| | | | |
|---|---|---|---|
| Bulletin de la Société belge de Géologie | 98-2 | pp.127-133 | Bruxelles 1989 |
| Bulletin van de Belgische Vereniging voor Geologie | 98-2 | pp.127-133 | Brussel 1989 |

# THE "CHEILOCERAS LIMESTONE", A FAMENNIAN (UPPER DEVONIAN) EVENT-STRATIGRAPHICAL MARKER IN HERCYNIAN EUROPE AND NORTHWESTERN AFRICA ?

by

*Roland DREESEN* [1]

## *ABSTRACT*

The *Cheiloceras* Limestone is a distinctive red-stained nodular cephalopod limestone interstratified within Famennian siliciclastics in NW-Germany. Despite its quickly changing facies this marker can be traced into the adjacent Verviers and Dinant Synclinoria of Belgium. Analogous, red *Cheiloceras* bearing nodular limestones ("griottes") are known from the same stratigraphical level in Southern France (Montagne Noire), Poland (Holy Cross Mountains) and Morocco (Tafilalt). Although paleogeographical settings are different, paleotectonic conditions and facies characteristics are very similar, so that a common epeirogenic/eustatic control might be proposed for their origin.

## *RESUME*

Le Calcaire à *Cheiloceras* est un calcaire à céphalopodes noduleux rouge caractéristique, interstratifié dans les dépôts siliciclastiques famenniens du nord-ouest de l'Allemagne. Malgré les variations latérales rapides de son faciès, ce niveau-repère peut être suivi jusque dans les Synclinoria avoisinants de Verviers et de Dinant. Des dépôts calcaires analogues, noduleux, rouges et riches en *Cheiloceras* (les "Griottes") sont connus au même niveau stratigraphique dans le sud de la France (Montagne Noire), en Pologne (les Montagnes de la Sainte-Croix) et au Maroc (Plateau du Tafilalt). Bien que leurs positions paléogéographiques soient différentes, les conditions paléotectoniques ainsi que les caractéristiques de faciès sont fort semblables, ce qui permettrait d'évoquer un mécanisme épirogénique/eustatique commun pour leur origine.

## *MOTS CLES*

calcaires à cephalopodes, biostratigraphie, conodontes, Dévonien Supérieur, faciès sédimentaires, pulsation transgressive, tectonique synsédimentaire.

## *KEY WORDS*

cephalopod limestone,, biostratigraphy, conodonts, Upper Devonian, sedimentary facies, transgressive pulse, synsedimentary tectonics.

## 1. REGIONAL OCCURRENCES, FACIES AND STRATIGRAPHY

### 1.1. The Ardenne-Rhenish Massif

Since its original definition by Holzapfel (1910), the "*Cheiloceras* Kalk" has been used by several workers as a stratigraphical marker for the geological mapping of the Famennian South of Aachen (Wulff, 1923 ; Wunstorf, 1943 ; Schmidt, 1951, 1954 ; Schmidt & Schroder, 1962).

In its type-locality the *Cheiloceras* Kalk consists of about 3-8 m of nodular limestone and nodular shale, with a variable but distinct red staining and containing a locally abudant cephalopod fauna (goniatites and orthoconic nautiloids). Index goniatites include a.o. : *Cheiloceras amblylobum* and *Cheiloceras circumflexum* (Sandberger) (Schindewolf, 1921).

Sartenaer (1957) was first to report the occurrences of the "*Cheiloceras* Zone" in Belgium. He stressed its unusual lithofacies and precised its stratigraphic position with respect toj the Famennian oolitic ironstone levels and to the Frasnian-Famennian boundary. However, this stratigraphic position, both biostratigraphically and lithostratigraphically is proved now to be rather incorrect.

[1] Institut National des Industries Extractives (INIEX), rue du Chéra 200 - B-4000 Liège.

Red and green nodular shales or nodular limestones are quite common in the Famennian S of Aachen, and if Cheiloceratids are lacking these facies are difficult to distinguish from the "true" *Cheiloceras* level. Therefore, a more precise biostratigraphic dating of the *Cheiloceras* Kalk was needed and was provided by conodonts (Dreesen, 1978 ; Kasig *et al.*, 1979).

Since then attempts have been made to trace the *Cheiloceras*-level westward into the adjacent Verviers Synclinorium. However, discontinuous outcrops, the loss of characteristic colouring, the increase in sand and its decreasing thickness made it hard to locate the level in the field.

Nevertheless, detailed micropaleontological investigation and microfacies analysis allowed the author to correlate the *Cheiloceras*-Kalk with thin cephalopod bearing ironstones (iron-wackestones) in the Verviers Synclinorium (Dreesen, 1982, 1989). The *Cheiloceras* Kalk s.s. is wedging out towards the W (fig. 1). The characteristic red-stained nodular shales and limestones (mudstone/wackestone) become gradually repalced by drabcoloured, very silty nodular limestones. The latter enclose scattered ferruginized bioclasts (crinoid ossicles mainly) and will laterally grade into pseudo-oolitic ironstones (iron wackstones and iron packstones).

The characteristic red coloring is due to the presence of fine hematite. A minimum of about 1.5 % is required but dilution with non-red silicates or carbonates will take the pigment content below the critical level and will produce a drab colour (Franke & Paul, 1980).

Recent biostratigraphic investigations revealed the existence of a slightly younger *Cheiloceras* bearing sublevel, which can be traced further westward into the eastern Dinant Synclinorium (Hamoir-Tohogne area, Dusar & Dreesen, 1984 ; Dreesen, 1988) and even as far as the Avesnois area in Northern France (Bouckaert *et al.*, 1978). This would confirm the observations by Holzappel (1910) and Wulff (1932) who distinguished a lower and an upper *Cheiloceras* level, the latter of which was correlated with the "Enkeberger Kalk" of Sauerland (Denckmann, 1895). Within the Enkeberger Kalk, House (1985) identified an ammonoid extinction event - the so-called Enkeberg Event - which marks the disappearance of *Cheiloceras* and the entry of the Clymeniina. However, conodonts indicate that the Upper *Cheiloceras* level and the Enkeberg Kalk are slightly different in age : Upper (most ?) *rhomboidea* versus Lower (most ?) *marginifera* Conodont Zones.

Instead, goniatite bearing oolitic ironstone level IV might possibly correlate with the Enkeberg Limestone (fig. 1).

The *Cheiloceras* Kalk s.s. is located at the lithostratigraphical transition from the Famenne Shale to the Esneux Sandstone. The latter represents the base of the Condroz/Velbert Sandstone regressive sequence South of the London-Brabant Massif (Thorez & Dreesen, 1986 ; Dreesen *et al.*, 1989).

The sudden insertion of a condensed cephalopod limestone in a generally siliciclastic sequence corresponds to an abrupt deepening and a break in the clastic supply. Both phenomena have been related to synsedimentary tectonic movements of small blocks (block tilting) in the NW-Rheinisches Schiefergebirge (Thorez & Dreesen, 1986 ; Paproth *et al.*, 1986 ; Dreesen *et al.*, 1989).

Detailed analysis of the conodont faunas revealed paleontological condensations with the *Cheiloceras* level(s). Microfacies analysis of the lowest coeval oolitic ironstone (level IIIa of Dreesen, 1982, 1989) points to an allochtonous character of the ferruginized allochems (impregnated bioclasts and coated grains). Here, a non-deposition event (emersion supposedly occurring during the Uppermost *crepida* through Lowermost *rhomboidea* conodont Zones) preceded a storm-induced transport of the ferruginized allochems.

The subsequent deposition of the ferruginous ooid-bearing limestones and of the laterally associated cephalopod limestone took place during the Lower - Upper *rhomboidea* Zone. A characteristic feature of the *Cheiloceras* level is the mixture of pelagic and benthic organisms. Noteworthy is the occurrence of small rugose corals (*Campophyllum*) and Charophycean-like oogonia (*Sycidium*) (Dreesen, 1982, 1989). The cephalopod limestones are silty and show evidence of intense burrowing. Locally, auloporid tabulates have been recognized as well (proto-hardgrounds ?).

The younger *Cheiloceras* level is located less than 1 m to several m above the *Cheiloceras* level s.s. It is composed of silty nodular limestones with pink encrinitic lenses and locally pseudo-oolitic hematite (fig. 1). Westwardly it grades into a thin pseudo-oolitic ironstone (level IIIb in the Verviers Synclinorium and the NE-border of the Dinant Synclinorium) or into a thick sequence of thin pink crinoidal-brachiopodal lenticular limestones embedded in shales and siltstones of the Aye Formation (SW-border of the Dinant Synclinorium). Ironstone level IIIb contains a condensed Upper *rhomboidea* to Lowermost *marginifera* conodont fauna, whereas the crinoidal-brachiopodal lenticular limestones yielded conodonts typical of the Upper (most) *rhomboidea* Zone (Dreesen, 1982 ; Bouckaert *et al.* ; Dreesen, 1988). Coquinas within the silty Aye Formation contain characteristic rhynchonellids such as : *Camarotoechia letiensis* Gosselet, *Basilicorhynchus basilicus gerardimontis* Sartenaer and *Evanescirostrum* sp.

The goniatite fauna of this younger level has been studied by J. Price (Hull, UK) and C. Clausen (Krefeld, FRG) and includes : *Cheiloceras verneuilli, Ch. amblylobum, Ch. pompeckji, Ch. circumflexum* and *Chf.* aff. *acutum* (pers. written comm. *in* : Dreesen, 1982 and Bouckaert *et al.*, 1978).

## 1.2. The Mediterranean Variscan Zone

### *1.2.1. The Montagne Noire (Southern France)*

In the Montagne Noire, the Mont Peyroux and the Minervois areas enclose the type localities of the Upper Devonian red pelagic limestone, known as "griotte" ; this griotte represents a characteristic cherry-red variety of nodular limestone enclosing numerous subglobular goniatites.

In the areas mentioned above, a sequence of 4 to 25 m of Lower Famennian "Vraies Griottes" is inserted between multicolored massive and brecciated Frasnian "Infragriottes" and variegated nodular and bedded Upper Fammenian "Supragriottes". The upper part of the "Vraies Griottes" is particulary rich in goniatites (Boyer *et al.*, 1968). Although a detailed biostratigraphic dating is difficult throughout the griottes (paucity or uneven distribution of goniatites ; less detailed conodont zonation) the *Cheiloceras* level can be identified : a reinterpretation of the conodont faunas listed by Boyer *et al.* (1968) allows a correlation of the lower and upper parts of the Vraies Griottes with respectively the "lower" and "upper" sublevels of the *Cheiloceras* Kalk in the Rhenohercynian Zone. The "Vraies Griottes Inférieures" contain conodonts typical of the Upper (most) *crepida* to (Lower) *rhomboidea* Zones, whereas the "Vraies Griottes Supérieures" yield conodonts of the Upper *rhomboidea* to Lowermost *marginifera* Zones. Condensed facies are common, pointing to non-deposition events : ferro- manganiferous crusts, iron-stained and iron-encrusted lithoclasts, shell debris and oncolites indicate intermittent and extremely reduced sedimentation rates (Tucker, 1974). The ferruginized allochems are sometimes overgrown by crinoids, encrusting tabulates and foraminifera (Wendt & Aigner, 1985). The faunal association consists of transported benthic organism and autochtonous "pelagic" goniatites, styliolinids and thin-shelled ostracodes. These condensed cephalopod limestones have been interpreted as being deposited on a shallow submarine (epicontinental) platform during a general lull in terrigenous sedimentation (Tucker, 1974 ; Franke & Walliser, 1983).

### *1.2.2. The Iberian Peninsula*

Although biostratigraphic dating is poor or unsatisfactory, potential localities to look for the existence of the *Cheiloceras* level include : the Maanamet Griotte of the Central Pyrenees (Castells section), the Guadalmez section in Central Iberia and the basal part of the Vidrieros Formation in the Cantabrian Zone (Collado de Anzo section) (Oliveira *et al.*, 1986 : fig. 10, 4B, 2d).

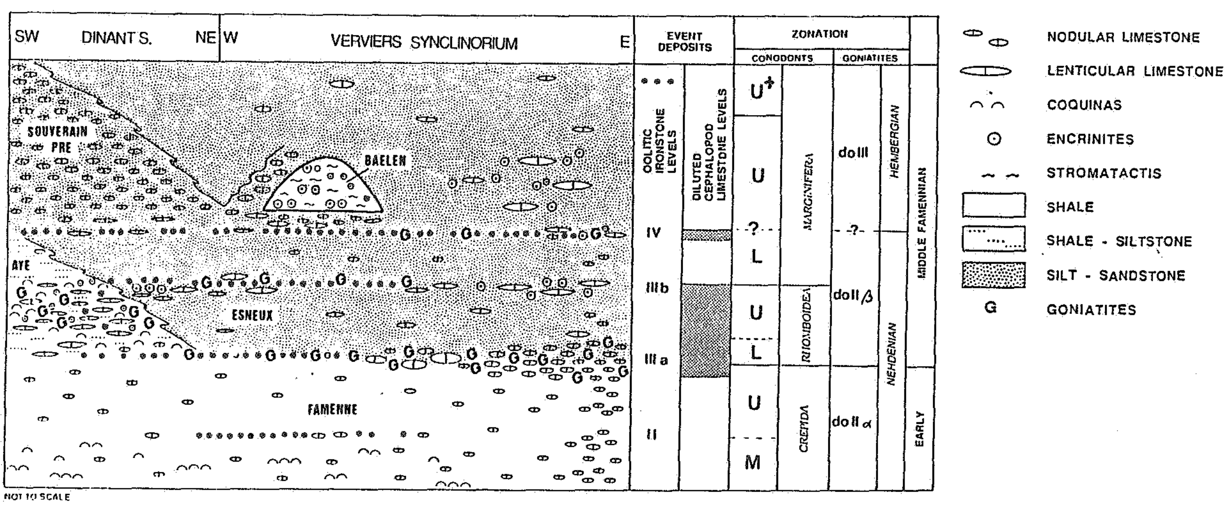


**Figure 1.** : Schematic lithostratigraphical correlation scheme and biostratigraphic dating of late early to early middle Famennian strata and event deposits in eastern and southern Belgium.

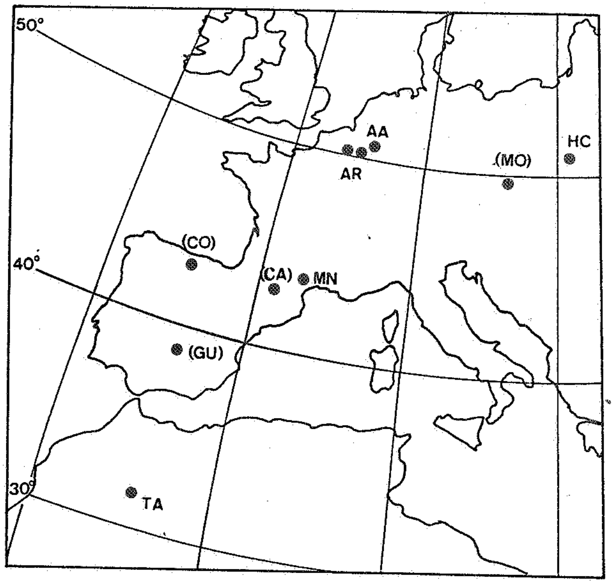


Figure 2. : Location map of studied sections (symbols between brackets are potential candidate sections containing the Cheiloceras Limestone [AA : Aachen, AR : Ardennes, HC : Holy Cross Mts, MO : Moravian Karst, MN : Montagne Noire, CA : Castells, CO : Collado de Anzo, GU : Guadalmez, TA : Tafilalt]).

## 1.3. The South-Polish carbonate Platform

### *1.3.1. The Holy Cross Mountains*

In the Upper Devonian of the southwestern Holy Cross Moutains (Poland) the growth of a shallow-water carbonate platform (including stromatoporoid reef episodes) ceased abruptly in the earliest Famennian : in Kielce (Kazielnia Hill) the late Frasnian carbonate complex is disconformably overlain by a condensed sequence of about 5 m of red-stained cephalopod limestones, locally known as the *Cheiloceras* Limestone (Sculczewski, 1971, 1979).

Conodonts indicate a condensed Upper ? *Crepida* to Lower *rhomboidea* Zone, whereas the marly shales directly overlaying the *Cheiloceras* Limestone yielded conodonts characteristic of the Upper ? *rhomboidea* to Lower *marginifera* Zones (Wolska, 1967 ; Sculczewski, 1979).

Iron oxide encrustations and impregnations occur parallel to the bedding plane surfaces and are associated with the disconformity surface, suggesting biostratigraphic breaks and short-term non-deposition events. Benthic fossils include small rugose corals (*Petraiella*) and small gastropods. The "pelagic" fauna consists of goniatites, nautiloids and entomozoan ostracodes, which are locally concentrated as coquinas in depressions and erosional channels on top of the underlying eroded Frasnian reefoid limestone complex.

This condensed pelagic cephalopod limestone has been interpreted as being deposited below normal wave base but still within the reach of current activity as evident by the presence of current-oriented shells in the erosional channels. The *Cheiloceras* Limestone is considered as the result of regional subsidence, drowning a previously exposed late Frasnian carbonate buildup (submarine rise) on a labile shelf. Blocks of the drowned "reefoid" limestone complex are incorporated in the base of the *Cheiloceras* Limestone. The shallowing event and subsequent emersion preceding the deposition of the *Cheiloceras* Limestone were presumably caused by epeirogenic movements.

### *1.3.2. The Moravian Karst*

In the Moravian geosynclinal basin (Czechoslovakia) condensed red to grey nodular cephalopod-bearing limestones of Famennian age (the Krtiny Limestone) occur on top of Upper Frasnian reefal limestones (the Vilemovice Limestone) (Dvorak *et al.*, 1986).

In the Mokra Quarry (NW-section of the quarry) the basal part the Krtiny Limestone yielded conodonts indicating a condensed Uppermost of *crepida* to Lower *marginifera* Zone (Dvorak *et al*, 1986). In the Jedovicne quarry, the time-equivalent deposit of the former cephalopod limestone is a 3 m thick sequence of purplish nodular limestones. The rapid lateral and vertical changes of the Famennian carbonate lithofacies covering the eroded and brecciated late Frasnian to earliest Famennian reefoid limestone complex are related to synsedimentary tectonic movements : differential subsidence of small blocks of the Proterozoic basement (Dvorak, 1986).

Although *Cheiloceras* has not (yet) been identified within those condensed cephalopod carbonates, the similarity in facies and in age points to the potential existence of the *Cheiloceras* level in Moravia. However, further detailed biostratigraphic research is needed here to prove this hypothesis.

## 1.4. Northwestern Africa

In the Moroccon Anti Atlas Mountains, the late Devonian Tafilalt Platform is an example of a drowned platform, probably caused by synsedimentary tectonic movements. It is characterized by highly reduced thicknesses, shallow subtidal to supratidal deposits (late Frasnian), unconformities near the Lower/Upper Frasnian and Frasnian/Famennian boundaries, short term emersions, local transgressions and deepening events during the Famennian (Wendt *et al.*, 1984 ; Wendt & Aigner, 1985).

Very conspicuous is a subaerial exposure in the earliest Famennian followed by an important transgression (the Upper Nehdenian-II$\beta$ -transgression). This transgression is preceded by block-faulting that resulted in the formation of tectonic fissures, angular unconformities and local weak folding (Wendt *et al.*, 1984).

This Upper Nehdenian transgression produced cephalopod limestones with cheiloceratids, representing a very diverse pattern of facies which grade laterally one into each other : quartz-rich brachiopod coquinas, pink to grey crinoidal limestones, thick-bedded red cephalopod limestones and thin-bedded red nodular limestones. It is the latter condensed and red-stained nodular limestone passing laterally into cephalopod limestones, that might be correlated with the *Cheiloceras* Limestone of Northwestern and Central Europe. Here it corresponds to a transgressive or deepening event, following a subaerial exposure. The latter emersion and erosional events most probably occured during a timespan covering the Upper(most ?) *crepida* through Lower *rhomboidea* conodont Zones.

Unlike the interpretation of Buggisch & Clausen (1972) we believe that the Tafilalt Platform was emergent during the Uppermost *crepida*-Lowermost *rhomboidea* Zone and drowned during the *rhomboidea* Zone, as can be deduced from the presence of a mixed Upper ? *rhomboidea* to Lowermost *marginifera* conodont fauna in the basalmost sample of the transgressive cephalopod limestone in the Erfoud section (Table I, bed 2I). However, it is clear that such highly condensed carbonates must be investigated very carefully and that they should be sampled at very closely spaced intervals in order to produce reliable biostratigraphic data.

Buggisch & Clausen reported the presence of iron-impregnated and iron-coated oncoids, coated grains and intraclasts. This is confirmed by detailed microfacies analysis of Wendt *et al.* (1984) and Wendt & Aigner (1982), who noted also the presence of finely-laminated ferro-manganiferous crusts, of limonite-stained and limonite-encrusted skeletal debris and of hardgrounds. Moreover they reported the presence, within the transgressive red cephalopod limestones, of stromatolitic layers, solitary rugose corals, *Spongeliomorpha*-type burrows and of encrusting tabulates (*Cladochonus*).

According to depositional and faunal evidences they considered the Tafilalt Platform as a current-swept shallow pelagic ridge during the early Famennian. The local transgression over a karst topography points to an initial minimum depth. The absence of calcareous algae and of micritic envelopes suggests a subsequent drowing of the platform to depths of some tens to about 100 m, probably caused by synsedimentary tectonic activity.

## 2. EVENT STRATIGRAPHY, DEPOSITIONAL AND PALEOTECTONIC SETTINGS

In all of the studied sections (fig. 2) the *Cheiloceras* Limestone and its time-equivalent lithofacies occur within a particular time interval of the Famennian. Although more biostratigraphic work is needed and high-resolution correlation techniques are required, the *Cheiloceras* Limestone allows already remarkable intrabasinal and interbasinal stratigraphic correlations.

Prior to the *Cheiloceras* cephalopod limestone deposition, underlying neritic carbonate platforms and clastic shelves may have been subaerially exposed. In all cases block-faulting has been proposed as a probable cause for the uplift. It is striking that this emersion has been followed by a relatively abrupt deepening, drowning or transgressive event.

Relative timing of this deepening event or transgressive pulse almost invariably indicates a (Lower ?) *rhomboidea* age. This might well correlate with the reinforcement of a first transgressive pulse within regressive depophase IIe of the qualitative eustatic curve for the Famennian (Johnson *et al.*, 1985).

Although synsedimentary tectonic activity has been responsible for local uplifts, for blocking of the clastic supply and for temporary emersions, the subsequent deepening might well have been triggered by a small, but geologically "instantaneous" eustatic rise in sea level.

The presence of ferruginized allochems and of hardgrounds points to non-deposition events and extremely reduced sedimentation rates, associated with the carbonate production. However, the frequent mixing of pelagic organisms with benthic organisms would indicate the effect of intermittent high-energy sedimentological processes such as storms and strong currents. The presence of heterogenous ferruginized coated grains within the *Cheiloceras* Limestone and time-equivalent pseudo-oolitic ironstones, has been related to the effects of high-energy storm waves (Dreesen, 1982, 1989). Similarly, the great abundance of current-oriented orthoconic nautiloids in the Upper Devonian cephalopod limestones of the Tafilalt Platform has been associated with strong northwesterly winds and storms (Wendt & Aigner, 1982, 1985). Pelagic organisms predominate normally over benthic organisms but in nearshore environments we observe the opposite. The presence of allochtonous shallow marine to restricted marine allochems would indicate the vicinity of a coastal area. Noteworthy is the presence of small rugose corals, algal oncoids, tabulates and even Charophytes. Burrowing is common and certain burrow types, such as *Spongeliomorpha*, reflect intertidal to shallow subtidal, or somewhat deeper subtidal conditions.

The sedimentary and tectonic environmental characteristics of the *Cheiloceras* Limestone are in agreement with the models proposed for the shelf or platform-type Paleozoic cephalopod limestones in the Variscan Belt (Wendt & Aigner, 1985 ; Franke & Walliser, 1983) : an epicontinental setting is essential, as well as the abundance of benthonic fossils and the frequency of non-deposition episodes. Generally, the development of cephalopod limestones takes place during an intermediate stage in the evolution of the Variscan geosynclines : between an initial phase of thick shallow-water carbonates or clastics and a final stage of flysch sedimentation.

In its type locality, the *Cheiloceras* Kalk represents a "diluted" cephalopod limestone which developed on shales over a drowned Lower Famennian clastic shelf and an underlying Frasnian carbonate shelf. The deposition of cephalopod-rich carbonates has been overwhelmed by the influx of prodelta silts and sands (Esneux Formation, basal part of the Condroz Sandsone Group). These siliciclastics have also hampered the development of recurring cephalopod limestone facies higher in the stratigraphic sequence (such as the "Upper" *Cheiloceras* level or the "Enkeberg Limestone" time-equivalent deposit : see fig. 1).

Synsedimentary tectonic movements preceding the development of the *Cheiloceras* Limestone have not only been reported from the Rhenohercynian Zone, but also from the opposed flank of the European Variscides (Moravia, Holy Cross Mountains) as well as from the "Paleothetys realm". Does this mean that the *"Cheiloceras"* Event not only reflects a regional deepening or even an eustatic sea level rise, but also that it coincides with or immediately postdates a tectonic event in the Variscan Belt ?

## *ACKNOWLEDGEMENTS*

The author gratefully acknowledges help and advice from Dr. Eva Paproth (Krefeld) in an earlier stage of this study. Drs. Burkhard Reissner (Aachen) most kindly provided the author with unpublished additional data on the *Cheiloceras* Level in Germany. Mr. Jean-Pierre Triplot is thanked for his technical assistance.

## *REFERENCES*

BOUCKAERT, J., DREESEN, R. & DRIJKONINGEN, F., 1978 - Recherches biostratigraphiques dans quelques coupes du Famennien de l'Avesnois (Nord de la France). *Ann. Soc. Géol. Belg.*, ***100*** : 115-123.

BOYER, F., KRYLATOV, S., LE FEVRE, J. & STOPPEL, D., 1968 - Le Dévonien Supérieur et la limite Dévono-Carbonifère en Montagne Noire (France). Lithostratigraphie-Biostratigraphie (Conodontes). *Bull. Centre Rech. Pau - SNPA*, *2/1*: 5-33.

BUGGISCH, W. & CLAUSEN, C.D., 1972 - Conodonten- und Goniatiten-Faunen aus dem oberen Frasnium und unteren Famennium Marokkos (Tafilalt, Antiatlas). *N. Jb. Geol. Paläont. Abh.*, *2*: 137-167.

DENCKMANN, A., 1895 - Zur Stratigraphie des Oberdevon im Kellerwalde und in einigen benachbarten Devon-Gebieten. *JhB. d. kön. preuss. geol. Landesantalt u. Bergakademie für das Jahr 1894*, *XV*: 8-64.

DREESEN, R., 1982 - Storm-generated oolitic ironstones of the Famennian (Fa1b - Fa2a) in the Vesdre and Dinant Synclinoria (Upper Devonian, Belgium). *Ann. Soc. Géol. Belg.*, ***105***: 105-129.

DREESEN, R., 1978 - Position stratigraphique de la Formation de Souverain-Pré dans le Synclinorium de Dinant et le Bassin de la Vesdre. *Serv. Géol. Prof. Paper*, ***1978/2, 150***: 1-74.

DREESEN, R., 1988 - Stop A11 of Field Trip A2. *In* : Ziegler (Ed.) : First International Senckenberg Conference and 5th European Conodont Symposium (ECOS V), Contributions I, *Cour. Forsch.- Inst. Senckenberg.*, ***102***: 74-75.

DREESEN, R., 1989, in press - Oolitic ironstones as event-stratigraphical marker beds within the Upper Devonian of the Ardenno-Rhenish Massif. *In*: Phanerozoic Ironstones (Young, T.& Taylor, G., eds.). *Geological Society Special Publication*, ***46***: 65-78.

DREESEN, R., PAPROTH, E. & THOREZ, J., 1989 - Events documented in Famennian sediments (Ardenne-Rhenish Massif, late Devonian, NW-Europe). *In* : Devonian of the World (McMillan, N.J., Embry, A.F. & Glass, D., eds.), *Canadian Society of Petroleum Geologists*, ***14/2***: 295-308.

DUSAR, M. & DREESEN, R., 1984 - Stratigraphy of the Upper Frasnian and Famennian deposits in the region of Hamoir-sur-Ourthe (Dinant Synclinorium, Belgium). *Serv. géol. Belg. Prof. Paper*, ***1984/5, 209***: 1-52.

DVORAK, J. *et al.*, 1986 - Field trip to the Famennian of the Moravian karst (CSSR). *In* : Late Devonian events around the Old Red Continent (M.J.M. Bless & M. Streel, eds.). *Ann. Soc. Géol. Belg.*, ***109***: 267-274.

FRANKE, W. & PAUL, J., 1980 - Pelagic redbeds in the Devonian of Germany - deposition and diagenesis. *Sediment. Geol.*, ***25***: 231-256.

FRANKE, W. & WALLISER, O., 1983 - "Pelagic" Carbonates in the Variscan Belt - Their sedimentary and tectonic environments. *In* : Intracontinental Fold Belts (Ed. by H. Martin, F.W. Eder), *Springer-Verlag, Berlin*: 77-92.

HOLZAPPEL, E., 1910 - Die Geologie des Nordafalles der Eifel mit besonderer Berücksichtigung der Gegend von Aachen. Mit einer geologischen Exkursionskarte für die Umgegend von Aachen von W. Wunstorf. *(Herausgegeben von der kön. Preuss. Geol. Landesanstalt)*.

HOLZAPPEL, E., 1911 - Erlaüterungen zur Geologisehen Karte von Preussen und benachbarter Bundesstaaten. *Lieferung 141. Blatt. Aachen Blatt. Stolberg.*

HOUSE, M., 1985 - Correlation of mid-Palaeozoic ammonoid evolutionary events with global sedimentary perturbations. *Nature, 313-5997*: 17-22.

JOHNSON, J.G., KLAPPER, G. & SANDBERG, C.A., 1985 - Devonian eustatic fluctuations in Euramerica. *Geol. Soc. America Bull., 96*: 567-587.

KASIG, W., DREESEN, R. & BOUCKAERT, J., 1979 - Zur Biostratigraphie des Famenniums südlich von Aachen (Deutschland). *Geol. Paläont., 13*: 165-172.

OLIVEIRA, J.T., GARCIA-ALCALDE, J.L., LINAN, E. & TRUYOLS, J., 1986 - The Famennian of the Iberian Peninsula. *In* : Late Devonian Events around the Old Red Continent (M.J.M. Bless & M. Streel, Eds.), *Ann. Soc. Géol. Belg., 109*: 159-174.

PAPROTH, E., DREESEN, R. & THOREZ, J., 1986 - Famennian paleogeography and event stratigraphy of Northwestern Europe. *In* : Late Devonian events around the Old Red Continent (by M.J.M. Bless & M. Streel, Eds.). *Ann. Soc. Géol. Belg., 109*: 175-186.

SARTENAER, P., 1957 - La découverte en Belgique, de la Zone à Cheiloceras. *Ann. Soc. Géol. Belg., LXXX*: B 463-470.

SCHINDEWOLF, O.H., 1922 - Versuch einer Paläogeographie des europäischen Oberdevonmeeres. *Z. deutsch. geol. Ges., XV*: 655-658, Berlin.

SCHMIDT, Wo., 1951 - Die stratigraphische Entwicklung des Famennien in der Gegend von Aachen. *Geol. Jb., 65*: 451-462.

SCHMIDT, Wo., 1956 - Neue Ergebnisse der Revisionskartierung des Hohen Venns. *Beih. Geol. Jb., 21*, 146 p.

SCHMIDT, Wo. & SCHRODER, E., 1962 - Erläuterungen zur Geologischen übersichtskarte der nördlichen Eifel 1:100 000. *Hochschulumgebungskarte Aachen*, 110 p.

SCULCZEWSKI, M., 1971 - Upper Devonian conodonts, stratigraphy and facial development in the Holy Cross Moutains. *Acta Geologica Polonica, 21/1*: 1-129.

SCULCZEWSKI, M., 1979 - Devonian and Carboniferous coral-bearing sequences of the Holy Cross Mountains. Guidebook of the Third International Symposium on Fossil Cnidarians, Warszawa, Sept. 24-28, 1979, *Polska Akademia Nauk, Zaklad Paleobiologii*: 5-33.

THOREZ, J. & DREESEN, R., 1986 - A model of a regressive depositional system around the Old Red Continent as exemplified by a field trip in the Upper Famennian "Psammites du Condroz" in Belgium. *In* : Late Devonian events around the Old Red Continent (M.J.M. Bless & M. Streel, Eds.). *Ann. Soc. Géol. Belg., 109/1*: 285-323.

TUCKER, M., 1974 - Sedimentology of Palaeozoic pelagic limestones : the Devonian Griotte (Southern France) and Cephalopodenkalk (Germany). *In* : Pelagic sediments on Land and under the Sea (Ed. by K.J. Hsü & H.C. Jenkyns). *Spec. Publ. Int. Ass. Sediment., 1*: 71-92, Blackwell Scientific Publications, Oxford.

WENDT, J. & AIGNER, T., 1982 - Condensed Griotte facies and cephalopod accumulations in the Upper Devonian of the eastern Anti-Atlas, Morocco. *In* : Cyclic and Event Stratification (Ed. by G. EINSELE & A. SEILACHER), 326-332, Springer-Verlag, Berlin.

WENDT, J., AIGNER, T. & NEUGEBAUER, J., 1984 - Cephalopod limestone deposition on a shallow pelagic ridge : the Tafilalt Platform (upper Devonian, eastern Anti-Atlas, Morocco). *Sedimentology, 31*: 601-625.

WENDT, J. & AIGNER, T., 1985 - Facies patterns and depositional environements of Palaeozoic cephalopod limestones. *Sedimentary Geology, 44* : 263-300.

WOLSKA, Z., 1967 - Upper Devonian conodonts from the southwest region of the Holy Cross Mountains, Poland. *Acta Palaeont. Pol., 12/4*: 363-456.

WULFF, R., 1923 - Das Famennium der Aachener Gegend. *Jb. preuss. geol. L.-A., 43*: 1-70.

WUNSTORF, W., 1943 - Erlaüterungen zu den Blättern Rötgen-Eupen und Nideggen. *Geol. Karte des Deutsch. Reiches 1:25 000 - Lfg. 318*, 76 p.