NEW CONSTRAINTS FOR THE LADINIAN-CARNIAN BOUNDARY IN THE SOUTHERN ALPS: SUGGESTIONS FOR GLOBAL CORRELATIONS

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INTRODUCTION

The Ladinian-Carnian boundary interval is represented in many localities of the Southern Alps (Northern Italy) by continuous and expanded basinal successions. The boundary interval is best exposed in Badia and Cordevole valleys (Dolomites); there, the Stuores Wiesen section has been indicated as a possible GSSP site for the Carnian stage (Broglio Loriga et al., 1999). The purpose of this study is to critically review the potential of Stuores Wiesen as a GSSP candidate, in the light of new data and interpretations that have arisen in the last eight years (e.g., Manco et al., 2004; Mietto et al., 2004).

GEOLOGICAL AND STRATIGRAPHIC SETTING

The Late Ladinian-Early Carnian sedimentation of the Dolomites is characterized by the growth and progradation of carbonate platforms on small, connected and articulated basins several hundred meters deep (Bosellini et al., 2003). The dismantling of volcanic edifices in the Dolomites (e.g., Predazzo) or in adjacent regions provided an abundant and continuous supply of volcanic arenites and clays. Active growth of platforms shed abundant carbonates into the basins during the Early Carnian.

This continuous supply of carbonate and terrigenous materials led to constantly high sedimentation rates, and guaranteed the expansion and continuity of stratigraphic series. The Ladinian-Carnian boundary interval in the Badia Valley is represented, in the basinal series, by the Wengen/La Valle and San Cassiano formations.

The Wengen/La Valle Formation is a flysch-like succession of turbiditic arenites, siltites and shales, organized in a long-term fining upward trend. A conglomeratic unit (Conglomerato della Marmolada) is present at its base. Calciturbidites or carbonate olistoliths and/or olistostromes are also present, and are thought to derive from the erosion of a subaerially exposed Ladinian carbonate platform or from local fringing reefs.

Above the Wengen/La Valle Formation lies the San Cassiano Formation, constituted by shales, marls, micritic limestones and fine to coarse calciturbidites, including oolites. The carbonate content of the San Cassiano Formation derives from the active growth of mostly prograding carbonate platforms (Cassianian 1 and 2).

STUDIED STRATIGRAPHIC SECTIONS

Being the most complete and thoroughly studied section of the Badia and Cordevole valleys area (Fig. 1), the Stuores Wiesen section is the natural choice as candidate for the GSSP of the Carnian stage (Fig. 2). The section is located at Pralongià, a few km south of the village of San Cassiano, in the high Cordevole Valley, and is accessible from the village of Corvara by chair-lift and an easy walk in less than one hour. It consists of a ca. 220-m-long composite succession encompassing the La Valle and San Cassiano formations (Fig. 3).

Other sections have been selected in the type area to better illustrate the faunal changes in the boundary interval. The Antersass section is located on the northern flank of Gardenaccia, south of the village of Longiarù in the middle Badia Valley. This section is totally within the San Cassiano Fm. and is noticeable for the abundance of fairly well preserved ammonoids. It contains the best record of the boundary between the canadensis and the aon subzones (Fig. 4).

The Bec de Roces section is located on the eastern flank of the Sella massif, near Passo Campolongo at the head of Cordevole Valley. It is a short section within the lower San Cassiano Fm. that best illustrates the ammonoid associations typical of the canadensis Subzone (Fig. 5).

Other stratigraphic sections of the Badia Valley or surroundings (Col da Oi, Passo Gardena, Passo Sella) have also been studied in the past years. Descriptions of these localities may be found in the literature (Mietto and Manfrin, 1995a, b).

MAGNETO-, CHEMO-, AND SEQUENCE STRATIGRAPHY

The magnetostratigraphic setting has not been modified after Brogli Loriga et al. (1999). The correlation with the coeval Mayerling section (Gallet et al., 1998, fig. 10) by comparison of magnetostratigraphic data and the vertical distribution of conodont taxa proposed at that time has been further confirmed by the new find of the conodont Paragondolella polygnathiformis noah (Hayashi) 70 cm above the first occurrence of Daxatina canadensis (Whiteaves). Stable C and O isotope investigations are still in process at the University of Innsbruck and will be reported soon.

The sequence stratigraphic framework is the same presented in Brogli Loriga et al. (1999) across the proposed boundary as well as its global correlation. The boundary is placed at the beginning of the regressive trend just after the Car 1 maximum flooding surface (sensu Gianolla et al., 1998) in a section presenting very high sedimentation rates (Gianolla, 1995). The mfs is one of the best traceable surfaces for basin-wide correlation. Thus the potential for correlation of the proposed boundary is enhanced by sequence stratigraphic interpretation, especially with sections characterized by lower sedimentation rates.

BIOSTRATIGRAPHY

Ammonoids

The taxonomic revision of the ammonoids from the Stuores Wiesen section and the joint studies of a rich fauna recovered at the Antersass and Bec de Roces sections and surroundings allow us to delineate better the faunal association of the canadensis Subzone from the Southern Alps, and to recognize those taxa which are useful to correlate different paleobiogeographic domains.

With reference to previous data (Mietto and Manfrin, 1995a, b; Brogli Loriga et al., 1999), the most important observations, chiefly new, regard the following taxa:

a) genus Daxatina: the comparison of Southern Alps specimens belonging to genus Daxatina with type materials from Canada (courtesy of M. Balini), demonstrates that Daxatina canadensis (Witheaves) occurs, indeed, in the Southern Alps. Thus, the previous Daxatina cf. canadensis Subzone should now be considered as canadensis Subzone, whose base coincides with the FAD of the index species. Among the material from the Stuores Wiesen section, another Daxatina species is present. Moreover, from the debris of the Antersass section, a specimen comparable with the Canadian species Daxatina laubei Tozer has been collected.

b) genus Frankites: a further paleontological study of the species...
FIGURE 1. Sketch map of the studied area.

FIGURE 2. Panoramic view of the Stuores Wiesen section.
FIGURE 3. Stuores Wiesen section.
FIGURE 4. Antersass section.
FIGURE 5. Bec de Roces section.
Frankites apertus (Mojsisovics) showed it is distinguished from Frankites regoledanus (Mojsisovics), but coincides with the North American species Frankites sutherlandi (McLear). Another Frankites species has been recovered in the regoledanus-canadensis subzones. This species, indicated as Frankites n. sp. in Figure 3, is characterized by a rather low number of ribs per whorl compared to the other species of the genus;

c) genus Trachyceras: at least two different species belonging to the genus Trachyceras have been documented within the biostratigraphic studied interval: Trachyceras bipunctatum (Münster) and T. muensteri (Wissmann). An exemplar of the latter species exhibits a subammonitic suture line typical of the genus Trachyceras, which is quite different from that of the genus Daxatina. Furthermore, in some species, the shape and dimensions of the nodes in ventral position seem to be useful to distinguish the two genera even if the suture line cannot be checked. In the Antersass section, the joint occurrence of Trachyceras aon (Münster) and Brothetheatrachyceras spp. marks the base of the aon Subzone. This subzone boundary is not so well documented in the Stuores Wiesen section.

d) genus Zestoceras: the Canadian species Zestoceras enode (Tozer) prudently identified here with open nomenclature, is documented in the regoledanus Subzone. In the canadensis Subzone, Zestoceras n. sp. A is instead common. This species is also recognizable in the ammonoid succession from the sutherlandi Subzone 2 of British Columbia (see Tozer, 1994, pl. 82, fig. 5, identified as Zestoceras enode). Specimens of Stuores Wiesen section previously referred to Clionitites sp. are now identified as Zestoceras barwicki (Johnston), a species known from the New Pass Range (Nevada, USA). As suggested by Johnston (1941), we consider Zestoceras barwicki (Johnston) exactly like the exemplar from Pozoritta (now Pojorita) in Bukowina (Rumania), labelled as Trachyceras armatum (Münster) by Mojsisovics (1882, pl. 34, fig. 2). More recently Tozer (1994) noticed the resemblance of the previous exemplar with the Canadian species Zestoceras cerastes Tozer, from the sutherlandi Subzone 2 of Tozer (1994). Since we consider those specimens as belonging to the same taxon, they should be identified as Zestoceras barwicki (Johnston) by priority.

e) Specimens previously determined as “Anolcites” ex gr. laricus (Mojsisovics) are now assigned to “Anolcites” thusneldae Mojsisovics. This species firstly occurs together with Daxatina canadensis (Witheaves) in bed SW 4 at Stuores Wiesen.

f) “Ceratites” sp., recovered in the upper part of the Stuores Wiesen section just below the canadensis/aon subzones boundary (Broglío Loriga et al., 1999), is now identified as “Ceratites” armatus (Münster), a taxon also documented in the aon Subzone. In the same part of the section Badiotites eryx (Münster) occurs.

The canadensis Subzone is chiefly characterized by the species Daxatina canadensis, Trachyceras muensteri, T. bipunctatum, Frankites apertus, Zestoceras n. sp. A, Z. barwicki and “Anolcites” thusneldae. Daxatina canadensis is documented in the Himalayas (Balini et al., 2001; Krystyn et al., 2004), in Alaska (Martin, 1926), in Canada (Tozer, 1994) and in the Svalbard Islands (Böhm, 1903, 1904; Mørk et al., 1992).

The ammonoid assemblage of the canadensis Subzone of the Southern Alps best resembles that of the sutherlandi Subzone 2 of North America. Because of the wide distribution of this species, D. canadensis is an excellent candidate as the primary marker for the base of the Carnian stage. The latter was historically marked by the occurrence of Trachyceras aon, which was considered the first Trachyceras. In the canadensis Subzone, two Trachyceras species different from T. aon predate the first appearance of the quoted genus. Hence, the assignment of a Carnian age to the canadensis Subzone perfectly fits also with an historical point of view.

The choice of Daxatina canadensis (Witheaves), a fairly cosmopolitan species, as biomarker for the base of the Carnian stage, and consequently the proposal of the Stuores Wiesen section as GSS and the bed SW4, in which D. canadensis appears, as Point for the base of the Carnian stage, guarantees a global correlation among several domains. This correlation potential is also confirmed by other taxonomic groups as well as by physical signals.

Conodonts

Although the Prati di Stuores/Stuores Wiesen section has been investigated several times for conodont biostratigraphy, a poor fauna has been recorded. This fauna is composed of Budurovignathus mungoensis (Diebel), Budurovignathus mostleri (Kozur), Budurovignathus diebeli (Kozur & Mostler), Budurovignathus longobardicus (Kovács) and by the long-ranged species Gladigondolella malayensis malayensis Nogami and Gladigondolella tethydis (Huckriede) (Broglío Loriga et al., 1999). All these species range at least from the upper part of the Longobardian (upper Ladinian) to the lower part of the Julian (lower Carnian).
Recently, *Paragondolella polygonathiformis noah* (Hayashi) has been recovered in the Prati di Stuores/Stuores Wiesen section (Fig. 6). This species is from sample SW 4c, 70 cm above the first occurrence of *Daxatina canadensis* (Whiteaves) (bed SW 4). The first occurrence of *Paragondolella polygonathiformis noah* (Hayashi) seems to be the most useful conodont biomarker to recognize the base of the Carnian stage.

**Palynomorphs**

Palynological assemblages from the Stuores Wiesen section are characterized by a well-diversified microflora, mainly including spores, pollen grains and subordinately organic-walled marine elements (acrocarps, foraminiferal linings and tasmanitids). The microflora of the *regoledanus* Subzone primarily includes sporomorphs ranging in age from the Ladinian to the Carnian. Successive steps of significant diversity increase are well recognizable throughout this subzone: the upper part is characterized by the first occurrence of Enzonulasporites vigens and Concentricisporites cf. Concentricisporites biamulus, and the uppermost part by the first occurrence of “Lueckisporites” cf. *singhii*. The association correlates with the uppermost part of secatus-vigens phase of *Van der Eem* (1983).

A more gradual microflora diversification is registered at the base of *canoledanus* subzones boundary as in the entire canadensis Subzone. The first occurrence of *Daxatina canadensis* at Stuores Wiesen is very close to a significant compositional change, mainly consisting in the replacement of Upper Ladinian-Carnian sporomorphs by typical Carnian taxa. The first occurrence in the section, from 3.2 to 48.1 m above the bed SW4 (see Fig. 3), of the Carnian species *fällasporites ignacii*, *Patinasporites densus* and *Aulisporites cf. A. astigmosus*, in association with *Enzonulasporites vigens*, allows us to refer the palynological associations from the lower part of the *canadensis* Subzone to the *vigens-densus* phase of *Van der Eem* (1983) as previously proposed by Broglio Loriga et al. (1999).

**Other Groups**

No new data on other fossil groups (e.g., foraminifers, microcrinoids, holothurian sclerites, molluscs and brachiopods and bivalves) have been reported since Broglio Loriga et al. (1999). The presence of “praehalobid” bivalves has been confirmed within the *canadensis* Subzone also in the Bec de Roces section (R. Posenato, pers. comm.).

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**REFERENCES**


