Annales de la Société Géologique de Belgique, T. 112 (fascicule 1) - 1989, pp. 171-176 Août 1989

COMPARED SEDIMENTOLOGY IN THE UPPER CARBONIFEROUS OF THE INDE- AND WURM-SYNCLINORIUM, W-GERMANY[1]

by

Bernd STEINGROBE & Adolphe MULLER[2]

(6 figures)

RESUME.- Environ 600 échantillons de sédiments du Carbonifère supérieur appartenant au district minier d'Aachen ont été analysés granulométriquement et utilisés pour une analyse factorielle. De cette manière, quatre groupes de sédiments ont été séparés et convertis en unités de faciès avec l'appoint de donnés bio-, litho- et stratofaciétales. Les séquences sédimentaires sont analysées à l'aide de chaînes de Markov. Les unités de faciès et les séquences conduisent à déterminer un environnement de dépôt deltaïque. Pendant le Namurien, la sédimentation est intervenue surtout sur une plaine deltaïque basse. La succession sédimentaire du Westphalien est dominée par des sédiments formés sur une plaine deltaïque haute.

ABSTRACT.- Nearly 600 samples of Upper Carboniferous sediments of the Aachen coal district were analysed granulometrically and used as input for a factor analysis. Thereby four groups of sediments were separated and converted in combination with bio- litho- and stratofaciel observations into facies units. The sedimentary sequences were analysed by using Markov chains. The facies units and the sequences lead to a deltaic depositional environment. During the Namurian, sedimentation mainly happened on the lower delta plain. The sedimentary succession in the Westphalian is dominated by sediments which were formed on the upper delta plain.

INTRODUCTION

Early geological studies within the Upper Carboniferous strata of the Aachen coal district had been carried out by Hahne (1931, 1936, 1942, 1947). The stratigraphical work of Hartung (1966), already carried out in the 40th, is of additional importance. Herbst (1962, 1967) published two maps of the surface of the Carboniferous. The early map concerns the Inde- the later one the Wurm-Synclinorium.

A first attempt for a sedimentological interpretation of the strata by the help of a facies concept was carried out in a Ph. D. thesis by Janda (1966).

Modern works concerning stratigraphy and tectonics within the Aachen coal district were done by Zeller (1985a, b) and Wrede (1985, 1987). A first try to create a basin model for the Aachen coal district was carried out by Steingrobe & Muller (1985).

GENERAL ASPECTS AND GEOLOGICAL SETTING

Within the Aachen coal district two synclinoria, the northern Wurm-Synclinorium and the southern Inde-Synclinorium, separated by the Aachen anticline, bear productive coal measures (fig. 1). Because of the relativ nearer position to the hercynian front the sediments within the Inde-Synclinorium are more proximal than in the Wurm-Synclinorium.

In the Inde-Synclinorium Upper Carboniferous sediments, reaching from Namurian A up to the upper part of the Westphanian A are preserved

1. Paper presented on November 27th, 1987 (Aachen-Liège Universities exchange days in Aachen), manuscript received in June 1988.

2. Lehr- und Forschungsgebiet Allgemeine und Historische Geologie der RWTH Aachen, Wüllnerstr. 2, D-5100 Aachen (R.F.A.).

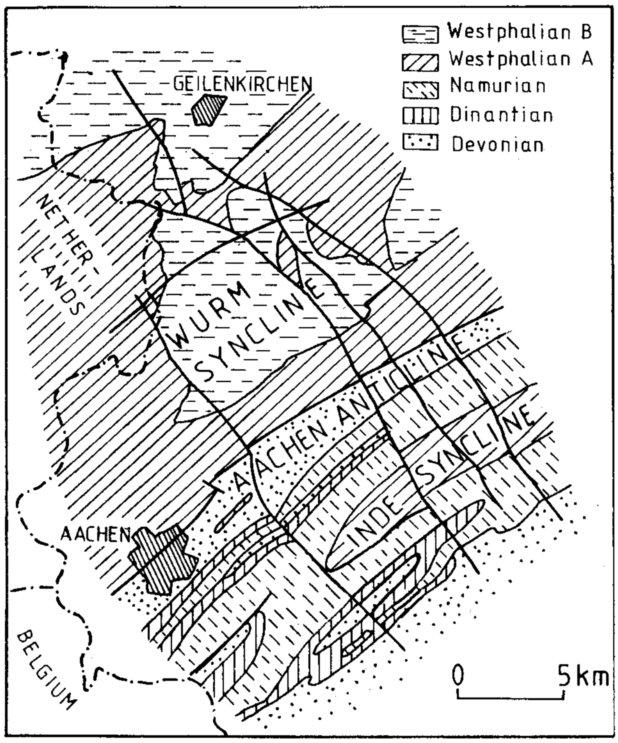

Fig. 1.- The Aachen coal district - simplified geologic overview (after Herbst, 1971)

(fig. 2). The early Namurian sediments appear directly above a paleocarst surface of the Lower Carboniferous Limestone (Steingrobe, 1987).

Within the Wurm-Synclinorium sediments of Namurian A and B age were never observed either in outcrops or boreholes. Namurian C is only known from one outcrop and appears in some old borings. The Westphalian is well known from outcrops in the Wurm-valley and from underground mining. The top of the Upper Carboniferous succession of the Wurm-Synclinorium lies within the middle part of the Westphalian B (fig. 2). Additional information for the Westphalian A derive from the boreholes Puffendorf 5 and Loverich 3, which were drilled in Eschweiler Bergwerks-Verein but recorded for the sedimentologic research in 1987.

The common stratigraphic part of the Inde- and Wurm-Synclinorium ranges from Namurian C to Westphalian A. This part of the Westphalian strata is badly exposed in the Inde-Synclinorium, therefore the borehole Frenzer Staffel 1 (1985) was drilled in the Inde-Synclinorium to analyse the common stratigraphic part. For the sedimentologic research stratofacies observations and sequence analysis of the strata were intensively carried out in outcrops as well as in drillings. Important information was brought in by the analysis of the granulometric composition and the clay mineral association of the sediments.

The results of the sedimentologic investigations are combined to a basin model which should yield general information for coal bearing basins.

CLASSIFICATION OF SEDIMENTS BY FACTOR ANALYSIS

The granulometric composition of about 600 Upper Carboniferous samples were used as input for a factor analysis. These sediments derive mostly from the Aachen coal region (520 samples), but also from the Erkelenz coal region, from the french Cevennes and the Western Alps. Within this analysis the Upper Carboniferous sediments are explained by four factors with a cumulative variance of 92 %. In factor analysis it is not expected that a great number of samples may be characterized by a factor loading of 100 % and are thus identic with the factors itself. These samples constitute basic lithologies.

The grain-size distribution curves of sediments with a factor loading higher than 85 % and with a communality exceeding 90 %, form four more or less distinct bundles (fig. 3) around the basic lithologies and form statistically defined sediment-groups. It is possible to enlarge these four sediment-groups by appending sediments of similar grain-size distributions.

The most finegrained sediment-group No. 1 consists of very fine siltstones and claystones. Grains smaller than 5,5 μm build up this samples by 55 to 75 %. The sorting of these sediments is absolutely bad. This group explains the whole population by about 47 %.

The mean grain size of sediment-group No. 2 is about 45 μm. The fine-grained suspension populations of the sediments are badly sorted, the saltation population well sorted. Within the coarse population the grains show remarkable secondary distributions. The totality of the analysed samples are explained by this group by about 21 %.

The sediment-group No. 3 with a mean grain size between 70 and 100 μm is represented by very fine sandstones. The grain-size distribution curves do not show any remarkable truncation points. Group No. 3 explains the total population by nearly 15 %.

The mean grain-size for sediment-group No. 4 ranges between 220 and 250 μm, i.e. within the fine sands. The grain-size distribution curves of this group bear great resemblance to group No. 3. But the grain-size distributions of group No. 4 are not as well sorted as those of the group No. 3. The total population is explained by this group by 9 %.

By this factor analysis 8 % of the analysed samples are not sufficient approximated. Conglo-

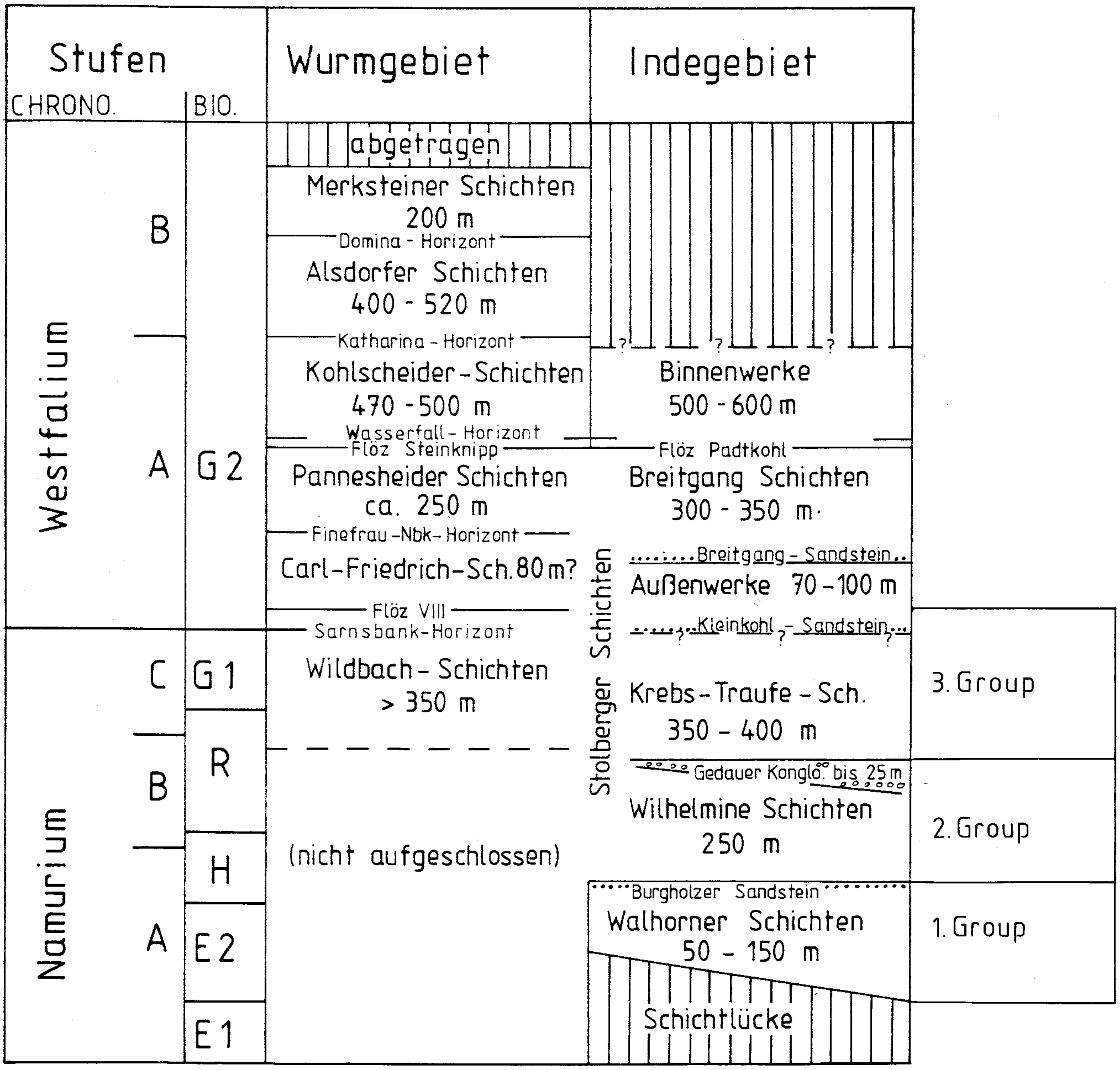

Fig. 2.- Stratigraphic subdivision of the Upper Carboniferous in the Aachen region

merates, for instance, are amoung these samples. As it is not meanful to analyse coals granulometrically, coals never appear in the factor analysis.

An interpretation of the granulometric data together with the stratofaciel, floristic and faunistic information converts the sediment-group into facies units. The granulometric interpretation of sediments belonging to the sediment-group No. 1, reveals that there are at least two different patterns. On one hand there are very fine silt- and claystones (samples 81.0401, 81.1025). Their comprehensive interpretation including faunistic and floristic observations permits the distinction of deposits of a lagoonal -, swamp -marsh -, flood plain - or clayey marine environments. On the other hand there are sediments with a very wide range in grain distribution normally up to 350 μm (sample 81.0442). The grain-population smaller than 5,5 μm reaches 55 %. This sediments are interpreted as slumpings, possibly near collapsing channel margins.

Sediments belonging to the sediment-group No. 2 show distinct truncations within their grain-size distributions. The absolutely bad sorted suspension population reaches up to 44 μm. The well sorted saltation population ranges from 44 to 63 μm in grain-size and represents about 45 % of the sediment. Sometimes up to 9 % of the coarse part of the sediment is remarkably secondary distributed. The grain-size distribution within this traction population ranges widely between 63 and 353 μm. This reflects partly low energetic condi-

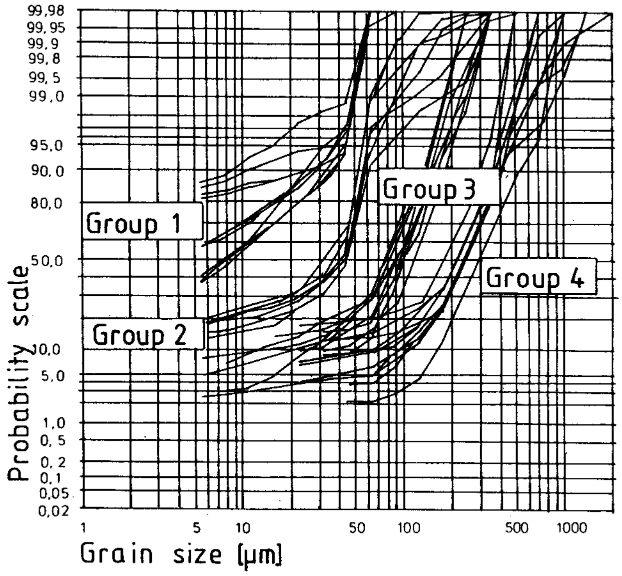

Fig. 3.- Grain size distribution curves of sediments with a factor loading of 85 % and a community of 90 %

tions during the deposition of these sediments. They are interpreted as mouth bar deposits.

The sediment-groups No. 3 and No. 4 are very similar as their grain-size distribution curves show a shovel-like shape without any significant truncation points. The mean grain-size for group No. 3 is about 100µm; for group No. 4 it is about 250µm. They are interpeted as fluvial channel deposits. The range of the mean grain-size reflects different energetic conditions and/or different size of channel sections.

The quoted facies characterization does not, in a statistical relevant manner, include coarse fluvial sandstones or conglomerates and coastal sandstones known from the field interpretation.

The grain-size distributions of samples deriving from the study areas Erkelenz, Cevennes or Western Alps are very similar to those of the Aachen Region. So it is thought, that the sediments might be deposited under similar conditions and in similar environments.

MARKOV CHAIN SUPPORTED ANALYSIS OF SEQUENCE

By using the method of Markov chains it is possible to define sequences in a statistical way. In general there are two different ways to carry out these investigations. The first method of constructing transition matrices uses fixed vertical intervals for recording. An important consideration here is the magnitude of the interval. If the matrix is based on fixed vertical intervals, the succession of lithologies and the thickness of each occurrence can be simulated. For the Upper Carboniferous a variety of magnitudes were

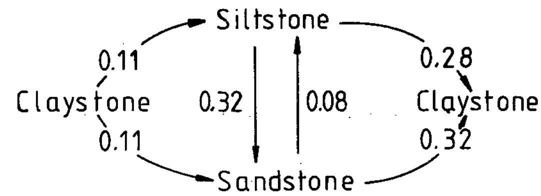

Fig. 4.- The array diagram for the sedimentary sequences of the first Namurian Group

tested. The best results were provided with a 20 cm vertical interval.

This interval methods was used to describe the sequences within 16 Namurian sections. The first group of the Namurian (fig. 2) is in general very fine grained, in particular at its base. Therefore only three lithologies clay-, silt- and sandstone were used as input in this basal group. The sections of the first stratigraphic group provided 360 observations points.

The transition probability matrix for this analysis shows a general coarsening up trend (fig. 4).

With a probability of 0.11 claystones are followed by siltstones. The top of the sequences are marked by sandstones. The transition from siltstone to sandstone is given with 0.32. Sometimes direct transitions from claystone to sandstone (0.11) occur. These sandstones always show an erosiv contact to the layers beneath and can be interpreted as channel sands.

The coarsening up trend may in some cases be restricted to the transition claystone to siltstone (0.11).

All these coarsening up sequences are rhythmical, because sandstones are overlain by claystones with a high probability of (0.32) and siltstones by claystones with a probability of (0.28).

In general the sedimentary sequences within the second and third group of the Namurian developes similarly to the sequences noted in the first group of the Namurian. In fact these sequences are more complex because the lithologies coal and conglomerates do appear in the successions.

The array diagram (fig. 5) shows the transition probabilities for the sequences of the second Namurian group containing coal seams.

In this case two developments are visible (fig. 5). On one hand the seams were formed directly at the top of the coarsening-up sequence claystone - siltstone - sandstone. On the other hand seams occur within claystones. These coal-bearing claystones often appear directly above the coarsening-up sequence.

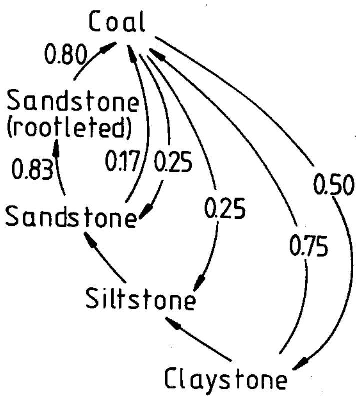

Fig. 5.- The array diagram for the sedimentary sequence of the second Namurian Group

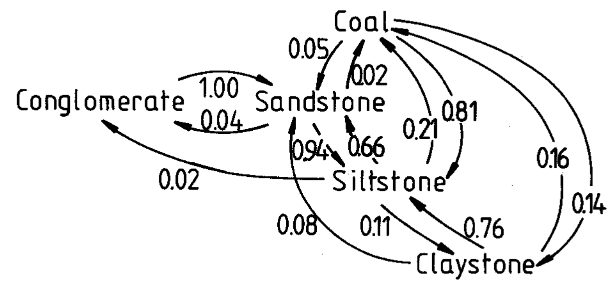

Fig. 6.- The array diagram for the coal-bearing sequences in the borehole «Frenzer Staffel 1» (1985)

The second way to carry out the Markov chain investigations is the lithology method. The probability matrix derives from transitions from one lithology to its successor. This was done for the sequences which contain coal seams within the Westphalian A research borehole «Frenzer Staffel 1 (1985)». Within the borehole it was possible to check the sequential situation for 22 seams (fig. 6). Only one seam, at a drilling depth of 219 m, had been found on the top-sandstone of a coarsening-up sequence. Within all other cases the seams occur at the top of fining upward sequences. Medium siltstone occurs beneath the coals 19 times, while very fine siltstone appears twice beneath the seams.

This analysis pointed out a remarkable difference to the coal-bearing sequences within the Namurian strata, where in most cases the Namurian seams occur above rootleted sandstones at the top of coarsening up sequences.

GENETIC INTERPRETATION OF THE INVESTIGATIONS

In the Namurian strata flood plain sediments predominate. The marine bands at the base of each Namurian group reveal the relative close connection with a marine environment, situated to the north. Numerous outcrops show large coarsening up trends, sometimes reaching up to a conglomeratic facies for instance the Burgholz Sandstone Facies at the top of the lowest stratigraphic group of the Namurian, or the Gedau Conglomerate Facies, at the top of the second Namurian group. It is thought, that for each of the three groups one deltaic progradation took place.

The marine influences at the base of the Namurian groups are most likely for the lower delta plain.

In the Westphalian marine sediments are largely missing. The sedimentation now mainly took place on the upper flood plain, the interdistributary area, in marsh, swamp and within the distributary channels. For these environments an upper delta plain is postulated.

The investigations reveal a general shift in sedimentation from the Namurian, were sediments of the lower delta plain are dominant, to the Westphalian were the sediments of the upper delta plain dominate the succession.

The sediments of the Inde- and Wurm-Synclinorium fit into one depositional model with coeval developments. In fact the sedimentologic investigations do not reveal information that there was a large distance between both synclinoria during the time of deposition.

BIBLIOGRAPHY

HAHNE, C., 1931. Die Stratigraphie der Walhorner und Stolberger Schichten des Indegebietes bei Aachen. *Jb. preuss. geol. L.A.*, Berlin, 51 759-804.

HAHNE, C., 1936. Die stratigraphische und fazielle Entwicklung der Alsdorfer und Merksteiner Schichten (Gas- und Gasflammkohlenschichten) und die Paläogeographie der Alsdorfer Scholle des Wurmkohlengebietes. *N. Jb. Mineral. Geol. Paläont.*, Stuttgart, Bd. 76 (B) : 192-323.

HAHNE, C., 1942. Das Aachener Gebiet. *Der deutsche Steinkohlenbergbau*, Essen, 1 : 193-226.

HAHNE, C., 1947. Namur und unteres Westfal A (Stolberger Schichten) im Wurmgebiet bei Aachen. *Bergb.-Arch.*

HARTUNG, W., 1966. Fossilführung und Stratigraphie im Aachener Steinkohlengebirge. *Fortschr. Geol. Rheinld. u. Westf.*, Krefeld, 13 (1): 339-564.

HERBST, G., 1962. Die Tektonik des flözführenden Oberkarbons in der Inde-Mulde (Aachener Revier), dargestellt an der Karbon-Oberfläche. *Fortschr. Geol. Rheinld. u. Westf.*, Krefeld, 3 (3) : 1159-1166.

HERBST, G., 1967. Die Tektonik des flözführenden Oberkarbons im Wurm-Revier (Aachener Steinkohlenbezirk), dargestellt an der Karbon-Oberfläche. *Fortschr. Geol. Rheinld. u. Westf.*, Krefeld, 13 (2) : 1345-1358.

HERBST, G., 1971. Stratigraphie und Tektonik. *In :* Die Karbon-Ablagerungen n der Bundesrepublik Deutschland. 2. Das Revier von Aachen-Erkelenz. *Fortschr. Geol. Rheinld. u. Westf.*, Krefeld, 19 : 61-68.

JANDA, J.W., 1966. Paläogeographische Untersuchungen im Aachen-Limburger Steinkohlenbezirk. Unveröff. Diss. RWTH-Aachen, Aachen.

STEINGROBE, B., 1987. Zum Sedimentationsbeginn des Oberkarbons im Aachener Revier. *Facies*, Erlangen, 17 : 231-236.

STEINGROBE, B. & MULLER, A., 1985. Sedimentology of Selected Upper Carboniferous Profiles from the Inde- and Wurm-Syncline (Aachen Coal District). *N. Jb. Geol. Paläont. Abh.*, 171 : 1

WREDE, V., 1985. Tiefentektonik des Aachen-Erkelenzer Steinkohlengebietes. *In :* Beiträge zur Tiefentektonik westdeutscher Steinkohlenlagerstätten; Krefeld : 9-103.

WREDE, V., 1987. Der Einfluss des Brabanter Massivs auf die Tektonik des Aachen-Erkelenzer Steinkohlengebietes. *N. Jb. Geol. Paläot. Mh.,* Stuttgart, 1987 : 177-192.

ZELLER, M., 1985a. Ein Versuch zur Flözgleichstellung im Oberkarbon (Westfal A) zwischen dem Inde-Revier und dem Wurm-Revier (Aachener Steinkohlengebiet). *Fortschr. Geol. Rheinld. u. Westf.,* Krefeld, 33 : 289-296.

ZELLER, M., 1985b. Vorschlag eines Richtschichtenschnittes für das flözführende Oberkarbon (Westfal A und B) des Aachen-Erkelenzer Steinkohlenreviers. *Fortschr. Geol. Rheinld. u. Westf.,* Krefeld, 33 : 265-287.