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THE PRATI DI STUORES/STUORES WIESEN SECTION (DOLOMITES, ITALY): A CANDIDATE GLOBAL STRATOTYPE SECTION AND POINT FOR THE BASE OF THE CARNIAN STAGE

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Riassunto. La sezione di Prati di Stuores/Stuores Wiesen (Formazione di San Cassiano), affiorante nei dintorni di Pralongià, a SW di San Cassiano/St. Kassian, sul versante meridionale del crinale che separa la Val Badia/Abtei (BZ) dalla Val Cordevole (BL), è nota come sezione tipo del Cordevolico. In tempi recenti sono stati individuati al di sotto della tradizionale Zona ad Aon, numerosi livelli con ammonoidi della Subzona a Regoledanus (Zona a Protrachyceras), seguiti da altri dove compaiono in particolare i generi *Daxatina* (*Daxatina* sp., *D.* cf. *canadensis*), *Clionitites* e *Trachyceras*, quest'ultimo rappresentato da specie diverse da *T. aon*. *Daxatina*, genere ritenuto tipico delle medie ed alte latitudini, risulta pertanto cosmopolita e *Trachyceras*, taxon delle medie e basse latitudini, viene confermato in livelli che precedono le faune ad Aon. Nella sezione è stata definita una nuova unità biostratigrafica, la Subzona a Daxatina cf. canadensis (Zona a Trachyceras) riferibile al Carnico, nella quale sono presenti anche "*Anolcites*" ex gr. *laricus*, *Zestoceras* n. sp. A, *Asklepioceras* e *Muensterites*. Il FAD di *Daxatina* viene indicato come marker del limite inferiore dell'unità. Tale limite cade all'interno della Fm. di San Cassiano, pochi metri al di sopra del limite con la Fm. di La Valle. La comparsa di *Trachyceras aon* ne segna il limite superiore. La subzona è individuabile anche in altre sezioni delle Dolomiti. I conodonti, molto scarsi in tutta la sezione fino a mancare nella parte bassa della Subzona a D. cf. canadensis, si inquadrano nella Zona di associazione a *Budurovignatus diebeli*. *Gondolella polygnathiformis*, segnalata nella Subzona ad Aon, manca sia nella Subzona a Regoledanus sia in quella a D. cf. canadensis; il suo significato di marker della base del Carnico, come proposta in questo lavoro risulta discutibile. Nella ricca palinoflora presente poco sopra il FAD di *Daxatina* si individua la fase a *vigens -densus*, già segnalata nella Subzona ad Aon. I foraminiferi bentonici (sezioni sottili e lavati) sono rappresentati da specie note soprattutto nel Carnico della Tetide. Alcune specie ad affinità carnica sono già presenti al di sotto della prima comparsa di *Daxatina* (es. *Gsollbergella spiroloculiformis*). I bivalvi appartengono a tre morfotipi di Posidoniidi (*"Posidonia" wengensis*, *"P." cf. wengensis*, ? *Halobia*). I rari brachiopodi sono limitati alla parte medio superiore della sezione (*Koninckina leonhardi*, *Retzia* sp.), dove pure si trovano nove specie di gasteropodi. Un picco di diversità tassonomica molto netto riguarda i foraminiferi bentonici isolati e le scleriti di oloturie ed è palese nella parte superiore della Subzona a Daxatina cf. canadensis. In particolare, vi compaiono scleriti finora segnalate nella Subzona ad Aon. Le variazioni in frequenza e diversità tassonomica di queste faune minori suggeriscono condizioni anaerobiche-disaerobiche del fondale nella parte medio-inferiore della sezione (0-105 m), quindi una tendenza ad ossigenazione più stabile nella parte superiore. La magnetostratigrafia mostra quattro intervalli a polarità normale e tre a polarità inversa. La base della Subzona a Daxatina cf. canadensis è prossima all'intervallo di polarità normale S2n. Dal confronto con i dati paleomagnetici della coeva sequenza di Mayerling (Austria), risulta che il tasso di sedimentazione a Stuores è circa otto volte superiore a quello dei carbonati pelagici della serie austriaca e che la prima presenza di *D.* cf. *canadensis* può cadere nella parte inferiore della Zona a Diebeli della suddetta serie. Sulla base degli ammonoidi, degli altri gruppi fossili e dei dati magnetostratigrafici unitamente ai requisiti storici, si propone il FAD di Daxatina come marker della base del Carnico e la sezione di Prati di Stuores, come GSSP del limite Ladinico-Carnico.

Abstract. The Prati di Stuores/Stuores Wiesen section (Dolomites, Italy) is proposed as a candidate Global Stratotype Section and Point for the base of the Carnian Stage. In addition to being a famous, richly fossiliferous locality, it includes the type-section of the Cordevolian substage. The section is located near Pralongià, along the southern slope of the crest separating the Badia/Abtei and Cordevole valleys. Below the levels with *Trachyceras aon*, the section contains a rich ammonoid fauna that characterizes the upper part of the Regoledanus Subzone and subsequently records the first appearances of the mid-high latitude genus *Daxatina* (*Daxatina* sp., *D.* cf. *canadensis*) and of traditional *Trachyceras* with species different from *T. aon*. Therefore, the Daxatina cf. canadensis Subzone is recognised above the Regoledanus Subzone. Very rare conodonts of the *Budurovignatus* group and species of *Gladigondolella* from the *diebeli* Assemblage Zone occur. *Gondolella polygnathiformis*, already known from the Aon Subzone, is absent. Palynomorphs, foraminifers, gastropods, bi-

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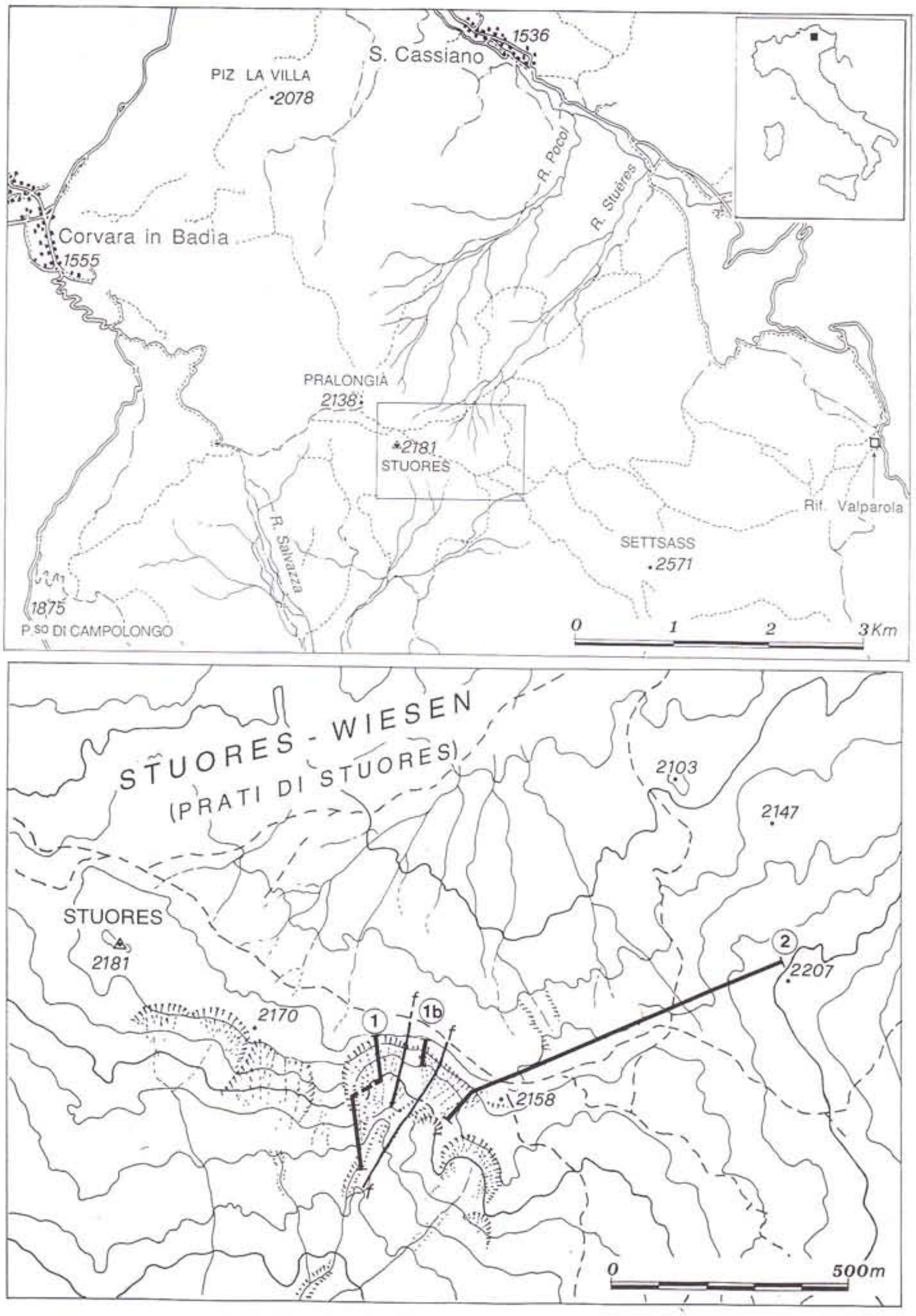

Fig. 1 - Location of the Prati di Stuores/Stuores Wiesen area and stratigraphic sections. Sections 1 and 1 bis correspond to the column in Fig. 3 and 13. Section 2 corresponds to the Stuores Wiesen section in Urlichs (1974, 1994) and to section SW5 in Neri et al. (1995).

valves, brachiopods, microcrinoids and holothurian sclerites were studied. Variations in frequency and taxonomic diversity of these faunas suggest anaerobic-disaerobic bottom conditions for the lower-middle part of the section (0-105 m), followed by a more stable oxygen content in the upper portion. Magnetostratigraphy showed four intervals with normal polarity and three intervals with reversed polarity. The Daxatina cf. canadensis Subzone falls close to the normal polarity interval S2n. The present study proposes the FAD of the cosmopolitan genus *Daxatina* as the marker of the base of the Carnian Stage, placing it at a lower stratigraphic level than previously indicated in the Stuores area. The Prati di Stuores section is proposed as GSSP of the Ladinian-Carnian boundary.

Introduction.

The Prati di Stuores/Stuores Wiesen section (Dolomites, Italy) is proposed as a candidate Global Stratotype Section and Point for the base of the Carnian Stage, in accordance with the guidelines for establishment of GSSP (Remane et al., 1996). The Stuores section consists of two parts (Fig. 1, and 3). The westernmost part, herein named section 1, corresponds exactly with section SW4 of Neri et al. (1995) and with the section illustrated by De Zanche & Gianolla (1995) and by Mietto & Manfrin (1995b). The latter extends downward for about 20 m below stake 1, which marks the base of the section described in this paper. The top of section 1 may be correlated to a short section (section 1 bis) located slightly to the east and separated from section 1 by faults of modest throw. Section 2 lies further to the east and corresponds to the Stuores Wiesen section of Urlichs (1974, 1994) and to section SW5 of Neri et al. (1995). Due to tectonic omission, the base of section 2 cannot be correlated with the top of section 1bis. Further details on the relationships between the Stuores section as used herein and the section in Urlichs (1974, 1994), were given by Neri et al. (1995). In the present paper, the term section 1 and 1bis refers to the Prati di Stuores/Stuores Wiesen section. The section supplied a rich ammonoid fauna which predates the first appearance of *Trachyceras* and includes the genus *Daxatina*, a taxon particularly significant in global correlations (Mietto & Manfrin, 1995a, b). This cosmopolitan genus allows correlations between different paleolatitudinal provinces. The use of its first appearance as a criterion for recognizing the base of the Carnian Stage is proposed, which would place this boundary at a stratigraphic level lower than previously adopted in the same area (cf. Urlichs, 1974, 1994; Krystyn, 1978).

The Stuores section 1 was marked permanently with twenty stakes to permit accurate localisation of the

Fig. 2 - Prati di Stuores/Stuores Wiesen section at the head of the Cordevole valley.

sampling sites. Other fossil groups, magnetostratigraphy and sequence stratigraphy were investigated recently. Differences and/or discrepancies with previous studies (e.g. Mietto & Manfrin, 1995b; De Zanche & Gianolla, 1995; Gianolla, 1995; Roghi, 1995) may result from the re-measurement and standardization of the stratigraphic section. The Authors responsible for the various fields of study are indicated at the beginning of each chapter.

Historical Background.

(Carmela Broglio Loriga)

The name Carnian was introduced in 1869 by Mojsisovics to define the stratigraphic interval corresponding to the Trachyceras aonoides Zone. Mojsisovics (1869) listed six localities, at that time under Austro-Hungarian rule, where these rocks crop out. However, the origin of the name Carnian (*Karnische Stufe*) is uncertain. According to Tozer (1967, 1984) it derives from the province of Carinthia (*Kärnten*), within which the locality of Raibl (ancient name of Cave del Predil), explicitly indicated by Mojsisovics, was situated. Alternatively, Gaetani (1995), though referring to the Raibl succession in Carnia, considers that the name derives from the Carnian Alps, although the section actually occurs in the Julian Alps.

Mojsisovics, Waagen & Diener (1895) redefined the Carnian Stage within their chronostratigraphic revision of the Triassic, and subdivided it into the Cordevolian, Julian and Tuvalian substages, corresponding respectively to the *Trachyceras aon*, *T. aonoides* and *Tropites subbullatus* ammonoid zones. The term Cordevolian is derived from the Cordevole Valley in the Dolomites, near the head of which the Stuores section occurs. The name Julian comes from the Julian Alps, in which the Raibl/Cave del Predil section mentioned above occurs, and Tuvalian is derived from Tuval, a locality in the Bavarian Alps near Berchtesgaden, less than 20 km south of Salzburg (e.g. Allasinaz, 1964).

No substantial modifications were made to this scheme until the sixties, when stratigraphic research resumed with the work of Jacobshagen (1961), Allasinaz (1964), Tozer (1967), Kozur (1976) and others. On the basis of the major bioevent philosophy, Krystyn (1978) considered the distinction between the Aon and Aonoides zones to be of little importance. He proposed a subdivision of the Carnian stage into two parts, the lower corresponding to the Julian substage, plus the Cordevolian, and comprising the Aonoides, Austriacum and "Sirenites" Zones, and the upper corresponding to the Tuvalian. This proposal was rejected by Bizzarini et al. (1986) and Urlichs (1994). On the basis of ammonoid biostratigraphy in the Southern Alps, and particularly in the Prati di Stuores section, Urlichs (1974, 1994) considered the original zonal statement of Mojsisovics to be still valid and therefore maintained the use of the Cordevolian substage.

The criterion adopted by most workers for recognizing the base of the Carnian has been the first appearance of the genus *Trachyceras*. This event is believed to occur at the base of the Aon Subzone/Zone in the Tethyan domain, while in North America it lies within the Desatoyense Zone (Tozer, 1967, 1984, 1994).

Mietto & Manfrin (1995a, b) defined a stratigraphic interval, characterised by *Daxatina*, *Clionitites* and species of *Trachyceras* different from *T. aon*, which, in the Stuores section, is located below the traditional base of the Carnian. These biostratigraphic data encouraged these two authors to suggest that the base of the Carnian should be placed at a lower stratigraphic level, thus including the upper part of the Frankites regoledanus Zone (Krystyn in Zapfe, 1983) in the Carnian, a zone usually considered Ladinian and correlated with the Frankites sutherlandi Zone of North America.

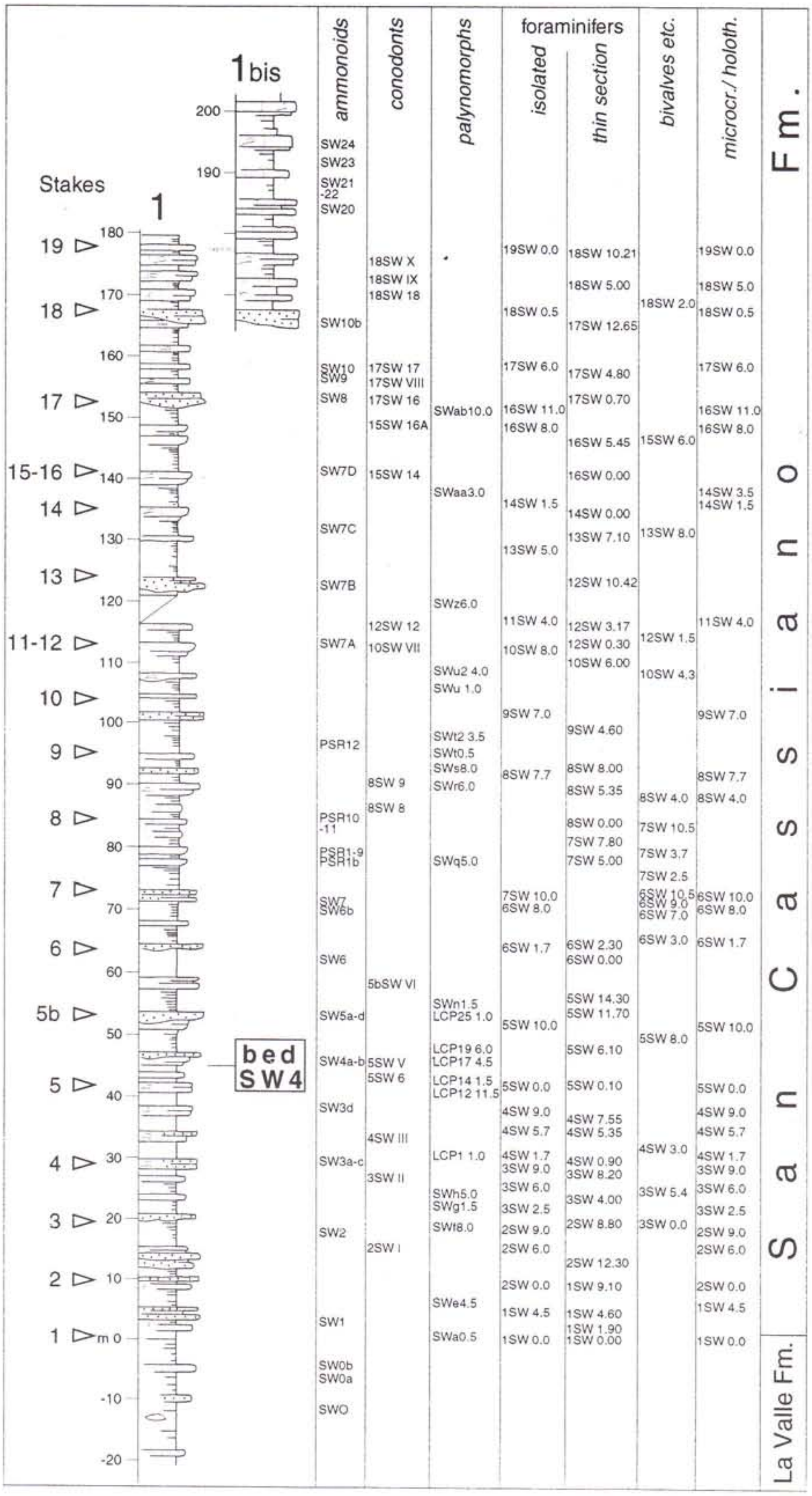

Fig. 3 - Stratigraphic position of the most paleontologic samples throughout the Prati di Stuores section (see Tables 1-7 for the complete sample position).

Definition of the base of the Carnian.

The Prati di Stuores/Stuores Wiesen section.

The Stuores section lies near Pralongià, along the southern slope of the crest that separates the Badia/Abtei and Cordevole valleys. The section is located within a wide, deeply eroded gully cut into the slope between the crest at about 2150 m, down to an altitude of 1980 m. It then continues beyond the crest and ends at the foot of the Richthofen Riff and the Settsass (Fig. 1). The section is accessible via footpath C.A.I. no. 23 from Hotel Pralongià towards Settsass, a few hundred metres ESE of Piz Stuores (2181 m). Pralongià may be reached by chair-lift or by dirt road both from San Cassiano/St. Kassian and Corvara (Badia/Abtei Valley) and from Arabba (Cordevole Valley).

Lithostratigraphy

(Vittorio De Zanche, Piero Gianolla & Claudio Neri)

The Prati di Stuores /Stuores Wiesen section is famous thanks to the classical works by Münster (1834), Wissmann & Münster (1841), Klipstein (1845), Laube (1869), Mojsisovics (1882), and Ogilvie (1893), in which geologic, stratigraphic and paleontologic aspects are discussed.

The locality is also in the type-area of the San Cassiano Fm., defined by Wissmann (Wissmann & Münster, 1841) as *Schichten von St. Cassian* and subsequently named *Cassianer Schichten*. The San Cassiano Fm. is a basinal unit, subdivided by Ogilvie Gordon (1900) into two members: "lower" (*Untere Cassianer Schichten*, UCS) and "upper" (*Obere Cassianer Schichten*, OCS) on the basis of lithologic features and paleontologic contents. The UCS overlie the La Valle Fm. (although their boundary was not well defined), and consist of alternating siltstones, claystones, calcarenites, marly limestones and turbidity volcanoarenites. According to Urlichs (1974), the OCS overlie the highest volcanoarenitic layer (*tuffsandstein*) and are made mainly of muddy beds, sil-

Stakes	Samples	metres from stake 1	*Lobites ellipticus*	*Asklepioceras sp.*	*Anolcites sp.*	*Frankites apertus*	*Lecanites glaucus*	*Sirenotrachyceras sp.*	*Frankites sp.*	*Joannites sp.*	*Proarcestes sp.*	*Zestoceras aff. enode*	*Pseudocarnites sp.*	*Protrachyceras sp.*	*Daxatina sp.*	*Daxatina cf canadensis*	*"Anolcites" ex gr. laricus*	*Clionitites sp.*	*Zestoceras n. sp. A*	*Trachyceras bipunctatum*	*Trachyceras muensteri*	*Romanites sp.*	*Lobites sp.*	*Trachyceras sp.*	*Muensterites sp.*	*"Ceratites" sp.*	*Klipsteinia sp.*	*Klipsteinia achelous*	*Trachyceras aon*	*Trachyceras dichotomum*	*Lobites ellipticoides*	*Paralobites spp.*	*Proarcestes bicarinatus*	*Joannites klipsteini*	Subzon
	URL1b						●																						●	●	●	●	●	●	●	Ao
	SW24	194.30					●																							o		o					
	SW23	191.30																								●											Daxatina cf. canadensis
	SW22	188.20					●																			●					o							
	SW21	188.00					●			o																	●	o									
19	SW20	183.80																										o									
	SW10b	165.20					●																													
	SW10	157.80		●				●	●							●			o		●				●										
	SW9	156.20	●	●			●		●						o						●					●									
15	SW8	153.00					●																												
14	SW7D	141.00					●																												
13	SW7C	131.50																							●										
	SW7B	122.40							●																●										
11-12	SW7A	113.00	o																																
9	PSR12	96.40																	●																
	PSR11	84.60					●			o									●																
8	PSR10	84.50								o									●		●			●											
	PSR9	79.40															●																		
	PSR8	79.30				●	●			o								●	●																
	PSR7	79.20	●							o									o			o													
	PSR6	79.15	●					o										●	●																
	PSR5	79.10					●											o	o		●														
	PSR4	79.00				o	●								o			●	●																
	PSR3	78.90					●			o					●		●	●	●		●	o	●												
	PSR2	78.80	●							o								●	●																
	PSR1	78.50																	●																
7	PSR1b	77.30													●																				
	SW7	71.00				●																													
6	SW6b	69.40					●																												
5b	SW6	61.50																		●															
	SW5d	52.90					●																												
	SW5c	52.70	●							o																									
	SW5b	52.40	●							o					●		●		●																
	SW5a	52.20													o			●																	
	SW4b	45.50	●																																
	SW4a	45.20		o																															
5	SW4	45.00													●	●	●																		
	SW3d	37.50	●																																Regoledanus
	SW3c	29.00												o																					
	SW3b	28.70	●							o				o																					
4	SW3a	28.50	●							o																									
2	SW2	17.00		o								●	●																						
1	SW1	2.20	●	●	o				●	o	●																								
	SW0b	4.90 -	●																																
	SW0a	7.00 -	●	o	o	●	●	●																											
	SW0	12.00 -	●																																

Tab. 1 - Ammonoid distribution in the Prati di Stuores sections 1 and 1bis. The layer URL 1b is located at the base of section 2 (cf. Urlichs, 1994); o = open nomenclature.

tstones and marls, with some limestone intercalations.

Subsequently, this lithostratigraphic definition was challenged by De Zanche et al. (1993), De Zanche & Gianolla (1995) and Neri et al. (1995) because paleogeography, i.e. the distance of the volcanic shoreline, controls the presence and/or the amount of volcanic debris within the La Valle and San Cassiano Fm. As a consequence, the volcaniclastic content does not seem to be a significant characteristic at the basin scale.

Considering the lithology, mainly grey and dark grey marls with intercalations of volcanoturbidites (La Valle Fm.) crop out in the lower part of the section, while in the upper part brown and yellowish marls with carbonate turbidites gradually prevail (San Cassiano Fm.). In agreement with Richthofen (1860), Fürsich & Wendt (1977) and Marinelli (1980), the La Valle Fm./San Cassiano Fm. boundary (at 1.5 m from the base of stake 0, Fig. 3) is marked by the appearance of oolitic turbidites, which indicate the progradation of a carbonate platform (Cassian Dolomite).

The over 200 m thick alternations of siliciclastic and carbonate turbidites, deposited in a relatively deep basin, together with the absence of unconformities and the gradual upward increase in sedimentation rate and carbonate content, show that the Prati di Stuores section records a marked continuity of sedimentation. No sudden or significant facies changes may be perceived either in the entire section or especially within the interval including the proposed Ladinian/Carnian boundary (base of bed SW4, Tab. 1).

Synsedimentary tectonics seem to be absent. Some minor slumps recognizable in the upper part of the section do not interfere with the continuity of the section.

Biostratigraphy

The ammonoid biostratigraphy of the Ladinian/Carnian boundary sequence, particularly in the Stuores section, was discussed by Urlichs (1974, 1994) and Mietto & Manfrin (1995a, b); the conodont biostratigraphy was documented formerly by Neri et al. (1994, 1995, 1996) and Mastandrea et al. (1997). The present study includes the biostratigraphic data of a segment underlying the Aon Zone. Research on ammonoids, conodonts and palynomorphs from Ladinian-Carnian stratigraphic sections of the Dolomites is still in progress, but the present paper summarizes the knowledge to date.

Ammonoids and ammonoid biozones.

(Stefano Manfrin & Paolo Mietto)

The Stuores section yielded many ammonoids (29 levels), particularly from beds below the interval studied by Urlichs (1974, 1994). The fauna was illustrated by Mietto & Manfrin (1995b), but new material has been collected (Pl. 1, and 2) and a revised ammonoid distribution is presented in Table 1.

The most significant ammonoid events recorded in the Stuores section are as follows.

1- The genus *Daxatina*, previously known in the mid-high latitudes, occurs also in the Tethyan domain;

2 - species of the low-intermediate latitudes genus *Trachyceras*, different from *T. aon* are found in levels older than previously known;

3 - the uppermost Ladinian Regoledanus Subzone (Protrachyceras Zone) *pars* and Daxatina cf. canadensis Subzone (Trachyceras Zone) were recognised in the segments 12 to 45 m and 45-194.3 m respectively;

4 - the correlation of the Daxatina cf. canadensis Subzone with the upper Sutherlandi Zone from British Columbia is justified;

5 - in considering the occurrence of the Carnian taxon *Trachyceras*, the Julian age was suggested for the Daxatina cf. canadensis Subzone (Mietto & Manfrin, 1995a, b).

Furthermore, new material from Prati di Stuores and sections outside the Stuores area (Mietto & Manfrin, 1995b) allowed a re-evaluation of the specimens attributed previously to"*Anolcites*" ex gr. *laricus* (Mojsisovics). The main result is that the genus *Zestoceras* occurs from the upper Neumayri Subzone, through the Regoledanus Subzone to the upper part of the Daxatina cf. canadensis Subzone (Fig. 4), extending the previously known range (Mietto & Manfrin, 1995a) and permitting more accurate correlations with North America (Tozer, 1994). Consequently, *Zestoceras* cf. *nitidum* Tozer occurs in the upper Neumayri Subzone (Fig. 4) and the ranges of Z. ex gr. *enode* (Tozer) and Z. aff. *enode* correspond to the lower and upper parts of the Regoledanus Subzone, respectively (Fig. 4). Finally, *Zestoceras* n. sp. A (cf. Mietto & Manfrin, 1995b, pl. 2, figs. 4-6) comes from beds which contain also *Daxatina* sp. and *D.* cf. *canadensis* (Fig. 4, and 13; Tab. 1).

Specimens such as that illustrated in Mietto & Manfrin (1995b: pl. 2, fig. 3) are retained as "*Anolcites*" ex gr. *laricus*, which is typical also of the Daxatina cf. canadensis Subzone and is preceded, in the upper part of the Regoledanus Subzone, by a faintly ornamented form here identified as "*Anolcites*" cf. *laricus*.

At the base of the Daxatina cf. canadensis Subzone, the genus *Daxatina* with *Daxatina* sp. and *Daxatina* cf. *canadensis* (Whiteaves) and "*Anolcites*" ex gr. *laricus* appear. *Clionitites* and *Trachyceras* [represented by *Trachyceras bipunctatum* (Münster)] appear at 52.2 m and 61.5 m, from the base of the section, respectively.

The lower boundary of the Daxatina cf. canadensis Subzone lies within the San Cassiano Formation, at 43.5 m above its boundary with the underlying La Valle Formation. The ammonoid fauna recovered below 45 m (bed SW4, Tab. 1) corresponds to the fauna of horizon C of the Regoledanus Subzone *sensu* Mietto & Manfrin (1995b), as indicated by the association of *Frankites apertus* (Mojsisovics), [ranging from -7 m (bed SW0a) to 79.3

PLATE 1

Ammonoids from the Prati di Stuores/Stuores Wiesen section.

Fig. 1 - cf. *Protrachyceras* sp. Sample SW3b.1, Regoledanus Subzone.
Fig. 2-7 - *Zestoceras* n. sp. A. Fig. 2) sample PSR10.9; Fig. 3) sample PSR8.2; Fig. 4) sample PSR3.6a; Fig. 5) sample PSR6.1; Fig. 6) sample PSR11.1a; Fig. 7) sample PSR3.42; Daxatina cf. canadensis Subzone.
Fig. 8-10 - *Clionitites* sp. Fig. 8) sample PRS3.6b; Fig. 9) sample PSR3.36; Fig. 10) sample PSR3.32; Daxatina cf. canadensis Subzone.
Fig. 11-12 - *"Anolcites"* ex gr. *laricus* (Mojsisovics). Fig. 11) sample PSR3.43; Fig. 12) sample SW4.2; Daxatina cf. canadensis Subzone.
Fig. 13 - *Zestoceras* aff. *enode* (Tozer). Sample SW2.1, Regoledanus Subzone.
Fig. 14-15 - *Muensterites* sp. Fig. 14) sample SW7B.1; Fig. 15) sample SW10.10, note the suture; Daxatina cf. canadensis Subzone.
Fig. 16 - *Asklepioceras* sp. Sample SW10.3, Daxatina cf. canadensis Subzone.
Fig. 17 - *Frankites apertus* (Mojsisovics). Sample PSR8.1, Daxatina cf. canadensis Subzone.

All figures x 1; all specimens are illustrated here for the first time; for other material from the Prati di Stuores section see Mietto & Manfrin (1995a, b).


1


2


3


4


8


5


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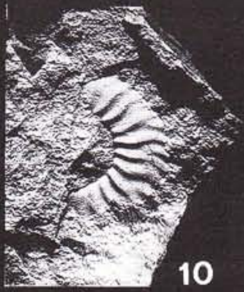
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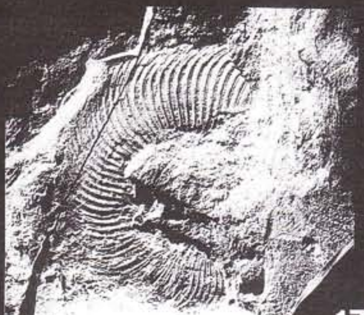
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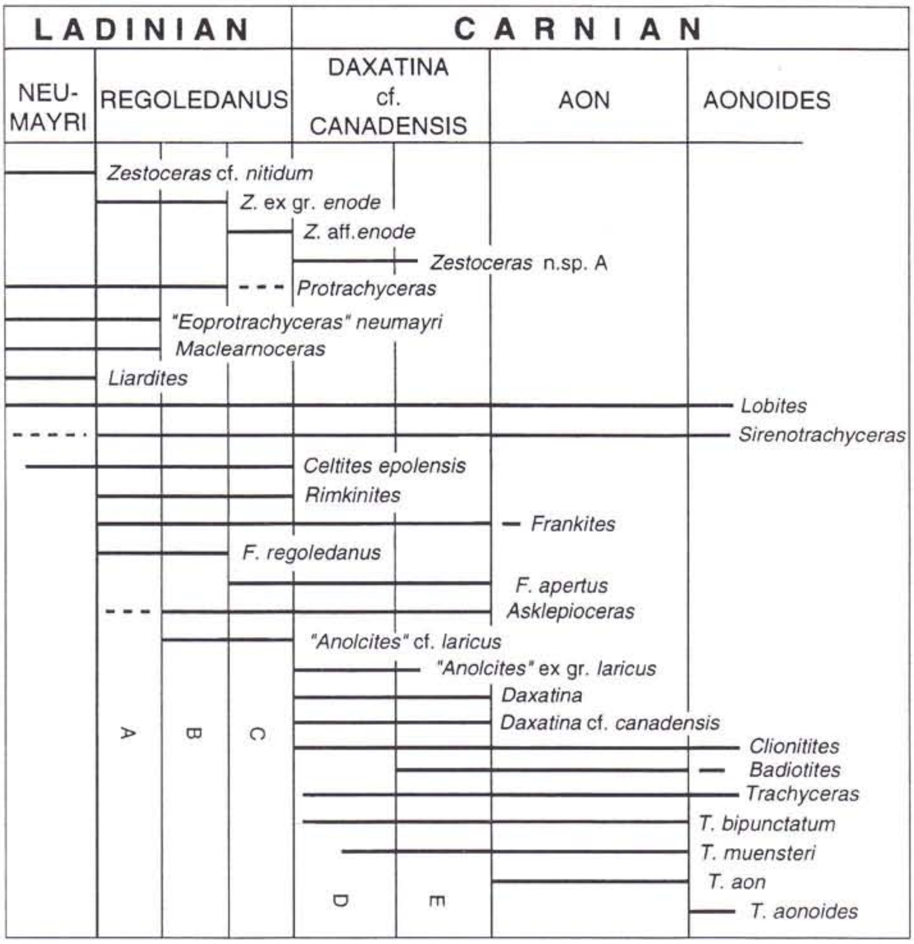


Fig. 4 - Range chart of the most significant uppermost Ladinian-lowermost Carnian ammonoids from Prati di Stuores and correlated sections in the Dolomites.

m (bed PSR8, Tab. 1)], together with *Zestoceras* aff. *enode* and probable *Protrachyceras* sp. (Fig. 13). However, *F. apertus*, associated with an ammonoid assemblage of the uppermost Daxatina cf. canadensis Subzone [*Badiotites eryx* (Münster), *Daxatina* ? sp., *Trachyceras* sp., *Clionitites basileus* (Münster) and *Sirenotrachyceras* sp.], was collected also from an isolated layer (bed SW11) which crops out near the small church of Pralongià (see Mietto & Manfrin, 1995b).

The upper boundary of the subzone is located at 194.3 m in section 1 bis (Fig. 1, and 13), which yielded a specimen of a probable *Trachyceras aon* (Münster). The Daxatina cf. canadensis Subzone is 149.3 m thick in the Stuores section, reflecting a high sedimentation rate. This subzone was recognised also in other similar sections throughout the Badia/Abtei Valley (Col da Oi, Kerpatscha, Col de Frea near Gardena Pass), in the area of Campolongo Pass (Bec de Roces, Crep de Mont), and in the eastern Dolomites (Rio Cuzze near Borca di Cadore), as mentioned partly in Mietto & Manfrin (1995b).

The predating of the first appearance of the genus *Trachyceras* within the Daxatina cf. canadensis Subzone allows the subunit to be placed at the base of the Trachyceras Zone of Mietto & Manfrin (1995a, b); this includes the T. aonoides Zone *sensu* Krystyn (1978). Although in the Stuores section, *Trachyceras* occurs a few meters above the FAD of *Daxatina*, the high sedimentation rate supports the idea that the FAD of *Trachyceras* is nearly coincident with the appearance of *Daxatina*.

Some specimens of *Daxatina* exhibit the suture line (Mietto & Manfrin, 1995b, fig. 6), but only one specimen of *Trachyceras* from the same interval shows unequivocal traces of the suture. The specimen of *Trachyceras muensteri* (Wissmann), illustrated in Pl. 2, fig. 2, shows the first lateral saddle triangular in shape, elongated and frilled. Other specimens in which the suture line is not clearly evident were referred to *Trachyceras* on the basis of their morphologic features. Tozer (1994) noted that *Daxatina* shows close morphologic similarity to Trachyceras, but the two genera are clearly differentiated on the basis of their suture line, which is of ceratitic type in *Daxatina*

PLATE 2

Ammonoids from the Prati di Stuores/Stuores Wiesen section.

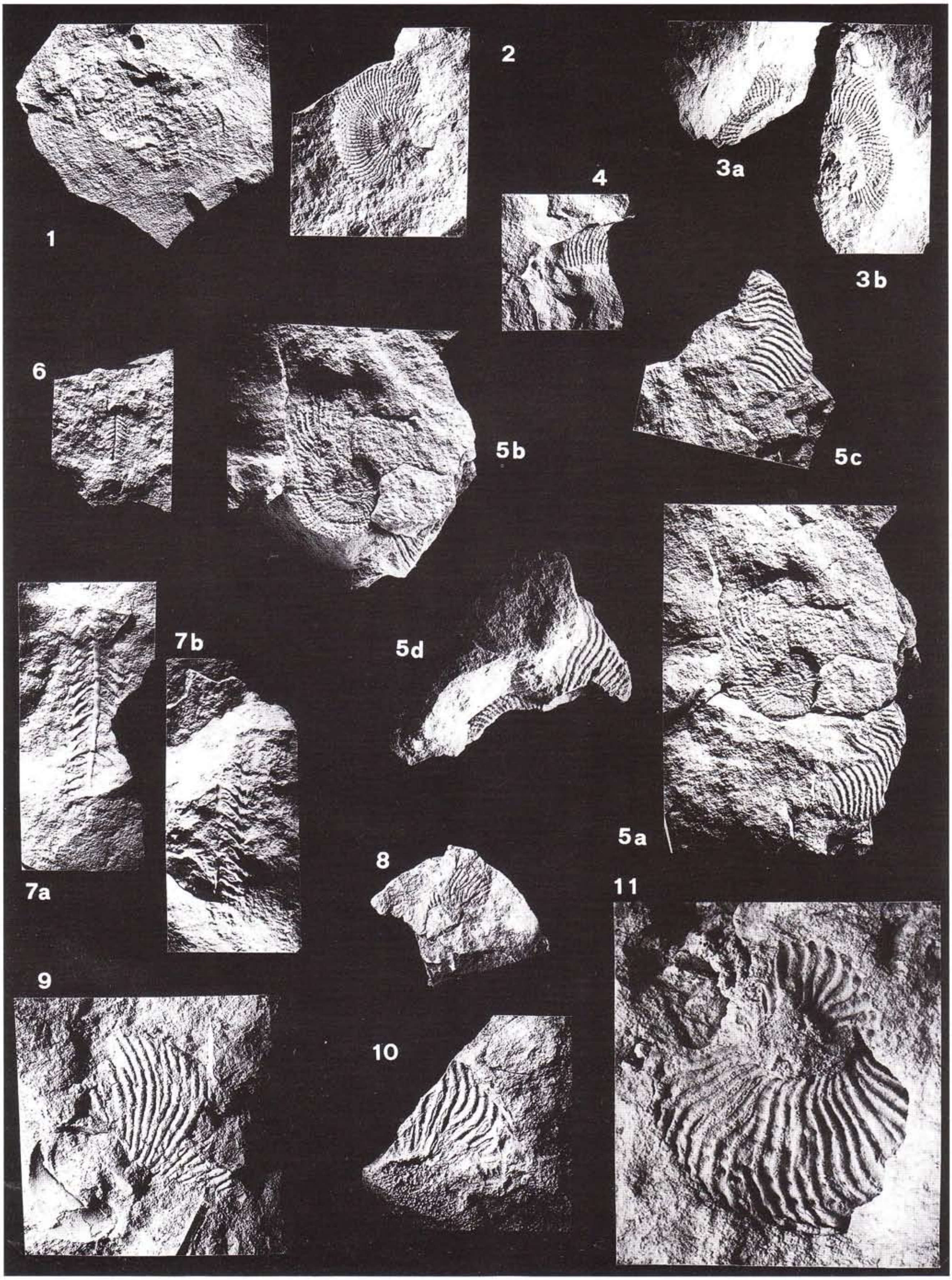
Fig. 1 - *Trachyceras bipunctatum* (Münster). Sample SW6.1a, Daxatina cf. canadensis Subzone.

Fig. 2-5 - *Trachyceras muensteri* (Wissmann). Fig. 2) sample PSR3.dt1, collected between PSR3 and PSR8; Fig. 3) sample PSR5.1, a) positive, b) negative; Fig. 4) sample PSR10.15; Fig. 5) sample PSR3.33, a) complete specimen, b) the same specimen but without the outer whorl, c) right side of the outer whorl, d) left side of the outer whorl; Daxatina cf. canadensis Subzone.

Fig. 6-9 - *Daxatina* sp. Fig. 6) sample PSR4.1; Fig. 7) sample PSR3.dt2, collected between PSR3 and PSR8, a) negative ventral area, b) positive ventral area; Fig. 8) sample PSR1b.1; Fig. 9) sample SW5b.7; Daxatina cf. canadensis Subzone.

Fig. 10-11 - *Daxatina* cf. *canadensis* (Witheaves). Fig. 10) sample SW10.11, note the suture; Fig. 11) sample SW10.1; Daxatina cf. canadensis Subzone.

All figures x 1; except for exemplars 2 and 11, all specimens are illustrated here for the first time; for other material see Mietto & Manfrin (1995a, b).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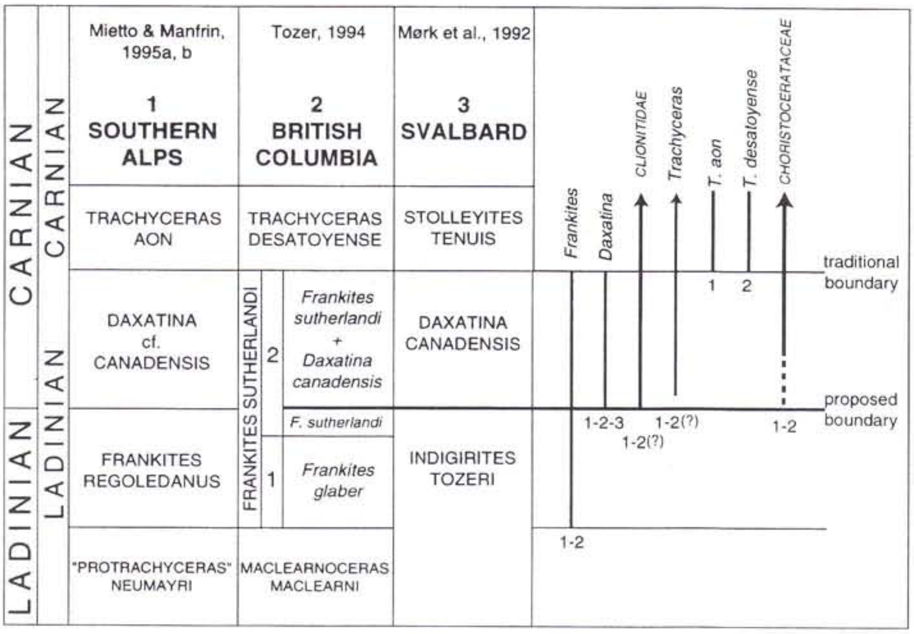


Fig. 5 - A comparison between the ammonoid scales adopted in Southern Alps, Canada and Arctic Ocean, with the most significant bio-events at the traditional and proposed Ladinian-Carnian boundary.

and of ammonitic type, with triangular elongated saddles, in *Trachyceras*. The characteristic presence in *Trachyceras* of two serried orders of spines adjacent to the ventral furrow and forming a typical raised structure is a further differentiating feature. In *Daxatina* the ventral area is quite different, and raised furrow boundaries bearing spines are nearly absent. Moreover, *Trachyceras* is generally more finely and more regularly ornamented than *Daxatina*.

Ammonoid correlations.

(Stefano Manfrin & Paolo Mietto)

The ammonoid fauna succession in the Stuores section and in other localities of the Southern Alps (Mietto & Manfrin, 1995b) records some bioevents which occur (in homotaxis) also in extra-tethyan areas (British Columbia; Svalbard) (Fig. 5).

The occurrence of genera with widespread to cosmopolitan distribution allows the tethyan biozones to be correlated with those defined in Canada (British Columbia) by Tozer (1967; 1994).

In agreement with Mietto & Manfrin (1995a, b), the Neumayri Subzone is considered equivalent to the Maclearni Zone or at least to the Subzones 2 and 3 as Tozer (1994), due to the presence of *Maclearnoceras* in association with *Liardites* (Fig. 4 and 5).

The appearance of *Frankites*, which marks the base of the Regoledanus Subzone, makes this tethyan unit correlatable with Subzone 1 of the Sutherlandi Zone from Canada. The appearance of *Daxatina* in the Daxatina cf. canadensis Subzone makes plausible the correlation of this tethyan unit with Subzone 2 of the Sutherlandi Zone from Canada, sensu Tozer (1994). As a matter of fact, *Daxatina* appears within Subzone 2 and is preceded at the base of the same subzone by the appearance of *Frankites sutherlandi* (McLearn). Therefore, the correlation of the biostratigraphic units mentioned above, pertaining to different domains, does not seem to coincide perfectly.

Some discrepancies in the vertical range of some taxa (i.e., *Asklepioceras*, *Muensterites*) may be only apparent. In particular, the placement of the *Clionitites*, *Trachyceras* and *Daxatina* association in the Desatoyense Zone (=base of the Carnian *sensu* Tozer, 1994) is not supported by the stratigraphic data; in addition, in the Prati di Stuores section the same genera appear and are associated inside the Daxatina cf. canadensis Subzone.

It is very important to note that in the Boreal domain (Barents Sea, Svalbard, Sverdrup Basin), the Daxatina canadensis Zone is currently used as a unit correlatable with the Sutherlandi Zone from Canada and with the Nathorstites Zone from Siberia (Mørk, Embry & Weitschat, 1989; Mørk, Vigran & Hochuli, 1990; Mørk et al., 1992a, b; Weitschat & Dagys, 1989). The correlation of this zone from the Boreal domain with the Daxatina cf. canadensis Subzone of the Tethys and with Subzone 2 (except its basal part) of the Sutherlandi Zone from Canada thus appears strongly plausible.

The proposal to identify the Ladinian/Carnian boundary with the FAD of *Daxatina* is supported also by the areal distribution of the taxon.

In fact, the genus is known as a characteristic taxon of the Boreal domain. Böhm referred the taxon to "*Dawsonites*" (Arctic Ocean, Bjørnøya; 1903, 1904). The type species "*Trachyceras*" *canadense* Whiteaves 1889 was found in the Liard River, British Columbia (cf. also Smith, 1927; McLearn, 1947a, b; Tozer, 1967, 1994). The same genus was noted in Alaska by Martin (1916), while Arkell, Kummel & Wright (1957) considered the genus as typical of the mid-high latitude. The occurrence of *Daxatina* in the Southern Alps and also in the Himalaya (L. Krystyn, pers. comm.) makes it the only cosmopolitan genus of the Ladinian-Carnian boundary interval.

Stakes	Samples	metres from stake 1	Conodonts							
			Gladigondolella tethydis	*Gladigondolella m. malayensis*	*Budurovignathus sp.*	*Budurovignathus mungoensis*	*Budurovignathus longobardicus*	*Budurovignathus diebeli*	*Budurovignathus mostleri*	*Gondolella sp.*
	18SW X	175.50	1					1	2	1
	18SW IX	172.60								
18	18SW 18	170.00		2						
	17SW 17	158.10	1							
	17SW VIII	156.00								
17	17SW 16	153.00								
	15SW 16A	148.98	4							
15-16	15SW 14	140.78					2			
11-12	12SW 12	116.25	8			5	4	1	2	
10	10SW VII	112.55		2		3		5		
	8SW 9	90.50		2				1		
8	8SW8	86.50	2					1		
5b	5bSW VI	58.05								
	5SW V	45.35			1					
5	5SW 6	42.94			base of the Daxatina cf. canadensis Sbz. (45 m)					
	4SW IV	41.50								
4	4SW III	33.00								
3	3SW II	26.50	3			1	2	7		
2	2SW I	15.00								

Tab. 2 - Range chart of conodonts in the Prati di Stuores section.

Conodont biostratigraphy.

(Adelaide Mastandrea)

The Prati di Stuores section is very poor in conodonts. Only eleven out of nineteen samples yielded specimens (1-19), and eight taxa were recognised, among which the species of the *Budurovignathus* group and two long-range species of the genus *Gladigondolella*: (*Gl. tethydis* (Huckriede), *Gl. m. malayensis* Nogami. The *Budurovignathus* group is represented by *B. mungoensis* (Diebel), *B. longobardicus* (Kovacs), *B. diebeli* (Kozur & Mostler) and *B. mostleri* (Kozur) (Pl. 3). All taxa are typical of the *diebeli* Assemblage Zone of Krystyn (1983), which was referred by the author to the uppermost Ladinian Regoledanus Zone.

The first occurrence of conodonts of the *Budurovignathus* group with *Gl. tethydis* is recorded at 26.50 m from stake 1 (Regoledanus Subzone) (Tab. 2 and Fig. 13). Unfortunately, the interval between 26.50 and about 86 m is barren of conodonts: *Budurovignathus* sp. occurs at 5SWV, 0.35 m above the FAD of *Daxatina* cf. *canadensis* (45 m from stake 1).

The segment of section between 86.5 m and about 149 m is relatively less poor. Particularly, sample SW12 (116.25 m from stake 1, mid-lower Daxatina cf. canadensis Subzone) contains *Gl. tethydis*, *B. mungoensis*, *B. longobardicus*, *B. diebeli* and *B. mostleri*. The upper part of the section still contains *Budurovignathus* and long-range Gladigondolellas (*Gl. tethydis*, *Gl. m. malayensis*). *Budurovignathus diebeli* and *B. mostleri* extend up to about 177 m, together with a broken specimen of *Gondolella* which, due to its poor preservation, has an uncertain classification at species level (*G. inclinata* vel *G. polygnathiformis*).

However, it should be noted that *G. polygnathiformis* was found together with *Trachyceras aon* near the base of section 2 (Fig. 1), which corresponds to the stratotype section of the Cordevolian Substage of Urlichs (1974). On the basis of data from sections in the Stuores 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 from the Stuores area, *B. diebeli* occurs together with *G. polygnathiformis*, confirming the overlap of the ranges of these taxa shown in other sections within Alpine Europe (Mastandrea et al., in progress).

Ammonoid vs. conodont biozones: comparison and problems.

(Adelaide Mastandrea, Paolo Mietto & Claudio Neri)

The vertical distribution of conodonts and ammonoids across the Ladinian/Carnian boundary was discussed by Krystyn (1983) in the Epidaurus section (Greece) and, more recently, by Kovacs et al. (1991) in the Füred Limestone in the Balaton Highlands (Hungary). These accounts present contrasting sets of data.

According to Krystyn (1983), in the Epidaurus section the conodont assemblage characterised by *Budurovignathus diebeli*, marker of the *diebeli* A.-Zone, is correlatable with the Regoledanus Zone *sensu* Krystyn (1983). The first occurrence of *Gondolella polygnathiformis* is considered to coincide with the base of the Aon Subzone (Krystyn, 1983). Unfortunately, in this section the ammonoids are scarce and represented only by specimens of *Trachyceras* sp. in the Aonoides Zone sensu Krystyn (1978). The ranges of *Budurovignathus diebeli*, *B. mungoensis* and *B. mostleri* do not show any overlap with that of *G. polygnathiformis*, even though, on the basis of sections such as the Mayerling section, Austria, Krystyn (in Gallet et al., 1998) concluded that the *Budurovignathus* group range extends into the Aonoides Zone.

Clear evidence of overlap between the ranges of *Budurovignathus* and *G. polygnathiformis* is supplied by the Prati di Stuores section and outcrops from the Apuseni Mts. (Roumania, Kozur, 1980; 1989). However, it is unclear whether the overlap is due mainly to a downward extension of the range of *G. polygnathiformis*, below the FAD of *Trachyceras aon*, or to the upward extension of the range of the *Budurovignathus* group into the Aonoides Zone.

In the Ladinian-Carnian succession of the Balaton Highlands, conodonts of the *Budurovignathus* group (including *B. diebeli*) occur with *G. polygnathiformis* at the base of the Füred Limestone (Kovacs et al., 1991), which contains Frankites sp., and is thus referable to the Regoledanus Zone. The conclusion of Kovacs et al. (1991) is that the base of the Carnian stage should be identified by the first appearance of *G. polygnathiformis*, and that the Regoledanus Zone is therefore included into the Carnian.

Two of the authors (S. Manfrin & P. Mietto) believe that the specimens of *Frankites* sp. in the Füred Limestone may pertain to *F. apertus* rather than to *F. regoledanus*. This is supported by a re-evaluation of the ammonoid fauna described in Frech (1911) from the same stratigraphic unit. This fauna includes "*Trachyceras (Anolcites) Richthofeni* MOJS.", which the two authors consider, with some reservations, to be *F. apertus*. If this interpretation is correct, it would 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 Stuores section 2 (Fig. 1) is the result of ecological control. A significant change from anoxic/disoxic to a fully oxygenated basin environment may occur in the upper D. cf. canadensis Subzone, below the Aon Subzone, as suggested by micro- and macrobenthos assemblages. This consideration may support the proposal to draw the Ladinian/Carnian boundary at the base of the Daxatina cf. canadensis Subzone, whose lower boundary occurs in the segment unaffected by significant paleoecological changes, and may thus be regarded as reflecting evolutionary control.

Furthermore, there is no agreement among the authors of the paper by Kovacs et al. (1991) about the real taxonomy of the conodonts classified as "*G. polygnathiformis*". According to Krystyn (pers. comm. to A. Mastandrea) *G. polygnathiformis* has never been found within the Regoledanus Zone.

Other data on conodont assemblages from stratigraphic sections of the Sella Pass, Gardena Pass and Punta Grohmann confirm the absence of *G. polygnathiformis* in the beds containing specimens of *Frankites apertus* (Neri et al., 1995; Mastandrea et al., 1997; Russo et al., 1997).

The problem requires further discussion in order to confirm whether the FAD of *G. polygnathiformis* really corresponds with that of *T. aon*, or whether it is within the upper Regoledanus Zone Auct. (=Daxatina cf. canadensis Subzone). Data from the Stuores area support the idea that the FAD of *G. polygnathiformis* and *T. aon* are broadly coeval; this interpretation is consistent with data from Epidaurus, and does not conflict with data from the Mayerling section, Austria (Gallet et al., 1998).

Paleontological and paleoecological contributions

In agreement with the revised guidelines for the establishment of global chronostratigraphic standards (Remane et al., 1996), other fossil groups were investigated in the staked Prati di Stuores section. Data on palynomorphs, which could be important biostratigraphic tools, and on benthic foraminifers, bivalves, gastropods, brachiopods, microcrinoids and holothurian sclerites, identified in the interval including the proposed Ladinian/Carnian boundary, are presented and discussed below.

Palynomorphs.

(Simonetta Cirilli & Guido Roghi)

Palynologic assemblages from the Stuores section were calibrated with the ammonoid zonation and therefore supply a basis for a more detailed chronostratigraphic study.

Most of the 36 samples yielded well preserved assemblages (Pl. 4, 5 and 6). A few samples (LCP3, LCP20, SWZ, respectively 31.5 m, 48.4 m and 120 m from stake 1) proved barren of organic matter; others yielded material deeply affected by diagenetic pyritization and degradation processes. A semiquantitative study of organic particles, including palynomorphs and palynomacerals, was carried out. The compositional va-

PLATE 3

Conodonts from the Prati di Stuores/Stuores Wiesen section.

Fig. 1-2 - *Budurovignathus longobardicus* (Kovacs). Fig. 1a) upper view, Fig. 1b) lower view, sample SW4/12, 150x; Fig. 2) upper-lateral view, sample SW4/12, 180x.

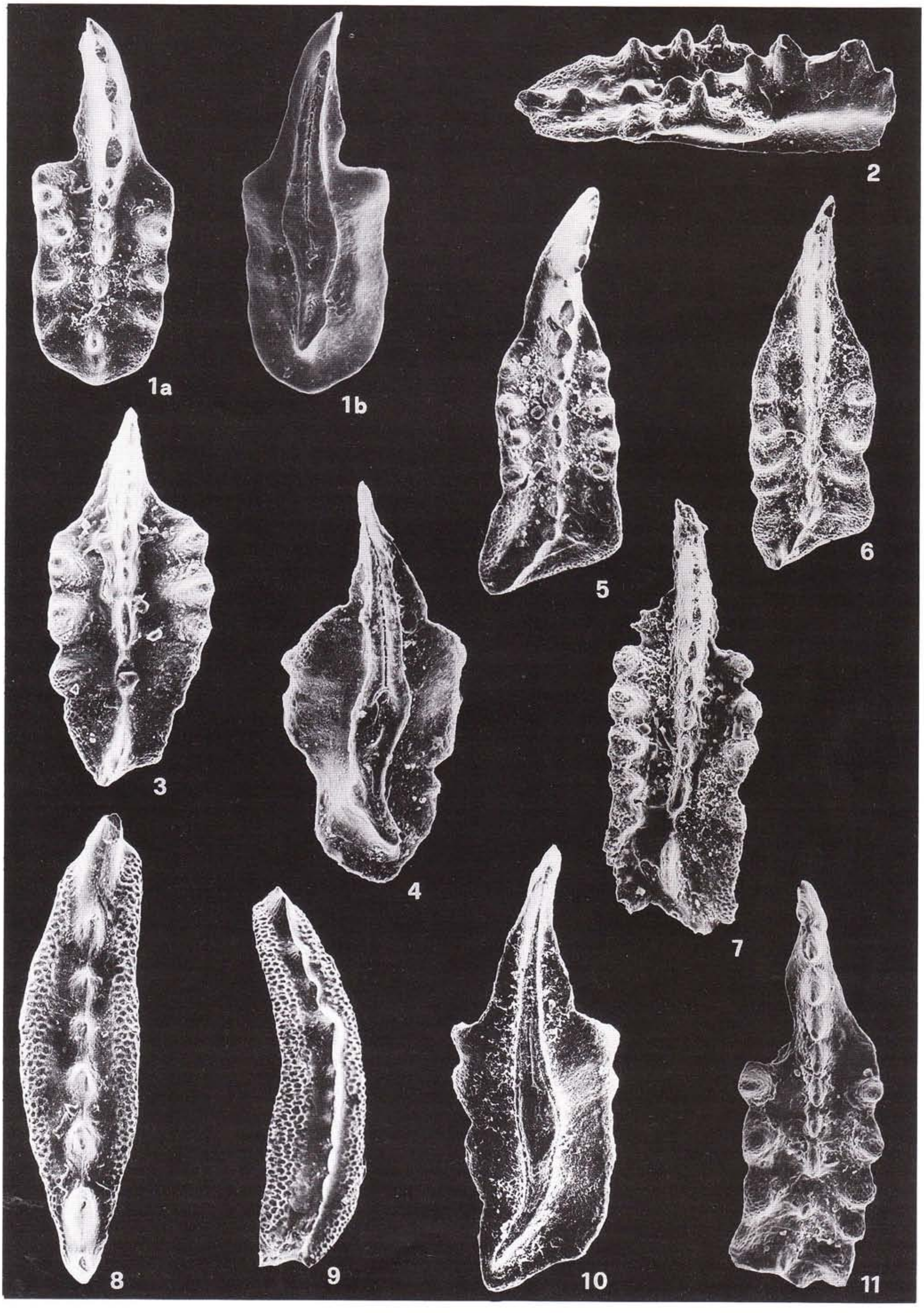
Fig. 3-4 - *Budurovignathus mostleri* (Kozur). Fig. 3) upper view, sample SW4/12, 200x; Fig. 4) lower view, sample SW4/12, 200x.

Fig. 5-6, 10 - *Budurovignathus mungoensis* (Diebel). Fig. 5) upper view, sample SW4/12, 140x; Fig. 6) upper view, sample SW4/VII, 150x; Fig. 10) lower view, sample SW4/VII, 200x.

Figs 7, 11 - *Budurovignathus diebeli* (Kozur & Mostler). Fig. 7) upper view, sample SW4/II, 200x.; Fig. 11) upper view, sample SW4/VII, 150x.

Fig. 8 - *Gladigondolella malayensis malayensis* Nogami. Upper view, sample SW4/18, 150x.

Fig. 9 - *Gladigondolella tethydis* (Huckriede). Upper view, sample SW4/16, 100x.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riation in miospore assemblages throughout the section is high, both in total abundance and number of species.

The palynologic content, with the exception of the marine elements, is presented in Tab. 3, summarized in Fig. 13, and described below.

- Assemblage A (0 to 48.7 m, upper part of Regoledanus Subzone and lowermost part of Daxatina cf. canadensis Subzone): it is highly diversified, containing 43 species, some of them making their first occurrence within the Stuores section 1 (Tab. 3, samples SWa to SWm, 0.5 m to 48.5 m). The most significant first occurrences are *Enzonalasporites vigens* and "*Lueckisporites*" cf. *singhii*, from sample SWh (24.1 m) and sample LCP16 (44.5 m; Tab. 3, and Fig. 13), respectively the last one, just 50 cm below the lower boundary of the Daxatina cf. canadensis Subzone. Both extend into the Daxatina cf. canadensis Subzone. *Partitisporites novimundanus* is first recorded here at LCP1 (30 m) and its abundance increases upwards. In addition, *Lunatisporites acutus* and *Neoraistrickia taylorii* occur in the Regoledanus Subzone. The most abundant species is the long ranging *Ovalipollis pseudoalatus*, which is present throughout the section; other sporomorphs are more or less constantly present in variable percentage throughout the section (see Tab. 3).

Concavisporites toralis, *Guthoerlisporites cancellosus*, *Alisporites ovatus*, *Densosporites* cf. *variomarginatus* and *Kyrtomisporis ervii* occur sporadically in the Regoledanus Subzone and disappear in the overlying Daxatina cf. canadensis Subzone. The percentage of bisaccates is high at the base of the section, decreasing slightly towards the Regoledanus/Daxatina cf. canadensis subzone boundary, but increasing again in the latter subzone.

PLATE 4

Palynomorphs from the Prati di Stuores/Stuores Wiesen section: Assemblage A

Fig. 1-2 - *Enzonalasporites vigens* Leschik. Fig. 1) sample SWi; Fig. 2) sample LCP16.
Fig. 3 - *"Lueckisporites"* cf. *singhii* Balme. Sample LCP16.
Fig. 4 - *Kyrtomisporis ervii* Van der Eem. Sample LCP12.
Fig. 5 - *Duplicisporites granulatus* (Leschik). Sample LCP1.
Fig. 6 - *Ovalipollis pseudoalatus* (Thiergart). Sample SWa.
Fig. 7 - *Sellaspora rugoverrucata* Van der Eem. Sample LCP1.
Fig. 8-9 - *Uvaesporites gadensis* Praehauser-Enzenberg. Fig. 8) sample LCP12; Fig. 9) sample LCP14.
Fig. 10 - *Aratrisporites fimbriatus* (Klaus). Sample LCP1.
Fig. 11 - *Calamospora tener* (Leschik) Mädler. Sample LCP1.
Fig. 12 - *Nevesisporites vallatus* De Jersey. Sample LCP16.
Fig. 13 - *Podosporites amicus* Scheuring. Sample LCP1.

Except Fig. 6 (300x), all figures x500.

PLATE 5

Palynomorphs from the Prati di Stuores/Stuores Wiesen section: Assemblage B

Fig. 1 - *Vallasporites ignacii* Leschik in Krausel & Leschik. Fig. 1a) proximal view, Fig. 1b) distal view, sample SWab.
Fig. 2-3 - *"Lueckisporites"* cf. *singhii* Balme. Fig. 2) sample LCP17; Fig. 3) sample SWab.
Fig. 4-5 - *Patinasporites densus* Leschik in Krausel & Leschik. Fig. 4) sample STWi ; Fig. 5) sample STWhx.
Fig. 6-8 - *Enzonalasporites vigens* Leschik in Krausel & Leschik. Fig. 6) sample LCP22; Fig. 7) sample SWt1; Fig. 8) sample LCP25.
Fig. 9 - *Camerosporites secatus* Leschik in Krausel & Leschik. Tetrad, sample SWn.
Fig. 10 - *Reticulatisporites muricatus* Kosanke. Sample SWt.
Fig. 11 - *Weylandites magmus* (Bose & Karr) Van der Eem. Sample SWz1.

All figures x500.

PLATE 6

Palynomorphs from the Prati di Stuores/Stuores Wiesen section: Assemblage B

Fig. 1, 5 - *Sellaspora rugoverrucata* Van der Eem. Fig. 1) sample LCP22; Fig. 5) sample Swaa.
Fig. 2 - *Gordonispora fossulata* (Balme). Fig. 2a) proximal view, Fig. 2b) distal view, sample SWs.
Fig. 3 - *Uvaesporites gadensis* Praehauser-Enzenberg. Sample SWr.
Fig. 4 - *Uvaesporites* sp. A. Sample SWr.
Fig. 6 - *Lycopodiacidites kokenii* Van der Eem. Sample SWn.
Fig. 7 - *Neoraistrickia taylorii* Playford & Dettmann. Sample SWs.
Fig. 8 - *Converrucosisporites* sp. A. Sample STWo.
Fig. 9 - *Concavisporites crassexinius* Nillson. Sample STWi.
Fig. 10 - *Partitisporites novimundanus* morphon (Leschik in Krausel & Leschik) Van der Eem. Sample LCP22.
Fig. 11 - *Duplicisporites granulatus* Leschik in Krausel & Leschik. Sample LCP22.

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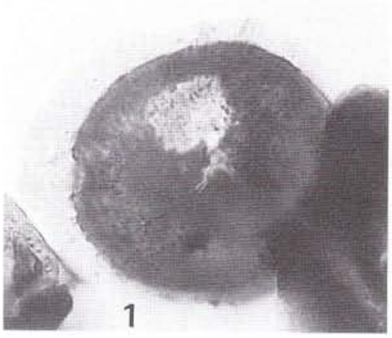
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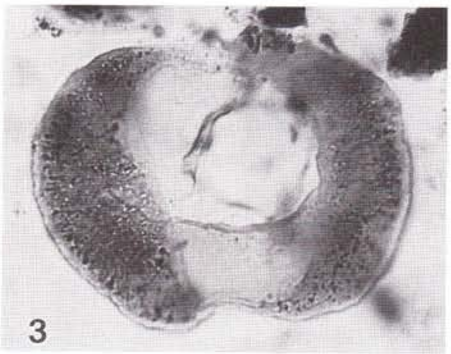
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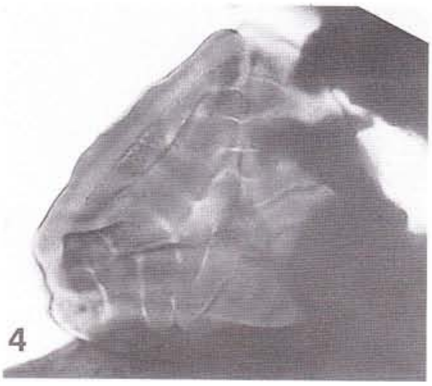
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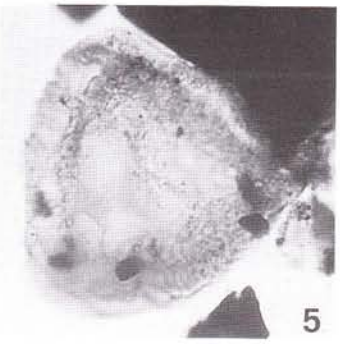
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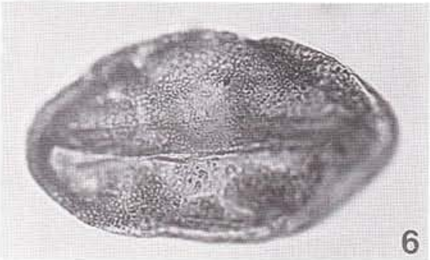
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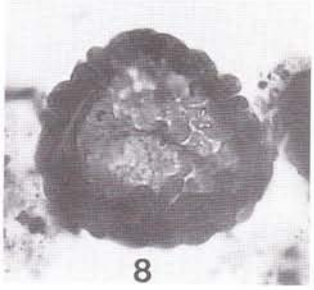
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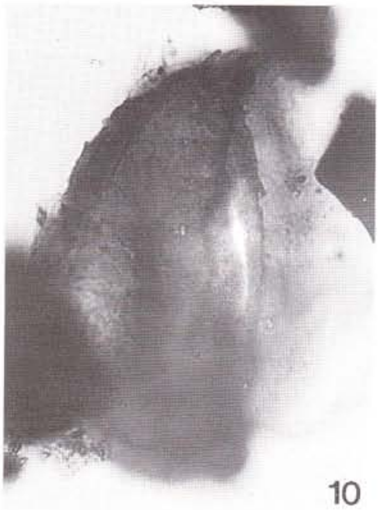
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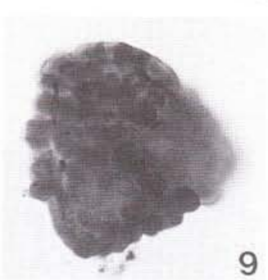
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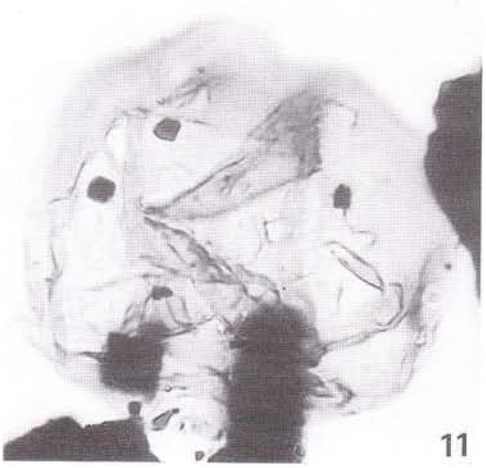
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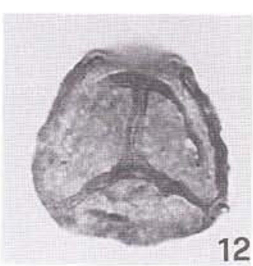
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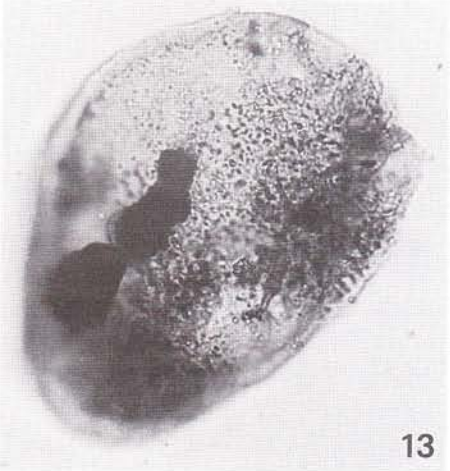
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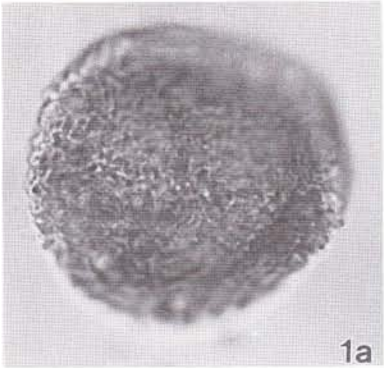
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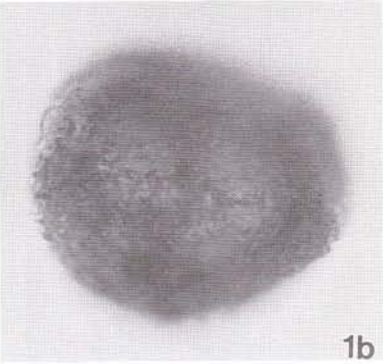
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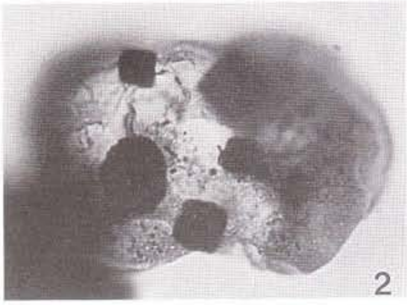
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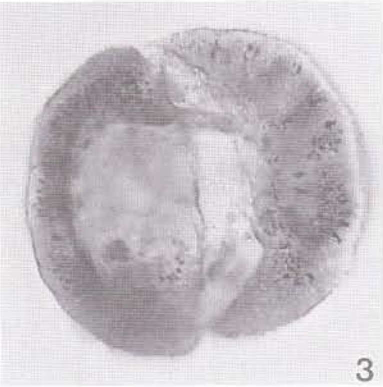
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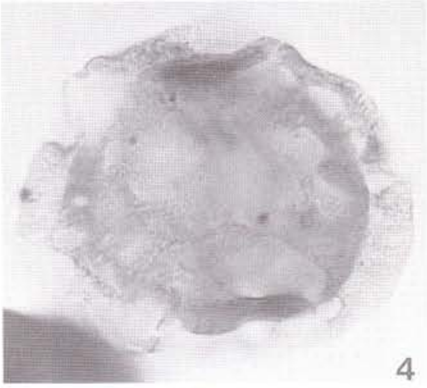
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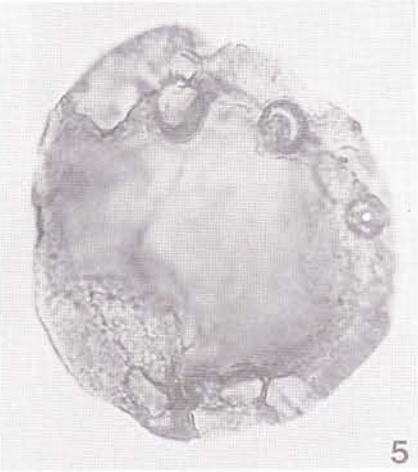
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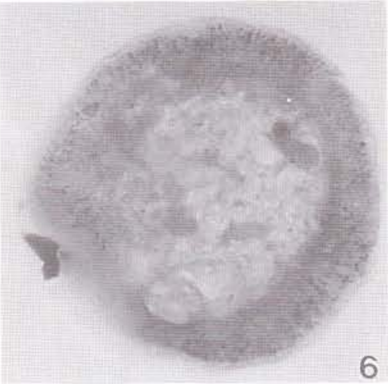
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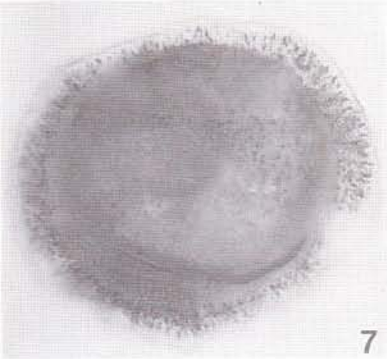
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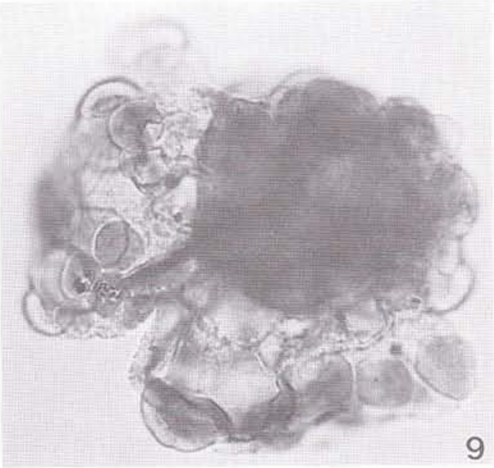
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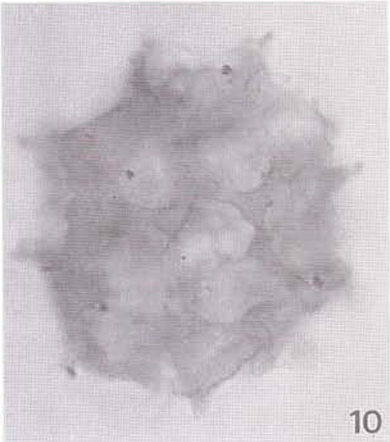
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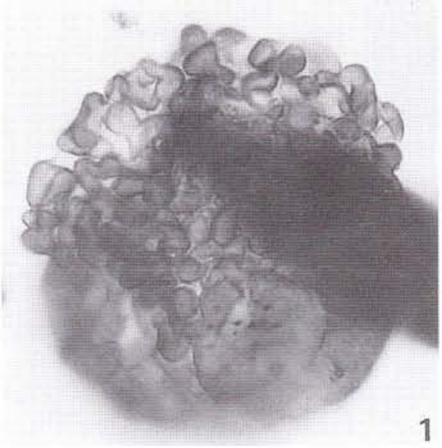
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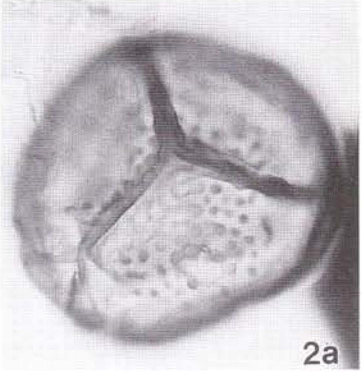
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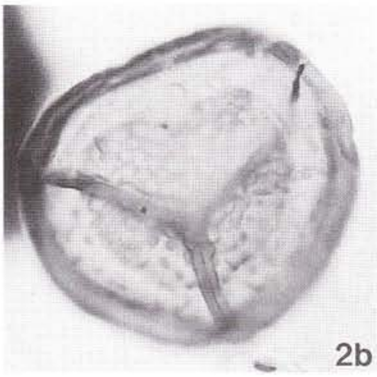
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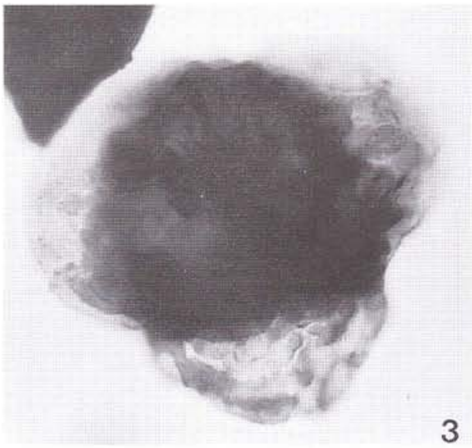
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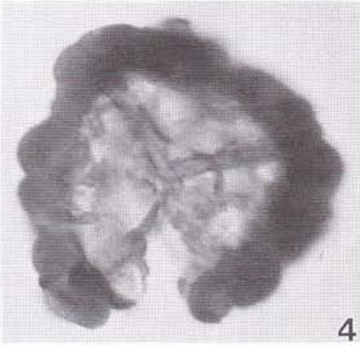
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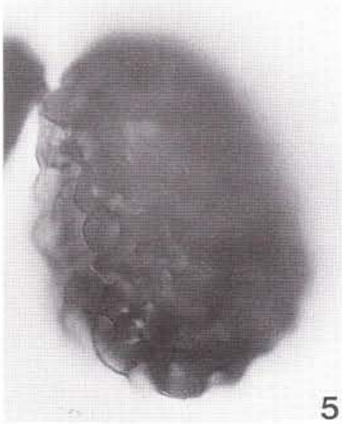
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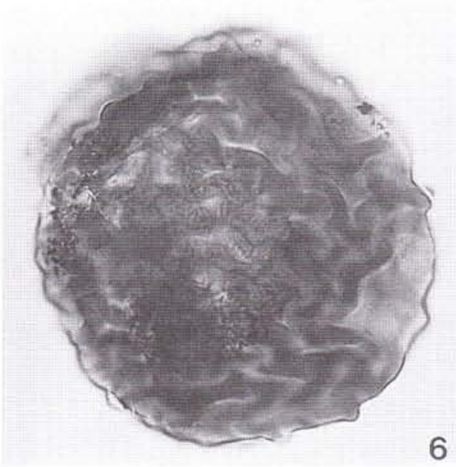
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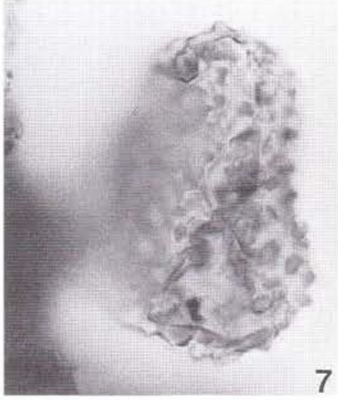
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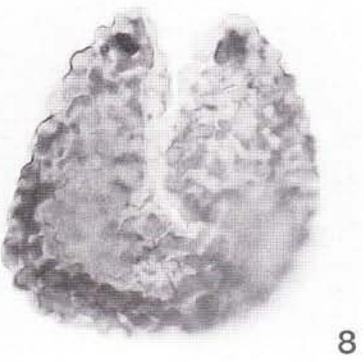
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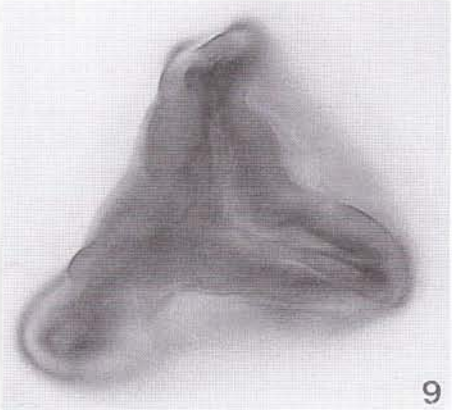
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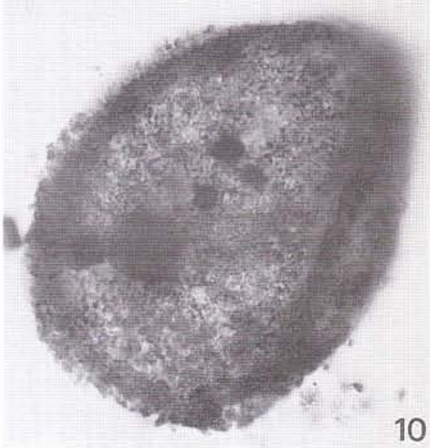
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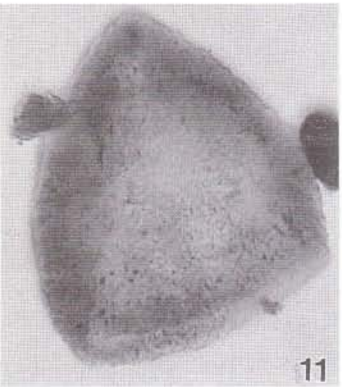

11

1	2		3		4			5							5b			7				8		9			10			11-12		14	15-16	Stakes
SWa 0.5	SWe 4.5	SWf 8.0	SWg 1.5	SWh 3.0	LCP1 1.0	SWi 2.0	LCP12 11.5	SWl 1.0	LCP14 1.5	LCP16 3.0	LCP17 4.5	LCP19 6.0	SWm6.5	LCP22 9.0	LCP24 0.0	LCP25 1.0	SWn1.5	SWq 5.0	STWbc 6.0	STWf 6.1	STWo 6.2	SWr 6.0	SWs 8.0	SWt 0.5	SWt1 2.0	SWt2 3.5	SWu 1.0	SWu1 2.0	SWu2 4.0	SWz 6.0	SWz1 7.0	SWaa 3.0	SWab 10.0	Samples
0.5	6.0	18.7	22.0	24.1	30.0	30.6	40.4	42.5	42.6	44.5	45.5	47.8	48.5	48.7	52.3	53.0	55.0	78.0	79.0	79.1	79.2	90.1	93.1	95.5	97.0	98.2	106.0	107.1	109.0	120.0	121.2	138.0	151.3	metres from stake 1
R	R					R		R			R			R	R					R				F	R		R				R		R	*Anapiculatisporites spiniger Leschik in Kräusel & Leschik, 1956*
R	R	R						R		R	R	R		R																			R	*Aratrisporites fimbriatus (Klaus, 1960) Mädler, 1964*
C	C								F		C								C			C	C	C	C	C	C					C		*Calamospora sp.A (cf. Van der eem, 1983)*
R																																		*Concavisporites toralis Leschik in Kräusel & Leschik, 1956*
R					R						R	C					R				R	C			R									*Converrucosisporites sp. A (cf. Van der Eem, 1983)*
C	R				F						R		R												R	R	R							*Infernopollenites sulcatus (Pautsch, 1958) Scheuring, 1970*
R											R						R						C								R			*Lycopodiacidites kokenii Van der Eem, 1982*
R				R						R	R																							*Nevesisporites vallatus De Jersey & Paten, 1964*
C	C		F	C	A	A	A	C	A	A	F	F	F	A	C	C	C	A	A	F	A	A	A	A	A	A	C		C		C	A	A	*Ovalipollis pseudoalatus (Thiergart, 1949) Schuurman, 1976*
R																					R													*Porcellispora longdonensis (Clarke, 1965) Scheuring, 1970*
R	R			R	R							R		C			R				R		R		R							R		*Staurosaccites quadrifidus Dolby in Dolby & Balme, 1976*
R					R	R			R			R		R			R		R					R								R	R	*Sellaspora rugoverrucata Van der Eem, 1982*
	R				R				R													R												*Deltoidospora minor (Couper, 1953) Pocock, 1970*
	R	F		F		F	F		R		R				R		R	R	R	R	R	F		R										*Foveosporites visscheri Van Erve, 1977*
	R									R							R																	*Guthoerlisporites cancellosus Playford & Dettmann, 1965*
	R										R		R						R															*Retitriletes sp.*
	R																R		R	R			C											*Verrucosisporites morulae Klaus, 1960*
				R	R				R			R		C		R	R									R								*Enzonalasporites vigens Leschik in Kräusel & Leschik, 1956*
				R																R			C											*Gordonispora fossulata (Balme, 1970) Van der Eem, 1983*
				R															R					F	F						F	F	R	*Lunatisporites acutus Leschik in Kräusel & Leschik, 1956*
					R																												*Alisporites ovatus (Balme & Hennelly) Jansonius, 1962*
					F				F		R			R						R														*Alisporites robustus Nilsson, 1958*
					R		R				R					R	R	R		R			C	C	R							R		*Aratrisporites tenuispinosus Playford, 1965*
					R	R				C	R	R		C	F	R	R	C	C			C	C	C	C	C	C		R		R	C	C	*Calamospora tener Leschik in Kräusel & Leschik, 1956*
					F		F																											*Densosporites cf. variomarginatus Playford, 1963*
					R												R	R		R											R		R	*Duplicisporites granulatus Leschik in Kräusel & Leschik, 1956*
					C									R							F										F		*Klausipollenites schaubergeri (Potonié & Klaus, 1954) Jansonius, 1962*
					F	F	F		F		R			R	R		R			R	R	A	C	R			F		R		C	C	C	*Partitisporites novimundanus morphon (cf. Van der Eem, 1983)*
					R												R		R				R		R									*Podosporites amicus Scheuring, 1970*
					C	C								R			R		R	R	R					R								*Schizosaccus keuperi Mädler, 1964*
						R			R					R			F								F						R			*Todisporites marginales Bharadwaj & Singh, 1964*
							R																										*Kyrtomisporis ervii Van der Eem, 1983*
							C					C		R				F					F											*Neoraistrickia taylorii Palyford & Detmann, 1965*
							F				F	R							F			R									R		R	*Uvaesporites gadensis Praehauser-Enzemberg, 1970*
									R	R	R									F	R										F	R	*Todisporites major Couper, 1958*
										F	R			F		R						R				R					F	F	*"Lueckisporites" cf. singhii Balme, 1970*
										R	R											R									F		*Todisporites minor Couper, 1958*
											F			R							R	R											*Uvaesporites sp. A (cf. Van der Eem, 1983)*
											R				F						F	C	R	F						F			*Deltoidospora mesozoicus (Thiergart, 1949) Pocock, 1970*
											R	R		R				R		R		F		R	R									*Ephedripites primus Klaus, 1963*
											R						R					R		R									R	*Osmundacidites cf. wellmanii Couper, 1953*
												R		R		R						R			R	R			R			R	R	*Concavisporites sp. A (cf. Van der Eem, 1983)*
													R					R	R		R	F	R	R	R	R						R		*Reticulatisporites muricatus Kosanke, 1950*
														R				R		R			R			F							R	*cf. Concentricisporites bianulatus (Neves, 1961) Antonescu, 1969*
														R	R						R													*Converrucosisporites sp. B (cf. Van der Eem, 1983)*
														R																	R			*Cycadopites sp.*
														R																				*Infernopollenites parvus Scheuring, 1970*
														R			R	F	A	R	F			A	A	C	C						R	*Patinasporites densus Leschik in Kräusel & Leschik, 1956*
														R	R																			*Triadispora modesta Scheuring, 1970*
														R						R		C	C	C	A	C	C		C		F	F	F	*Vallasporites ignacii Leschik in Kräusel & Leschik, 1956*
															R		F		R		F	F					C				R	C	F	*Camerosporites secatus Leschik in Kräusel & Leschik, 1956*
															R																			*Concavisporites crassexinus Nilsson, 1958*
															R		R						R											*Sellaspora foveorugulata Van der Eem, 1982*
																	R																	*Guttatisporites ambiguus Tiwari & Rana, 1980*
																		R		F				F										*Alisporites grauvogelii Klaus, 1964*
																		C																*Convolutispora sp.A (cf. Vsn der Eem, 1983)*
																		R		R					R									*Falcisporites stabilis Balme, 1970*
																		F							R									*Reticulatisporites dolomiticus Blendinger, 1988*
																		F		C														*Klausipollenites sp.*
																		R																*Triplexisporites playfordii (De Jersey & Hamilton, 1967) Foster, 1979*
																		R				C		C	R		R							*Verrucosisporites applanatus Mädler, 1964*
																			C					C										*Palaeospongiosporis europaeus Schulz, 1965*
																			R															*Sulcatisporites kraeuselii Mädler, 1964*
																			R		R					R						R		*Weylandites magmus (Bose & Kar, 1966) Van der Eem, 1982*
																				C	R	C		A								R		*Angustisulcites sp.*
																					R		R		R	R								*Brachysaccus neomundanus Leschik in Kräusel & Leschik, 1956*
																					R											R		*Triadispora obscura Scheuring, 1970*
																					R													*Aulisporites astigmosus (Leschik in Kräusel & Leschik, 1956) Klaus, 1960*
																						R												*Triadispora falcata Klaus, 1964*
																								F										*Concentricisporites insignis (Pautsch, 1971) Pautsch, 1973*
																								R							R			*Triadispora crassa Klaus, 1964*
																								F										*Triadispora staplinii (Jansonius, 1962) Klaus, 1964*
																									R									*Triadispora suspecta Scheuring, 1970*
																										R								*Triadispora plicata Klaus, 1964*
																											R							*Corbulispora sp. B (Cf. Van der Eem, 1983)*
																													R		R	R	C	*cf. Partitisporites maljawkinae Klaus, 1960*
																																R		*Alisporites australis De Jersey, 1962*
																																R		*Platysaccus queenslandi De Jersey, 1962*

base of the
Daxatina cf. canadensis Sbz.
(45 m)

Tab. 3 - Range chart of palynomorphs in the Prati di Stuores section. Number at right hand of the sample name refers to the distance in metres from the underlying stake; R = rare, C = common, F = frequent, A = abundant.

1		2			3			4			5		6		7	8	9	10	11-12	13	14	15-16		17	18	19	Stakes
1SW 0.0	1SW 4.5	2SW 0.0	2SW 6.0	2SW 9.0	3SW 2.5	3SW 6.0	3SW 9.0	4SW 1.7	4SW 5.7	4SW 9.0	5SW 0.0	5SW 10.0	6SW 1.7	6SW 8.0	7SW 10.0	8SW 7.7	9SW 7.0	10SW 8.0	11SW 4.0	13SW 5.0	14SW 1.5	16SW 8.0	16SW 11.0	17SW 6.0	18SW 0.5	19SW 0.0	Samples
0.0	4.5	9.1	15.1	18.1	21.7	25.2	28.2	30.3	34.3	37.6	41.8	51.8	64.1	70.4	72.4	92.0	102.0	112.4	117.2	128.7	136.1	148.8	151.8	158.7	167.5	177.7	metres from stake 1
●																											*Paleolituonella meridionalis*
●		●	●		●	●		●			●							●				●					*Ammodiscus cf. infimus*
●					●			●			●																*Glomospirella ?facilis*
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●		●	●	●		*Duostomina biconvexa*
●	●		●		●			●			●				●				●	●	●	●			●		*Lenticulina excavata*
●	●	●	●		●			●	●		●				●		●			●	●	●				●	*Lenticulina bochardi*
●	●		●	●	●		●	●	●		●					●	●			●	●			●			*Pseudonodosaria obconica*
●	●	●	●	●	●	●		●	●		●		●		●	●	●	●	●	●	●			●	●	●	*Kriptoseptida klebelsbergi*
	●												●			●						●					*Ammodiscus annulinoides*
	●			●				●			●			●			●					●			●		*Ammodiscus tenuissimus*
	●			●	●	●		●	●	●	●		●	●	●	●	●	●	●		●	●	●	●	●	●	*Dentalina ex gr. subsiliqua*
		●											●				●				●						*Reophax eominutus*
		●							●															●	●		*Ammodiscus incertus*
		●																			●						*"Endothyra" kuepperi*
		●			●			●	●	●			●	●		●											*Ophtalmidium cf. exiguum*
			●	●							●						●	●				●	●				*Glomospira perplexa*
				●														●							●	●	*Duostomina alta*
				●		●	●	●	●	●	●																*Duostomina turboidea*
					●	●	●	●		●	●	●	●	●	●	●								●			*Glomospirella hemigordiformis*
					●			●			●		●	●	●												*Lenticulina cassiana*
					●	●			●		●	●			●		●	●			●	●	●	●	●	●	*Lenticulina karnica*
					●																						*Dentalina cassiana*
								●	●								●					●	●	●			*Reophax asperus*
													●														*Oberhauserella sp.*
										●					●												*Nodosaria primitiva*
													●														*Glomospirella sp.*
														●						●	●						*Dentalina guembeli*
															●					●		●			●		*Nodosaria nitidana*
																	●										*Schlagerina sp.*
																					●	●	●				*Papillaria altoconica*
																					●						*Reophax horridus*
																					●	●					*Variostoma pralongense*
																					●	●			●		*Variostoma exile*
																					●	●	●	●	●		*Aulotortus ex gr. sinuosus*
																					●	●	●		●		*Lamelliconus multispirus*
																					●	●	●		●		*Lamelliconus procerus*
																					●	●	●		●		*Ophtalmidium fusiforme*
																					●						*Ophtalmidium cf. macfadyeni*
																					●				●		*Ophtalmidium cf. lucidum*
																					●						*Paralingulina ploechingeri*
																					●						*Austrocolomia marschalli*
																					●						*Dentalina cf. vadaszi*
																					●						*Grillina grilli*
																					●		●		●		*Diplotremina astrofimbriata*
																					●						*Oberhauserella cf. alta*
																					●						*Kollmannita ladinica*
																					●				●	●	*Kollmannita multiloculata*
																					●						*Schmidita sp.*
																						●				●	*Papillaria sp.*
																							●			●	*Ammobaculites hiberensis*
																									●		*Lamelliconus ex gr. ventroplanus*

base of
Daxatina cf. canadensis Sbz.
(45 m)

Tab. 4 - Isolated foraminifer range chart in the Prati di Stuores section. Number at right hand of the sample name refers to the distance in metres from the underlying stake.

Tab. 5 - Foraminifer (thin section) range chart in the Prati di Stuores section. Number at right hand of the sample name refers to the distance in metres from the underlying stake.

Stakes	Samples	metres from the base	*Reophax sp*	*Textularia sp.*	*Ammobaculites sp.*	*Duostomina sp.*	*Ophthalmidium plectospirus*	*Nodosariidae*	*Gsollbergella spiroloculiformis*	*Semimeandr. karnica-planispira*	*Turriglomina carnica*	*Glomospirella sp.*	*Glomospira sp.*	*Endoteba sp.*	*Piallina tethydis*	*Ophthalmidium sp.*	*Gordiospira triassica*	*Palaeolituonella meridionalis*	*Variostoma sp.*	*Gheorghianina sp.*	*Lamelliconus multispirus*	*L. procerus.*
	18SW 10.21	177.16	●	●	●	●			●	●			●	●							●	●
18	18SW 5.00	171.95		●		●			●	●	●	●	●		●	●					●	●
	17SW 12.65	165.30				●																
	17SW 4.80	157.45	●		●								●							●		
17	17SW 0.70	153.35	●			●																
	16SW 5.45	146.23								●	●					●						
15-16	16SW 0,00	140.78							●						●							
14	14SW 0.00	134.60				●			●	●	●											
13	13SW 7.10	130.78	●	●	●	●						●	●	●				●	●	●		
	12SW 10.42	123.62						●														
	12SW 3.17	116.37												●								
	12SW 0.35	113.55								●					●							
	12SW 0.30	113.50								●	●											
11-12	12SW 0.20	113.40								●	●					●						
	10SW 8.50	112.90						●		●												
	10SW 8.30	112.70				●	●									●						
	10SW 6.45	110.85				●		●		●												
10	10SW 6.00	110.40				●				●												
9	9SW 4.60	99.60				●		●														
	8SW 8.00	93.30							●	●	●											
	8SW 5.35	89.65				●																
8	8SW 0.00	84.30						●														
	7SW 8.20	81.40				●		●			●											
	7SW 8.00	81.20				●			●	●												
	7SW 7.90	81.10				●			●													
	7SW 7.80	81.00				●			●													
7	7SW 5.00	78.20				●			●													
	6SW 2.30	64.70						●														
6	6SW 0.00	62.40				●																
	5SW 14.30	56.10				●																
	5SW 11.90	53.70						●														
	5SW 11.70	53.50				●						●	●									
	5SW 6.10	47.90				●							●									
	5SW 6.00	47.80				●		●	●													
	5SW 1.40	43.20				●				●					●			●				
5	5SW 0.10	41.90				●			●	●	●				●							
	4SW 7.80	36.38				●		●														
	4SW 7.55	36.13				●			●								●					
	4SW 5.85	34.43						●														
	4SW 5.40	33.98				●				●						●						
	4SW 5.35	33.93				●				●					●							
	4SW 0.90	29.48		●		●						●	●									
	4SW 0.60	29.18						●	●	●	●											
4	4SW 0.00	28.58	●			●		●														
	3SW 8.20	27.35							●		●											
	3SW 5.50	24.65				●			●					●								
	3SW 4.00	23.15				●				●	●											
3	3SW 0.00	19.15				●			●		●			●	●	●						
	2SW 8.80	19.90				●			●	●	●			●	●							
	2SW 6.90	19.00										●	●									
	2SW 4.30	13.40										●										
	2SW 3.20	12.30							●	●												
2	2SW 0.50	9.60	●			●																
	1SW 9.10	9.10							●	●	●											
	1SW 8.60	8.60				●	●	●														
	1SW 4.60	4.60																				
	1SW 4.35	4.35																				
	1SW 1.90	1.90			●	●																
1	1SW 0.00	0.00	●	●																		

base of
Daxatina cf. canadensis Sbz.
(45 m)

At the Regoledanus/Daxatina cf. canadensis subzone boundary, an apparent diversification was recorded. *Deltoidospora mesozoicus*, *Ephedripites primus*, *Osmundacidites* cf. *wellmanii*, and *Uvaesporites* sp. A (cf. Van der Eem, 1983) first occur just above the boundary and are followed, slightly higher, by *Concavisporites* sp. A (cf. Van der Eem, 1983) and *Reticulatisporites muricatus*.

Marine elements such as acritarchs (*Baltisphaeridium* sp. and *Micrhystridium* sp.) and foraminiferal test linings are generally uncommon.

The first appearance of *E. vigens* and "*L*". cf. *singhii* traditionally falls in the Upper Ladinian (Scheuring, 1970, 1974, 1978; Clement-Westerhof et al., 1974; Schuurman, 1977, 1979; Visscher et al., 1980; Visscher & Brugmann, 1981; Van der Eem, 1983). According to Van der Eem (1983), the appearance of *E. vigens* marks the beginning of the *secatus-vigens* phase (Longobardian), whereas "*L.*" cf. *singhii* appears in the upper part of the same phase.

- Assemblage B (48.7 to 160 m, Daxatina cf. canadensis Subzone) contains 37 species. In sample LCP22 (48.7 m), the typical Carnian species *Patinasporites densus* and *Vallasporites ignacii* appear, together with cf. *Concentricisporites bianulatus*, *Infernopollenites parvus* and *Triadispora modesta*. *Camerosporites secatus* appears in sample LCP24 (52.3 m), within the Daxatina cf. canadensis Subzone.

Other characteristic elements are *Weylandites magmus*, which appears in sample STWhx (79 m) and *Aulisporites astigmosus*, from sample SWo (79.2 m). In the uppermost part of the subzone, from sample SWu2 (109 m), rare specimens of cf. *Partitisporites maljawkinae* are recorded. Other new sporomorph appearances in the Daxatina cf. canadensis Subzone are shown in Tab. 3.

Marine elements are more common than in the Regoledanus Subzone; they include acritarchs (*Balthisphaeridium* sp., *Micrhystridium* sp., *Dictyotidium te-*

nuiornatum), Prasinophytae algae (*Cymatiosphaera* sp. A and *Tasmanites*) and foraminiferal test linings.

Previous palynologic studies of the Stuores section were carried out by Van der Eem (1983) who defined the base of the *vigens-densus* phase at the first occurrence of *Patinasporites densus* and *Vallasporites ignacii*. However, Van der Eem's samples were collected in younger strata (Aon Subzone), from section 2 (Fig. 1), corresponding to the section in Urlichs (1974). As these forms occur also in the underlying layers (section 1), the base of the *vigens-densus* phase is now revised and is placed close to the base of the Daxatina cf. canadensis Subzone (Tab. 3 and Fig. 13). Both *Weylandites magmus*, which occurs exclusively in the *secatus-vigens* phase, and *Camerosporites secatus*, whose first appearance is considered Late Ladinian in age (Schuurman, 1977, 1979; Visscher & Krystyn, 1978; Visscher & Brugman, 1981; Van der Eem, 1983; Blendinger, 1988; Brugman et al., 1993; Warrington, 1996), occur within the Daxatina cf. canadensis Subzone.

In summary, the Regoledanus Subzone in the Stuores section is characterised by the first occurrence of *Enzonalasporites vigens* and of "*Lueckisporites*" cf. *singhii* (close to the top of the subzone). Within this ammonoid subzone, significant last occurrences are those of *Concavisporites toralis*, *Guthoerlisporites cancellosus*, *Densosporites* cf. *variomarginatus* and *Kyrtomisporis ervii*.

The Daxatina cf. canadensis Subzone is characterised by the appearances of *Patinasporites densus* and *Vallasporites ignacii*, together with the occurrences of *Camerosporites secatus* and *Weylandites magmus*. Furthermore, the *Triadispora* group becomes more diversified towards the upper part of the subzone.

In addition, it should also be noted that Assemblage B of the Daxatina cf. canadensis Subzone from the Prati di Stuores section can be correlated with G/H Assemblages of the Barents Sea (Hochuli et al., 1989, fig. 2) for the presence of *Patinasporites summus* and *Camerosporites secatus*. These boreal assemblages include the presence of *Daxatina canadensis* and are referred to the uppermost Ladinian. However, the typical boreal index taxa of Assemblage G, such as *Echinitosporites iliacoides* and *Retisulcites perforatus* (Hochuli et al., 1989), are lacking in the palynoflora from the Prati di Stuores section.

Benthic foraminifera.

(Carmela Broglio Loriga, Donato di Bari & Roberto Rettori)

The study of foraminifers was carried out both in thin section and washed material to obtain the most realistic assemblages (Pl. 7, and Pl. 8). Fifty-one species were extracted from 27 samples of marls and clays, and twenty taxa were identified in over 300 thin sections from calcarenitic levels and muddy limestones.

Three segments were distinguished in the Stuores section on the base of FO and abundance of the taxa from both washed materials and thin sections. The foraminiferal succession is as follows (Table 7 and 8).

A) 0 to 45 m (Regoledanus Subzone). This segment ranges from stake 0 to the FAD of Daxatina.

Isolated foraminifers (Tab. 7) - A rich fauna dominated by agglutinated forms such as *"Endothyra" kuepperi* Oberhauser, *Palaeolituonella meridionalis* (Luperto), *Ammodiscus* cf. *infimus* (Strickland), *A. incertus* (d'Orbigny), *Glomospirella ? facilis* Ho, *Glomospira perplexa* Franke, *Reophax eominutus* Kristan-Tollmann, etc., together with *Dentalina* ex gr. *subsiliqua* Franke, *D. cassiana* Gümbel, *Nodosaria primitiva* Kübler & Zwingli, *Pseudonodosaria obconica* (Reuss), *Kriptoseptida klebelsbergi* (Oberhauser), *Lenticulina cassiana* (Gümbel), *L. karnica* (Oberhauser), etc.; in addition *Duostomina biconvexa* Kristan-Tollmann, *D. alta* Kristan-Tollmann, *D. turboidea* Kristan-Tollmann and *Ophthalmidium* cf. *exiguum* Köhn-Zaninetti occur.

Thin section (Tab. 8) - In a mudstone layer at 9.10 m the appearance of the *Gsollbergella spiroloculiformis* (Oravecz-Scheffer), *Semimeandrospira* ex gr. *karnica -planispira* (Oravecz-Scheffer) and *Turriglomina carnica* (Dager) assemblage was recorded. *Piallina tethydis* Rettori et al. first occurs in a fine-grained unit at 19.90 m. The appearance of *Gordiospira triassica* Urosevic was recorded at 36.13 m, but this species is absent in the rest of the section. *Gsollbergella spiroloculiformis* occurs throughout the succession in both calcarenites and muddy limestones. *Turriglomina carnica*, when present, is more abundant above 29.18 m. In addition, a solitary specimen of *Palaeolituonella meridionalis* (Luperto) was recognised (43.2 m from stake 1). All these taxa are small and, at present, known exclusively from the Carnian of western and eastern Tethys.

Specimens of *Ammobaculites, Gheorghianina, Glomospira, Glomospirella, Duostomina, Endoteba, Ophthalmidium* and *Reophax* may be associated with the fauna mentioned above. Nodosariidae and Textulariidae were also noted (Tab. 8).

B) 45 to about 130 m (Daxatina cf. canadensis Subzone *p.p.*).

Isolated foraminifers - Few new taxa gradually appear. Most of the foraminifers present at lower levels such as *Lenticulina excavata* Terquem, *L. bochardi* Terquem, *L. karnica* (Oberhauser), *Glomospirella hemigordiformis* Tscherdinzev, etc. persist above 45 m, but the nodosariids, including *Dentalina guembeli* Schwager and *Nodosaria nitidana* Brand, become dominant. Other new taxa belonging to the *Oberhauserellidae*, such as *Schlagerina* sp. and *Oberhauserella* sp., were identified.

Thin section - The changes noted in the assemblages from this segment are the bloom of *S.* ex gr. *karnica -planispira* at 113.4 m and the decrease of the taxa present further below.

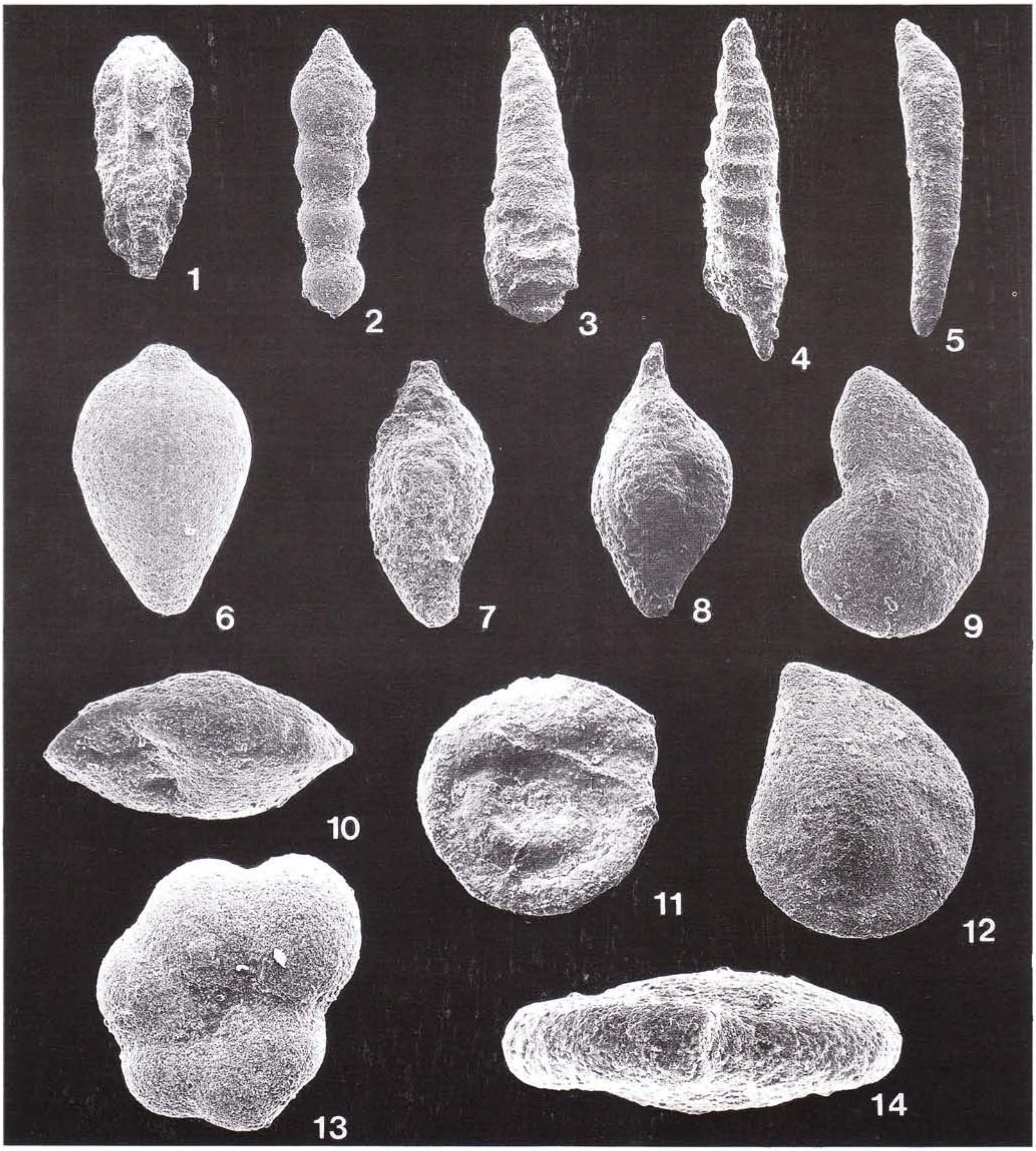


PLATE 7

Isolated foraminifera from the Prati di Stuores/Stuores Wiesen section.

Fig. 1 - *Paralingulina ploechingeri* (Oberhauser). Sample 14SW 1.5, 70x.
Fig. 2 - *Nodosaria nitidana* Brand. Sample 13SW 5.0, 60x.
Fig. 3-4 - *Lamelliconus procerus* (Liebus). Fig. 3) 75x; Fig. 4) 100x; Sample 16SW 11.0.
Fig. 5 - *Dentalina* ex gr. *subsiliqua* Franke. Sample 14SW 1.5, 170x.
Fig. 6 - *Pseudonodosaria obconica* (Reuss). Sample 4SW 1.7, 70x.
Fig. 7 - *Ophthalmidium fusiforme* (Trifonova). Sample 16SW 8.0, 90x.
Fig. 8 - *Ophthalmidium lucidum* (Trifonova). Sample 18SW 0.5, 100x.
Fig. 9 - *Lenticulina excavata* (Terquem). Sample 13SW 5.0, 60x.
Fig. 10 - *Duostomina biconvexa* Kristan-Tollmann. Sample 14SW 1.5, 120x.
Fig. 11 - *Glomospirella hemigordiformis* (Tscherdynzew). Sample 6SW 1.7, 90x.
Fig. 12 - *Lenticulina bochardi* (Terquem). Sample 14SW 1.5, 100x.
Fig. 13 - *"Endothyra" kuepperi* (Oberhauser). Sample 14SW 1.5, 100x.
Fig. 14 - *Aulotortus* ex gr. *sinuosus* (Weynschenk). Sample 16SW 11.0, 230x.

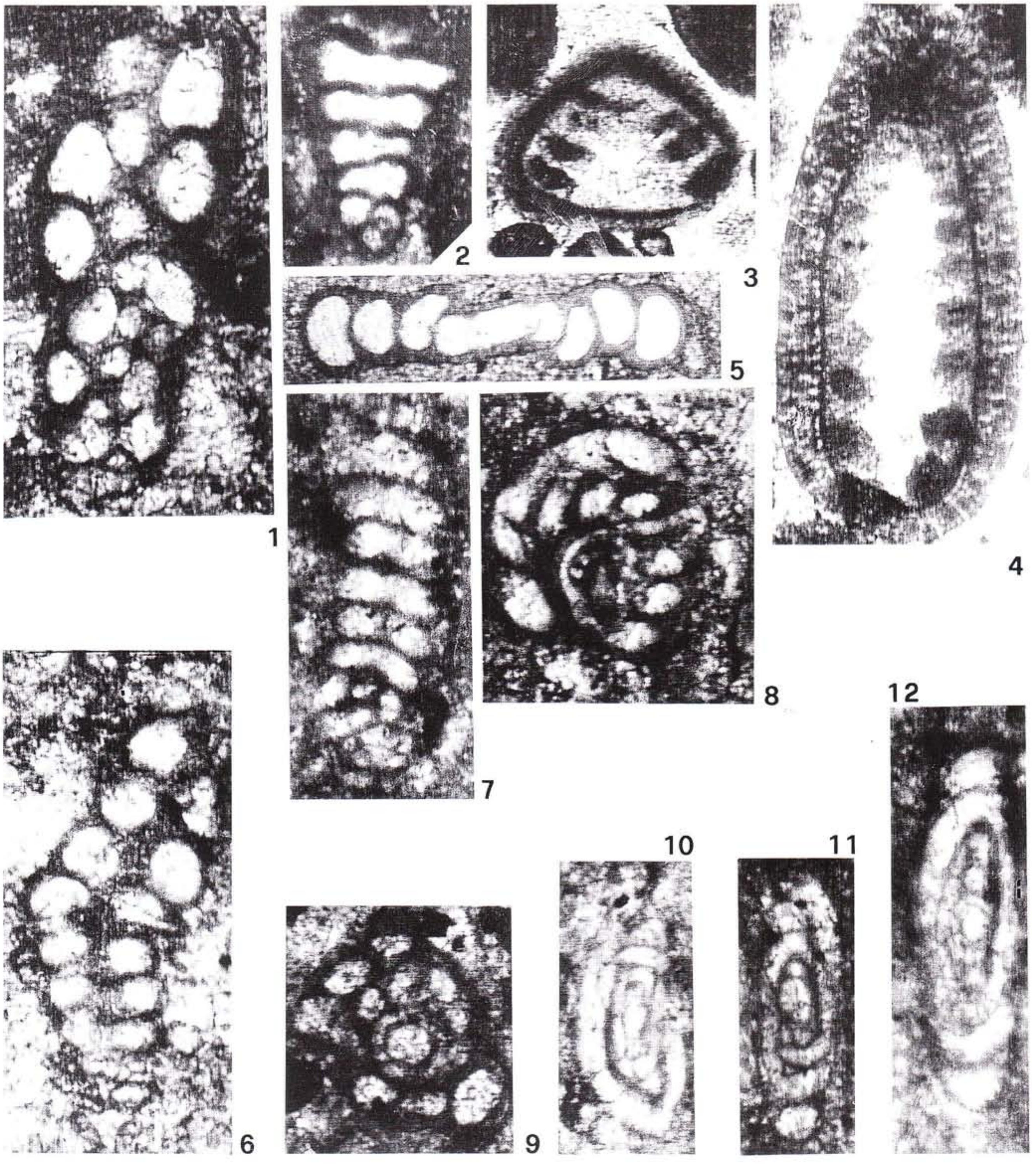


PLATE 8

Foraminifera in thin section from the Prati di Stuores/Stuores Wiesen section.

Fig. 1 - *Piallina tethydis* Rettori et al. Sample 2SW 10.25, 420x.
Fig. 2 - *Palaeolituonella meridionalis* (Luperto). Sample 5SW 1.40, 115x.
Fig. 3 - *Lamelliconus multispirus* (Oberhauser). Sample 18SW 5.0, 65x.
Fig. 4 - *Lamelliconus procerus* (Liebus). Sample 18SW 5.0, 100x.
Fig. 5 - *Gordiospira triassica* Urosevic. Sample 4SW 17.55, 155x.
Fig. 6-9 - *Turriglomina carnica* (Dager). Fig. 6) sample 3SW 9.95, 420x; Fig. 7) sample 1SW 9.10, 420x.
Fig. 8-9 - *Semimeandrospira* ex gr. *karnica-planispira* (Oravecz-Scheffer). Fig. 8) sample 1SW 9.10, 420x; Fig. 9) sample 16SW 5.45, 420x.
Fig. 10-12 - *Gsollbergella spiroloculiformis* (Oravecz-Scheffer). Fig. 10,12) sample 1SW 9.10, 420x; Fig. 11) sample 7SW 5.0, 420x.

C) about 130 m to the top (Daxatina cf. canadensis Subzone *p.p.*)

Isolated foraminifers - The taxonomic diversity of the assemblage suddenly increases. Duostominids and involutinids are dominant. The first occurrence of involutinids such as *Aulotortus* ex gr. *sinuosus* Weynschenk, *Lamelliconus multispirus* (Oberhauser) and *L. procerus* (Liebus), is noted at 136.1 m. *Ophthalmidium fusiforme* (Trifonova) and *O. lucidum* (Trifonova) appear also for the first time. *Lamelliconus* ex gr. *ventroplanus* (Oberhauser) appears at 167.5 m.

Other main taxa are *Duostomina biconvexa* Kristan-Tollmann, *Diplotremina astrofimbriata* Kristan-Tollmann, *Variostoma pralongense* Kristan-Tollmann, *V. exile* Kristan-Tollmann, *Papillaria altoconica* (Kristan-Tollmann), *Papillaria* sp.; moreover, a few nodosariaceans, oberhauserellids and agglutinated forms are present.

Thin section - The shallow water biota from the platform environment (Dolomia Cassiana) such as *Tubiphytes*, bryozoans, *Cayeuxia*, calcareous sponges, thick-shelled bivalves, encrusting foraminifers becomes more abundant from 130.78 m.

At 171.95 m, the foraminiferal assemblage is dominated by involutinids (Lamelliconinae) mainly referred to *Lamelliconus multispirus* (Oberhauser) and *L. procerus* (Liebus), associated with forms present at lower levels in the Prati di Stuores section (*Gsollbergella spiroloculiformis*, *Semimeandrospira* ex gr. *karnica-planispira*, *Turriglomina carnica*, *Piallina tethydis*). Agglutinated forms and duostominids are present also.

The comparison between isolated foraminiferal assemblages and those in thin sections allows the following remarks to be made.

1 - *Aulotortus* seems absent in the thin sections.

2 - *Prorakusia*, formerly known from the San Cassiano Fm. (di Bari & Laghi, 1994) and from Calcare del Predil (Cordevolian Auct.) (Rettori et al., 1998) is absent in the Stuores section.

3 - The Carnian affinity of the foraminiferal assemblages in the Regoledanus and lower Daxatina cf. canadensis Subzones is indicated mainly by taxa observed only in thin section such as *Gsollbergella spiroloculiformis*, *Semimeadrospira* ex gr. *karnica-planispira*, *Turriglomina carnica* and *Piallina tethydis.*

4 - Assemblages recognised in washed materials and in thin sections from the upper part of the D. cf. canadensis Subzone are comparable mainly because of the occurrence of involutinids (*Lamelliconus*).

5 - The most prominent increase in taxonomic diversity occurs in the upper Daxatina cf. canadensis Subzone (segment C).

6 - Most species occurring in the Stuores section are recorded in the Carnian strata of Turkey (Altiner & Zaninetti, 1981; Dager, 1978; Rettori et al., 1993); West Carpathians (Salaj et al., 1983), the Balkanides (Trifonova, 1992; 1993), the Transdanubian Central Range (Oravecz-Scheffer, 1987), Eastern Serbia (Urosevic, 1988), the Northern Calcareous Alps (Oberhauser, 1957; Kristan-Tollmann, 1960; Köhn-Zaninetti, 1969; Zaninetti, 1969, 1976), the Julian Alps (Rettori et al., 1998), China (He & Yue, 1987; He & Norling, 1991) and Israel (Benjamini, 1988).

7 - Changes in taxonomic compositions may be partly related to ecological factors such as oxygen content.

Autochthonous deep water benthic foraminifers characterise the Stuores section mainly from the base to about 130 m (Regoledanus Subzone, lower Daxatina cf. canadensis Subzone). The shallow water taxa commonly inhabiting the adjacent platform environment are found in the basinal sediments of the San Cassiano Fm. from about 131 m to the top of the section and are dominant in the upper Daxatina cf. canadensis Subzone.

According to the relationships between foraminiferal test morphology and energy-oxygen level suggested by Kahio (1989) and Boudiche & Ruget (1993), *Dentalina*, *Pseudonodosaria* and *Nodosaria* belong to the elongated and cylindric morphotype and *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 the epifauna inhabiting shallow to deep water during the Early Mesozoic. The morphotype association suggests disaerobic and low energy conditions of the sedimentary environment.

The duostominid- and involutinid-dominated associations above 130 m to the top of the section (upper Daxatina cf. canadensis Subzone) may record an increase in energy and oxygen levels of the environment.

Bivalves, gastropods and brachiopods.

(Renato Posenato)

Bivalves in the Stuores section are mainly posidoniids. Gastropods are very rare in the lower part of the section, but become relatively frequent in the upper part, where they are mostly represented by allochthonous specimens. Brachiopods are rare and occur only in the upper part of the section (Tab. 6).

The majority of posidoniids have only concentric undulations or ribs and a long hinge margin (Pl. 9, fig. 6). Specimens with the same outline and ornamentation were classified by Kittl (1912; pl. 1, fig. 6-12) as *Posidonia wengensis* (Wissmann). However, the generic attribution of this species is questionable because *Posidonia* is characterised by a short hinge line (Cox, 1969). Other specimens with the same outline and concentric ornamentation bear hardly perceptible radial costellae or grooves on the posterior region; these are classified here as "*Posidonia*" cf. *wengensis* (Pl. 9, fig. 1, 5) and could represent a juvenile stage of *Daonella* or a transition to *Halobia*. Some other rare specimens, without radial co-

Stakes	Samples	metres from stake 1	Bivalves										Brac		Gastropods								
19			*"Posidonia" wengensis*	*"Posidonia" cf. wengensis*	*? Halobia sp.*	*? Enteropleura sp.*	*Leda dubia*	*Cassianella sp.*	*Mysidioptera sp.*	*? Pachycardia sp.*	*Entolium cf. hallense*	*Plicatula sp.*	*Koninckina leonhardi*	*Retzia sp.*	*Polygyrina lommeli*	*Eustylus sp.*	*Goniogyra armata*	*Gosseletina fasciolata*	*Anoptychia supraplecta*	*Dicosmus maculosus*	*? Purpurina sp.*	*Anoptychia canalifera*	*Turbo orthostoma*
	debris	167-178												●									
18	18SW 2.0	169.0									●												
	debris	141-153				●						●					●				●	●	●
15-16	15SW 6.0	146.8	●																				
13	13SW 8.0	131.7	●																				
	debris	113-124	●														●		●	●	●		
11-12	12SW 1.5	114.7	●																				
	debris	104-113	●					●	●	●			●				●	●					
10	10SW 4.3	108.7	●																				
8	8SW 4.0	88.3	●																				
	7SW 10.5	83.7														●							
	7SW 6.1	79.3	●	●	●		●																
	7SW 3.7	76.9		●																			
7	7SW 2.5	75.7	●																				
	6SW 10.5	72.9		●																			
	6SW 9.0	71.4													●								
	6SW 7.0	69.4	●																				
6	6SW 3.0	65.4	●																				
5	5SW 8.0	49.8			●																		
4	4SW 3.0	31.6	●																				
	3SW 5.4	24.6	●																				
3	3SW 0.0	19.2	●																				

base of
Daxatina cf. canadensis
Sbz.
(45 m)

Tab. 6 - Occurrences of bivalves, brachiopods and gastropods in the Prati di Stuores section 1. Number at right hand of the sample name refers to the distance in metres from the underlying stake.

stellae or with only a posterior groove, have a small and narrow anterior auricle (Pl. 9, fig. 2); they are tentatively referred to *Halobia*. More, and better preserved material is necessary to clarify the classification of these posidoniids, in particular whether they belong to a single or different species, and whether they represent a juvenile or ancestral stage of *Daonella* or *Halobia*.

Posidoniid bivalves are considered traditionally as pseudoplanktic or nectoplanktic forms, even though epibenthic, epibyssate or free-lying habits have been proposed (Wignall & Simms, 1990; Aberhan & Palfy, 1996). Posidoniids frequently occur in laminated black shale facies associated with nektic forms (cephalopods). Sedimentologic and paleontologic features of the posidoniid-bearing layers suggest that they are a marker of lower disaerobic (low bottom-water oxygen values) communities (Allison et al., 1995).

In the Stuores section, posidoniids occur mainly in the laminated dark grey clay and argillaceous marl alternated with tuffites and calcarenites transported to the basin from shallower environments. According to Fürsich & Wendt (1977) Posidonia is a typical element of the "pelagic assemblage" of the San Cassiano Fm. which is characterised by the absence of benthic forms and the dominance of nektic forms and was deposited in the deeper parts of the basin. Due to either (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 & Wendt, 1977). According to the new hypothesis concerning the tolerance of posidoniids to low-oxygen values, the latter of these environmental factors seems to have played a dominant role in the pelagic assemblage of the Stuores section.

Transported shallow-water forms, associated with autochthonous bivalve specimens of *Koninckina leonhardi*, first occur at 105-115 m; allochthonous patch reef taxa (corals, *Dicosmus maculosus*, etc.) occur at 115-125 m. According to Fürsich & Wendt (1977), the trophic nucleus of the *K. leonhardi* association is represented by low-level suspension feeders which therefore needed aerobic conditions at the water-sediment interface. Pelitic intercalations contain *"P". wengensis* below 147 m, suggesting a likely alternation of disaerobic-aerobic conditions in the water near the bottom in the interval from 105 to about 150 m. The disappearance of *"P". wengensis* and the frequent occurrence of nuculoids (section 2) above 150 m may suggest a change of the redox boundary which shifted inside the sediments.

In conclusion, the depositional environment of the Stuores section corresponds to a basin in which prevailing anaerobic to disaerobic conditions of the bottom water occurred in the lower part (from 0 to 104 m). As the sediment filled the basin, water circulation increased leading to frequent aerobic events (*Koninckina* beds) alternated with disaerobic events (*"Posidonia"*-bearing marls) in the middle part (from 104 to 150 m). 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.

(Gian Franco Laghi and Mariacarmela Rechichi)

Microcrinoids (Crinoidea, Echinodermata) were noted formerly from the San Cassiano Fm. but were studied only recently by Kristan Tollmann (1970) who considered the high frequency of these fossils as an indicator of typical facies of the mid-upper Triassic of the Tethys, and compared them with the Jurassic *Saccocoma* Facies (Kristan Tollmann, 1970).

Stakes	Samples	metres from stake 1	Microcrinoids											Holothurian												
			Osteocrinus rectus	*Osteocrinus saklibelensis*	*Osteocrinus goestlingensis*	*Axicrinus sp.*	*Osteocrinus acus*	*Nodolanx multinodosa*	*Axicrinus alexsandri*	*Ossicrinus reticulatus*	*Osteocrinus sp.*	*Somphocrinus sp.*	*Tulipacrinus sp.*	*Etheridgella pentagonia*	*Acanthotheelia spinosa*	*Calclamnoidea canalifera*	*Eocaudina cassianensis*	*Theelia guembeli*	*Theelia serta*	*Theelia pralongiae*	*Theelia tubercula*	*Theelia planorbicula*	*Calcligula triassica*	*Sinapta sp.*	*Placerotapsis subplanatus*	*Tetravirga imperforata*
19	19SW 0.0	177.7	●					●								●	●									
	18SW 5.0	171.9	●					●	●					●	●	●	●									
18	18SW 0.5	167.5	●	●			●	●	●	●	●				●		●			●			●			
17	17SW 6.0	158.7	●	●	●		●				●															
	16SW 11.0	151.8	●													●				●						●
15-16	16SW 8.0	148.8	●	●			●			●						●	●									●
	14SW 3.5	138.1	●	●						●			●		●		●		●	●	●	●	●	●	●	
14	14SW 1.5	136.1	●		●		●	●	●	●	●			●	●	●	●		●	●						●
11-12	11SW 4.0	117.2	●	●		●	●	●		●		●			●		●	●							●	
9	9SW 7.0	102.0	●	●			●																			
	8SW 7.7	92.0	●				●			●																●
8	8SW 4.0	88.3	●				●		●																	
	6SW 10.0	72.4	●	●	●		●																			
	6SW 8.0	70.4	●		●		●																			
6	6SW 1.7	64.1	●	●			●	●			●					●										
	5SW 10.0	51.8	●																							
5	5SW 0.0	41.8	●	●		●	●	●		●	●				●											
	4SW 9.0	37.6	●		●																					
	4SW 5.7	34.3	●				●																			
4	4SW 1.7	30.3	●			●	●	●	●					●												
	3SW 9.0	28.2																								
	3SW 6.0	25.2	●					●																		
3	3SW 2.5	21.7	●				●	●																		
	2SW 9.0	18.1	●																							
	2SW 6.0	15.1	●																							
2	2SW 0.0	9.1	●	●	●																					
	1SW 4.5	5.5	●	●	●	●																				
1	1SW 0.0	0.0	●	●																						

base of
Daxatina cf. canadensis Sbz.
(45 m)

Tab. 7 - Range chart of microcrinoids (left) and holothurian sclerites (right) in the Prati di Stuores section. Number at right hand of the sample name refers to the distance in metres from the underlying stake.

Bizzarini et al. (1989) and Bizzarini (1993) then investigated the stratigraphic ranges of some taxa in the San Cassiano Fm. particularly from the Prati di Stuores - i.e. the type locality of the several species described by Kristan Tollmann (1970)- where the traditional Aon Zone is documented.

New data from the Prati di Stuores section (Tab. 7) record the occurrences of eleven and thirteen taxa of microcrinoids and holothurian sclerites, respectively. On the basis of the vertical ranges of the taxa and their assemblage sequences, three segments were distinguished as follows.

0 - 41.8 m (Regoledanus Subzone). Seven out of eleven microcrinoid taxa gradually appear. At 41.8 m, close to the first appearance of *Daxatina* the assemblage includes *Osteocrinus rectus* Kristan-Tollmann, *O. saklibelensis* Kristan-Tollmann, *O. acus* Kristan-Tollmann, *O.* sp., *Axicrinus* sp., *Nodolanx multinodosa* Kristan-Tollmann and Ossicrinus reticulatus Kristan-Tollmann. Only two species of holothurian sclerites (*Etheridgella pentagonia Kristan, Acanthotheelia spinosa* Frizzel & Exline) appear at 30.3-41.8 meters from the base of the section.

45 -102 m (lower Daxatina cf. canadensis Subzone). Apart from the first occurrence of the single sclerite species *Calclamnoidea canalifera* Kristan-Tollmann (64.1 m), no significant change in the taxa of microcrinoid and holothurian assemblages from lower levels is noted. The holothurian sclerites are always very rare.

102 - 177.7 m (upper Daxatina cf. canadensis Subzone). A sudden increase in the holothurian sclerite taxa causes a remarkable diversity peak in their assemblages at 136.1-138.8 meters. In comparison with the eight genera, each represented by a single species, it is to be noted that the genus *Theelia* includes four species. Microcrinoids are abundant also as individuals, but no prominent peak is recorded.

In conclusion, the results are as follows.

Microcrinoids.

1- The assemblage, apart from minor changes, is similar to that of the Carnian Aon Subzone; the last occurrence of *Osteocrinus acus* in the Daxatina cf. canadensis Subzone is the most prominent event that distinguishes the two subzones.

2 - The assemblage characteristic of the traditional Lower Carnian becomes complete at the first occurrence of *Daxatina* cf. *canadensis.*

3 - *Osteocrinus rectus* is the most frequent taxon, and is found in all the "*Osteocrinus* Facies". In addition, the other species such as *Osteocrinus gestlingensis* Kristan Tollmann and *O. saklibelensis* Kristan Tollmann are longe-range species.

Holothurian Sclerites.

1 - A great diversity of the species belonging to the genus *Theelia*, characterises the upper Daxatina cf. canadensis Subzone.

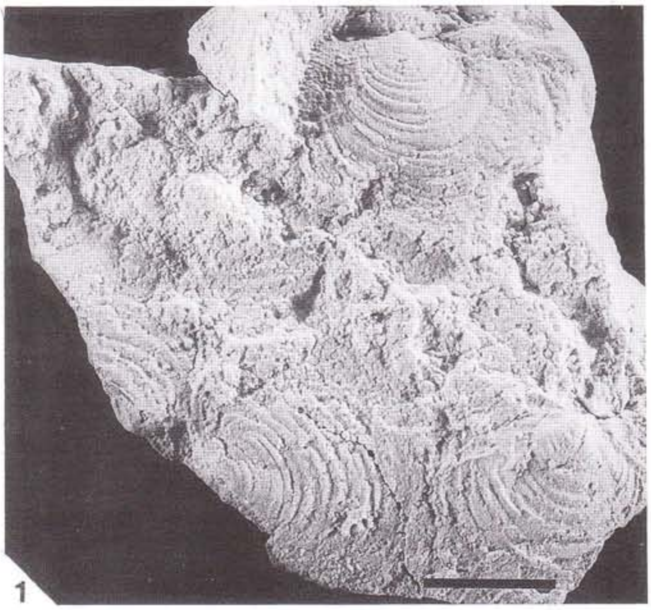
2 - The same assemblage continues, into the Aon Subzone but becomes poorer.

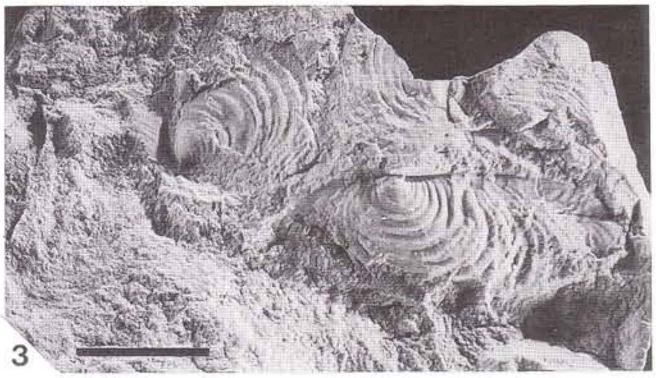
Paleomagnetism.

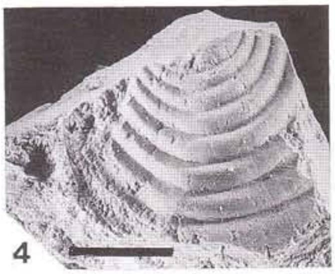
(Giovanni Muttoni & William Lowrie)

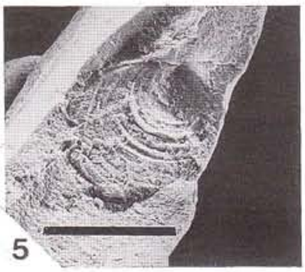
Paleomagnetic techniques.

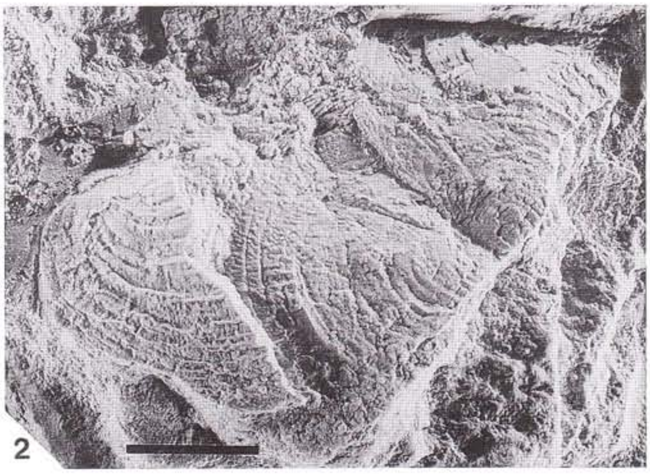
Paleomagnetic samples at Stuores were collected with a portable water-cooled rock drill and oriented











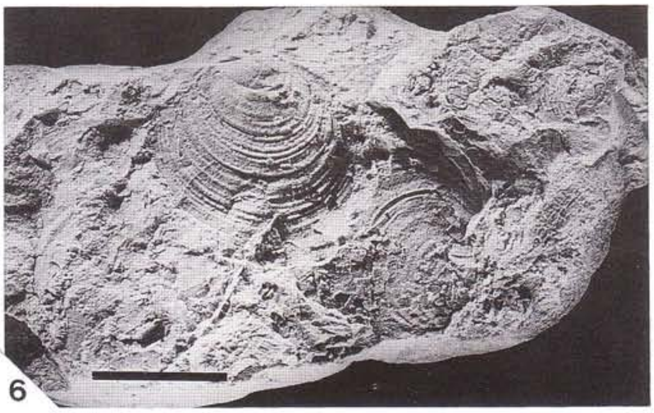


PLATE 9

Posidoniidae in the Prati di Stuores/Stuores Wiesen section.

Fig. 1 - "*Posidonia*" cf. *wengensis* (Wissmann). Sample 7SW 3.7, the specimen at the top has very fine radial grooves and costellae on the posterior region.

Fig. 2 - ? *Halobia* sp. Sample 5SW 8.0, the specimen on the left has a narrow ridge placed forward of the umbo which may represent the anterior auricle; thus, it could be classified into *Halobia*. However, radial sculpture is only represented by a sharp posterior groove.

Fig. 3 - ? *Halobia* sp. Sample 7SW 6.1, the larger specimen, on the right, has very fine radial costellae on the posterior region, but the anterior auricle is lacking.

Fig. 4 - ? *Enteropleura* sp. From debris between stakes 16 and 17.

Fig. 5 - "*Posidonia*" cf. *wengensis* (Wissmann). Sample 6SW 10.5, interior surface of a right valve with a posterior radial groove.

Fig. 6 - "*Posidonia*" cf. *wengensis* (Wissmann). Sample 10SW 4.3.

Scale bar 1 cm.

with a magnetic compass. Drilling was performed almost exclusively in the harder sandstone and siltstone beds, thus resulting in a somewhat coarser sampling in the marly upper part of the section compared to the lower sandy-silty part (Fig. 6a). All but two of the 98 2.5 cm diameter field core samples yielded one standard 11 cc specimen for analysis (two samples did not survive cutting in the laboratory). Paleomagnetic analyses were carried out at the paleomagnetic laboratory of ETH Zürich. Stepwise thermal demagnetization treatments and measurements of natural remanent magnetization (NRM) were performed on all specimens in a shielded room with ambient fields less than 300nT. Heating and cooling were done in a shielded demagnetizer in which ambient fields are less than 5nT. Magnetic remanences were measured on a 2G Model 760 3-axis cryogenic magnetometer mounting DC SQUID sensors. After each thermal demagnetization step, the initial susceptibility of selected specimens was measured with a Bartington MS2 susceptibility bridge to monitor any mineralogical alteration resulting from the heating procedure. Least-square analysis (Kirschvink, 1980) was used to determine the component directions of the natural remanent magnetization, chosen by inspection of vector end point demagnetograms (Zijderveld, 1967). 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) (Lowrie, 1990).

Paleomagnetic directions.

The initial NRM intensity has a mean value of 0.2*10-4A/m in the volcaniclastic-rich lower part of the section, whereas in the upper part it drops by about one order of magnitude. The initial susceptibility conforms to this trend with mean values of 4*10-3SI and 5*10-4SI in the lower and upper part, respectively. A sharp decrease in both NRM and susceptibility values can be therefore traced within the "Untere Cassianer Schichten" between 73.3 and 77.3 m above the base of section (Fig. 6b). Susceptibility varies proportionally to NRM (Fig. 7), which suggests that both parameters are controlled primarily by lithology rather than by the Earth's magnetic field intensity variations.

Paleomagnetic samples typically show the presence, in geographic (*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 96 specimens. In particular, a bipolar characteristic component oriented in situ north and positive (Fig. 8a) or south-southwest and negative (Fig. 8b) was isolated in 72% of the specimens in the temperature range between about 200°C and 450°C up to 550/580°C (Fig. 6c). In 10% of the specimens the characteristic component could be followed up to maximum unblocking temperatures of 600 to 630°C (Fig. 6c). 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 polarity reversal. The initial susceptibility often shows a sudden increase above about 400-450°C which is related to mineralogical alterations during heating (Fig. 9). However, this alteration did not usually hamper the recovery of the characteristic com-

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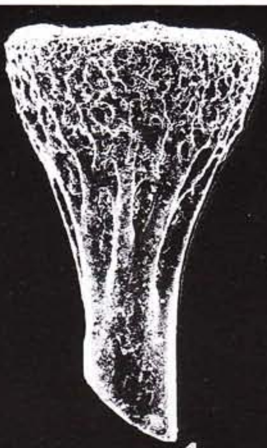
PLATE 10

Microcrinoids and holothurian sclerites from the Prati di Stuores/Stuores Wiesen section.

Fig. 1, 5 - *Osteocrinus acus* Kristan-Tollmann. Fig. 1) base of the dorsal spine, lateral view, sample 11 SW 4.0, 130x; Fig. 5) needle of the dorsal spine, sample 9SW 7.0, 75x.
Fig. 2-3 - *Osteocrinus rectus* Kristan-Tollmann. Fig. 2) base of the dorsal spine, lateral view, sample 11SW 4.0, 100x; Fig. 3) radial plate, frontal view, sample 8SW 7.7, 40x.
Fig. 4 - *Osteocrinus goestlingensis* Kristan-Tollmann. Radial plate, frontal view, sample 6SW 10.0, 50x.
Fig. 6 - *Osteocrinus reticulatus* Kristan-Tollmann. Base of the dorsal spine, lateral view, sample 18SW 0.5, 130x.
Fig. 7 - *Osteocrinus sakliebelensis* Kristan-Tollmann. Base of the dorsal spine with radial ring, lateral view, sample 11SW 4.0, 100x.
Fig. 8-9 - *Nodolanx multinodosa* Kristan-Tollmann. Fig. 8) radial shield, frontal view, sample 11SW 4.0, 40x; Fig. 9) aboral shield, frontal view, sample 19SW 0.0, 35x.
Fig. 10 - *Acanthotheelia spinosa* Frizzel &Exline. Holothurian sclerite, sample 14SW 3.5, 100x.
Fig. 11 - *Theelia guembeli* Kristan-Tollmann. Holothurian sclerite, sample 11SW 4.0, 170x.
Fig. 12 - *Axicrinus* sp. Brachial plate, lateral view, sample 11SW 4.0, 25x.
Fig. 13 - *Theelia pralongiae* Kristan-Tollmann. Holothurian sclerite, sample 14SW 3.5, 140x.
Fig. 14 - *Theelia serta* Speckmann. Holothurian sclerite, sample 14SW 3.5, 180x.
Fig. 15-16 - *Axicrinus alexandri* Kristan-Tollmann. Fig. 15) radial shield, frontal view, sample 14SW 3.5, 35x; Fig. 16) brachial plate, lateral view, sample 14SW 1.5, 40x.
Fig. 17 - *Theelia tubercula* Kristan-Tollmann. Holothurian sclerite, sample 14SW 3.5, 190x.
Fig. 18 - *Calcligula triassica* (Frizzel & Exline). Holothurian sclerite, sample 18SW0.5, 100x.
Fig. 19 - *Placerotapis subplanus* Kozur & Mostler. Holothurian sclerite, sample 14SW3.5, 180x.
Fig. 20 - *Tulipacrinus* sp. Radial ring, ventral view, sample 14SW3.5, 30x.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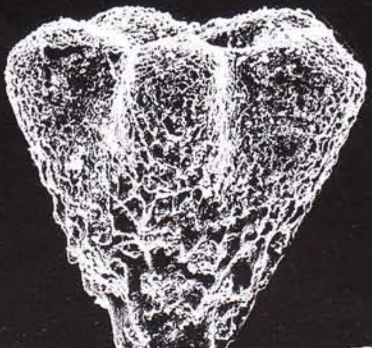
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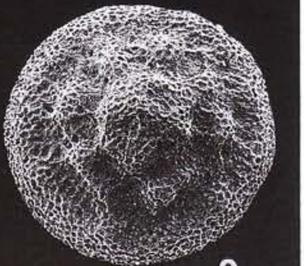
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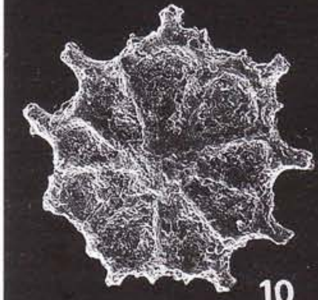
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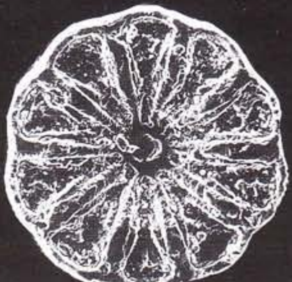
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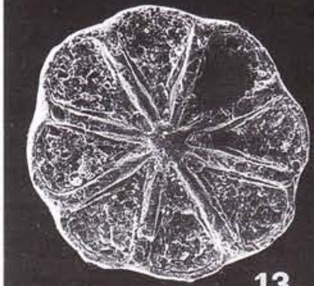
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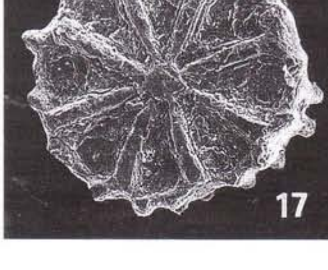
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19


20

Sample	Meters	VGP lat	Polarity
1+1.70	1.5506	70.5	N
1+3.20	2.9187	80.9	N
1+4.45	4.0588	64.6	N
1+5.90	5.3814	75.6	N
1+7.13	6.5033	64.5	N
1+7.73	7.0505	57.7	N
1+9.23	8.4187	75.7	N
1+9.90	9.0298	73.8	N
2+1.30	10.406	83.8	N
2+2.15	11.261	81.8	N
2+3.35	12.467	66.8	N
2+4.20	13.321	75.6	N
2+5.30	14.426	85.6	N
2+5.40	14.527	76.6	N
2+8.25	17.391	84.4	N
2+8.95	18.094	45.2	N
2+10.00	19.150	80.7	N
3+0.90	20.050	81.7	N
3+1.70	20.850	69.2	N
3+4.50	23.650	80.6	N
3+5.50	24.650	81.8	N
3+7.35	26.500	84.1	N
4+0.0	28.580	79.8	N
4+0.50	29.080	79.8	N
4+1.13	Dead during cutting		
4+4.36	32.940	85.6	N
4+4.56	33.140	65.6	N
4+5.39	33.970	78.8	N
4+6.06	34.640	-20.9	T/R
4+9.23	37.810	-62.8	R
4+13.18	41.760	75.2	N
5+0.07	41.850	77.0	N
5+1.16	42.940	-81.2	R
5+1.29	43.070	77.7	N
5+2.04	43.820	70.7	N
5+3.57	45.350	81.7	N
5+5.19	46.970	74.7	N
5+6.09	47.870	81.5	N
5+9.34	51.120	83.3	N
5+11.34	52.850	83.7	N
5+12.59	54.100	85.4	N
5+13.69	55.200	82.6	N
5+15.24	56.750	87.0	N
5+16.54	58.050	83.6	N
5+17.88	59.390	72.5	N
5+19.88	61.390	74.4	N
6+0.03	62.430	36.0	T/N
6+0.68	63.080	84.9	N
6+1.96	64.360	72.6	N
6+3.08	65.480	43.1	T/N
6+4.17	66.570	85.1	N
6+8.72	71.120	78.4	N
6+9.53	71.930	79.5	N
7+0.05	73.300	85.2	N
7+4.05	77.300	79.3	N
7+5.75	79.000	24.4	T/N
7+6.15	79.400	84.9	N
7+6.43	79.680	Unstable	
8+4.89	89.190	73.8	N
8+8.34	92.640	87.9	N
8+8.99	93.290	69.8	N
8+9.99	94.290	52.5	N
9+0.18	95.102	83.1	N
9+5.58	98.175	40.5	T
9+10.01	100.70	Unclear	
9+10.66	101.07	79.8	N
9+11.60	101.60	-28.6	T/R
9+13.38	Dead during cutting		
10+4.00	108.35	-15.9	T/R
10+7.10	111.45	-66.9	R
10+8.20	112.55	Unclear	
11+0.11	113.31	-59.4	R
12+1.77	14.90	-5.2	T
12+3.17	116.25	65.5	N
12+9.42	122.27	88.7	N
12+10.42	123.23	81.0	N
12+10.62	123.42	74.6	N
13+0.70	124.29	72.0	N
13+7.10	129.86	-39.7	T/R
13+8.55	131.12	29.3	T/N
13+9.05	131.55	-15.8	T/R
13+12.56	134.60	-67.9	R
14+3.40	138.04	-76.6	R
14+6.10	140.78	-85.4	R
16+5.45	146.18	-62.6	R
16+7.00	147.72	-74.7	R
16+7.30	148.01	Unclear	
16+8.28	148.98	Unclear	
16+11.98	152.65	-68.6	R
17+0.25	152.93	Unstable	
17+0.70	153.44	-75.8	R
17+4.80	158.08	-62.9	R
17+12.65	166.95	59.4	N
18+5.00	172.23	82.2	N
18+5.35	172.59	Unclear	
18+8.61	176.03	59.0	N
18+10.21	177.72	72.1	N
19+0.55	178.27	69.5	N

In situ overall mean direction:
Declination 2.0, Inclination 39.8, k=7, a95=5.9, N=89

Tilt corrected overall mean direction:
Declination 359.4, Inclination 16.5, k=7, a95=6, N=89

Tilt corrected mean paleopole calculated at 46.55N/11.87E (Stuores coordinates):
Longitude 192.8, Latitude 51.9, dp/dm=3.2/6.2

Tab. 8 - Paleomagnetic data from the Prati di Stuores section. "Sample" is paleomagnetic sample; "Meters" is meters from base of section; "VGP lat" is latitude of virtual geomagnetic pole; "Polarity" is polarity interpretation: "N" ("R") is full normal (reversed) polarity, i.e. +90<VGP<+45 (-90<VGP<-45), "T/N" ("T/R") is transitional polarity comprised between 0<VGP<+45 (-45<VGP<0).

ponent or, when it did, it was only with respect to the component higher unblocking temperature tail such that least-square analysis was usually still possible to perform.

Paleomagnetic overall mean direction and paleopole.

The bipolar and transitional characteristic component directions become shallower upon correction for bedding tilt (Fig. 10). The overall mean normal and reversed directions in bedding coordinates deviate from antipodality by 16° probably because of unresolved contamination of the characteristic magnetizations by the present-day or random overprint. We minimize the biasing effect due to contamination by inverting to common polarity the normal and reversed directions in order to calculate a tilt corrected average value of Dec.= 359.4°, Inc.= 16.5° and a paleomagnetic pole located at Long.= 192.8°E, Lat.= 51.9°N (dp= 3.2°, dm= 6.2°) (Tab. 8).

Bulk-rock magnetic properties.

The thermal unblocking characteristics of orthogonal-axes IRM show that all lithologies sampled at

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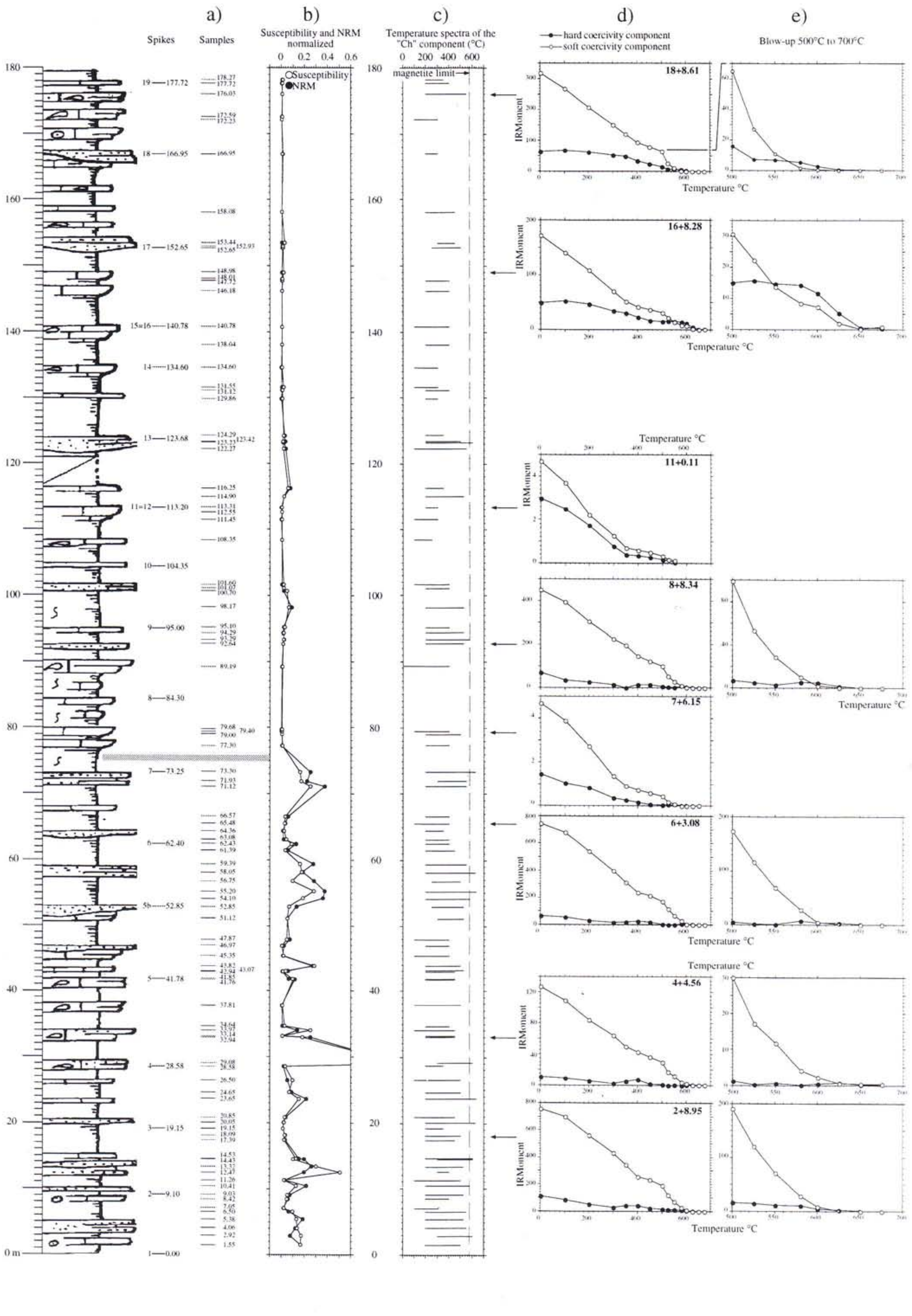
Fig. 6 (facing page) - Rock magnetic data from the Prati di Stuores section. To the right of lithostratigraphy column is: a) the position of the reference stakes and of the paleomagnetic samples expressed in meters from stake 1, b) the normalized NRM and susceptibility intensity variations with respect to stratigraphic position, c) the temperature spectra of the characteristic component with respect to stratigraphic position, d) the thermal unblocking characteristics of orthogonal-axes isothermal remanent magnetization (IRM) for selected samples located at different stratigraphic positions, e) enlargement of some diagrams d) for the temperature range comprised between 500 and 700°C. The susceptibility and NRM intensities are normalized with respect to their maximum values of, respectively, 3.4*10-2SI and 1.7*10-4A/m.


a)
b)
c)
d)
e)
Spikes
Samples
Susceptibility and NRM normalized
0 0.2 0.4 0.6
Susceptibility
NRM
Temperature spectra of the "Ch" component (°C)
0 200 400 600
magnetite limit
hard coercivity component
soft coercivity component
Blow-up 500°C to 700°C
0 m
20
40
60
80
100
120
140
160
180
19—177.72
18—166.95
17—152.65
15=16—140.78
14—134.60
13—123.68
11=12—113.20
10—104.35
9—95.00
8—84.30
7—73.25
6—62.40
5b—52.85
5—41.78
4—28.58
3—19.15
2—9.10
1—0.00
18+8.61
16+8.28
11+0.11
8+8.34
7+6.15
6+3.08
4+4.56
2+8.95
IRMoment
Temperature °C

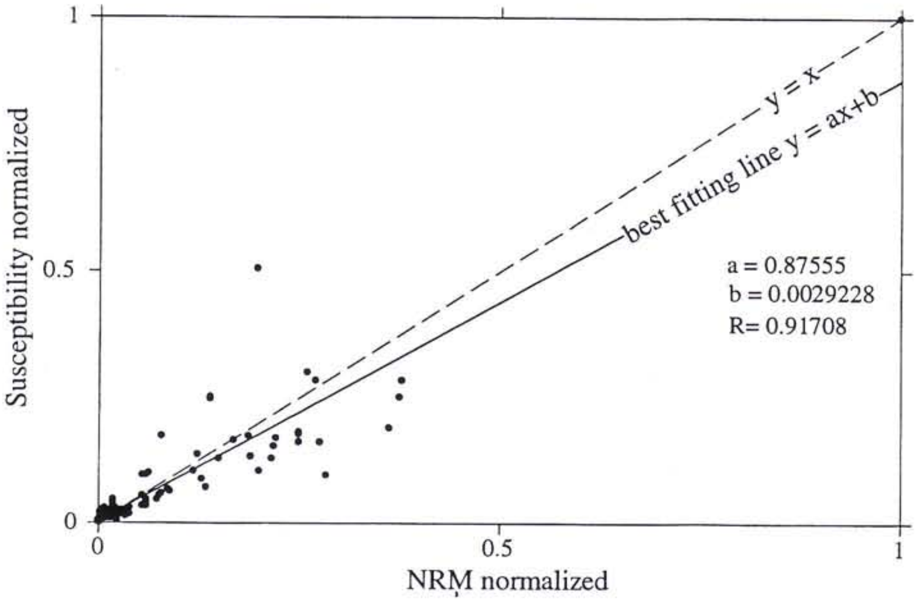


Fig. 7 - Diagram of normalized susceptibility versus natural remanent magnetization (NRM) values for the Prati di Stuores samples. The susceptibility and NRM intensities are normalized with respect to their maximum values of, respectively, 3.4*10-2SI and 1.7*10-4A/m.

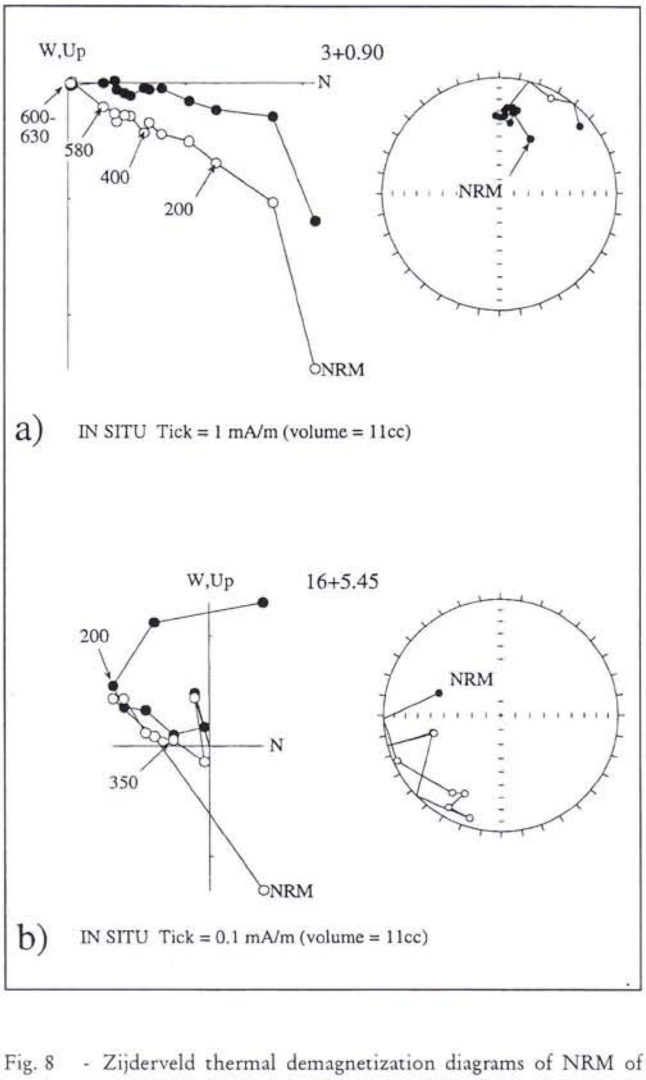


Fig. 8 - Zijderveld thermal demagnetization diagrams of NRM of representative samples from the Prati di Stuores section with normal a) and reversed b) polarity characteristic magnetizations. Closed symbols are projections onto the horizontal plane and open symbols are projections onto the vertical plane in *in situ* coordinates. Demagnetization temperatures in °C.

Stuores are dominated by a low coercivity and ca. 580°C maximum unblocking temperature phase interpreted as magnetite, maybe co-existing with subsidiary sulphurs characterised by ca. 320-350°C maximum unblocking temperatures (Fig. 6d). Moreover, careful inspection of these curves show that a subsidiary magnetic phase with higher coercivity and unblocking temperature, like hematite, may be also present at places (e.g. sample 16+8.28, Fig. 6d, e). Such a conclusion supports the previous observation that in a few cases the bipolar characteristic component of NRM could be traced up to a maximum unblocking temperature of 630°C.

Magnetostratigraphy and magnetostratigraphic correlations.

A virtual geomagnetic pole (VGP) was calculated for each characteristic component stable endpoint direction after correction for bedding tilt. The latitude of the specimen VGP with respect to the overall mean north paleomagnetic pole was used to delineate the magnetic polarity stratigraphy (Kent et al., 1995). VGP relative latitudes approaching +90°N (-90°N) are interpreted as recording normal (reversed) polarity (Fig. 11a, Tab. 8). For polarity magnetozone identification, we adopt the nomenclature used by Kent et al. (1995). We assign integers in ascending numerical order from the base of the section to polarity intervals as defined by successive pairs of predominantly normal and predominantly reversed magnetozones. Each ordinal number is prefixed by the acronym for the source of the magnetostratigraphy (i.e., "S" for Stuores), and has a suffix for the dominant polarity ("n" is normal, "r" is reversed) of each constituent magnetozone. Polarity intervals that may occur within a magnetozone are referred to as submagnetozones and can be labelled in a parallel man-

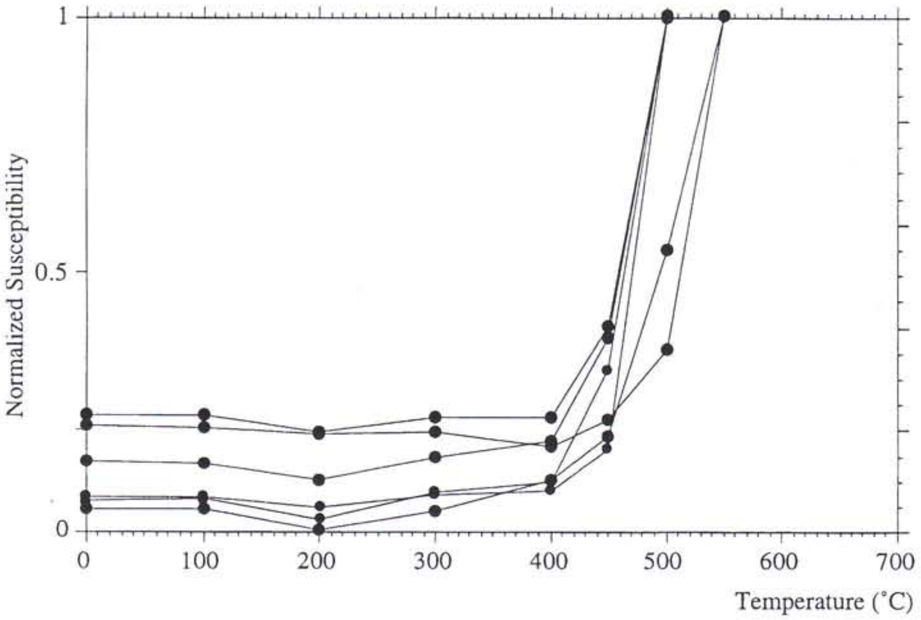


Fig. 9 - Diagram of normalized susceptibility as function of temperature for representative samples from Prati di Stuores section. Susceptibility is normalized with respect to a maximum value of 1.7*10-2SI.

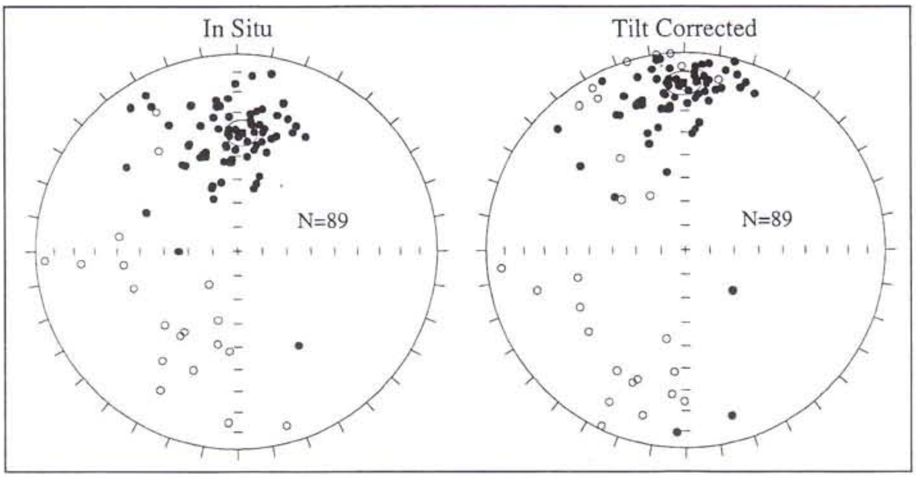


Fig. 10 - Equal-area projections before (*in situ*) and after bedding tilt correction of the bipolar and transitional characteristic component which yielded an overall mean direction in tilt corrected coordinates of Dec.= 359.4, Inc.= 16.5 for the Prati di Stuores section.

ner by assigning to successive pairs of submagnetozones subordinal integers (ascending upsection) which are then appended after a decimal point to the higher-order magnetozone designation and given a suffix indicating dominant 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) magnetozone sequence (Fig. 11b). 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 magnetozone S2n.

On the basis of magnetostratigraphic data and the vertical distribution of conodont taxa, the Ladinian/Carnian boundary at Stuores can be tentatively correlated with the coeval Mayerling section from Austria (Gallet et al., 1998, fig. 11). We propose that the reversed magnetozone S1r at Stuores correlates with magnetozone MA3r at Mayerling, and that the normal magnetozone S2n at Stuores corresponds to submagnetozone MA4n.1n at Mayerling (Fig. 12). Towards the top the correlation becomes less clear. It is possible that the reversed magnetozone S2r at Stuores correlates at Mayerling with a "submagnetozone" located somewhat below 40m and here named ?MA4n.1r. It is worth noting that the "submagnetozone" ?MA4n.1r at Mayerling occurs at or very close to a sharp lithological transition located in the upper part of the Diebeli conodont zone, between thinly-bedded limestones below and thickly-bedded limestones above (see figure 10 in Gallet et al., 1998). Therefore, a hiatus may be present at Mayerling which encompasses most of the reversed magnetozone S2r at Stuores. If so, the overlying normal magnetozone S3n at Stuores corresponds to submagnetozone MA4n.2n at Mayerling, S3r to magnetozone MA4r and, finally, S4n to submagnetozone MA5n.1n (Fig. 12). This correlation would suggest that the first occurrence of *Gondolella polygnathiformis* at Stuores, presently located in the lowermost part of the section 2 (Fig. 1), may be lower, within magnetozone S3n. Moreover, the base of the Carnian at Stuores, placed at the first occurrence of

Daxatina, can be traced at Mayerling in the lower part of the Diebeli Assemblage- Zone. Finally, the correlation proposed here implies that the sedimentation rate of the turbidite sediments at Stuores was on average about 8 times higher than that of the pelagic carbonates at Mayerling.

Sequence stratigraphy.

(Piero Gianolla & Claudio Neri)

The Prati di Stuores section is illustrative of the basinal stratigraphy in the western Dolomites after the late Ladinian peak in volcanic activity (Fig. 13). The upper part of the La Valle Fm. (lowermost part of the section) records a marked decrease in sedimentary supply and consists of calcilutites, marls and claystones. A progressive upward increase in shallow-water carbonate content and a new increase in volcano-sedimentary supply follow (San Cassiano Fm.). The carbonate supply records the progradation of a carbonate platform (Dolomite), while siliciclastics indicate the presence of a near volcano-terrigenous coastline.

The sequence stratigraphy of the crucial interval, including the Ladinian/Carnian boundary, has already been taken into consideration by many authors (Brandner, 1984, 1991; Doglioni et al., 1990; Bosellini, 1991; Masetti et al., 1991; Yose, 1991; De Zanche et al., 1993; Neri et al., 1994, 1996; Mastandrea et al., 1997; Gianolla, 1995; Gianolla et al., 1998). On the whole, most of these authors agree on a sequence stratigraphy setting including a LST and a TST made up by the La Valle Fm. and a HST documented by the progradation of a carbonate platform and equivalent basinal deposits of the San Cassiano Formation.

According to De Zanche et al. (1993) and Gianolla (1995), the whole Prati di Stuores/Stuores Wiesen section belongs to the Car 1, 3rd order, depositional sequence (DS). The Car 1 DS includes the La Valle Fm., the lower part of the San Cassiano Fm. and the Cassian Dolomite 1.

In the Dolomites the Car 1 sequence boundary (SB) corresponds to a regional unconformity. In the carbonate shelf areas it is represented by a major erosion and karst surface lying on top of the Sciliar Dolomite 3 or the oldest carbonate platform. In the basinal areas the Car 1 SB is an important submarine erosional surface on Upper Ladinian volcanics or volcaniclastics; locally the erosion cuts deeply into older, underlying units.

The lowstand systems tract (LST) consists mostly of more or less coarse-grained volcano-sedimentary deposits (e.g. Marmolada Conglomerate). Layers including carbonate olistholiths ("Cipit limestones" *p.p.*) are characteristic. They derive partly from the destruction of previous carbonate buildups, and partly from carbonate fringing reefs grown on a previous slope during the late LST. TST deposits are defined by the strong decrease in terrigenous content and the appearance of fine-grained terrigenous-carbonate facies (upper part of the La Valle Fm.). In the Prati di Stuores, the maximum flooding surface (mfs) seems to lie close to La Valle Fm./San Cassiano Fm. boundary; it yielded ammonoids belonging to the topmost Regoledanus Subzone (sensu Mietto & Manfrin, 1995b). In the basinal areas the Car 1 HST corresponds to the lower part of the San Cassiano Fm., interfingered with the Cassian Dolomite 1 (De Zanche et al., 1993). In carbonate shelf areas, the next sequence boundary (SB) is placed at the top of the eroded and karstified Cassian Dolomite 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 Stuores/Stuores Wiesen (cf. Urlichs, 1974, 1994), i.e. above biocalcarenitic and oolitic turbidites (Car 1 HST).

In the Prati di Stuores/Stuores Wiesen section, characterised by a high sedimentation rate, the proposed Ladinian/Carnian boundary lies within the Car 1 early HST. In correlated sections with low sedimentation rate throughout the Dolomites, it likely falls very close to the maximum flooding surface (mfs).

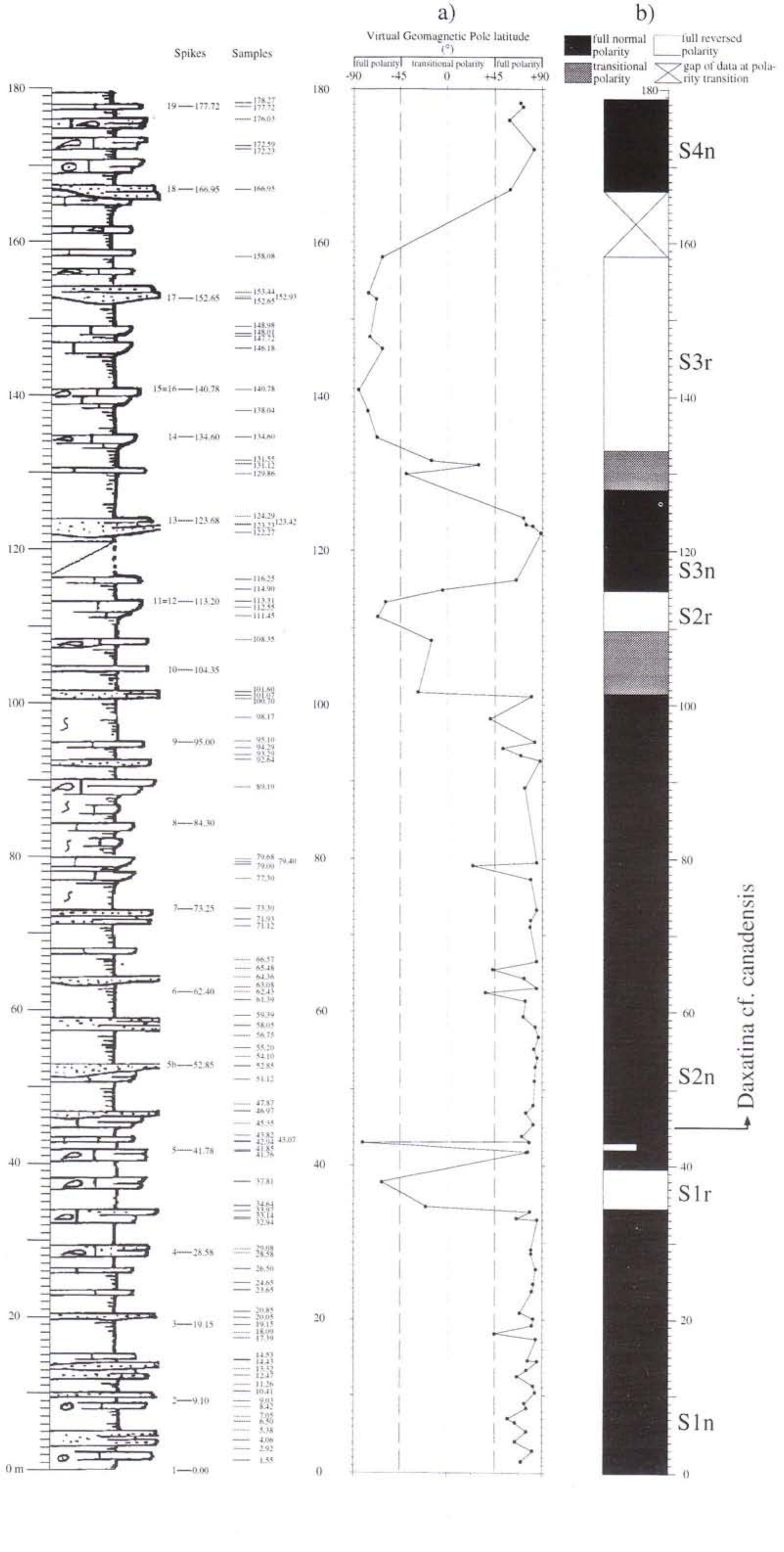
The possibility of correlating the Car 1 DS over a great distance indicates its chronostratigraphic value.

In the eastern part of the Northern Calcareous Alps, the Car 1 DS can be recognised within the Reiflinger Kalk. Taking the Scheiblinggraben section as a reference (Mostler & Scheuring, 1974; Krystyn, 1991), the *Daonella lommeli*-bearing marls represent the LST, and the overlying cherty limestones (FS 19 to FS 18) and the radiolarian micritic limestones correspond to the TST and the HST, respectively. The overlying shales represent the Car 2 LST. On the basis of conodonts, the Ladinian/Carnian boundary should fall just above sample FS 19.

In the western part of the Northern Calcareous Alps, the Car 1 DS may be correlated with the L4 DS in Rüffer & Zülcke (1995).

In the German domain, the Car 1 DS corresponds to part of the K2 DS (Hauptsandstein-Obere Lettènkeuper-Grenzdolomit-lower part of the Gipskeu-

Fig. 11 - Plot of the relative VGP latitudes of the characteristic component as a function of stratigraphic position with polarity interpretation for the Prati di Stuores section. Magnetic polarity zones (i.e. magnetozones) are shown by filled (open) bars for normal (reversed) polarity; single-sample polarity zones are shown by half bars. Transitional VGPs are represented by shaded bars. Thickness is expressed in meters from the stake 1.


a)
Virtual Geomagnetic Pole latitude (°)
full polarity
transitional polarity
full polarity
-90
-45
0
+45
+90
b)
full normal polarity
full reversed polarity
transitional polarity
gap of data at polarity transition
Spikes
Samples
19—177.72
18—166.95
17—152.65
15=16—140.78
14—134.60
13—123.68
11=12—113.20
10—104.35
9—95.00
8—84.30
7—73.25
6—62.40
5b—52.85
5—41.78
4—28.58
3—19.15
2—9.10
1—0.00
0 m
20
40
60
80
100
120
140
160
180
S4n
S3r
S3n
S2r
S2n
S1r
S1n
Daxatina cf. canadensis

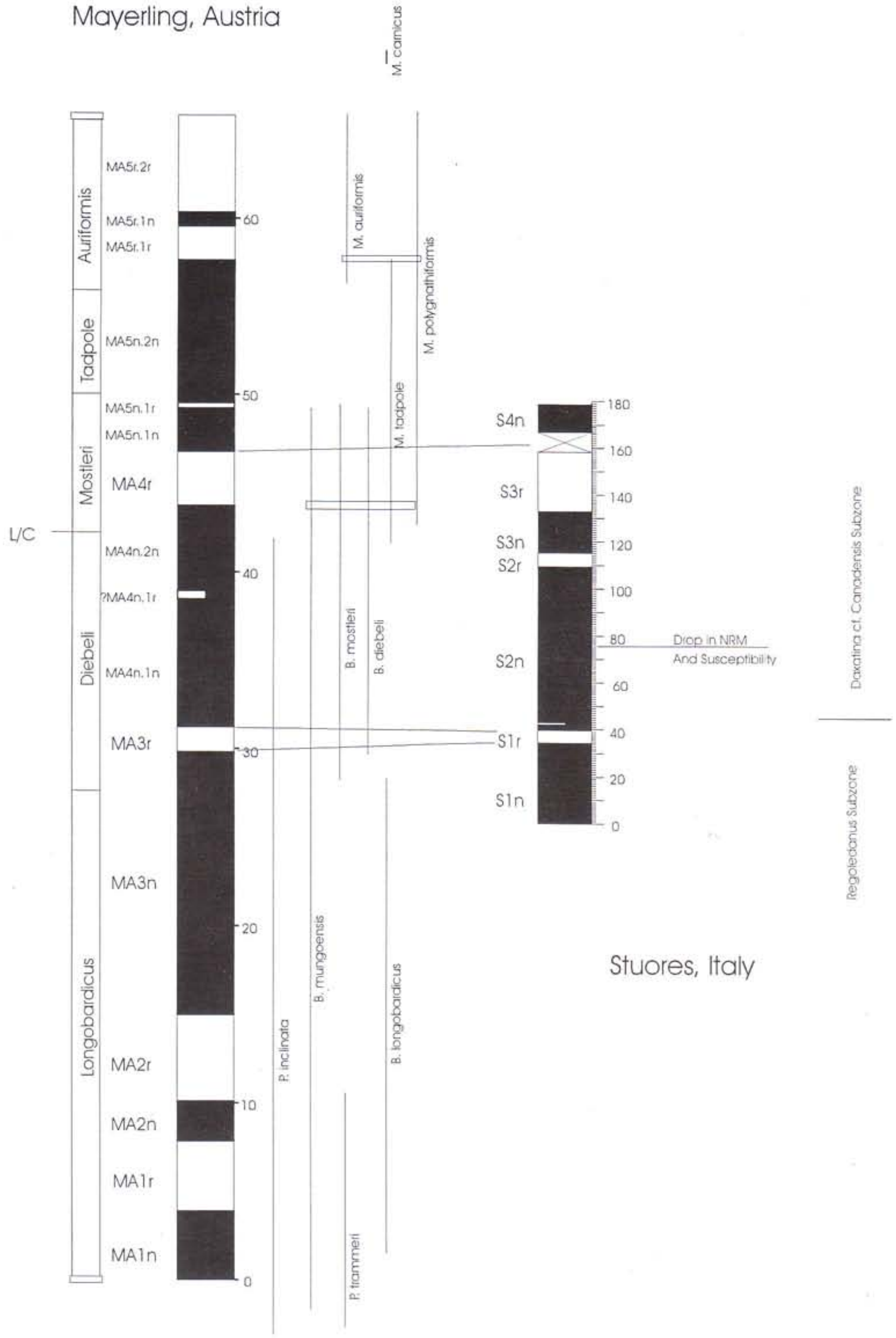


Fig. 12 - Comparison of magnetostratigraphic and biostratigraphic data from this study and the Mayerling section from Austria (Gallet et al., 1998) for the Ladinian/Carnian boundary of the Tethys realm. Biostratigraphy at Mayerling is based on conodonts. Polarity nomenclature at Mayerling is here informally introduced for clarity because it was not formally established in Gallet et al. (1998, fig. 10). We follow for Mayerling the system described for the Stuores section which we prefer to the system consisting of letters in ascending alphabetical order from the base of section which was used in Broglio Loriga et al. (1998, fig. 3) and in the composite magnetostratigraphic scale of Gallet et al. (1998, fig. 12). Magnetic polarity intervals MF-, MG+, MH-?, MI+, ML- and MM+ in Broglio Loriga et al. (1998) correspond to MA3r, MA4n.1n, ?MA4n?1r, MA4n.2n, MA4r and MA5n.1n in this paper, respectively. The thickness of the reversed magnetozone located at Mayerling in the lowermost part of the Diebeli conodont zone, and here informally named MA3r, has been reinterpreted (i.e., shortened) after Gallet et al. (1998, figure 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 ?MA4n.1r. This "submagnetozone" occurs at or close to a lithological transition. Mayerling magnetozones MA3r and MA4n correspond to magnetozones L- and M+ in the composite magnetostratigraphic scale of Gallet et al. (1998, figure 12). At Stuores, the boundary between the *Regoledanus* and *Daxatina* cg. *canadensis* ammonoid subzones is reported. Thicknesses are expressed in meters form the base of sections.

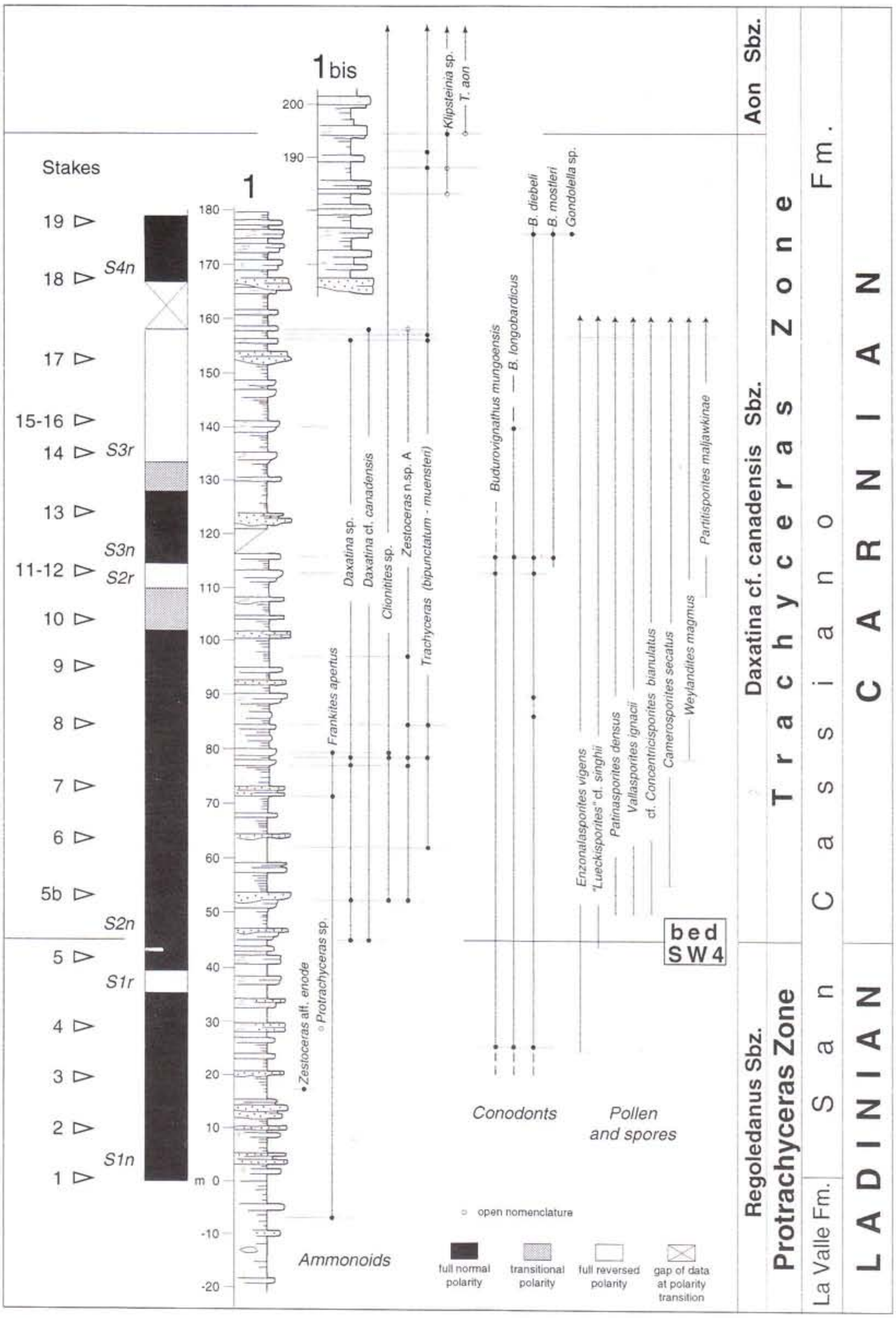
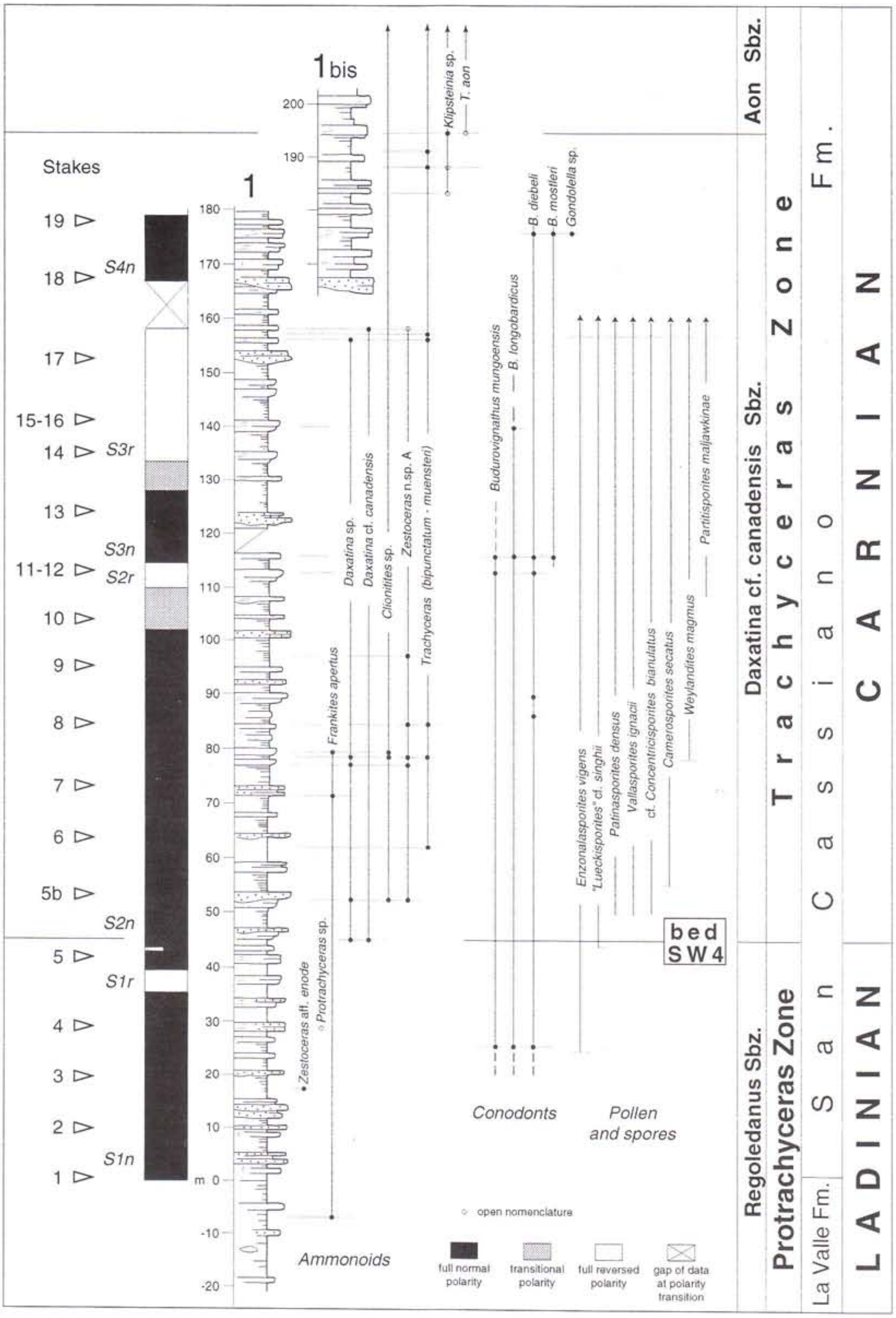


Fig. 13 - A synthesis of the main stratigraphic results in the Prati di Stuores section. Lithostratigraphic columns correspond to the sections 1 and 1 bis in Fig. 1. Numbers and triangles on the left indicate the stakes. Ammonoid, conodont and palynomorph distribution refer to selected taxa.

per) in the sequence stratigraphy framework of the German Triassic by Aigner & Bachmann (1992). The rest of the K2 DS (= upper part of the Gipskeuper) forms a new DS (Car 2). Palynomorphs allow the correlation of the upper part of the La Valle Fm. (Car 1 TST) and the Obere Lettenkeuper, which both bear the characteristic *Keuperisporites baculatus*, referred to the uppermost Ladinian (Brugman et al., 1993). On the other hand, Brugman (1983) pointed out that the appearance of *Enzonalasporites vigens* in the lower part of the Gipskeuper (HST), also occurs in the Prati di Stuores section.



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