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PRECISION AND PRACTICABILITY : ON THE DEFINITION OF THE DEVONIAN-CARBONIFEROUS BOUNDARY

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(1 figure)

PRECISION AND PRACTICABILITY OF A STRATOTYPE

The main task of the Working Group on the Devonian-Carboniferous boundary is to propose an acceptable definition for the Devonian-Carboniferous boundary to the International Commission on Stratigraphy. An agreement on the biostratigraphic position of the boundary had been made by the Group in 1979 : the new operational definition placed it at the first appearance of the conodont *Siphonodella sulcata* within the evolutionary lineage from *Siphonodella praesulcata* to *Siphonodella sulcata;* this first appearance immediately precedes the entry of the goniatite *Gattendorfia* in the Hönnetal.

It was then necessary to find a stratotype that "best defines the age of the boundary which is its diagnostic character" (HEDBERG, 1976 : 83).

A golden spike is sufficient to mark a certain level in a section where the isochrone of the Devonian-Carboniferous boundary passes, indicating the end of the Devonian and the beginning of the Carboniferous. Nevertheless, biostratigraphic boundaries ". . . may serve as local guides to chronostratigraphic position" (HEDBERG, 1976 : 86). The Working Group members thought them to be indispensable as means for extending the Devonian-Carboniferous boundary from the stratotype to all sections concerned, in the marine and the non marine/continental facies, in consideration of the widespread superposition and interbedding of marine and continental sediments in uppermost Devonian and lowermost Carboniferous rocks.

Whereas chronostratigraphic boundaries are "inherently independent of all other kinds of stratigraphic boundaries" (HEDBERG, 1976 : 86), these latter depend on environmental influences. There should have been no climatic nor palaeogeographic hindrances for the fossils to appear, and there should have been a niche available.

It is difficult, if not impossible, to prove the completeness of a rock body (see below); even fossils taken out of an "evolutionary lineage" (which necessarily is a supposition) do not guarantee by themselves that the first appearance of a species really is the first or oldest representation of that group - particularly if the ancestor survives (which is the case in the *praesulcata* → *sulcata* lineage). In these conditions, a sedimentological investigation of a candidate stratotype seems recommendable if not indispensable. Biostratigraphic subdivision is only one of the characters to be studied in a section. The incoming and disappearance of fossils in rock bodies should be observed in the sedimentological context and in the palaeogeographic framework.

Boundary stratotypes should be within sequences of continuous deposition (HEDBERG, 1976 : 71). But it seems difficult to prove the completeness of a rock succession. In the first hand only rarely sedimentation rates can be measured in Palaeozoic rocks (centimeter thickness per time unit). The time necessary for the deposition of a certain rock sequence has been called "short" because the sediments belong to only one biozone defined by a rapidly developing fossil group (conodonts/spores). But another fossil group (spores/conodonts) permits the distinction of several biozones within the same rock sequence. The only conclusion to be drawn from this observation is that during a certain time interval, that corresponds to the sedimentation of a rock body, the biozones of one fossil group seem to be longer than the biozones of another fossil group. Different fossil groups will generally define different (shorter or longer) biostratigraphic units, and experience suggests that the duration of biozones defined by one fossil group may change in the course of time.

Hierarchic principles in regard to guide fossils ("ortho" and "para" biostratigraphic guide fossils) seem to depend somehow on the history of (bio-) stratigraphy. Every fossil group that permits a stratigraphic subdivision should and will be used. The group which permits the finest biostratigraphic subdivision of a rock body is the best for that time span, independent of its systematic position. Anyhow, biostratigraphic methods give information about the relative age of rocks, and they produce a relative time scale.

Secondly, the thickness of a rock succession is a relative measure for its completeness. Only if the lithology is exactly the same in two sections of the same age, a thicker succession means a completer one. But in any case by far most of the time gone is not represented by rocks. The Working Group demonstrated that at its first field trip in 1978 to relatively thin sections of the Devonian-Carboniferous boundary beds (on the NW European continent and SW England) and to about 100 times thicker rocks of the same age (in southern Ireland). Thick turbiditic rocks (in southern Ireland) have been deposited in a relatively short time. Overlying turbidites eroded and incorporated still plastic parts of underlying turbidites. Nevertheless, there seems no reasonable doubt possible, that the time of deposition of a turbidite was considerably shorter than the time intervals of non-deposition in between the sedimentation of consecutive turbidites.

Sharp boundaries of rock bodies to underlying and overlying sediments often seem to reflect interruptions of sedimentation and therefore more or less extensive gaps in the rock succession. This seems to be true in many cases : the abrupt change from prevailing siliciclastics to prevailing carbonates (or vice versa) may reflect a reorganization of the depositional and erosional areas which might have caused a shorter or longer time of non-sedimentation at the locality under consideration. But usually lithological characters alone cannot measure the time necessary for the sedimentation of a rock body nor indicate the time not represented by rocks. If a gap is shorter than a biozone, its relative duration may only be suggested by the observation of (lower and upper) boundaries of other biozones in the section (and the boundaries of these biozones used should be well known in the area).

Neither the thickness and lithology of a rock body, nor its subdivision by one or more biozones seem to permit the evaluation of the (numerical) time its formation needed. Both characters (thickness/lithology and number of subdividing biozones) belong to relative time scales.

DEVONIAN-CARBONIFEROUS BOUNDARY BEDS

Siphonodella praesulcata first occurs in the equivalent of the Wocklumer Kalk of the Rheinisches Schiefergebirge and may be present until and within the equivalent of the lower part of the Hangenberg Kalk of the same region, where it coexists with *S. sulcata*.

In the absence of a rock sequence with transitional specimens between these species which would designate the exact horizon where *S. praesulcata* "produces" *S. sulcata*, we have to rely on other criteria to trace this horizon.

SANDBERG & ZIEGLER (1984) explain that a "brief eustatic fall in sea level" occurred just before the first entry of *S. sulcata* and that the "short stratigraphic interval wherein the pelagic siphonodellid biofacies is interrupted" might be recognized by a shallower protognathodid biofacies, characterized by *Pr. kockeli* (the lower *Protognathodus* Fauna).

Here we are faced to several problems : did in fact the protognathodid biofacies result from an eustatic, say world-wide and synchronous, event and, if so, was it brief ?

We might as well consider that the first appearance of *P. kockeli* is just linked to the change of facies and cannot be used to demonstrate the simultaneousness. There is some circle argument here that we should try to avoid. The duration of this "shallower protognathodid biofacies" may only be brief because the limestone where conodonts are available is thin. It is always closely restricted to the uppermost portion of a more shaly or sandy sequence (the Hangenberg Schiefer and Sandstein in the Rheinisches Schiefergebirge). This shaly or sandy sequence seems to be devoid of conodonts. It might also represent a shallow facies interval and we know that this interval corresponds with at least the miospores of two zones which have been found in several hundred metres of sediment in the shelf facies of southern Ireland.

It must be supposed therefore that the first occurrence of *P. kockeli* (marking the base of the upper *praesulcata* Zone) as well as the first occurrence of *S. sulcata* correspond to facies changes. They are time markers only if these facies changes are world-wide events what they might well be, but how to demonstrate it ?

A way out of this calamity seems to observe the lowermost occurrence of *S. sulcata* in relation to independent criteria (not to other conodonts).

To use the first occurrence of *Acutimitoceras* does not seem to provide any alternative answer as most of the arguments about a possible link between the first entry of this group and the first availability of the limy facies would have to be repeated.

To avoid difficulties, we should use levels of fossil successions which are less linked to the critical "shallower to deeper" facies changes.

There are at short distance (time ?), on both sides of this facies change, biostratigraphical criteria which, if any, may be less dependent of facies control. They are offered, in the Rheinisches Schiefergebirge by the trilobite zonation (the *A. abruptirhachis/A. drewerensis* limit of BRAUCKMANN & HAHN, 1984) for the Hangenberg Kalk and by the miospore zonation (the LN/VI limit of HIGGS & STREEL, 1984) for the Hangenberg Schiefer.

The trilobites (and goniatites) may be used in this area for the recognition of the oldest *S. sulcata* available (fig. 1). The first *S. sulcata* are associated with *A. abruptirhachis* at Hasselbachtal, but with *A. drewerensis* at Müssenberg and Oberrödinghausen (LUPPOLD *et al.*, 1984). At Oese, the first *S. sulcata* might be still younger in terms of the available goniatites (Upper *subinvoluta* Zone after KULLMANN). *S. sulcata* has not been found at Stockum.

Obviously, the Hasselbachtal section possesses the more complete record of (the oldest) *S. sulcata* on the Hangenberg Kalk side. Parts of the basal limestone are obviously lacking (eroded ?) at Oese and Oberrödinghausen (see also VAN STEENWINKEL, 1984).

The "distance" between the *abruptirhachis/drewerensis* limit and the LN/VI limit is longest at Stockum, slightly shorter at Hasselbachtal, unknown in the sections Oberrödinghausen and Müssenberg where there are arguments however that parts of or nearly all the shales are lacking. Indeed, ostracodes (BLESS & GROOS-UFFENORDE, 1984) and cephalopods suggest that the top of the Wocklumer Kalk has the same age at Müssenberg, Oberrödinghausen, Oese and Hasselbachtal. There is no argument to suggest that the Hangenberg Schiefer and Sandstein of Hasselbachtal, Oese or Oberrödinghausen might have their time equivalent in a limy facies at Müssenberg (see KORN 1982). Hangenberg Schiefer and Sandstein which are several metres thick in these sections might well be lacking or condensed to the 5 cms of shales present at Müssenberg between bed 3 and bed 4. In addition, the miospore assemblage (LL Biozone) found in most of the Hangenberg Schiefer at Oberrödinghausen is obviously older than the miospore assemblage (LN Biozone) in the upper portion of the Hangenberg Schiefer at Oese and Hasselbachtal. Therefore we have to deduce that the shaly interval is more and more reduced from Oese, through Oberrödinghausen, to Müssenberg.

There are no conodont arguments available in this interval, the so called "middle *praesulcata* Subzone" corresponding to the interval between the top of *Palmatolepis gracilis gonioclymeniae* (here in the Wocklumer Kalk) and the first occurrence of *Protognathodus kockeli* (ZIEGLER & SANDBERG, 1983).

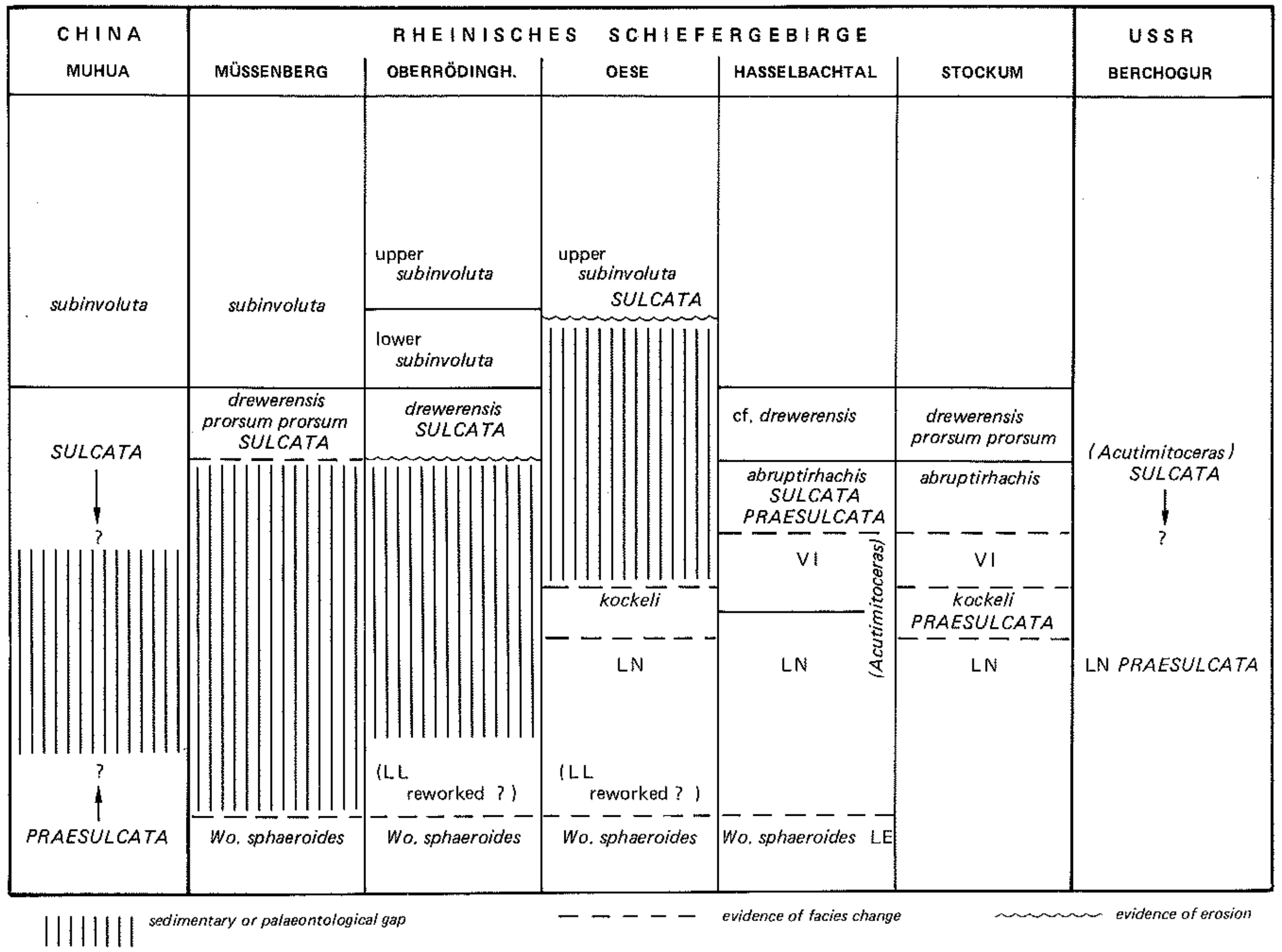

Fig. 1. Comparison at the Devonian-Carboniferous boundary between several sections of the Rheinisches Schiefergebirge and the sections of Muhua in China and Berchogur in USSR.

If we add the data obtained from the Hangenberg Kalk to those obtained from the Hangenberg Schiefer, the Hasselbachtal section is undoubtly the most complete/the less uncomplete among those containing *S. sulcata* (BECKER *et al.,* 1984). Stockum might be more complete but lacks *S. sulcata* and also displays some evidence of reworking processes in the critical levels.

On fig. 1 the sections of the Rheinisches Schiefergebirge are compared to the Muhua (China) (HOU HON-FEI *et al.,* 1984) and Berchogur (USSR) (BARSKOV *et al.,* 1984) sections.

In term of conodonts, the Muhua section shows many of the characteristics of Müssenberg. In Muhua, the most recent conodont level of the *praesulcata* Zone might well be not younger that the lower *praesulcata* Subzone. The first *S. sulcata* is found a few decimeters below *G. subinvoluta,* a situation also very similar to Müssenberg. The Muhua section is however much less documented than the latter as far as accompanying fauna is concerned.

The Berchogur section is very similar to the Stockum section but has *S. sulcata* which first occurs with an *Acutimitoceras* fauna very similar to that of the "Stockum *Imitoceras* lenses". Some 130 centimetres below, *S. praesulcata* has been found at nearly the same level as a miospore assemblage equivalent to the upper LN Biozone in the Rheinisches Schiefergebirge. The critical interval (top of LN/base of *drewerensis*) is however less well documented that at Stockum, which unfortunately has anyway no *S. sulcata.*

REFERENCES

BARSKOV, I.S., SIMAKOV, K.V., ALEKSEEV, A.S., BOGOSLOVSKY, B.I., BYVSHEVA, T.V., GAGIEV, M.H., KONONOVA, L.N., KOCHETKOVA, N.H., KUSINA, L.F. & REITLINGER, E.A. (1984) : Devonian-Carboniferous transitional deposits of the Berchogur Section, Mugodzary, USSR (Preliminary report). - - Cour. Forsch.-Inst. Senckenberg,

BECKER, T., BLESS, M.J.M., BRAUCKMANN, C., FRIMAN, L., HIGGS, K., KEUPP, H., KORN, D., LANGER, W., PAPROTH, E., RACHEBOEUF, P., STOPPEL, D., STREEL, M. & ZAKOWA, H. (1984) : Hasselbachtal, the section best displaying the Devonian-Carboniferous boundary beds in the Rhenish Massif (Rheinisches Schiefergebirge). - - Cour. Forsch.-Inst. Senckenberg,

BLESS, M.J.M. & GROOS-UFFENORDE, H. (1984) : The Ostracodes at the Devonian-Carboniferous boundary. - - Cour. Forsch.-Inst. Senckenberg.

BRAUCKMANN, C. & HAHN, G. (1984) : Trilobites as index fossils at the Devonian-Carboniferous boundary. - - Cour. Forsch.-Inst. Senckenberg,

HEDBERG, H.D. (Ed.) (1976) : International Stratigraphic Guide. A guide to stratigraphic classification, terminology and procedure. - - John WILEY & Sons, New York : 179 p.

HIGGS, K. & STREEL, M. (1984) : Spore stratigraphy at the Devonian-Carboniferous boundary in the northern "Rheinisches Schiefergebirge", Germany. - - Cour. Forsch.-Inst. Senckenberg,

HOU HONG-FEI, JI QIANG, XIONG JIAN-FEI & WU XIANG-HE (1984) : A possible stratotype of Devonian-Carboniferous boundary in Guizhou province, South China. - - Cour. Forsch.-Inst. Senckenberg,

KORN, D. (1984) : Die Goniatiten der Stockumer *Imitoceras*-Kalklinsen (*Ammonoidea;* Devon/Karbon-Grenze). - - Cour. Forsch.-Inst. Senckenberg,

LUPPOLD, F.W., HAHN, G. & KORN, D. (1984) : Trilobiten-, Ammonoideen- und Conodonten-Stratigraphie des Devon/Karbon-Grenzprofiles auf dem Müssenberg (Rheinisches Schiefergebirge). - - Cour. Forsch.-Inst. Senckenberg,

SANDBERG, C.A. & ZIEGLER, W. (1984) : Narrowing of worldwide search for conodont-based Devonian-Carboniferous boundary stratotype. - - The Geological Society of America 1984 meeting : abstract n° 43888.

VAN STEENWINKEL, M. (1984) : Sedimentology of the Devonian-Carboniferous boundary sediments in the Oberrödinghausen 1 borehole (Germany). - - Cour. Forsch.-Inst. Senckenberg,

ZIEGLER, W. & SANDBERG, C.A. (1983) : *Palmatolepis*-based revision of upper part of standard late Devonian Conodont zonation. - - The Geological Society of America 1983 meeting : abstract n° 26932.

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ABSTRACT

The requirements for the definition of a chronostratigraphic boundary and the identification of its biostratigraphical characters are recalled and the difficulty to prove the completeness of a rock body, emphasized.

The oldest occurrence of *Siphonodella sulcata* is evaluated in different sections from the "Rheinisches Schiefergebirge", China and USSR.