by Betty A. Skipp, Paul L. Brenckle, Vladimir I. Poletaev, Tamara I. Nemirovskaya, H. Richard Lane, and Walter L. Manger

The continuing international search for a Mid-Carboniferous boundary Stratotype—Donets Basin, USSR, 1988

*In September 1988, members of the Mid-Carboniferous Boundary Working Group and other interested participants visited a proposed boundary stratotype section at Beshevo Reservoir in the Donets Basin of the eastern Ukraine, USSR. This trip was part of the working group's continuing effort to examine favorable stratotypes worldwide and came after excursions to the Craven Basin in the United Kingdom and to eastern Gansu Province in the People's Republic of China. The middle Carboniferous boundary at Beshevo Reservoir appears to lie within terrigenous clastic rocks between the lower and upper limestones D_5^8 of the Zapaltyubinsky Horizon. Work is progressing to pinpoint the stratigraphic appearance of the boundary-defining conodont *Declinognathodus noduliferus* and other pertinent taxa.*

Introduction

The Subcommittee on Carboniferous Stratigraphy (SCCS) of the International Union of Geological Sciences approved in 1983 a recommendation that a mid-Carboniferous boundary be selected at the first occurrence of the conodont *Declinognathodus noduliferus* in a continuously deposited sequence of rocks, a position coinciding approximately with the *Eumorphoceras-Homoceras* ammonoid zonal transition. This boundary would separate lower and upper subdivisions of the Carboniferous System intercontinentally (Lane and Manger, 1985a, b).

At the instigation of the SCCS, H.R. Lane organized in 1985 a working group consisting of 20 persons, representing 12 countries, to select a middle Carboniferous boundary stratotype. Since that time, the working group has examined proposed stratotypes in the United Kingdom (Craven Basin) in 1985 and in the People's Republic of China (eastern Gansu Province) in 1987 (fig. 1). In 1988, the working group visited a proposed stratotype section at Beshevo Reservoir in the Donets Basin of the eastern Ukraine, USSR (fig. 1). This report summarizes descriptions of the proposed stratotype sections in the United Kingdom and China, discusses in more detail this recent visit to the Donets Basin, and outlines future activities.

Proposed stratotypes

Craven Basin, Stonehead Beck section

The Stonehead Beck section (formerly Gill Beck) in the Craven Basin, North Yorkshire, United Kingdom (fig. 1), consists of 34 m (meters) of basinal Sabden Shales interbedded with minor amounts of limestone, siltstone, and sandstone. Details of the section and the sequence of its goniatites, bivalves, spores, and conodonts are published in Riley and others (1987). The section spans the Arnsbergian (*Eumorphoceras* 2)—Chokierian (*Homoceras* 1) stage boundary (fig. 2) and is the type locality for the goniatite (*Isohomoceras subglobosum*, a marker fossil for the basal Chokierian. Conodonts include *Gnathodus bilineatus bollandensis* and *Rhachistognathus minutus* in the late Arnsbergian and *Declinognathodus noduliferus* in the early Chokierian. A few meters of seemingly barren strata intervene between rocks that have late Arnsbergian fauna and those that have early Chokierian fauna (Lane, 1988). The section has been designated a Site of Special Interest (SSI) by the British Government to guarantee its preservation.

Eastern Gansu Province, Yushuliang section

The Yushuliang section in Jingyuan, eastern Gansu Province, People's Republic of China (fig. 1), consists of well-exposed paralic to

Figure 1.—Location of proposed middle Carboniferous boundary stratotypes in 1. Craven Basin (UK); 2, eastern Gansu Province (People's Republic of China); and 3, Donets Basin (USSR). Possible boundary stratotypes proposed for future examination include 4, western Utah and southern Nevada (USA), 5, Béchar Basin (Algeria); and 6, Luosu, southern Guizhou Province (People's Republic of China).

BOUNDARY-DEFINING TAXON	UNITED KINGDOM CRAVEN BASIN	PEOPLE'S REPUBLIC OF CHINA EASTERN GANSU PROVINCE	USSR DONETS BASIN, UKRAINE
<i>Declinognathodus noduliferus</i>	Lower Chokierian Stage (H_1)	Possible Hiatus	Lower Voznesensky Horizon
Mid-Carboniferous Boundary	Upper Arnsbergian Stage (E_2)	Upper Tsingyuan Formation	Upper Zapaltyubinsky Horizon
			D_5^{10} D_5^8 upper ? D_5^8 lower

Figure 2.—Correlation chart showing middle Carboniferous boundary relationships as presently understood in the Craven Basin (from Riley and others, 1987), eastern Gansu Province (from Li and others, 1987, and Lane, 1988), and the Donets Basin (from Poletaev and others, 1988, and this report). Abbreviations: H_1 , Homoceras 1 Zone; E_2 , Eumorphoceras 2 Zone; D, limestone.

Figure 3.—Proposed middle Carboniferous boundary stratotype at Yushuliang, eastern Gansu Province, People's Republic of China. Boundary is the contact between the upper shaly mudstone of the Tsingyuan Formation and the basal limestone of the overlying Hongtuwa Formation near Wang Zhihao's left foot. Dr. Wang works for the Institute of Geology and Palaeontology, Academia Sinica, Nanjing, Jiangsu Province, People's Republic of China. Photo by P.L. Brenckle.

continental deposits of the Tsingyuan Formation (50 m) and overlying Hongtuwa Formation (75 m). Lenticular limestone in the grayish-black mudstone, sandstone, and sandy conglomerate of the upper Tsingyuan Formation contain the ammonoid *Eumorphoceras bisulcatum* and the conodont *Gnathodus bilineatus bollandensis*. The conodont *Declinognathodus noduliferus* appears in thin limestone beds of the overlying Hongtuwa Formation (fig. 3), the base of which is the proposed middle Carboniferous boundary. Plant-bearing clastic beds separate the ammonoid- and conodont-bearing beds of the upper Tsingyuan from the basal limestone of the Hongtuwa Formation, and these clastic beds also are interbedded with the thin marine limestone beds in the basal 6 m of the Hongtuwa (Li and others, 1987).

Figure 4.—Logo of the Mid-Carboniferous Boundary Working Group field excursion to the Donets Basin (Donbass), September 1988. Designed by V.I. Poletaev.

Upon cursory examination at the Yushuliang site in 1987, members of the working group and their colleagues inferred that possible gaps exist in the conodont and goniatite successions at the proposed boundary (fig. 2) and that the clastic strata between the conodont faunas in the basal Hongtuwa Formation contain some vascular land plants not found as low as the Chokierian Stage in western Europe. The Yushuliang section is being more fully studied and mapped, so that it may be better correlated. The section has good exposure, access, and a wide variety of fossils (Lane, 1988).

Donets Basin, Zhelvakovaya Valley section

In September 1988, 11 members of the Mid-Carboniferous Boundary Working Group met Soviet stratigraphers and paleontologists in Kiev, Ukraine, USSR, and were escorted to a proposed boundary stratotype section on the southwestern shore of Beshevo Reservoir in the Donets Basin southeast of the city of Donetsk (figs. 1, 4). The following voting members or their representatives participated: H.R. Lane (USA, Chairman), A.C. Higgins (UK, Secretary), P.L. Brenckle (USA), O.L. Einor (USSR), E. Groessens (Belgium) representing J. Bouckaert, W.L. Manger (USA), T.I. Nemirovskaya (USSR), W.H.C. Ramsbottom (UK), Ruan Yi-ping (China), B.A. Skipp (USA), and Yang Jing-zhi (China). The American participants gratefully acknowledge travel support from the National Science Foundation (Grant EAR88-17286).

Strata in the vicinity of the Beshevo Reservoir, north of the town of Starobeshevo in the Kal'mius River valley, are beds of shallow-water limestone and terrigenous clastic rocks of both the Zapaltyubinsky Horizon (=Formation) and the overlying Voznesensky Horizon (Poletaev and others, 1988) (fig. 2). The boundary between these two horizons coincides with that between the *Eumorphoceras* 2 and *Homoceras* Zones (fig. 5).

Conodont, ammonoid, and foraminiferal faunas collected from outcrops and drill holes in the Donets Basin were examined in Kiev by members of the working group and their colleagues, who determined that the middle Carboniferous boundary lies within the upper Zapaltyubinsky Horizon between limestones D_5^8 lower and D_5^8 upper, below limestone D_5^{10} at the base of the Voznesensky Horizon (fig. 2). The 5-to-6 m thickness containing siltstone, sandstone, and mudstone between the lower and upper D_5^8 limestones is present at both the Zhelvakovaya and Bezmyannaya sections on the southwestern shore of the reservoir (fig. 5, localities 1 and 2, respectively). Both collection sites were examined; the lithologies were deemed more

Figure 5.—Geologic map of the Beshevo Reservoir area in the Donetsk Basin of the Eastern Ukraine, USSR, modified from a field map used during the excursion. Locality 1, Zhelvakovaya Valley section, Locality 2, Bezmyannaya Valley section. Arrow at locality 1 points to location of trenched sections of figure 7.

favorable for fossil recoveries at Zhelvakovaya Valley, the type area for the upper part of the Zapaltyubinsky Horizon.

The lower and upper limestones D_5^8 form ledges in several places in the Zhelvakovaya Valley. The intervening terrigenous rocks mostly are covered; therefore, trenching was necessary to expose as complete a succession as possible. Two trenches, one about 5 m long on the valley hillside and the other less than 2 m long at reservoir level, were dug with picks and shovels during an international effort that lasted 1½ days and involved at least 10 persons, including scientists from several countries and many students (fig. 6). The trenches were located approximately 100 m apart. Preliminary rock descriptions and thicknesses were recorded (fig. 7), and paleontologic and lithologic samples were collected. Initial examination of the trench sections did not reveal any obvious stratigraphic breaks,

Figure 6.—Five members of the Mid-Carboniferous Boundary Working Group wielding picks and shovels during trenching of the Zhelvakovaya Valley hillside section ZA (fig. 7). From left to right, W.H.C. Ramsbottom and A.C. Higgins (UK), T.I. Nemirovskaya (USSR), and H.R. Lane and W.L. Manger (USA). Photo by P.L. Brenckle.

Figure 7.—Columnar diagrams of two trenched sections between the D₅ lower and the D₅ upper limestones in the upper part of the Zapalyubinsky Horizon at Zhelvakovaya Valley on the southwestern shore of Beshevo Reservoir (fig. 5, locality 1). Most of the interval is exposed in the hillside section (ZA), but the uppermost beds are found nearby in the section at reservoir level (ZB). The correlation between the two sections is not exact, but local mapping suggests that they are nearly continuous or perhaps overlap. Sections described and measured by W.L. Manger and recorded by B.A. Skipp on September 22, 1988.

but the depositional environment of the sandstone layers has yet to be determined. Detailed paleontologic and sedimentologic studies of the Zhelvakovaya Valley section are now in progress in the Soviet Union.

The working group recognizes the Zhelvakovaya Valley section as a potential boundary stratotype for the following reasons. (1) The Zapaltubinsky Horizon contains conodont, foraminiferal, and ammonoid faunas that can be correlated worldwide. (2) Strata are relatively well exposed, are unmetamorphosed, and appear to constitute an uninterrupted succession. (3) The section contains interbedded marine faunas and terrestrial spores and megaflores. The latter groups may prove useful for determining stratigraphic continuity within the terrigenous beds across the boundary, and a detailed study of the floral distribution is critical. Beds at the top of trenced hillside section ZA (fig. 7) may be slumped, which would necessitate another excavation nearby for a section between the lower and upper limestones D₅⁸. Access to the area by foreign scientific personnel would have to be assured if the section is to be considered a candidate for the middle Carboniferous boundary stratotype.

In September 1989, members of the Mid-Carboniferous Boundary Working Group visited proposed stratotype sections in the western United States in conjunction with the biennial meeting of the SCCS at Provo, Utah (fig. 1). Sections were examined in the Oquirrh Mountains and Confusion Range of western Utah and in Arrow Canyon in southern Nevada. The field trips were coordinated by G.D. Webster of Washington State University, Pullman, Washington.

An excursion to visit mid-Carboniferous exposures in the Béchar Basin of Algeria is planned in fall 1990, and 1992 is being considered for a visit to a proposed boundary stratotype in southern

China (fig. 1). In the intervening year, 1991, the 12th International Carboniferous-Permian Congress will convene in Argentina, where the working group will meet to discuss progress on the stratotype search.

References

- Lane, H.R., 1988, Working group on the mid-Carboniferous boundary: Newsletter on Carboniferous Stratigraphy, no. 6, chapter 4.4, p. 18-19.
- Lane, H.R. and Manger, W.L., 1985a, Toward a boundary in the middle of the Carboniferous (1975-1985): Ten years of progress, in: Lane, H.R., and Ziegler, W., eds., Toward a boundary in the middle of the Carboniferous: Stratigraphy and Paleontology: Courier Forschungsinstitut Senckenberg, v. 74, p. 15-34.
- , 1985b, The basis for a mid-Carboniferous boundary: Episodes, v. 8, no. 2, p. 112-115.
- Li Xingxue, Shen Guanglong, Wu Xiuyuan, and Tong Zaishan, 1987, A proposed boundary stratotype in Jingyuan, eastern Gansu, for the Upper and Lower Carboniferous of China, in Wang Chengyuan, ed., Carboniferous boundaries in China: International Congress of Carboniferous Stratigraphy and Geology, 11th, Beijing, China, 1987, Contribution, p. 69-88.
- Poletaev, V.I., Makarov, I.A., Nemirovskaya, T.I. and Maslo, A.I., compilers, 1988, The guidebook to excursion to the Lower/Middle Carboniferous boundary deposits of Donbas: Kiev, Institute of Geological Sciences, Ukrainian Academy of Sciences, 92 p.
- Riley, N.J., Varker, W.J., Owens, B., Higgins, A.C., and Ramsbottom, W.H.C., 1987, Stonehead Beck, Cowling, North Yorkshire, England: A British proposal for the mid-Carboniferous boundary stratotype, in Brenckle, P.L., Lane, H.R. and Manger, W.L. eds., Selected studies in Carboniferous paleontology and biostratigraphy: Courier Forschungsinstitut Senckenberg, v. 98, p. 159-177. □

B.A. Skipp is a Research Geologist at the U.S. Geological Survey, Box 25046, M.S. 913, Denver, Colorado 80225, USA. Her research interests include structural and stratigraphic studies of Idaho and Montana and lower to middle Carboniferous calcareous foraminifers. She is a member of the Mid-Carboniferous Boundary Working Group.

T.I. Nemirovskaya is a Senior Scientist in the Institute of Geology, Ukrainian Academy of Sciences, ul. Chkalova 55b, 252054 Kiev, USSR. She specializes in the study of Carboniferous conodonts from the Ukraine and other regions of the Soviet Union. She is a member of the Mid-Carboniferous Boundary Working Group.

P.L. Brenckle is a Research Associate at Amoco Research Center, Box 3385, Tulsa, Oklahoma 74102, USA. His work focuses on the biostratigraphy and taxonomy of lower to middle Carboniferous calcareous microfossils. He is a Titular Member of the Subcommittee on Carboniferous, Chairman of the Lower Carboniferous Boundaries Working Group, and a member of the Mid-Carboniferous Boundary Working Group.

H.R. Lane is a Group Supervisor in the West Texas/Eastern New Mexico Division, Amoco Production Company, Box 3092, Houston, Texas 77253, USA. His research interests include Devonian through Early Pennsylvanian conodont taxonomy, biostratigraphy, and paleozoogeography. He is a Titular Member of the Subcommittee on Carboniferous Stratigraphy and Chairman of the Mid-Carboniferous Boundary Working Group.

V.I. Poletaev is a Senior Scientist in the Institute of Geology, Ukrainian Academy of Sciences, ul. Chkalova 55b, 252054 Kiev, USSR. His specialty is the study of Carboniferous brachiopods from the Donets Basin, Ukraine. He is a member of the Lower Carboniferous Boundaries Working Group.

W.L. Manger is Chairman of the Geology Department at the University of Arkansas, Fayetteville, Arkansas 72701, USA. His paleontologic specialty is taxonomy and biostratigraphy of Carboniferous ammonoids. He is a member of the Mid-Carboniferous Boundary Working Group.