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AACHEN-LIEGE UNIVERSITIES EXCHANGE DAYS IN AACHEN NOVEMBER 27th, 1987

Organized by R. WALTER, RWTH Aachen,
E. POTY & M. STREEL, Paleontology, University of Liège

in cooperation with the Société géologique de Belgique, Liège
and the Natural History Museum, Maastricht

Thema : ASSESSMENT OF PALEOGEOGRAPHIC DISTANCES : IMPLICATIONS FOR APPLIED GEOLOGY

THE LATE CRETACEOUS BETWEEN ANTWERP AND AACHEN : DIFFERENTIATION IN SEDIMENTARY FACIES AS A RESPONSE TO TECTONIC ACTIVITY

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Reappraisal of biostratigraphy data on the Upper Cretaceous deposits between Aachen (FRG) and Antwerp (Belgium) learns that these do not represent an uninterrupted, continuous succession of sediments. On the contrary, there is evidence for frequent and even considerable hiatuses which are interpreted as a response to local differential warping of the intensely block-faulted basement. Moreover, in contrast to former opinions, there are good biostratigraphic tools (belemnites, ammonites, foraminifera, ostracodes, bioclast assemblages) demonstrating the strongly diachronic character of sedimentary facies. For instance, the lower half of the white chalk (Zeven Wegen Chalk) of the Upper Campanian at Halembaye (CPL Quarry of Haccourt) and Maastricht (Kastanjelaan and Heugem boreholes) is absent in the intermediate area of Lixhe and 's-Gravenvoeren and passes into a glauconitic, sandy marl to the north (Bunde borehole; cf. Herngreen *et al.,* 1986), north east (De Dael outcrop near Heerlen) and east (Hombourg borehole and Zeven Wegen outcrop; cf. Jagt *et al.,* 1987). These lateral changes in lithofacies are so «dramatic» and take place over so extremely short distances that, until recently, nobody accepted that these might be coeval. These differences are now explained by synsedimentary tectonics, long-shore currents and other sedimentary models (Bless *et al.,* 1987).

This example shows that contrasting lithologies or fossil assemblages do not yield a clue for identifying their original distance or nearness.

BLESS, M.J.M., FELDER, P.J. & MEESSEN, J.P.M.Th., 1987. Late Cretaceous sea level rise and inversion : their influence on the depositional environment between Aachen and Antwerp. *Ann. Soc. géol. Belg.,* 109 : 333-355.

HERNGREEN, G.F.W., FELDER, W.M., KEDVES, M. & MEESSEN, J.P.M.Th., 1986. Micropaleontology of the Maestrichtian in borehole Bunde, the Netherlands. *Rev. Palaeobot. Palynol.,* 48 : 1-70.

JAGT, J.W.M., FELDER, P.J. & MEESSEN, J.P.M.Th., 1987. Het Boven-Campanien in Zuid-Limburg (Nederland) en Noordoost België. *Natuurhist. Maandblad Limburg,* 76 (4) : 94-110.

THE ORDOVICIAN OF BRITANNY AND PORTUGAL, SIMILAR SEDIMENTARY SEQUENCES DEPOSITED SEVERAL HUNDREDS OF KILOMETERS APART

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The Ordovician deposits of Britanny and Portugal show a remarkable similarity in the succession of lithologies and their thickness (tab. 1).

Table 1.- Comparison between the Ordovician rocks of the Presqu'île de Crozon (Britanny) and The Serra de Buçaco (Portugal), after Henri *et al.,* 1974.

AGE	CROZON (BRITANNY)	BUÇACO (PORTUGAL)
Ashgill	Rosan Formation (tuffs and lavas)	Porto do Santa-Anna Fm. (tuffs and lavas)
	Kermeur Formation (alternating micaceous siltstones and quartzitic sandstones) thickness : max. 300 m	Louredo Formation (alternating micaceous siltstones and quartzitic sandstones) thickness : max. 250 m
Llandeilo Llanvirn	Postolonnec Formation (micaceous siltstones intercalated by quartzitic sandstones; fine-grained siltstones in lower quarter) thickness : 300-350 m	Cacemes Formation (micaceous siltstones intercalated by quartzitic sandstones; fine-grained siltstones in lower third) thickness : 300 m
Arenig	Grès Armoricain (thick-bedded quartzitic sandstones with in upper portion micaceous sandstones thickness : 100-1000 m	Grès Armoricain (thick-bedded quartzitic sandstones with in upper portion micaceous sandstones) thickness : 400-700 m

Also the fossil assemblages (notably those of the Postolonnec and Cacemes Formations) are very similar as far as chitinozoans, ostracodes and trilobites are concerned. This was noticed already in 1901 by Kerforne, who wrote: ... «les listes de fossiles de Vallongo et de Bussaco données par M. Delgado (loc. cit.) semblent être des listes de localités armoricaines.» Henri *et al.* (1974) noticed that there is not only a qualitative but also quantitative similarity between these fossil assemblages.

This example demonstrates that the depositional history of rather distant regions (even if we take into account their original paleogeographical position during the Ordovician) may be almost the same. In this case this is true for a succession of sedimentary environments and their life conditions. In other cases, there is an astonishing alikeness of lithofacies and their fossil contents during a relatively short period, for instance the regularly observed black shale deposits (often interpreted as «event» deposits).

These examples prove that the similarity in lithologies and fossil contents is not a clue for the recognition of relative nearness or relative distance.

HENRI, J.L., NION, J., PARIS, F. & THADEU, D., 1974. Chitinozoaires, ostracodes et trilobites de l'Ordovicien du Portugal (serra de Buçaco) et du massif Armoricain : essai de comparaison et signification paléogéographique. *Com. Dos Serviços Geol. Portugal*, 57 : 303-345.

KERFORNE, F., 1901. Etude de la région silurique occidentale de la presqu'île de Crozon. Thèse Univ. Rennes : 234 p.

THE WESTPHALIAN C IN THE CAMPINE BASIN : COAL CONTENT INFLUENCED BY TECTONICS

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INTRODUCTION

In the northeastern part of the Campine coal basin in Belgium, coal exploration by means of reflection seismics and coreholes carried out between 1979 and 1985 has yielded new information on the terminal coal bearing strata of Upper Westphalian C - Lower Westphalian D age. The Westphalian coal measures in the Campine basin have been deposited in an upper delta plain environment. However the average coal content may vary considerably for sequences of similar age event on very short distances. This variation in coal content cannot be explained in terms of dynamic depositional models only. In some instances synsedimentary block faulting may have led to different subsidence patterns influencing the facies distribution. Tectonic control of subsidence rates and coal distribution may be fairly widespread as proposed by Fielding (1987). Bless *et al.* (1977) emphasized the importance of sediment thicknesses for the paleogeographical reconstructions of the northwest european coalfields.

STRATIGRAPHY

In the Campine basin Westphalian C-D strata attain a maximum thickness of ± 1425 m, composed of ± 400 m for the Lower Westphalian C (between the Aegir or Maurage marine band and Tonstein Nibelung), ± 475 m for the Upper Westphalian C (between Tonstein Nibelung and the base of the Neeroeteren Sandstone), and ± 550 m for the «Westphalian D» (above the base of the Neeroeteren Sandstone, 300 m cored in borehole 146 Neerglabbeek, 250 m added from seismic data). The occurrence of *Neuropteris ovata* which should indicate the international base of the Westphalian D, about 50 m below the base of the Neeroeteren Sandstone has not been confirmed by recent paleobotanical studies (comm. G. Borremans). Further stratigraphic subdivisions were proposed by Paproth *et al.* (1983). Guidelines for seam to seam correlation within this sequence were provided by Dusar *et al.* (1985).

TECTONIC CONTROL OF SUBSIDENCE

Five boreholes drilled for the coal exploration programme of the Belgian Geological Survey have traversed the Westphalian C/D sequence in the northeastern Campine. Maximal distance between these boreholes is 8 km in a direction parallel to the graben margin and to the main Jurassic-Tertiary faults (fig.). Correlation between boreholes which fit in the general stratigraphic framework become problematical from southeast to northwest. The coal content and coal reserves in potentially exploitable coal seams diminish in the same direction.

Differential subsidence of adjacent structural blocks rather than lateral differences in a wandering depositional environment probably forms the dominant control mechanism for the observed variation (Bouckaert & Dusar, 1987). The limits between these blocks represent ancient lineaments already affecting the Cambro-Silurian basement of the Brabant Massif. The Gruitrode lineament which crosses the exploration area southeast of borehole 169 represents a major block margin.

In this way each structural block can be considered as a small rather homogeneous coalfield with comparable sequence (e.g. boreholes 161 and 168). Individual coal seams may vary in thickness or present splitting phenomena. However coal seam groups and reserves estimates for thick coal seams will remain more constant.

It is also noteworthy that differential subsidence varied considerably in time leading to standstills or to inversions in sedimentation rate (fig.). A thickness reduction by one third for the Upper Westphalian C on the northwestern block is mostly absorbed, without faults, near its base (deposition time of the Rubezahl - Tristan coal seam groups according to the German stratigraphic nomenclature). In this interval no correlations are possible. It is also shown that limnic facies types are more widespread in roof shales of the northwestern bloc (70 %) than of the southeastern block (45 %). Also the distribution of channel or crevasse splay sandstones is very uneven.

In the Lower Westphalian C thick coal seams are again very prominent on the block (borehole 172) which shows no prospect for exploitation in the Upper Westphalian C.

CONCLUSIONS

With respect to the symposium theme, observations from the Upper Carboniferous in the Campine basin imply that prediction of paleogeographic distances from purely sedimentary models is unreliable since synsedimentary tectonic activity has controlled subsidence regimes and hence coal content. The synsedimentary structural blocks are delimited along reactivated basement faults. The observed structures and facies changes are certainly not unique for the Brabant Massif and the Campine basin.

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DUSAR, M., MEYSKENS, M., BLESS, M.J.M., SOMERS, Y. & STREEL, M., 1985. The Westphalian C-D strata in the northeastern Campine. Possibilities for seam to seam correlations. *Ann. Soc. géol. Belg.*, 108 : 412-413.

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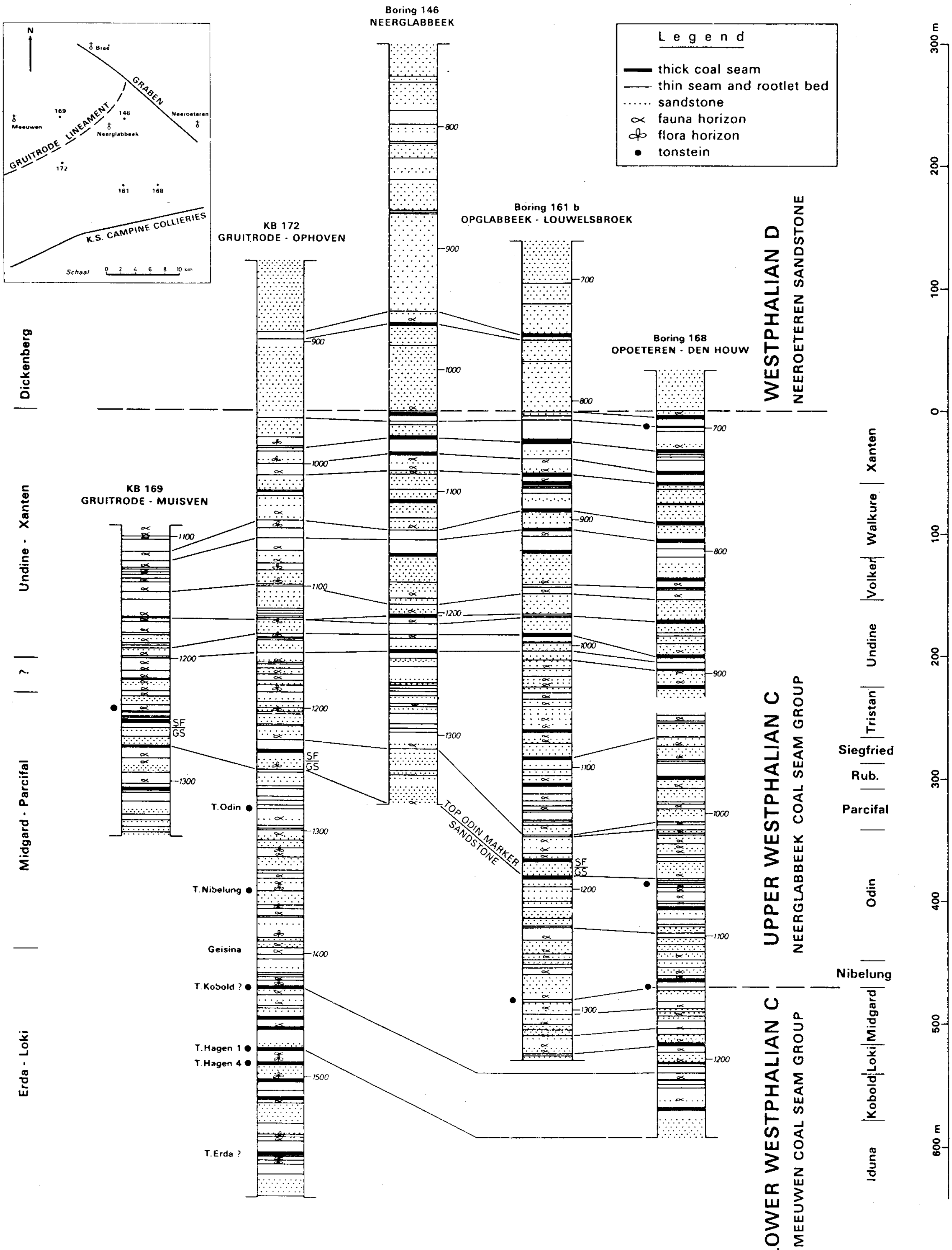

BOREHOLE CORRELATION N-E CAMPINE

REEF-BASIN DISTANCE IN THE DEVONIAN OF THE CARNIC ALPS

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See this volume : 159-163.

SIMILAR TECTONO-SEDIMENTARY EVOLUTIONS AND IMPORTANT LATERAL CHANGES IN A BLOCK-FAULTING SYSTEM

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The eastern end of the Brabant Massif was affected by block-faulting tectonics at least during the Devonian and the Carboniferous. The limits and the relative movements of the blocks have been defined through the sharp lateral variations in the stratigraphy, the nature and the thickness of the deposits and from the evolution of these latter.

Five main tectonic units have been recognized (fig. 1, 2).

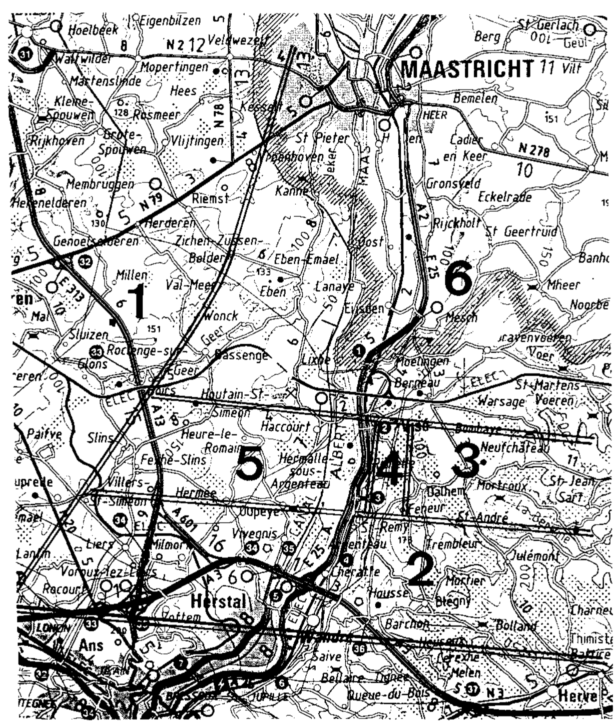

Fig. 1.- Main recognized tectonic units. For explanation see at fig. 2.

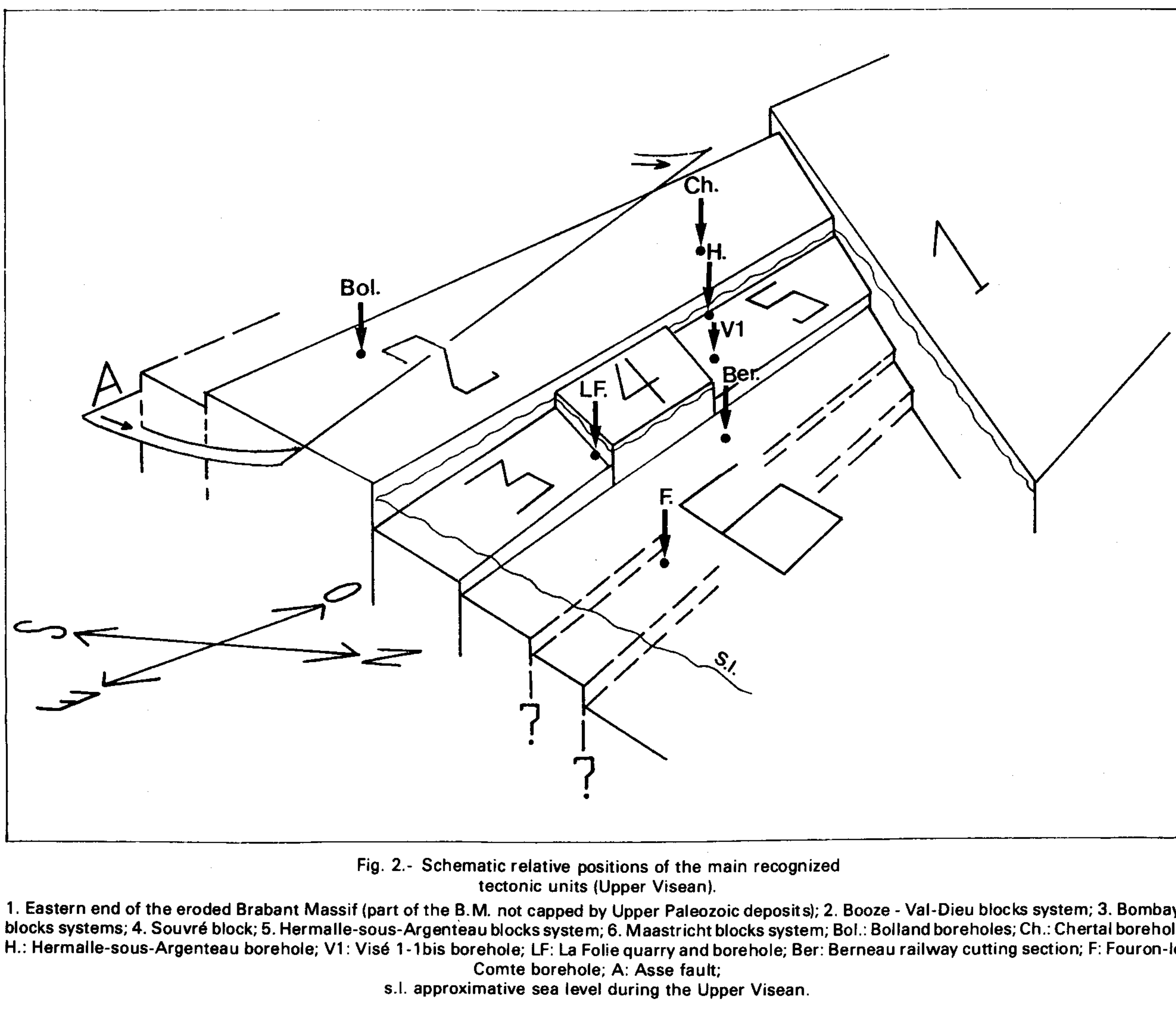

Fig. 2.- Schematic relative positions of the main recognized tectonic units (Upper Visean).

1. Eastern end of the eroded Brabant Massif (part of the B.M. not capped by Upper Paleozoic deposits); 2. Booze - Val-Dieu blocks system; 3. Bombaye blocks systems; 4. Souvré block; 5. Hermalle-sous-Argenteau blocks system; 6. Maastricht blocks system; Bol.: Bolland boreholes; Ch.: Chertal borehole; H.: Hermalle-sous-Argenteau borehole; V1: Visé 1-1bis borehole; LF: La Folie quarry and borehole; Ber: Berneau railway cutting section; F: Fouron-le-Comte borehole; A: Asse fault;
s.l. approximative sea level during the Upper Visean.

1. The Booze - Val-Dieu blocks system which was subsident during the Lowermost Devonian, the Upper Frasnian and the Famennian, but which formed a high from the Siegenian to the Middle Frasnian and during the Dinantian.

2. The Souvré block, only subsident during the Givetian (?) and the Frasnian, which formed an emerged high during most of the Devonian and the Dinantian. Famennian palaeokarsts affect the Frasnian limestones in this block.

3. The Hermalle-sous-Argenteau blocks system which was evolving as the Souvré block during most of the Devonian but which was subsident from the Uppermost Devonian. Collapse breccias related to the palaeokarsts affect the Frasnian limestones.

4. The Bombaye blocks system, evolving almost as the Hermalle-sous-Argenteau blocks system.

5. The Maastricht blocks system («Maastricht grabben») deeply subsident at least from the Frasnian and characterized by the deposition of more than 1000 m of Dinantian carbonates.

These units have been capped by Namurian and Westphalian deposits of locally variable thickness.

In this block faulting model, important lateral changes in the deposits do not necessary need a large transitional area but can occur on both sides of synsedimentary active faults. Thus the Eodevonian of the Booze - Val-Dieu blocks system (observed in the Bolland borehole) might stop sharply, perhaps during its deposition, at the boundary with the Hermalle-sous-Argenteau, Souvré and Bombaye blocks systems where no Lower Devonian is known. In this case, neither a bevel of the deposits to the north nor the erosion of the whole of the Lower Devonian deposits supposedly present on the positive parts of the Brabant Massif (here the Hermalle-sous-Argenteau, Souvré and Bombaye blocks systems) would have to be considered.

On the other hand, a similar evolution in the sequence of the deposits in closely nearby areas suggests that these latter belong to a common block (or blocks system). Thus, the Chertal area and the Booze - Val-Dieu area which show a similar stratigraphical sequence probably belong to the same block system, suggesting that there was not an important displacement along the Asse Fault which is actually between the two areas.

CARBONATE FACIES AND BIOSTRATIGRAPHY IN THE UPPER DEVONIAN OF THE INDE-SYNCLINORIUM

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See The Givetian-Frasnian boundary at the southern border of the Inde Synclinorium, this volume : 165-170.

COMPARED SEDIMENTOLOGY IN THE UPPER CARBONIFEROUS OF THE INDE- AND WURM SYNCLINORIUM, W. GERMANY

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This volume : 171-176.

REWORKING OF PALYNOMORPHS AS A TOOL FOR PALEOGEOGRAPHIC RECONSTRUCTION : AN EXAMPLE IN THE LOWER DEVONIAN

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The subject of the talk is developped in the article printed in the present volume : «Paléogéographie de l'Eodévonien ardennais et des régions limitrophes».

LATERAL DISTRIBUTION OF MIOSPORES AS A TOOL FOR ASSESSMENT OF PALEOGEOGRAPHIC DISTANCES

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Miospore assemblages with similar list of species content can be observed from far distant localities, often within a same paleophytogeographic belt, and cannot therefore be used for assessment of paleogeographic distance. However quantitative data may help if they are computed from a lateral sequence of contemporaneous samples. Indeed the miospore concentration in sediments (in number of miospores/gr. of sediment) decreases sharply, but progressively from very near-shore to off-shore environments.

Thus, there is some relationship between the miospore concentration of a sediment and the distance between where it has been deposited and the shore-line. Difficulties in the reconstruction of such paleoenvironments arise however from the need of accurate datations by independant (paleontological) controls and of suitable sediments for palynomorphs.

RELATIONS BETWEEN INDE- AND WURM SYNCLINE (AACHEN COAL DISTRICT, F.R.G.)

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Wurm syncline and Inde syncline form two parts of the Aachen Coal District. They are situated on the northern flank of the Venn Anticlinorium and are separated by the Devonian of the Aachen Anticline. Within the Wurm Syncline strata of Namurian to Westphalian B age are exposed. Within the Inde Syncline a stratigraphic sequence is known which ranges from Upper Devonian to the Westphalian A/B boundary.

The Aachen Anticline is dissected by the Aachen Overthrust and some accompanying thrusts, which have a lithostratigraphic throw of up to 1.4 km. South of the Inde Syncline another important thrust system is exposed : the Venn Thrust. This thrust system has a maximal throw of up to 4.000 m : the Ordovician of the Venn Anticline has been moved above Namurian strata.

The Aachen Thrust System and the Venn Thrust are regarded to be the eastern prolongations of the nappe-like thrusts well-known from the northern border of the Ardenne in Belgium and northern France (Faille du Midi, Faille Eifelienne).

The tectonic style of the Wurm Syncline is that of an intensively special-folded monocline forming the northern flank of the Aachen Anticlinorium. The Inde Syncline, however, has the shape of a northward tilted box-fold. The tectonic situation of the Inde Syncline in general is determined by its position between the two mentioned thrust belts.

Due to seismic results a nappe interpretation for the Aachen Thrust System has been favoured during the last years. An intensive seismic reflector in about 4 km depth has been interpreted as a detachment horizon, which outcrops at the surface to the north in the Aachen Thrust.

However, connected to this nappe interpretation for the Aachen Thrust is a number of problems not solved until today. First of all, the question about the origin or root zone of the nappe is highly problematic. Likewise, there is no determination of the eastern border of the Dinant nappes in the hanging wall of the Aachen Thrust which has to be expected in the Rhenanian Uplands south of the Lower Rhine Embayment. The sedimentary basins of the Siegerland continue towards west right into the Dinant nappe.

On the other hand there is no indication of an allochthonous position of the eastern Rhenish Massif in relation to the Ruhr Carboniferous for instance.

Thus a more detailed investigation of the eastward and downward extensions of the Aachen Thrust is necessary. It can be observed that the amount of throw of the Venn Thrust System as well as of the Aachen Thrust diminishes work depth. Within the axis culmination of the Venn Massif, where deeper tectonic stockwerks are exposed, the Venn Thrust disappears within Revinian strata. analogous the throw of the Aachen Thrust is much smaller in the exposures in the Geul Valley on the Belgian-Dutch border than in the Aachen area. Finally a deep boring at Grand Halleux in the Belgian Ardenne exposed a structural style that in a smaller scale is well known from the Ruhr Carboniferous too. Following this point of view the root zone of the Aachen Thrust and its transition into folds has to be expected still on the northern flank of the Venn Anticlinorium.

The most eastward hints to the existence of the Aachen Thrust come from a number of borings situated within the Jackerath Horst in the center of the Lower Rhine Embayment. These borings revealed a tectonic setting which is quite similar to that of the Aachen area : intensively folded strata of Lower Westphalian and Namurian age bordering Upper Devonian strata in the hanging wall of the Aachen Thrust. According to these borings and other exploration results within the basement of the Lower Rhine Embayment the Velbert Anticline east of the Rhine is the continuation of the Aachen Anticline and the Remscheid-Altena Anticline that of the Venn Anticline. Within the Devonian strata of the Velbert Anticline no significant overthrusts are known; likewise the thrust tectonics within the Remscheid-Altena Anticline are of small importance, too. So in the direction of strike the same substitution of thrusts by folding is to be observed as it has been towards depth. This confirms the conception that folds and overthrusts have been formed syngenetically and in close mechanic relation to each other.

This concept of the development of thrusts is reflected by the stratigraphc development of the Aachen area, too. Based on palaeogeographic investigations and a comparison of the stratigraphic sequences within the Wurm and Inde areas it is evident that the sedimentary conditions of these basins during the Namurian and Lower Westphalian A have been similar. Within the Upper Westphalian A, however, a progressive differentiation of the facial development of Wurm and Inde syncline becomes remarkable.

Finally, in the upper part of the Westphalian A a conclusive comparison between the strata of both synclines is no longer possible. So it is conclusive that during the Namurian and the Lower Westphalian A there was only one sedimentary basin for both the Wurm and Inde Synclines. During the Upper Westphalian A the approaching Variscan front created a barrier between these areas, that later, during the orogenic development, has been transformed in the Aachen Anticline. Under the specific tectonic conditions at the southern border of the Brabant Massif which restrained folding, and depending on stockwerk tectonic conditions this anticline simultaneously has been the nucleus for the development of the Aachen Thrust. So, although there are the above mentioned relations to the nappe-like thrusts of the Ardenne the Aachen Thrust seems to be more likely a fault of the «folded overthrust» type.

According to this interpretation it is possible to project the tectonic section through Wurm and Inde Syncline towards top and depth applying rules which have been developed for this type of faults within the Ruhr Carboniferous. From this model an orogenic shortening of the area can be deduced which reaches an amount of about 60 %. Thus the areas of Wurm and Inde Syncline, which today are about 10 km apart, originally had a distance of about 25 km during time of sedimentation.

STRATIGRAPHICAL AND SEDIMENTOLOGICAL COMPARISON BETWEEN INDE- AND WURM AREA

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CONCLUSIONS

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The recognition of tools for the assessment of paleogeographic distances formed the theme of this meeting, that was attended not only by students and staff of the geological institutes of Aachen and Liège, but also by geologists from Brussels, Ghent, Bonn, Hannover, Krefeld and Maastricht. Several approaches have been discussed, vayring from the comparison of structural styles or tectono-sedimentary evolution in nearby or distant areas to the use of purely paleontological methods.

An interpretation of the structural relationship between the Inde Syncline (south of the Aachen Thrust) and the Wurm Syncline (north of the Aachen Thrust) was presented by V. Wrede. This author argued that the root of the Aachen Thrust is to be found north of the Venn Anticline, and he concluded that the present-day distance between Wurm and Inde synclines is only slightly less than the original one. However, in the discussion it was pointed out that analysis of seismic profiles through these areas has yielded a completely different interpretation. Thus the study of structural styles does not necessarily result in an irrefutable answer as far as palinspatic relationships are concerned.

Various authors have focussed their attention on the tectono-sedimentary evolution of different (nearby or distant) areas. Comparable trends in the Devono-Dinantian of the Visé/Booze-Val Dieu/Bolland regions (NE of Liège) are used as an argument for the original proximity of these geological structures north and south of the Aachen-Midi Thrust (E. Poty).

However, the example of the Ordovician in Britanny and Portugal (M.J.M. Bless) shows that an almost identical tectono-sedimentary evolution (matched by an identical qualitative and quantitative paleontological record) may occur at relatively large distances, even if the paleogeographic reconstructions for the original position of Portugal and Britanny are accepted. This means that comparable or even identical trends in tectono-sedimentary settings cannot yield an irreversible argument for the assessment of paleogeographical distances.

Differential warping of neighbouring blocks may result in sometimes dramatic changes in the thickness of deposits, their lithofacies and/or paleontological contents, as demonstrated for the Upper Carboniferous of the Campine mining area by M. Dusar and for the Upper Cretaceous between Aachen and Antwerp by M.J.M. Bless.

Maybe the most spectacular example of an extremely rapid lateral change in the sedimentary environment has been presented by L. Kreutzer for the Middle Devonian in the Kellerwand area (Carnic Alps), where a facies change from reff-nearshore to pelagic basin could be established within a few thousand metres !

Comparison of sedimentary sequences always presupposes a reliable (bio-)stratigraphical correlation (cf. B. Reissner for the Upper Devonian «Grenzschichten» in the Inde Syncline). If the stratigraphical framework may be disputed (discussions after the presentation on the Upper Carboniferous strata in the Wurm and Inde Synclines by. B. Steingrobe & A. Müller, and by M. Zeller) any conclusions on lithofacies trends or on paleogeographic distances may be disputed as well.

Qualitative and quantitative paleontological approaches may support in an excellent way paleogeographic reconstructions. This has been shown for reworked palynomorphs in the Lower Devonian of Belgium by Ph. Steemans (paper presented by Ph. Gerrienne), and for miospore distribution near the Devonian-Carboniferous boundary in Belgium and the Federal Republic of Germany by M. Streel. However, these data only get their special supporting value within a broader context. These are meaningless without it.

Summarizing the above experience we must conclude that the presented evidence has not yielded the badly needed tools for palinspastic reconstructions. The various approaches may help in understanding the structural-sedimentary setting or support the assessment of relative paleogeographic distances. However, these only have a meaning in a broader context. Their interpretation is frequently ambiguous and the figures never give absolute information on the original distance to, for example, a source or a shoreline.