477.4 m indicates that the basal part of the cored section at KSL-02 is of a latest Famennian (Strunian) age. There is long-standing controverse regarding the palynological zonations of the Strunian and Devonian-Carboniferous boundary interval (viz. the status of the PL-Zone and the LE, LN and LL Subzones, see e.g., Maziane et al., 1999; Higgs et al., 2013 and Denayer et al., 2021). Nevertheless, the absence of *Indodtriradites explanatus* (the basis for the uppermost Famennian LE Subzone) suggests an early-mid Latest Famennian (Strunian) age for this interval. This is further supported by the relatively large size (>70 µm, see S3.5) of specimens of *Retispora lepidophyta* in the sample at 477 m. As pointed out Maziane et al. (2002) this taxon underwent an evolution from larger to smaller size towards the D/C-boundary. This supports the assertion that the Condroz fm. strata at KSL-02 are early-middle Strunian in age. It is possible that some geological time is missing at the (fault) contact between the Condroz en Hastiere fm. at KSL-02 (i.e., the LE-Zone, middle Strunian). This cannot be stated with certainty.

Samples 447.55 and 447.8 m
Interpreted age: latest Latest Famennian (latest Strunian)
Confidence of age-interpretation: high

This interpretation is based on:
- the LOD of *Retispora lepidophyta* (small) at 447.55 m
- the LOD of *Grandispora famennensis* at 447.55 m

Remark: Bless et al. (1981) assign the three samples between 447.55 and 462.8 to the Strunian PL-Zone of Paproth and Streel (1971). According to Bless et al. (1981) the size distribution of specimens of (between 46 – 61 µm) *R. lepidophyta* suggests a late Latest Famennian age, close to the extinction of the taxon at the Devonian-Carboniferous boundary (see Maziane et al., 2002). The apparent absence of *Verrucosisporites nitidus*, which has a widely first occurrence in the latest Famennian (base of the LN-Zone, see Marshall et al., 2018), is a widely recognised phenomenon in Belgium and surroundings. Its absence is ascribed to ecological differences with sections elsewhere (Denayer et al., 2021).

Samples 430.3 and 424.6
Interpreted age: Early Tournaisian, based on superposition
Confidence of age-interpretation: low

Remark: The samples are very poorly preserved and lack definite marker taxa for a Tournaisian age. The LODs of *Raistrickia variabilis* and *Rugospora versabilis* at 430 m indicate an age close to the D/C-boundary.

Samples 391.6 391.8 and 395.1 m
Interpreted age: early Tournaisian (older than PC-Zone; Clayton et al. 1977).
Confidence of age-interpretation: high

This interpretation is based on:

- FOD of *Aurorospora macra* and *Indotriradites explanatus* at 395.1 m
- The absence of younger Tournaisian occurrences such as *Knoxisporites hibernicus, Vallatisporites vallatus* and/or *Raistrickia clavata* (PC-Zone of Clayton et al., 1977)

Remark: The absence of *Verrucosisporites nitidus* is widespread phenomenon in the study area (Denayer et al., 2021).

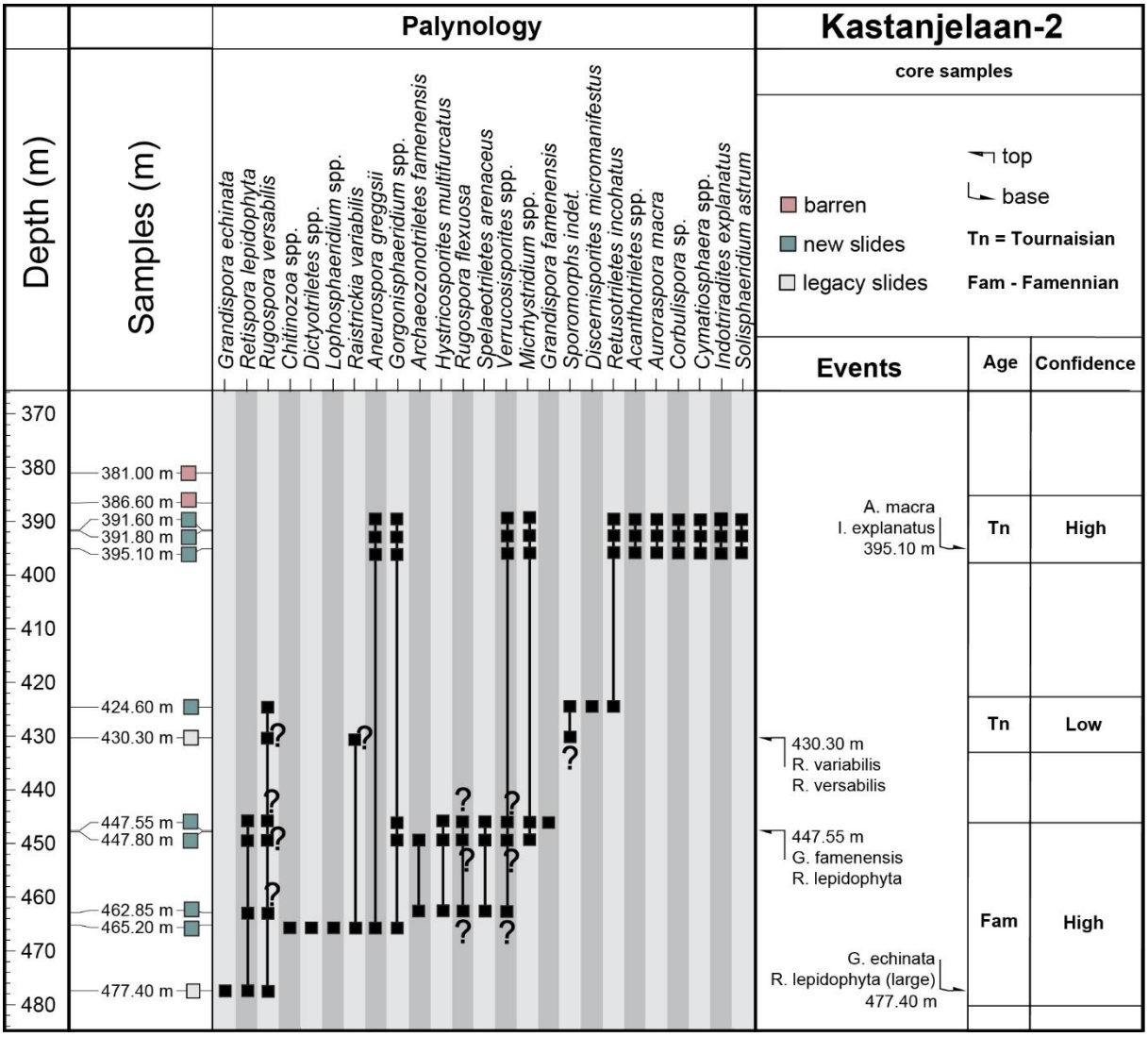


Figure S3.4. Range chart for the KSL-02 borehole showing the presence of miospore taxa.

3.7 Dalhem outcrop

Location: XRD 178805, YRD 302377
Interpreted age: late Carboniferous, Westphalian-A
Confidence of age-interpretation: Low

Two samples were processed from the outcrop section exposed near the train tunnel in Dalhem. They both yield rich but very poorly preserved miospores. The spore coloration is very dark, comparable to the specimens encountered in well KSL-02. The samples are dominated by long-ranging Carboniferous Namurian and younger spores; *Lycospora pusilla*, *Densosporites annulatus* and *Crassispora kosankei*. However the samples also contains very poorly preserved pollen resembling the genera *Florenites* and *Endosporites*. In addition, *Cirratriradites saturni* and *Mooreisporites fustis* were possibly encountered. This cannot be stated with certainty due to compromised preservation. Yet, this together argues for a younger Westphalian (SS-Zone or RA-Zone of Clayton et al., 1978), although the marker taxa for this zone were not identified.

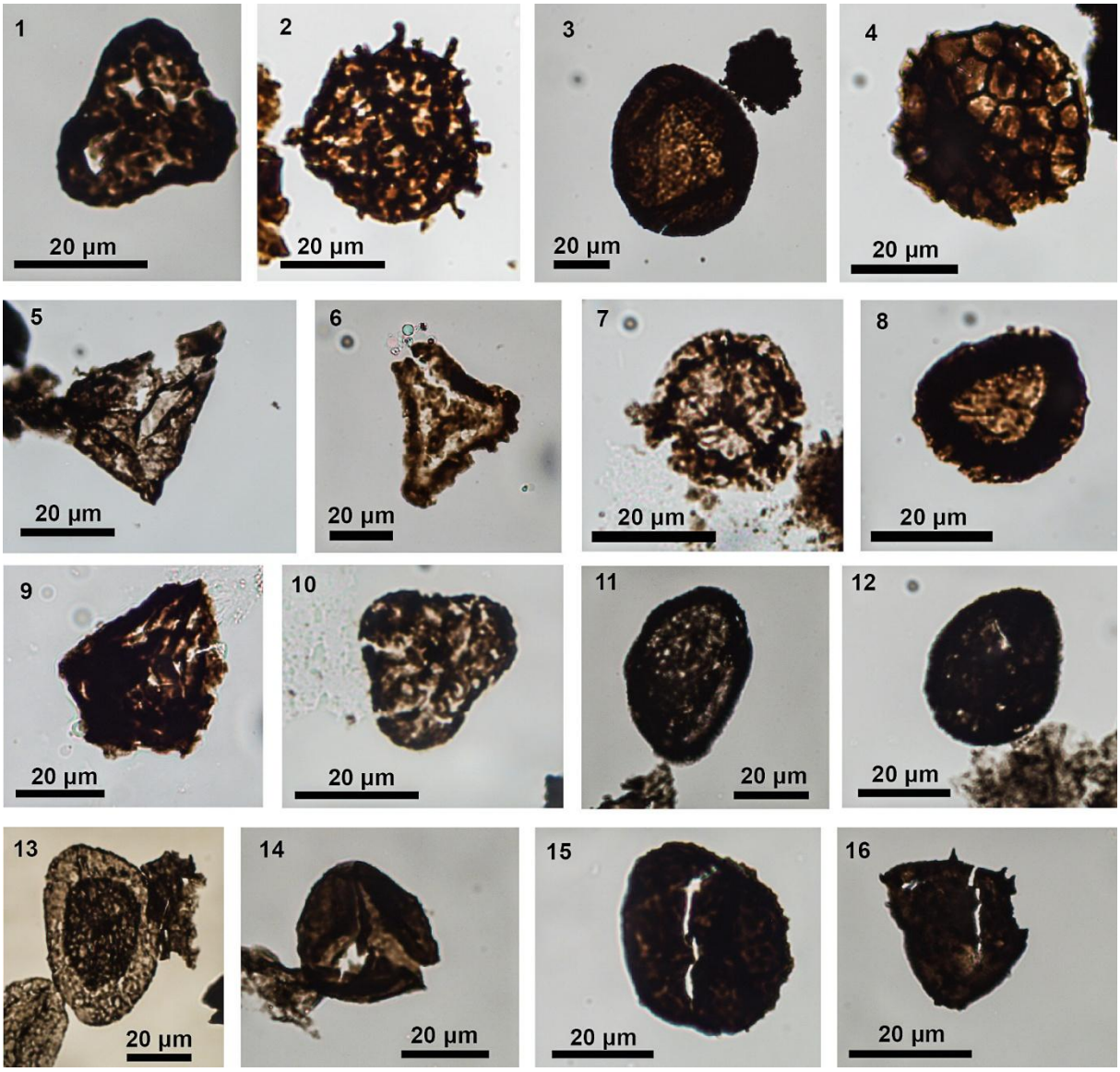


Figure S3.5. Photomicrographs of selected palynomorphs, see next page for identification.

1.	*Triquitrites sculptulis*	RWTH-1	20 m
2.	*Raistrickia* spp.	RWTH-1	40 m
3.	*Crassispora kosankei*	RWTH-1	40 m
4.	*Dictyotriletes bireticulatus*	RWTH-1	40 m
5.	?*Moreisporites fustis*	Dalhem oucrop sample	
6.	*Rotaspora fracta*	RWTH-1	400 m
7.	*Lycospora pusilla*	RWTH-1	400 m
8.	*Densosporites annulatus* group	RWTH-1	40 m
9.	*Savitrisporites nux*	RWTH-1	400 m
10.	*Bellispores* cf. *nitidus*	RWTH-1	400 m
11.	*Rugospora flexuosa*	KSL-02	430.5 m
12.	*Rugospora variabile*	KSL-02	430.5 m
13.	*Retispora lepidophyta*	KSL-02	177.4 m
14.	*Retusotriletes* spp.	Terziet-2	139 m
15.	*Grandispora echinata*	Terziet-2	139 m
16.	*Grandispora cornuta*	Terziet-2	139 m

4. Other data and materials

4.1 Stratigrpahic mismatches in geologic map

Comparing borehole stratigraphy as indicated by geodatabase viewers revealed 23 mismatches (Fig. S4.1). Of these mismatches, four are due to false presentation by geodatabase viewers (see main text section 4.3.3). Hence, the geologic map contains 22 stratigraphic errors. The comparison is based on 738 boreholes, of which 50 are unknown or described as Carboniferous - '*Sokkel Primair*'. From the coalfields, 295 boreholes are compared at the stage level Westphalian and therefore reveal no mismatches. As research was historically focused on the coalfields, we expect this region to be well-mapped on an intra-stage level.

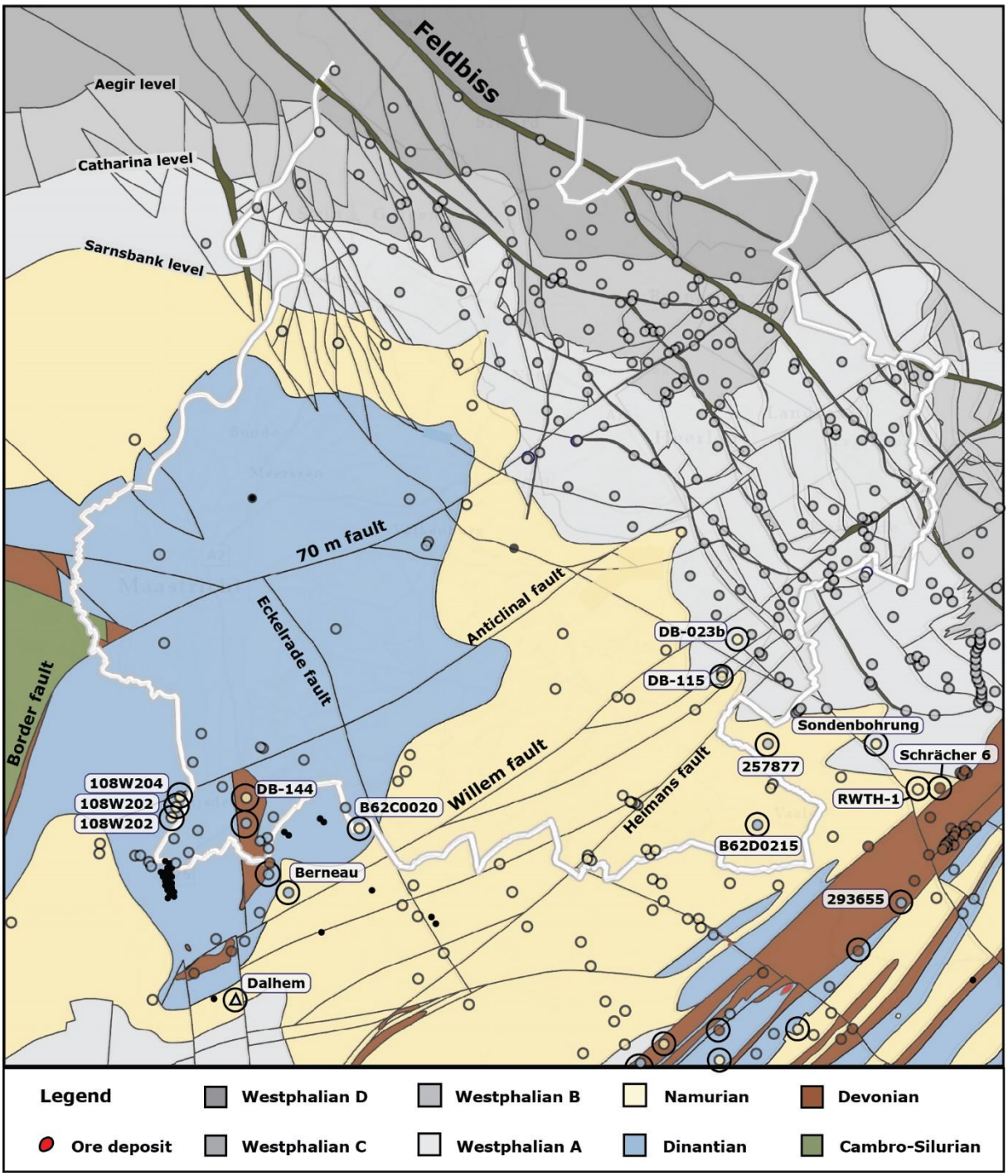


Figure S4.1 Geologic map showing the top-Paleozoic surface, layout adjusted from RGD, (1995). Stratigraphic mismatches between the map and borehole reports or geodatabases are indicated with circles. Note the Dalhem outcrop is indicated as a triangle.

4.2 Val Dieu-Dalhem road section

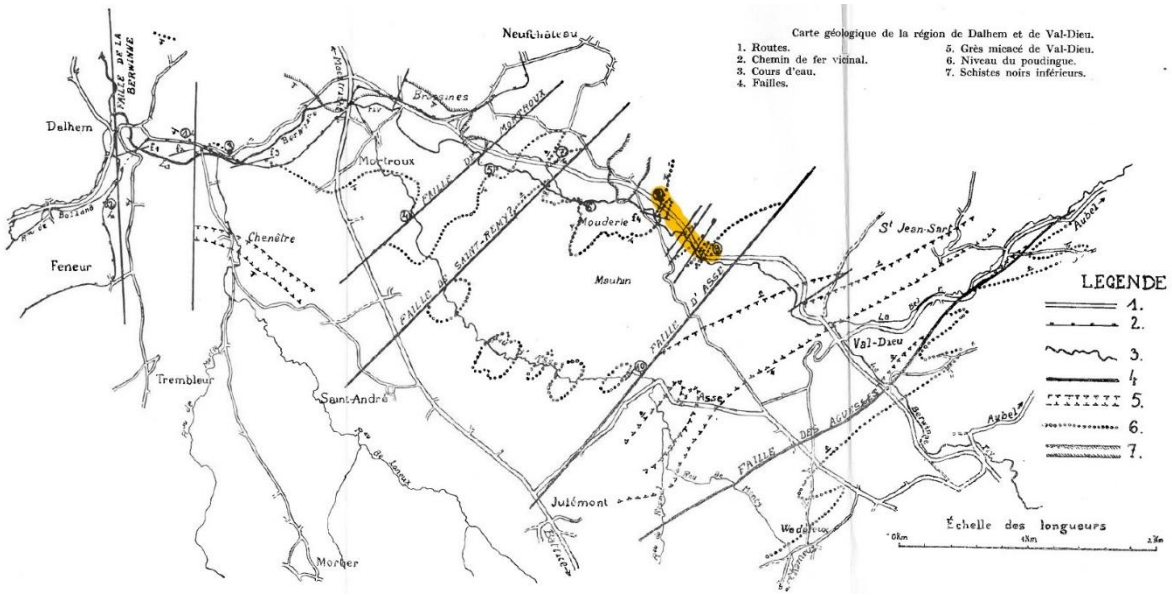


Figure S4.2 Map showing the location of the Val Dieu-Dalhem road section presented in the text as Figure 7 (Raucq, 1942).

4.3 Digital Elevation Model

The Digital Elevation Model shown in Figure 5 of the main text consists of a hill shade and an elevation map downloaded from https://www.mapsforeurope.org/datasets/euro-dem (MAPS for Europe n.d.). The model describes the terrain, excluding vegetation and buildings. The elevation model was converted to the coordinate system - Amersfoort RD new – using ArcGIS Pro® (Esri, 2016). The greyscale was adjusted to gain more contrast by adjusting levels in Adobe Photoshop (Adobe Inc. 2024).

5. Terminology

Type	Term	Explanation
a	ambiguity	the recognition that data can be interpreted in two or more ways probable ways.
a	ambiguous lithofacies	lithofacies that are non-exclusive to a particular stratigraphic unit
a	reworked microfossils	when older microfossils are eroded from their original sedimentary deposit and then get redeposited into younger sediments
a	uphole contamination in cuttings	when material falls into the borehole and mixes with the cutting sample during acquisition, resulting in the artificial introduction of microfossils from overlying strata.
a	indiscernible data	data that reveals little to no information, so that no interpretation can be drawn
b	uncertain scaling heuristics	the uncertainty of using fault zone thickness as indicator for fault offset and other fault dimensions
b	variable fault dimensions	natural variation of fault zone thickness within a single fault or compared to other faults
b	fracture-bedding similarity in BHI	the resemblance of similarly oriented bedding planes and fractures in borehole image logs
b	uncertainty in fault recognition	uncertainty arising from interpreting ambiguous breccia textures
b	uncertainty in interpreting fault zone thickness	uncertainty arising from problems in pinpointing the outer limit of a fault damage zone
c	semantic misunderstanding	a mismatch that occurs when processed data is understood differently as intended by the data provider
c	unincorporated updates	stratigraphic amendments for specific boreholes that remain unincorporated in geodatabase viewers, creating a mismatch between the latest knowledge and the data presented
c	data reworking	adjustments made to processed data or input materials in a collective dynamic
d	change in biostratigraphic framework	biostratigraphic calibration of microfossil assemblages is changed in respect of the chronostratigraphic chart, creating inconsistencies with older literature.
d	change in concepts	interpretations are made under an assumption or paradigm that has evolved after scientific knowledge has accumulated, and new insights have progressed
d	invalid assumption	interpretations were made under reasonable assumptions that were later revealed to be invalid by new data
d	cognitive bias	an umbrella term for different unconscious biases affecting interpretation and decision-making

Table S5.1. Terms indicated in Figure 17 of the main text and theirexplanations. Typers refer to table 1 of the main text.