Redefinition of the Upper Pennsylvanian Virgilian Series in Kansas

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Abstract

The Virgilian Series was defined nearly 60 years ago to include those rocks lying between the Missourian Series and the base of the Permian System. In the type area in east-central Kansas, the Virgilian Series comprised the Douglas, Shawnee, and Wabaunsee Groups. In Kansas, the upper boundary of the Virgilian (Pennsylvanian–Permian boundary) was placed at the top of the Brownville Limestone Member on the basis of what was then believed to be a regional disconformity rather than on paleontological criteria. Recent advances in fusulinid and conodont biostratigraphy provide tentative criteria upon which to effect a change in the placement of the Virgilian–Permian boundary. It is now generally agreed that the base of the Permian System is approximated by the first occurrence of *Pseudoschwagerina*, an inflated schwagerinid. Furthermore, the Subcommission on Permian Stratigraphy has informally agreed that the base of the Permian should coincide with the first occurrence of the conodont species *Streptognathodus barskovi*. Inflated schwagerinids (*Paraschwagerina kansasensis*) first occur along with evolutionary changes in the Conodonta in the Neva Limestone of the Council Grove Group. Consequently, the Virgilian Series is herein redefined to include rocks present between the top of the Missourian Series and the base of the Neva Limestone.

To increase compatibility between chronostratigraphic and lithostratigraphic nomenclature, the following changes are made: 1) the Admire Group is redefined to include rocks between the base of the Onaga Shale and the base of the Neva Limestone; 2) the Admire is reassigned to the upper Virgilian Series; 3) the Neva Limestone is elevated to formational status; 4) the Grenola Limestone is redefined to include strata between the top of the Roca Shale and the base of the Neva Limestone; 5) the overlying Council Grove Group is redefined to include strata lying between the base of the Neva Limestone and the base of the Chase Group; and 6) regionally the base of the emended Council Grove Group marks the base of the Permian System. The emended Council Grove Group is lower Wolfcampian in age and is time equivalent with the Neal Ranch Formation of the west Texas type Wolfcampian.

Introduction

As originally defined, the Virgilian Series comprised the youngest rocks of Pennsylvanian age in the midcontinent (Moore, 1932, 1949). Boundaries of the chronostratigraphic unit were defined at regional disconformities, rather than by biostratigraphic zonations. The lower boundary was placed at the disconformity developed at the top of the Missourian Series (base of the Stranger Formation). However, placement of the upper boundary, or base of the Permian System, has been in dispute for decades. After numerous vascillations, Moore (1940) concluded that the top of the Virgilian sequence (base of the Permian System) should be placed at what he believed to be a major disconformity immediately above the Wood Siding Formation, the uppermost unit in the Wabaunsee Group (fig. 1). Mudge and Yochelson (1962) coordinated an exhaustive study of stratigraphy and paleontology of the Pennsylvanian–Permian boundary in Kansas. However, they did not examine the paleontology in detail above the Americus Limestone Member, and they eventually reached the conclusion that: "As there is no clear agreement as to what constitutes the Permian, especially in regard to definition on the basis of fossils, any boundary established in Kansas must be regarded as tentative and subject to change when more is known of the type area in Russia or of the standard sequence for North America" (Mudge and Yochelson, 1962, p. 127). That arbitrary stratigraphic position of the Pennsylvanian–Permian boundary at the base of the Admire Group has since been followed by the Kansas Geological Survey (O'Connor and others, 1968; fig. 2).

Much of the early confusion resulted from lack of agreement by Russian geologists on what rocks were to be included in the type Permian (Baars, 1990). Since Likharev (1959) placed the Carboniferous–Permian boundary at the base of the Asselian in Russia, most stratigraphers followed this practice (Waterhouse, 1978; Chuvashov, 1989). Confusion existed also regarding critical fusulinid nomenclature that clouded the issue. "Many European fusulinid specialists retain the name *Schwagerina*, in the sense of Möller (1878) and so apply this name to species which . . . should by placed in *Pseudoschwagerina*" (Ross, 1963, p. 45). General agreement exists among fusulinid paleontologists that the base of

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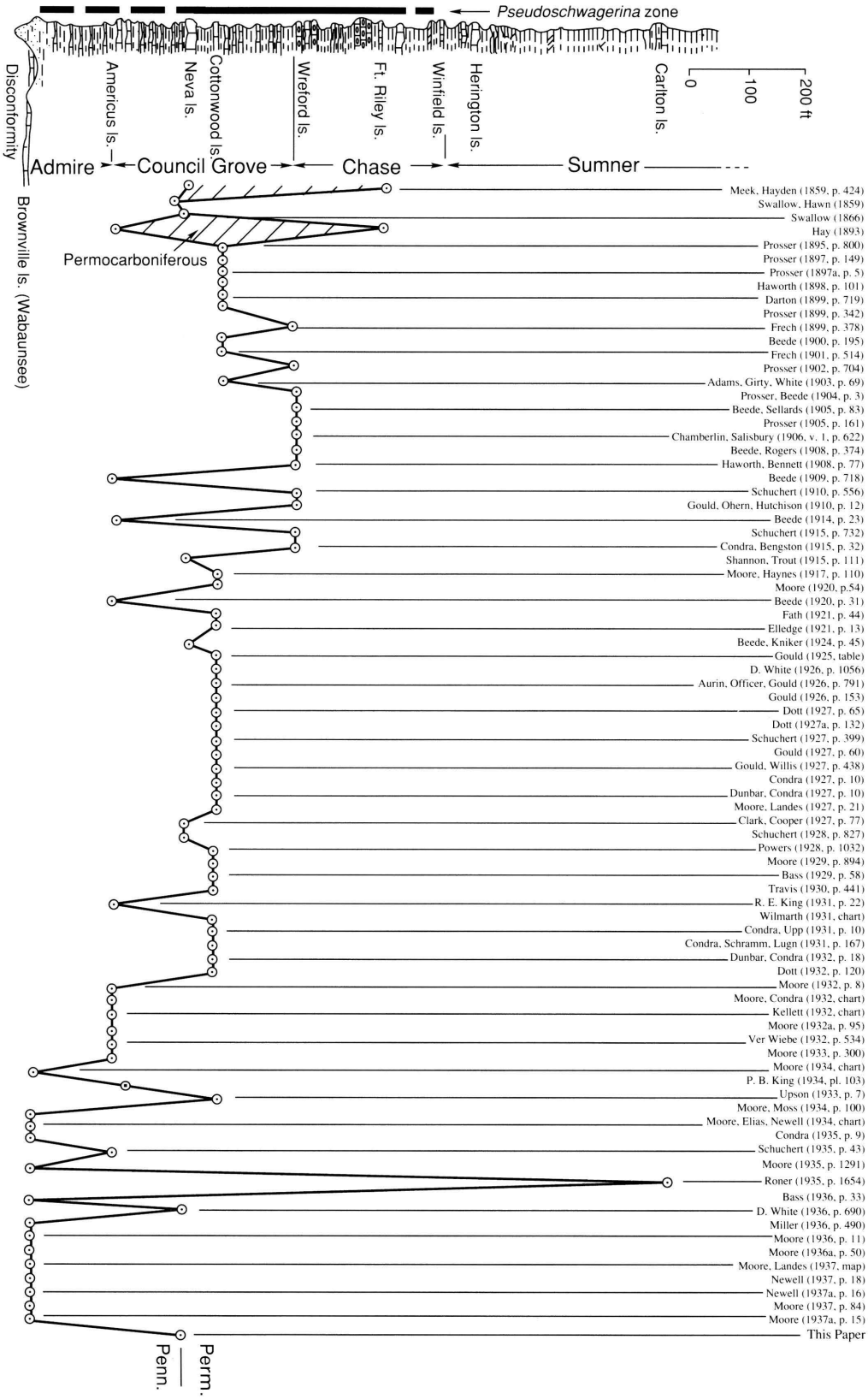

FIGURE 1—Diagram taken from Moore (1940), showing the history of placement of the Carboniferous–Permian boundary relative to the rock section of Kansas between 1859 and 1937. Moore (1940) concluded that the boundary should be placed at a disconformity *below* the first occurrence of the *Pseudoschwagerina* biozone, which is present in the Neva Limestone.

the *Pseudoschwagerina* biozone marks the base of the Permian System (Ross, 1989), although not adopted by the International Commission on Stratigraphy. "The *Pseudoschwagerina* zone is characterised by *Pseudoschwagerina* and *Paraschwagerina*, but it includes other genera such as *Schwagerina* and *Triticites* . . ." (Ross, 1963, p. 45. Ammonoid (Furnish, 1989) and conodont (Wardlaw, 1989; Ritter, 1989) paleontologists tend to generally concur with that selection. This biozone first occurs in Kansas in the Neva Limestone, which contains *Paraschwagerina kansasensis* (Ross, 1963; King, 1988).

Placement of the base of the Permian at the base of the Neva Limestone necessitates repositioning the top of the Pennsylvanian upward stratigraphically to that boundary. A section including the Admire Group and the lower formations of the Council Grove Group necessarily must be reassigned to the upper Pennsylvanian System. This section has traditionally been considered as early Wolfcampian in North America for decades, and includes the Bursum and Pueblo intervals in Texas and New Mexico (Ross, 1963), and the Elephant Canyon Formation of eastern Utah. Microfaunas in this Admire–Bursum–Pueblo interval include the *Triticites–Schwagerina* biozone that predates the zone of *Pseudoschwagerina*, and is considered to be latest Carboniferous in Europe. This reassignment makes the top of the Pennsylvanian in North America coincident with the top of the Carboniferous in Europe. Ross and Ross (1987, 1988) showed these correlations, but did not formally propose a change. The same authors indicated the age of the Carboniferous–Permian boundary is 286±6 Ma (Ross and Ross, 1987, p. 145).

<table>
<tr><th colspan="3">O'Connor et al., 1968</th><th colspan="5">This report</th><th colspan="2">Ural Mtns.
Russia
(Chuvashov, 1989)</th></tr>
<tr><td rowspan="4">Permian System</td><td rowspan="3">Gearyan Stage</td><td>Chase Group</td><td>Wreford Limestone</td><td>Chase Group</td><td rowspan="2">Wolf-campian Series</td><td rowspan="2">Permian System</td><td rowspan="3">Asselian Series</td><td rowspan="2">Permian System</td></tr>
<tr><td rowspan="2">Council Grove Group</td><td>Speiser Shale
Funston Limestone
Blue Rapids Shale
Crouse Limestone
Easly Creek Shale
Bader Limestone
Stearns Shale
Beattie Limestone
Eskridge Limestone
Neva Limestone</td><td>Council Grove Group</td></tr>
<tr><td>Grenola Limestone
Roca Shale
Red Eagle Limestone
Johnson Shale
Foraker Limestone
Janesville Shale
Falls City Limestone
Onaga Shale</td><td>Admire Group</td><td rowspan="3">Virgilian Series</td><td rowspan="3">Pennsylvanian System</td><td rowspan="3">Upper Carboniferous</td></tr>
<tr><td rowspan="4">Pennsylvanian System</td><td></td><td>Admire Group</td><td></td><td></td></tr>
<tr><td rowspan="3">Virgilian Stage</td><td>Wabaunsee Group</td><td>Wood Siding Formation

Severy Shale</td><td>Wabaunsee Group</td><td rowspan="2">Gzhelian Series</td></tr>
<tr><td>Shawnee Group</td><td>Topeka Limestone

Oread Limestone</td><td>Shawnee Group</td></tr>
<tr><td>Douglas Group</td><td>Lawrence Formation
Stranger Formation</td><td>Douglas Group</td><td></td></tr>
<tr><td>Missourian Stage</td><td>Lansing Group</td><td>Stanton Limestone</td><td>Lansing Group</td><td>Missourian Series</td><td></td><td></td></tr>
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FIGURE 2—STRATIGRAPHIC COLUMN SHOWING PREVIOUS ASSIGNMENTS UNDER THE COLUMN LABELLED O'CONNOR ET AL., 1968, COMPARED WITH THE PROPOSED USAGE OF THIS REPORT, relative to generally accepted standard Russian terminology.

Conodonts

Conodonts are important index fossils in most systems from the Cambrian to the Triassic; however, they have played only a minor role, subordinate to that of the fusulinids and ammonoids, in determination of the Carboniferous–Permian (C–P) boundary. Latest Carboniferous to Early Permian conodont faunas are low in diversity and consist of elements of two evolutionary cycles. Holdovers from the Late Carboniferous include *Idiognathodus*, *Streptognathodus*, and *Cavusgnathus*. The Early Permian is ushered in by the inception of *Sweetognathus* and novel species of *Neogondolella*. Because conodonts undergo a faunal replacement, two approaches to a conodont-based boundary have been advocated. Some workers have suggested using the first occurrence of uniquely Permian *Sweetognathus whitei* to define the C–P boundary at the base of the Sakmarian Stage. During the past 15 years, Soviet workers have established a reliable biostratigraphic zonation for the Gzhelian and Asselian Series based upon speciation events in the genus *Streptognathodus*. Conodonts are present and often abundant in at least select lithofacies within the Wabaunsee, Admire, and Council Grove Groups. These faunas are dominated by species of *Streptognathodus*, with modest but significant occurrences of *Sweetognathus*. These faunas indicate that the beginning of the *Sweetognathus–Neogondolella* provides a sound conceptual and practical basis for placing the C–P boundary at the level of the Neva Limestone.

The first occurrence of *Sweetognathus* in the midcontinent is within the Neva Limestone in both northern Oklahoma and southern Nebraska. The Neva specimens have an adenticulate carina and are assigned to *Sweetognathus expansus* (Perlmutter), the founding species of the genus. In the midcontinent this species is joined or succeeded stratigraphically by *Sw. merrilli* (Kozur), *Sw. inornatus* (Ritter), and *Sw. whitei* (Rhodes) in the overlying Council Grove and Chase Groups. *Sweetognathus expansus* has not been recovered, however, from the Neva Limestone in Kansas nor has it been reported from sections outside of the United States. Hence, this seminal species may have only limited application as an indicator of the C–P boundary.

The appearance of *Sw. expansus* is preceded and accompanied by important changes in the more widespread holdover genera *Idiognathodus* and *Streptognathodus*. Evolutionary trends within these genera in the midcontinent are similar to those reported from the type Permian of Russia. We recognize four nearly identical conodont faunal intervals in Gzhelian to Asselian rocks of both Russia and the midcontinent. A straw vote of the Working Group on the C–P Boundary on July 13, 1989, tentatively established the first occurrence of *Streptognathodus barskovi* accompanied by the base of the *Schwagerina moelleri–Pseudofusulina fecunda* (*Pseudoschwagerina*) fusulinid zone as the base of the Permian System.

In the midcontinent, the base of this interval is characterized by a sharp decline in the relative abundance of *S. wabaunsensis*, the appearance and predominance of narrow elongate streptognathodids with extremely short carina, and the appearance of *Sweetognathodus expansus*. These changes are first noted in the lower part of the Neva Limestone. The exact time of these changes is obscured by the near absence of conodonts in the Howe Limestone through Salem Point Shale Member. *S. barskovi* has its earliest occurrence in the Bennett Shale Member but constitutes less than 2% of the total fauna. *S. barskovi* is present in the Neva Limestone where it is slightly more common.

Virgilian Series Redefined

The Virgilian Series was defined originally to include all rocks from the top of the Missourian Series to the base of the Permian System. As such, the top of the Virgilian must now be placed at the base of the Neva Limestone of the Council Grove Group that contains fusulinids of the *Pseudoschwagerina* biozone, the first appearance of the conodont genus *Sweetognathus*, and the species *Streptognathodus barskovi* (Ritter, 1989). The base of the Virgilian remains unchanged at the base of the Stranger Formation.

The reference section of the series is exposures along the Verdigris River in Greenwood County, Kansas. The top is here extended stratigraphically upward to the base of the Neva Limestone. This revised Virgilian section is, in many respects, more in line with Moore's (1932) original definition of the Virgilian, the top of which he placed at the Americus Limestone in Kansas. Thus the Admire Group and lower Council Grove Group, as previously defined, are of latest Virgilian age. Regionally, the controversial Bursum–Pueblo–Elephant Canyon intervals, containing the *Triticites–Schwagerina* biozone, are here included in the latest Virgilian.

Admire Group Redefined

To compartmentalize and simplify lithostratigraphic nomenclature accompanying redefinition of the Virgilian Series, the Admire Group is here redefined to include all strata from the base of the Onaga Shale to the base of the Neva Limestone. Thus, the Admire Group now includes (ascending) the Onaga Shale, Falls City Limestone, Janesville Shale, Foraker Limestone, Johnson Shale, Red Eagle Limestone, Roca Shale, and the Sallyards Limestone, Legion Shale, Burr Limestone, and Salem Point Shale Members of the Grenola Limestone. The base of the Neva Limestone, as here redefined, will constitute the base of the Council Grove Group and the base of the Wolfcampian Series (Lower Permian) (fig. 2).

The Admire Group (revised) now comprises a thicker series of cyclical carbonates and fine clastics, but still displays approximately the same geographic distribution and significance as the former group. It overlies the Wabaunsee Group and underlies the Council Grove Group as previously used, but is reassigned to the latest Virgilian Series.

Council Grove Group Redefined

To accommodate changes in latest Pennsylvanian nomenclature, the Council Grove Group, as here redefined, is proposed to consist of all strata from the base of the Neva Limestone to the base of the Wreford Limestone Formation. The Neva Limestone is elevated to formation status to simplify lithostratigraphic terminology and to begin the redefined Permian System and Council Grove Group with a sequence boundary. As a lithostratigraphic unit, the Neva is an excellent marker bed throughout the subsurface of Kansas and is readily mapped at most surface exposures. The Neva Limestone contains the first occurrences of fusulinids of the *Pseudoschwagerina* biozone.

Thus, the Council Grove Group consists of (ascending) the Neva Limestone, Eskridge Shale, Beattie Limestone, Stearns Shale, Bader Limestone, Easly Creek Shale, Crouse Limestone, Blue Rapids Shale, Funston Limestone, and Speiser Shale (fig. 2). It is underlain by the Admire Group and overlain by the Chase Group, and is of lower Wolfcampian (Lower Permian) age, biostratigraphically equivalent to the Neal Ranch Formation of the type Wolfcampian (Ross, 1963).

Conclusions

1) The Neva Limestone contains the first occurrences of the *Pseudoschwagerina* biozone, and thus constitutes the base of the global Permian System. It is here elevated to formation status.
2) To accommodate the relocated base of the Permian System, the Virgilian Series is extended stratigraphically upward to include all rocks above the Missourian Series and below the Neva Limestone.
3) The Admire Group is here redefined to include strata between the base of the Onaga Shale up to the base of the Neva Limestone. The group is latest Virgilian (latest Pennsylvanian and latest Carboniferous) in age.
4) The Council Grove Group is redefined to include all strata between the base of the Neva Limestone and the base of the Chase Group. The group is earliest Wolfcampian (Lower Permian) in age.

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