OSTRACODES, ROCK FACIES AND MAGNETIC SUSCEPTIBILITY OF THE TROIS-FONTAINES / TERRES D'HAURS TRANSITION IN THE TYPE LOCALITY FOR THE GIVETIAN

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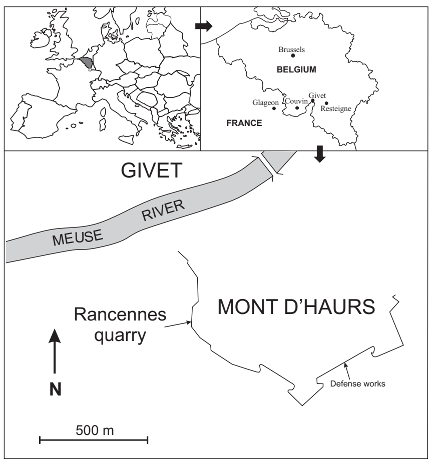
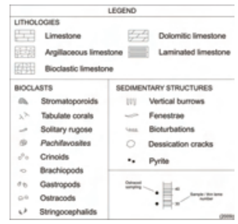
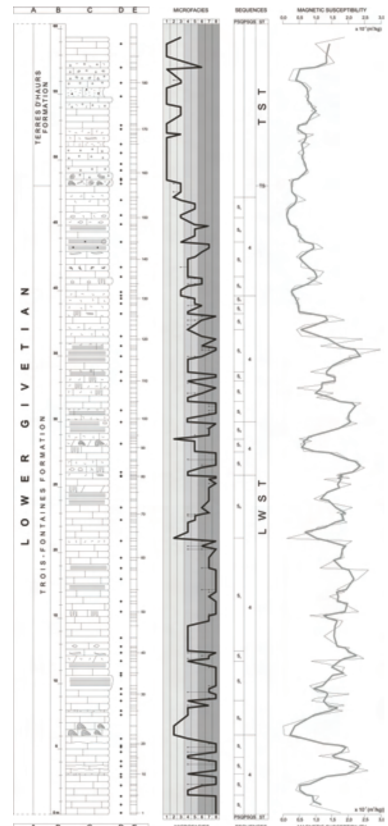
The Rancennes quarry is located 1 km south of Givet, at the Mont d'Haurs, and along the western rampart of an entrenched camp built in the end of the XVIIth century by VAUBAN, the military architect of LOUIS XIV. The series exposed in the quarry is particularly homogeneous and consist of 46 m of well bedded fine-grained greyish mudstones, wackestones and laminites (= Trois-Fontaines Fm, base of the Givetian Group) overlain by 14 m of thicker beds of clayey slightly nodular wackestones, packstones and floatstones with crinoids, corals and various shelly bioclasts (= Terres d'Haurs Fm). The base of the Terres d'Haurs Fm is marked by a clayey nodular biostrome.
The Rancennes quarry completes the stratotype of the Terres d'Haurs Fm located on the southeastern flank of the entrenched camp of the Mont d'Haurs where the Trois-Fontaines Fm / Terres d'Haurs Fm boundary is not visible.



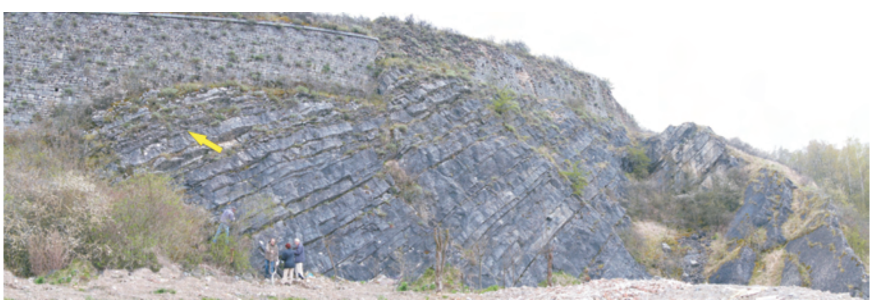
Locality map of the Rancennes quarry



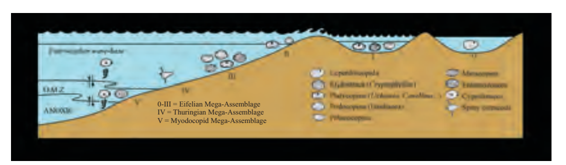
Lithological column of the Rancennes quarry: (A) stratigraphy; (B) thickness; (C) lithology; (D) position of ostracode samples; (E) position of samples for thin section and MS analysis.



The Trois Fontaines Fm / Terres d'Haurs Fm boundary



The Rancennes quarry



Devonian ostracode assemblages

Three mega-assemblages are recognized in the Devonian: 1. The Eifel Mega-Assemblage generally characterized by a rich and diversified ostracode fauna is indicative of shallow marine (neritic), semi-restricted or lagoonal environments; 2. The Thuringe Mega-Assemblage characterized by spiny ostracodes is indicative of deep and (or) cold marine environments; 3. The Myodocopida Mega-Assemblage characterized by entomozoid and (or) cyprinoid ostracodes is indicative of poorly oxygenated water conditions.

Ostracodes

1,200 ostracodes were extracted by the hot acetolysis method from 64 samples collected in the Rancennes quarry, and 49 species were recognized. The richness and diversity of ostracodes are very variable and the monospecificity prevails in numerous samples. Ostracodes appertain to the Eifelian Mega-Assemblage, and more precisely to several assemblages indicative of shallow marine, semi-restricted and lagoonal environments.

1. Trois-Fontaines Fm: The very base of the section investigated (MH-1 to MH-10) was shallow marine, agitated, and well oxygenated as indicated by the presence of broken carapaces and by the predominance of Podocopina belonging to two thick shelled genera of the Pachydomellidae (*Tubulibairdia* and *Microcheilinella*). Then from sample MH-12 to MH-119, the environment was generally lagoonal as attested by the abundance of Leperditicopida belonging to the genus *Herrmannina.* The absence of ostracodes between samples MH30 and MH37, and between samples MH-43 and MH-68, is probably indicative of very stressful lagoonal conditions. Sometimes the environment was semi-restricted with a strong marine influence (samples MH-25, MH-43). In the top of the Trois-Fontaines Fm, the ostracodes are scarce and poorly diversified (MH-145, 154), or absent (MH149, 151), attesting of very shallow semi-restricted water conditions.

2. Terres d'Haurs Fm: In the upper part of the investigated section, the environment was semi-restricted (MH-157, 158 and 180 in which the monospecificity prevails) or more frequently shallow marine (MH-165 and MH-186) but in that case, the energy of the environment was apparently never very strong. In sample MH-165 some stacked valves have been extracted. These stacked ostracode valves are related to the action of a moderate but continue action of waves.

The thickness of the level rich in Leperditicopida which reach about 40 m in the Trois Fontaines Fm exposed in the Rancennes quarry, is recognizable on hundreds kilometers.

MONT D'HAURS	1	4	7	9	10	12	14	17	18	19	21	24	25	28	30	37	40	43	68	72	80	83
Tubulibairdia clava (Kegel, 1933)	*																					
Fellerites? sp. indet.		*																				
Fellerites sp. indet.		*											*									
Kozlowskiella? sp. indet.		*										*										
Bairdiacypris sp. *in* Coen (1985)			?				?								?			*				
Healdianella? longissima (Kummerow, 1953)				*	*							*	*	*								
Bairdiocypris symmetrica (Kummerow, 1953)				?								*	*	?				*				
"Healdianella" budensis Olempska, 1979?					*																	
Microcheilinella affinis Polenova, 1955					*						*		*	*				*				*
Herrmannina consobrina (Jones, 1896)						?	*	*		*		*					?		*	*	*	
Evlanella cf. *lessensis* Casier, 1991							*						*					*				
Buregia ovata (Kummerow, 1953)									?			*						*				
Coeloenellina sp. indet.										*												
Uchtovia kloedenellides (Adamczak, 1968)										*		*	*					*				
Coeloenellina minima (Kummerow, 1953)										*		*										
"Orthocypris" sp. indet.											*											
Gravia alatus (Kummerow, 1953)												*										
Parapribylites hanaicus Pokorny, 1950												?										
Amphissites sp. indet.													*									
Palaeocopida indet. *in* Casier & Preat (1990)													*									
Fellerites crumena (Kummerow, 1953)													*			*		*				
Bairdia cf. *tischendorfi* Becker, 1965													?					*				
Bairdia sp. B													*									
Bairdiocypris sp. indet. *in* Casier & Préat (1992)													?	*				*				
Bairdia sp. A *in* Casier & Préat (1991)													*									
Samarella? sp. A													*					*				
Bairdiocypris aff. *marginata* Adamczak, 1976													*					*				
Cavellina macella (Kummerow, 1953)													*									
Coeloenellina n. sp. A, aff. *bijensis sensu* C. & P. (1991)													?									
Cytherellina perlonga (Kummerow, 1953)													?	*				*				
Bairdia paffrathensis Kummerow, 1953													*			?						
"Cytherellina" dubia (Kummerow, 1953)													*					*				
Kozlowskiella mamillata (Kummerow, 1953)													*					*				
Amphissites tener omphalotus Becker, 1964													*									
Ctenoloculina sp. A, aff. *kelletae* Pokorny, 1950													?									
Cryptophyllus sp. C *in* Casier & Préat (1991)													*	*		*		*				
Evlanella germannica Becker, 1964													*									
Evlanella sp. indet.													*					*				
Bairdiocypris sp.														*								
Marginia sculpta multicostata Polenova, 1953														*				*				
Palaeocopida? indet.																*						
Evlanella lessensis Casier, 1991																?		*				
Scrobicula sp. indet.																		*				
Kozlowskiella n. sp. A, aff. *mamillata in* C. & P. (1991)																		*				
Uchtovia cf. *abundans* (Pokorny, 1950)																		*				
Aparchites sp. indet.																						*
Cytherellina obliqua sensu Becker, 1965																						
Kozlowskiella cf. *wenniana* Groos, 1969																						
Bairdia cf. *paffrathensis* Kummerow, 1953																						
Cavellina sp. indet.																						
Acratia sp. A *in* Casier & Préat (1991)																						
Parapribylites cingulatus (Kummerow, 1953)																						
Svantovites primus Pokorny, 1950																						
Poloniella cf. *tertia* Krömmelbein, 1953																						
Falsipollex? sp. 3G *in* Milhau, 1988?																						

MONT D'HAURS	91	99	102	110	113	116	119	121	126	129	130	131	132	137	139	154	158	159	162	164	165	170	171	180	183	186
Tubulibairdia clava (Kegel, 1933)													?													
Fellerites? sp. indet.																										
Fellerites sp. indet.							*																			
Kozlowskiella? sp. indet.													*													
Bairdiacypris sp. *in* Coen (1985)				?								*	*							?						
Healdianella? longissima (Kummerow, 1953)					*								*													
Bairdiocypris symmetrica (Kummerow, 1953)							*		*			*														*
"Healdianella" budensis Olempska, 1979?																										
Microcheilinella affinis Polenova, 1955				*								*	*					*								*
Herrmannina consobrina (Jones, 1896)		*	*				*							?	*										?	
Evlanella cf. *lessensis* Casier, 1991												*												*		
Buregia ovata (Kummerow, 1953)				*											*		?		*		*	*	?	*		*
Coeloenellina sp. indet.													*													
Uchtovia kloedenellides (Adamczak, 1968)	?											*	?													
Coeloenellina minima (Kummerow, 1953)				*								*	*	*												*
"Orthocypris" sp. indet.				*																						
Gravia alatus (Kummerow, 1953)																										
Parapribylites hanaicus Pokorny, 1950												*	*						?		*					*
Amphissites sp. indet.																										
Palaeocopida indet. *in* Casier & Preat (1990)																										
Fellerites crumena (Kummerow, 1953)																										
Bairdia cf. *tischendorfi* Becker, 1965																										
Bairdia sp. B										*																
Bairdiocypris sp. indet. *in* Casier & Préat (1992)	*																									
Bairdia sp. A *in* Casier & Préat (1991)												*														
Samarella? sp. A													*													
Bairdiocypris aff. *marginata* Adamczak, 1976												?	*													
Cavellina macella (Kummerow, 1953)						*	*						*													
Coeloenellina n. sp. A, aff. *bijensis sensu* C. & P. (1991)												*	*					?								
Cytherellina perlonga (Kummerow, 1953)																					*					
Bairdia paffrathensis Kummerow, 1953				*									*					*	*		*					
"Cytherellina" dubia (Kummerow, 1953)				*		*	*		?									*			*					
Kozlowskiella mamillata (Kummerow, 1953)	*			*					*	*		*								*	*				*	
Amphissites tener omphalotus Becker, 1964													*		*											*
Ctenoloculina sp. A, aff. *kelletae* Pokorny, 1950																			*		*					?
Cryptophyllus sp. C *in* Casier & Préat (1991)				*	*					*	*		*			*										*
Evlanella germannica Becker, 1964	?												*					*			*					*
Evlanella sp. indet.	*			*		*									*		*				*					*
Bairdiocypris sp.																										
Marginia sculpta multicostata Polenova, 1953										*		*									*	?				*
Palaeocopida? indet.																										
Evlanella lessensis Casier, 1991																										
Scrobicula sp. indet.																										
Kozlowskiella n. sp. A, aff. *mamillata in* C. & P. (1991)																										
Uchtovia cf. *abundans* (Pokorny, 1950)												*														
Aparchites sp. indet.													*													
Cytherellina obliqua sensu Becker, 1965				*		*	*											*	*	*	*					*
Kozlowskiella cf. *wenniana* Groos, 1969					*		*																			
Bairdia cf. *paffrathensis* Kummerow, 1953								*																		
Cavellina sp. indet.										*																
Acratia sp. A *in* Casier & Préat (1991)												*	*													
Parapribylites cingulatus (Kummerow, 1953)													?													*
Svantovites primus Pokorny, 1950																			*							
Poloniella cf. *tertia* Krömmelbein, 1953																					*					
Falsipollex? sp. 3G *in* Milhau, 1988?																					*					

Distribution of ostracodes in the Trois-Fontains Fm and Terres d'Haurs Fm. The boundary is located between samples 154 and 158.

PLATE 1. 1. *Herrmannina consobrina* (JONES, 1896), MH-14; **2.** *Amphissites tener omphalotus* BECKER, 1964, MH-25; **3.** *Amphissites* sp. indet., MH-25; **4**. *Falsipollex?* sp. 3G *in* MILHAU (1988)? MH-165; **5**. *Scrobicula* sp. indet., MH-43; **6**. *Kozlowskiella mamillata* (KUMMEROW, 1953), MH-165; **7.** *Kozlowskiella* n. sp. A aff. mamillata (KUMMEROW, 1953) *in* CASIER & PRéAT (1991). MH-43; **8.** *Kozlowskiella* cf. *wenniana* GROOS, 1969. MH-119; **9**. *Fellerites crumena* (KUMMEROW, 1953), MH-25; **10**. *Fellerites?* sp. indet. MH-4; **11.** *Aparchites* sp. indet., MH-132; **12.** Palaeocopida? indet., MH-37; **13.** *Ctenoloculina* sp. A, aff. *kelletae* POKORNY, 1950, MH-165; **14**. *Gravia alatus* (KUMMEROW, 1953), MH-24; **15.** *Parapribylites hanaicus* POKORNY, 1950, MH-132.

PLATE 2. 1. *Parapribylites cingulatus* (KUMMEROW, 1953), MH-186; **2.** *Buregia ovata* (KUMMEROW, 1953), MH-43; **3.** *Samarella?* sp. A, MH-25; **4.** *Poloniella* cf. *tertia* KRöMMELBEIN, 1953, MH-165; **5.** *Uchtovia kloedenellides* (ADAMCZAK, 1968), MH-25; **6.** *Coeloenellina minima* (KUMMEROW, 1953), MH-110; **7.** *Coeloenellina* n. sp. A, aff. *bijensis* (ROZHDESTVENSKAJA, 1959) *sensu* CASIER & PRéAT (1991), MH-132; **8.** *Coeloenellina* sp. indet., MH-132; **9.** *Marginia sculpta multicostata* POLENOVA, 1953; **10.** *Cavellina macella* (KUMMEROW, 1953), MH-119; **11.** *Cavellina* sp. indet., MH-129; **12.** *Evlanella germannica* BECKER, 1964, MH-165; **13.** *Evlanella lessensis* CASIER, 1991, MH43; **14.** *Evlanella* cf. *lessensis* CASIER, 1991, MH14; **15.** *Evlanella* sp. indet., MH-43.

PLATE 3. 1. *Svantovites primus* POKORNY, 1950, MH-162; **2.** *Cytherellina obliqua* (KUMMEROW, 1953) *sensu* BECKER, 1965, MH-165; **3.** *Cytherellina perlonga* (KUMMEROW, 1953), MH-28; **4.** *"Cytherellina" dubia* (KUMMEROW, 1953), MH-43; **5.** *Healdianella? longissima* (KUMMEROW, 1953), MH-9; **6.** *Microcheilinella affinis* POLENOVA, 1955, MH-43; **7.** *Bairdiocypris* aff. *marginata* ADAMCZAK, 1976, MH-43; **8.** *Bairdiocypris symmetrica* (KUMMEROW, 1953), MH-43; **9.** *Bairdiocypris* sp. indet. *in* CASIER & PRéAT (1992), MH-43;**10.** *"Orthocypris"* sp. indet., MH-110; **11.** *Acratia* sp. A *in* CASIER & PRéAT (1991), MH-132;**12.** *Bairdia paffrathensis* KUMMEROW, 1953, MH-165; **13.** *Bairdia* cf. *paffrathensis* KUMMEROW, 1953. MH-121; **14.** *Bairdia* cf. *tischendorfi* BECKER, 1965, MH-43;**15.** *Bairdia* sp. A *in* CASIER & PRéAT (1991), MH-25; **16.** *Bairdia* sp. B. MH-129;**17.** *Bairdiacypris* sp. *in* COEN (1985), MH-131; **18.** *Cryptophyllus* sp. indet., MH-43.

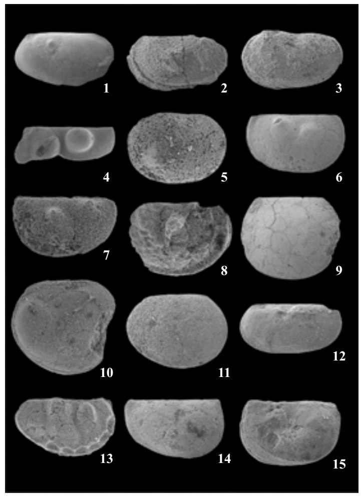


PLATE 1

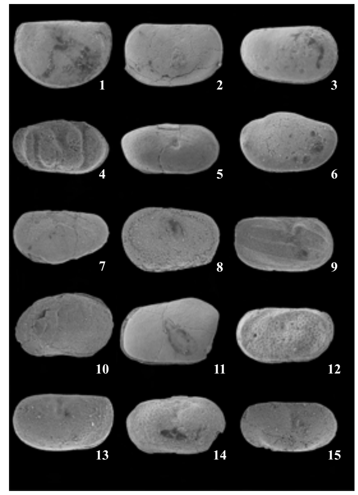


PLATE 2

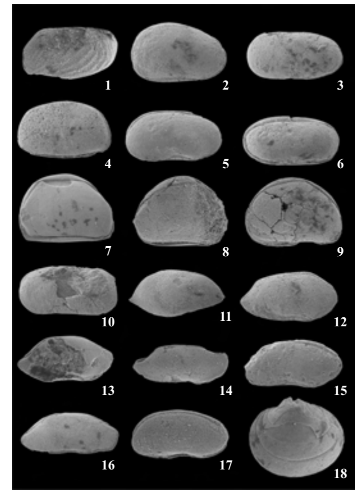


PLATE 3

Rock facies

187 samples have been collected for the petrography in order to constrain the paleoenvironments. The eight recognized microfacies point to a tidal flat system with various subenvironments such as restricted intertidal, supratidal and channel deposits (microfacies 3-7). The system was bordered by more subtidal open marine deposits where former reefal constructions have been destroyed (microfacies 3). Frequent oscillations in this low-gradient shallow platform led to the exposure and modification of marginal ponds, floodplain environments or palustrine areas (microfacies 8). No evaporitic environments or sakkha have been encountered.

Detailed distribution of the microfacies reveals that the Trois-Fontaines Fm consists mainly of a protected shallow lagoon with different environments from the back-reef area to the continental plain and that the Terres d'Haurs Fm is characterized by open marine environments. In the first formation, the fauna and microflora are endemic and dominated by a few species (algae, ostracodes), in the second the organisms are diversified and abundant. In reality, the sedimentary system shows the evolution of a shallow restricted carbonate platform (Trois-Fontaines Fm) which is very extensive to a carbonate ramp setting which is probably of large extension. This evolution of the platform to a ramp could be related to the disappearance of the active role of the reefal barrier related or unrelated to synsedimentary tectonism and block faulting.

MF	LITHOLOGY	PALEOENVIRONEMENT	GIVETIAN STANDARD SEQUENCE
1	Crinoidal-brachiopod packstones with reefal bioclasts	Open marine, fore-reef slope	MF3
2	Stromatoporoid floatstones	Subtidal peri-reefal channels	MF6
3	Oolitic bioclastic packstones	Intertidal sandy shoals	MF7c
4	Bioclastic packstones and calcispherid-Lepediticopida wackestones	Subtidal restricted lagoon	MF8-9
5	Issinellid bafflestones	Intra-lagoonal algal shoals	MF10
6	Spongiostromid bindstones and loferites	Inter- supratidal lagoonal ridge	MF11
7	“Cryptalgal” laminites	Inter- supratidal levees	MF12
8	Mudstone-wackestones with laminar crusts and rhizoconcretions	Palustrine and paleosols	MF13?

Main features of Rancennes microfacies (MF1-8, first column; lithology, second column and palaeoenvironment, third column) and comparison with Givetian microfacies of the Standard Sequence established by PREAT & MAMET (1989) in fourth column.

PLATE 5 (Microfacies 1, 2 and 3 : Open marine environment). **1.** Dolomitized crinoidal packstone with a few issinellids (algae) and micritized molluskan bioclasts. Open marine environment near crinoidal meadows and issinellid shoals at the SWB/FWWB interface. MF1, MH-163; **2.** Peloidal packstone with abundant issinellid microbioclasts. The centre of the photo shows an oncoidal encrustment of *Bevocastria* (Cyanobacteria) around a pelecypod. Open marine environment, with intermittent agitation near the FWWB. MF1, MH-158; **3.** Peloidal packstone with abundant issinellid microbioclasts. A subrounded oolitic microbreccia is present at the centre of the picture which contains a large *Bevocastria* fragment. Tempestite in the open marine environment. MF1, MH158; **4.** Stromatoporoid floatstone with a bioclastic (brachiopods, issinellids) packstone matrix. Agitated peri-reefal environment near a bioconstruction. M-F2, MH-64. **5.** Coral (*Trachypora*) floatstone. The matrix is an oolitic, peloidal and issinellid packstone. Agitated peri-reefal environment near intertidal channels. MF2-3, MH-145; **6.** Peloidal and oolitic packstone with coarse-grained microbreccia (the left one is muddy with bipyramidal quartz, the right one contains a coral bioclast). Agitated back-reefal environment near buildups. MF3, MH-157. **7.** Oolitic (ß oolite *sensu* Purser, 1980 or 3- and 4-type oolite *sensu* Strasser, 1986) wackestone with irregular lumps. MF3, MH-187. **8.** Packstone with crinoids, gastropods, ostracods, kamaenids (very small fragments). The micritic matrix is slightly microsparitized. MF3, MH-187.

PLATE 6 (Microfacies 4, 5 et 6 : Restricted lagoonal environment). **1.** Wackestone with archaegastropods, issinellids, *Kamaena* and calcispheres. Shallow restricted lagoonal environment. MF4a, MH-43; **2.** Calcispherid wackestone with a large cyanobacterial (*Bevocastria*) lump or nodule. Restricted lagoon. MF4a, MH-105; **3.** Calcispherid wackestone (="calcispherite") with *Labyrinthoconus* (alga). Restricted lagoon. MF4a, MH-116; **4.** Packstone with stacked Leperdicopida ? valves (ostracods), *Labyrinthoconus* and calcispheres. Numerous small-sized 'umbrella' fenestrae below the ostracods. Very shallow restricted lagoon. MF4a, MH-109; **5.** Bioclastic (gastropods, pelecypods,) packstone with a few peloids. Tempestite in a restricted lagoon. MF4b, MH-123; **6.** Peloidal issinellid packstone-bafflestone. Intralagoonal algal shoals. MF5, MH-89; **7.** Mudstone with a vadose cavity filled with laminar mud followed by yellow fibrous and white granular calcitic cements. Subaerial intertidal-supratidal restricted environment. MF6, MH-101; **8.** Mudstone with vertical dolomitic burrows. The matrix contains a few microbioclasts (kamaenids, issinellids). Intertidal lagoonal environment. MF6, MH-143.

PLATE 7. (Microfacies 7 and 8 (figs. 1-4) : Continental environment and pyrite (figs. 5-8). **1.** Laminite consisting of the alternation of continuous thin mudstone and thicker peloidal and algal (issinellids, kamaenids) packstone layers. Intertidal-supratidal levees between the shoreline and inland marshes. M-F7, MH174; **2.** Mudstone with an alveolar-septal structure? or an altered *Aphralysia*-like algal thallus. Subaerial environment (calcrete ?). MF8, MH-51; **3.** Wackestone with abundant microbioclasts (ostracods, undetermined algae). Oblique and sub-horizontal sheet-cracks in the micrite. Continental environment ("calcrete") developed on a lagoonal parental micrite. MF8, M-H57; **4.** Calcispherid and ostracod wackestone with concentric patches containing abundant thin calcite needle (probably related to rhizolites colonized by fungi). Pedogenetic alteration on a lagoonal parental micrite. MF8, MH-79; **5.** Calcispherid, issinellid and microbioclastic wackestone. Pyrite is concentrated in large irregular zones, and present as cubic and hexagonal minerals of various sizes. MF4, MH-142; **6.** Microbioclastic wackestone with irregular dissolution veins and cavities. Pyrite is preferentially observed in the cavities or along the veins and fissures. MF4, MH-147; **7.** Microbioclastic wackestone with oblique dolomitic burrow or fenestrae? Pyrite hexagonal or cubic preferentially associated with the lower part of the burrow. The finer pyrite between the dolomitic rhombs is sometimes filamentous. MF8, MH-67; **8.** Microbioclastic (issinellids, calcispheres) wackestone with abundant very small-sized (< 5µm) framboidal pyrite. MF8, MH-63.

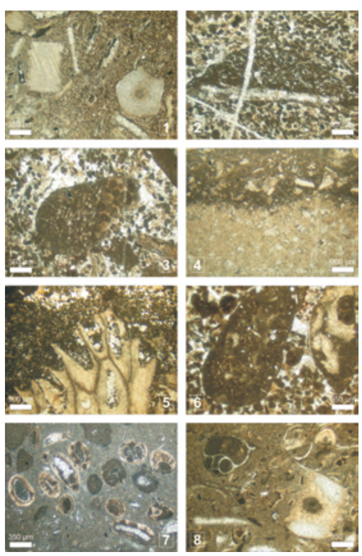


PLATE 4

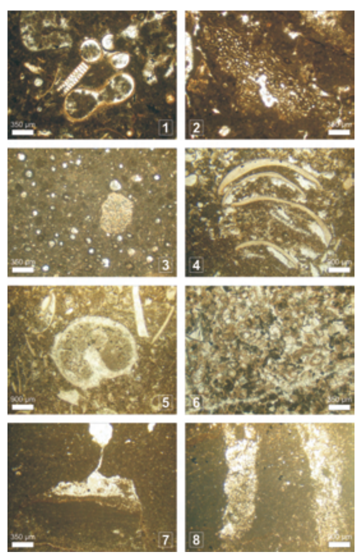


PLATE 5

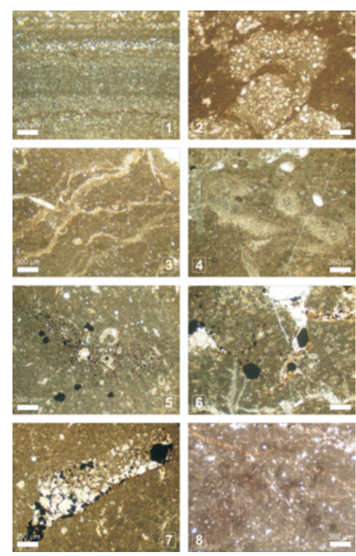


PLATE 6

Magnetic susceptibility

Magnetic susceptibility (MS) data were acquired with a Kappabridge MFK1-A. MS values range between 0.1 x 10^{-7} and 3.0 x 10^{-7} m^3/kg. The comparison between MS and sedimentological curves suggests a relative good correlation and indicates that MS and microfacies evolutions are more or less correlated in the studied section. The section reveals a MS long-term evolution and numerous short-term variations which can be subdivided in smaller sequences particularly in the Trois-Fontaines Fm. The highest MS values are observed in the Trois-Fontaines Fm. The lowest MS values are recorded close to the boundary between Trois-Fontaines Fm and Terres d'Haurs Fm. The base of the Terres d'Haurs Fm records a large increasing trend from 0.2 x 10^{-7} towards nearly 2.0 x 10^{-7} m^3/kg.

Thermomagnetic analyses were undertaken with a CS-3 furnace device on 30 selected samples based on MS values, microfacies and sedimentological observations. These data were coupled with hysteresis measurements made with a J-Coercivity meter. Thermomagnetic data shows that MS are controlled by ferromagnetic minerals *s.l.* and paramagnetic minerals (mostly clays and pyrite). The study demonstrated that magnetite grains are partly primary detrital grains and the main carrier controlling the MS signal in these Givetian limestones.

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