Introduction

This paper is a slightly modified version of the proposal for the GSSP of the base of the Carnian Stage presented by Broglio Loriga et al. (1998, 1999) for discussion among the members of the L/C working group of the STS (M. Gaetani chairman), concerning the Prati di Stuores/Stuores Wiesen candidate section.

This proposal and its contents follow the guidelines published on p. 61 of Albertiana 26. Of the items listed in these guidelines, the discussion of cycle stratigraphy and point 4B are excluded here. About the latter, no other candidate sections have been proposed.

1. Stratigraphic Rank Of Boundary

Base Of The Carnian Stage And The Upper Triassic Series

2. Proposed Gssp - Geographic And Physical Geology

2a Geographic Location

The GSSP candidate at Prati di Stuores/Stuores Wiesen (Province of Belluno, Veneto Region, NE Italy) is located on the left side of the Cordevole Valley, on the southern slope of the crest separating the Badia/Abtei and the Cordevole valleys (Dolomites, Southern Alps).

The Prati di Stuores section (German: Stuores Wiesen) lies few hundreds meters east of Pralongià, a locality sited NE of Arabba (Cordevole Valley). The section extends from an altitude of 1980 m and reaches the crest at 2150 m a.s.l., within a vast gully-eroded depression, deeply incised within the slope. Upwards, it continues inside the overlying meadows and ends at the toe of the vertical walls of the Piccolo Settsass (the well-known Richthofen Riff of Mojsisovics, 1879) and of the Settsass (Fig. 1).

The section can be easily reached from Rif. Pralongià following C.A.I. footpath n. 23 towards Settsass, a few hundreds meters ESE of Piz Stuores (2181m). Pralongià is easily attainable by many footpaths (C.A.I.n.22, n. 23, n.3) from all the surrounding localities, San Cassiano/St. Kassian, Corvara/Kurfar (Badia/Abtei Valley) and from Campolongo Pass, but also by gravel roads from Corvara/Kurfar (intersection at km 35, SP 244) and Renaz (intersection at km 88, SR 48) and by chair-lift from Rifugio Cherz near Campolongo Pass.

2b Geological Location

The Prati di Stuores/Stuores Wiesen section (Fig. 2) is located in the Dolomites that constitute the central-northern portion of the Southern Alps (Doglioni, 1987; Castellarin and Cantelli, 2000). The Southern Alps derived from the comparatively gentle deformation of the passive continental margin of the Mesozoic Tethys Ocean into a non metamorphic, south-vergent thrust belt belonging to the Alpine Belt. In the Dolomites, the sedimentary succession spans from late Permian to Cretaceous time, but it is a worldwide reference area for the Triassic (Bosellini et al., 2003).

The Dolomites stratigraphy records several tectonic and magmatic events including the Late Ladinian emplacement of epicrustal intrusions (Monzoni, Predazzo, Cima Pape) and shoshonitic volcanism (Sloman, 1989). This is a key event in the stratigraphic record of the Dolomites and it
is responsible for huge input of volcaniclastics and lava flows both in subaerial and marine conditions (Fernazza Fm). The tectonic activity related to the volcanic event also triggered submarine collapses of the pre-volcanic succession, and their embodying as megabreccias into the coeval volcanoclastics. These units constitute the base of the described succession at Prati di Stuores (Broglio Loriga et al., 1999). After the rapid emplacement of the volcanic edifices, the stratigraphic succession records their erosion as a thick volcanodetritic unit (Wengen Fm) enhanced by a sea level fall. The Wengen Fm shows an internal organisation controlled by the progradation of turbiditic lobes towards deeper basins, lithofacies are thus controlled by the distance from source areas. Locally, small carbonate platforms are documented (mostly with fringing reef geometries): they are responsible for the exportation of carbonatic boulders called “Cipit” as well as finer biocalcarenites. The reduced rates of erosion, related to the sea level rise and the start-up of rimmed carbonate platforms (Cassian Dolomite), lead to a reduced siliciclastic input in favour of carbonate sediments in the basins (San Cassiano Fm). The typical organisation of this interval, exhibiting strong volcaniclastic input, sharp reduction and again increase in siliciclastic and shallow water-derived carbonates, is well documented in the area of Prati di Stuores/Stuores Wiesen. The subsequent basin evolution is characterized by a progressive shallowing, resulting in a complete closure of the basin itself during Late Carnian time (Heiligkreuz, Travenanzes Fms).

Figure 1: Location map of the Prati di Stuores/Stuores Wiesen section (from Broglio Loriga et al., 1998, mod.).
2C Location of level and specific point

Several outcrops exposing the upper Wengen and the San Cassiano Formations are present at Prati di Stuores/Stuores Wiesen. Most of them expose long sections, which are easily correlated by tracing conspicuous beds. The section, exposed at 46°31’37”N and 11°55’49”E, 1980 m a.s.l., WGS84 datum, is indicated as Standard Section, because it exposes the longest succession (Figs 1, 3). This section is represented on Italian topographic map at scale 1:25000 number 11-I-SE “Corvara in Badia”, 5th ed., 1963, published by the Istituto Geografico Militare Italiano.

The proposed GSSP is located at the base of bed SW4, at 45 m from the base of the San Cassiano Fm in the Prati di Stuores/Stuores Wiesen stratigraphic section (Figs 1, 4, 5). Bed SW4 is a marly limestone immediately underlying an arenite bed in the lower San Cassiano Formation. The bed yields ammonoids, including *Daxatina canadensis* (Whiteaves), proposed as the principal marker to identify the boundary.

2D Stratigraphic completeness

The Prati di Stuores/Stuores Wiesen section is characterized by a thick interval of marine sediments deposited below storm wave-base. The depositional motif consists of hemipelagites and thin turbidite beds (both siliciclastic and from nearby carbonate platforms) documenting high but variable sedimentation rates. In detail, a slight increase in sedimentation rate is noticed towards the upper part of the section accordingly to the overall regressive trend. Taking as a whole, terrigenous sedimentation seems to decrease upwards in favour of the carbonate supply coming from the progradation of carbonate platforms (Cassian Dolomite). Slumps and slump scars are recognized in the upper part of the section, but are absent around the proposed GSSP level. Such slumps-slump scars do not involve considerable thickness and therefore do not correspond to significant stratigraphic gaps. Hard-ground and non-depositional and/or condensed levels are absent in the studied interval.

2E Adequate thickness and stratigraphic extent

The Prati di Stuores/Stuores Wiesen section encompasses 180 meters of hemipelagic beds of the Wengen and San Cassiano Fms, which become more than 200 once the physically correlated section 1bis is considered (Fig. 5). Lateral continuity of the outcrops is also in the order of many hundreds of meters (Fig. 3). Ammonoids are common throughout the section.

Below the proposed GSSP, 45 m of marls and arenites referred to the San Cassiano Fm and ca. 20 m of Ladinian shales are exposed in the section; this interval represent the top of the Upper Ladinian *regoledanus* Subzone.

The first biozone of the Carnian, the *canadensis* Subzone, is well represented in the section up to m 194.30, where the boundary with the overlying *aon* Subzone is documented in section 1bis.

The Prati di Stuores/Stuores Wiesen section thus encompasses three ammonoid subzones. This stratigraphic interval is relatively short, if compared with the thickness of the succession; this is a consequence of the high sedimentation...
rate that characterized the Cassian basin between the late Ladinian and early Carnian. The considerable stratigraphic extent below and above the proposed boundary level is then sufficient to ensure a stable definition of the GSSP.

2F Provisions for conservation and protection

The accessibility of the Prati di Stuores/Stuores Wiesen section is historically documented from the early XIX Century, thanks to the classical works by Münster (1834), Wissmann and Münster (1841), Klipstein (1845), Laube (1869), Mojsisovics (1882), Ogilvie (1893), Ogilvie Gordon (1900, 1929), Urlichs (1974, 1994), and others. This historical record clearly documents a long-lasting persistence of the natural outcrops. The section area is involved in small but frequent landslides, due to the steep exposure and the lithological nature of the involved unit, consisting of marls, volcanoclastic arenite and thin bio-calcarenite alternations. The chosen section, however, lies on a steep rise, about 75 metres above the slope base, a high-standing location preventing the landslide and debris flow deposits from accumulating on the section outcrop. The large lateral continuity of the outcrop also support a good preservation potential of the proposed GSSP.

The Prati di Stuores/Stuores Wiesen area belongs to a Dolomites area nominated for subscription to the UNESCO World Heritage List. The area benefits from significant degree of environmental protection, supporting its long-lasting preservation. The area is protected by the Law 8/8, 1985, n. 431 (Galasso), preserving the whole of the territories above 1600 m, and it extends within the Col di Lana - Settsass - Cherz protected area (ZPSIT3230086), related to the directive Natura 2000 (92/43/CE, 79/409/CE). The local administrations (Comune di Livinallongo del Col di Lana and Provincia di Belluno) intend to maintain and label the section access and to disseminate the related information to the general public.

3. Primary and secondary markers

3A principal correlation event (marker) at gssp level

The proposed GSSP-level at Prati di Stuores/Stuores Wiesen is defined by the first appearance of the ammonoid genus *Daxatina* (i.e. *Daxatina canadensis*), as recognized in the bed SW4.

The genus *Daxatina* is documented in several sections of the Southern Alps: Prati di Stuores/Stuores Wiesen, Bec de Roces near Campolongo Pass, Antersass in Badia Valley, Rio Cuzze near Borca di Cadore and Pista Nera near Sappada (Mietto and Manfrin, 1995a, 1995b; Broglio Loriga et al., 1998, 1999; Manco et al., 2004; Mietto et al., 2007). After the early findings in British Columbia (Whiteaves, 1889), in the Svalbard Archipelago (Böhm, 1903, 1904) and in Alaska (Martin, 1926), more recently the new occurrences in the Himalayas region (Spiti valley: Balini, Krystyn and Torti, 1998; Krystyn, Balini and Nicora, 2004) and in Nevada (New Pass Range: Balini and Jenks, 2007; Balini et al., 2007) testify the worldwide distribution of the quoted genus.

For this reason the proposed GSSP-level provides an excellent tool for trans-Panthalassan correlations, between low to middle-high palaeolatitude domains.

3B Other stratigraphy

3B.1 Biostratigraphy

Ammonoids

In the Prati di Stuores/Stuores Wiesen section, three ammonoid subzones have been recognized: *regoledanus, canadensis* and *aon*. The *regoledanus* Subzone is documented from the base of the section (Wengen Fm) to 45 m...
from the base of the San Cassiano Fm. Within this interval (Fig. 5) cf. Protrachyceras and Zestoceras cf. enode Tozer occur. The latter species is also documented in other stratigraphic sections of the Southern Alps, always associated with longobardian ammonoid fauna (Mietto et al., submitted). The canadensis Subzone starts from the base of the bed SW4 in which, with the strongly ornamented species Daxatina canadensis, the genus Daxatina firstly appears. Successively, 16.50 m above the same bed a finely ornamented trachyceratid specimen occurs. This specimen was previously attributed to Trachyceras bipunctatum (Münster) (Mietto and Manfrin, 1995a, 1995b; Broglio Loriga et al., 1999; Mietto et al., 2007) but is now attributed to Daxatina cf. laubei Tozer, 1994 (Mietto et al., submitted).

Above, representatives of Daxatina (chiefly D. canadensis) are scattered along 145 m of the Prati di Stuores/Stuores Wiesen section. Above this interval, the first appearance of Trachyceras cf. aon (Münster) is checked in bed SW24. The interval zone comprised between the first occurrence of D. canadensis and the first occurrence of T. aon was originally defined as Daxatina cf. canadensis Subzone. Later on, based on the direct comparison with type material from Canada, this unit is formally named canadensis Subzone. In the past, this biozonal interval was considered equivalent to the sutherlandi Zone (Urlichs, 1974, 1977) then comprised in the tethysian regoledanus Zone (Urlichs, 1994). Almost 34 m above the bed SW4, the first occurrence of genus Trachyceras is recorded by the species T. muensteri (Wissmann). In particular, this taxon is characterized by a subammonitic suture line, but less indented than, e.g., in T. aon. After the attribution of most specimens to D. cf. laubei, the occurrence of T. bipunctatum in the canadensis Subzone at Prati di Stuores/Stuores Wiesen cannot be confirmed anymore. Nevertheless, this species has been found in the Antersass section, in the uppermost part of the biozone (Mietto et al., 2007, submitted).

Two species of Frankites are documented at Prati di Stuores/Stuores Wiesen: the most abundant and widespread is Frankites apertus (Mojsisovics). This taxon, which is considered synonymous of Frankites sutherlandi (McLearn) from North America by Mietto et al. (submitted), occurs from the upper part of the regoledanus Subzone to the lower part of the canadensis Subzone at least. A second species, Frankites johnstoni Mietto and Manfrin (in Mietto et al., submitted), occurs sparsely in the lower part of the latter subzone, but its total range comprises, in other sections, also most of the regoledanus Subzone.

The best documented genus in the canadensis Subzone is Zestoceras. In bed SW5b, 7.40 m above SW4, Zestoceras lorigae Mietto and Manfrin (in Mietto et al., submitted) occurs. This species is widespread along the canadensis Subzone, where its seems to be confined. A second species, Zestoceras barwicki (Johnston), originally assigned by Johnston (1941) to the genus Clionites (sic!), is equivalent to Zestoceras cerastes Tozer. We consider these taxa as synonyms (Mietto et al., 2007, submitted).

Moreover, the bed SW4 yields also Sirenotrachyceras thusneldae (Mojsisovics), which is scattered, at present,
Figure 5: Stratigraphic column of the Prati di Stuores/Stuores Wiesen section with distribution of main fossils and magnetostratigraphy (from Broglio Loriga et al., 1996; mod.).

- Zostoceras cf. erode
- Protrachyceras sp.
- Frankites johnstoni
- Fr. apertus
- Stenomacrocystites albasneidi
- Daxatina sp.
- D. canadiensis
- Z. harwickei
- Z. lourigue
- Daxatina cf. lahebi
- Trachyceras muensteri
- Budrovignatites mungoensis
- Budrovignatites longobardicus
- Budrovignatites diebeli
- Budrovignatites moesteri
- Gondolella sp.
- Paragondolella polygnathiformis novi
- Eozonalaspisites vigens
- cf. Concentricisporites bicornutus
- "Lueckisporites" cf. singhii
- Vallasporites ignaci
- Patinaisporites densus
- Camerospiridites secatius
- Weymannites magnus
- Porospora

Protrachyceras Zone
San Cassiano Fm.
Wangen Fm.

Ladinian
Carnian
within the lower part of the subzone.

In the last ten meters of the biozone, taxa documented also in the aon Subzone [e.g. Klipsteinia cf. aelchous (Münster), “Ceratites” armatus (Münster)] occur. In a bed of a nearby section (SW 11), correlated with the uppermost part of the Prati di Stuoress/Stuoress Wiesen section, Badiotites eryx (Münster) is also recorded. The canadensis Subzone is directly overlaid by the aon Subzone; the latter is marked by Trachyceras cf. aon (Münster), as documented in the section 1b (Fig. 5), at 194,30 m from the base of the San Cassiano Fm (bed SW24). The canadensis/aon subzones boundary is better exposed in the Antersass section (Fig. 10) and is marked, in particular, by Trachyceeras aon (Münster), Brothearcyctus spp. and Hannoaceras sp. (Mietto et al., 2007; submitted).

Conodonts

Although the Prati di Stuoress/Stuoress Wiesen section has been investigated several times for conodont biotratigraphy, a poor fauna has been recorded. This fauna is composed of Budurovignathus mungoensis (Diebel), Budurovignathus modesti (Kozur), Budurovignathus diebeli (Kozur and Mostler), Budurovignathus longobardicus (Kovács) and by the long-ranging species Gladigondolella malayensis malayensis Nogami and Gladigondolella tethydis (Huckriede) (Mastandrea in Broglio Loriga et al., 1999). All these species range at least from the upper part of the Longobardian (late Ladinian) to the lower part of the Julian (early Carnian).

Other coeval sections, Antersass and Bec the Roces sections, have been studied both for ammonoid and conodont biotratigraphy (Mietto et al., 2007). A similar conodont fauna have been recovered from both sections with the addition of Paragondolella foltiata Budurov and the two subspecies Pseudofurnishius murcianus precurson Guillo and Kozur and Pseudofurnishius murcianus murcianus Van den Boogaard from Antersass section (Mietto et al., 2007). Recently, Paragondolella polygnathiformis noah (Hayashi) has been recovered in the Prati di Stuoress/Stuoress Wiesen section (Manco et al., 2004; Mietto et al., 2007; and Fig. 5).

Paragondolella polygnathiformis noah (Hayashi) lies on the phylogenetic lineage of Paragondolella inclinata – Paragondolella polygnathiformis polygnathiformis – Paragondolella polygnathiformis noah, a branch of the excelsa-stock which evolved during the late Ladinian – early Carnian (Kovács, 1983). During the last years, the species here named Paragondolella polygnathiformis (Budurov and Stefanov) has been ascribed into different genera by various authors, e.g Neogondolella, Paragondolella, Metapolygnathus. Considering the phyletic evolution and considering the peculiarities which distinguish the above-mentioned genera, as summarized by Kozur (1989), this species has been here interpreted as belonging to genus Paragondolella.

Paragondolella polygnathiformis noah (Hayashi) is characterized by a geniculation point or an abrupt anterior step on both the anterior lateral margins. The presence of this feature on only one of the anterior margins is typical for the transitional forms between Paragondolella inclinata (Kovács) and Paragondolella polygnathiformis polygnathiformis (Budurov and Stefanov) during the latest Ladinian. Paragondolella polygnathiformis polygnathiformis (Budurov and Stefanov) differs from Paragondolella polygnathiformis noah (Hayashi) for the absence of a free blade since the platform tends to reach the point of the blade.

Historically, the FO of Paragondolella polygnathiformis has been used to define the base of the Carnian, the occurrence of which was considered coincident with the base of the Trachyceras aon Subzone (Krystyn, 1983). Later, it has been demonstrated a downward extension of the range of Paragondolella polygnathiformis below the FAD of Trachyceras aon (Kozur, 1980, 1989; Kovács et al., 1991, Gallet et al., 1998; Rigo et al., 2007), that means within the canadensis Subzone. At Spiti (India), the FO of Paragondolella polygnathiformis noah along with Paragondolella polygnathiformis polygnathiformis is some meters below the FO of Daxatina canadensis.

At Prati di Stuoress/Stuoress Wiesen, Paragondolella polygnathiformis noah (Hayashi) has been collected from sample SW 4c, 70 cm above the first occurrence of Daxatina canadensis (Whiteaves) in bed SW 4. The FAD of Paragondolella polygnathiformis noah (Hayashi) is practically coincident with the FAD of Daxatina canadensis, and might be an useful additional marker event for the base of the Carnian stage.

Halobiids and other macrofossils

The lower San Cassiano Fm deposited within a deep basin, well below the photic zone, with a high sedimentary rate and oxygen-deficient bottom conditions (e.g. Fürsich and Wendt, 1977; Broglio Loriga et al., 1999). These conditions only permitted the proliferation of posidonioids, an opportunistic bivalve group, well adapted to low-oxygen benthic habitats (e.g. Wignall, 1994; Aberham, 1994). Posidonioids are common throughout the whole canadensis Subzone, where they generally occur in the laminated dark grey clay and argillaceous marls alternated with turbidites. For these reasons, bivalves of the lower San Cassiano Fm of Prati di Stuoress/Stuoress Wiesen section (uppermost regolesinus and canadensis subzones) are mainly represented by members of the superfamily Posidonioidae (sensus Waller in Waller & Stanley, 2005), while gastropods and brachiopods are rarer. Specimens of the latter two groups mostly occur since the middle canadensis Subzone (Posenato in Broglio Loriga et al. 1999: tab. 6).

The posidonioids of the canadensis Subzone were distinguished into three groups (Posenato in Broglio Loriga et al., 1999): a) “Posidonia” wengensis (Wissmann); b) “Posidonia” cf. wengensis; c) Halobia sp.

On the base of the recent revision of T. R. Waller (in Waller & Stanley 2005), the first species is attributed to Bositra, although this author include in the Family Posidonidae those posidonioids with the “hinge line generally much shorter than shell length” (op. cit., p. 19), while “Posidonia” wengensis is characterized by a long hinge margin (see
also Wissmann in Münster 1841, pl. 16, fig. 12), thus the attribution of Wissmann's species to *Bositra* is not completely convincing. The species is common in the Longobardian Wengen beds Auct. of the Dolomites, from which the type-material was found (Wissmann in Wissmann and Münster, 1841). The second group (b) yields "*Posidonia* wengensis" - like valves with weak radial costellae. Radial plications characterise *Daonella* and *Halobia* and for this reason the hypothesis that the group B) "could represent juvenile stage of *Daonella* or a transition to *Halobia*" was proposed (Posenato in Broglio Loriga et al., 1999: p. 60). Both the just above quoted genera have species groups which show transitional features to "*Posidonia* such as the *Gruppe der posidonoiden Daonellaformen* and *Gruppe der schwach verzieren Halobien* and *Gruppe der Halobia styriaca* (Kittl, 1912). Also the specimens reported by Mi etto et al. (2007) from the canadensis Subzone of Bec de Roces section, and classified as "prachalobids", belong to this group. However, radial ribbing may also occur in the family Posidonidae, to which *Bositra* belongs (Waller and Stanley, 2005). Fine radial ribs were also noted by Kittl (1912: p. 19) in some shells by him referred to Wissmann's species. However, in absence of an abundant population, which depicts the sculpture variability and in absence of unquestionable features of possible derived genera (i.e. the anterior auricle/tube of *Halobia*), we again refer to *Bositra* both the groups and distinguish them only at specific level (*Bositra wengensis* and *Bositra cf. wengensis*).

The third group (c) consists of very rare specimens collected from two beds (75W6.1 and SSW8.0, see Broglio Loriga et al. 1999: tab. 6). The reason of this classification is discernible in the left specimen of pl. 9, fig. 2 of Broglio Loriga et al. (1999): it is a left valve with prevailing commarginal folds and a slightly curved anterior tube/ear - like process, which induced us to refer tentatively it to *Halobia* (?) *Halobia* sp., Posenato in Broglio Loriga et al., 1999).

According to several authors (e.g. Mojsisovics, 1874; Kittl, 1912; Gruber, 1976; McRoberts, 2000), *Halobia* (an halobiid with the anterior auricle -or tube- separated from the disk), derived directly from *Daonella* (a D-shaped and radially plicated halobiid lacking of the anterior auricle), or through the intermediate genus *Aparimella* Campbell, 1994. According to this hypothesis, the ancestral species have well developed radial plications, which have to be considered a primitive, plesiomorphic character of the Halobiidae, considering this family as a natural, monophyletic taxon (Campbell, 1994; McRoberts, 2000). However, *Halobia* contains more than 300 species and subspecies (McRoberts, 1993), and many authors consider this genus a polyphyletic group (e.g. Kittl, 1912; Ichikawa, 1958; Gruber, 1976; Polubotko, 1988; McRoberts, 2000). Among the eleven *Halobia* species-groups proposed by Kittl (1912), two are characterized by a reduced radial ribbing. They are the *Gruppe der schwach verzieren Halobien* and *Gruppe der Halobia styriaca*. Some species of the former group (e.g. *H. disperscinsecta* Kittl) are closely related to species of the second group [e.g. *H. lenticularis* (Gemellaro): Cafiero and De Capoa Bonardi (1980, 1982)] for which the new genus *Perihalobia* Gruber, 1976 was proposed. According to Gruber (1976), *Halobia* derived from *Daonella*, while *Perihalobia* from "*Posidonia*" as indicated by the outline and sculpture pattern of the early species *H. lenticularis* from the late Carnian - lower Norian of Sicily and Montenegro (Cafiero and De Capoa Bonardi, 1980, 1982). A direct origin of *Halobia* from "*Posidonia*" was also sustained by Polubotko (1984, 1988), who considered *Halobia*, with seven subgenera, as derived from "*Posidonia*", while he erected the new genera *Zittelihalobia* and *Indigirohalobia*, and respectively two and three subgenera, for those halobiids derived from *Daonella*. A group of halobiids with feeble or without radial plications was also recognized by Campbell (1994), who classified it as *Halobia* (Parahalobia Yin and Hsu).

The early sure Halobiids of the Prati di Stuores/Stuores Wiesen occur in the middle *aan* Subzone (*Halobia casiana* Mojsisovics, bed 13b) and across the *aan-*aonoides subzones boundary (*Halobia fluxa* Mojsisovics, beds 18-19) (Urlighs 1974, 1994). The latter species belong to the *Halobia rugosa* group of Kittl (1912), which also contains *H. zitelli* Lindström and *H. viscaurita* Kittl, two species with a well developed radial ribbing, and restricted, in the western Tethys, to the *aan* Subzone (Gruber, 1976; Krynyst, 1978). Both the *Halobia* species from the upper San Cassiano Fm of Prati di Stuores/Stuores Wiesen have a well developed radial sculpture, thus the early sure Halobiids of the Prati di Stuores/Stuores Wiesen section do not belong to a group with reduced sculpture, hypothetically derived from "*Posidonia*". In conclusion, the lacking of posido-noids with an undisputable anterior ear impedes the sure identification of *Halobia* in the canadensis Subzone of the Prati di Stuores/Stuores Wiesen, although the specimen of the group c) could contribute to the debate on the phyletic connection between *Bositra*, *Daonella* and *Halobia*.

**Palynomorphs**

The distribution of spores, pollen grains and marine elements (acritarchs, foraminiferal linings and tasmanites) in the Prati di Stuores/Stuores Wiesen section reflects the evolution of the terrestrial and marine flora before and after the proposed boundary. Thirtyfour samples have been studied in order to define the distribution and the main LADs and FADs present along the succession. Typical upper Ladinian-lower Carnian spornmorphs as *Uvaesporites gadenensis*, *Kuglerina meieri*, *Ovalipollis pseudoalatus*, *Todisporites spp.*, *Aratrisporites spp.*, *Recitalisporites dolomiticus*, *Sellaspora rugovernuccata* and the circumpoles form *Partitispores novimundanus* are present throughout the section.

In the upper part of the regoledanus Subzone, *Concentricispores* cf. *C. buianlatus*, *Enzonalaspores vigens*, *Krytombisporis ervii*, *Gordonispora fossulata* and *Dupliscorites granulatus* have their first occurrence (Fig. 6). "Lueckisporites" cf. *singhii* firstly appears very close to the top of the regoledanus Subzone.

Moreover, *Nevesisporites vallatus*, *Todisporites marginales*, *Calamospora* sp. *A. Apicalisporites parvispinosus* and *Densosporites* cf. *variomarginatus* are, in the Prati di
**forspace reasons the alete bisaccate pollen grains are grouped together, because also of their long stratigraphic range; **

S. speciosus is not included in the alete bisaccate pollen grains because of its more restricted stratigraphic range.

Figure 6: Palynomorphs distribution in the Prat di Stuores/Stuores Wiesen section.
Stuores/Stuores Wiesen section, restricted to the regoledanus Subzone. Nevesisporites vallatus has its last occurrence at the proposed boundary.

Above the proposed boundary, in the lower part of the canadensis Subzone, Vallaspores ignacii, Patinasporites densus and Aulisporites cf. A. aigmognus, together with Duplicitisporites verrucosus and Camerosporites sectatus, have their first occurrence.

In the samples from the uppermost part of the canadensis Subzone, the first occurrences of Weylandites magmns, Camerosporites pseudoverrucatus and Samarophorinites speciosus are found. No other significant bioevents are documented in the overlying aon Subzone.

The palynological content of the Prati di Stuores/Stuores Wiesen section supports the proposal to place the boundary at the FAD of Daxatina canadensis. This ammonoid event occurs very closely to significant changes of the palynological association, consisting in the replacement of upper Ladinian sporomorphs by typical Carnian microflora.

The first appearance of Patinasporites densus marks the base of the vigens-densus phase and is associated with the first appearance of Vallaspores ignacii (Van der Eem, 1983); their common occurrence has been traditionally considered to be close to the base of the Carnian (Van der Eem, 1983, Fisher, 1972; Visscher and Brugman, 1981; Fisher and Dunay, 1984; Warrington, 1996; Hochuli and Frank, 2000; Roghi 2004).

On the base of a previous palynological work (Van der Eem, 1983), the Ladinian/Carnian boundary was placed in the Prati di Stuores/Stuores Wiesen section at sample Stu 2-09 AL, corresponding to the base of the author’s vigens-densus phase and, always in the same section, to sample 3 of Urluchs (1994). Van der Eem’s sample Stu 2-09 AL is located above our uppermost sample (sw af, metres 193.5), thus, the base of the vigens-densus phase in the Prati di Stuores/Stuores Wiesen section is lowered by at least 130 metres with respect to Van der Eem (1983). In fact, the occurrence of the typical Carnian species Vallaspores ignacii and Patinasporites densus very close to the proposed GSSP boundary, in association with Enzonasporites vigens, allows to refer the palynological associations from the lower part of the canadensis Subzone to the vigens-densus phase of Van der Eem (1983). These data reinforce the proposal to place the base of the phase close to the base of the canadensis Subzone (Broglio Loriga et al., 1999).

On the basis of the first occurrence, in the Prati di Stuores/Stuores Wiesen section, of Concentricisporites cf. C. biamamatus within the regoledanus Subzone, the base of the Concentricisporites cf. C. biamamatus assemblage (Roghi, 2004) is late Ladinian (Longobardian) in age.

Other microfossils

There are no new data about foraminifers, microcrinoids and holothurian sclerites besides those exposed in Broglio Loriga et al. (1998, 1999). Benthic foraminifers in particular were studied by C. Broglio Loriga, R. Rettori and D. di Bari (Broglio Loriga et al., 1999). In a preliminary proposal (Broglio Loriga et al., 1998), these authors concluded that:

1. A Carnian affinity in the portion of section belonging to the lower canadensis (m. 45 to 145) ammonoid subzones is suggested by taxa observed in thin sections.
2. The assemblages recognized in isolated material and thin sections in this lower interval are, however, closely comparable to those of the upper canadensis Subzone (m 145 to 180).
3. Most of the species occurring in the Prati di Stuores/Stuores Wiesen section 1 (Fig. 4) are quoted in the Carnian of the Taurus, Carpatho-Balkans, Transdanubian Central Range, Serbia, Northern Calcareous Alps, Julian Alps, China and Israel.
4. Change in taxonomical diversity may strongly depend on ecological factors.

Microcrinoids and holothurian sclerites were studied by G.F. Laghi and M. Rechichi (Broglio Loriga et al., 1999). Again, the conclusions of the preliminary proposal (Broglio Loriga et al., 1998) can be summarized as follows:

1. Between m 20 to 45, the first occurrences of many microcrinoids are documented.
2. From m 120 to 150, a short peak of abundance in both microcrinoids and sclerites can be recognized.
3. Above this peak, the taxonomic diversity decreases. According to Bizzarini (1993), holothurian sclerites increase again upwards.
4. Close to the top of the section, a few species disappear. The last occurrence of Osteocrinus acus is the most prominent event.

The microcrinoid and holothurian sclerites association seems to be rather typical of the 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.

3B.2 Magnetostratigraphy

A total of 96 paleomagnetic core samples were analyzed for magnetostratigraphy (Broglio Loriga et al., 1999). A bipolar characteristic component of magnetization oriented in geographic coordinates 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 up to 550-580°C. In 10% of the specimens the characteristic component could be followed up to maximum unblocking temperatures of 600–630°C. An additional 11% of the samples show transitional directions associated with polarity excursions or acquired during field polarity reversals. The bipolar and transitional characteristic component directions become shallower upon correction for bedding tilt. Rock-magnetite experiments point to magnetite as the main carrier of the magnetic remanence; subsidiary sulphurs and haematite are occasionally present. The
Figure 7: Chemostratigraphic data from the Prati di Stuores/Stuores Wiesen section
latitude of the specimen virtual geomagnetic pole (VGP) with respect to the overall mean north paleomagnetic pole was used to delineate magnetic polarity stratigraphy. The latitude of the VGPs defines, from bottom to top, a lower normal (S1n)-reverse (S1r)-normal (S2n)-reverse (S2r)-normal (S3n)-reverse (S3r)-normal (S4n) polarity sequence. The base of the Carnian, as defined by the FAD of *Daxatina canadensis*, falls towards the base of S2n. The Prati di Stuores/Stuores Wiesen section can be tentatively correlated with the coeval Mayerling section from Austria of Gallet et al. (1998). According to this correlation (Broglio Loriga et al., 1999), the first appearance of *Daxatina canadensis* at Prati di Stuores/Stuores Wiesen would fall at Mayerling within the *diebeli* conodont Assemblage Zone.

### 3B.3 Chemical stratigraphy

Prati di Stuores/Stuores Wiesen section has never been investigated in detail with the purpose of describing stable Carbon, Oxygen, and Strontium isotopes variations. To improve our knowledge in this time interval 102 samples have been collected so far along the whole section of Prati di Stuores/Stuores Wiesen for analyse Carbon and Oxygen stable isotopes’ ratios. Samples are unequally spaced (see Fig. 7), being collected exclusively from siltitic marls that were not potentially involved in turbidites. From each sample, a small amount of rock (few grams) has been hand-drilled, avoiding macrofossils (like bivalves shells), intraclasts or fractures filled by calcite. The drilled powder is thus considered representative of the bulk composition of the sample.

Powders were reacted with phosphoric acid and analyzed using an automated continuous-flow isotope ratio mass spectrometer at the University of Innsbruck. Results were calibrated against NBS and IAEA standards and have been reported relative to VPDB scale. The long-term analytical uncertainties are ±0.07‰ for δ¹³C, and ±0.08‰ for δ¹⁸O (reported at the 1σ level, Spötl and Vennemann, 2003).

Preliminary results of our analyses are plotted in Fig. 7: for graphical purposes, in δ¹³C box seven mild outliers* are not shown lower than -2‰ and clearly isolated from the data cloud. For the same reason, six mild outliers are not shown in δ¹⁸O box, being lower than -7‰ or greater than -2‰ δ¹⁸O. Oxygen isotopes values are strongly drifted towards very low values, being potentially overprinted by diageneric. δ¹³C values appear to be constant albeit sensibly scattered along the whole section, with no evidence of excursions close to the proposed Ladinian/Carnian boundary, or anywhere else throughout the section except close to Stakes 11-12. δ¹³C values, ranging between 0 ± 2‰ VPDB, seem compatible with the expected values for this time interval (Korte et al., 2005, Veizer et al., 1999). It is necessary, however, to highlight the preliminary nature of these data: further analyses both at Prati di Stuores/Stuores Wiesen and in correlated sections seem necessary to identify diageneric influences and ultimately unravel the primary geochemical trend within this interval.

*: mild outliers are defined as data points whose values are < Q₁-1.5 · (Q₃-Q₁) or > Q₃+1.5 · (Q₃-Q₁), where Q₁ and Q₃ are the first and third quartiles for the given dataset, respectively.

### 3B.4 Sequence stratigraphy

Comparing to Broglio Loriga et al. (1999), there are no significant variations of the sequence stratigraphic interpretation across the proposed boundary, as well as its global correlation (Fig. 8). The only differences are related to the slightly younger age of the supposed sequence boundary defining the base of the sequence Car 1. New biostratigraphic data from the Southern Alps (Dolomites and Lombardy) and Transdanubian Range (Hungary), allows us to put it in the lower part of the *regoledanus* Subzone instead of the *neumayri* Subzone.

The proposed GSSP is placed at the beginning of the regressive trend just after the Car 1 (sensu Gianolla et al., 1998) or Lad 3 (sensu Hardenbol et al. 1998) maximum flooding surface (mfs), dated to the upper *regoledanus* Subzone, in a section presenting very high sedimentation rates (Gianolla, 1995). This *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, specially when compared with sections characterized by lower sedimentation rates.

### 3B.6 Other event stratigraphy

Up to now, no other physical or chemical surfaces have been recognized that could be used for correlations outside the Dolomites area. Tephra layers of latest Ladinian age have been discovered recently in some sections of the Dolomites (cf. chapter 3B.8), but are not yet been identified at Prati di Stuores/Stuores Wiesen. Their correlation potential, however, should be limited to the eastern Southern Alps. No cyclostratigraphic analyses have been carried out in Prati di Stuores/Stuores Wiesen section. Masetti et al. (1991) studied a slightly younger succession of the San Cassiano Fm. some kilometres from Stuores (Lavarella section, near San Cassiano village). There, these authors recognized a cyclic organisation of stratal patterns. Such regular organization was not observed at Prati di Stuores/Stuores Wiesen, probably because of the greater distance of this section from carbonate slopes of the Cassian carbonate platforms.

### 3B.7 Marine-land correlation potential

The palynological association of Prati di Stuores/Stuores Wiesen allows correlation of the proposed boundary in terrestrial sections.

In Switzerland, *Vallasporites ignacii* and *Patinaspores densus* appear in the upper part of the middle Gipskeuper (interval F in Scheuring, 1970 and Mostler and Scheuring, 1974). In south Germany (Franken), *Vallasporites ignacii* appears in the upper “Myophorienschichten” both in outcrop and in the Obersee borehole, while *Patinaspores densus* in the overlying “Estherienschichten”. On the base of these first appearances, the proposed GSSP level can be correlated to in the upper part of the Myophorienschichten (Van den Berg, 1987, Brack et al., 1999).
Figure 8: Lithostratigraphy and sequence-stratigraphic interpretation around the Ladinian/Carnian boundary at the Punta Grohmann section, 14 km westward from Prati di Stuores. This section is representative of the sedimentary evolution in this time interval in the Dolomites.
In England, on the base of the occurrences of *Camerosporites secatus* and *Enzonalasporites vigens*, the boundary lies within the “Keuper marl” (Warrington, 1970).

In the Temple Mountain Member of the Chinle Formation (southwestern U.S.A.), typical Carnian associations are described from the base of the succession but the proposed boundary is not identifiable (Litwin et al., 1991; Litwin and Ash, 1993).

In the Newark Supergroup (eastern U.S.A.), *Vallasporites ignacii* and *Patinasporeites densus* appear in the Stockton Formation; on the base of these findings the boundary was placed inside this formation. (Fowell et al., 1994). Recent magnetostratigraphic studies, however, suggested this correlation and rather suggest the GSSP level should lie below the succession of the Newark Supergroup (e.g., Muttoni et al., 2004).

### 3B.8 Amenability to geochronometry

No datable layers are known from the Prati di Stuores/Stuores Wiesen section. Recent studies have recognized several primary and reworked ash beds in correlatable sections from the surroundings of the proposed stratotype section (Furin, 2007), further ash beds have been sampled during summer 2007. Among all the studied primary ash beds, only one layer yielded enough zircon crystals for radiometric dating. This bed, collected in the Alpe di Siusi area (24 km west of Prati di Stuores/Stuores Wiesen) has good biostratigraphic control based on ammonoids and conodonts. With the reference to ammonoids, the ash bed is within the lower part of the *regoledamus* Subzone (sensu Mietto and Manfrin, 1995), below the Carl sequence boundary (see paragraph 3B.4). Chemical Abraded, ID-TIMS radiometric age of the mentioned layer is expected to be published in 2008. Further ash beds have been collected in the Punta Grohmann section (14 km westward from Prati di Stuores) from ash beds between the Carl sequence boundary and the first occurrence of *Frankites apertus* (Mojsisovics), but data are still preliminary. No radiometric ages are known so far in this area above the proposed boundary. Published radiometric ages bracketing the proposed Ladinian/Carnian boundary are 238.0 +0.4 -0.7 Ma (Mundil et al., 1996) and 230.91±0.33 Ma (Furin et al. 2006). The two ages are excessively older/younger than the proposed boundary (see above) so any interpolation between these two pinpoints is extremely inaccurate (and potentially erroneous). The older age is obtained by U/Pb TIMS analyses on eight air-abraded Zircon crystals from an ash bed collected at Seceda (17 km NE from Prati di Stuores/Stuores Wiesen). The layers belong to the *archelaurus* Zone (sensu Brack and Rieber, 1993, i.e., corresponding to the *longobardicum* to *neumayri* subzones in Mietto and Manfrin, 1995a), based on the presence of *Daonella lommeli*. The younger age is obtained by Chemical Abraison ID-TIMS technique on eight zircon crystals from a layer collected in the Southern Apennines (Southern Italy – more than 700 Km SE). Biostratigraphic control on the latter layer is given by conodonts and palynomorphs: according to Kozur and Weems (2007) the layer belongs to the *Carnepigondolella zoae* conodont zone, leading to middle to upper Tuvalian (Upper Carnian) age. According to many Authors (Gallet et al., 2003; Kozur and Weems, 2007) the expected age for the Ladinian/Carnian boundary should fall approximatively at 237 Ma.

### 3C Demonstration of regional and global correlation

#### 3C.1 Regional correlation

The litho-, sequence-, magneto- and biostratigraphic correlation of Ladinian/Carnian boundary interval within the Southern Alps is widely illustrated and discussed in De Zanche et al. (1993), De Zanche and Gianolla (1995), Mietto and Manfrin (1995b) and Broglio Loriga et al. (1998, 1999). From a biostratigraphic point of view, several stratigraphic sections and localities in the Southern Alps provide ammonoid faunal assemblages referred to the *canadensis* Subzone. Bed-by-bed distributions of ammonoids, conodonts and palynomorphs in selected key sections are showed in Mietto et al. (2007, submitted).

#### 3C.2 Long distance and global correlation

The succession of ammonoid faunas in the Prati di Stuores/Stuores Wiesen section and in other correlated localities in the Southern Alps, records some bioevents which occur in homotaxic also in the Tethys and extra-tethysian domains (Himalayas, Nevada, British Columbia, Svalbard). With reference to Mietto and Manfrin (1995b) and Broglio Loriga et al. (1999), the occurrence of taxa with widespread distribution allows the tethysian biozones to be correlated with those defined in British Columbia by Tozer (1967, 1994). In particular, the *canadensis* Subzone has been considered nearly equivalent to the sutherlandi Subzone 2 of Canada for the concurrent occurrence of *Daxatina canadensis* and *Frankites apertus* (= sutherlandi), and correlatable by the first appearance of the former taxon. Nevertheless, the uppermost Ladinian to lowermost Carnian part of the North America ammonoid Standard Scale needs to be revised because of the partial overlapping between the sutherlandi and desatoyense Zones, demonstrated in Nevada (Balini, in press). The “Daxatina canadensis Zone”, defined in the Svalbard Archipelago (Bjornoya, see Mork et al., 1992), is also correlated with the *canadensis* Subzone. Magnetostratigraphic correlation based on ammonoids vs conodonts calibration between Prati di Stuores/Stuores Wiesen and Mayerling in Northern Calcareous Alps is showed in Broglio Loriga et al (1999), and is now confirmed by the finding of *Paragondolella polygonathiformis noah* in the bed SW4c (Mietto et al., 2007).

The ammonoid succession recently reported from the *canadensis* Subzone in Himalayas (Guling 1 and Muth 3 sections in Spiti Valley: Balini, Krystyn and Torti, 1998; Krystyn, Balini and Nicora, 2004) and in Nevada (New Pass Range: Balini and Jenks, 2007; Balini et al., 2007; Balini, in press) is consistent with the ammonoid succes- sion at Prati di Stuores/Stuores Wiesen. The correlation is illustrated in detail by Balini et al. (in prep.).
4. Selection process

4A Relation of the GSSP to historical usage

The history of concepts regarding the Ladinian/Carnian boundary is summarized in Gaetani (1995) and Broglio Loriga et al. (1999). As well known, the base of the Carnian traditionally coincides with the appearance of *Trachyceras aon*, considered the first representative of the genus. *Trachyceras* is documented at Prati di Stuores/Stuores Wiesen by *Trachyceras muensteri* that occurs associated with *Daxatina canadensis*; in the Antersass section *T. bipunctatum* also occurs in the *canadensis* Subzone. This implies the predation of genus *Trachyceras* and allows to consider the *canadensis* Subzone Carnian in age (Mietto and Manfrin, 1995a, 1995b). Also conodonts, palynomorphs and halobiids corroborate this assumption.

4C votes

During “The Global Triassic” Conference in Albuquerque (23-28 May, 2007), the STS session voted that the primary marker for the definition of the GSSP for the base of the Carnian Stage is the first appearance of the genus *Daxatina*. Voted secondary markers are the first appearance of *Para-gondolella polygnathiformis noah* and halobiids. The Prati di Stuores/Stuores Wiesen section in the Southern Alps (NE Italy), and the bed SW4 in which *Daxatina canadensis* firstly appears, were considered a good candidate for the GSSP of the base of the Carnian.

Figure 9: Stratigraphic column of the Bec de Roces section, with distribution of main fossils.
Figure 10: Stratigraphic column of the Antersass section, with distribution of main fossils.
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4D selected publications


5. Other useful sections

The most relevant complementary sections in the Southern Alps, significative for the definition of the Ladinian/Carnian boundary have been described in Mietto et al. (2007, submitted).

The Bec de Roces section is located on the eastern flank of the Sella Massif, near Passo Campolongo not far from Stuores (Fig. 9). It is a short section that best illustrates the ammonoid association typical of the canadensis Sub-zone. The Anterass section is located on the northern flank of Gardenaccia in the middle Badia Valley. This section is noticeable for the abundance of fairly well preserved ammonoids that best records the boundary between the canadensis and aon subzones (Fig. 10).

Acknowledgements

We wish to thank all the authors who contributed to the original GSSP proposal (Broglio Loriga et al., 1998, 1999), including those who not appear as authors of this paper. Some are no more with us, and we wish to remember them especially, and with love: Carmela Broglio Loriga, Vittorio De Zanche and Claudio Neri. Special gratitude is extended to M. Balini and M. Gaetani for useful discussion and accurate revision. We would like to thank Fabrizio Tagliavini and Damiano Maragna for the help in the field. Nicola Michelon is also acknowledged for the assistance in the graphics.

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First detailed carbon isotope curve through the Ladinian-Carnian boundary: The Weissenbach section (Austria).

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Abstract - We present here a preliminary carbon isotope curve of the Ladinian-Carnian Boundary Interval from the Weissenbach-Mayerling section, Northern Calcareous Alps (NCA). The δ¹³C_carb data measured in hemipelagic limestones record two negative excursions of small amplitude immediately below and above the boundary interval. If confirmed by data from other sections these two negative excursions might be relevant chemostratigraphic markers for the Ladinian-Carnian boundary.

1. Introduction
Carbon isotope curves have been widely used as correlation tool and their application is recommended by the ICS within the frame of GSSP definitions. But up to now, there is no detailed carbon isotope curve available for the Ladinian-Carnian boundary (LCB). Prati di Stuores/Stuores Wiesen in the Southern Alps (Italy), the currently only candidate GSSP (Broglio Loriga et al., 1998; 1999; Mietto et al., 2007), has no published carbon isotopic records. The only available δ¹³C_carb curves for this time slice are from Romania (Atudorei, 1999) and Oman (Hauser et al., 2001), but without adequate biostratigraphic control for this interval and a low isotopic resolution for the Oman section (Hauser et al., 2001). The Weissenbach section in the Northern Calcareous Alps of Austria is important because of its reliable magnetostratigraphy (Gallet et al., 1994, 1998; in these papers the section is named Mayerling) and is approximately correlative to the Stuores Wiesen section using conodonts and magnetostratigraphy. We present here a preliminary carbon isotope curve through the LCB.

2. Geological setting
The Weissenbach section is located approximately 30 km southwest of Vienna, in the vicinity of the village of Weissenbach near Mayerling (Fig. 1). Gallet et al. (1994) used the name ‘Mayerling’ (rather than Weissenbach) because of its well-known historical background. From a paleogeographical point of view, this section belongs to the Northern Calcareous Alps (NCA), which are considered as a part of the northwestern Tethyan continental margin (e.g. Bosselini et al., 1980). The section is situated along a railway cutting (1, Fig. 1), with beds dipping 55° towards southeast (Gallet et al., 1994). The section sampled consists of 22 m of thick-bedded, whitish, fine-grained, deep-water pelagic limestones (Fig. 2). This uniform lithology is best suited for carbon isotopic studies (Atudorei, 1999).

3. Method
Twenty-four samples were taken within 15 m of the presumed LCB. For isotopic analyses, powders were produced from selected micritic samples using a diamond-tipped drill. Hand specimens were carefully examined to avoid cracks, veins and weathering features and drilled on the counterpart of thin sections. The samples were analyzed using an automated carbonate preparation system connected to a DeltaplusXL mass spectrometer (Spötl and Vennemann, 2003) at Innsbruck University. Reproducibility of replicate analyses was better than ±0.1‰ for standards and ±0.15‰ for sediment samples for both carbon and oxygen isotope values. All isotope results are reported using the conventional δ notation, defined as per mil (%) deviation vs. VPDB.

4. Results and discussion
4.1 Biostratigraphy
The biostratigraphy of the sequence is based exclusively on conodonts, a difficult task in absence of a modern revision of Upper Ladinian to Lower Carnian faunas and...
considering the highly contradicting views on the taxonomy of the time-diagnostic genera *Budurovignathus* and *Metapolygnathus*. Published species ranges of the mentioned taxa are therefore highly subjective and may vary considerably rendering a comparison and correlation difficult. A high-resolution stratigraphic interpretation of the Weissenbach section is further hampered by two other factors, i.e. discontinuous data below the indicated LCB interval (Fig. 2), and the apparent difference in faunal composition of the exclusively *Budurovignathus*-bearing samples in the lower part of the section versus the mixed budurovignathid-gondolellid associations above.

In absence of generally accepted definitions, we provide the here used defining criteria for *Budurovignathus* and *Metapolygnathus* species. Forms with a short rectangular, terminally rounded to slightly squared platform and a lower un-bifurcated keel are included in a morphologically expanded *Budurovignathus longobardicus* (Kovacs)
with an extended range from the Upper Ladinian to the lowest Carnian (cf. 'oon-Zone specimens from Stuores Wiesen figured *Budurovignathus diebeli* in Neri et al., 1995). Specimens with an elongated rectangular, posteriorly squared platform and a well bifurcating, Y-shaped terminal keel are assigned to *Budurovignathus diebeli* (Kozur & Mostler) and might - in this restricted sense - become a valuable marker for the new LCB. The *Metapolynathus polygnathiformis* group is differentiated in *M. polygnathiformis* s. str. (plus newly described specimens in Orchard & Balini, 2007), and *M. cf. noah* for morphotypes close to Hayashi’s type figure of this species. Orchard & Balini (2007), however, argues to restrict this name to Upper Carnian representatives and not to use it for Lower Carnian homoeomorphs. Neglecting long-ranging species occurring throughout the late Ladinian and basalmost Carnian (*B. mungoensis, B. longobardicus, M. inclinatus, M. fyllatus*) there remain three taxa (*B. diebeli, M. polygnathiformis, M. cf. noah*), which may be of time-significance for the LCB in Weissenbach. These three forms share successive appearances in the section within a 6 m interval starting with *B. diebeli* followed by *M. polygnathiformis* and closely above by *M. cf. noah*. Such a low-resolution record does not allow any direct correlation with the Stuores Wiesen sequence, though our gray shaded “boundary interval” (see Fig. 2) may come close to the ammonoid-defined LCB in the candidate GSSP.

### 4.2 Magnetostratigraphy

The section contains four magnetic polarity intervals with the second one being much longer than the other three (Fig. 2). Muttoni’s magnetostratigraphic comparison of Weissenbach-Mayerling with Stuores Wiesen (in Broglio Loriga et al., 1998) lacked a proper chronostratigraphic time frame. He equated a rather long time interval in Weissenbach (complete *regoledanus-Zone = Longobardian 3* in Gallet et al., 1994) with a much shorter one in Stuores (*Daxatina cf. canadensis Zone = upper part of regoledanus-Zone* sensu Gallet et al., 1994). The magnetic correlation used in the present paper fits the biostratigraphic data much better. The sedimentation rate, which is 15 to 20 times lower in Weissenbach than in Stuores Wiesen, has as consequence that the sampling interval in Weissenbach (30-60 cm) is in proportion much coarser than in Stuores (< 5-9 m). This might explain the absence of the two thin Stuores Reversals S1r and S2r in the Weissenbach section. Consequently, we correlate the first long Weissenbach Normal with the three Stuores Normals S1n to S3n. At Stuores Wiesen, the base of the *Daxatina cf. canadensis Zone* is located low in S2n (Broglio Loriga et al., 1998). Translating this position into the long Normal of Weissenbach would lead to a LCB close to the base of the gray shaded LCB interval in Fig. 2, the probably most realistic value achievable.

### 4.3 Chemostratigraphy

The lithology, which is rich in carbonate (>99%) and very poor in organic matter, the study of thin-sections, the low thermal overprint (Conodont CAI 1) and the absence of a significant correlation between δ¹³C and δ¹⁸O values, strongly suggest that diagenesis did not alter the δ¹³C values. The uniform lithology permits to record isotope variations, which would most likely be difficult to identify in a less homogenous limestone. Within the measured interval the δ¹³C values vary between 2.4‰ and 3.3‰. δ¹⁸O values are slightly increasing from 2.7‰ to 3.2‰ in the first 6 m. The curve then records two negative excursions of 0.7‰ in amplitude, one beginning just below the interval presumably comprising the LCB (shaded interval in Fig. 2) and the second one beginning immediately above it. If confirmed by subsequent studies the suggested position of the LCB at the base of the shaded interval will provide a possibility to correlate this boundary within the first negative excursion.

In Dobrogea (Romania) Atudorei (1999) showed constant values in the two lower thirds of the Ladinian followed by an increase of 1.5‰ to 2‰ and again constant values in the Lower Carnian. Unfortunately, the available biostratigraphic data do not allow to decide if this increase occurred in the Upper Ladinian or in the Lower Carnian. Our results suggest that this increase did not occur around the boundary, but either below or above it and thus cannot serve as marker for the LCB. Further isotope studies are needed.

<table>
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<td>2.8</td>
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<tr>
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Table 1: δ¹³C and δ¹⁸O values of the Weissenbach section.
necessary to 1) define the exact biostratigraphic position of the δ¹³C increase recorded in Dobrogea, and 2) confirm the reproducibility and the wider correlation of the two small negative excursions around the LCB in the Weissenbach section.

Acknowledgments

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References


