by Eva Paproth, Raimund Feist, and Gerd Flajs

Decision on the Devonian-Carboniferous boundary stratotype

The Global Stratotype Section and Point for the Devonian-Carboniferous boundary has been agreed upon now. The boundary is defined in trench E' at La Serre in the southeastern Montagne Noire, France.

Introduction

The Working Group on the Devonian-Carboniferous Boundary was established in 1976 by the International Commission on Stratigraphy (ICS). Its first field meeting visited 22 localities in northwestern Europe in 1978. One of the most impressive experiences of that 10-day trip was the opportunity to compare depositional environments that ranged from bathyal to continental and had rates of sedimentation that were more than 100 times greater in some areas than in others. It was apparent that obvious or inferable discontinuities were present in almost all the sections we visited.

The conclusion reached on our field trip in 1978 was confirmed during highly detailed research that was carried out on sediments and fossils near the Devonian-Carboniferous boundary in Europe, Asia, Africa, Australia, and America in succeeding years (Paproth and Streel, 1984; Flajs and others, 1988). The position of the boundary in the biostratigraphic sequence was established near the "classic" base of the *Gattendorfia* Zone: "This new definition is at the first appearance of the conodont *Siphonodella sulcata* within the evolutionary lineage from *Siphonodella praesulcata* to *Siphonodella sulcata*. . ." (Paproth and Streel, 1984, p. 5). This recommendation was submitted by R.H. Lane (USA), C.A. Sandberg (USA), and W. Ziegler (Germany) and was accepted in 1979 by the working group. The following 9 years were spent searching for a section that shows this evolutionary lineage. Both species occur worldwide but are restricted to pelagic facies.

In 1983 the working group recommended that work be concentrated on four sections: Hasselbachtal (Germany), Muhua (China), and Kija and Berchogur (USSR). The two in the USSR were dropped later for various reasons. In 1983 Hasselbachtal was chosen provisionally as a Global Stratotype Section and Point (GSSP). However, the final decision was postponed in order to reconsider the sections, as none of them was ideal because of the discontinuities of sedimentation and fossil transition near the boundary. The group planned to meet again in a "conclave" in May 1988 in Courtmacsherry, southern Ireland, for the purpose of finalizing the decision.

After a few years of seeming apathy, four more sections were proposed as possible candidate stratotypes following a "last call for candidate stratotypes," which was published in 1985 in several journals. The merits of these four sections were fiercely contended, an experience already described by Hedberg (1976, p. iv). These sections were Nanbiancun (China; Yu, 1988), La Serre (France; Feist and Flajs, 1987; Flajs and Feist, 1988), Drewer (Germany; Clausen and others, 1987, 1989 (additional description)), and Grüne Schneid (Austria; Schönlaub and others, 1988).

By the conclave meeting in May 1988, appropriate descriptions and documentation had been published or otherwise brought to the attention of the working group for only four of the six candidate sections: Nanbiancun (Yu, 1988), Hasselbachtal (Becker and others, 1984), Muhua (Hou and others, 1984), and La Serre (Flajs and Feist, unpublished manuscript). Although the date and decisive character of the conclave meeting had been known for about 4 years in advance, not all the competing specialists succeeded in attending the meeting. Nevertheless, outstanding specialists, members, and nonmembers of the working group thoroughly discussed the sections and fossils submitted to them. The specialists who were present voted on a "package," as follows: La Serre section, at the base of bed 89, is to be a Global Stratotype Section and Point, because it was the only section where "the first appearance of the conodont *Siphonodella sulcata* within the evolutionary lineage from *Siphonodella praesulcata* to *Siphonodella sulcata*" has been observed, the Hasselbachtal section and the Nanbiancun section being Auxiliary Stratotype Sections (Cowie and others, 1986, p. 5).

A postal ballot of the working group membership confirmed the above choice on 1 September 1988. The "Proposal of the Global Stratotype Section and Point (GSSP) for the Devonian-Carboniferous Boundary" was sent to the ICS and the International Union of Geological Sciences (IUGS) for acceptance and ratification in January 1989. During the ICS meeting in Washington, D.C., USA, in July 1989, La Serre section was accepted by that body, and in February 1990, it was accepted by IUGS.

La Serre section is far from being an ideal GSSP, but it was the only section known at the time that showed the "evolutionary lineage of *Siphonodella praesulcata* to *Siphonodella sulcata*." The inconveniences of La Serre section, such as the lack of some other important stratigraphic guides (for example, cephalopods, spores, and ash layers for radiometric dating) and the existence of reworking, induced the working group to support La Serre section by the Auxiliary Stratotype Sections of Hasselbachtal and Nanbiancun. These two meticulously described sections confirm and guarantee without any reasonable doubt the right position of the Devonian-Carboniferous boundary at the base of bed 89 in La Serre.

Another Chinese stratotype candidate (Dapoushang) was presented in 1989 (Ji Quiang and others, 1989). It seemed to have disadvantages similar to those of the nearby Muhua section, which had been given up earlier. The section came to the knowledge of the working group only after the decisive vote.

In summary, the experience of 12 years of study of this well-defined, short timespan from many parts of the world has taught us that no rock succession is or can ever be a complete representation of time; only a quick change of life (fossils) and environment (rocks) permits the worldwide correlation and recognition of beds of a defined age; these inevitable "irregularities" in fossil and rock sequences cause difficulties in finding suitable stratotype sections; and the political and psychological difficulties in determining stratotype boundaries should not be underestimated.

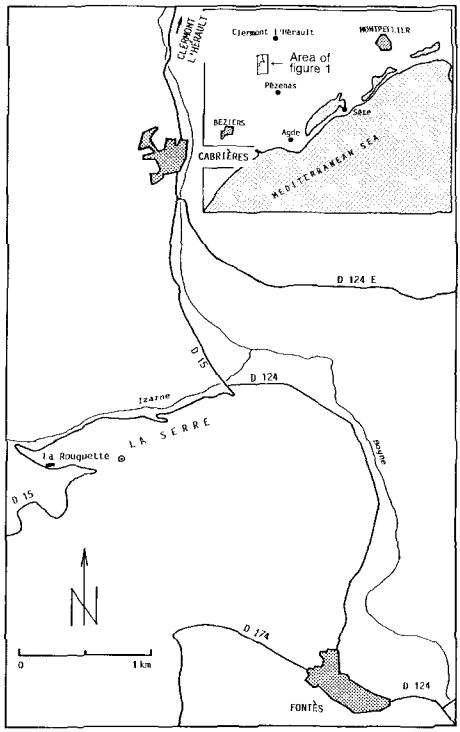

Figure 1.—Inset showing southern France and geographic location of La Serre hill and vicinity.

Titular Members of the working group for all or parts of its existence are M.J. Bless, I. Chlupáč, B.F. Glenister, H. Hollard†, M.R. House, L.I. Kononova, M. Lys, B.L. Mamet, E. Paproth, G. Playford, E.A. Reitlinger, C.A. Sandberg, P. Sartenaer, G.D. Sevastopulo, K.V. Simakov, M. Streel, Wang Chen-Yuan, and W. Ziegler.

Boundary stratotype (GSSP)

La Serre section is situated in the southeastern Montagne Noire, Département Hérault, District of Cabrières, southern France (figs. 1, 2). The rocks in the trench, as well as all of La Serre hill and vicinity, are part of the geologic unit named "Klippen of Cabrières." Artificial trench E', which averages 80 cm in depth on the southern slope of La Serre hill, is about 125 m south of the hilltop (252 m), about 525 m east of La Rouquette farmhouse, 2.5 km southwest of the village of Cabrières, 2.5 km northeast of the village of Fontès,

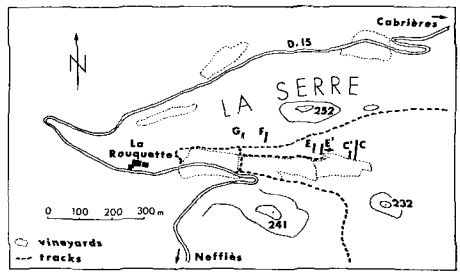

Figure 2.—La Serre hill and the trenches (E'=GSSP) near La Rouquette farmhouse south-southwest of the village of Cabrières.

and about 7 km northeast of the village of Neffiès (sheet 1:25,000 Pézenas XXVI/4, 1–2, x=682.55, y=140.12). The trench exposes about 35 m of "boundary beds" in a dipping section (figs. 3–5). The individual beds, which can be followed laterally, dip 70° to the south. They are not overturned, and schistosity and tectonic complications are absent.

Easy access is possible from Route Départementale D 15. There are no political or geographical problems of access. The area is macchia land ("garrigue," typical arid Mediterranean vegetation including sclerophyllous evergreens and thorn thickets, that is, *Ulex*, *Cistus*, *Juniperus*), and farmland use is not possible. The site cannot be overbuilt. The landowner, M. René Roux of La Rouquette farm, accepts the protection of La Serre site. The Cabrières officials are ready to apply for complete protection as a "site classé" at the departmental level.

The Devonian-Carboniferous boundary beds are described in detail by Engel and others (1982), Feist and Flajs (1987), Flajs and Feist (1988), Legrand-Blain and Martinez Chacon (1988), Semenoff-Tian-Chansky (1988), and Vachard (1988). These descriptions include location maps, columnar diagrams, and profiles showing relevant sedimentological and paleontological (fig. 6) data.

The presence of wocklumeriids indicates the upper *Parawocklumeria paradoxa* Zone for the topmost layers of the platy and nodular cephalopod-bearing limestones that are found below the oolite units. These layers can be correlated with the upper part of the lower *Siphonodella praesulcata* Zone, as *Pseudopolygnathus marburgensis trigonicus* occurs without protognathodids. The index fossil *S. praesulcata* enters the section together with the first protognathodids, such as *Protognathodus collinsoni* and *meischneri*, in the lower oolite unit at beds 73 and 70, respectively. This index fauna is joined by *Protognathodus kockeli* and transitional forms between *S. praesulcata* and *S. sulcata* at the base of the upper oolite unit (bed 85), which indicates an age at the beginning of the upper *S. praesulcata* Zone. Undoubted morphotypes of *S. sulcata* first occur in bed 89, at the base of which the actual GSSP is defined accordingly.

One single siphonodellid fragment from bed 85 is problematic, as it is controversially considered by Cowie and others (1989) to be a typical representative of *S. sulcata*. However, the slight longitudinal arch and the narrow symmetrical outline of the platform adjacent to the carina, which presents a "broken" curvature, are untypical features following the revised diagnosis and figures given by Sandberg and others (1972) (the holotype of *S. sulcata* is lost). This specimen, therefore, has been regarded as representing an intermediate morphotype between *S. praesulcata* and *S. sulcata*.

Figure 3.—View from the east looking at the stratotype section (La Serre trench E') that contains the Devonian-Carboniferous boundary GSSP (arrow). The box is 30 cm in width.

Figure 4.—Closeup view of the upper oolite unit showing the position of the GSSP between the top of bed 88 and the base of bed 89. The number "90" is 4 cm high.

Figure 5.—Superposition of boundary beds 88 and 89 in complete continuity to the west of the GSSP. The numbers are 4 cm high.

Boundary bed 89 yields a great number of diversified microfaunas and macrofaunas that are of correlative value. The trilobites include *Belgibole abruptirhachis*, which also occurs immediately above the Hangenberg Schiefer interval in various cephalopod-bearing sections from the Rhenish Slate Mountains (Germany), the Holy Cross Mountains (Poland), and the Carnic Alps (Austria). Although generally associated with the first *sulcata*, it may occur slightly earlier at Müssenberg (Sauerland, Germany) and at Grüne Schneid (Carnic Alps). Other trilobites to be found in bed 89, such as *Archegonus* (*Phillibole*) and *Carbonocoryphe*, are related closely to forms from the basal Tournaisian of Carboniferous time at Dalnia (Holy Cross Mountains), Dapoushang (Guizhou, China), and Grüne Schneid, everywhere occurring in cephalopod-bearing limestones. *A. (Phillibole) drewerensis* appears at a slightly younger level (bed 98), as it does in the Carnic Alps and in several sections on the northern side of the Variscan belt, as well as in south China (Dapoushang). Representatives of the shallow biodetrital facies are *Brachymetopus germanicus*, known from Rhineland (Germany), and a new form ("*Perliproetus*") that is related closely to *Pudoproetus missourensis* from the topmost Famennian of Devonian time in Missouri and Utah (USA), as well as to *P. guangxiensis* from the *S. sulcata* Zone at Nanbiancun (near Guilin, Guangxi, China).

The brachiopod and coral faunas are quite diverse, and the first results have been published by Legrand-Blain and Martinez Chacon (1988) and by Semenoff-Tian-Chansky (1988), respectively. These shallow-water communities, together with numerous foraminifera, such as *Quasiendothyra regularis* vel *communis*, algae, and microproblematica (Vachard, 1988), permit correlation with platform communities that are widespread on the Franco-Belgian and Russian platforms.

The mixture of pelagic elements and nearshore biotas underwent quasicontemporaneous, short-lasting transport by debris flows before lithification. As stated by Legrand-Blain and Martinez Chacon (1988) for the brachiopods, the allodapic fossils within the boundary beds show features of transport but have no signs of stratigraphic reworking. These fossils permit, in particular, direct correlation of the deeper basinal domain with the shallow-water environment of the "Kohlenkalk" platform type. As far as conodonts are concerned, only "autochthonus" basinal conodonts from the matrix are considered.

Because of its exceptional paleogeographic position under direct nearshore influence, the stratotype section shows a series of transgressive and regressive pulses that, if of eustatic origin, may be of value for correlation of earliest Carboniferous time.

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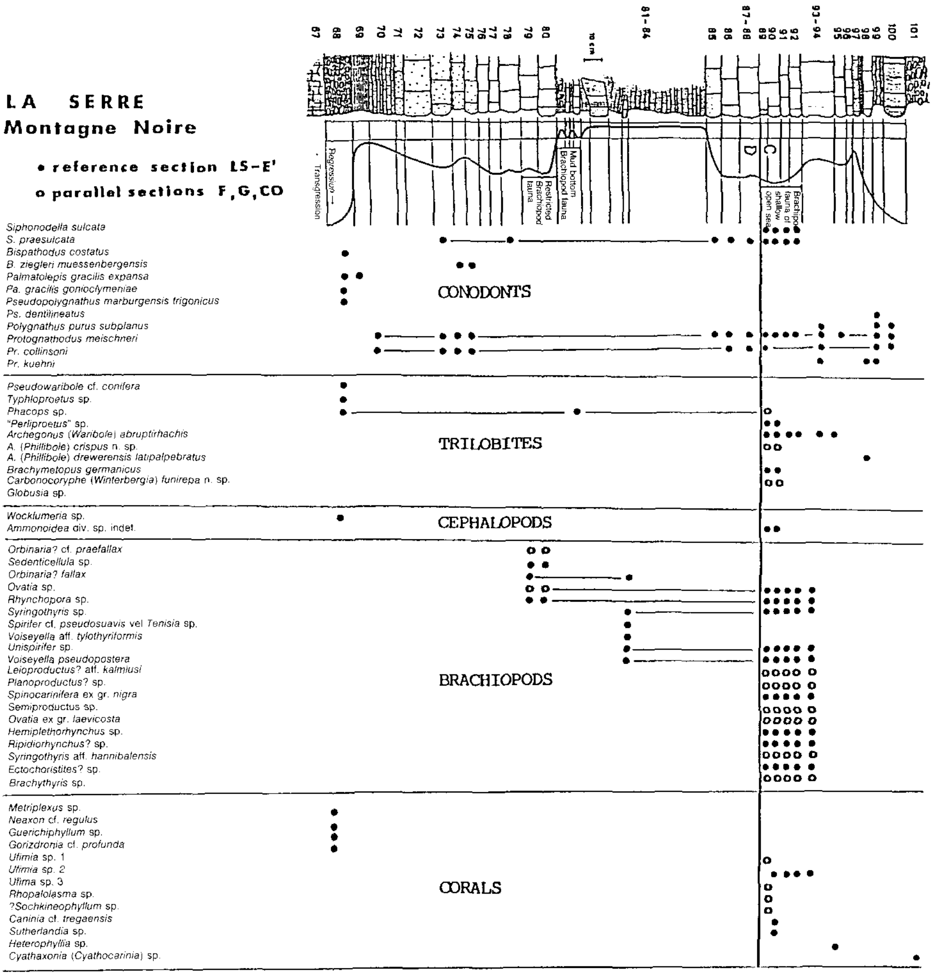

Figure 6.—Fossil content of the boundary beds in La Serre trench E' and environmental interpretation of some sedimentologic and faunal features (modified from Flajs and Feist, 1988; Legrand-Blain and Martinez Chacon, 1988; Semenoff-Tian-Chansky, 1988; Vachard, 1988; and additional determinations). Abbreviations: D, Devonian; C, Carboniferous; LS, La Serre; F, G, CO, profiles parallel to the stratotype section. See figure 2 for locations of sections.

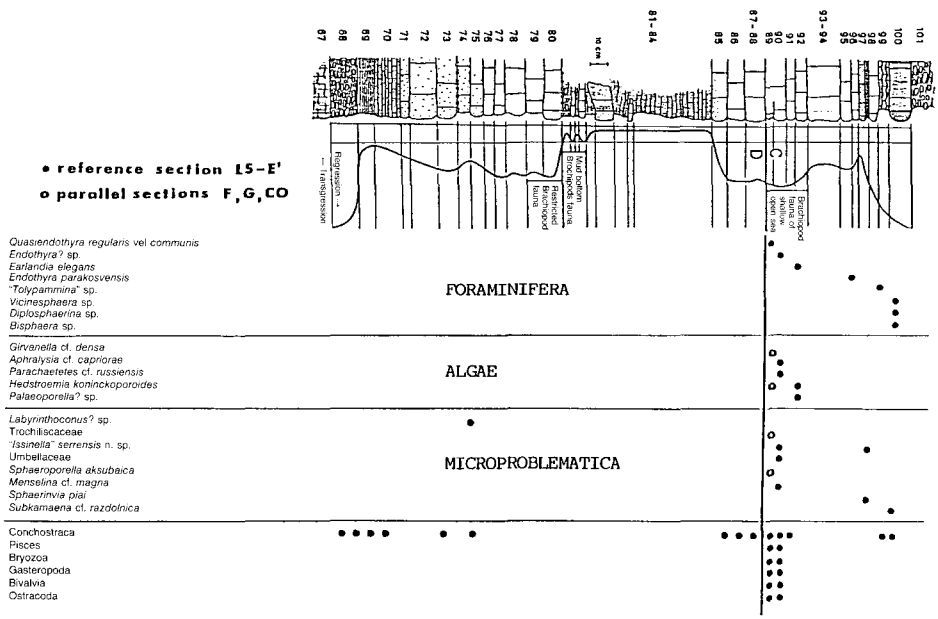

Figure 6.—Continued.

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