Decision on the Lochkovian – Pragian Boundary Stratotype (Lower Devonian)

by Ivo Chlupáč and William A. Oliver, Jr.

The Global Stratotype Section and Point (GSSP) for the Lochkovian-Pragian Stage (middle Lower Devonian) has now been agreed upon. The boundary is defined at the first occurrence of the zone conodont Eognathodus sulcatus sulcatus at the base of bed 12 in the Velká Chuchle Quarry, in the northwest part of Prague, Czechoslovakia.

Introduction

The Lower Devonian stages, from oldest to youngest, are Lochkovian, Pragian, and Emsian. The base of the Lochkovian coincides with the base of the Lower Devonian Series and of the Devonian System and has been formally defined as the Silurian-Devonian boundary (Martinsson, ed., 1977). The boundary between the Lochkovian and the Pragian is the subject of this paper. That between the Pragian and Emsian is undefined and is the subject of ongoing discussions within the International Subcommission on Devonian Stratigraphy (SDS), a unit of the International Commission on Stratigraphy (ICS) of IUGS. The names of the Lower Devonian Stages were adopted by SDS in 1983, recommended to ICS in 1984, and ratified by IUGS in 1985 (Bassett, 1985).

Regional Setting

The boundary beds have been studied in detail at several localities in the Barrandian area, southwest of Prague (Fig. 1). Three localities were described in detail by both Weddige (1987) and Chlupáč, Lukeš and Weddige (1988). The three, Černá rokle, Velká Chuchle and Cikánka Quarry, represent a progression from low to high energy environments. Černá rokle has the best megafauna while Cikánka Quarry has the most abundant conodont fauna. Velká Chuchle is intermediate and was selected as stratotype because of the good intermixture of conodonts and megafossils.

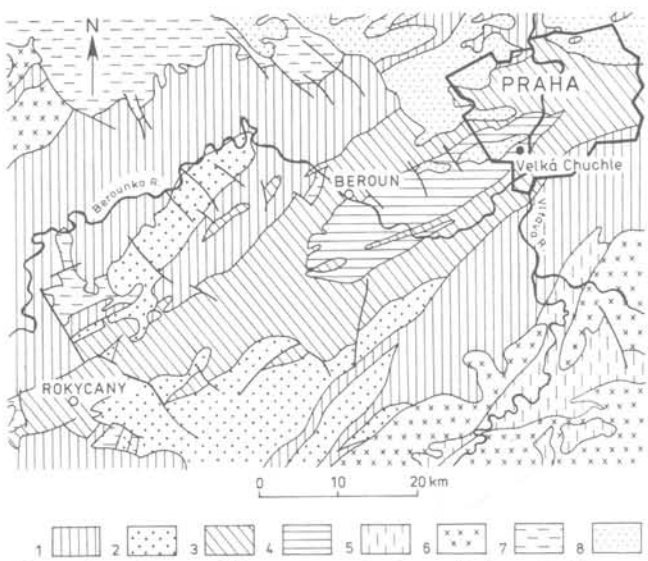

Figure 1: Geographic and geologic setting of the stratotype section in the Barrandian area of central Bohemia. 1- Proterozoic, 2- Cambrian, 3- Ordovician, 4- Silurian and Devonian, 5- metamorphic Proterozoic and lower Paleozoic, 6- granitoids, 7- continental Upper Carboniferous, 8- Upper Cretaceous and Tertiary sedimentary rocks.

Ranges of key species at the three localities are very similar; at each locality the sulcatus boundary is a short distance below the previously accepted megafossil boundary. Chlupáč and others (1985) published extensive range charts and lists of fossils from these and other boundary sections, together with discussions of the stratigraphic significance and usefulness of the major groups of fossils of the Lochkovian-Pragian interval.

The boundary is closely related to an event-stratigraphy level of probable global importance, namely the "Lochkovian-Pragian Boundary Event," which, however, lies close above the Pragian base. This event-boundary (most likely a eustatic fall in sea level) may be useful in identifying the broader boundary interval on a worldwide scale (compare the interval before Cycle Ia in Johnson, Klapper and Sandberg 1985, and applications in the stratotype area, in Chlupáč and Kukal 1986, 1988). Paleomagnetic studies are in progress by Dr. M. Krs in Prague. Preliminary results suggest that the Velká Chuchle section has been remagnetized. The color alteration index of Velká Chuchle conodonts is 3 (Schönlaub, written communication, 1989).

Prior to the naming of the Pragian Stage in 1958 and its acceptance by SDS in 1983, the "Siegenian Stage" was used by many workers for the middle stage of the Lower Devonian. This was based on benthic, near-shore fossils, principally brachiopods, and was sufficiently useful up to about 1950 when pelagic fossils such as conodonts began to predominate in long-range correlations. With continuing refinement of intercontinental correlations, it became clear that the "Siegenian Stage" could not be satisfactorily defined in its type area (West Germany) and the shift to Pragian resulted.

Recent studies in northern Spain, Brittany and West Germany show that the base of the Pragian is nearly correlative with the base of the "Siegenian" in the sense of Carls (1987). One option would have been to select a GSSP for the "Siegenian" in a pelagic facies (e.g., Czechoslovakia), but the SDS decision to use the term "Pragian" reflects the feeling that the term "Siegenian" is too closely regarded in terms of a Rhenish, near-shore clastic, benthic facies, whereas "Pragian" signifies a diverse fossil assemblage that includes widespread pelagic fossils.

Boundary Stratotype (GSSP)

The position of the Lochkovian-Pragian boundary and the GSSP for it were accepted by the International Subcommission on Devonian Stratigraphy in August-October 1988, and approved by the International Commission on Stratigraphy and ratified by the Executive Committee of IUGS during January-February 1989. The stratotype is to be marked by

a plaque with explanation, and a permanent metal line is to be inserted in the rock face at the boundary. Marking and maintenance will be done by the Geological Survey of Czechoslovakia, in collaboration with the Center for Natural Reserves, also in Prague.

The GSSP of the sulcatus boundary is in southwestern Prague, in the section of Velká Chuchle (Fig. 1). This is an old quarry on the road from Praha-Velká Chuchle to Slivenec on V dolích Street (Přídoli), 8 km southwest of the city center. The quarry is on the nature reserve called "Homolka," in the district of Prague 5; the distance from a city bus terminus is about 400 m (Figs. 2 and 3). In the Velká Chuchle section, the stage boundary is defined as the base of Bed 12, at the first occurrence of E. sulcatus sulcatus.

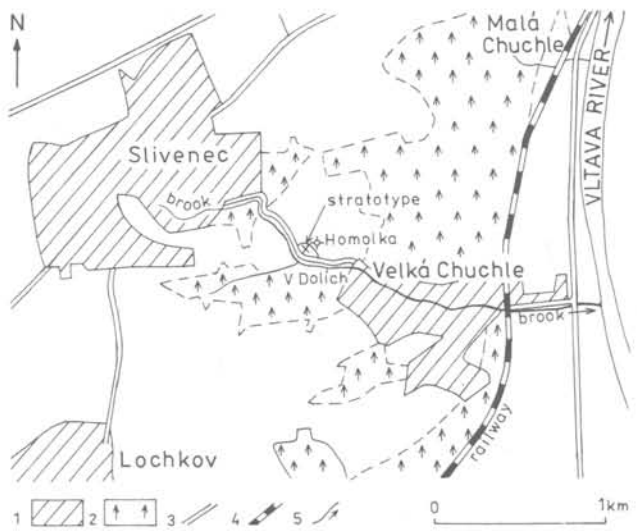

Figure 2: Map of immediate vicinity of Velká Chuchle and the stratotype section. 1- urbanized areas, 2- forests, 3- highways, 4- railway, 5- brooks.

The outcrops have been studied since Barrande's time (early 19th century), and the structure was clarified in the second half of the 19th century. Biostratigraphic studies of the Lochkovian and Pragian were carried out by Chlupáč in the 1950s, and detailed investigation of the boundary interval by Chlupáč, Lukeš, Paris and Schönlaub (1985) and Weddige (1987). The outcrop was visited by the Devonian Subcommission in 1986 (described in Chlupáč, Hladil, and Lukeš, 1986).

The outcrop exposes a synclinal structure formed by Lochkovian strata (limbs) and Pragian strata (core). The Lochkovian-Pragian boundary beds are exposed in both western and eastern limbs of the syncline. The section on the western side, where the beds form several simple folds, is the stratotype (Figs. 4, 5). In the eastern limb of the syncline the beds are vertical.

The upper Lochkovian consists of gray, fine-grained, biodetrital, bituminous platy limestones with uncommon cherts and subordinate very thin intercalations of calcareous mudstone beds that are millimetres to a few centimetres thick. The Lochkovian-Pragian boundary, based on the first occurrence of Eognathodus sulcatus, lies within this sequence, which shows no marked lithologic change.

Except for its lowest part, the Pragian sequence is represented by the Dvorce-Prokop Limestone. This is light gray, biomicritic to finely biodetrital in the lowest part and passes upward into darker gray micritic limestones. Bedding planes are knobby; the characteristic nodular structure is developed in micrites and biomicrites with Chondrites burrows that start 2 to 3 m above the stage boundary.

Boundary Level (base of Pragian)

The stage boundary was chosen by SDS in 1988 to coincide with the lower boundary of the Eognathodus sulcatus conodont Zone defined by the first occurrence of E. sulcatus sulcatus Philip, 1965. In some discussions this has been referred to as the sulcatus boundary. The E. sulcatus Zone was first defined by Fahraeus, 1971, and has since been accepted as part of the standard conodont zonal sequence (Klapper and Johnson, 1982). The name taxon and zone are now recognized in Czechoslovakia, Germany, Austria, China, Australia, U.S.A. (Nevada, Alaska) and Canada (see Weddige, 1987, p. 484-5, for details). Although nearly world-wide in distribution, it has not yet been recorded or recognized in the Soviet Union or eastern North America. These are major geographic gaps, but it seems likely that the former, at least, will be filled. Maximum provincialism and inappropriate lithofacies in eastern North America make it less likely that the zone will be recognized in this area, but other criteria permit approximate correlations.

E. sulcatus sulcatus is thought to be part of a lineage that proceeds from Ozarkodina pandora (early and late forms) to E. sulcatus (early and late forms). A series of morphotypes described in each species has biostratigraphic usefulness (Murphy, Matti and Walliser, 1981). The general sequence in the Pragian type region is illustrated by Weddige (1987, figs. 2-6). The defining morphologic character of the earliest sulcatus is remarkably clear (Weddige, 1987, p. 481).

Graptolite zonation. The boundary level lies above the graptolite Zone with Monograptus hercynicus, which is traditionally included in the upper Lochkovian. Nearly worldwide in distribution, it is known from Czechoslovakia, Thuringia, the Carnic Alps, Yugoslavia, Bulgaria, Sardina, NW Africa, the northern Ural mountains, Fergana, Central Asia, Malaya, Thailand, South China, Alaska, and western North America (Jaeger, 1979; Koren, 1979).

Dacryoconarid (tentaculite) zonation. The boundary is above the Paranowakia intermedia Zone, which is traditionally included in the upper Lochkovian and is also widespread (Europe, northwest Africa, Asia, and Australia). The base of the subsequent Zone with Nowakia sororcula (possibly = N. kabylica, see Alberti, 1988) lies just below the

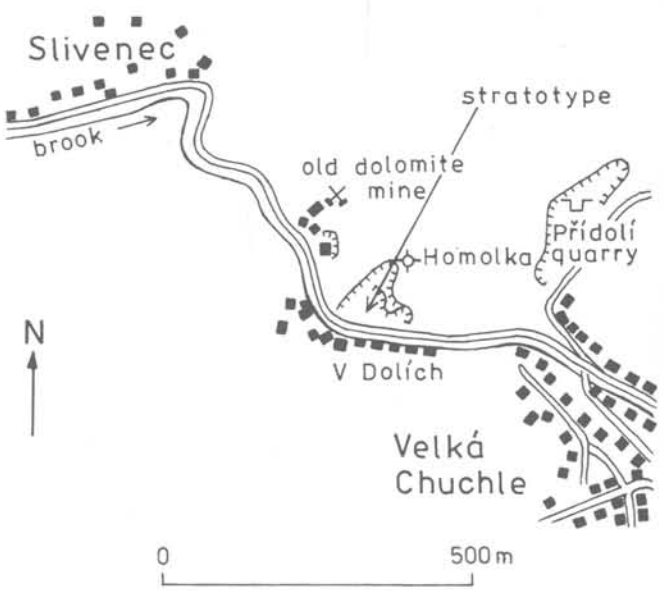

Figure 3: Detailed map of stratotype location.

Figure 4: View of the wall of the old quarry. A--A marks the boundary interval shown in Figure 5.

boundary, while the lowest occurrence of typical specimens of the worldwide Pragian index Nowakia acuaria s.s. is above the boundary; N. cf. acuaria occurs below the boundary (see Chlupáč, Lukeš, Paris and Schönlaub, 1985). N. acuaria is known from Europe (Bohemia, Thuringia, Franconia, Moravia, Harz Mts., Rhineland, Spain, Sardinia, Carnic Alps, Amorican Massif), Asia (Urals, Central Asia, Siberia, Burma, Tibet, China), northwest Africa (Morocco, Algeria), North America (Alaska, Canadian Arctic) and Australia (see summaries of occurrences in Alberti, 1979, 1987, Lütke 1979, 1985).

Chitinozoan zonation. This is the most promising method for the correlation of terrigenous clastic and non-marine sequences. The boundary falls just below the lowest occurrence of the Pragian index Angochitina comosa, close to the first occurrence of Gotlandochitina philippoti, and close to the last occurrence of Eisenackitina bohemica (Paris, 1981, and in Chlupáč et al., 1985).

It is inevitable that some of the ranges shown for taxa in the Velká Chuchle section will prove to be incomplete when studied on a worldwide basis, but the correlation potential of the boundary level is worldwide and can be approximated by means of several different groups of fossils with intercontinental distribution.

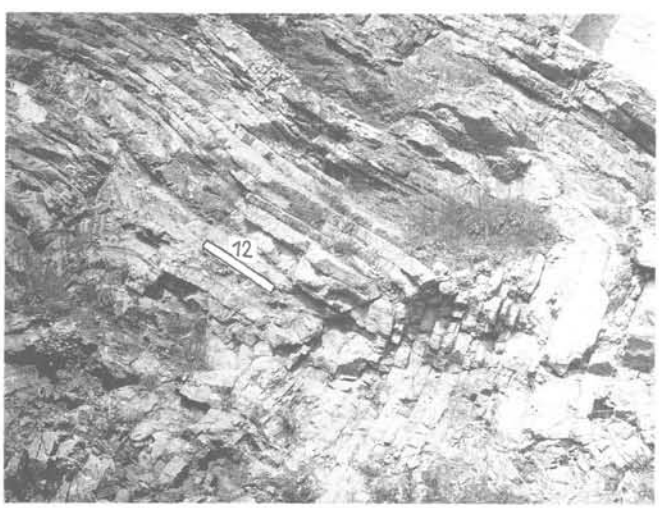

Figure 5: Boundary interval at stratotype section. The top of the white bar marks the boundary at the base of bed 12. The bar is approximately 0.7 m long.

Fossils

The occurrences of conodonts, chitinozoans and other index fossils are summarized in Figure 6 and detailed in Figure 7. The uppermost Lochkovian contains mostly fragmental macrofossils identical with those from other nearby localities: trilobites (Lepidoproetus lepidus lepidus, Ranunculoproetus heteroclytus, Leonaspis lochkovensis, Otarion novaki, Spiniscutellum plasi, and others); small chonetid, strophomenid (index Areostrophia interjecta, and others), atrypid and rhynchnonellid brachiopods; thin-shelled bivalves (Neklania, Hercynella, Panenka), gastropods, nautiloids, phyllocarids, etc. The characteristic upper Lochkovian macrofossils continue up into bed No. 12, that is above the first occurrence of Eognathodus sulcatus.

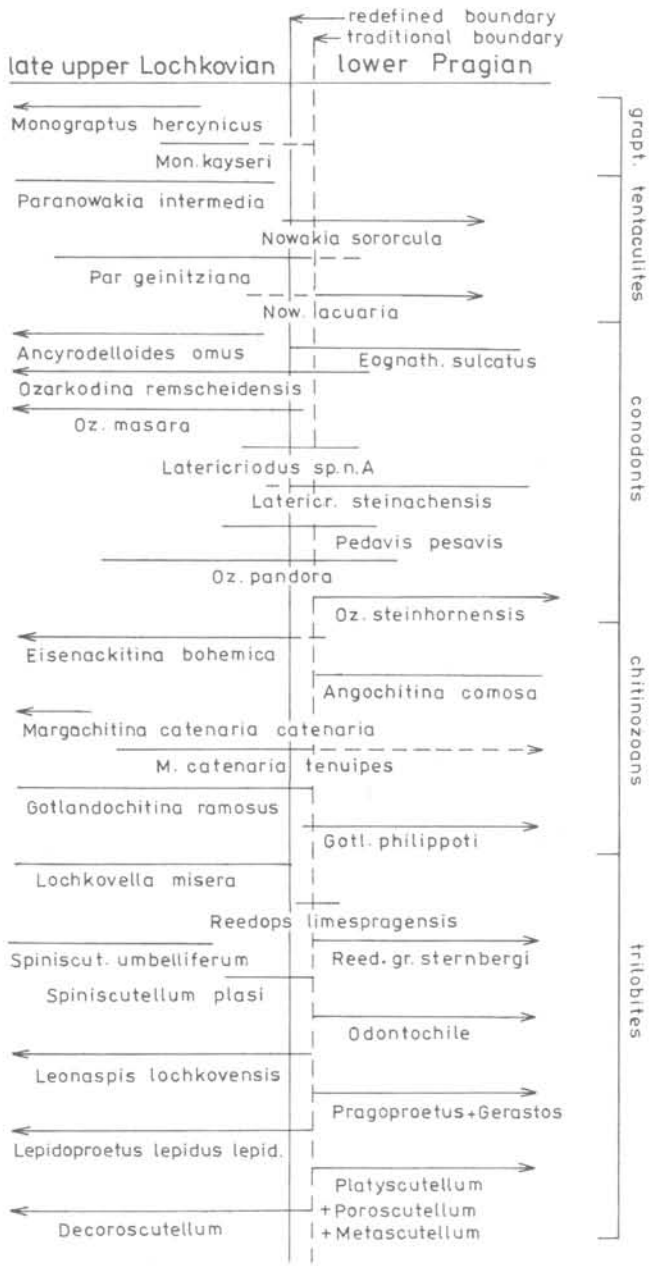

Figure 6: Ranges of selected index fossils as currently known in the Lochkovian-Pragian boundary interval in the Barrandian area. The interval shown is approximately 5 m above and below the boundary. Ranges are from sources cited in the text.

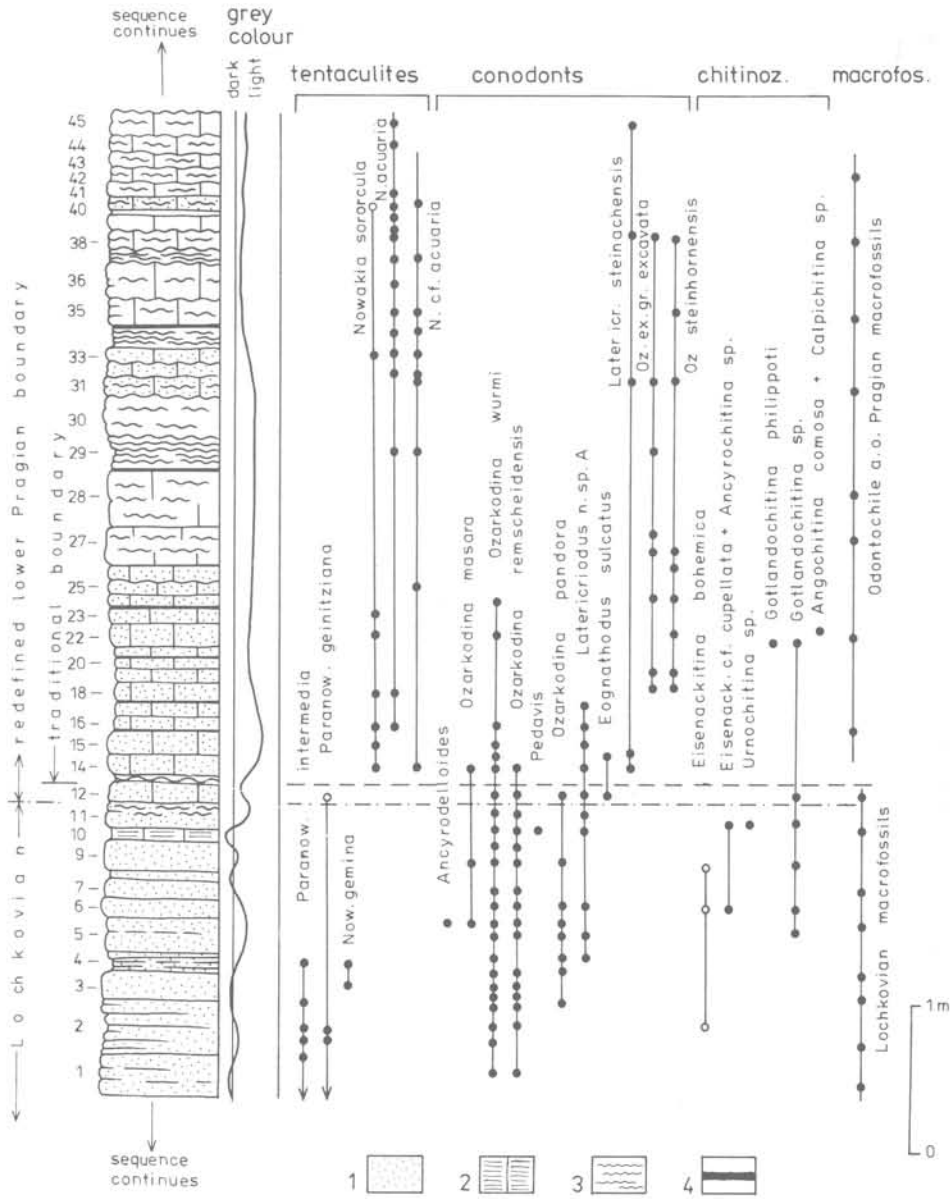

Figure 7: Columnar section of boundary interval at Velká Chuchle Quarry stratotype section; lithology and ranges of key fossils are shown. After Chlupáč, Lukeš, Paris and Schönlaub (1985) and Weddige (1987) with addition of new data (1988). 1- fine biodetrital to biomicritic limestones, 2- laminated micrites, 3- nodular micrites, 4- shale intercalations.

Dacryoconarid tentaculites are represented by all important zonal taxa of the upper Lochkovian-lower Pragian, and the same is true of conodonts (Figs. 6, 7). Chitinozoans are less common (1 to 4 specimens per gram of rock) but are also represented by index taxa.

Typical Pragian macrofossils, e.g. trilobites (Reedops prospicens, Reedops gr. sternbergi, Odontochile hausmanni and allied species, Crotalocephalus globifrons, Platyscutellum formosum formosum) and the brachiopod Dalejodiscus subcomitans are found in the lowest 5 m of the Dvorce-Prokop Limestone sequence. The lowest occurrence of the index Pragian tentaculite Nowakia acuaria (typical specimens) is about 50 cm above the lower limit of the Dvorce-Prokop Limestone and the species becomes abundant about 2 m higher.

The GSSP, the sulcatus boundary at the base of bed 12 (Figs. 5, 7), is 0.1 m below the traditional boundary, based on megafossils, at the base of the Dvorce-Prokop Limestone. Bed 12 has "Lochkovian" lithology and megafauna, indicating that the advent of E. sulcatus was not related to local facies change.

Summary

The E. sulcatus Zone is worldwide in extent and the name conodont has greater potential for recognition and correlation than any known fossil that occurs anywhere near the traditional Lochkovian-Pragian boundary. The position of the sulcatus boundary is 0.1 m below the traditional (megafossil) boundary in the type section (see Fig. 7).

The proposed stratotype is in a neritic facies of intermediate energy level and contains a highly diverse fauna of traditional and "new" index fossils. Because of this diversity, the Pragian Stage has become the preferred standard in many world regions. Selection of the GSSP permits greater precision in recognition of Pragian strata in other parts of the world. The GSSP is on the edge of Prague, Czechoslovakia, in a nature reserve where access is easy and preservation is assured.

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Dr. Ivo Chlupáč is a senior geologist with the Czechoslovakian Geological Survey, (Malostranské náměstí 19, 118-21 Praha 1). He works on Paleozoic (mainly Devonian) stratigraphy, and the paleontology of arthropods and goniatites. He is Chairman of the Czechoslovak Stratigraphic Commission, Vice-Chairman of the International Subcommission on Devonian Stratigraphy, and a member of the International Subcommission on Stratigraphic Classification and several other international stratigraphic bodies.

Dr. W.A. Oliver, Jr. is a research paleontologist with the U.S. Geological Survey (E-305 Natural History Bldg., Smithsonian Institution, Washington, D.C. 20560). His research interests are Late Silurian and Devonian rugose corals and biostratigraphy. He is a past president of the Paleontological Society, the Paleontological Research Institution and the American Geological Institute, and current Chairman of the Subcommission on Devonian Stratigraphy.

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