



EPICONTINENTAL TRIASSIC INTERNATIONAL SYMPOSIUM

Halle/S.  Germany
September 21 – 23, 1998

STS MEETING, HALLE 22 SEPTEMBER 1998

The Meeting of the Subcommittee on Triassic Stratigraphy will be held in Halle during the International Symposium on the Epicontinental Triassic, the 22 of September at 4.00 p.m.

Provisional Agenda

- 1) President' announcements.
- 2) Status of GSSP' selection. To be noted that any decision cannot be taken during the meeting, because all the decisions must be done by postal ballot.
- 3) Up-dating of the list of Voting and Correspondent Members.
- 4) Next meetings.
- 5) Any other questions.

Maurizio GAETANI



FROM THE EDITOR

Several colleagues reacted on the announcement in ALBERTIANA 20 that I might be forced to step down as editor. All expressed their great appreciation for the work that has been done over the past eight years to establish ALBERTIANA as a flourishing STS newsletter and discussion forum. However, the general feeling was that ALBERTIANA should further be produced in Europe. Nevertheless, several North American colleagues offered to help editing texts written by non-English/American authors. This offer is greatly appreciated because editing of such texts often appears to be one of the most critical and time-consuming parts of the production process. With joint efforts the production process of ALBERTIANA can surely be speeded up considerably, thereby keeping the workload acceptable for everyone involved. With the support of a small editorial committee I will surely be able to continue my work for ALBERTIANA. Finally, I once again would like to thank for all the encouraging and positive reactions.

Hans KERP

**A GSSP CANDIDATE FOR THE LADINIAN/CARNIAN BOUNDARY:
THE PRATI DI STUORES/STUORES WIESEN SECTION
(DOLOMITES, ITALY).**

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G.F. Laghi, W. Lowrie, S. Manfrin, A. Mastandrea, P. Mietto,
G. Muttoni, C. Neri, R. Posenato, M. Rechichi,
R. Rettori and G. Roghi**

Introduction

An Italian *ad hoc* working group, co-ordinated by C. Broglio Loriga, proposes the Prati di Stuoeres/Stuoeres Wiesen section (Dolomites, Italy) as a GSSP candidate for the definition of the base of the Carnian stage. The Prati di Stuoeres/Stuoeres Wiesen area is famous thanks to the classical works by Münster (1834), Wissmann and Münster (1841), Klipstein (1845), Laube (1869), Mojsisovics (1869, 1882), Ogilvie Gordon (1893). Besides being a rich and famous fossiliferous locality, it also includes the type-section of the Cordevolian substage *sensu* Mojsisovics, Waagen and Diener (1895) and Urlichs (1974). The Prati di Stuoeres/Stuoeres Wiesen section lies in the neighbourhood of Pralongià, on the southern slope of the crest separating the Badia/Abtei Valley and the Cordevole Valley (Fig. 1).

The section supplies a rich ammonoid fauna which predates the first appearance of *Trachyceras* and documents the presence of genus *Daxatina*, a particularly significant taxon for global correlations (Mietto and Manfrin, 1995a, b). Due to its possibility of correlating different paleolatitudinal provinces, the presence of the cosmopolitan genus *Daxatina* suggests placing the Ladinian/Carnian boundary in a lower position than previously indicated in the same section (cf. Urlichs, 1974, 1994; Krystyn, 1978).

The candidature of the Prati di Stuoeres/Stuoeres Wiesen section is here outlined in a synthetic form with the indications of its main stratigraphical, biostratigraphical and magnetostratigraphical features. Lithostratigraphy and sequence stratigraphy are by V. De Zanche and P. Gianolla (Padova) and C. Neri (Ferrara), magnetostratigraphy by W. Lowrie and G. Muttoni (Zürich), ammonoids and biochronostratigraphy by S. Manfrin and P. Mietto (Padova), conodonts by A. Mastandrea (Modena), palynomorphs by S. Cirilli (Perugia) and G. Roghi (Padova), isolated foraminifers by D. di Bari (Modena), foraminifers in thin section by C. Broglio Loriga (Ferrara) and R. Rettori (Perugia), gastropods, bivalves and brachiopods by R. Posenato (Ferrara), microcrinoids and holothurians by G.F. Laghi and M. Rechichi (Modena).

The Prati di Stuoeres/Stuoeres Wiesen section was permanently stacked out in order to avoid any possible dissension between samplings carried out by workers at different times.

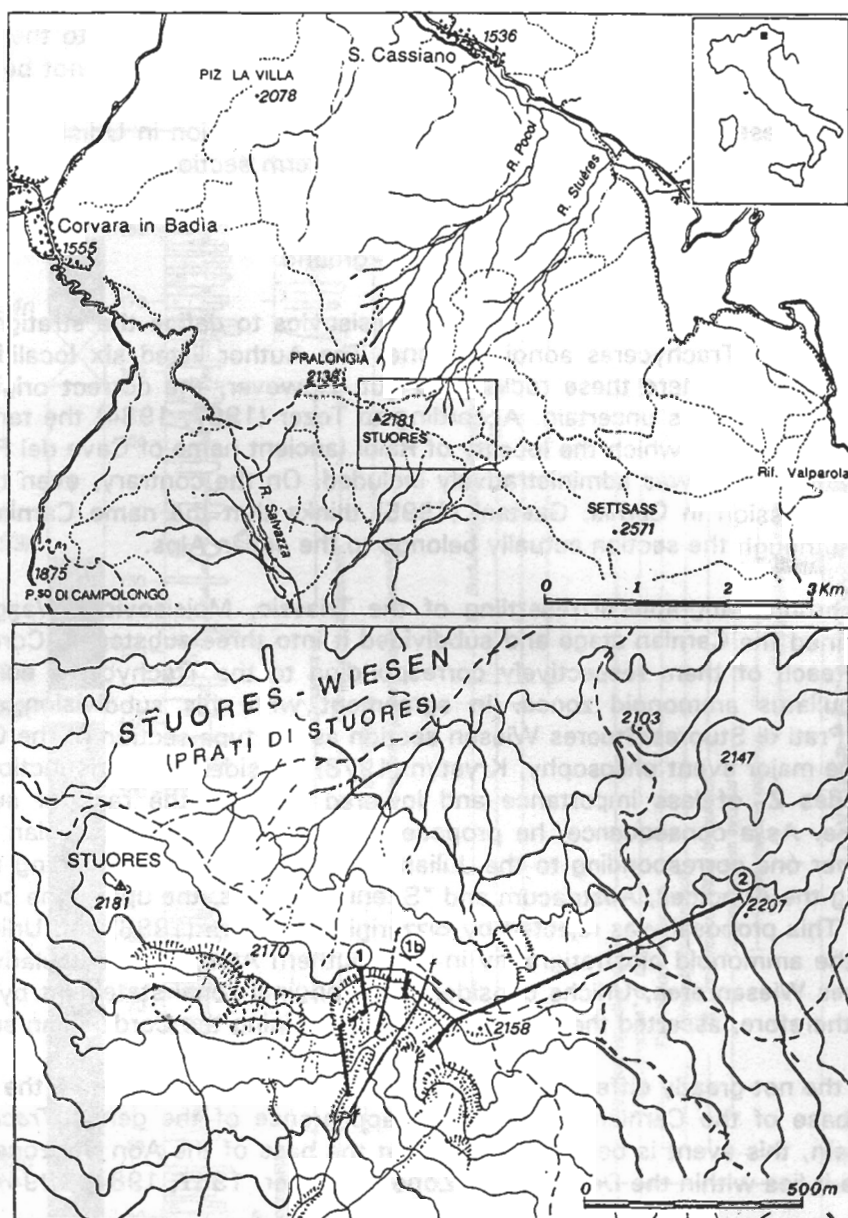


Fig. 1. Location of the Prati di Stuores/Stuores Wiesen area and stratigraphic sections. Sections 1 and 1 bis correspond to the column in Fig. 2. Section 2 corresponds to the Stuores Wiesen section in Ulrichs (1974, 1994) and to the section SW5 in Neri et al. (1995).

The section consists of two parts (Figs. 1 and 2). The westernmost one, herein named section 1, exactly corresponds to section SW4 in Neri et al. (1995) and to the section illustrated by De Zanche and Gianolla (1995) and by Mietto and Manfrin (1995 b). It extends downward for about 20 m below picket 0, which marks the base of the section studied by the team. The top of section 1 is correlatable to a short section (section 1 bis), lying just eastward, not stacked out and separated by faults with modest throw. Lastly, an eastern section (section 2) exists, which

corresponds to the Stuoeres Wiesen section in Urlichs (1974, 1994) and to the section SW5 in Neri et al. (1995). Due to tectonic omission, the base of the section 2 cannot be correlated with the top of the section 1 bis. Further indications on the relationships between the Prati di Stuoeres/Stuoeres Wiesen section as intended herein and the section in Urlichs (1974, 1994) are reported in Neri et al. (1995). In the following text, the term section 1 is intended as the Prati di Stuoeres/Stuoeres Wiesen section.

Historical background

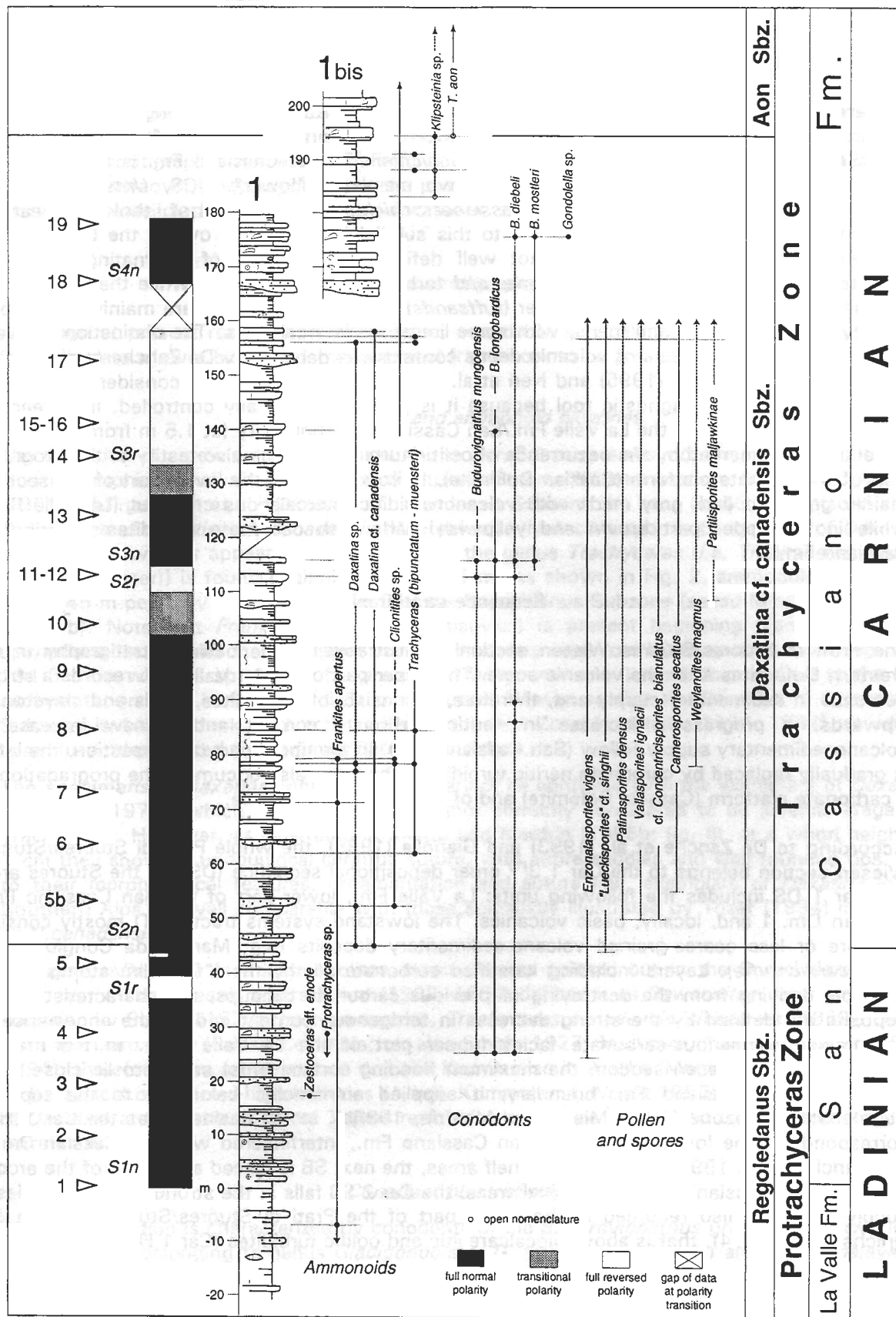
The name Carnian was introduced in 1869 by Mojsisovics to define the stratigraphical interval corresponding to the *Trachyceras aonoides* Zone. The Author listed six localities, then under Austro-Hungarian rule, where these rocks crop out. However, the correct origin of the name Carnian (*Karnische Stufe*) is uncertain. According to Tozer (1967, 1984) the term derives from Carinthia (*Kärnten*), within which the locality of Raibl (ancient name of Cave del Predil), explicitly indicated by Mojsisovics, was administratively included. On the contrary, even though referring to the Raibl succession in Carnia, Gaetani (1995) thinks that the name Carnian derives from Carnian Alps, although the section actually belongs to the Julian Alps.

Within their chronostratigraphical resettling of the Triassic, Mojsisovics, Waagen and Diener (1895), re-defined the Carnian stage and subdivided it into three substages, Cordevolian, Julian and Tuvanian, each of them respectively corresponding to the *Trachyceras aon*, *T. aonoides*, *Tropites subbullatus ammonoid* zones. In agreement with this subdivision, Urlichs (1974) considers the Prati di Stuoeres/Stuoeres Wiesen section as the type-section of the Cordevolian. On the basis of the major event philosophy, Krystyn (1978) considered the distinction between *Aon* Z. and *Aonoides* Z. of less importance and lowered them to the rank of subzones of the *Aonoides* Zone. As a consequence, he proposed a subdivision of the Carnian stage into two parts: the lower one corresponding to the Julian substage, obviously including the Cordevolian and comprising the *Aonoides*, *Austriacum* and "Sirenites" zones, the upper one corresponding to the Tuvanian. This proposal was rejected by Bizzarini and others (1986) and Urlichs (1994). On the basis of the ammonoid biostratigraphy in the Southern Alps, and particularly in the Prati di Stuoeres/Stuoeres Wiesen area, Urlichs considered the original zonal statement by Mojsisovics to be valid and, therefore, asserted the opportunity of maintaining the Cordevolian substage.

Leaving aside the not greatly differing opinions of various authors, up to now the general rule for locating the base of the Carnian was the first appearance of the genus *Trachyceras*. In the Tethyan domain, this event is believed to occur at the base of the *Aon* Subzone/Zone, while in North America it lies within the *Desatoyense* Zone (cf. Tozer, 1967, 1984, 1994).

Recently, Mietto and Manfrin (1995a, b) have defined a stratigraphical interval, characterized by species of *Trachyceras* different from *T. aon* and associated with *Daxatina* and *Clionitites*, which, in the Prati di Stuoeres/Stuoeres Wiesen section, is placed below the traditional base of the Carnian. The earlier occurrence of *Trachyceras* and the concomitant occurrence of a cosmopolitan genus such as *Daxatina*, encouraged the two authors to suggest the lowering of the Ladinian/Carnian boundary. In this way, the lowermost Carnian should include the upper part of the *Frankites regoedanus* Zone (Krystyn in Zapfe, 1983), usually considered Ladinian and correlated with the *Frankites sutherlandi* Zone in North America.

Fig. 2. A synthesis of the main stratigraphic results in the Prati di Stuoeres/Stuoeres Wiesen section. Lithostratigraphic columns correspond to sections 1 and 1 bis in Fig. 1. Numbers and triangles on the left indicate stakes. Ammonoid and palynomorph distribution refer to selected taxa.



Lithostratigraphy

The area is placed to SW of the village of San Cassiano/St. Cassian and belongs to the type-area of the San Cassiano Fm., defined by Wissmann (in Wissmann and Münster, 1841) as *Schichten von St. Cassian* and then named *Cassianer Schichten*. The S. Cassiano Fm. is a basinal unit, subdivided by Ogilvie Gordon (1900) into two members: "lower" (UCS, *Unterer Cassianer Schichten*) and "upper" (OCS, *Oberer Cassianer Schichten*) on the basis of lithological features and paleontological contents. According to this subdivision, the UCS overlies the La Valle Fm. (although their lower boundary is not well defined) and consist of alternating siltstones, claystones, calcarenites, marly limestones and turbiditic volcanoarenites, while the OCS, which overlies the highest volcanoarenitic layer (*tuffsandstein* in Urlichs, 1974), are mainly made up of muddy beds, siltstones and marls, with some limestone intercalations. The distinction between UCS and OCS on the basis of volcanic debris content was debated by De Zanche et al. (1993), De Zanche and Gianolla (1995) and Neri et al. (1995): they prefer not to consider the volcanic debris content as a diagnostic tool because it is paleogeographically controlled. In agreement with Richthofen (1860), the La Valle Fm./San Cassiano Fm. boundary (at 1.5 m from the bottom in section 1) is marked by the occurrence of oolitic turbidites, which also testify to the progradation of a carbonate platform (Cassian Dolomite). In conclusion, in the lower part of the section, mainly grey and dark grey marls with volcanoturbiditic intercalations crop out (La Valle Fm.), while in the upper part brown and yellowish marls with carbonate turbidites prevail (San Cassiano Fm.).

Sequence stratigraphy

The Prati di Stuares/Stuares Wiesen section is illustrative of the basinal stratigraphy in the western Dolomites after the volcanic acme. The upper part of the La Valle Fm. records a strong decrease in sedimentary supply and, therefore, it consists of calcilutites, marls and claystones. Upwards, a progressive increase in neritic carbonate content and a new increase in volcanosedimentary supply follow (San Cassiano Fm.). In the upper part of the section, the latter is gradually replaced by carbonate neritic turbidites. The latter also document the progradation of a carbonate platform (Cassian Dolomite) and of a terrigenous coastline.

According to De Zanche et al. (1993) and Gianolla (1995), the whole Prati di Stuares/Stuares Wiesen section belongs to the Car 1 3rd order depositional sequence (DS). In the Stuares area, the Car 1 DS includes the following units: La Valle Fm., lower part of the San Cassiano Fm., Cassian Dm. 1 and, locally, basic volcanics. The lowstand systems tract (LST) mostly consists of more or less coarse-grained volcano-sedimentary deposits (e.g. Marmolada Conglomerate, *Pachycardientuffe*). Layers including karstified carbonate olistholiths ("Cipit limestones" *p.p.*), probably deriving from the destroying of previous carbonate buildups, are characteristic. TST deposits are defined by the strong decrease in terrigenous content and by the appearance of fine-grained terrigenous-carbonate facies (upper part of the La Valle Fm.). In the Prati di Stuares/Stuares Wiesen section, the maximum flooding surface (mfs) seems to lie close to La Valle Fm./San Cassiano Fm. boundary; it supplied ammonoids belonging to the topmost Regoledanus Subzone (*sensu* Mietto and Manfrin, 1995b). In the basinal areas the Car 1 HST corresponds to the lower part of the San Cassiano Fm., interfingered with the Cassian Dm. 1 (De Zanche et al., 1993). In carbonate shelf areas, the next SB is placed at the top of the eroded and karstified Cassian Dm. 1; in basinal areas, the Car 2 SB falls at the strong increase of clastic supply which is also recorded in the upper part of the Prati di Stuares/Stuares Wiesen (cf. Urlichs 1974, 1994), that is above biocalcarenic and oolitic turbidites (Car 1 HST).

According to De Zanche et al. (1993) and to Gianolla et al. (1998), the Car 1 DS has a supra-basinal value. On the contrary, Mastandrea, Neri and Russo (1997) think that the complex stratigraphic setting of the western Dolomites during Ladinian-Carnian is so strongly controlled by tectonics that the eustatic signal is overcome. Therefore, according to the authors, a sequence stratigraphic framework defined in the Dolomites cannot be considered as a global standard. Moreover, they suggest that the post-volcanic succession in the region should include more carbonate platforms than those indicated in De Zanche et al. (1993) and Gianolla et al. (1998).

Biostratigraphy

Although at present research on ammonoids, conodonts and palynomorphs is still in progress, available data allow a biochronostratigraphical framework to be presented.

Ammonoids and ammonoid biozones

The definition of a new subzonal unit below the Aon Subzone is the most important result of the biostratigraphical analysis in the Prati di Stuares/Stuares Wiesen section. Mietto and Manfrin (1995 a, b) named it as the *Daxatina* cf. *canadensis* Subzone. Its base (at 45 m) is placed at the appearance of *Daxatina* cf. *canadensis* (Whiteaves), which corresponds to the FAD of *Daxatina*; the genus *Clonitites* appears at 52.2 m, while the genus *Trachyceras* [i.e. *Trachyceras bipunctatum* (Münster)] is found beginning from 61.5 m. As shown in Fig. 2, ammonoid fauna lying below 45 m perfectly fits with horizon C of the Regoledanus Subzone (*sensu* Mietto and Manfrin 1995 b). Note that *Frankites apertus* (Mojsisovics) is present beginning from this horizon upwards at least till 79 m. The upper subzone boundary crops out in the section 1 bis (Fig. 2) at 194.3 m in which a specimen of a probable *Trachyceras aon* (Laube) occurs. Due to the high sedimentation rate, in the Prati di Stuares/Stuares Wiesen section the *Daxatina* cf. *canadensis* Subzone is 149 m thick. It directly underlies the Aon Zone in Ulrichs (1974, 1994), at whose base the Author placed the Ladinian/Carnian boundary.

The specimens of *Daxatina* considered here cannot be confused with the exemplars of *Daxatina* in Ulrichs (1974), which later (1994) the author correctly considered to be juvenile stages of *Trachyceras*. However, as illustrated in Mietto and Manfrin (1995b: fig. 6), at a whorl height of 1 cm they show an unequivocal ceratitic suture, with entire saddles and well rounded tips. Due to their morphological features, ornamentation and suture line, exemplars of *Daxatina* in the Southern Alps are well comparable with those splendidly illustrated by Tozer (1994) in Canada as *D. canadensis*.

The genus *Daxatina* is a cosmopolitan taxon. It was pointed out in the Boreal domain (e.g. Bjørnøya, Arctic Ocean), where Böhm (1903, 1904) defined it as *Dawsonites*; later emended in *Daxatina* by Strand (1929). Its type-species, *Trachyceras canadensis* Whiteaves (1889), comes from the Liard River (British Columbia; cf. also Smith, 1927; Mc Learn, 1947a, b; Tozer, 1967, 1994), therefore from a mid-latitude domain. Known also in Alaska (Martin, 1916), it is believed to be typical of the mid-high latitudes (Arkell, Kummel and Wright, 1957). Lastly, the discovery of *Daxatina* at low latitude in the Tethys realm allows it to be considered a useful tool for global correlation.

Conodont biostratigraphy

The whole section is characterized by conodonts of the *Budurovignathus* group and by two long-range species belonging to genus *Gladigondolella*: *G. tethydis* (Huckriede) and *G. m. malayensis*

Nogami. The *Budurovignathus* group is represented by *B. mungoensis* (Diebel), *B. longobardicus* (Kovacs), *B. diebeli* (Kozur and Mostler) and *B. mostleri* (Kozur). All these taxa are typical of the *diebeli* Assemblage Zone in Krystyn (1983), referred by the author to the Regoledanus Zone (= uppermost Ladinian).

As shown in Fig. 2, the first occurrence of conodonts of the *Budurovignathus* group is documented at about 26 m. Unfortunately, the interval between 26 and 85 m is barren in conodonts: it contains the FAD of *Daxatina* cf. *canadensis* (at 45 m).

The upper part of the section (above 85 m) still contains *Budurovignathus* and long-ranging gondolellas (i.e. *G. tethydis*, *G. m. malayensis*). *B. diebeli* and *B. mostleri* occur until about 177 m, together with a broken specimen of *Gondolella* that, due to its bad preservation, had an uncertain classification (*G. inclinata* vel *G. polygnathiformis*).

G. polygnathiformis occurs together with *Trachyceras aon* near the base of section 2 (Fig. 1) which corresponds to the section in Ulrichs (1974) as the stratotype of the Cordevolian substage. On the basis of data from sections in the Stuoeres area, it seems that the FAD of *Pseudofurnishius murcianus murcianus* is located slightly below the first occurrence of *G. polygnathiformis*. Moreover, in the lower samples of section 2, *B. diebeli* occurs together with *G. polygnathiformis*, confirming the overlap of the ranges of these taxa shown by a number of stratigraphic sections within Alpine Europe (Mastandrea et al. in progress).

Ammonoid vs. conodont biozones: comparison and problems

The vertical distribution of conodonts and ammonoids across the Ladinian/Carnian boundary was discussed by Krystyn (1983) in the Epidaurus section and, more recently, by Kovacs et al. (1991) with regard to the Füred Limestone in the Balaton Highland. The above quoted papers present two contrasting sets of data.

According to Krystyn (1983), in the Epidaurus section the conodont assemblage characterized by *Budurovignathus diebeli*, marker of the Diebeli Zone, is correlatable with the Regoledanus Zone *sensu* Krystyn (1983). The first occurrence of *Gondolella polygnathiformis* is considered by Krystyn (1983) to coincide with the base of the Aon Subzone. Unfortunately, the "Carnian" tract of the section is quite poor in ammonoids, only represented in the Aonoides Zone *sensu* Krystyn (1978) by specimens of *Trachyceras* sp. The ranges of *Budurovignathus diebeli*, *B. mungoensis* and *B. mostleri* do not show any overlap with the range of *G. polygnathiformis*, although subsequently, on the basis of other stratigraphic sections (i.e. the Mayerling section), Krystyn reached the conclusion that the range of the *Budurovignathus* group goes upward into the Aonoides Zone (Gallet et al., 1998).

Clear evidence of overlap between the ranges of *Budurovignathus* and *G. polygnathiformis* are supplied by a number of stratigraphic sections, including the Prati di Stuoeres/Stuoeres Wiesen section and outcrops from the Apuseni Mts. (Romania, Kozur, 1980; 1989). The real question is if the overlap is due mainly to a downward extension of the range of *G. polygnathiformis*, below the FAD of *Trachyceras aon* or, on the contrary, to the upward extension of the range of the *Budurovignathus* group into the Aonoides Zone.

In the Ladinian-Carnian succession of the Balaton Highland, conodonts of the *Budurovignathus* group (including *B. diebeli*) occur together with *G. polygnathiformis* from the base of the Füred Limestone (Kovacs et al., 1991); the lowermost part of the formation contains *Frankites* sp., and has been referred by the above quoted authors to the Regoledanus Zone. The conclusion of Kovacs et al. (1991) is that the base of the Carnian stage has to be located at the first appearance of *G. polygnathiformis* and thus they include the Regoledanus Zone in the Carnian.

According to two of us (S. Manfrin and P. Mietto), it is possible that the specimens of *Frankites* sp. in the Fured Limestone pertain to *F. apertus* rather than to *F. regoledanus*. This opinion is supported by a re-evaluation of the ammonoid fauna in Frech (1911) from the same stratigraphic unit: it includes "*Trachyceras (Anolcites) Richthofeni* MOJS.", classified, with some doubts, as *F. apertus* by Mietto and Manfrin (in progress). If this interpretation is correct, it may be possible to argue that the FAD of *G. polygnathiformis* falls within the Daxatina cf. canadensis Subzone and that its occurrence at the base of the Aon Subzone in the Prati di Stuoeres/Stuoeres Wiesen section 2 (Ulrichs, 1974, 1994) is ecologically controlled. A significant environmental change from anoxic/dysoxic to fully oxygenated basin may occur near the base of Aon Subzone, as suggested by macro- and microbenthos assemblages. This fact may enforce the proposal to draw the Ladinian/Carnian boundary at the base of the Daxatina cf. canadensis Subzone: its lower boundary falls into a tract of section not affected by significant paleoecological changes and thus may be regarded as "evolutionary"-controlled.

However, there is no agreement between the co-authors of the paper by Kovacs et al. (1991) about the real taxonomy of the conodonts classified as "*G. polygnathiformis*". According to Krystyn (personal communication to A. Mastandrea), *G. polygnathiformis* has never been found within the Regoledanus Zone (which, as intended by L. K., includes the Daxatina cf. canadensis Subzone).

The problem needs further discussion, in order to attest if the FAD of *G. polygnathiformis* is really more or less concomitant with the FAD of *T. aon* or, on the contrary, is within the upper Regoledanus Zone Auct. (= Daxatina cf. canadensis Subzone). Data from the Stuoeres area support the idea that the first appearance of *G. polygnathiformis* and *T. aon* are approximately coeval. This interpretation is congruent with data from Epidaurus; moreover, it is not in contrast with data from the Mayerling section (Gallet et al., 1998).

If the proposal to put the Ladinian/Carnian boundary at the base of Daxatina cf. canadensis Subzone is accepted, it must be taken into account that it most probably does not coincide with significant events affecting the conodont assemblages.

Paleontological-paleoecological contributions

In order to make easier the comprehension of the paleontological characteristics of the interval including the Ladinian/Carnian boundary, data both on palynomorphs, which could be important from the biostratigraphic point of view, and on other fossils, which can give significant environmental indications, are included.

Palynomorphs

Palynological analysis gave interesting preliminary results that have to be compared on a regional scale to be confirmed. Previous palynological studies (Van der Eem, 1983) on this area only concerned younger strata (cf. Ulrichs levels). The palynological assemblages evolved, from the bottom to the top, as follow.

Assemblage A (from 0.5 to 45 m, Regoledanus Subzone): the palynological assemblage is highly diversified. In this interval, *Enzonalasporites vigens* Leschik occurs first. "*Lueckisporites*" cf. *singhii* Balme makes its first occurrence at just 50 cm below the Regoledanus/Daxatina cf. canadensis subzones boundary, and ranges up into the Daxatina cf. canadensis Subzone. Other important occurrences are *Lunatisporites acutus* Leschik and *Neoraistrikia taylori* Playford and Dettman. The most abundant species is the long ranging *Ovalipollis pseudoalatus* (Thiergart) Schuurman, which is present throughout the section.

Assemblage B (from 45 to 160 m, Daxatina cf. canadensis Subzone): at the Regoledanus/Daxatina cf. canadensis subzones boundary, a great diversification has been recorded. The Daxatina cf. canadensis Subzone is characterized by the first occurrence of *Patinasporites densus* Leschik and *Vallasporites ignacii* Leschik. Other important elements are *Camerosporites secatus* Leschik, *Weylandites magnus* (Bose and Kar) Van der Eem, *Concentricisporites bianulatus* (Neves) Antonescu, *Converrucosisporites* sp. B (cf. Van der Eem, 1983), *Concavisorites* sp. A (cf. Van der Eem, 1983) and *Concentricisporites insignis* Pautsch. In the uppermost part of the subzone, bad preserved specimens of *Partisporites maljawkinae* (Klaus) Van der Eem also occurs for the first time. The long ranging species already present in the underlying subzone can also be regularly found together with new long ranging elements. The *Triadispora* group becomes more diversified towards the upper part of this subzone.

As reported by several authors (Clement-Westerhof et al., 1974; Schuurman, 1979; Scheuring 1978; Visscher et al., 1980; Visscher and Brugmann, 1981; Van der Eem, 1983), in this section the first appearances of *E. vigens* and "*L.* cf. *singhii*" also occur respectively in the upper (*secatus-vigens* phase, Longobardian) and uppermost Ladinian. Differently, *W. magnus*, whose first occurrence was recorded by Van der Eem (1983) at the base of the *secatus-vigens* phase, first occurs in this section within the Daxatina cf. canadensis Subzone. The first income of *C. secatus*, which is considered Late Ladinian in age (Schuurman, 1979; Visscher and Krystyn 1978; Visscher and Brugman, 1981; Van der Eem, 1983; Brugman et al., 1994) also occurs in this section within the Daxatina cf. canadensis Subzone. The Carnian age of other important elements such as *P. densus* and *V. ignacii* is fully confirmed.

Benthic foraminifers

In order to obtain the most realistic assemblages, the study has been carried out both in thin section and washed material. Isolated foraminifers have been investigated from 33 samples of marls and clays. Foraminiferal assemblages from calcarenitic levels and muddy limestones have been studied in over 300 thin sections.

The foraminiferal assemblage evolves as follows:

- A) 0 to 45 m (Regoledanus Subzone). This segment ranges from the base of the section to the FAD of *Daxatina*.

Isolated foraminifers - A rich fauna dominated by agglutinated foraminifers, such as *Endothyra kuepperi* Oberhauser, *Palaeolituonella meridionalis* (Luperto), *Ammodiscus* cf. *infimus* (Strickland), *A. incertus* (d'Orbigny), *A. tenuissimus* Gümbel, *A. annulinoides* Kristan-Tollmann, *Glomospira perplexa* Frank, *Glomospirella facilis* Ho, *G. hemigordiformis* (Tscherdynzew), *Reophax eominutus* Kristan-Tollmann together with the nodosariids *Dentalina* ex gr. *subsiliqua* Franke, *D. cassiana* Gümbel, *Nodosaria primitiva* Kübler and Zwingli, *Pseudonodosaria obconica* (Reuss), *Kriptoseptida klebelsbergi* (Oberhauser), *Lenticulina cassiana* (Gümbel), *L. excavata* (Terquem), *L. bochardi* (Terquem), *L. karnica* (Oberhauser) are present. The species *Duostomina* sp., *D. biconvexa* Kristan-Tollmann, *D. alta* Kristan-Tollmann, *D. turboidea* Kristan-Tollmann and *Ophthalmidium* cf. *exiguum* Köhn-Zaninetti are also present.

Thin section - In a mudstone layer at 9.10 m the appearance of the very important assemblage *Gsollbergella spiroloculiformis* (Oravec-Scheffer) - *Semimeandrospira* ex gr. *karnica-planispira* (Or.-Scheff.) - *Turriglomina karnica* Dager was recorded. *Piallina tethydis* Rettori et al. first occurs in a fine grained level at 19.25 m. The appearance of *Gordiospira triassica* Urosevic was recorded at 34 m, but this species is scarcely present in the rest of the section. *Gsollbergella spiroloculiformis* is constant along the succession both in

calcareenites and in muddy limestones, whilst *T. carnica* is more frequent from 29.60 m. In addition, just one specimen of *Palaeolituonella meridionalis* (Luperto) was recorded at 43.40 m. All taxa are small and, at present, are exclusively known in the "Carnian" of western and eastern Tethys, but very few species have been dated by ammonoids or conodonts. Several species belonging to *Ammobaculites*, *Gheorghianina*, *Glomospira*, *Glomospirella*, *Duostomina*, *Endoteba*, *Ophthalmidium*, *Reophax* and *Variostoma* may be associated. Nodosariidae and Textulariidae also occur.

B) 46 to 145 m (Daxatina cf. canadensis Subzone p.p.).

Isolated foraminifers - Most foraminifers in segment A continue their presence, but the nodosariids become dominant and some new taxa, such as *Schlagerina* sp., *Oberhauserella* sp., *Dentalina guembeli* Schwager, *Fronicularia* sp. and *Nodosaria nitidana* Brand occur.

Thin section - Any peculiar change in foraminiferal assemblage was recorded in this segment except for the bloom of *S. ex gr. carnica-planispira* at 114 m. An increase in carbonate platform biota (*Tubiphytes*, bryozoans, *Cayeuxia*, calcareous sponges, thick shelled bivalves and encrusting foraminifers) become more abundant from 131.10 m.

C) 146 to 180 m (Daxatina cf. canadensis Subzone p.p.).

Isolated foraminifers - The foraminiferal assemblage is dominated by duostominids and involutinids. The taxa mainly represented are: *Duostomina biconvexa* Kristan-Tollmann, *Diploremmina astrofimbriata* Kristan-Tollmann, *Variostoma pralongense* Kristan-Tollmann, *V. exile* Kristan-Tollmann, *P. altoconica* (Kristan-Tollmann), *Papillaria* sp., *Lamelliconus ex gr. ventroplanus* (Oberhauser), *Aulotortus ex gr. sinuosus* Weynschenk, *Lamelliconus multispirus* (Oberhauser). In addition, a few nodosariids and agglutinated foraminifers also occur. The first appearance of *Ophthalmidium fusiforme* (Trifonova) and *Ammobaculites hiberensis* Marquez and Trifonova occurs at the top of the section.

Thin section - At 172 m, the foraminiferal assemblage is at first dominated by involutinids (Lamelliconinae) mainly referred to *Lamelliconus multispirus* (Oberhauser) and *L. procerus* (Liebus) in association with *G. spiroloculiformis*, *S. ex gr. karnica-planispira*, *T. carnica* and *P. tethydis* already quoted in the previous segments.

Segments A and B are mainly characterized by autochthonous deep-water foraminifers. According to the relations between foraminiferal test morphology and energy-oxygen level suggested by Kahio (1989) and Boudiche and Ruget (1993), *Dentalina*, *Pseudonodosaria* and *Nodosaria* belong to elongated and cylindric morphotype; *Fronicularia* to the elongated and flattened one; *Lenticulina* to the flattened and planispiral type. Deep-water infaunal habits have been inferred for these taxa. Agglutinated and tubular tests of *Glomospira*, *Glomospirella* and *Ammodiscus* pertain to epifauna which inhabits shallow- to deep-water during Early Mesozoic. The association of all three morphotypes suggest disaerobic and low-energy conditions of the sedimentary environment. Moreover, the duostominid and involutinid dominated associations in segment C (upper part of the Daxatina cf. canadensis Subzone) records an increase in energy and oxygen level of the environment.

In conclusion, foraminifers allow the following remarks.

- 1 - The Carnian affinity in segments A and B is mainly testified by the taxa occurring in thin section.
- 2 - Mainly on the basis of the involutinids, the assemblages recognized in washed material and in thin section are closely comparable in segment C.

- 3 - Most species occurring in the Prati di Stuores/Stuores Wiesen section 1 are quoted in the Carnian of the Taurus (Altiner and Zaninetti, 1981), Carpatho-Balkans (Salaj et al., 1983; Trifonova, 1992, 1993), Transdanubian Central Range (Oravec-Scheffer, 1987), Serbia (Urosevic, 1988), Northern Calcareous Alps (Oberhauser, 1957; Kristan-Tollmann, 1960, Köhn-Zaninetti, 1969; Zaninetti, 1969, 1976), Julian Alps (Rettori et al., in print), Turkey (Dager, 1978; Rettori et al., 1993), China (He and Yue, 1987; He and Norling, 1991) and Israel (Benjamini, 1988).
- 4 - Change in taxonomical compositions may strongly depend on ecological factors.

Bivalves, gastropods and brachiopods

Bivalves in the Prati di Stuores/Stuores Wiesen section mainly consist of *Posidonia wengensis* (Wissmann), while no specimens of *Daonella* or *Halobia* have been found. Brachiopods are rare and only occur in the upper part of the section. *P. wengensis* is mainly contained in laminated dark grey clays and argillaceous marls alternated with tuffites and calcarenites. According to Fürsich and Wendt (1977), *Posidonia* is a typical element of the San Cassiano Fm. "pelagic assemblage". The latter is characterized by the absence of benthic and dominance of nektic forms and was deposited in the deeper parts of the Cassian basin (depocentre). Due to: (1) high turbidity, (2) high water-content of the bottom sediment (very soupy substrate) or (3) oxygen-deficient bottom-waters, this assemblage lacks benthic suspension feeders (Fürsich and Wendt, 1977). According to the new hypothesis concerning the tolerance of posidoniids to low-oxygen values and their benthic life habit (Wignall and Simms, 1990), the latter environmental factor seems to have played a dominant role in the composition of the "pelagic assemblage" occurring in the section.

Above 150 m, the disappearance of *P. wengensis* and the frequent occurrence of nuculoids (section 2) may suggest a change of the redox boundary which moved inside the sediments.

In conclusion, the depositional environment of the Prati di Stuores/Stuores Wiesen section corresponds to a basin in which prevailing anaerobic to disaerobic conditions of the bottom water occurred in the lower part (from 0 to 105 m). As the sediment infilled the basin, the water circulation increased. In the middle part (from 105 to 150 m), frequent aerobic events (*Koninckina* beds) alternated with disaerobic events (*Posidonia*-bearing marls). In the upper part of the section (from 150 to 180 m) more stable aerobic conditions allowed the settlement of nuculoids, which occur frequently in section 2 (Aon Subzone).

Microcrinoids and holothurian sclerites

In the middle-upper Triassic of the Tethys Realm many microcrinoid occurrences have been observed. Kristan-Tollman (1970) compared this phenomenon to the Jurassic *Saccocoma* facies. Many species belong to Somphocrininae Peck and particularly to the genus *Osteocrinus* Kristan-Tollman. Many holothurian sclerites are also documented.

In the section 1, the taxonomic diversity of the microcrinoids is very high. The following species can be recognized: *Osteocrinus rectus* Krist.-Toll., *O. goestlingensis* Krist.-Toll., *O. saklibelensis* Krist.-Toll., *O. acus* Krist.-Toll., *O. sp.*, *Ossicrinus reticulatus* Krist.-Toll., *Axicrinus alexandri* Krist.-Toll., *A. sp.*, *Somphocrinus sp.*, *Tulipacrinus sp.* and *Nodolanx multinodosa* Krist.-Toll.

Osteocrinus rectus, the close species *O. goestlingensis*, and the hardly determinable *O. saklibelensis*, commonly have a much wider range with respect to the extension of the Prati di

Stuores/Stuores Wiesen section. However, strictly concerning the latter, it is possible to make the following considerations:

- between 20 and 45 m the first occurrences of many microcrinoids are documented;
- from 120 to 150 m, a short peak both in microcrinoids and sclerites can be recognized;
- above the peak, the taxonomic diversity decreases. According to Bizzarini (1993), the holothurian sclerites increase upwards;
- close to the top of the section, a few species disappear: the last occurrence of *Osteocrinus acus* is the most prominent event.

The above mentioned microcrinoid and holothurian sclerite association seems to be rather typical of the Daxatina cf. canadensis Subzone; with minor modifications, it also extends upwards into the Aon Subzone.

The variations in taxonomic diversity can probably be referred to ecological factors.

Paleomagnetism

A total of 96 paleomagnetic core samples were analysed at the paleomagnetism laboratory of ETH Zürich. Stepwise thermal demagnetization treatments and measurements of natural remanent magnetization (NRM) were performed on all specimens in a shielded room. Magnetic remanences were measured on a 2G Model 760 3-axis cryogenic magnetometer mounting DC SQUID sensors. Least-square analysis was used to determine the component directions of the NRM, chosen by inspection of vector end point demagnetograms. Mean directions were determined with standard Fisher statistics. The rock magnetic properties were investigated by means of thermal unblocking characteristics of orthogonal-axes isothermal remanent magnetization (IRM).

Paleomagnetic directions

Paleomagnetic samples typically show the presence, in *in situ* coordinates, of a scattered low unblocking temperature component of viscous origin consistent with acquisition along the present-day field direction and/or induced at random during drilling or cutting. Above this low temperature component, interpretable paleomagnetic directions were obtained in 93% of the specimens. In particular, a bipolar characteristic component oriented *in situ* north and positive or south and negative was isolated in 72% of the specimens in the temperature range comprised usually between about 200°C and 450°C to 550/580°C. In 10% of the specimens the characteristic component could be followed up to maximum unblocking temperatures of 600 to 630°C. An additional 11% of the samples show *in situ* westerly stable-end-point trajectories interpreted as transitional directions associated with excursions of the Earth's magnetic field or acquired during a field polarity reversal. The bipolar and transitional characteristic component directions become shallower upon correction for bedding tilt.

The thermal unblocking characteristics of orthogonal-axes IRM show that all lithologies are dominated by a low coercivity and ca. 580°C maximum unblocking temperature phase interpreted as magnetite, maybe co-existing with subsidiary sulphurs characterized by ca. 320-350°C maximum unblocking temperatures. A higher coercivity and unblocking temperature phase, like haematite, may be also present at places.

Magnetostratigraphy

The latitude of the specimen virtual geomagnetic pole (VGP) with respect to the overall mean north paleomagnetic pole was used to delineate the magnetic polarity stratigraphy. VGP relative latitudes approaching +90°N (-90°N) are interpreted as recording normal (reversed) polarity.

The latitude of the VGPs defines at Stuores a lower normal (S1n)-reversed (S1r)-normal (S2n)-reversed (S2r)-normal (S3n)-reversed (S3r)-normal (S4n) polarity sequence. Intermediate VGP latitudes are preferentially located at polarity transitions. The base of the Carnian, as defined by the base of the *Daxatina* cf. *canadensis* Subzone, falls towards the base of normal polarity interval S2n.

The Ladinian/Carnian boundary at Stuores can be tentatively correlated with the coeval Mayerling section in Austria from the literature (Gallet et al., 1998, fig. 10). We propose that the reversed polarity interval S1r in the Prati di Stuores/Stuores Wiesen section correlates with polarity interval MF- at Mayerling, and that normal polarity interval S2n at Stuores corresponds to interval MG+ at Mayerling (Fig. 1) [polarity nomenclature at Mayerling is here informally introduced after Gallet et al (1998) for clarity]. Towards the top the correlation becomes less clear. It is possible that the reversed polarity interval S2r at Stuores correlates at Mayerling with a small "excursion" located somewhat below meter 40 at a lithological transition, and here named MH-?. If so, the overlying normal polarity interval S3n at Stuores corresponds to interval MI+ at Mayerling and so forth. This correlation would suggest that the first occurrence of *Gondolella polygnathiformis* at Stuores, presently located at the base of section 2, may be lower, within normal polarity interval S3n.

Conclusions and proposals

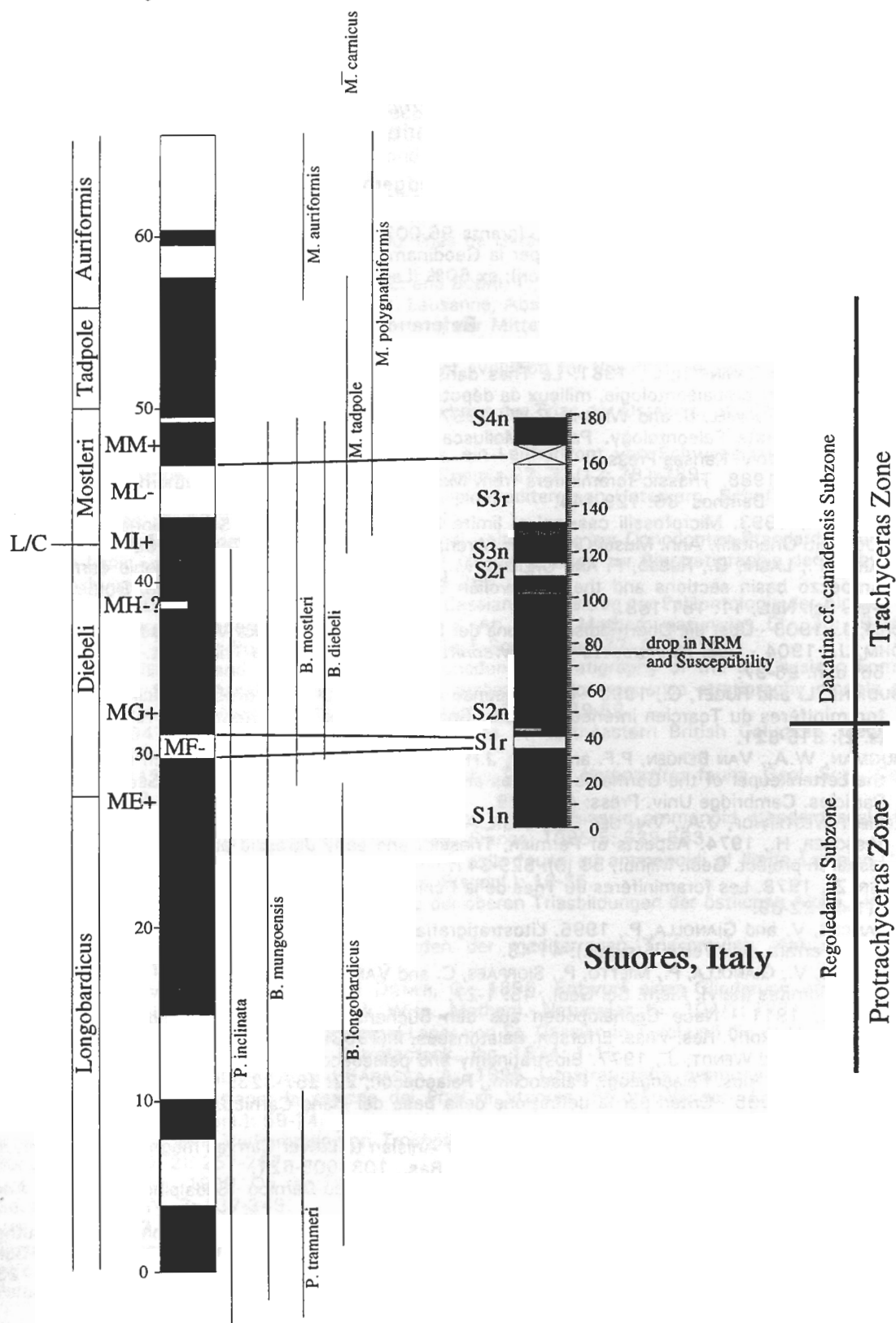
The present paper proposes that the base of the Carnian stage should be placed at the base of the *Daxatina* cf. *canadensis* Subzone. This assumption is mainly supported by the occurrence of the genus *Trachyceras* below the FAD of *T. aon*, within the *Daxatina* cf. *canadensis* Subzone. Also due to its good magnetostratigraphic record, the Prati di Stuores/Stuores Wiesen section is proposed as the candidate stratotype for the Ladinian/Carnian boundary.

The proposal is supported by the following data:

- 1) *Daxatina* is the only cosmopolitan genus within the studied chronological interval, occurring both in Tethyan and Boreal realms, while the distribution of the genus *Trachyceras* is restricted to low-intermediate latitudes. Moreover, the vertical range of *Daxatina* is distinctly narrow;
- 2) no significant biostratigraphic event seems to affect the ammonoid assemblage at the base of the Aon Subzone (as well as in its boreal equivalent, Desatoyense Zone); a significant faunal turn-over may only be identified at the FAD of *Daxatina*;
- 3) the base of the Carnian, as defined by the base of the *Daxatina* cf. *canadensis* Subzone, falls towards the base of normal polarity interval S2n;
- 4) the biostratigraphic events affecting conodont assemblages do not seem to be synchronous with ammonoid events: *Gondolella polygnathiformis* occurs at the base of the Aon Subzone in a number of sections, including the section 2 in the Stuores area; although data from

Fig. 3. Comparison of magnetostratigraphic and biostratigraphic data from this study and the Mayerling section from Austria (Gallet et al., 1998). Biostratigraphy at Mayerling is based on conodonts. The thickness of the reversed polarity interval located at Mayerling in the lowermost part of the Diebeli conodont zone, and here informally named MF-, has been here reinterpreted (i.e., shortened) after Gallet et al. (1998, fig. 10). A small departure of the characteristic component direction towards shallower inclinations observed at Mayerling in the upper part of the Diebeli conodont zone is here highlighted and informally named MH-. This "excursion" occurs at or close to a lithological transition. Thicknesses are expressed in meters from the base of sections.

Mayerling, Austria



Balaton may suggest that its occurrence within basinal successions may be ecologically controlled, further data are required in order to define the fitting between ammonoid and conodont events. The correlation between Mayerling and Stuores would suggest that the first occurrence of *Gondolella polygnathiformis* at Stuores, presently located at the base of section 2, may be lower, within normal polarity interval S3n.

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