Chapter 2 International stage stratotypes

All of the Upper Carboniferous stages in the so-called 'Heerlen Classification', from the Chokierian to the Bolsovian, have their base stratotypes in northern England (the Westphalian D base stratotype has yet to be selected, although sites in South Wales will probably be strong contenders). Because of their importance for stabilizing the definitions of the stages, these stratotypes have a rather different status from the other sites dealt with in this volume; they were automatically selected as GCR sites and did not have to go through the normal processes of critical assessment and comparison. Most also do not fit into the network of sites used to demonstrate the Upper Carboniferous stratigraphy in the main regions of Britain (River Darwen is the main exception); in fact, it is possible that some of the sites would not have been included in the GCR coverage, if it were not for their stratotype status. To reflect their distinct status, the history and description of each of the stratotypes is given separately in this chapter.

Historical background

The stages are part of what is known as the Heerlen Classification. The outlines of the scheme had been originally formulated by Munier Chalmas and de Lapparent (1893), but it was at the first two congresses on Carboniferous stratigraphy (held at Heerlen in 1927 and 1935) that it became established as a formal chronostratigraphical classification (Jongmans, 1928; Jongmans and Gothan, 1937). In its 1935 form, three stages were recognized in the Upper Carboniferous: Namurian, Westphalian, Stephanian. The Namurian and Stephanian were subdivided into three substages, and the Westphalian into four (e.g. Namurian A, Westphalian D).

During the 1960s and early 1970s, the classification underwent a number of changes. The most significant was that the three stages were upgraded to series. This was first done for the Namurian following proposals by Ramsbottom (1969b). It was also proposed that, instead of the tripartite subdivision of the Namurian, seven stages should be recognized, based on the ammonoid biostratigraphy that had been developed in Britain (Bisat, 1928; Hudson and Cotton, 1943; Hodson, 1957). The changes were formally adopted by the Subcommission on Carboniferous Stratigraphy (hereafter referred to as the SCCS) in 1967 (George and Wagner, 1969).

The Stephanian was the next to undergo revi sion. The boundary between the Westphalian and Stephanian had been an ongoing problem since the two intervals were proposed in 1927. The classic Westphalian sequences are in the paralic coalfields of northern Europe, while the classic Stephanian sequences are in the intra-montane basins of central and southern France; virtually nowhere (at least in western or central Europe) do they occur together. One of the few exceptions is the Saar–Lorraine coalfield. Even here the contact (at the base of the Holz Conglomerate) is unconformable, but it was widely assumed that the time gap involved was small and so it was used to define the Westphalian–Stephanian boundary (Jongmans and Gothan, 1937). However, subsequent work on the more complete sequences in northern Spain showed that this time gap was much larger than previously thought, and that there was consequently a gap in the sequence of stages (Wagner, 1969). To fill this gap, it was proposed in 1971 to introduce the Cantabrian Stage, which was to be the lowest subdivision of the Stephanian (George and Wagner, 1972). Whether the Stephanian was to be a stage or series was still a matter of disagreement in 1969 (George and Wagner, 1970). However, the acceptance of the Cantabrian Stage as the lower subdivision of the Stephanian meant that the latter had to become a series.

Details of the stratotype and definition of the Cantabrian, as now accepted by the SCCS, are given by Wagner and Winkler Prins (1985). It has altered since the original 1971 proposal, because of changes in detailed correlation between the marine and non-marine sequences in northern Spain. However, these changes have little direct bearing on the chronostratigraphy of the British sequences. Wagner and Winkler Prins (1985) also proposed that the Stephanian A should be renamed the Barruelian Stage, again with a base-stratotype in northern Spain. The Stephanian B and Stephanian C are still awaiting new names.

It has been proposed to introduce a fifth stage at the top of the Stephanian — the 'Stephanian D' (Bouroz and Doubinger, 1977). This is connected with the so-far unresolved complications concerning the recognition of the

Carboniferous-Permian boundary in non-marine sequences (e.g. Kozur, 1984), and no decision has been made by the SCCS on the status of the 'Stephanian D'.

Compared with the forgoing series, the Westphalian has remained more or less stable since the 1935 definition, with four subdivisions. The bases of the lower three subdivisions were defined at prominent marine bands, while the base of the top subdivision (Westphalian D) was informally linked to the base of the range of the plant fossil *Neuropteris ovata* Hoffmann. Following on the coat-tails of the Namurian and Stephanian, the Westphalian was upgraded to a series in 1971 (George and Wagner, 1972). The subdivisions, now being stages, required formal names, and have been renamed Langsettian, Duckmantian and Bolsovian, with stratotypes designated in northern England (Owens *et al.,* 1985); the Westphalian D remains the only stage without a designated stratotype or a formal name.

Details of the historical changes to the Upper Carboniferous part of the Heerlen Classification is shown in (Figure 1.2). For a more complete account, the reader is directed to Wagner (1974, 1989).

Reasons for selecting stratotypes in Britain

As the name suggests, the concept of a Namurian stage was first developed in Belgium ('étage namurien' of Purves 1883). However, there has always been a close link with the Millstone Grit sequences in northern England, initially through the work of Bisat (1924, 1928). When it proved impossible to find suitable stratotype sections in Belgium, it was thus not surprising that the SCCS decided to turn to Britain for alternative sites (George and Wagner, 1969). Particularly in the basinal sequences of northern England, extensive marine fossil assemblages can be found, which provide good biostratigraphical control. The sites also tend to be in areas of relatively low population density, thus reducing the potential conservation problems.

The Westphalian Series has its historical links with the Ruhr Coalfield in Germany (Munier Chalmas and de Lapparent 1893). This persisted until the 1960s, but during the 1965 SCCS meeting at Sheffield, it was pointed out that there were no surface exposures in the Ruhr to provide permanent stratotype sections. Initially, a possible move to the Nord-Pas-de-Calais Coalfield in northern France was considered but, again, there is an absence of permanent exposure. The obvious choice, at least in northern Europe, was South Wales, which is the only coalfield to provide both a continuous succession through the Westphalian and extensive natural outcrop. The SCCS therefore decided to look there for stratotypes (George and Wagner, 1972) but, for reasons that are far from clear, they failed to find any suitable candidates (Calver and Owens, 1977). This now seems strange in view of the fact that in the mid-1970s Cwm Gwrelych–Nant Llyn Fach provided an even more complete sequence than it does today. Whatever the reason, however, it was decided to search for sites in the Pennines Basin, and it is here that the base-stratotypes for the lower three subdivisions have been selected (Owens *et al.,* 1985).

The Westphalian D is rather different from the other Westphalian stages. It was traditionally linked with the Assise de la Houve in the intramontane Saar–Lorraine Basin (Jongmans and Gothan, 1937), but there are no outcrops of this formation to provide a suitable stratotype. The SCCS has investigated various other areas for a suitable stratotype section, including South Wales (George and Wagner, 1972). However, the relevant working group has not yet produced any concrete proposals.

Geographical limits of the Heerlen Classification

The first Heerlen congress specifically dealt with the Carboniferous stratigraphy of Europe (Jongmans, 1928). Consequently, the classification that was first outlined there was only intended to be used in a European context. Subsequent congresses attempted to take a wider view but, by the fourth meeting, it was concluded that 'worldwide correlations are utterly impossible' (van der Heide, 1960). Thereafter, it became normal to talk in terms of regional chronostratigraphies in the Carboniferous, reflecting the palaeogeography and biogeography of the time. A scheme put forward by Bouroz *et al.* (1978) attempted to unify the classification for the palaeoequatorial belt but, particularly for the Upper Carboniferous, it was impossible to integrate the evidence from the northern temperate (Angaran) and southern temperate and boreal (Gondwanan) sequences. Recently, the SCCS has been looking again at the possibility of a global

classification, the first manifestations of which have been investigations into a so-called 'Mid-Carboniferous boundary' (Lane *et al.,* 1985b). Other levels which might be capable of being identified globally are also being investigated, and these might provide the basis of a truly international chronostratigraphy (Engel, 1989). In the absence of such a scheme however, the local chronostratigraphies still provide the only practical means of classifying these strata.

The Namurian Series and its component stages are most easily identified in the siliciclastic deposits of northwestern and central Europe. Detailed correlations with some of the sequences in North America (e.g. Manger and Sutherland, 1985) suggest that the Namurian stages can also be identified there, but American workers still tend to use their local classification. In the USSR, coeval strata belong to all but the lowest Serpukhovian and the lower Bashkirian (Wagner *et al.,* 1979). Fossils indicative of the Alportian Stage have been tentatively identified from the upper Serpukhovian but until recently it has been impossible to recognize the other Namurian stages (N.J. Riley, pers. comm. now claims that the Namurian stages can be recognized in the Urals). In north Africa, the fossils are most comparable to those of the USSR, and so the Soviet classification is now normally used there (Wagner *et al.,* 1985).

The Westphalian and Stephanian series and their component stages are mostly used in the essentially non-marine sequences of western and central Europe and north Africa. Other than the lower three stages of the Westphalian, which in the paralic basin of northern Europe can be identified by marine bands and non-marine animal fossils, the boundaries between the stages of the Heerlen Classification are best identified using plant fossils (palynology is still unable to provide an accurate fix on the stage boundaries). This has proved fully successful in the intramontane basins of Europe (e.g. Cleal, 1984b) and the mixed marine/non-marine sequences of south-western Europe (e.g. Wagner and Winkler Prins, 1985). The Heerlen Classification has also been applicable to eastern North America through plant. biostratigraphy (e.g. Zodrow and Cleal, 1985). However, plant fossils are so poorly documented through much of the rest of North America that it is so far impossible to use the Heerlen Classification there with any accuracy. There are also problems with using it in the European part of the USSR, although this is more due to apparent discrepancies in the ranges of some of the plant fossil species than an absence of reliable records (Fissunenko and Laveine, 1984).

References

Stages (1927)	Stages (1935)	Stages (current)	Series (current)	Subsystems (current)
Autunian	Autunian	Autunian		Lower Permian
Stephanian	Stephanian	Stephanian C Stephanian B Barruelian	Stephanian	
? ? ?	? ? ?	Cantabrian		
Westphalian C	Westphalian	D Westphalian D	Westphalian	Upper Carboniferous
Westphalian B		C Bolsovian B Duckmantian		
Westphalian A		A Langsettian		
Namurian	Namurian	C Yeadonian B Marsdenian Kinderscoutian Alportian A Chokierian Arnsbergian Pendleian	Namurian	
Visean	Visean	Brigantian Asbian	Visean	Lower Carboniferous

(Figure 1.2) Historical development of the Heerlen Classification of the Upper Carboniferous.