



Stages of the Devonian System

by W. Ziegler and G. Klapper

The Subcommittee on Devonian Stratigraphy has formally agreed upon the nomenclature for seven Standard Stages of the Devonian System. A basal boundary stratotype is described in this article for the Eifelian Stage, coincident with the base of the Middle Devonian Series. Criteria for recognizing a Givetian-Frasnian Stage boundary (= base of Upper Devonian Series) and a Frasnian-Famennian Stage boundary are also outlined. Future work will complete the definition of basal boundary stratotypes for each Stage.

Introduction

Annual meetings of the Subcommittee on Devonian Stratigraphy (SDS) have been held since its foundation in 1973, with important decisions summarized here on stratigraphic standards being made in 1979, 1981, 1982 and 1983; these have now been formally ratified by IUGS. Each of these meetings, associated with field excursions to the Devonian of many countries, stimulated a wealth of Devonian research throughout the world. An earlier account in Episodes (Ziegler and Klapper, 1982) summarized the SDS decisions then taken; certain diagrams in that paper are repeated here so as to make this account self-contained.

Devonian Stage Names

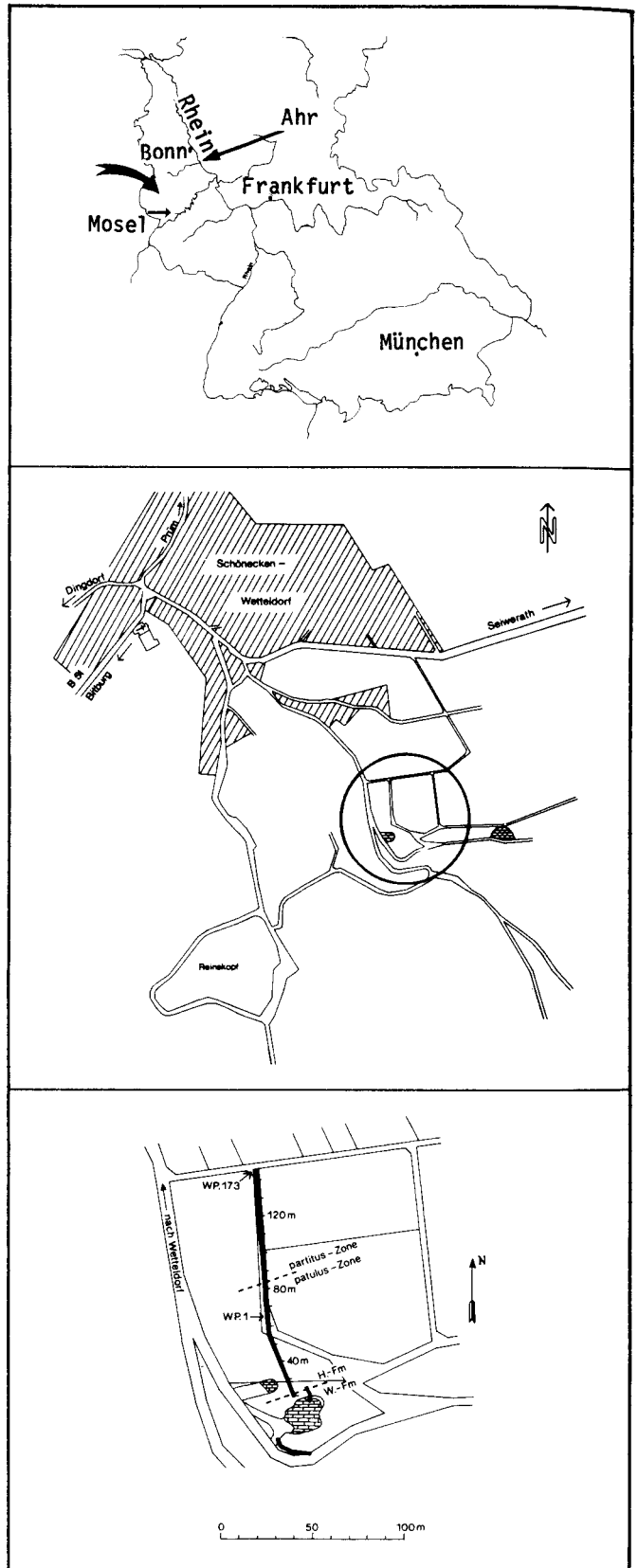
The agreed Stage names of the Devonian System (see accompanying article by Bassett) are as follows:

- Upper Devonian - Famennian
- Frasnian
- Middle Devonian - Givetian
- Eifelian
- Lower Devonian - Emsian
- Pragian
- Lochkovian

With the exception of the lower limit of the Lochkovian Stage, which coincides with the lower boundary of the Devonian System (McLaren, 1973), all the Lower Devonian stages still await new boundary definitions. The decision on the nomenclature of the Devonian stages also contains the statement that the classic areas of the Lower Devonian in the Ardenno-Rhenish Region (Belgium - West Germany) are no longer acceptable as satisfactory for Lower Devonian stage boundaries. Decisions on the lower levels of the Pragian and Emsian stages will be based on different regions in the next few years.

The decision on the Lower-Middle Devonian Series boundary (see below) also emphasizes the fact that Eifelian is the name of the first Middle Devonian stage. The lower level of the Givetian Stage needs further studies prior to its formal definition.

Figure 1: Locality maps of the site of the boundary stratotype of the partitus-boundary at the Wetteldorf Richtschnitt, Eifel Hills, F.R.G. Bottom section shows site of old trenches (= solid black line) and 1982 trench (= parallel line with hatches at both ends); WP 1-173 = measured units; dashed oblique line between patulus Zone and partitus Zone = Lower-Middle Devonian Series Boundary. H.-Fm. = Heisdorf Formation, W.-Fm. = Wetteldorf Formation.



The lower limit of the Upper Devonian Series coincides with the lower limit of the Frasnian Stage; the definition of chronostratigraphic level is discussed in the following. The lower limit of the second Upper Devonian Stage, the Famennian Stage is also newly defined.

LOWER-MIDDLE DEVONIAN SERIES BOUNDARY

Definition

The boundary between the Lower and Middle Devonian Series is coincident with the lower boundary of the Eifelian Stage. The exact boundary level is chosen to coincide with the first occurrence of the conodont *Polygnathus costatus partitus* Klapper, Ziegler and Mashkova, 1978 (= *partitus* boundary). This stratigraphic level is the lower limit of the *partitus* Zone, a zonal subdivision of the conodont standard zonation that was established during the 1970s (Klapper, 1971; Weddige and Ziegler, 1977; Weddige, 1977; Weddige et al., 1979; Klapper et al., 1978; Klapper and Ziegler, 1979).

Boundary Stratotype

The holostatotype of the *partitus* boundary is in the section exposed in the Wetteldorf Richtschnitt, near the town of Schönecken-Wetteldorf, Eifel Hills, Federal Republic of

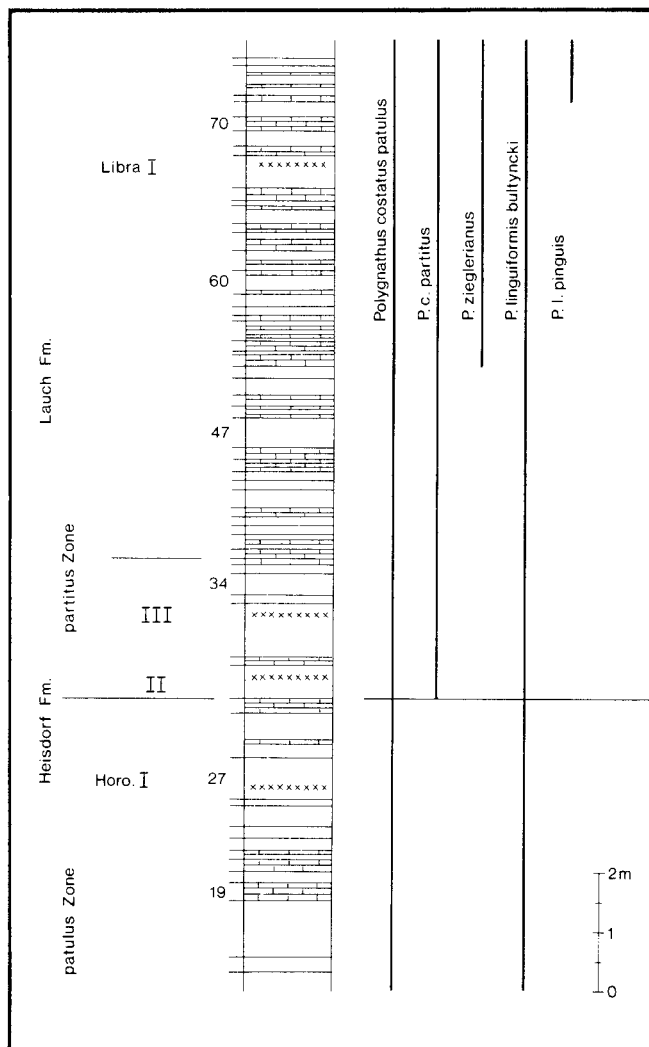


Figure 2: Columnar section of basal Middle Devonian boundary stratotype, at the base of measured unit WP 30 in the Wetteldorf trench. The section is composed of limestones, bentonites (Horologium I, II, III and Libra I - xxx) and siltstones and marls (white portions).

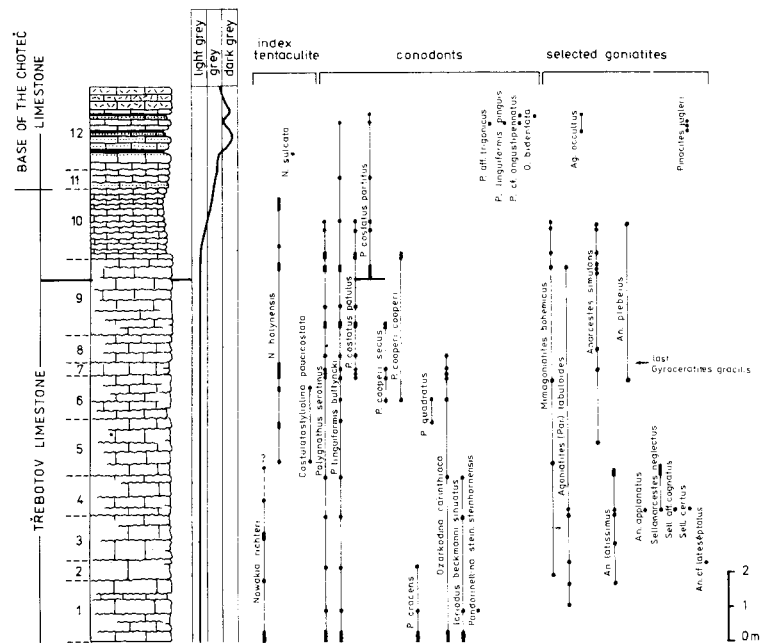


Figure 3: Parastratotype columnar section of Lower-Middle Devonian Series Boundary, at Prastav quarry, near Prague, Czechoslovakia. Numbered intervals are beds.

Germany (Schönecken mapsheet 1:25000, r 33 765 h 57 130; see Fig. 1). The Richtschnitt section is in a trench that was first dug in 1937 (R. Richter, 1942; G. Solle, 1942) following an international conference held in Düsseldorf on the Lower-Middle Devonian Series boundary. The boundary between the Heisdorf Formation and the Lauch Formation, regarded as the classic boundary between the Emsian and Eifelian of long-standing German usage, was established in this reference section.

For renewed discussions on the Emsian-Eifelian boundary, the trench was reopened in the early 1970s, and to enable study by the SDS it was widened and entrenched more deeply in 1982 (Werner and Ziegler, in Ziegler and Werner, 1982; see Fig. 3 of Ziegler and Klapper, 1982).

The boundary section is exposed for a length of 45 m across the strike of beds in the nearly N-S trench (Fig. 1), situated about 650 m SE of the Wetteldorf church. The area is pasture land that cannot be overbuilt by city expansion, and the Senckenberg Research Institute has rented the area of the trench (about 1000 m²) from the community for 60 years. The whole area is fenced off in order to prevent uncontrolled access and intermittent destruction of the section, and there is full access for scientific researchers. The exposed beds are part of the southern limb of the Prüm synclinal structure; the dip is to the NNW at 75°.

A parastratotype section for the *partitus* boundary has also been established. This is located at Prastav quarry, near Prague, Czechoslovakia about 300 m east of the railway station Praha - Holyně, and about 400 m north of the city bus terminal "Holyně" (Chlupáč, in Ziegler and Werner, 1982).

Lithostratigraphy of the Stratotype and Reference Sections

Holostratotype: The 1982 trench exposes, as did the earlier ones, beds of the neritic Upper Heisdorf Formation and the Lower Lauch Formation (lower part of Wolfenbach Member). It contains sample stations WP. 1 to WP. 90 of the 1971 trench. The Lower-Middle Devonian Series boundary (*partitus* boundary) section lies at 21.25 m of the exposed section (see Figs. 1, 2).

The Upper Heisdorf Formation comprises grey and green mudstones and siltstones with little carbonate content and a few argillaceous limestone beds or calcareous sandstones. Toward the top there is a distinct increase of regularly interbedded carbonate beds.

slightly above the *partitus* boundary. This faunal change is recognizable from North Africa through Europe to Central Asia and China, and analogues of this change are also recognizable in eastern North America (Werner and Ziegler, in Ziegler and Werner, 1982).

Comment

In addition to the *partitus* boundary, three other levels were originally considered. The first was the lower boundary of the *patulus* Zone defined on the entry of *P. costatus patulus*. This level approximates to the base of the Couvinian Stage, long used for the base of the Middle Devonian of the Ardennes.

A second candidate was the lower boundary of the *costatus costatus* Zone defined on the entry of *P. c. costatus*. This coincides closely with the base of the Chotec Limestone in the Barrandian area. The third alternative was the lower boundary of the *dehiscens* Zone defined on the entry of *P. dehiscens* Phillip and Jackson. This approximates to a level (the base of the *Favosites regularissimus* Zone) used for many years as the base of the Middle Devonian in the Soviet Union.

Prior to the formation of the Subcommittee in 1973, the question of the Lower-Middle Devonian boundary was seen in a new light by the publication of Carls and others (1972) in which a number of new and provocative correlations were postulated.



Figure 7: SDS members examining Middle-Upper Devonian limestones on Bou Tschrafine Ridge, near Erford, Morocco. These and other Moroccan sections have played a significant role in the clarification of stratigraphical, palaeontological, facies, and palaeogeographical problems of the Middle-Upper Devonian.

Conodont Zonation		Ammonoid Faunas
asymmetricus Zone	Upper Zone	<i>Manticoceras auratum</i> Belgium, W-Germany ?
	Middle Zone	
	Lower Zone	
	Lowermost Zone	
disparilis Zone	Upper	<i>Denticeras pernai</i> Morocco, W-Germany
	Lower	
Bermannia-variata Zone	Upper Subzone	multilobate <i>Phacoceras</i> Morocco
	Lower Subzone	
varcos Zone	Upper Subzone	<i>Phacoceras amplexum</i> (New York, Morocco) <i>Manticoceras cerebratum</i> (Morocco, W-Germany)
	Middle Subzone	

Figure 6: Diagram showing conodont zones and related positions of ammonoid faunas across the the Middle-Upper Devonian Boundary. After Ziegler and Klapper (in Ziegler and Werner, 1982). The *disparilis* Zone is divided informally into lower and upper parts.

The fact that there were four competing levels for the series boundary stimulated a great amount of research over a period of eight years. This included especially research on conodonts and conodont zonation (e.g. Weddige, 1977; Klapper et al., 1978), on dacryoconarids (e.g. Lotke, 1974, 1979; Lukeš, 1977; Alberti, in Ziegler and Werner, 1982), and goniatites (e.g. Chlupáč and Turek, 1983). After much discussion and deliberation, the *partitus* boundary gained a clear majority vote over the other levels.

MIDDLE-UPPER DEVONIAN SERIES BOUNDARY

Definition

The boundary between the Middle and Upper Devonian Series is coincident with the lower boundary of the Frasnian Stage. The exact level is chosen to coincide with the lower boundary

of the Lower *asymmetricus* conodont Zone, defined by the first occurrence of *Ancyrodella rotundiloba* (Bryant) and referred to as the Lower *asymmetricus* Boundary. The Lower *asymmetricus* Zone is a subdivision of the conodont standard zonation that was established in the early 1960s (Ziegler, 1962) and revised in the early 1970s (Ziegler, 1971).

Criteria for Correlation

Ancyrodella rotundiloba is an easily recognizable species that is part of a well documented phylogeny. Its predecessor species is *Ancyrodella binodosa* Uyeno, 1967, and transitional forms between *A. binodosa* and *A. rotundiloba* have been illustrated by Bultynck and Jacobs (1981). *A. rotundiloba* was the rootstock of later species of *Ancyrodella* within the Lower *asymmetricus* Zone: *A. alata* Glenister and Klapper, 1966; *A. pramosica* Perri and Spalletta, 1981; *A. rugosa* Branson and Mehl, 1934; and *A. africana* Garcia-Lopez, 1981. All of these permit additional means of identification of the Lower *asymmetricus* Zone. A detailed description of the evolution of the early *Ancyrodella* species is given by Klapper (1985). *A. rotundiloba* is a widespread taxon ecologically, occurring widely in both neritic and pelagic facies, and the species is well known from all relevant Devonian areas.

The following goniatite genera also have their first occurrences within the Lower *asymmetricus* Zone: *Koenenites* (in the sense used by M.R. House and W.T. Kirchgasser), *Probeloceras*, and *Manticoceras*.

Comment

An historic level for the series boundary (and the lower limit of the Frasnian) coincides with the base of the Assise de Frasnies in the Ardennes (Sartenaer, in Errera et al., 1972). This level is only slightly below the lower limit of the Lower *asymmetricus* Zone.

Two other biostratigraphic levels were also considered from time to time for the Middle-Upper Devonian series Boundary. The first was marked by the entry of the *Phacoceras amplexum* fauna, which coincides with the entry of *Ozarkodina semialternans* (Wirth) in the uppermost Middle *varcos* Subzone. This biostratigraphic level was strongly favoured by a few Devonian stratigraphers because of its coincidence with one of the historic levels for the base of the Upper Devonian (House, in Ziegler and Werner, 1982).

House argued that this coincides with the entry of the *Phacoceras amplexum* fauna (Fig. 6) within the Tully Limestone of New York, and further that this fauna was inter-

preted as part of the lunulicosta Zone, long regarded by ammonoid specialists as denoting the base of the Upper Devonian. A counter-argument (Zeigler, in Ziegler and Werner, 1982) is that the amplexum fauna is distinctly older, according to the conodont zonation, than the lunulicosta Zone in its original scope. The latter has a stratigraphic range through six, and possibly a seventh, conodont zonal or subzonal divisions and therefore is not sufficiently precise for definition of the Stage and Series boundary. Furthermore, Pharciceras is unknown in the Assise de Fromennes and P. amplexum is known only in New York and Morocco (Figs. 7, 8 and 9).

The second level considered was the lower limit of the disparilis Zone, defined on the entry of Palmatolepis disparilis Ziegler and Klapper, 1976. The goniatite fauna characterized by the earliest occurrence of Ponticeras (P. kayseri, P. pernai pernai, P. pernai appanata (see Ziegler and Klapper, in Ziegler and Werner, 1982) occurs within the disparilis Zone.

The first vote of SDS in 1981 was divided between the disparilis and Lower asymmetricus boundaries, and effectively eliminated the Pharciceras amplexum level from further consideration. In the first vote in the 1982 meeting, five titular members voted for the disparilis Zone and five against. Subsequently seven titular members voted for, and three against the base of the Lower asymmetricus Zone as the biostratigraphic level for the base of the Upper Devonian. A final large majority vote was in favour of the Lower asymmetricus Zone, and included the decision that the stratotype for the base of the Frasnian Stage and the Upper Devonian Series will be in pelagic facies. However, a stratotype has not yet been selected and remains a matter for future consideration.

LOWER BOUNDARY OF THE FAMENNIAN STAGE

Definition

The exact level at which the basal boundary of this stage is to be defined is coincident with the lower limit of the Middle Palmatolepis triangularis conodont Zone. This is defined by the first occurrence of Palmatolepis delicatula Branson and Mehl. This is a subdivision of the conodont standard zonation that was established in the early 1960s (Ziegler, 1962).

Criteria for Correlation

Palmatolepis delicatula comprises two subspecies, P. d. delicatula and P. d. clarki, that evolved from the P. triangularis stock. P. delicatula is widespread in pelagic facies, and in conodont terms in the Palmatolepis biofacies (Ziegler, 1962, 1971; Klapper and Ziegler, 1979). Correlation with near-shore facies is enabled by the first occurrence at about this level of Icriodus iowaensis, which occurs in both facies (Sandberg and Dreesen, 1984).

The lower boundary of the Middle triangularis Zone lies within close proximity to the historic base of the Famennian Stage (lower limit of the Schistes de Senzeilles, see e.g., Bouckaert et al., 1972). The lowermost beds of the Schistes de Senzeilles in the type area are characterized by brachiopods, especially by Pampocilorhynchus lecomptei and P. nux praenx (Bouckaert et al., 1972).

The lower boundary of the Famennian Stage is slightly below the first occurrence of the goniatite genus Cheiloceras, which apparently first occurs near the base of the Upper Palmatolepis triangularis Zone. The highest occurrence of the goniatite genus Crickites is in the Lower triangularis Zone below the proposed boundary level.



Figure 8: Middle-Upper Devonian sequence at Jebel Ihrs, south of Erford, Morocco. Backpack for scale.



Figure 9: Examples of the rich Upper Devonian ammonoid faunas known from Morocco. Abundant specimens such as these are commonly sold throughout Morocco to tourists.

A boundary stratotype has not yet been selected for the base of the Famennian Stage; it also remains a matter for future consideration.

Comment

The much-discussed Frasnian-Famennian biotic crisis during which mass extinction in many invertebrate fossil groups occurred (McLaren, 1983) seems to have been restricted to the Uppermost gigas Zone and Lower triangularis Zone or parts thereof (Ziegler, 1984). In many areas of neritic and pelagic facies during this interval, physical breaks in sedimentation or condensation are observed. Therefore, although the lower limit of the Lower Palmatolepis triangularis Zone is for palaeontological reasons an excellent contender for the Frasnian-Famennian Boundary, and possibly also in close proximity with the traditional boundary, it is not regarded now as a desirable level at which to fix this boundary.

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