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«SESSION EXTRAORDINAIRE» OF THE TWO BELGIAN GEOLOGICAL SOCIETIES ON THE LATE CRETACEOUS AND QUATERNARY IN THE LIEGE-MAASTRICHT-HEERLEN AREA, 12-14 JUNE 1987

by Martin J.M. BLESS (1), Rabah DJAIZ (2), P.J. (Sjeuf) FELDER (1), John W.M. JAGT (3) & Wil ROEBROEKS (4).

ABSTRACT - In 1987, the "session extraordinaire" of the two Belgian geological societies coincided with the centenary of the first geological excursion of the Société belge de Géologie in the environs of Maastricht in 1887. Several localities visited in 1887 by Casimir Ubaghs and his colleagues were revisited in 1987. Modern views on some Upper Cretaceous and Quaternary aspects are briefly discussed in this report.

RESUME - En 1987, la session extraordinaire des deux sociétés belges de géologie coïncidait avec le centenaire de la première excursion géologique de la Société belge de Géologie à Maastricht en 1887. Plusieurs localités visitées par Casimir Ubaghs et ses collègues en 1887 ont été revisitées en 1987 en y intégrant des conceptions nouvelles sur le Crétacé supérieur et le Quaternaire de cette région.

KEY WORDS - Late Cretaceous stratigraphy and paleoenvironment ; Quaternary stratigraphy and prehistory.

MOTS CLES - Stratigraphie et paléoenvironnement du Crétacé terminal ; Stratigraphie et préhistoire du Quaternaire.

I. INTRODUCTION

A century ago, in 1887, the Société belge de Géologie, de Paléontologie et d'Hydrologie organized its first excursion to the Maastricht region (South Limburg, SE Netherlands). Excursion leader then was Casimir Ubaghs, a famous Dutch amateur geologist and collector of fossils. His lively report of that trip was published in the first volume of the Bulletin of the Société belge (Ubaghs, 1887). Twenty-eight people, members of the Société belge de Géologie, the Société d'Anthropologie de Bruxelles and the Société d'Archéologie de Bruxelles, attented this meeting. Amongst them were specialists in the Late Cretaceous such as C. Ubaghs himself, E. van den Broeck and A. Rutot, as well as the archaeologists M. de Puydt and E. de Munck.
The three day's programme of September 1887 was devoted to the Cretaceous chalk of Maastricht (subterranean quarries and outcrops of the Sint-Pietersberg) and Kunrade near Heerlen, as well as to the prehistoric flint industry of "Grand Atelier" at Rijckholt/St.-Geertruid. Ubaghs' 1887 report presents a detailed "state of arts" of the contemporary views on Late Cretaceous stratigraphy and lateral facies changes, and also on the pre-

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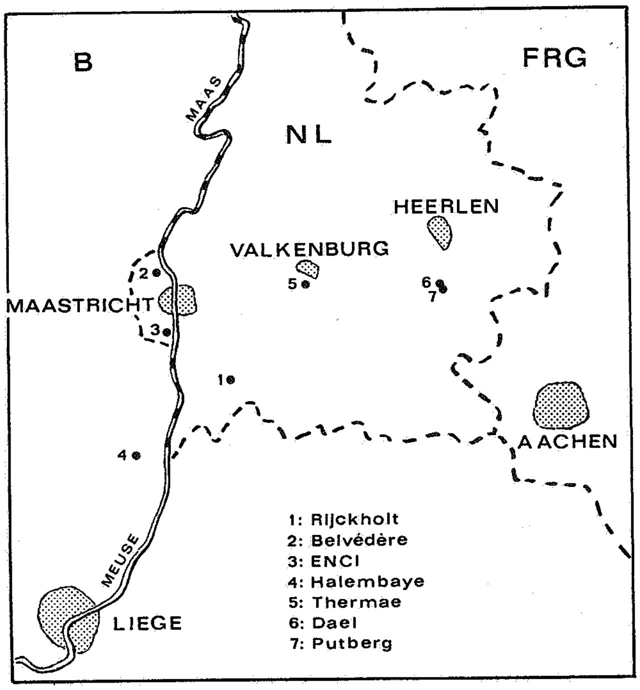


Figure 1. Location of sites visited during the 1987 excursion of the two Belgian geological societies.

historic flint industry. Following customary usage of that time his account also trancends the human note : an evening session until midnight, pouring rain on the second day, and a train missed on the third (the problem was solved by hiring cabs to the Kunrade outcrop !).

One hundred years later it is in accordance with tradition that the two Belgian geological societies, the Société belge de Géologie and the Société Géologique de Belgique, have joint annual "sessions extraordinaires". These are alternately organized by one of the two societies and consist of a two/three-days excursion devoted to a special theme. In this way the Société Géologique de Belgique was responsible for the 1987 trip to the Cretaceous and Caenozoic in the Maas Valley north of Liège (fig. 1). The Natuurhistorisch Museum Maastricht acted as local organizer on account of its seventy-fifth anniversary. The IUGS International Working Group on the Coniacian to Maastrichtian also attented this meeting since the Late Cretaceous formed the main topic (fig. 2). It was the Secretary-General of the Société belge de Géologie, Eric Groessens, who first noted the curious coincidence between the 1987 session and the centenary of that first Maastricht excursion by the Société belge in 1887, the year of its foundation. The meeting was held from Friday to Sunday, June 12-14 1987. It was attended by 48 people from eight

Figure 2. Members of the IUGS Working Group on Coniacian to Maastrichtian who participated in the "session extraordinaire" of 1987. The black arrow indicates the position of the limestone layer in the De Dael outcrop (Ubaghsberg near Heerlen) that yielded *Belemnitella mucronata* and *"Pachydiscus stobaei"* sensu GIERS proving a Late Campanian age of these sediments. Standing from left to right : Herbert Summesberger (Vienna, ammonites), Friedrich Schmid (Hannover, belemnites), Ehrhard Voigt (Hamburg, bryozoans), Jim Kennedy (Oxford, ammonites), Martin J.M. Bless (Maastricht, ostracodes), Francis Robaszynski (Mons, planktonic foraminifera) and Walter Kegel Christensen (Copenhagen, belemnites). Squatting from left to right : Jan P.M.Th. Meessen (Heerlen, benthic foraminifera), P.J. (Sjeuf) Felder (Maastricht, bioclast assemblages) and John W.M. Jagt (Venlo, echinoderms and cephalopods).

different countries : Algeria, Austria, Belgium, Denmark, the Federal Republic of Germany, France, Great Britain and the Netherlands. Among these we may mention Ehrhard Voigt, the well-known and still active bryozoan specialist from Hamburg who started his studies in the Maastricht area as far back as 1921, the present chairman (Walter Kegel Christensen from Copenhagen) and former chairman (Friedrich Schmid from Hannover) of the International Working Group on the Coniacian to Maastrichtian, and Eric Groessens from Brussels, Secretary-General of the Société belge de Géologie, who acted as president of the meeting.

As in 1887, a rainy day was followed by a sunnier one. In contrast to 1887, there was no need for trains or taxis ; transport was by bus. But following the example of our 1887 colleagues the "dinner session" in the Natural History Museum also continued until midnight !

2. EXCURSION PROGRAMME (M.J.M.B. & P.J.F.)

The meeting started with an afternoon session in the Maastricht Natural History Museum on Friday, June 12th. This session was organized by the IUGS Working Group on Coniacian to Maastrichtian. Walter Kegel Christensen acted as chairman. There were short communications on Upper Cretaceous ammonites (W.J. Kennedy) and belemnites (W.K. Christensen), and on the Upper Cretaceous biostratigraphy in South Limburg (J.W.M. Jagt) and in the Mons Basin (F. Robaszynski and W.K. Christensen). After dinner in the canteen of the Museum a general introduction to the excursion was presented (M.J.M. Bless).

The first excursion day (Saturday, June 13th) started with a visit to the Belvédère Quarry at Maastricht, where an *in situ* Palaeolithic site in a Saalian-Weichselian sequence is being studied since 1980 by W. Roebroeks (Leiden State University) and collaborators (cf. chapter 4). Afterwards the classic outcrops of ENCI and Halembaye were visited, where the Upper Campanian white chalk and Upper Maastrichtian chalk with flint layers in the lower two/thirds and biocalcarenites with hardgrounds in the upper third portion could be observed. A titre d'exemple it was shown that Ubaghs'1887 figure of the Slavante section is still valid, although the names of individual beds and the stratigraphic interpretation have since been adjusted (fig. 3 ; chapter 5). Mrs P.G. Lázár-Schilthuis, alderman of culture and education in Maastricht, was our guest of honour during the dinner session in the Museum that evening.

On Sunday, June 14th, the Neolithic flint mines of Rijckholt/St.-Geertruid were visited. On the historic ground of the "Grand Atelier" discovered by De Puydt in 1887, Sjeuf Felder presented us with a crash course in prehistoric mining techniques and focused on the correlation of flint layers and the then (almost 6000 years ago) changing environment as shown by the study of snail assemblages (cf. chaper 3). At the location of the Thermae boreholes at Valkenburg aan de Geul the complex mechanism of Late Cretaceous inversion tectonics

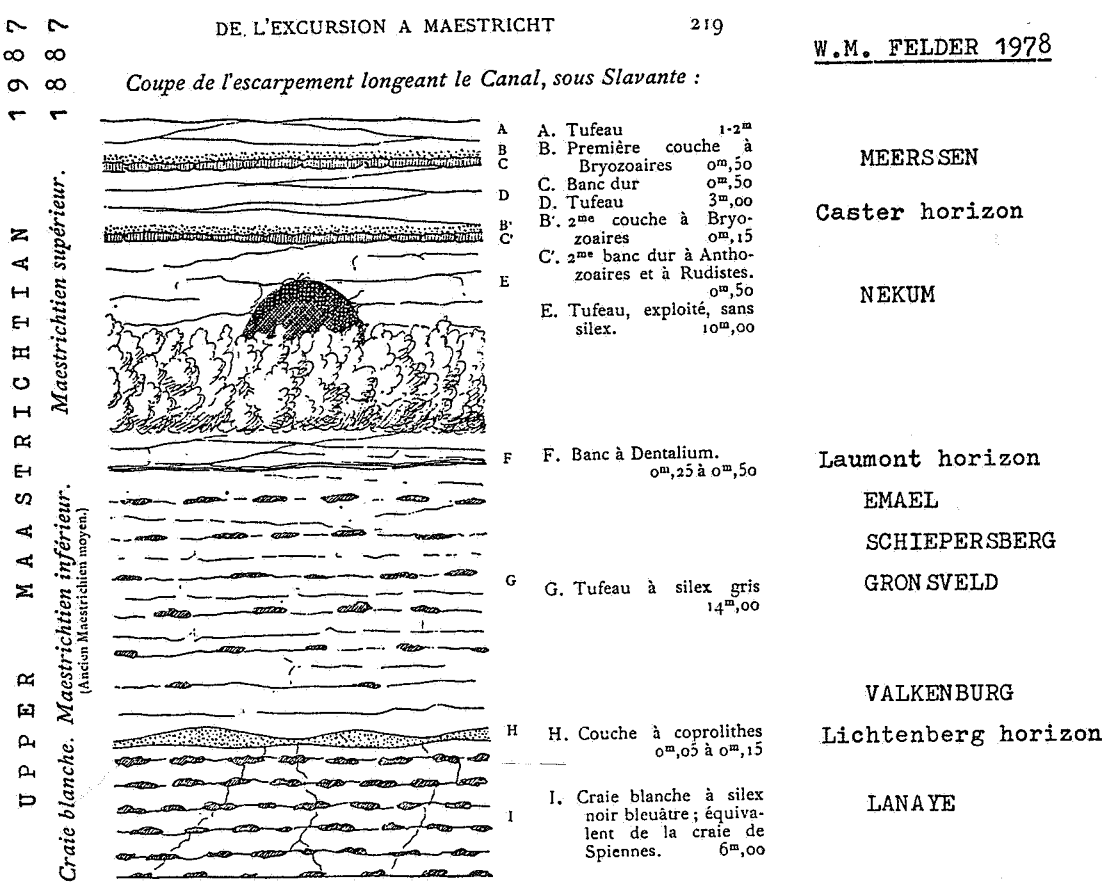


Figure 3. Slavante section (immediately north of actual ENCI quarry) as published by Ubaghs (1887) with to the left the 1987 interpretation of the chronostratigraphic age, and to the right the lithostratigraphic subdivision of the sequence according to W.M. Felder (1978).

and related differential compensating rates of subsidence were discussed (fig. 4). And finally, at the locations of De Dael and Putberg in Ubachsberg near Heerlen the nearshore equivalents of the Upper Campanian white chalk of Halembaye (the "sandy chalk of Benzenrade" sensu Staring 1860) and the Upper Maastrichtian chalk with flint were studied. Thanks to recent discoveries of belemnites and ammonites (Jagt *et al.*, 1987 ; chapter 5) it could be shown that, although the "sandy chalk of Benzenrade" at De Dael displays a certain lithological resemblance with the Lower Campanian Vaals Formation, it in fact represents the lateral equivalent of the white chalk of Late Campanian age. Most surprisingly, one of the participants, Nico Vanderbeke from Aalst, discovered a fifty cm large specimen of the ammonite *"Pachydiscus stobaei"* sensu Giers right there and then. This is the third find of this Upper Campanian guide at de Dael we know of. It is now housed in the Maastricht Museum. The discussion concentrated on the depositional environment and on correlation problems of these lithologically quite different sediments, and examples were presented of correlation by means of foraminifera, bioclasts (chapter 6) and ostracodes (chapter 7).

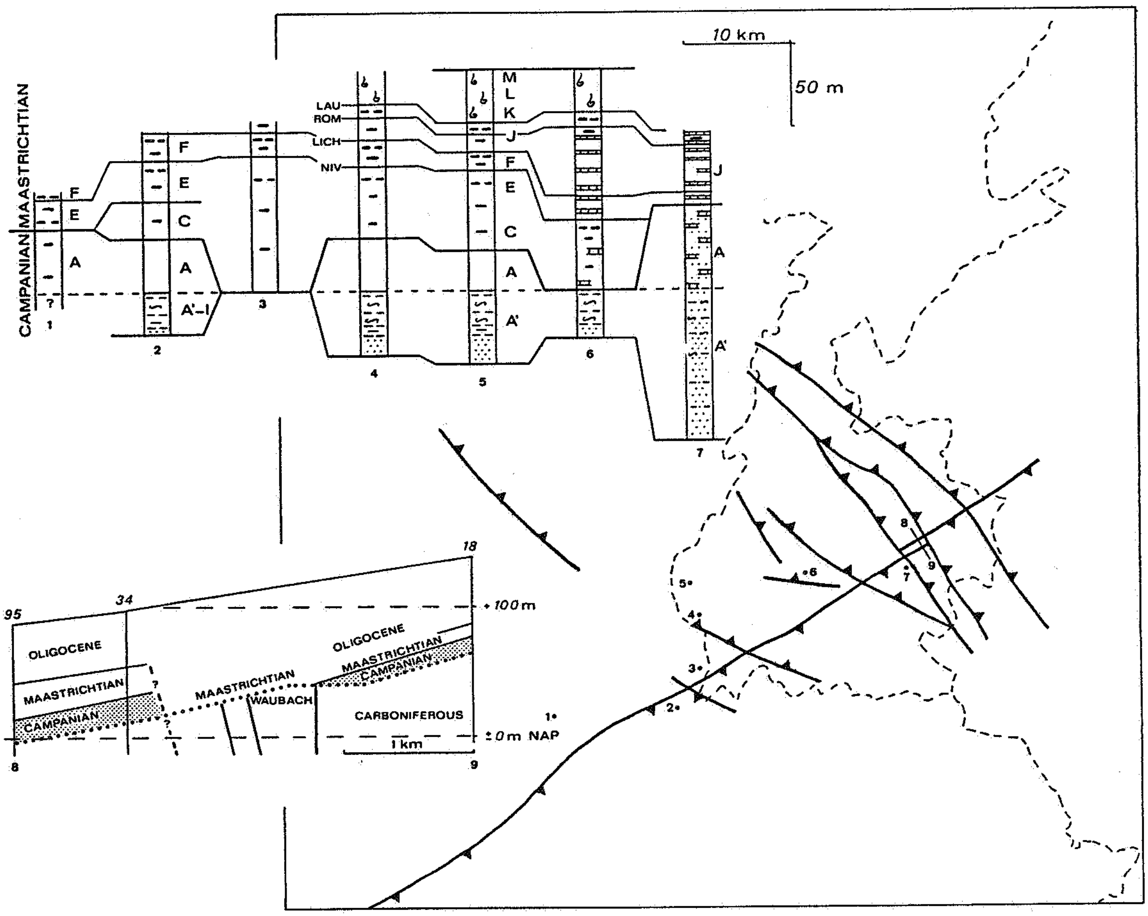


Figure 4. Influence of Late Cretaceous inversion tectonics on sedimentation. Differential compensating rates of subsidence resulted in comparable total thicknesses for Campian-Maastrichtian sediments, notably for the interval of foram zones A-J. Increased thickness of Upper Maastrichtian foram zones C-E at Lixhe (section 3) compensates absence of Lower/Upper Campanian deposits. Increased thickness of Upper Maastrichtian foram zone J in Thermae boreholes (section 6) compensates absence of Upper Campanian. Absence of foram zone C in Diets-Heur (section 1) is compensated by an increased thickness of Upper Campanian deposits. Absence of foram zones C-E in Kunrade area (section 7) is compensated by extreme thickness of Campanian and of forma zone J. Note that Campanian deposits near the Rur Valley Graben are sandier that those farther to the WSW. This suggests that the Rur Valley area acted as clastic source during that period. Upper Maastrichtian sediments near the Rur Valley (foram zones C-J) are marked by frequent hard limestone intercalations, whereas sections to the WSW are characterized by flint layers. The youngest Upper Maastrichtian strata (foram zones K-M) consist predominantly of rather coarse-grained biocalcarenites.
Sections 1 : Diets-Heur, 2 : Halembaye, 3 : Lixhe, 4 : ENCI, 5 ; Kastanjelaan, 6 : Thermae, 7 : Kunrade.
Differential block movements along Bordière-Oranje faults are shown in section 8-9. This section is based on exploration boreholes 18, 34 and 95, and on numerous upward-directed boreholes made in the former coalmines for recognition of the Carboniferous subcrop (after Kimpe *et al.*, 1978). This means that Late Cretaceous/Caenozoic block movements not only occurred along NW-SE directed border faults of the Rur Valley Graben, but also along at least the eastern end of the SW-NE directed Bordière-Oranje faults bordering the Brabant Massif. This matches the observations of Legrand (1968, p. 145) who stated that the Bordière Fault was reactivated during the Mesozoic and Tertiary which resulted in vertical throws in the order of "one to several tens of metres".

The excursion ended almost exactly on schedule. Dr. Groessens, as President of the session, thanked all the participants and offered the Medal E. van den Broeck (struck on the occasion of the centenary of the Société belge de Géologie) to the Maastricht Natural History Museum. In due time it will be exhibited along with the ammonite found at De Dael.

3. NEOLITHIC FLINT MINES OF RIJCKHOLT/ST.-GEERTRUID (P.J.F.)

The Neolithic flint industry of Rijckholt/St.-Geertruid was discovered by M. de Puydt from Liège in 1881. The flint dump of the "Grand Atelier" was visited by the Société belge de Géologie in 1887 (Ubaghs, 1887). At that time is was still unknown that this enormous mass of flint waste (estimated some 250 m3 by Ubaghs, 1887 ; more than 1250 m3 by Kraaijenhagen, 1979) was the result of subterranean flint mining activities. The first flint mines were discovered in 1910 and 1914 by J. Hamal-Nandrin from Liège.

Between 1964 and 1972 the "Werkgroep Prehistoriche Vuursteenmijnbouw", a working group of the Dutch Geological Association, explored the former flint mines. To that purpose they made a horizontal gallery of some 2X2 m in diameter and about 150 m in length starting at the "Grand Atelier". The flint mines on both sides of the main gallery and the excavated mines have been preserved so that these could be visited during the 1987 excursion of the two Belgian Geological Societies.

The flint mines consist of 6-12 m deep shafts with a star-like pattern of radiating galleries (fig. 5). The length of these increases when the shaft becomes deeper. All but one of these galleries in each mine had been refilled with chalk

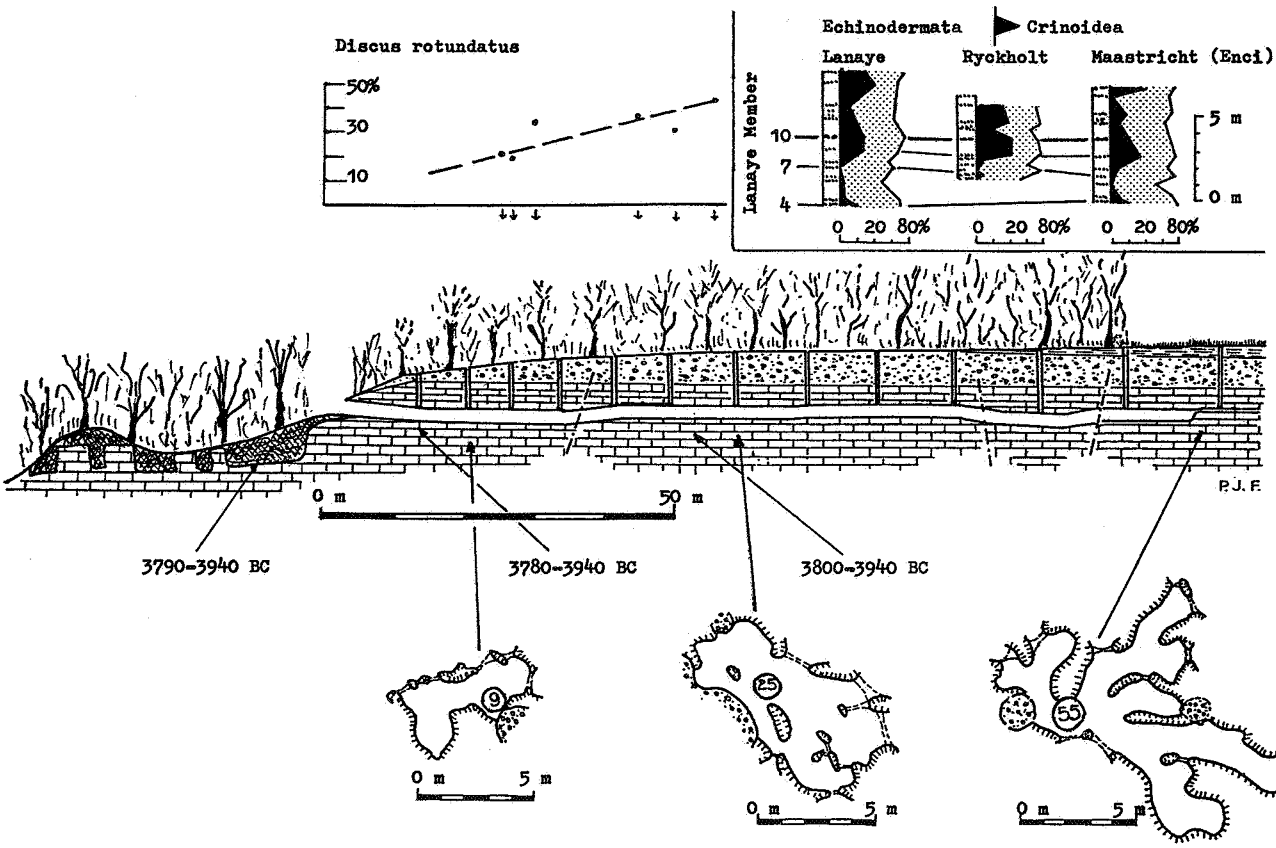


Figure 5. Cartoon showing synthetic cross-section of Neolithic flint mines at Rijckholt/St.-Geertruid and main gallery made during the period 1964-1972. Three schemes of the flint mines 9, 25 and 55 are shown, indicating that the production surface of the mine gradually increased when the shafts became deeper.
The gradual increase of the relative number of the snail *Discus rotundatus* in shaft fillings in the first 60 m of the complex is shown in the upper left.
The correlation of the productive flint bed of Rijckholt with flint bed n° 10 in Lanaye and Enci by means of echinoderms/crinoids is shown in the upper right.

rubble by the prehistoric miners. Some 15,000 flint picks have been found, part of these had been broken by the miners, another part had apparently never been used and "forgotten about". Chopping tools found in the mines suggest that picks may have been resharpened underground. A human skull without lower jaw was discovered in 1965. Presumably it represents a ceremonial skull burial.

Charcoal finds in some of the mines, as well as an antler pick from a mine below the "Grand Atelier" all indicate that mining must have taken place between 3750 and 3950 B.C.

Over 15,000 snails belonging to 24 different species have been found in 24 shaft infills in the first 60 m of the complex. The absence of snails in later shafts suggests that these had been refilled rather quickly after extraction of the flint. The presence of the genera *Succinea, Vitrina* and *Vitrea* indicates a slightly more humid climate for that period (Atlanticum) than today. Remarkable is the gradual increase in number of *Discus rotundatus* between shaft 8 and shaft 21 from some 20 to over 44 %. In modern snail assemblages this species makes up some 10 % in forest environments, but more than 60 % in the more open landscape around farms. The relative increase of *D. rotundatus* may therefore be an indication of a gradual disafforestation of the area.

The productive flint layer of Rijckholt has been correlated by means of bioclasts with flint bed 10 at Lanaye and ENCI (P.J. Felder, 1979).

4. MAASTRICHT-BELVEDERE PROJECT (W.R.)

Since 1980, the loess- and gravelpit Belvédère at Maastricht (South Limburg, the Netherlands) has been the object of systematic archaeological research by a team representing several disciplines. A first synthetic review of the Quaternary research in the pit has recently been published (Van Kolfschoten & Roebroeks, eds., 1985). A monograph dealing with the archaeology is in preparation.

The most important archaeological find level is situated in fine-grained fluviatile deposits (Unit 4, fig. 6), associated with a rich mammal (twenty-five species) and mollusc (seventy species) fauna of interglacial character. The combined dating evidence points to a pre-Eemian interglacial age for the Middle Palaeolithic assemblages recovered from this fluviatile unit (Unit 4), with a TL age of 270 ± 22 ka, and a preliminary ESR age of 220 ± 40 ka. The period of human occupation can be placed in the cli-

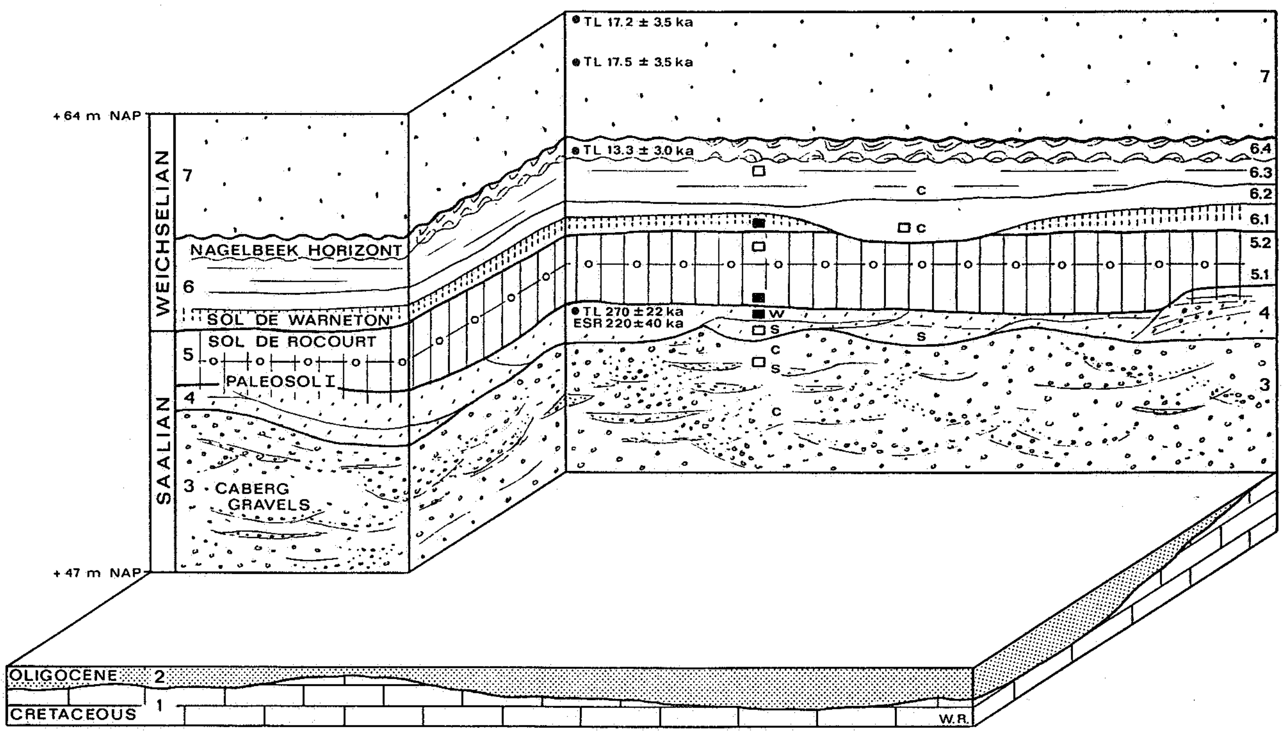


Figure 6. Idealized E-W section through the Pleistocene deposits (Units 3-7) at Maastricht-Belvédère (vertical scale exaggerated 6x).
1 : Unit 1 (Palaeocene chalk subsoil), 2 : Unit 2 (Oligocene clayey sands), 3 : Unit 3 (Caberg Middle Terrace gravels), 4 : Unit 4 (fine-grained fluviatile deposits), 5 : Unit 5 ("loams"), 6 : Unit 6 (silty loams = "Middle Loess"), 7 : Unit 7 (silty loam = "Upper Loess").

■ = level with archaeological finds "in situ"

□ = level with reworked archaeological material.

C, S, W : levels with faunal remains, indicating "cold" (C), "warm-continental" (S), or humid "warm-temperate" (W) climatic conditions.
Thermoluminescence (TL) and Electron Spin Resonance (ESR) dates are expressed in ka (1000 years BP).
The drawing is based on interdisciplinary work as reported in Van Kolfschoten and Roebroeks (eds.) 1985, and on the 1987 fieldwork of the Instituut voor Aardwetenschappen, Vrije Universiteit Amsterdam.

matic optimum of the warm-temperate phase. Faunal remains associated with the archaeological material include fossils of straight-tusked elephant (*Elephas antiquus*), steppe rhinoceros (*Dicerorhinus hemitoechus*), giant deer (*Cervus (Megaceros) giganteus*), red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*). Study of the archaeological material recovered in primary archaeological context, has yielded important data on the "spatial behaviour" of Middle Pleistocene man.

A rescue dig in the summer of 1986 recovered an Early Weichselian site (Site J), present in a "humic loam" ("Sol de Warneton") at the base of the Weichselian loess in the pit (Unit 6.1). The industry in which scrapers dominate, is characterized by the absence of flakes struck from prepared cores. The presence of a few small handaxe resharpening flakes suggests that a handaxe formed part of the toolkit of the Middle Palaeolithic group responsible for the formation of this assemblage.

At the time of the excursion of the two Belgian Geological Societies a rescue excavation at the base of Unit 5.1, which was probably formed during the same warm-temperate phase as Unit 4, had just recovered a large site, with many thousands of flint artefacts present. The artefact assemblage, dominated by convergent scrapers and points, seems to be present in situ.

5. UPPER CRETACEOUS BIOSTRATIGRAPHY (J.W.M.J.)

Recent investigations allow a more detailed picture of the stratigraphy of the Late Cretaceous strata to be drawn. In one of the key sections (fig. 7) west of the River Maas at Haccourt, the Vaals Formation has recently been demonstrated to be the equivalent of the lower part of the *lingua/quadrata* Zone sensu germanico (Christensen & Schmid, 1987). The ammonite fauna of this unit, to be described shortly, supports this assignment (Jagt in prep., *see* also Kennedy, 1986).

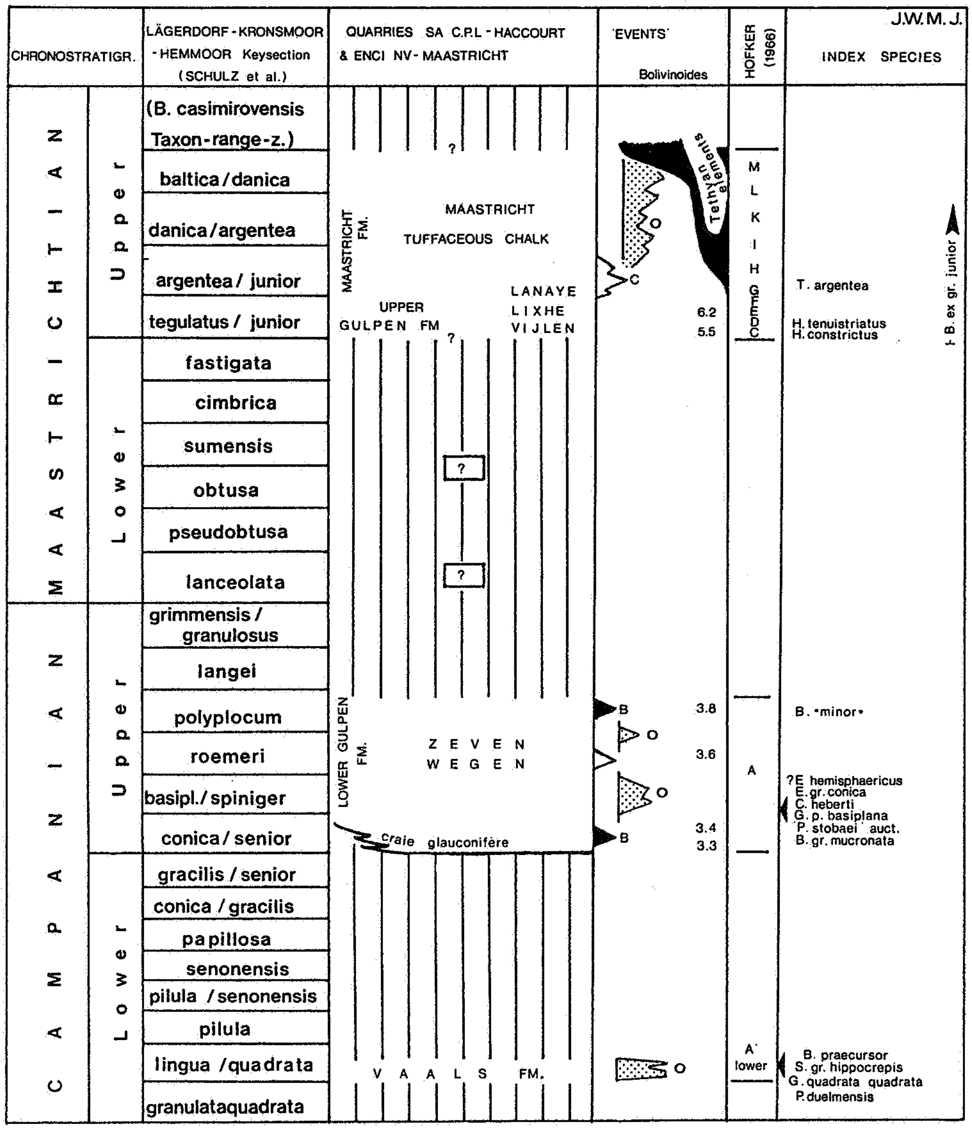


Figure 7. Correlation with the keysection for the NW German white chalk of the strata exposed in the S.A. Ciments Portland Liégeois quarry at Haccourt and the ENCI N.V. quarry at Maastricht, stratotype of the Maastrichtian stage as presently defined. Further details in text.

Upper Campanian strata are here developed in a white chalk facies that can be correlated rather well with other NW European occurrences. Ammonites are rare : of interest in the presence of "*Pachydiscus stobaei*" auct. (pers. comm. J.J.P. Zijlstra, June 1987 ; specimen now housed in Maastricht Museum) in this part of the section (+ 2-3 m above base of white chalk). In the Lanaye Member a Tethyan influence becomes apparent, which reaches its peak in the upper part of the Maastricht Formation (Meerssen Member). Due to the difference in facies and palaeo- (bio)geographical unrelatedness this part of the Liège-Maastricht-Heerlen Upper Cretaceous is very difficult to correlate with the NW German white chalk. Belemnites, which abounded in the older strata now make up only a very small part of the faunal assemblages. A more detailed account of the stratigraphy and fauna of the section exposed in the CPL quarry at Haccourt will be found in a paper now in preparation.

The picture that emerges from combining several sections in the Heerlen-Benzenrade-Vaals/Aachen area is the one presented in Figure 8. The outcrop at De Dael-Ubachsberg has turned out to be especially interesting since the fauna collected there allowed us (Jagt *et al.*, 1987) to correlate the Benzenrade sandy chalk (= "Pre-Valkenburg strata") with the Zeven Wegen white chalk on the basis of cephalopod evidence, bioclast assemblages, ostracodes and the foram genus *Bolivinoides*. Three peaks in belemnites and/or prismatic bivalves and two peaks in ornamented ostracodes can be distinguished within the Upper Campanian and these are traceable as far west as the Antwerp Campine.

Of particular interest in the occurrence of *Hoplitoplacenticeras marroti* (Coquand) in a so-called Vaals Greensand facies at the type locality of the Zeven Wegen Member. This record (Kennedy, 1986) necessitates a reappraisal of the stratigraphy of this outcrop.

Two so-called belemnite graveyards are present in this region. Current data

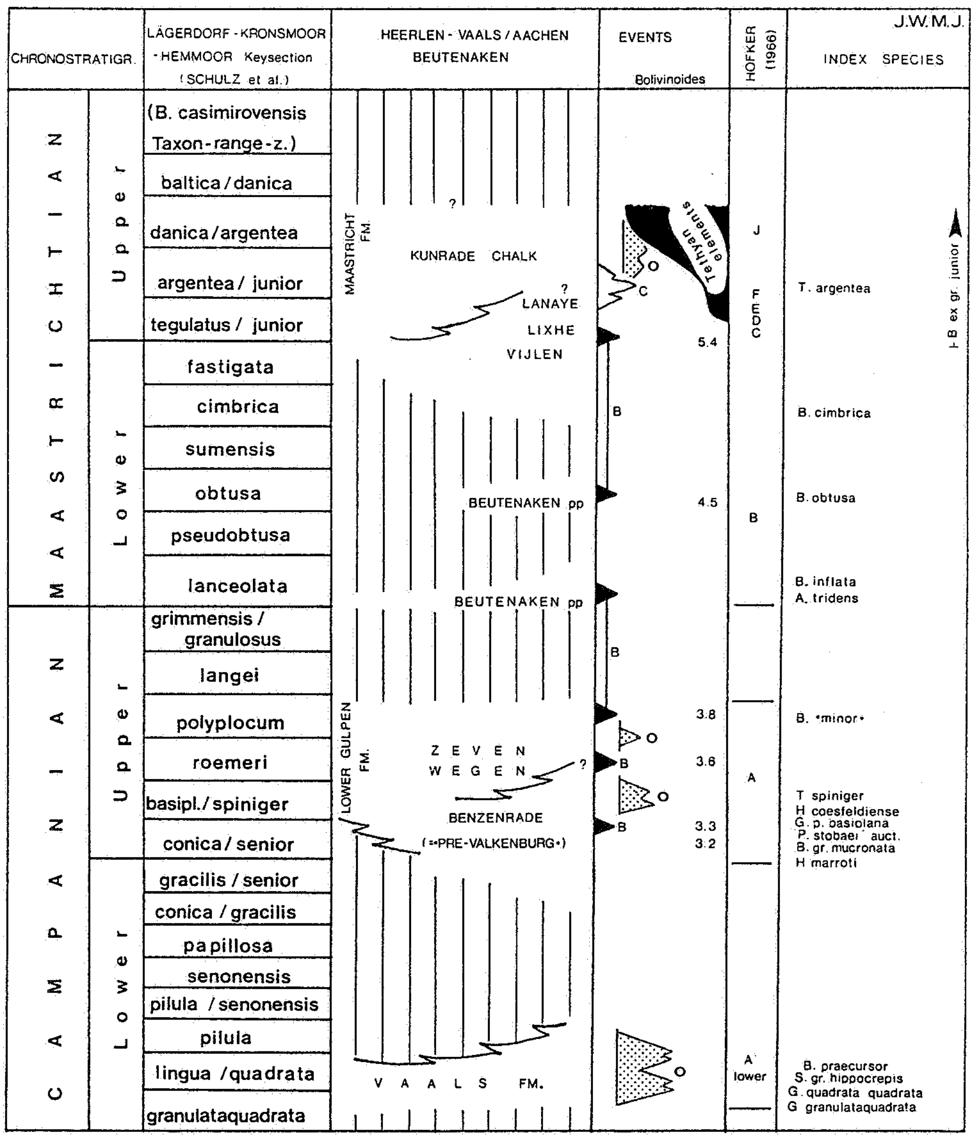
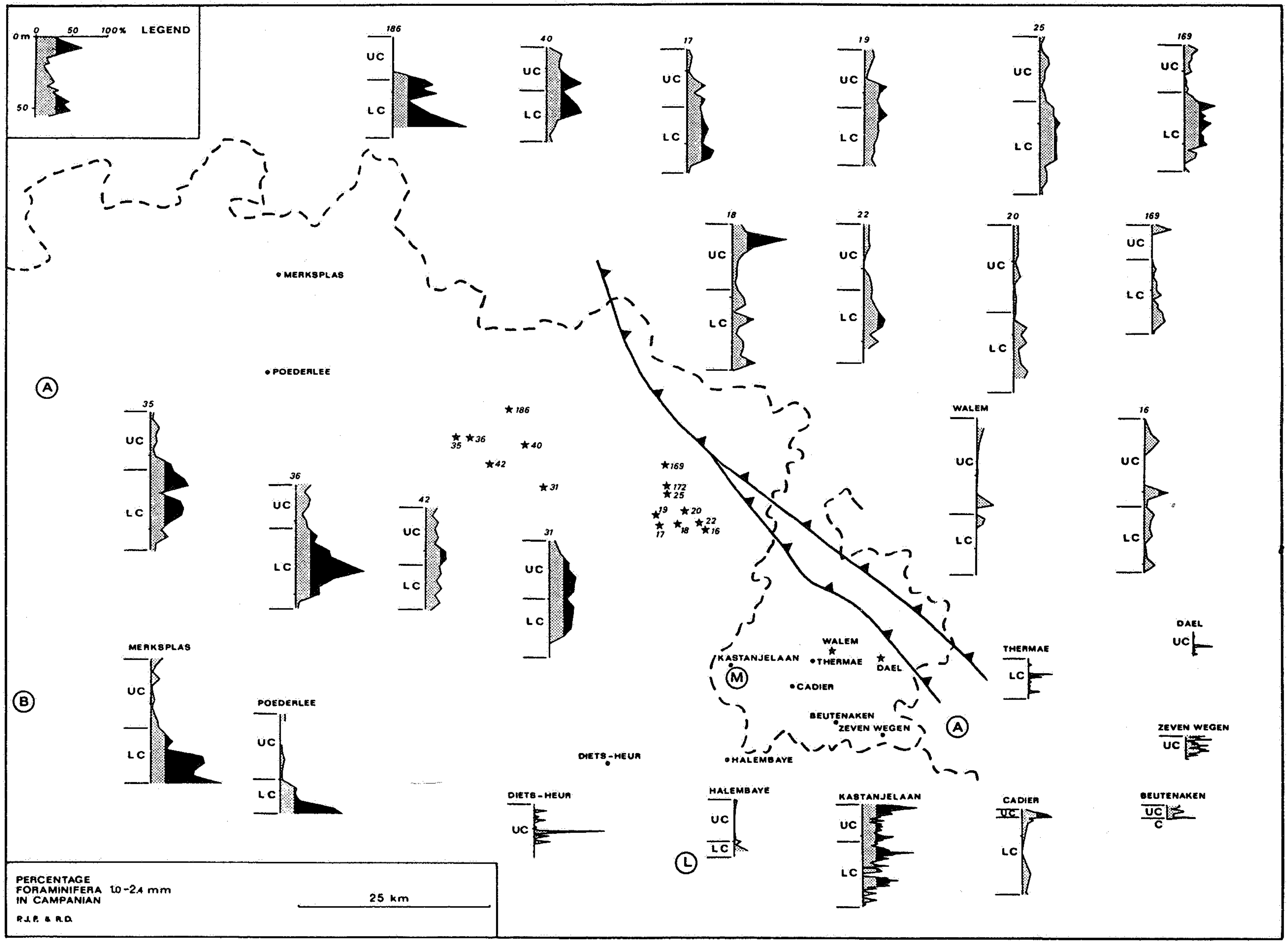


Figure 8. Correlation with the keysection for the NW German white chalk of the strata exposed in several outcrops in the eastern part of southern Limburg (The Netherlands). Further details in text.



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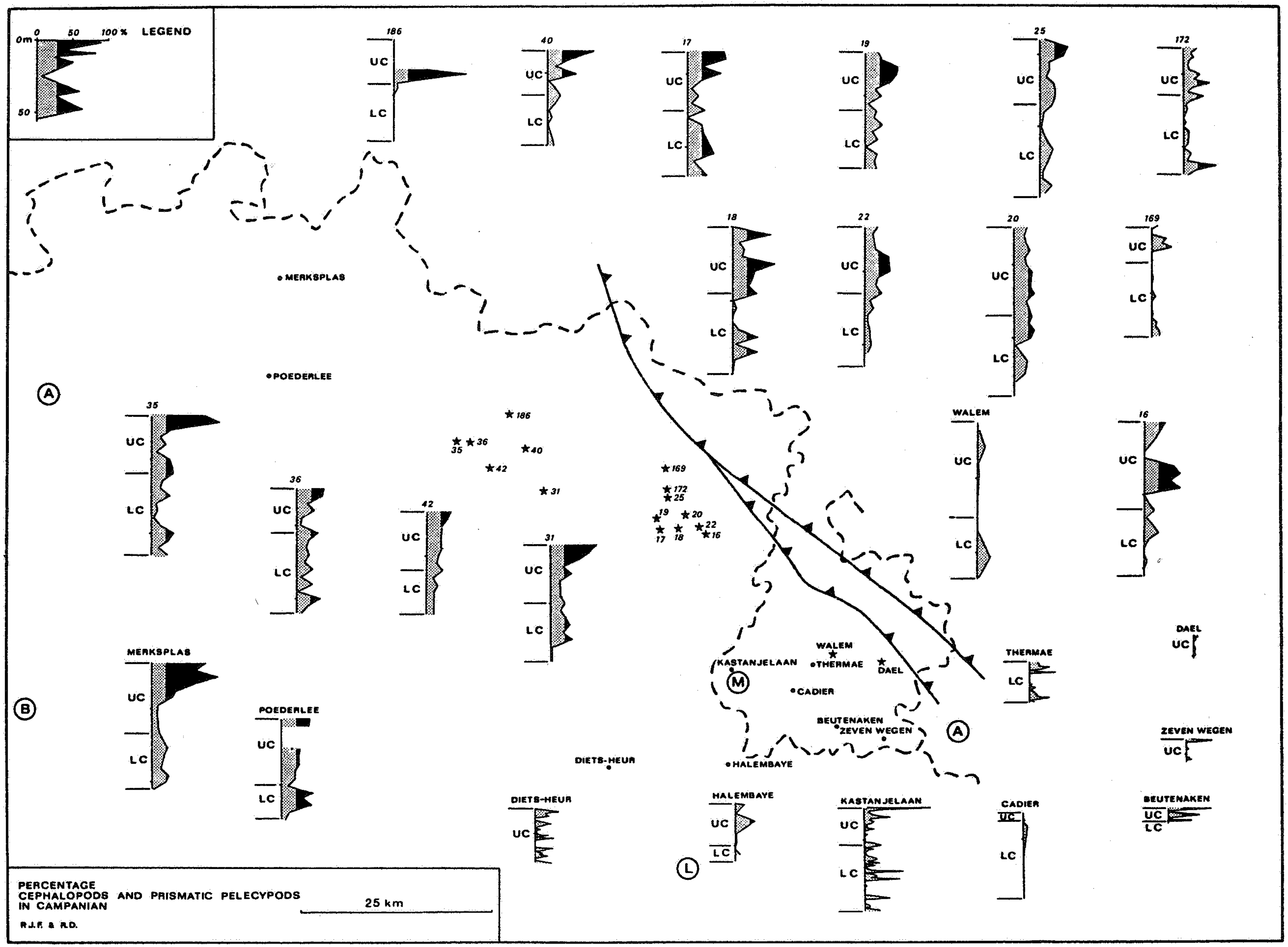
IN CAMPANIAN
R.J.P. & R.D.

Figure 9.



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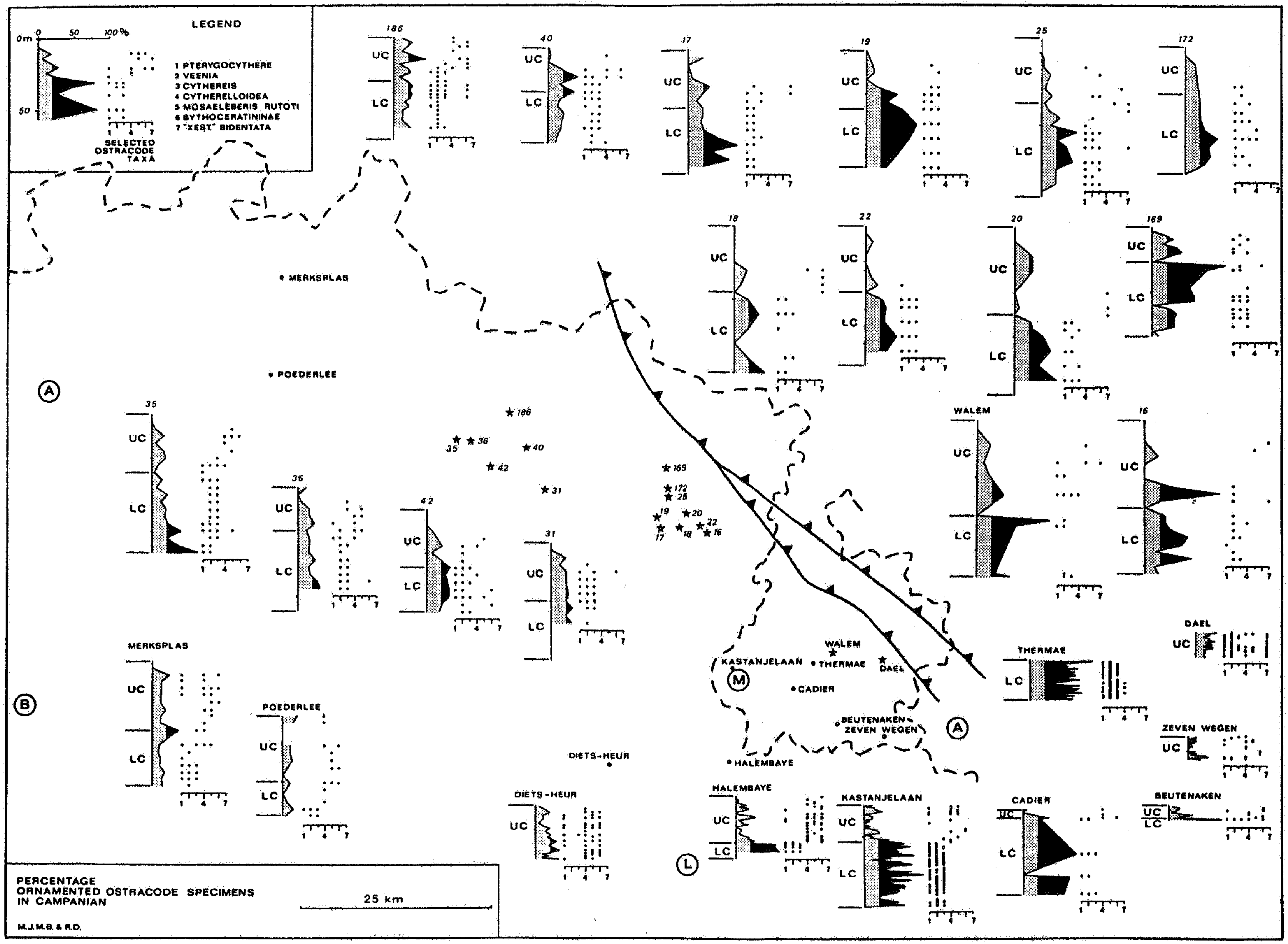
PERCENTAGE
CEPHALOPODS AND PRISMATIC PELECYPODS
IN CAMPANIAN
R.J.F. & R.D.
25 km

Figure 10.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SELECTED OSTRACODE TAXA
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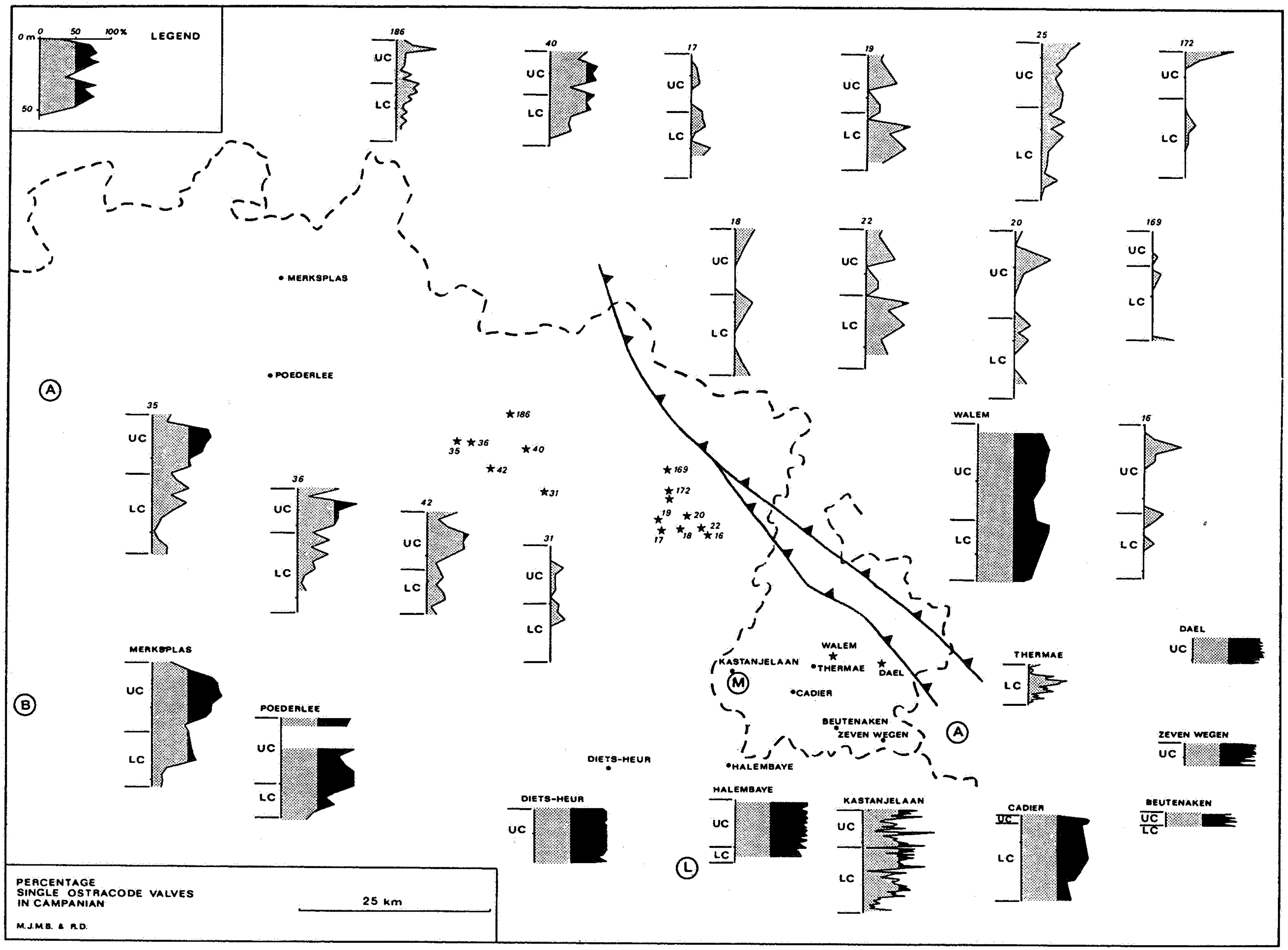
PERCENTAGE
ORNAMENTED OSTRACODE SPECIMENS
IN CAMPANIAN
M.J.M.B. & R.D.
25 km

Figure 11.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HALEMBAYE
PERCENTAGE
SINGLE OSTRACODE VALVES
IN CAMPANIAN
25 km
M.J.M.B. & R.D.
UC
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Figure 12.

suggest that these should be looked upon as the result of condensation and sediment winnowing rather than of reworking and as such they contain material of at least two belemnite zones each. The Vijlen Chalk in this region is, at least partly, slightly older than that in the CPL quarry. The Tethyan influence reaches this area somewhat earlier than the environs of Maastricht.

6. BIOCLASTS (P.J.F. & R.D.)

Bioclasts of varying size form an important constituent of the Upper Cretaceous marine deposits in the SE Netherlands and NE Belgium. These are certainly not randomly distributed in the sediments. Relatively high numbers of a special group of bioclasts may characterize a particular bed or interval, that may be traced over at times considerable distances. This was already noted in the past century for macroscopically recognizable fossils. In this way the "Belemnite Graveyards" have been and are still used as marker beds. The relative abundance of bioclasts of smaller size (e.g. 1-2.5 mm) may also be used in characterizing specific layers (P.J. Felder *et al.*, 1985a, 1985b). To this purpose a limited number of easily recognizable major fossil groups is distinguished in the bioclast assemblages (e.g. foraminifera, echinoderms, crinoids, molluscs plus brachiopods). Frequency profiles based on the absolute number of bioclasts of a given size per kilogram sediment or on the relative abundance (expressed in percentages) of any of these major fossil groups within the bioclast assemblages present similar trends over large distances, even when the lithofacies changes.
This is exemplified for the Lower to Upper Campanian in figures 9 and 10.

The Campanian deposits near the Rur Valley Graben (locations marked with an asterisk) are distinguished from those farther away by their relatively higher amount of sand in the Lower Campanian and sand-silt-clay in the Upper Campanian. The amount of siliciclastics in the Upper Campanian near-Graben sediments is so high that these have been included sometimes in the Vaals Formation (e.g. Kuyl, 1980). P.J. Felder *et al.* (1985a, 1985b) have placed these sediments in their basal "Pre-Valkenburg" deposits.

It should be noted that the quality of the frequency diagrams in figures 9 and 10 is somewhat variable because of different sampling techniques (outcrops vs. boreholes, varying drilling methods, varying sampling distances between 0.5-1.0 m in outcrops and 1.0-5.0 m in boreholes). Even so, the frequency profiles of foraminifera (fig. 9) in the bioclast assemblages (1.0-2.4 mm) usually show four (complex) maxima, two in the Lower and two in the Upper Campanian. This may point to some kind of cyclicity in the Campanian sediments.

Cephalopods (here all belemnite fragments) and prismatic bivalves (only prisms or fragments of the prismatic layer of possibly *Inoceramus*-type bivalves) have been combined in the frequency diagrams in figure 10, for it was noted that for some unknown reason these molluscs may replace each other in the bioclast assemblages. The frequency profiles generally exhibit five (complex) maxima : two in the Lower Campanian and three in the Upper Campanian (fig. 10). In Halembaye and in De Dael the lowest peak in the Upper Campanian is marked by the presence of *Belemnitella mucronata* and the foraminifer *Bolivinoides decorata* with a mean number of pustulae on the last chamber of 3.2 tot 3.3 (Jagt *et al.*, 1987). In Halembaye the upper peak in the Upper Campanian coincides with finds of *Belemnitella "minor"* and *Bolivinoides decorata* with a mean number of pustulae on last chamber of 3.7 to 3.8 (Jagt *et al.*, 1987). Up to now it is not clear which of these two belemnite species occurs in association with the middle Upper Campanian maximum.
Just as in the foraminifer profiles, the absolute percentages of each maximum in the cephapolod/prismatic bivalve profiles may vary considerably from one locality to the other. Sections with one or more pronounced maxima (> 20 %) appear to be randomly distributed.

7. OSTRACODES (M.J.M.B. & R.D.)

Quantitative studies of ostracode assemblages have been carried out either by subdividing these in specimens with a smooth and with an ornamented test, or by distinguishing between complete carapaces and single valves.

According to the original working hypothesis high percentages of ornamented ostracode specimens might suggest a relatively high water energy level and a corresponding shallow water depth (say above wave base) ; and low percentage would correspond to low water energy (well below wave base). In order to arrive at a repeatable method lists have been made of taxa considered as smooth or ornamented (Bless *et al.*, 1983). The working model is here tested for the Lower and Upper Campanian in figure 11. The frequency diagrams show similar trends in all sections with two (complex) maxima in the Lower Campanina and two in the Upper Campanian. These maxima largely match those established for large foraminifera (1.0-2.4 mm) in the same section (fig. 9). Most curiously the ornamented ostracode percentages for the Lower Campanian are distinctly higher in the east (South Limburg and eastern Campine mining area) than in the west (Antwerp Campine and western Campine mining area). This may indicate a westward deepening of the basin, a hypothesis supported by the rather massive appearance of planktonic foraminifera in the Lower Campanian of the western most sections Merksplas and Poederlee (F. Robaszynski *in* P.J. Felder *et al.*, 1985a).
It should be noted that the use of frequency profiles for ornamented ostracodes seems to permit a more detailed correlation than the use of selected taxa (fig. 11).

The frequency diagrams of single valves in the Lower to Upper Campanian (fig. 12) may yield some clue in the interpretation of the sedimentary processes. Usually, the ostracode carapace disintegrates into single valves a few hours or at the most a few days after its death, even in standing waters such as pools or aquariums. Exceptions are burrowing taxa and specimens buried alive. As shown in figure 11 by the distribution of selected taxa it may be accepted that burrowing species and genera are distributed at random in the basin and thus do not play a part in the lateral frequency variations of single valves and complete carapaces.

As shown on figure 12 the relative number of single valves in the Lower and Upper Campanian displays a peculiar distribution pattern. The percentages are

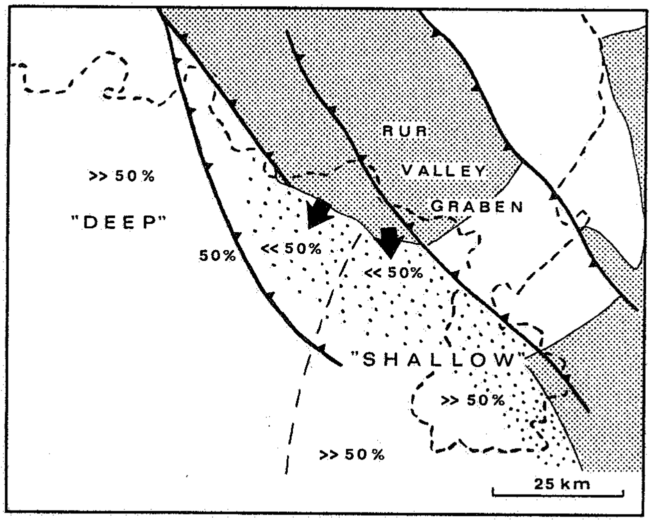

Figure 13. Map showing distribuion of sandy to marly Campanian lithofacies in NE Belgium and SE Netherlands (coarse punctuation), relative number of single ostracode valves in Campanian ostracode assemblages (in percentages ; cf. also figure 12) and relative water depth during Lower Campanian as deduced from proportional distribution of large foraminifera (cf. figure 9) and ornamented ostracodes (cf. figure 11). Fine punctuate shading indicates region where Lower Cretaceous and older deposits subcrop below Tertiary (after Van Wijhe, 1986). This region may have been the main source for clastic influx into the basin (black arrows). Note that low numbers of single ostracode valves in Campine mining area suggest repeated sudden burial of (living) organisms (tempestites ?, turbidites ?). High numbers of single ostracode valves in sandy/marly Campanian deposits of South Limburg may indicate that this sediment was redistributed somehow (long-shore currents ?). High numbers of single ostracode valves (more than 50 %) in Lower Campanian clay and Upper Campanian white chalk point to very low sedimentation rates.

high to extremely high (well above 50 %) in the west (Merksplas, Poederlee), south (Diets-Heur, Halembaye) and east (South Limburg). In the western and eastern Campine mining areas the percentages are usually much lower (well below 50 %) with some exceptions of around 50 % in the western mining area (locations 35, 36, 40). Comparison with the Pre-Tertiary subcrop map of Van Wijhe (1986, fig. 13) shows that these are nearest to that part of the Rur Valley Graven where Upper Cretaceous deposits are completely absent due to inversion. This suggests that these sections with the lowest percentages of single valves in the Campanian were nearest to a potential source area for siliciclastics. If we accept the hypothesis that many of these Campanian deposits may have been introduced into the basis as tempestites or turbidites, we have a mechanism that could have caused the necessary rapid (almost sudden) burial of the (living) benthos.

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COMPTES RENDUS

RECOGNITION OF URANIUM PROVINCES -
Proceedings of a technical committee meeting on recognition of Uranium Provinces, organised by the International Atomic Energy Agency and held in London 18-20 Sept. 1985.
Uitgegeven door : International Atomic Energy Agency, Vienna 1988 in de Panel Proceedings Series.
ISBN 92-0-141088-2.
Prijs : 940 Shilling - 459 p.

Het boek is het resultaat van een bijeenkomst van experts onder auspiciën van de IAEA.
Naast de voordrachten die door verscheidene auteurs gegeven werden over de algemene kenmerken en de oorsprong van de Uranium provincies, gestaafd met praktische voorbeelden van de meest karakteristieke types en uit alle werelddelen, bevat het boek ook de conclusies waartoe de discussies geleid hebben.
De meest verscheidene afzettingstypes worden behandeld en gedocumenteerd met gekende voorbeelden :

- Vroeg Proterozoïsche Kwarts-conglomeraten : placer type (vb. Elliot Lake Witwatersrand)
- Proterozoïsche discordantie - gebonden afzettingen : lage temperatuur metamorfisme (vb. Alligator river, Athabasca enz)
- Afzettingen in aders van hydrothermale oorsprong (vb. Massif Central, Tsjecho-Slovakije, enz)
- Afzettingen in zandstenen van Postcambrische plateauformaties (vb. Colorado-plateau - Lake Frome Embayment)
- Gedissimineerde afzettigen in magmatische en metamorfe gesteenten (vb. Rössing ; Poços de Caldas)
- Duricrust en Calcrete afzettingen (Yeelirrie).

Daarnaast werden ook zeer algemene aspecten behandeld zoals de processen die bij de vorming van U-afzettingen tussenkomen ; de rol van de mantel en de platentektoniek ; de verdelingspatronen van de U-afzettingen in ruimte en tijd en de toepassing van al deze kenmerken bij de exploratie naar Uranium.

Die boek weerspiegelt dan ook de stand van zaken van de huidige kennis over de Uranium provincies. Het geeft een zeer verhelderend overzicht van de problemen, hun interpretatie en de blijvende vragen.

H. GOETHALS

THE ORIGIN OF ARCS edited by F.-C. WEZEL.
Developments in geotectonics 21 -
Elsevier 1986 - Amsterdam (NL).
588 pages.

Les principales interventions (23) au Congrès International "Origin of Arcs". tenu à Urbino (Italie), nous sont présentées au sein de cinq chapitres respectivement consacrés à :

- la géotectonique globale
- la géophysique et la géochimie
- la région "Alpes-Méditerranée"
- le domaine des Caraïbes
- le Pacifique

Quarante-sept auteurs nous proposent ainsi une analyse des concepts relatifs aux processus orogéniques et post-orogéniques participant à l'édification des arcs insulaires et des arcs montagneux.

Les auteurs tentent ainsi de nous apporter un début de réponse à quelques questions fondamentales :

- les arcs sont-ils primaires ou induits ?
- comment ces alignements orogéniques ont-ils acquis leurs formes régulières et similaires ?
- quelles relations existent entre les arcs "primaires", actifs, et les arcs montagneux "secondaires" ?
- quel est le processus dynamique majeur qui engendre ces arcs ?
- quelle est la signification tectonique de la zone de Benioff et quelle est sa vraie nature ?

Ce volume s'inscrit logiquement dans la série : "Developments in geotectonics" éditée par Elsevier. Il concrétise efficacement la collaboration multidisciplinaire dans l'investigation géologique.