The Basis for a Mid-Carboniferous Boundary

by H.R. Lane and W.L. Manger

A decade of progress in Carboniferous stratigraphy has led to international agreement on the biostratigraphic criteria to be used in recognizing and correlating a mid-Carboniferous Boundary. In the immediate future the Subcommittee on Carboniferous Stratigraphy will focus attention on potential stratotype sections in which to define this boundary formally.

Introduction

The Subcommittee on Carboniferous Stratigraphy (SCCS) meeting at the Tenth Congress on Carboniferous Stratigraphy and Geology in Madrid, 1983, approved a recommendation that a boundary be selected in a continuously deposited sequence of rocks at a position corresponding to the appearance of the conodont *Declinognathodus noduliferus* and coinciding approximately with the *Eumorphoceras-Homoceras* ammonoid zonal transition. This boundary should be used intercontinentally to separate lower and upper subdivisions of the Carboniferous System. These proposals were the culmination of a series of events set in motion at the Eighth Carboniferous Congress in Moscow, 1975. A meeting in Nottingham, Great Britain, this July will begin evaluation of potential stratotype sections around the world that contain the proposed boundary horizon.

Eighth Congress - Moscow 1975

A proposal from five Titular Members of the SCCS for a unified, international classification of the Carboniferous System was presented at the SCCS meetings held in conjunction with the 1975 Moscow congress and subsequently published (Bouroz et al., 1977, 1978a, 1978b). The scheme by A. Bouroz (France, then chairman of SCCS), O.L. Einor and S.V. Meyen (U.S.S.R.), M. Gordon (U.S.A.), and R.H. Wagner (U.K.) combined aspects of the three existing classifications from western Europe, the Soviet Union and North America.

By integrating these established units, they felt that changes would be kept to a minimum and that previous information and experience concerning their identification and correla-

tion could be used to fullest advantage. The proposal was concerned primarily with the general framework of Carboniferous subdivisions. Although faunal and floral evidence was reviewed to support identification of natural breaks of chronostratigraphic significance, specific details of the various boundary horizons were not addressed.

The foundation of this proposal was a subdivision of the Carboniferous into subsystems utilizing the names Mississippian and Pennsylvanian from North America (Fig. 1). The boundary between those subsystems was thought to coincide with the appearance of the ammonoid genus *Reticuloceras*, and, therefore, it was regarded as equivalent to the base of the Kinderhookian Stage (R_1) of the Namurian Series of western Europe. The subsystems were divided in turn into series, one for the Mississippian and two for the Pennsylvanian. The name Mississippian was repeated as a series designation, while the Pennsylvanian encompassed a lower, unnamed series succeeded by the Stephanian Series from western Europe. The series were divided into stages whose names were derived from the Russian Platform, except for retention of the well known western European Tournaisian and Visean Stages.

The 1975 SCCS meetings at Moscow were opened for the first time to all interested persons because of the significance of this proposal, and vigorous and prolonged debate followed. While no one suggested that a unified, international classification of the Carboniferous System was undesirable or impossible, it became clear that no consensus existed for a bipartite versus tripartite system division. Moreover, disagreement surrounded the various boundary horizons utilized for the main subdivisions, and there was dissatisfaction with the names and, by inference, reference sections for the chronostratigraphic units selected.

Particularly significant was the discussion of the level of the Mississippian-Pennsylvanian boundary, which represented the fundamental division of the proposal and also served as both a Series and Stage boundary (Table 1). Alternatives suggested to the appearance of *Reticuloceras* included a lowering to the appearance of the ammonoid genus *Homoceras* (base of the western European Chokierian Stage H_1), and a raising to the appearance of the ammonoid genus *Gastrioceras* (base of the western European Westphalian Series).

As a consequence of this lack of agreement, the proposal was tabled by the titular membership of SCCS and not submitted for ratification by the Commission on Stratigraphy. While lack of uniformity in Carboniferous stratigraphic nomenclature and placement of major boundaries continued, the Moscow Congress clearly established the direction for chronostratigraphic research during the next decade.

Ninth Congress - Urbana 1979

Interest generated by publication of the proposal by Bouroz and others encouraged the organization at the May 1979 Carboniferous Congress (Washington, D.C. and Urbana,

Figure 1: International Classification of the Carboniferous System proposed at the Eighth Carboniferous Congress in Moscow, 1975.

SYSTEM	SUBSYSTEM	SERIES	STAGE
CARBONIFEROUS	PENNSYLVANIAN	STEPHANIAN	GZHELIAN
		-----	KASIMOVIAN
	MISSISSIPPIAN	UNNAMED	MOSCOVIAN
		MISSISSIPPIAN	BASHKIRIAN
			SERPUKHOVIAN
			VISEAN
			TOURNAISIAN

NORTH AMERICA			ENGLAND	
System	Series	Ammonoid Zones	Stages	Series
PENNSYLVANIAN	MORROWAN	G _{1b}	Yeadonian	NAMURIAN
		G _{1a}		
		R _{2c}	Marsdenian	
		R _{2b}		
		R _{2a}		
		R _{1c}	Kinderscoutian	
		R _{1b}		
		R _{1a}		
		H _{2a-c}	Alportian	
		H _{1b}	Chokierian	
		H _{1a}		
MISSISSIPPIAN	CHESTERIAN	E _{2c}	Arnsbergian	
		E _{2b}		
		E _{2a}		

Table 1: North American and British Series and Stages of the mid-Carboniferous.

Illinois) of a symposium and related field trips on the Mississippian-Pennsylvanian Boundary in North America. Eight papers described relationships in areas of North America where highest Chesterian (Mississippian) strata (Table 1) are succeeded by those of the Morrowan Series (Pennsylvanian). Most papers emphasized use of foraminifera and conodonts, and to a lesser extent megafauna to recognize biostratigraphically the Mississippian-Pennsylvanian boundary in their particular area. While for the most part lacking an intercontinental perspective, these papers provided a valuable data base for usage of Mississippian and Pennsylvanian as chronostratigraphic concepts in North America.

Two symposia at Urbana anticipated the Leeds meeting of 1981 by discussing the succession of various faunal and floral groups through the Carboniferous, and many contributors provided range charts of biostratigraphically useful taxa across the Mississippian-Pennsylvanian boundary (Sutherland and Manger, 1984).

Figure 2: Key fossils used in identification of the agreed biostratigraphic level of the mid-Carboniferous boundary. **Left**, the conodont *Declinognathodus noduliferus* (Ellison and Graves), holotype specimen in collections at University of Missouri, Rolla (MSM 7143), X 44, from the Lower Pennsylvanian Dimple Limestone of the Marathon Region of Texas, originally figured by Ellison and Graves, 1941, pl.3, fig.40 (photo G. Klapper). **Centre**, the foraminifer *Globivalvulina moderata* Reitlinger (= *Globivalvulina* sp. D of Brenckle, 1973); holotype specimen (Reitlinger, 1949) in collections of Geological Institute, Soviet Academy of Sciences, Moscow (3278/4), X 87, from Bashkirian Stage, Prikam, Soviet Union (photo P.L. Brenckle). **Right**, the goniatite *Isohomoceras* cf. *I. subglobosum* (Bisat), X 3.9, from lower member of Tagnana Formation, Horreitar, Bechar Region, Algeria, locality 72-1381 of Manger et al. (1985).

Leeds Field Meeting, 1981

The occasion of the SCCS field and General Meeting held at Leeds, Great Britain, in 1981-2, provided an opportunity to approach the boundary question again, but in a different fashion. A call was issued to synthesize up-to-date biostratigraphic data available for all major mid-Carboniferous fossil groups and to evaluate significant changes that might provide useful mid-Carboniferous boundary choices. These reviews were intended to be without prejudice to either the existing stratigraphic classification or "orthochronological" rankings of fossil groups. Contributors were merely asked to report the available biostratigraphical boundaries in their own particular speciality, regardless of changes in other fossil groups. That approach was seen as a means of permitting objective evaluation and encouraging participation by all specialists prior to developing a specific, formal proposal for systemic division and boundary selection.

The results of the Leeds Symposium, published the following year (Ramsbottom et al., 1982), demonstrate the great deal of information available upon which to base selection and definition of a mid-Carboniferous boundary. The choice was consistently narrowed to two potential boundary levels: the base of the Chokierian (H₁) Stage, and the base of the Kinderscoutian (R₁) Stage (Table 1).

Support for the base of the Chokierian was strongest among ammonoid and some conodont specialists, since in those groups that level marks a major change between strongly contrasting Carboniferous faunas. This boundary was also supported by the foraminiferal and, to some extent, by the brachiopod, coral and palynomorph record, and even though they at that time favoured the second boundary choice, its biostratigraphic significance was acknowledged by specialists such as O.L. Einor and Z.S. Rumyantzeva.

The second, higher, alternative at the base of the Kinderscoutian Stage found support among specialists in brachiopods, palynomorphs, megafloora, and crinoids. There was, in some cases, a lack of precise information about fossil distributions in the Alportian and Chokierian Stages (impoverished and perhaps unrepresented in a hiatus), and this may have had the effect of over-emphasizing the extent of the faunal or floral changes. However, support in favour of recognizing the higher boundary was not entirely of a biostratigraphic nature. Its proponents point out that it is presumed to coincide with the base of the North American Pennsylvanian and with the Soviet Lower-Middle Carboniferous boundary. Lower Kinderscoutian sequences are also widely distributed and well represented in many parts of the world, in contrast to the Chokierian Stage, which is either apparently missing (notably in much of North America) or represented by unfavourable facies with low diversity fauna, where present.

Figure 3: Gill Beck, near Cowling, Yorkshire, Great Britain is the stratotype section for the base of the Chokierian Stage and will be examined as a potential mid-Carboniferous boundary stratotype during the Nottingham meeting.

At Leeds, a Mid-Carboniferous Boundary Committee, chaired by H.R. Lane (U.S.A.) was established to investigate and evaluate the information available with regard to a possible mid-Carboniferous boundary. This was directed to emphasize biostratigraphy from all parts of the world, and to provide a report and recommendation to be presented at the following SCCS meeting in Madrid in 1983.

Tenth Congress - Madrid 1983

The comprehensive report of the Committee was presented at the 1983 Congress in Madrid. The procedure, advocated by this committee and most of SCCS membership, to formalize the boundary is first to decide on the stratigraphic level dictated by available biostratigraphic data, and then to examine potential stratotypes. Presentations illustrating the proposed boundary definition in potential stratotype sections were made by specialists from North America, Western Europe, the U.S.S.R. and China.

The recommendations made by the Committee were discussed extensively in a general debate at Madrid. This was particularly significant in highlighting the need to define a boundary that can be used not only in the Carboniferous palaeoequatorial belt (containing most of the detailed biostratigraphic references) but that also reflects, insofar as possible, the major changes affecting the Gondwana Realm and that of Angara at the same time. It was recognized that those equivalencies can only be approximate, and that the search is for the biostratigraphic expression of a major, world-wide, faunal and floral event.

Early in the debate it was conceded that regional chronostratigraphic classifications should be retained on a separate basis from the worldwide chronostratigraphic classification involved with the proposed boundary. The latter constitutes the most obvious task of the SCCS, whereas the former may be left to the appropriate working groups.

Figure 4: Excursion to Bashkirian rocks of the Donets Basin, U.S.S.R.

Following discussions with specialists on the Gondwana Realm the revised recommendations by the Mid-Carboniferous Boundary Committee (see Lane and Manger, 1985), informally approved by the Titular Members present, were as follows:

1. That an international mid-Carboniferous boundary shall correspond approximately to the time of change from the Eumorphoceras to Homoceras ammonoid zones. Although the boundary is to be selected in the Eumorphoceras-Homoceras zonal transition, the known distribution of Homoceras is restricted geographically and thus, Homoceras is not a suitable taxon for world-wide recognition of a mid-Carboniferous boundary.

2. For this reason another, more widely distributed group, the conodonts, can be utilized for recognition of that boundary. The conodont *Gnathodus girtyi simplex* Dunn gives rise to its successor *Declinognathodus noduliferus* (Ellison and Graves) at approximately the same stratigraphic level and occurs abundantly in the palaeoequatorial belt (Fig. 2). It is recommended, therefore, that the stratigraphic level that marks the appearance of *Declinognathodus noduliferus* should be used in selecting a mid-Carboniferous boundary-stratotype. In parts of the Gondwana Realm, in the absence of *Declinognathodus noduliferus*, it appears that the top of the range of *Gnathodus girtyi simplex* approximates that same level.

3. That the evolutionary appearance of other species, especially those from other fossil groups, be utilized as auxiliaries to recognize or approximate that boundary independent of *D. noduliferus*. Currently, these auxiliary species include the foraminifers *Globivalvulina* sp. D. of Brenckle, 1973 (equals *G. moderata* Reitlinger; personal communication, P.L. Brenckle, April 30, 1985; Fig. 2), *Millerella pressa* Thompson, and *Millerella marblensis* Thompson, and the conodonts *Adetognathus lautus* (Gunnell), *Rhachistognathus primus* Dunn and *Rhachistognathus minutus* (Higgins and Bouckaert). Other species also may be taken into account as their usefulness is demonstrated.

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In a postal ballot, these proposals were carried by a considerable majority. In calculating the overall response (17 yes, 3 no, 3 abstentions, 6 no response - counted as abstentions), a "yes" vote was tallied if 2 of the 3 points were favoured, a "no" if 2 of the 3 points were rejected.

Nottingham and The Future

Upon submittal of the mid-Carboniferous boundary proposal, the Committee was dissolved, and Dr. Lane was charged by the SCCS with the formation of a Working Group to begin deliberations for the selection of a stratotype encompassing the approved boundary horizon. The mid-Carboniferous boundary proposal was forwarded by the officers of SCCS for ratification by the International Commission of Stratigraphy at the International Geological Congress, Moscow, 1984. That ratification was not forthcoming, however, because the Commission regarded the proposal as incomplete and preliminary without designation of a stratotype. Thus, it is clear that the next step in our efforts to formalize the mid-Carboniferous boundary must be stratotype selection. That stratotype will be examined and described in detail by the Working Group, and then recommended to the titular membership for approval.

The organizational meeting of the stratotype selection working group is being held at Nottingham, England, this July. While feeling no sense of urgency in stratotype selection, it is important to start compiling an inventory of potential sections, beginning with those proposed at Madrid, and to organize excursions for first-hand examination. This will begin at Gill Beck in Yorkshire in July (Fig. 3) and will probably require the next decade for its completion. It will be the responsibility of the new Working Group to disseminate information regarding sections under study to all interested parties, to solicit candidate sections, and to encourage integrated and detailed biostratigraphic investigation of all potential sections.

The decade 1975-1985 has seen considerable progress toward understanding the Carboniferous System intercontinentally and in the development of a unified system of classification. That classification remains unsettled, but deliberations concerning selection of a mid-Carboniferous boundary stratotype should foster and encourage further research, understanding and progress.

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