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LADINIAN/CARNIAN AMMONOIDS AND CONODONTS FROM THE CLASSIC SCHILPARIO - PIZZO CAMINO AREA (LOMBARDY): REVALUATION OF THE BIOSTRATIGRAPHIC SUPPORT TO CHRONOSTRATIGRAPHY AND PALEOGEOGRAPHY

MARCO BALINI, DANIELA GERMANI, ALDA NICORA & EUGENIO RIZZI

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Riassunto. Questo lavoro conclude uno studio sulla distribuzione degli ammonoidi e dei conodonti in alcune formazioni bacinali medio triassiche dell'area compresa tra la Val di Scalve e la Val Camonica (Alpi Meridionali). Questa zona ha rivestito un ruolo fondamentale in due momenti storici diversi dello sviluppo delle conoscenze sulla stratigrafia triassica. Nel XIX secolo diversi ammonoidi raccolti nella Formazione di Wengen hanno contribuito alla definizione del sottopiano Longobardico da parte dei paleontologi della scuola di Vienna, mentre negli anni '60 lo studio delle facies di questa zona ha permesso la revisione su basi moderne della litostratigrafia triassica della Lombardia.

Le indagini si sono svolte per la prima volta sulla base di campionamenti strato-per-strato e si sono concentrate in particolare sulla Formazione di Wengen e sul Calcare di Pratotondo, nelle quali per la prima volta sono stati ritrovati conodonti.

Sulla base delle faune ritrovate vengono cambiate le età di alcune formazioni medio triassiche, che si dimostrano essere più giovani di quanto in generale riportato in letteratura:

- la sommità della Formazione di Wengen è attribuita con sicurezza al Carnico inferiore per buona parte dell'area studiata. La successiva piattaforma carbonatica, fino ad ora attribuita al Calcare di Esino di età Ladinico superiore, risulta definitivamente carnica, quindi coeva alla Formazione di Breno della Val Camonica meridionale.

- l'età del Calcare di Pratotondo risulta Ladinico sup./Carnico inf., mentre la successiva Argillite di Lozio è sicuramente carnica.

I dati nuovi mettono in discussione l'equivalenza F. di Wengen = Zona ad Archelaus = Longobardico definita nel secolo scorso e spesso seguita sino in tempi recenti. In realtà si dimostra come la Zona a Regoledanus rappresenti gran parte della Formazione di Wengen, mentre nella parte sommitale della stessa formazione sia documentata una fauna di età Carnico inferiore riferibile alla Zona a Daxatina o alla Zona ad Aon.

La revisione biocronostratigrafica delle formazioni bacinali consente di modificare sostanzialmente sia gli schemi cronostratigrafici che la storia paleogeografica dell'intervallo Ladinico-Carnico del settore lombardo delle Alpi Meridionali.

Abstract. The aim of this paper is to revise the ammonoid and conodont biostratigraphy of the Middle Triassic basinal formations in the classic area between the Scalve and Camonica Valleys (Southern Alps).

This area played a key role in defining Middle Triassic stratigraphy. In the nineteenth century the study of several ammonoids collected in the Wengen Formation served as a basis for the definition of the Longobardian substage of the Ladinian. Moreover, during the 1960's the modern Triassic lithostratigraphy of Lombardy was founded on sections from this area.

The present study represents the first bed-by-bed sampling of this area and is focused mainly on the Wengen Formation and Pratotondo Limestone. In particular, conodonts were found in both units for the first time.

The age of some Middle Triassic formations is revised:

- the top of the Wengen Formation belongs definitively to the Lower Carnian in a sizeable portion of the study area. The overlying carbonate platform, previously attributed to the Upper Ladinian Esino Limestone, is instead Carnian and is coeval to the Breno Formation in the Southern Camonica Valley.

- the Pratotondo Limestone is dated Late Ladinian/Early Carnian, while the overlying Lozio Shale is Carnian.

These new data contradict the equivalence "Wengener Schichten" = Archelaus Zone = Longobardian so common in the literature. We demonstrate that the Regoledanus Zone represents a great part of the Wengen Formation. Moreover, at the top of the Wengen Formation the ammonoid and conodont fauna represents the Early Carnian Daxatina or Aon Zone.

The biochronostratigraphic revision of the basinal formations requires modification of both the chronostratigraphic schemes and the paleogeographic history of the lombardian Southern Alps during Ladinian-Carnian time.

Introduction.

The Southern Alps provided essential data during the development of Triassic stratigraphy since some stages, substages and chronozones were defined on the basis of sedimentary successions and/or fossiliferous localities studied in Lombardy, the Dolomites and Carnia.

The Middle Triassic Ladinian stage, for instance, was defined by Bittner (1893) to replace Mojsisovics' Norisch, based on the succession of the Buchenstein and Wengen Beds of the Southern Alps (Fig. 1). Lithological

- Dipartimento di Scienze della Terra, Università degli Studi di Milano, Via Mangiagalli 34, 20133 Milano, Italy. marco@e35.gp.terra.unimi.it; gerlin@e35.gp.terra.unimi.it; aldanic@e35.gp.terra.unimi.it; eugenio@achab.it

Definition of the Ladinian Stage: Bittner, 1893

Ladinisch	**Wengener Schichten**
	Buchensteiner Schichten

Definition of Ladinian Substages: Mojsisovics in Mojsisovics et al., 1895

Substage	Zone	Lithofacies
Longobardisch	**P. archelaus**	**Wengener Schichten**
Fassanisch	D. avisianus	Marmolatakalk
	P. curionii	Buchensteiner Schichten

The ammonoid Zones: Mojsisovics, 1882

Zone	Ammonoid faunas	Taxa	Localities
T. archelaus	**1) Wengener Schichten**	38 taxa (19 n. sp.; 4 indet./aff.)	Schilpario, Giudicarie, Badia Valley
	2) thonarmen kalksteine	70 taxa (42 n. sp.; 11 indet. /aff.)	Esino, Marmolada, Clapsavon, Bakony etc.
T. reitzi	1) Buchensteiner Schichten	21 taxa (13 n. sp.; 3 indet. /aff.)	Giudicarie, Trompia V., Schilpario, Recoaro, Gardena V., etc.
	2) gelben kieselreichen Kalk des Bakonyer W.	16 taxa (6 n. sp.; 2 indet. /aff.)	Felso-Ors, Forrashegy, Mencshely

Fig. 1 - The most important steps for the definition of Ladinian chronostratigraphy. The strong support of lithostratigrapghy in the definition of chronostratigraphic units is well evident. In 1895 Mojsisovics did some changes in the ammonoid zones. The Reitzi Zone was renamed as Curionii, and the Archelaus Zone of 1882 was splitted by the separation of the fauna of the Marmolatakalk (part of 2nd lithofacies) as Avisianus Zone. The stratigraphic units are quoted with the original German spelling.

data were also important for defining the two substages of the Ladinian, i.e. the Fassanian and the Longobardian. These substages appear to have been based on ammonoid zones with a lithologic reference (Mojsisovics, Waagen & Diener, 1895, Fig. 1), but in fact the lithologic information is not of secondary importance. The ammonoid zones defined by Mojsisovics were based not on a fauna, but on a list of species including all the taxa reported in all the fossil-bearing localities with the same lithology, even if there were differences in faunal composition from locality to locality. This kind of biostratigraphic unit is well known as Oppel-zone (see Hedberg, 1976, p. 57), and its chronostratigraphy is not proven paleontologically, but is deduced from lithological data.

The Longobardian substage, in particular, was defined on the Archelaus Zone in the facies of the Wengen Beds (Mojsisovics in Mojsisovics et al., 1895; Fig. 1). No type locality was selected at that time, but possible candidates can be found in the monograph that provided Mojsisovics the biostratigraphic background (at least for the Southern Alps) for his chronostratigraphic revision of the Triassic (Mojsisovics, 1882). The fossil-bearing localities of the Wengen Beds reported by Mojsisovics are concentrated primarily in three small areas of the Southern Alps (Mojsisovics, 1882): Schilpario (i.e., Epolo, the Paludina Valley, M. Roncaglie), Giudicarie (i.e., Prezzo, Dos dei Morti, Corno Vecchio, the Daone Valley), and the Badia Valley in the Dolomites (i.e., Corvara, Pescol, Wengen, Mundevilla, S. Cassian). Historically, Schilpario is the only area located in the Lombardian Alps, but from a faunistic standpoint, the Badia Valley is the most important area with 22 taxa vs. 18 taxa in Giudicarie and 11 at Schilpario. The locality yielding the richest fauna is Prezzo (Giudicarie) with 15 species. However, the tectonic setting of the Prezzo site is complex and at present there are no possibilities of carrying out bed-by-bed sampling. In contrast, the Schilpario area has great potential for sampling.

The stratigraphic importance of the Schilpario area has been demonstrated in classic papers of the nineteenth century, as well as more recently, when it provided information for the modern lithostratigraphic setting of the Triassic of Lombardy - Giudicarie (Assereto & Casati, 1965).

The initial intention of this project was to improve the biostratigraphy of the Ladinian basinal succession in the classic area of Schilpario. However, new data collected during the course of these studies have allowed the revision of the chronostratigraphic and paleogeographic schemes of the Western Southern Alps.

Regional stratigraphic framework.

The modern Triassic lithostratigraphy of Lombardy - Giudicarie (Western Southern Alps) was founded by Assereto & Casati (1965) whose revision was based on a stratigraphic approach completely different from that followed for more than one century: the work on stratigraphic sections. This work provided a better definition of "old" lithologic units, but also formalized several new formations. For instance, classification of the Triassic platforms was set up, separating the Carnian platform (Breno Formation) from the classic Ladinian and Norian platforms of Esino Limestone and Dolomia

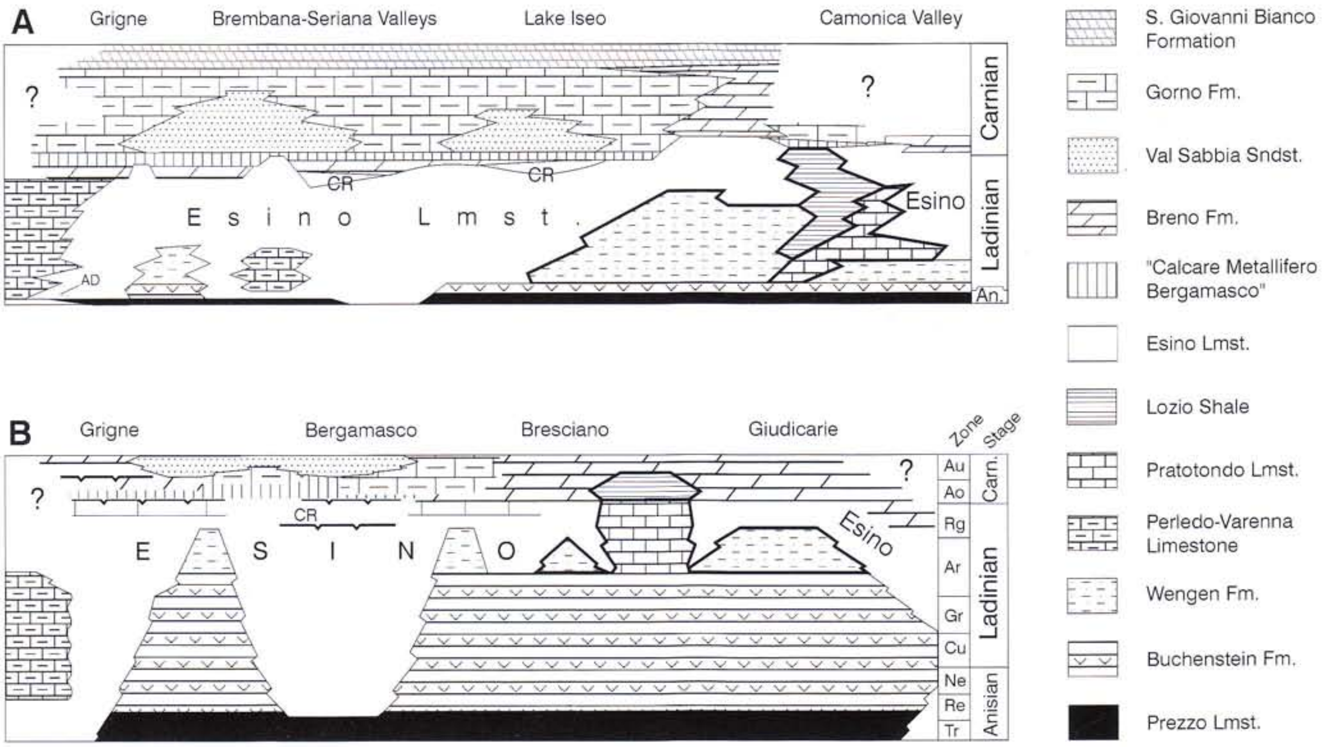


Fig. 2 - Stratigraphic reconstructions for Upper Anisian to Carnian of the Western Southern Alps. A) The classical model (Pisa, 1974; Casati & Gaetani, 1979; Brusca et al., 1982; Jadoul & Rossi, 1982) redrawn from Jadoul & Rossi (1982). B) Brack & Rieber (1993) viewpoint. Abbreviations: CR: "Calcare Rosso"; AD: Albiga Dolomite. Thick lines emphasize out the stratigraphic relationships between the basinal units in the Scalve-Camonica Valleys.

Principale, respectively. However, the revision did not provide a similar amount of new biostratigraphic data.

Since Assereto & Casati (1965), a great deal of work has been done on the Triassic successions of the Western Southern Alps, but most contributions have focused on lithostratigraphy in conjunction with facies analysis. The Carnian-Norian units (Breno Fm., Gorno Fm., Val Sabbia Sandstone, Dolomia Principale) have been investigated in more detail than the Ladinian formations, such that the stratigraphic reconstructions suggested for the Ladinian in the last 25 years are stable and show almost the same picture. According to all suggested models (Pisa, 1974; Casati & Gaetani, 1979; Brusca et al., 1982; Jadoul & Rossi, 1982) (Fig. 2A) the carbonate platform of the Esino Limestone started in the Late Anisian-Early Ladinian in the Grigne-Brembana Valley and grew into a buildup, gradually surrounding some deep and narrow basins. During the Early Ladinian the sedimentation in the basins was carbonatic and volcanic (Buchenstein Fm.), then in the Late Ladinian it became terrigenous (Wengen Fm.). These tongue-like basins were filled up in the latest Ladinian by the progradation of the Esino Limestone. The general model is followed also by Brack & Rieber (1993; Fig. 2B), who on the contrary suggested a different interpretation of the Late Ladinian-Early Carnian formations in the area between the Camonica and Scalve Valleys. There, the Lozio Shale and Pratotondo Limestone are interpreted not as Late Ladinian distal facies (the former) and proximal facies (the latter) deposited in a deep basin coeval to the Esino Limestone (Fig. 2A), but rather as a two-stage filling of the same basin. In particular, the Lozio Shale is coeval to the Carnian Breno Formation and overlies the Late Ladinian Pratotondo Limestone (Fig. 2B).

Geological setting.

The geology of the area between the Scalve and Camonica Valleys is very complex due to the coexistence of very diversified Triassic (Anisian to Carnian) environments, whose sedimentary record is deformed and thrusted in a complex tectonic setting.

The main structural element on the left side of the Scalve Valley (Fig. 3) is the Pizzo Camino thrust, that separates an upper tectonic unit (Pizzo Camino unit, PC) thrusted from the North on a mosaic of tectonic units belonging to the "Parautoctono sudalpino" (Gaetani & Jadoul, 1979; Forcella, 1988; Forcella et al., 1990): Autochthonous of Scalve Valley (AVS), Costa di Valnotte unit (CV), and Camuno sector (Fig. 3).

The sections studied were measured in the less disturbed tectonic units of Pizzo Camino and the Autochthonous of Scalve Valley (AVS). The *Pizzo*

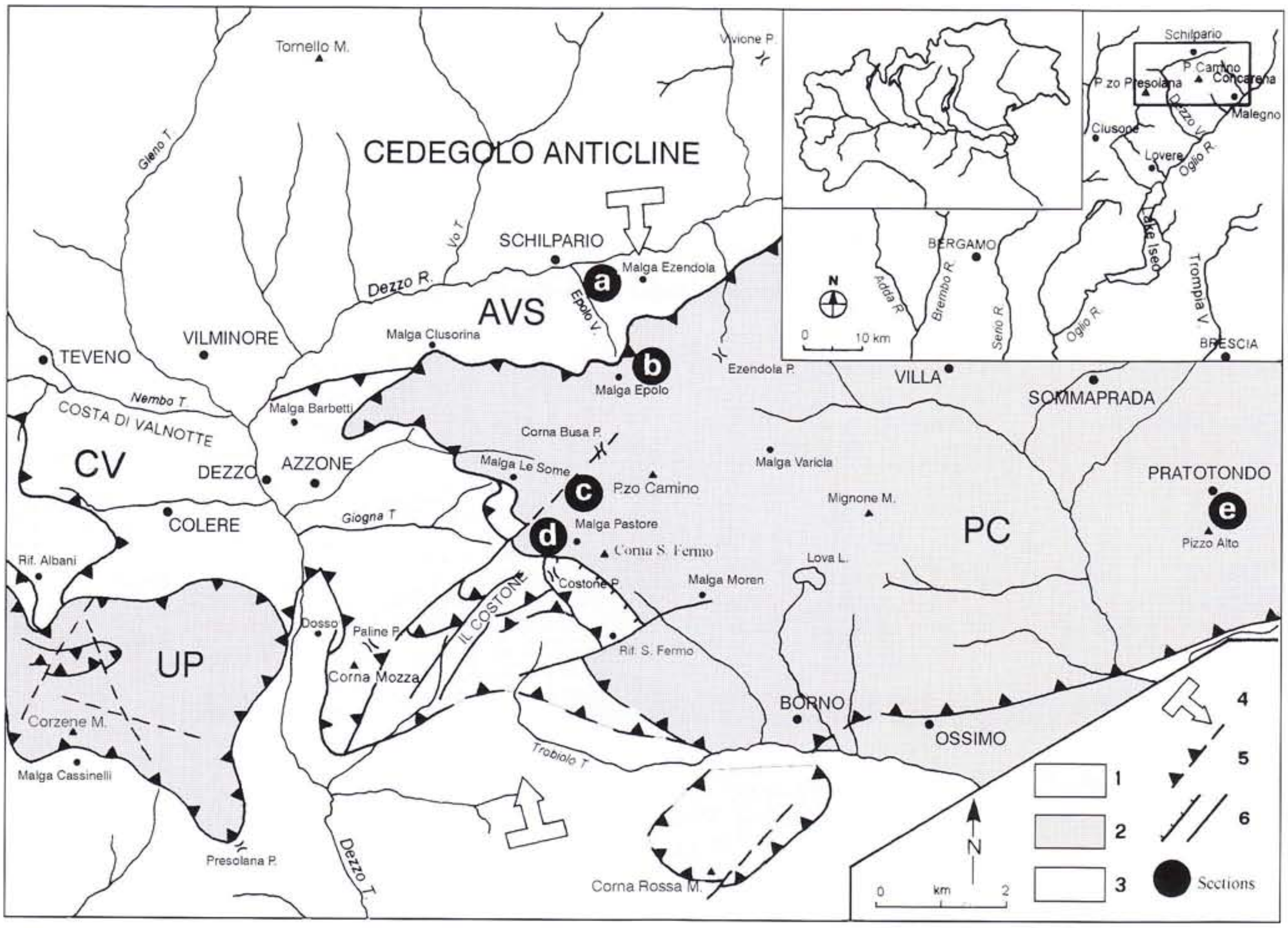


Fig. 3 - Geographic sketch map and structural setting of the Pizzo Camino-Corna S. Fermo area (redrawn from Forcella, 1988) with location of the studied sections. 1) "Parautoctono sudalpino" (CV: Costa Valnotte unit; AVS: Alta Val di Scalve autochthonous); 2) Pizzo Camino unit (PC) and Presolana unit (UP); 3) Camuno sector 4) regional attitude; 5) thrust; 6) fault. Sections: a) Lower Epolo Valley (LEV); b) Upper Epolo Valley (UEV); c) Fopponi; d) Corna S. Fermo West (CSFW); e) Pratotondo.

Camino unit (PC = upper tectonic unit) shows two different sedimentary trends. According to the literature, in the northern part of the unit, from the northern boundary to the WSW-ENE ridge of the Corna S. Fermo - Pizzo Camino - Concarena, the succession starts with subtidal dark limestones (Angolo Lmst) overlain by rocks indicating a deepening trend until the Early/Late Ladinian boundary (Prezzo Lmst., Buchenstein and Wengen Fm.). This trend is suddenly reversed by the deposition of the Esino Lmst. (carbonate platform) overlying the Wengen Fm. In the central and southeastern part of the tectonic unit the succession is similar until the Buchenstein Fm. Then deposition does not turn into the carbonate platform but towards a shaly-dominated deep basin (Pratotondo Lmst. and Lozio Shale). The Esino Lmst. is not present, and the relations between the Pratotondo - Lozio basin and the platform of the Esino Lmst. were interpreted as tectonic (De Sitter & De Sitter Koomans, 1949; Schiavinato et al., 1969) or stratigraphic (i.e., Rossetti, 1966a; Brack, 1984; Forcella, 1988).

The *Autochthonous of Scalve Valley* (AVS = lower tectonic unit) has a more controversial sedimentary succession and several interpretations were proposed. The first was provided by Assereto & Casati (1965) who described the succession Prezzo Lmst. - Buchenstein Fm., overlain by the Lozio Shale. This interpretation was accepted in sheets 19 (Schiavinato et al., 1969) and 34 (Desio et al., 1970) of the Geological Map of Italy 1:100,000, and by Forcella (1988). According to the second interpretation (Rossetti, 1966a, fig. 2 and p. 131), the Lozio Shale does not overlay directly the Buchenstein Fm., but the Wengen Fm. and the Pratotondo Lmst. can be recognized in between. Another point under discussion is the stratigraphic attribution of the carbonatic cliff capping the Lozio Shale, that was referred to the "Calcare Metallifero Bergamasco" (Assereto & Casati, 1965), the Breno Fm. (Schiavinato et al., 1969; Forcella, 1988), and the Gorno Fm. (Rossetti, 1966a; Desio et al., 1970).

Three sections were sampled in the Pizzo Camino unit (Fig. 3): the Corna S. Fermo West (CSFW) com-

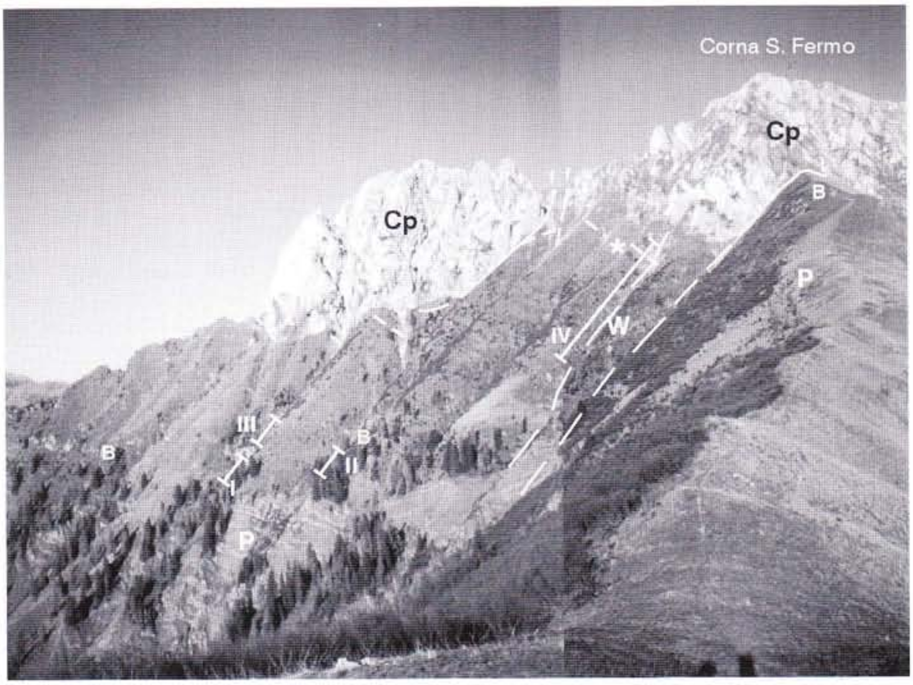


Fig. 4 - Western slope of Corna S. Fermo, with position of the segments I to IV of CSFW composite section. The tectonic setting is complex and only major faults are drawn. Asterisk shows the site of sample DG5. This sample has the same stratigraphic position of sample MB124. The upper boundary of Wengen Fm. is emphasized by dashed line. Abbreviations: P=Prezzo Limestone; B=Buchenstein Fm.; W=Wengen Fm.; Cp="Carbonate platform"; f=major fault.

posite section (Fig. 4), Fopponi and Pratotondo sections. The Pratotondo section is the best section in the type area of the Pratotondo Limestone, a lithostratigraphic unit named by Rossetti (1966a) only on the basis of a short lithological description. An additional section was sampled in the upper part of Epolo Valley (UEV section: Fig. 5). This section consists of two segments well exposed in the steep gullies of the northwestern ridge of Mount Sossino, W of Passo Ezendola. In the AVS unit only one section was selected for sampling, i.e. the Lower Epolo Valley (abbreviated as LEV) composite section on the right side of the Epolo Valley.

The new data: lithostratigraphy and biostratigraphy.

Prezzo Limestone.

Lithology. The formation was not studied in detail. In both units (Pizzo Camino and AVS) the Prezzo Limestone shows the typical lithology consisting of alternations of dm-thick dark grey marly limestone with similar thickness of dark grey marls or marly shales (Assereto & Casati, 1965; Gaetani, 1969; Kovács et al., 1990). The average thickness of beds and interbeds (30-35 cm) is unusually greater than normal (20 cm) and the total thickness of the formation is also greater than in Camonica-Giudicarie (about 120 m *vs* about 80 m). As in Camonica-Giudicarie the uppermost part of the formation is characterized by several very thin tuff intercalations.

Distribution of fossils. Ammonoids and daonellids occur frequently in the upper part of the formation, even cleavage often prevents samples from being obtained. Some well preserved *Asseretoceras camunum* (Assereto) and *Pisaites* were collected in the Gatti Valley (E of Epolo Valley) in the AVS unit.

No fossils were found in the lower part of the formation. However, recently, Brack et al. (1998) located a fossil-bearing level with *Balatonites* cf. *ottonis* (Buch) in the uppermost Angolo Lmst. of the Gatti Valley, a few meters below the Angolo/Prezzo Lmst. boundary, in the Pizzo Camino unit. In the nineteenth century some specimens from this level were collected by Curioni (1877) and studied by Mojsisovics (1882; see Balini, 1994).

Correlation and age. The occurrence of *Asseretoceras* and *Pisaites* as well as tuff intercalations in the topmost part of the formation (cf. Brack & Rieber, 1993, fig. 10) allow time correlation with the topmost part of the formation of the Camonica-Giudicarie area. In the same way the occurrence of *Balatonites* cf. *ottonis* (Buch) in the Scalve and Giudicarie Valleys some meters below the lower boundary of the Prezzo Lmst. (Brack et al., 1998) demonstrates that also the lower boundary of the formation is coeval. As a consequence, the greater thickness of Prezzo Limestone in the Scalve Valley (upper and lower tectonic units) with respect to the Camonica-Giudicarie is due to a higher sedimentation rate.

Buchenstein Formation.

Lithology. The unit crops out in both the Pizzo Camino and AVS units and shows a notable variation in lithology. The formation can be subdivided informally into four lithofacies, i.e. lower cherty limestone, thin bedded cherty limestone, "Pietra verde", and upper cherty limestone (Fig. 6 and 7).

Lower cherty limestone. This portion is rather constant in the study area and fits very well with the lower

Fig. 5 - Upper part of Epolo Valley with the position of the two segments of Upper Epolo Valley section (1 and 2). The fossiliferous debris that most probably corresponds to the classical ammonoid localities discovered by Curioni (1877; see also Balini, 1994) is shown with asterisk. AVS tectonic unit: L=Lozio Shale; Cu=Carnian undifferentiated fms. Pizzo Camino tectonic unit: A=Angolo Lmst.; P=Prezzo Limestone; B= Buchenstein Fm.; W=Wengen Fm.; Cp="Carbonate platform" traditionally attributed to Esino Limestone.

part of the formation in the Camonica - Sabbia - Giudicarie Valleys. Following Assereto & Casati (1965) the lower boundary of the Buchenstein Fm. is drawn at the first lithologic change that affects the very constant lithology of the Prezzo Limestone, that is at the sudden appearance of abundant chert in Prezzo-like bedded limestones and marls. This lithology ("transitional beds" of Brack & Rieber, 1986, 1993; interval b in Fig. 6B and a in Fig. 7) is followed by a few meters (4.9 at CSFW: interval c; 7.5 at LEV: interval b) of wavy to nodular limestones with chert in dm- scale beds (Brack & Rieber's "Knollenkalk"). Tuff intercalations are very common and mostly follow Brack & Rieber's classification (see 1993, fig. 10).

Thin bedded cherty limestone. This lithofacies, already mentioned by Brack & Rieber (1986), is peculiar to the study area. It is documented in both CSFW (Fig. 6B: interval d-e) and LEV (Fig. 7: interval c-d) sections (18.1 and 15 m thick, respectively) and consists of a lower part made of evenly and thinly bedded limestones with spread chert and an upper part made of very thinly bedded chert and limestone with cherty nodules. Thin tuff intercalations are very common in the upper part, especially at the CSFW section.

"Pietra verde". At the CSFW section a thick succession dominated by volcaniclastic rocks overlies the second lithofacies (Fig. 6B: intervals f to o, 59.2 m thick). The facies is represented by greenish volcaniclastic siltstones and sandstones with planar lamination and/or normal grading that strongly recalls the "Pietra verde" of the Eastern Dolomites (i.e. Cernera, Zoldo Valley). In the upper part the lithology becomes rather variable, and thinly bedded limestones and marls are interbedded by tuffaceous marls and tuffaceous sandstones.

Upper cherty limestone. This facies is well developed at the LEV section (Fig. 7: intervals e-f, 15.4 m thick), where it overlies the "Thin bedded cherty limestone". The lithology is equivalent to the "Knollenkalk", and consists of wavy to nodular limestones with chert in dm-scale beds. The lithology is rather constant at the LEV section, while at CSFW this facies includes one interval with tuffitic marls and tuffaceous sandstones recalling the upper part of the "Pietra verde" (Fig. 6B: intervals p-t).

Biostratigraphy. The Paludina Valley (Curioni, 1877; Mojsisovics, 1882), near Schilpario, is the type locality of *Eoprotrachyceras curionii* (Mojsis.), one of the most important species of Lower Ladinian ammonoids. Information gathered in Schilpario allowed us to locate the site Paludina Valley, never reported in the maps, in the lower part of the Epolo Valley. However, it is not known whether the specimen collected by Curioni was found *in situ* or in the debris.

During our field surveys no macrofossils were found in the AVS unit, while only one small *Eoprotrachyceras* was collected in the Pizzo Camino unit at the CSFW section in the middle part of the "Thin bedded cherty limestone" (sample DG71). This occurrence proves an Early Ladinian age at least for the upper part of this lithologic informal unit.

A total of 24 conodont samples was processed, but only 6 yielded conodonts (Tab. 1, 3) which are often broken. At the LEV section a conodont association of *Paragondolella szaboi* (Kovács), *Neogondolella longa* (Budurov & Stefanov), *P. eotrammeri* Krystyn, *N. postcornuta* Kovács, *N. constricta* (Mosher & Clark) was found in the "Knollenkalk" of the "Lower cherty limestone" (sample DG33). This fauna characterizes the upper part of the Reitzi Zone (Kovács, 1993; Krystyn, 1983; Nicora & Brack, 1995).

In the upper part of the "Lower cherty limestone" (sample DG37bis) a poorly preserved *Budurovignathus*

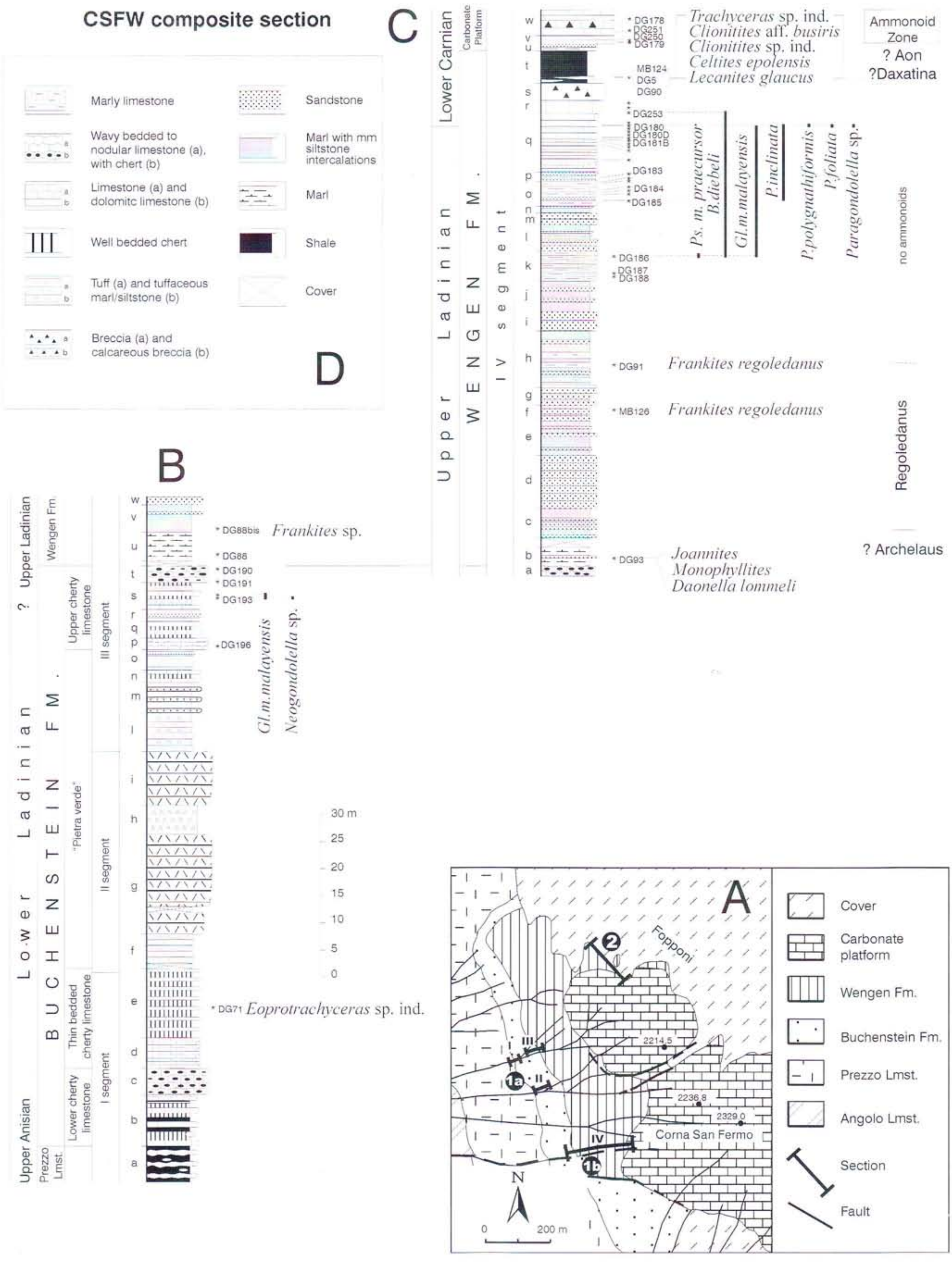


Fig. 6 - A) Geological sketch map of Corna S. Fermo with the position of CSFW composite section (1a and 1b) and Fopponi section (2). B) Segments I to III of CSFW section; C) segment IV of CSFW section; D) lithologic legend for all the sections. Small letters refer to lithologic subdivisions of the sections. The asterisks show the position of all the samples, even those which resulted barren.

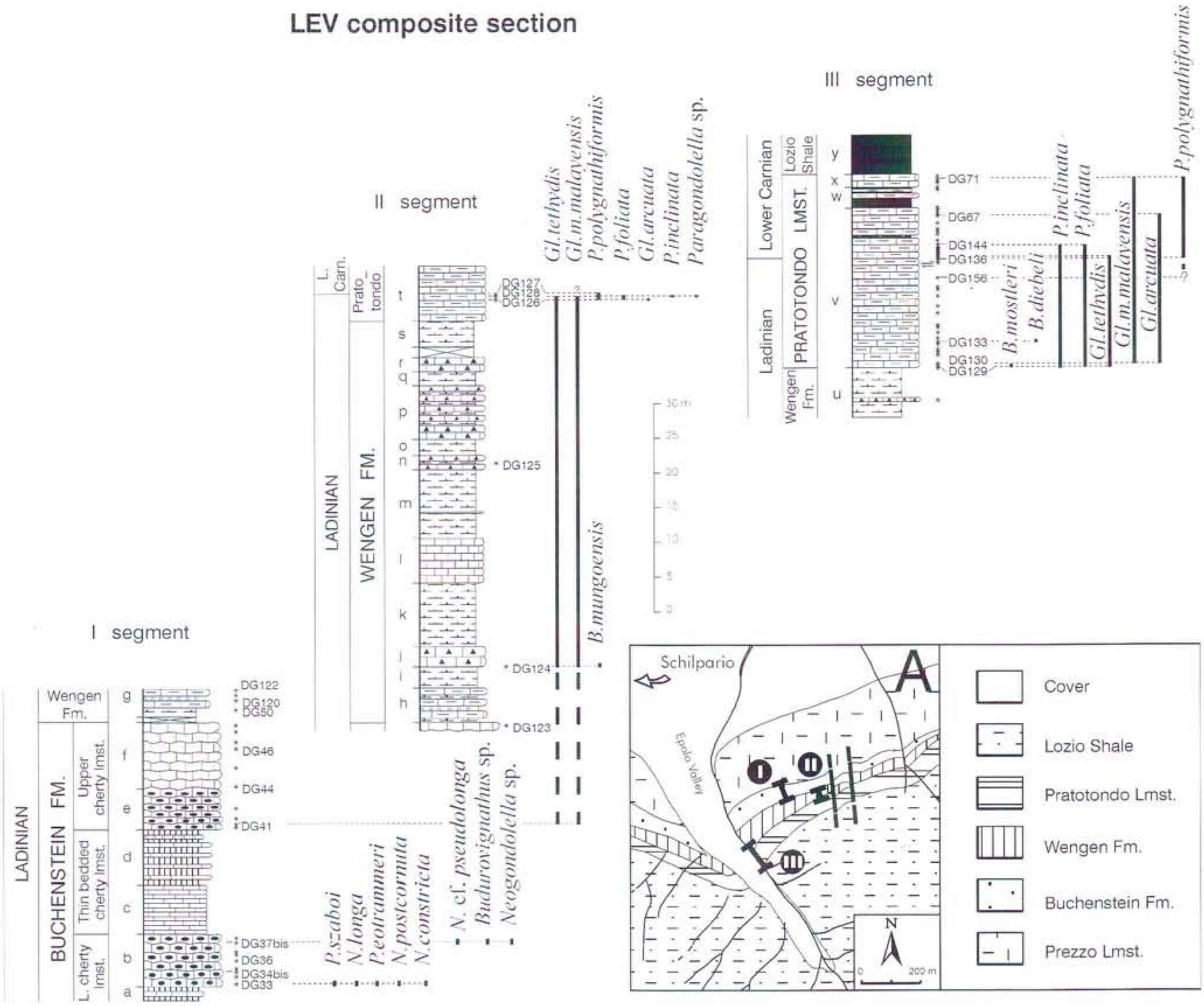


Fig. 7 - Lower Epolo Valley composite section (LEV). A) Geological sketch map showing the position of the three segments of the section.

sp. was found along with *N.* cf. *pseudolonga* (Kozur, Kovács & Mietto) and *Neogondolella* sp. The genus *Budurovignathus* Kozur ranges from the Fassanian (Curioni Zone) to the Late Longobardian (Krystyn, 1983). Kozur (1980) extends its range to the Cordevolian (Sutherlandi - Aonoides Zones).

At the CSFW section in the "Upper cherty limestone" *Gladigondolella malayensis malayensis* Nogami and *Neogondolella* sp. were found. *Gl. malayensis malayensis* is recorded from the Middle Longobardian (Archelaus Zone of Slovenia; Kolar-Jurkovsek, 1991) until the end of the Julian (Kovács et al., 1991).

		Samples	m	*P.szaboi*	*N.longa*	*P.eotrammeri*	*N.postcornuta*	*N.constricta*	*B.* sp.	*N.* sp.	*N.* cf. *pseudolonga*	*Gl.m.malayensis*	*Gl.tethydis*	Ramiforms	Age
Buch. Fm.	Upper Cherty	DG 122	44.53							2				2	Ladinian
		DG 41	25.28									1	2		
	Lower Cherty	DG 37bis	8.11						1	1	1				
		DG 33	2.00	1	1	1	1	1							Up. Anisian

Tab. 1 - Position of samples and numerical distribution of conodonts in the I segment of LEV section.

	Samples	m	*Gl.tetydis*	*Gl. arcuata*	*Gl.m.malayensis*	*B.mungoensis*	*P.polygnathiformis*	*P.inclinata*	*P.foliata*	*P.* sp.	Ramiforms	Age
Pratotondo Lmst.	DG 127	64.00			1?		1			2		Carnian
	DG 128	63.72	1		1			1	2	2	4	
	DG 126	63.20	1	1	1		1		1	1	3	
Wengen Fm.	DG 124	9.13	1		1	1						Ladinian

Tab. 2 - Position of samples and numerical distribution of conodonts in the II segment of LEV section.

Based on the conodont associations, the investigated Buchenstein Fm. ranges from the upper Reitzi Zone into at least the Archelaus Zone (Late Anisian-middle Longobardian).

Wengen Formation.

The Buchenstein Fm. is overlain by the Wengen Fm. in both tectonic units. In the Pizzo Camino unit the Wengen Fm. is well exposed on the western and northern slope of the Corna S. Fermo (Fig. 4, 8) as well as in the steep gullies of the upper part of the Epolo Valley (Fig. 5). The total thickness of the formation increases strongly from the western to the northern side of Corna S. Fermo. It is about 96 m at the CSFW section (Fig. 6C), while it becomes about 235 m at the Fopponi section (Fig. 9). A thickness of more than 200 m is confirmed also in the upper part of the Epolo Valley.

Lithology. In all the sections of the upper tectonic unit the Wengen Fm. is subdivided into two informal members, i.e. a terrigenous lower one, and a calcareous upper one.

The terrigenous member (52.5 m at the CSFW section, IV segment, intervals b-j; probably about 160 m at the Fopponi section) consists of evenly thin-bedded marls, siltstones in cm-thick beds and sandstones in dm to 1 m thick beds. Siltstones often show planar to cross lamination, while the sandstone are generally massive, with weak normal grading and rare cross laminations. The sandstone-siltstone/marl ratio shows wide vertical and lateral changes. The boundary with the terrigenous member is transitional.

The calcareous member (43.5 at CSFW, about 75 m at Fopponi) is made of thinly bedded, more or less marly, limestone with marl interbeds and rare thin calcareous breccia intercalations. These breccias are mud supported and include calcareous intraplasts (commonly 1-2 cm, max 3-5 cm), without any size-sorting. In the uppermost part of the member at the CSFW and Fopponi sections a 3 to 5 m thick coarse grained paraconglomerate with erosional base (Fig. 10) occurs. Three groups of clasts can be recognized: "clay chips" (up to 1.5 x 0.5 m), limestones and planar laminated sandstone (both up to 30 cm of size). Some breccia-layers occur also above the paraconglomerate, but these breccias are grain-supported, with cement and scarce matrix. The clasts are calcareous.

In the southern part of the Pizzo Camino unit (Pratotondo section) and in the AVS unit (LEV section)

Fig. 8 - Wide angle view of Fopponi section (thick dashed line) on the northern side of Corna S. Fermo. The upper boundary of Wengen Fm. is drawn with a thin dashed line, while the lower boundary is badly exposed in an outcrop on the right side of the picture. The star shows the place where a *Frankites regoledanus* (Mojsisovics) was found in debris. The stratigraphic position of the specimen is unknown, however it cannot come from levels below the finding place.

	Samples	m	*Gl.m.malayensis*	*N.* sp.	Ramiforms	*Frankites* sp.	Age
Wengen Fm.	DG 88bis (Am)	41.02				1	Ladinian
Buch. Fm	DG 192	28.80	1		2		
	DG 193	28.26	2	1?	2		

Tab. 3 - Position of samples and numerical distribution of conodonts in the III segment of CSFW section. The distance is from the base of the segment (base of interval l in Fig. 6B).

the subdivision into two members cannot be applied. At the Pratotondo section only 4.5 m of silty marls without macrofossils can be attributed to the Wengen Fm. At the LEV section the Buchenstein Fm. is overlain by 57 m of dark grey marls to shaly marls with planar to wavy dark grey marly limestones with intraplasts. Limestones comprise a wide range of lithologies, from mudstone to the very typical mud-supported calcareous breccias with intraplasts. Sandstones are extremely rare, and only one 5 cm-thick sandstone layer was found in the lower 4 m of the formation.

Distribution of fossils. Epolo Valley is one of the most important fossiliferous localities for the Wengen Fm. in Lombardy (Curioni, 1877; Mojsisovics, 1882; Balini, 1994). However, on the basis of our field experience we conclude that Curioni's sites are mostly in the debris. The "M.ga Epolo" site is the debris of the main gully below the UEV section, while "Val Paludina" is almost certainly the middle-lower part of the Epolo Valley. The richest fossiliferous site is "M. ga Epolo" where fossil-bearing blocks are common, but *in situ* sampling from the steep sides of the ravine is extremely difficult and dangerous because of very frequent rockfalls.

In general macrofossils are quite rare in the Wengen Fm. and sometimes only isolated specimens can be found on the outcrop surface. Unfortunately, ammonoids and conodonts are not found together, making the biostratigraphic subdivision of the formation difficult.

Most of the biostratigraphic data come from sections in the upper tectonic unit, in particular from the CSFW section. Ammonoids were found in the lower and upper part of the formation; in between a very dense conodont sampling was carried out. In the terrigenous member of the Wengen Fm. ammonoids are found in the lower-middle part. The first 2 m yielded some leiostraca ammonoids (*Monophyllites* and *Joannites*) accompanied by frequent daonellids. The first occurrence of *Frankites* is recorded by 2 poorly preserved specimens at 7 m from the base (sample DG88bis). *F. regoledanus* (Mojsis.) is identified from 23 to 37 m (samples MB126 and DG91). In the upper part of the calcareous member a very thin

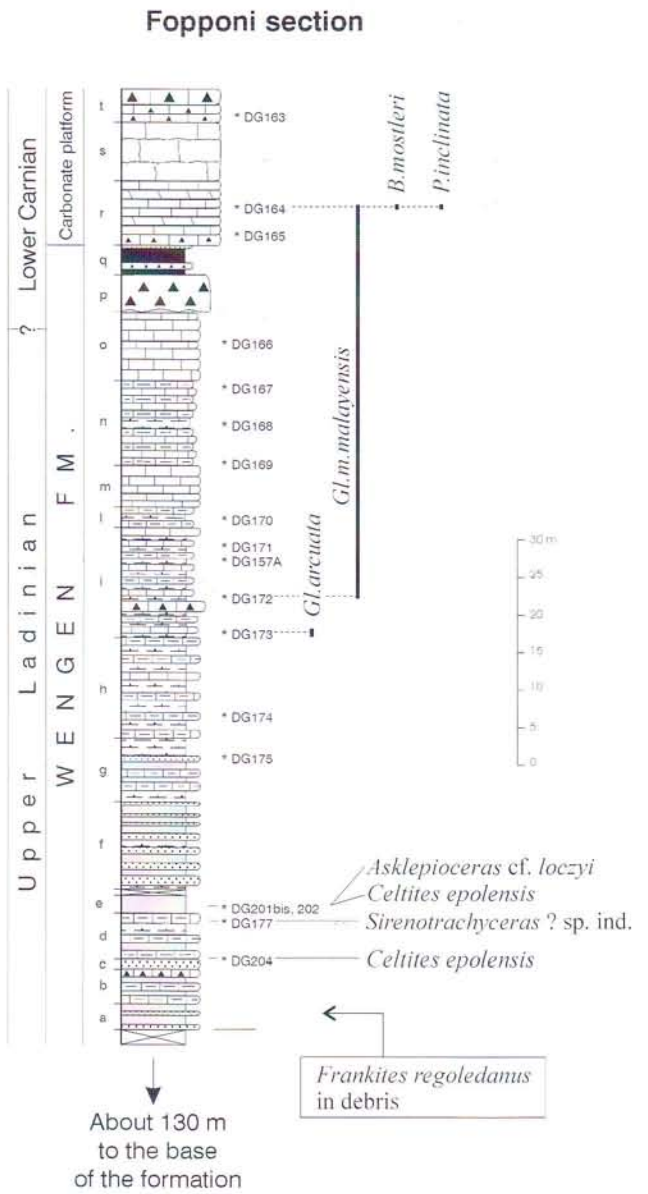


Fig. 9 - Fopponi section.

fossil-bearing bed (sample MB124 = DG5) provided *Trachyceras* sp. ind., *Clionitites* aff. *busiris* (Münster), *Clionitites* sp. ind. as well as *Lecanites glaucus* (Münster).

Extensive sampling for conodonts was done in the calcareous member. A total 42 samples were collected, and 10 provided fossils (Tab. 2-5).

Two conodont faunas are recognized in the IV segment of the CSFW section between the *F. regoledanus* and the *Trachyceras* ammonoid faunas (Tab. 4). The lower conodont fauna is characterized by *Gladigondolella malayensis malayensis* Nogami, *Pseudofurnishius murcianus praecursor* Gullo & Kozur and *Budurovignathus diebeli* (Kozur & Mostler). Higher up *Paragondolella foliata* Budurov, *P. inclinata* (Kovács), *P. polygnathiformis* (Budurov & Stefanov) are present. In this section, below the *Trachyceras* sp. level and above the FO of *P. polygnathiformis*, a transitional form

Fig. 10 - Boundary between Wengen Formation and "Carbonate platform" at Fopponi section (dashed line). Letters refer to the lithologic unit on Fig. 9. The erosional base of the paraconglomerate is highlighted with dotted line.

between *B. diebeli* and *B. mungoensis* is also present. This finding resembles the situation of Balaton Upland (Kovács et al., 1991; Gallet et al., 1994). The *polygnathiformis* elements show primitive characters (carina not too high anteriorly, units not too arched), but the characteristic abrupt step of the platform in lateral view is well evident (Pl. 3 , Fig. 3-4).

The Fopponi section (Tab. 5) is of minor significance in term of fossil distribution when compared to the CSFW section. Ammonoids are found in the upper part of the terrigenous member [*Sirenotrachyceras* ? sp. ind., *Celtites epolensis* Mojsisovics, *Asklepioceras* cf. *loczyi* (Diener)]. In the calcareous member just a reference sampling for conodonts was carried out, and only the long ranging conodonts *Gladigondolella malayensis malayensis* Nogami and *Gl. arcuata* Budurov were found.

In the AVS unit (LEV section) and in the southern part of the Pizzo Camino unit (Pratotondo section) no macrofossils were found, while some conodont samples are positive (Tab. 2). At the LEV section *Gladigondolella tethydis* (Huckriede) and *Gl. malayensis malayensis* Nogami occur from about 9 m above the base of the formation (sample DG124) to the top. In DG124 *Budurovignathus mungoensis* (Diebel) was found also.

Biostratigraphic significance of the faunas and age. The Late Ladinian/Early Carnian ammonoid scales are not yet well established. However, some of the ammonoid taxa identified are of undisputed chronologic significance. Since 30 years ago, the Sutherlandi Zone (index *Frankites* Tozer, 1971) represents the latest Ladinian in the North American scales (Silberling & Tozer, 1968). In the Western Tethys the biostratigraphic position of the LO of *Frankites* is under discussion (Broglio Loriga et al., 1998a, 1998b, 1999; Balini et al.,

	Samples	m	*Gl.m.malayensis*	*Ps.m.praecursor*	*B.diebeli*	*P.polygnathiformis*	*P.inclinata*	*P.foliata*	*P.* sp.	Ramiforms	*Joannites* sp.	*Monophyllites* sp.	*Frankites regoledanus*	*Trachyceras* sp.	*Clionitites* sp.	*Clionitites* aff. *busiris*	*Celtites epolensis*	*Lecanites glaucus*	Age
Wengen Formation	MB 124=DG 5=DG 90 (Am)	90.00												1	1	7	1	1	Carnian
	DG 253	83.40			1*														
	DG 180	81.25	1			6	1	1	5										
	DG 180D	79.35	1							1									Ladinian
	DG 181B	78.80	1																
	DG 185	67.61	1				2		2										
	DG 186	57.35	3	1	1														
	DG 91 (Am)	37.20											1						
	MB 126 (Am)	29.1											1						
	DG 93 (Am)	1.50									2	1							

Tab. 4 - Position of conodont and ammonoid (Am) samples and numerical distribution of conodonts in the IV segment of CSFW section. The specimen with asterisk is a transitional form between *B. diebeli* and *B. mungoensis*.

	Samples	m	*Gl.arcuata*	*Gl.m. malayensis*	*B.mostleri*	*P. inclinata*	*Celtites epolensis*	*Sirenotrachyceras* (?) sp.	*Asklepioceras* cf. *loczyi*	Age
Carbonate platform	DG 164	109.85		5	1?	1				Ladinian
Wengen Fm.	DG 172	57.8		1						
	DG 173	52.95	1							
	DG 201bis=DG 202 (Am)	16.33					2		1	
	DG 177 (Am)	14.88						1		
	DG 204 (Am)	9.87					1			

Tab. 5 - Position of conodont and ammonoid (Am) samples and numerical distribution of conodonts at Fopponi section.

1998), but in any case the species *F. regoledanus* (Mojsis.) is typical of the latest Ladinian (Urlichs, 1974, 1977; Krystyn, 1983; Mietto & Manfrin, 1995a, 1995b; Broglio Loriga et al., 1998a, 1998b, 1999), while the genus *Trachyceras* is index for the base of the Carnian (Urlichs, 1974, 1977; Krystyn, 1983; Balini et al., 1998).

Considering conodont biostratigraphy, *Pseudofurnishius murcianus praecursor* Gullo & Kozur ranges from middle to late Longobardian (middle and upper part of *mungoensis* A.Z. *sensu* Kozur, 1980; Mastandrea et al., 1997).

According to Kozur & Mostler (1971), Kozur (1980), Kovács & Kozur (1980), Budurov & Sudar (1990), *Budurovignathus diebeli* (Kozur & Mostler) is Late Ladinian-Early Carnian. Krystyn (1983) defines the range of the species as late Longobardian (uppermost Archelaus and Regoledanus Zone; *diebeli* A.Z.).

Budurovignathus mungoensis (Diebel) has a wide distribution within the Tethyan Province. It is reported by Kozur (1980) and Kovács & Kozur (1980) from the Late Ladinian to the Cordevolian (Archelaus - Aon Zones), while Krystyn (1983) describes *B. mungoensis* from the upper Gredleri to the end of the Regoledanus Zones (upper part of early to late Longobardian).

The lowest conodont association, found above the *regoledanus* fauna, mostly characterized by *Budurovignathus*, *Pseudofurnishius* and *P. inclinata*, can be attributed to the late Longobardian. The first occurrence of *P. polygnathiformis* marks the Ladinian/Carnian boundary (Krystyn, 1983; Mastandrea, 1994; Mastandrea et al., 1997; Neri et al., 1995). The presence of *Budurovignathus* above the FO of *P. polygnathiformis*, as in Balaton Upland (Kovács et al., 1991) and in Austria (Gallet et al., 1994), is proved also here and thus the extension of *Budurovignathus* into the Carnian is confirmed.

Pratotondo Limestone.

The unit is present in the southern part of Pizzo Camino and in the AVS units. In the type area of Pratotondo (Pizzo Camino unit) outcrops are not very good. The middle-upper part of the Pratotondo Limestone ("Nero venato") is usually well exposed in old quarries, but the lower and upper boundaries are often covered or folded. The best outcrop is in the quarry ENE of M. Pizzo Alto where, despite the cover in the lower part, it is possible to pinpoint the lower boundary of the unit, that does not seem to be folded. This section is proposed here as type section for the formation (see Appendix for description).

Name and rank. The unit was described as limestone (Rossetti, 1966a) but the lithology includes also shales and marly shales. However, the most typical feature of the unit with respect to the underlying and overlying rocks is represented by the presence of carbonatic sediments.

The unit was described as a member of the Esino Limestone (Rossetti, 1966a), but afterwards was generally ranked as a formation (Jadoul & Rossi, 1982; Brack, 1984; Brack et al., 1985).

Stratigraphic position. In the sections studied the Pratotondo Limestone overlies the Wengen Fm. and it is covered by the Lozio Shale.

Boundaries. At the type section the lower boundary is fixed at the base of the dark grey shales with planar dark grey marly limestone intercalations. At the LEV section the lower boundary is drawn at the base of the first dark grey marly limestone bed overlying the silty marls of the Wengen Fm. The upper boundary is fixed at the top of the last limestone bed.

Lithology. In the type area the formation is 166 m thick and can be subdivided into 3 parts (Fig. 11). The lower part (95.3 m thick; intervals c-f) is not very well exposed and consists of dark grey shales with dark grey planar marly limestone in 10 to 20 cm thick beds, sometimes displaying normal grading. The middle part ("Nero venato", 42 m thick, intervals g-m) consists of dark grey limestones and marly limestones (intrabioclastic wackestones to packstones, occasionally grainstones) with planar lamination, normal grading and microslumpings.

The upper part (29 m thick, intervals n-q) consists of dark grey marly limestones with dark grey shales to marly shale interbeds.

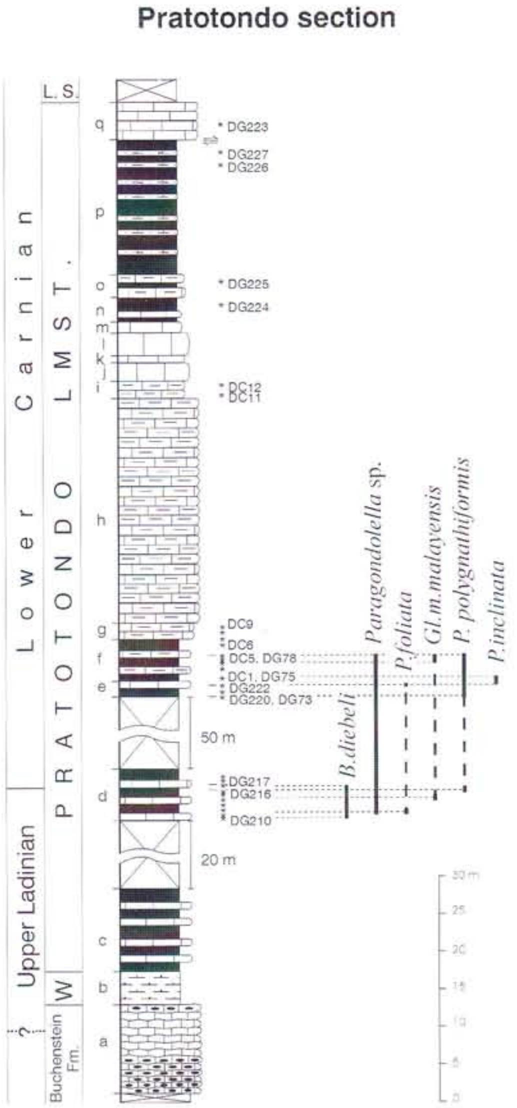


Fig. 11 - Pratotondo section. For the lithological description see Appendix.

At the LEV section the Pratotondo Lmst. is only 28 m thick and the subdivision into three parts cannot be applied (Fig. 7). The lithology is rather homogeneous and similar to the middle part of the Pratotondo section as it consists of wavy, dark grey marly limestones. The wavy bedding along with the scarcity of outcrops are probably the reasons why this lithofacies was not distinguished from the Buchenstein Fm. (Assereto & Casati, 1965; Desio et al., 1970; Forcella, 1988).

Depositional environment. The formation is interpreted as distal carbonate turbidites. The reduction in thickness and the change in lithology between the Pratotondo and LEV sections suggest that the source area of the turbidites is a carbonate platform in the North, making the LEV section more distal. In both the sections studied 2 shale-limestone cycles can be recognized: the first cycle is recorded by the interval c-m at the CSFW section (Fig. 6C), while at LEV it is represented by interval v (Fig. 7). The second cycle is made of interval n-q at CSFW, correlated with w-x at LEV. These cycles represent two growth (prograding?) stages of the carbonate platform. The top of the Pratotondo Lmst. documents the death of the platform.

Biostratigraphy. In the literature no fossils were reported from the formation. In this study no macrofossils were found in the sections studied. However, the conodont content of the formation is quite rich, as 57 samples on 89 are positive.

At the Pratotondo section conodonts were found only in the lower part of the formation (Tab. 6). Samples DG210-DG217 (interval d in Fig. 11) are characterized by *Budurovignathus diebeli* (Kozur & Mostler). In this interval the FO of *Gladigondolella malayensis malayensis* Nogami and *Paragondolella polygnathiformis* (Budurov & Stefanov) are recorded. Higher up (samples DG222 and DG75) the conodont association includes *P. foliata* Budurov, *P. inclinata* (Kovács) along with *P. polygnathiformis* and *Gl. m. malayensis*.

	Samples	m	*Gl.m.malayensis*	*B.diebeli*	*P.polygnathiformis*	*P.inclinata*	*P.foliata*	*P.* sp.	Ramiforms	Age
Pratotondo Limestone	DC 5 (DG78)	110,75	3		7			4		Carnian
	DC 3 (DG77)	108,16	1		6			1	1	
	DC 2 (DG76)	107,36			4			4		
	DC 1 (DG75)	106,08				1				
	DG 222	105,39				1	1			
	DG 221 (DG74)	104,85			1				2	
	DG 220 (DG73)	103,80			2				2	
	DG 217	52,18		1						
	DG 216	51,93			1					
	DG 214	50,45	1							Ladinian
	DG 213	49,45		5						
	DG 211	48,60		1			1	1	2	
	DG 210	47,60		1						

Tab. 6 - Position of samples and numerical distribution of conodonts at Pratotondo section.

	Samples	m	*Gl.tethydis*	*Gl.arcuata*	*Gl.m.malayensis*	*Gl.* sp.	*B. diebeli*	*B. mostleri*	*B.* sp.	*P.polygnathiformis*	*P. foliata*	*P.inclinata*	*P.* sp.	Ramiforms	Age
Pratotondo Limestone	DG 70	34.49			1					1					Carnian
	DG 69	34.23			1					1					
	DG 152	33.97			1										
	DG 151 b	33.27												1	
	DG 151	32.92											2		
	DG 67	29.13		1	2										
	DG 148	28.20			6					2				5	
	DG 147	26.93			1					9				5	
	DG 145	25.61			1					3				2	
	DG 144	24.82								10	1	1	2	1	
	DG 20 (DG 66)	24.69			7	2				3					
	DG 143	24.55								4					
	DG 142	24.35								2	1		1	2	
	DG 141	24.23				1				2			1	6	
	DG 140	24.09		1		1				4			1		
	DG 139 t	23.93			2					9			2	1	
	DG 139 b	23.80				4								1	
	DG 139	23.75												1	
	DG 138	23.65	1		1										
	DG 137	23.48								2				1	
	DG 136	22.83								6			1		
	DG 156	20.06								1?					
	DG 135	18.66			1						1		1	7	Ladinian
	DG 153	13.38	2		2									2	
	DG 15 (DG64)	11.53	2	2	7										
	DG 133	11.05			2	1	2							7	
	DG 132	10.65												2	
	DG 63	9.09				1									
	DG 130	8.35			1									3	
	DG 62	8.00				1									
	DG 61	7.64		2	5				1						
	DG 60	7.50	1					1							
	DG 129	7.48	4					1			1	1		2	

Tab. 7 - Position of samples and numerical distribution of conodonts in the III segment of LEV section.

At the LEV section (Tab. 7) the Pratotondo Lmst. was sampled in the upper part of segment II (Tab. 2) and in segment III (Tab. 7). In both segments the lower part of the formation is characterized by the association of *Gl. m. malayensis*, *P. foliata*, *P. inclinata* and *Gl. arcuata* Budurov. These species are accompanied by *Gl. tethydis* (Huckriede) and by *P. polygnathiformis* in segment II, while in segment III *Budurovignathus mostleri* (Kozur) was found. In this segment the FO of *P. polygnathiformis* is recorded a little higher up, for certain at level DG136.

Based on the conodont associations from this section, the lower portion of the Pratotondo Fm. is late Longobardian in age, while the upper portion is Carnian. In contrast, in the Pratotondo section the lower portion of the formation is already Carnian.

Lozio Shale.

The name Lozio Shale was introduced by Assereto & Casati (1965) for a thick shaly unit cropping out in the Scalve (AVS unit) and Lozio (Pizzo Camino unit) Valleys. The type section is located in a narrow valley 1.5 km East of the LEV section, in the AVS unit (Assereto & Casati, 1965).

Lithology. The formation consists of a thick (193 m at the type locality, Assereto & Casati, 1965) and monotonous succession of dark grey to black shales and very fine grained siltstones, sometimes slightly marly.

Boundaries. The original lithostratigraphic setting of the Lozio Shale provided by Assereto & Casati (1965) must be updated after the description of the Pratotondo Lmst. by Rossetti (1966a) and our results. In the type section as well as at the LEV section, the Lozio Shale overlies the Pratotondo Lmst. The succession Prezzo Lmst. – Buchenstein Fm.- Wengen Fm. – Pratotondo Lmst. is well exposed in the type section of the Lozio Shale, but it is too steep to be accessed and described. Probably for this reason Assereto & Casati did not notice the Wengen Fm. and misidentified the Buchenstein Fm. The succession Pratotondo Lmst. – Lozio Shale is also confirmed in the Lozio Valley, in particular at the type area of the Pratotondo Lmst. (Pratotondo section).

ple and double nodes which are often important for the taxonomy of *Trachyceras*. In conclusion, level MB124 is left in open position because it cannot be directly correlated either with the *Daxatina* or with the Aon Zones.

The fauna collected at Fopponi in the upper part of the terrigenous member of the Wengen Fm. does not have special stratigraphic value. *Celtites epolensis* Mojsis. is a typical long ranging form of the Archelaus "fauna"; *Asklepioceras* cf. *loczyi* (Diener) is reported for the first time from the Wengen Fm. The biostratigraphic attribution of these occurrences cannot be directly proved, however the finding of a good *Frankites regoledauns* (Mojsis.) in the debris some meters below suggests a correlation with the Regoledanus Zone.

In conclusion, the new data demonstrate that in the sections studied the Regoledanus Zone represents a large part of the Wengen Fm. Moreover, at the top of Wengen Fm. a fauna never reported before is of Early Carnian age.

Lithostratigraphic and paleogeographic implications of the new data.

At a local scale most of Rossetti's lithostratigraphic interpretation of the stratigraphic sequence in the lower Epolo Valley (AVS unit) (Rossetti, 1966a, fig. 2 and p. 130-131), i.e. the succession Prezzo Lmst., Buchenstein Fm., Wengen Fm. and Pratotondo Lmst, is confirmed.

Chronostratigraphically, the age of some Middle Triassic formations is upgraded on the basis of the new data, and in general the change consists in a rejuvenation. The Pratotondo Limestone whose type section is described here, is definitely latest Ladinian to (mostly) Early Carnian. The top of the Wengen Fm. is of Early Carnian age, on the basis of the FO of the conodont *P. polygnathiformis* and the ammonoid *Trachyceras*. This dating is certain at least for the central and western part of the Pizzo Camino unit. Consequently, the age of the overlying "Carbonate platform" is undoubtedly Carnian. At present, no biostratigraphic data are available for the eastern part of the Pizzo Camino unit. At Passo Campelli (North of Concarena) the thickness of the Wengen Fm. is reduced (about 60 m: Forcella & Rossi, 1980) and only the terrigenous member seems to be represented. However, the upper boundary of the formation is not exposed.

A new look at the platforms.

The problem of the lithostratigraphic classification of the "Carbonate platform" in the Pizzo Camino-Corna S. Fermo ridge provides the opportunity to discuss the dating of Ladinian and Carnian carbonate platforms in the Western Southern Alps.

In Lombardy the Ladinian platform is usually classified as Esino Limestone, while the Carnian platform is attributed to the Breno Formation. Actually, in literature the separation is not usually proved by fossils, but it is based on lithology and in part on the stratigraphic position, i.e. the massive carbonates are attributed to the Esino Lmst., while the bedded limestones and dolomites are included in the overlying Breno Fm. The new data lead to a rejection of the correlation of massive carbonates = Esino Lmst. = Ladinian so common in the literature.

Fig. 13 shows the available high resolution biostratigraphic dating of the Ladinian-Carnian carbonate platforms in Lombardy, roughly arranged along a W-E transect. In the type area of Grigna, the Ladinian age of the Esino Lmst. is documented by classical ammonoid "faunas" of the Archelaus Zone (Mojsisovics, 1882; Rossi Ronchetti, 1960) attributed to the Archelaus Zone *sensu* Krystyn, 1983 by Fantini Sestini (1996). There, the platform interfingers and covers a basin where the Wengen Fm. is at least in part of Early Ladinian age (Gaetani et al., 1987; Gaetani et al., 1998).

During the Ladinian some differences in the subsidence must have occurred, because the platform is prograding in the Grigne while it is aggrading in the Parina Valley (Fig. 13). In the Parina Valley, very rich Ladinian ammonoid faunas occur from about 300 to 550 - 600 m above the base of the Esino Lmst. and the Curionii, Gredleri and Archelaus (= Longobardicum Subzone in Mietto & Manfrin, 1995a) Zones are well documented (Jadoul et al., 1992; Fantini Sestini, 1994, 1996). The stratigraphic position of these faunas within the Esino Lmst. is slightly different with respect to Grigne, however this is not necessarily due to different age, but could be explained by the different development of the platforms. Jadoul et al. (1992) report a Late Ladinian age of the topmost Esino on the basis of the algal flora.

Further to the East there are only indirect data, but it is clear that an age difference in the platform development took place. In our study area a Carnian age of the platform is demonstrated. In particular the platform is younger than the Regoledanus Zone, that is never documented by fossils in the Esino Lmst. of the Western localities.

The Carnian age of the Breno Formation is proved undoubtly by ammonoids of the Aonoides Zone in the upper member of the formation (Campolungo Member) at Rifugio Albani (Allasinaz, 1968), North of Presolana (Presolana unit). The North Presolana section exemplifies also the stratigraphic problems derived from the schematic litho(chrono)logic classification of Triassic platforms. In this locality the upper member of the Breno Fm. overlies an approximately 400 m-thick massive carbonate succession that is not referred to the Breno Fm., but to the Esino Lmst. (Allasinaz, 1968; Desio et al., 1970; Forcella, 1988) and then to the Ladin-

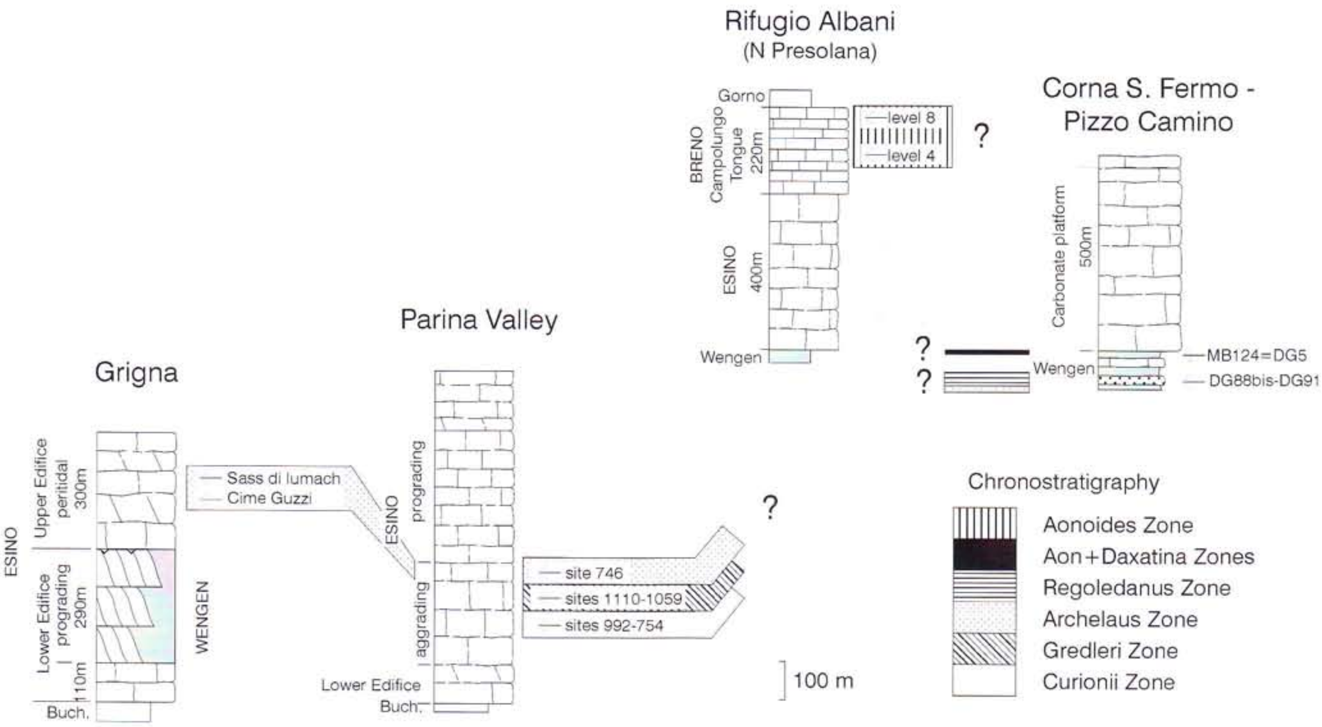


Fig. 13 - Schematic sketch displaying the high resolution ammonoid dating of the Ladinian to Carnian carbonate platforms of Western Southern Alps. Grigna section is simplified from Gaetani et al. (1998, fig. 7): the faunas are classified by Rossi Ronchetti (1960) and Fantini Sestini (1996); the fossiliferous sites have been located by Gaetani (pers. com.). Val Parina section is based on data reported by Jadoul et al. (1992), while the localities are plotted from Fantini Sestini (1994, 1996). Rifugio Albani section is from Allasinaz (1968), who also described the fauna. The thickness of the underlying Esino Lmst. is estimated from Forcella (1988, fig. 5). The development of the platforms is taken from the quoted papers. Here the Archelaus Zone is comprehensive of Longobardicum and Neumayri (sub)Zones sensu Mietto & Manfrin (1995a).

ian (i.e. Desio et al., 1970). This notwithstanding, the identification of the Aonoides Zone (2nd zone of the Early Carnian according to Krystyn, 1978) poses the question of which part of the succession is of earliest Carnian age (Aon Zone or Daxatina and Aon Zones, depending on the scales).

The new data demonstrate that the classification of the platforms is inadequate and must be updated.

Which age for the Wengen basins?

According to the literature, in Lombardy-Giudicarie the Wengen Fm. displays a quite wide variation in thickness (from some tens of m to 400 m) but it is always overlain by the Esino Limestone, always of Ladinian age, except in a small area in the Camonica Valley where it is overlain by the Pratotondo Lmst. (Jadoul & Rossi, 1982; Fig. 2A). The new data suggest a different interpretation. The deposition of the Wengen Formation in Lombardy-Giudicarie is much more complex. From locality to locality the thickness of the formation is neither directly related to its time span nor to its age. In the Grigne area the "Wengen Fm." is a good 400 m thick (Gaetani et al., 1987) but it is overlain by the Upper Edifice of the Esino Limestone (Fig. 13; Gaetani et al., 1998 and pers. comm.). The sedimentation rate here is very high and the age of the formation is not younger than the Archelaus Zone, but most likely is older and is at least in part of Early Ladinian age.

In the study area the Wengen Fm. is younger than in Grigne, but its low/medium thickness (about 96 m at CSFW section) does not indicate a short time span because at least three ammonoid zones are documented (?*Archelaus*, *Regoledanus* and ?*Daxatina* or *Aon*). Some increasing in thickness may occur (from CSFW to Fopponi and UEV) but the upper boundary is coeval.

Very few biostratigraphic data are available for the other areas (Presolana, Dosso Alto-Bagolino, M. Corona-Stabol Fresco). At Presolana, very close to the West of the study area, the age of the Wengen Fm. should be

Fig. 14 - Correlation chart of the studied sections showing the distribution of the most important fossils: conodonts *Budurovignathus* and *Paragondolella polygnathiformis*, and ammonoids *Eoprotrachyceras*, *Frankites* and *Trachyceras*. The Ladinian/Carnian boundary (thick line) is drawn at the FO of *P. polygnathiformis*. For graphic reason Pratotondo and LEV sections are shifted downward. Dashed line shows correlations of lithologic units below the rank of formation.

Considering the upper boundary of the Lozio Shale, we have no elements to solve the great uncertainty concerning the formation overlying Lozio Shale in the AVS unit.

Biostratigraphy and age. Neither macro- nor microfossils were found, however the new data on the age of the Pratotondo Limestone allow a Carnian age to be attributed to the Lozio Shale.

"Carbonate platform".

In the northernmost sections of the study area (Pizzo Camino unit) the basinal succession Buchenstein-Wengen Fms. is overlain by a thick carbonate platform traditionally attributed to the Esino Limestone (De Sitter & De Sitter-Koomans, 1949; Rossetti, 1966a, 1966b; Schiavinato et al., 1969; Desio et al., 1970; Forcella & Rossi, 1980; Brack, 1984; Forcella, 1988). The unit was not investigated in detail. At the CSFW, Fopponi and UEV sections the lower part consists mostly of grey to dark grey rudstones, locally dolomitized, in 10 cm- to 1 m- thick beds. The thickness of the "Carbonate platform" is difficult to estimate because this facies forms the top of the Pizzo Camino-Corna S. Fermo ridge, so that the upper boundary is not preserved. At Corna S. Fermo this unit is at least 250 m thick, while at the UEV section the Wengen Fm. is overlain by at least 500 m of platform carbonates.

Biostratigraphy. In the literature no fossils are reported from the "Esino Limestone" of Pizzo Camino. The Carnian bivalve faunas reported by Allasinaz (1964) from Cima Camino, were actually collected from a lithofacies overlying the southern slope of the platform (Gorno Fm. *sensu* Allasinaz, 1964 = Sommaprada Lmst. *sensu* Rossetti 1966a).

During our field work 7 conodont samples were collected, however only sample DG164 at the Fopponi section successfully yielded *Budurovignathus mostleri* (Kozur), *Paragondolella inclinata* (Kovács) and *Gl. m. malayensis* Nogami.

According to Krystyn (1983) *Budurovignathus mostleri*, is limited to the upper *diebeli* A.Z. (Regoledanus Zone *pars*= upper part of Longobardian) while Kozur (1980) and Kovács et al. (1991) extend its range from the late Longobardian to the Cordevolian (Sutherlandi - Aonoides Zones).

P. inclinata ranges from the early Longobardian to the latest Julian (Kovács & Kozur, 1980; Kovács, 1983) or from the Upper Gredleri Zone to the Upper Austriacum Zone (Krystyn 1983).

Age. The base of the "Carbonate platform" at Fopponi is coeval with the CSFW section, as demonstrated by the thick conglomerate event at the top of the Wengen Fm (Fig. 10). The Early Carnian age of the conglomerate is well proved by the FO of *P. polygnathiformis* and the occurrence of *Trachyceras* sp. ind. at the CSFW section. As a consequence, the age of the conodont fauna found at the base of the "Carbonate platform" is Early Carnian.

Nomenclatural problems. The "Carbonate platform" is left in open lithostratigraphic nomenclature because its Carnian age is younger than the age of the Esino Lmst., while the lithology (rudstones and breccias) does not fit with the Breno Formation (Assereto & Casati, 1965; Gaetani, 1985; Gnaccolini & Jadoul, 1988). In some respects it is similar to the Cassian Dolomite of the Dolomites.

Conclusions: synthesis and open-ended problems.

The new biostratigraphic data allow the upgrade of the chronostratigraphy at different levels. From an historical point of view the new data on ammonoids lead to a rejection of the equivalence "Wengener Schichten" = Archelaus Zone = Upper Ladinian, while ammonoids and conodonts data together compel a general revision of the Ladinian/Carnian chronostratigraphic reconstructions as well as the paleogeographic history of the Western Southern Alps.

The ammonoids of the Wengen Fm. and the problem of the Archelaus Zone.

The Archelaus Zone is at present one of the most important chronostratigraphic problems of the Upper Ladinian of the Tethys. The best description of this zone was done by Mojsisovics (1882, p. 311-312) in his monograph on the Triassic ammonoids of the Western Tethys (Fig. 1). From his description it is clear that the *P. archelaus* zone is an Oppel-zone (Hedberg, 1976), being based on an all-inclusive list of taxa found in several localities where neither the taxon index, nor the whole list is found in all the sites. A second important feature of this zone is that it was described from a wide variety of facies. The zone was not only based on the entire cephalopod content of the "Wengener Schichten" of Schilpario, Giudicarie and Dolomites, but it was enlarged to comprise also the "faunas" of several quite different lithologic units grouped together under the vague name of "thonarmen Kalksteine" (limestones without shale). In this way the "fauna" of carbonate platform limestones of several areas of the Southern and Northern Alps (Esino Lmst., Marmolada Lmst. and Wetterstein Lmst.) was included with the fauna of condensed red limestones (Clapsavon Lmst.).

After Mojsisovics, the stratigraphic value of this zone was never revised, and it became indirectly the reference for the Longobardian substage of the Ladinian (Mojsisovics in Mojsisovics et al., 1895). In addition the

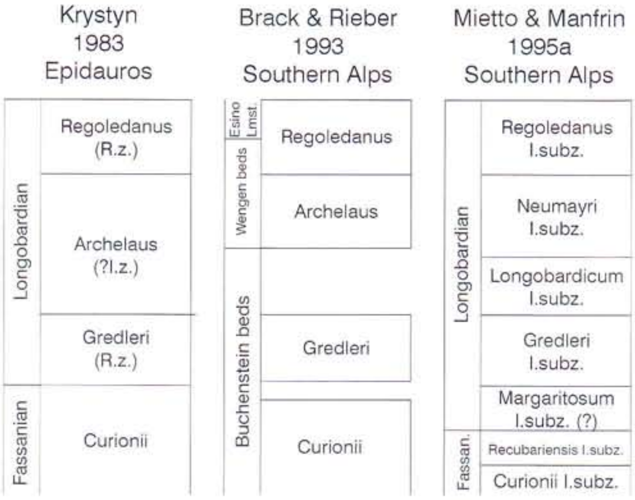


Fig. 12 - Most recent proposals for the subdivisions of the Upper Ladinian in the Western Tethys based on ammonoids. The correlation of the different scales is difficult because often the same names are used by different authors with different meaning.

name derivation indicates the great importance of the Lombardian ammonoid faunas. In the last 30 years there have been some attempts to improve the Late Ladinian ammonoid scale of the Tethys (Pisa, 1966; Krystyn, 1983; Mietto & Manfrin, 1995a, 1995b), however, no new proposals were supported by bed-by-bed sampling in the classic areas. In general, the suggested revisions consist of the subdivision of the Upper Ladinian, usually regarded as equivalent to the *P. archelaus* Oppel-zone in the "Wengener Schichten", into two or three parts (Fig. 12).

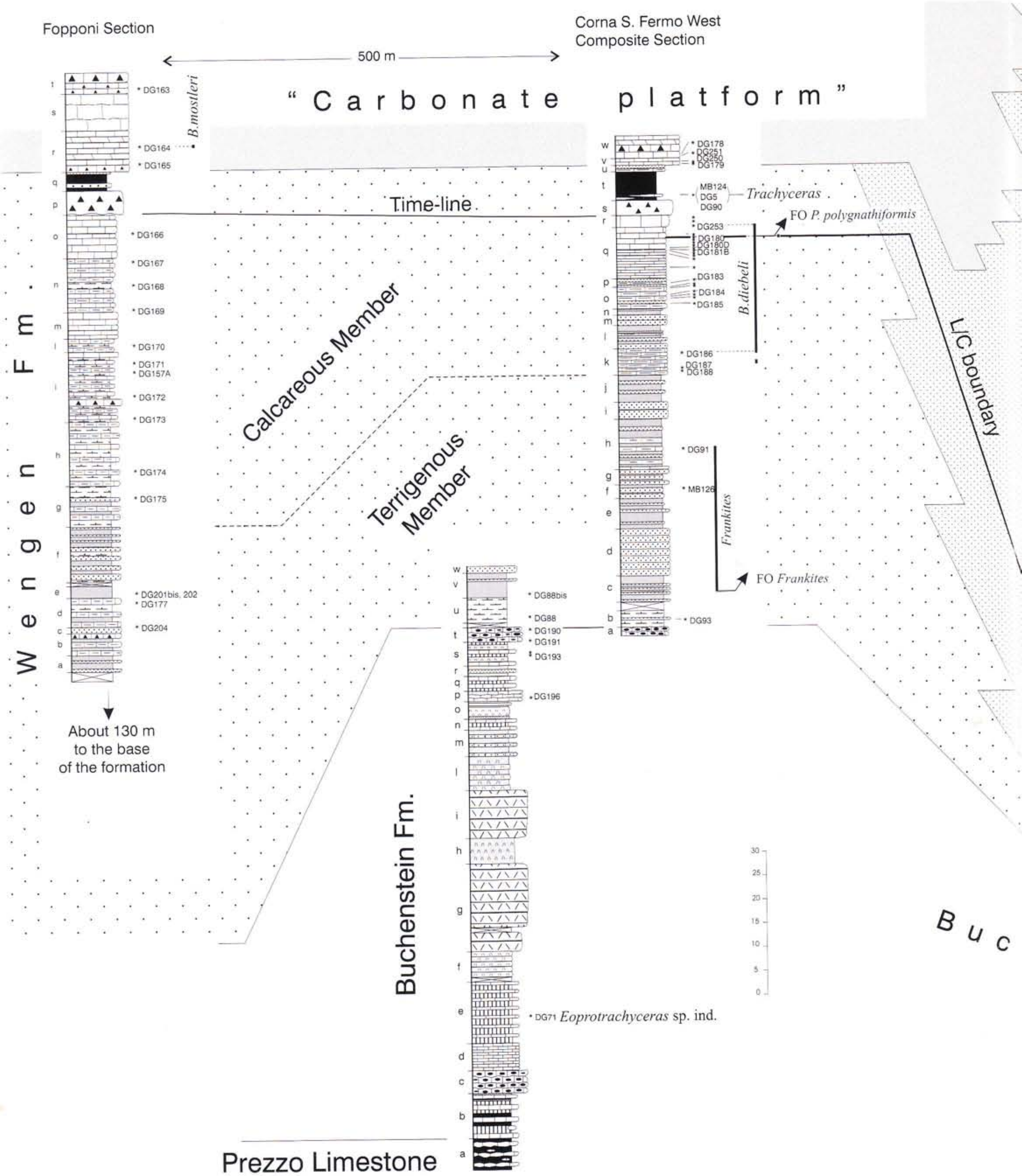
The first proposal was presented by Krystyn, based on new bed-by-bed data from the Hallstatt-like condensed red limestone of Epidauros (Greece). He found no stratigraphic overlaps in the distribution of *Protrachyceras* cf. *gredleri* (Mojsisovics), *P. archelaus* (Laube) and *Frankites regoledanus* (Mojsisovics) (1983: fig. 3 and p. 234), then he suggested the separation of the Gredleri and Regoledanus Zones from the Archelaus *s.s.* Zone. The stratigraphic setting of *P.* of the *gredleri* group is of special interest, because *P. gredleri* was described from the Clapsavon Lmst. where *P. archelaus* was not found (Mojsisovics, 1882).

After Krystyn the Regoledanus Zone was accepted by the entire scientific community while the position of the Gredleri Zone was discussed by Brack & Rieber (1993; Fig. 12). This zone is documented in the Buchenstein Fm. (i.e., in the lithostratigraphic unit that is the historical reference for the Fassanian substage), positioning it below the classic "fauna" of the Wengen Fm. More recently Mietto & Manfrin (1995a, 1995b) divided the interval between the Gredleri and Regoledanus (Interval) Subzones into Margaritosum and Neumayri (Interval) Subzones. However, there is not a single section where all the three subzones are superimposed (Mietto & Manfrin, 1995a, fig. 4) and the new subdivision is not based on Mojsisovics' classical localities.

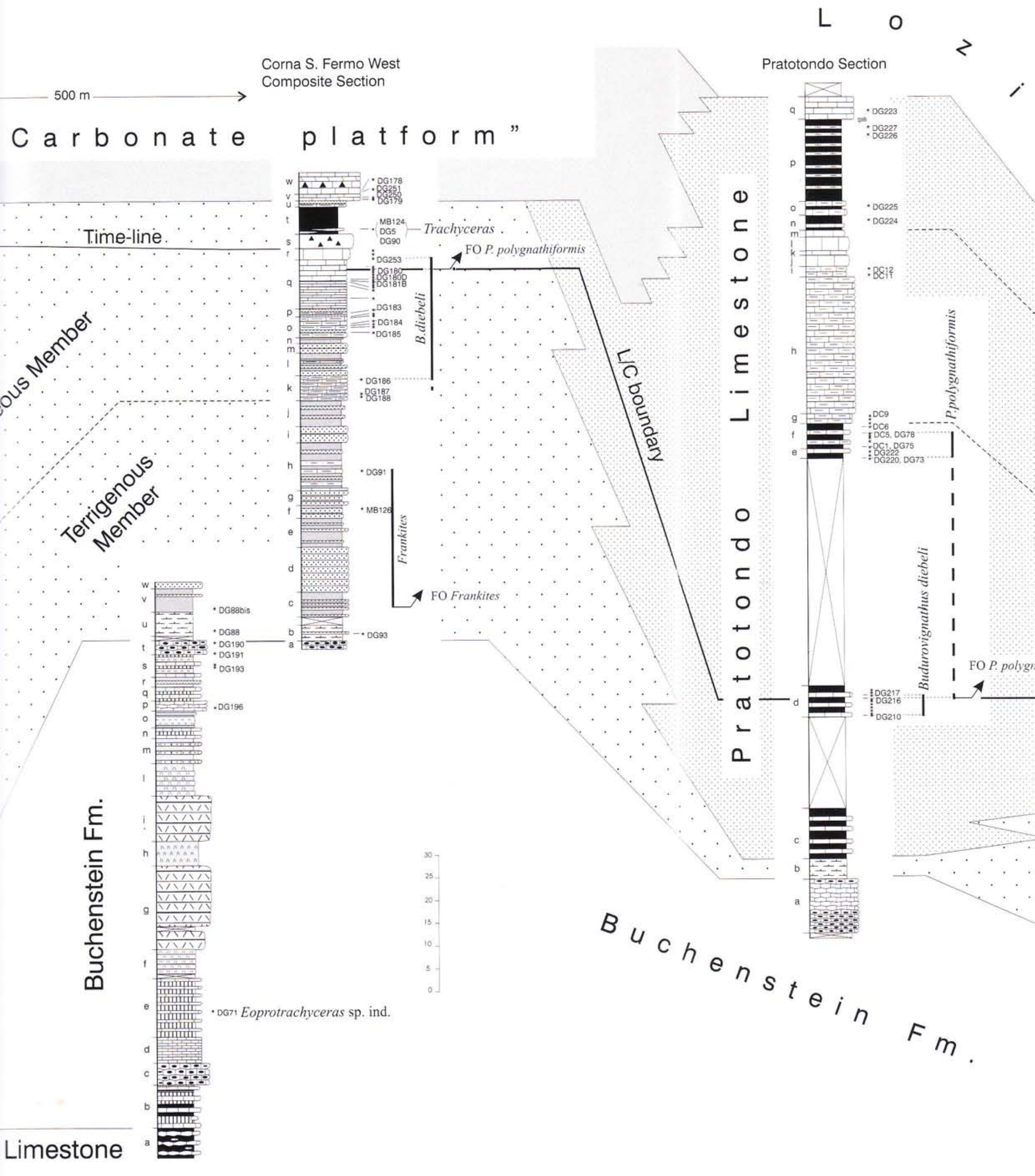
Due to the complex history of the *P. archelaus* Oppel-zone, the new albeit scarce data have some significance. The classic localities are in debris, but in the neighborhood some *in situ* collections are possible. For instance some ammonoids were collected in the CSFW and Fopponi sections. These new findings are of interest since they may lead to an understanding of where and how the *P. archelaus* Oppel-"fauna" of Mojsisovics is recorded in the Wengen Fm.

The CSFW section has the best documentation. The collection of some *Frankites regoledanus* (Mojsis.) leads to a recognition of the Regoledanus Zone. At the moment, the lower boundary of this zone is drawn at the FO of Frankites, and it is worth noting that this occurrence is recorded only 7 m above the base of the formation (sample DG88bis). The biostratigraphic position of the lowest 7 m of the Wengen Fm. at the CSFW section is open because no age diagnostic ammonoids were found. Brack & Rieber (1993) report *P. archelaus* from the lower part of the Wengen Beds at Bagolino, and they correlate this part with the Archelaus Zone. However, according to Mietto & Manfrin (1995a, 1995b) *P. archelaus* (Laube) occurs not only in the Margaritosum and Neumayri Subzones, but also in the Regoledanus Subzone.

The biostratigraphic attribution of the upper fossil-bearing level at the CSFW section (MB124= DG5=DG90) is more complex. The fauna is completely different from the classic "fauna" of the *P. archelaus* Oppel-zone of Mojsisovics and in some respects it is more similar to the "fauna" of the *T. aon* Oppel-zone, but it is mostly composed by long ranging forms or by specimens with indefinite taxonomic position. *Lecanites glaucus* (Münster) is a long ranging species reported by Urlichs (1974, 1977) from the Late Ladinian to the Early Carnian Aon Zone. The genus *Clionitites* also ranges from the Late Ladinian (Regoledanus Zone: Balini et al., 1998) to the Early Carnian (Tozer, 1994). The single *Trachyceras* sp. ind. could be a useful element for dating, however the knowledge on the early *Trachyceras* is poor. The *Trachyceras* of the Aon Zone were revised (Krystyn, 1978; Urlichs, 1994), but the specimen at hand does not fit with these classical forms (see Systematic paleontology). Considering the recent discovery of *Trachyceras* at Prati di Stuores in the beds yielding *Daxatina*, underlying the classical Aon fauna (Mietto & Manfrin, 1995b; Broglio Loriga et al., 1998a, 1998b, 1999), the comparison is difficult. The taxonomic study is not yet concluded, so that descriptions are not yet available. Moreover the typical preservation of the specimens (often crushed and partly covered by marl) does not allow one to distinguish from the plates very fine details such as the sim-



Fopponi Section
Corna S. Fermo West
Composite Section
500 m
"Carbonate platform"
B.mostleri
Time-line
Trachyceras
FO P. polygnathiformis
B.diebeli
Calcareous Member
Terrigenous Member
L/C boundary
Frankites
FO Frankites
Wengen Fm.
About 130 m
to the base
of the formation
Buchenstein Fm.
DG71 Eoprotrachyceras sp. ind.
Prezzo Limestone
Buc


L o z i
500 m
Corna S. Fermo West Composite Section
Pratotondo Section
Carbonate platform"
Time-line
ous Member
Terrigenous Member
Trachyceras
FO P. polygnathiformis
B.diebeli
L/C boundary
Frankites
FO Frankites
Pratotondo Limestone
P.polygnathiformis
Budurovignathus diebeli
FO P. polygn
Buchenstein Fm.
Limestone
Buchenstein Fm.
DG71 Eoprotrachyceras sp. ind.
DG178
DG251
DG250
DG179
MB124
DG5
DG90
DG253
DG180
DG180D
DG181B
DG183
DG184
DG185
DG186
DG187
DG188
DG91
MB126
DG93
DG88bis
DG88
DG190
DG191
DG193
DG196
DG223
DG227
DG226
DG225
DG224
DC12
DC11
DC9
DC6
DC5, DG78
DC1, DG75
DG222
DG220, DG73
DG217
DG216
DG210
30
25
20
15
10
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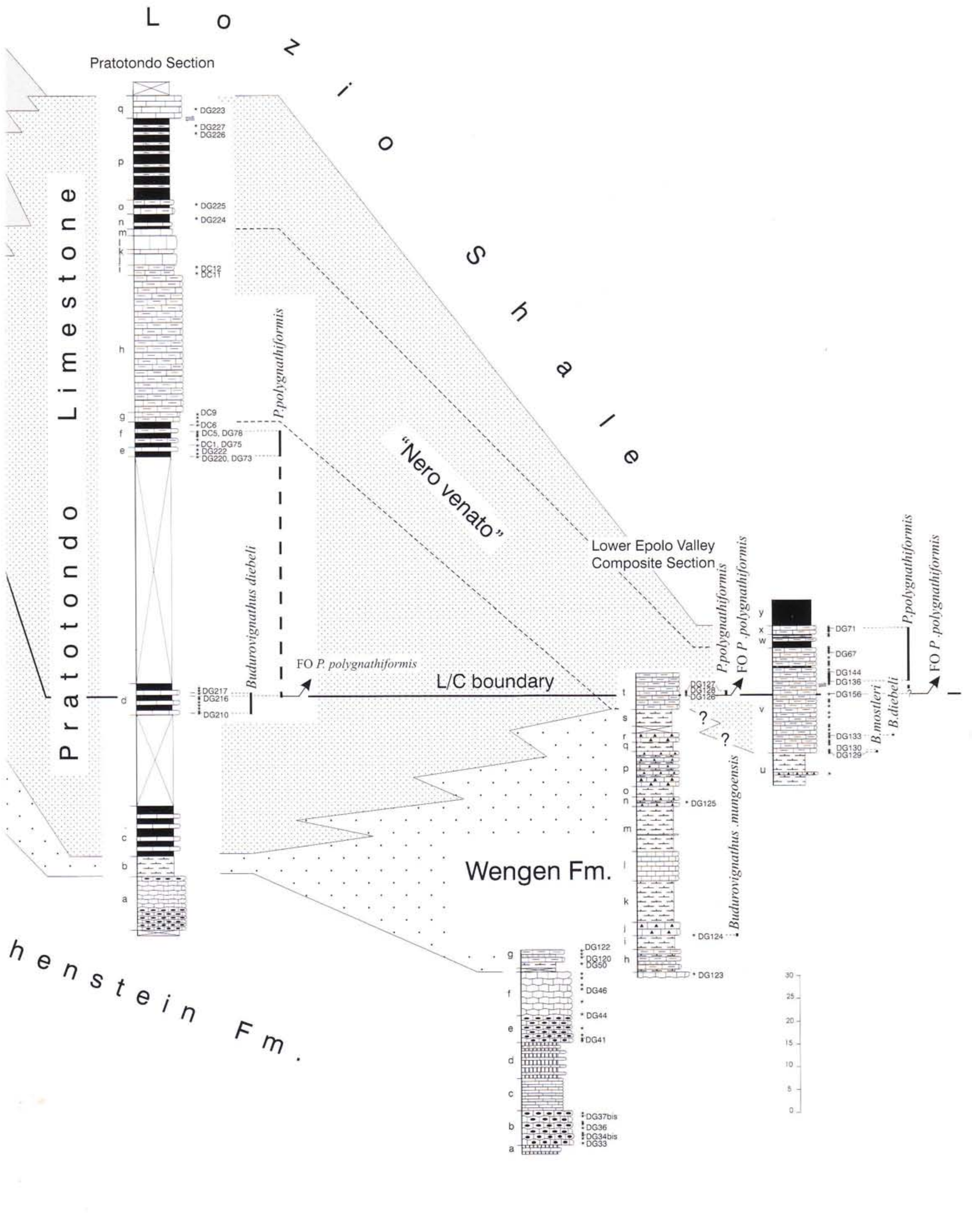
0



Lozio Shale
Pratotondo Section
Pratotondo Limestone
"Nero venato"
Lower Epolo Valley Composite Section
L/C boundary
FO P. polygnathiformis
P.polygnathiformis
Budurovignathus diebeli
Budurovignathus mungoensis
B.mostleri
B.diebeli
FO P. polygnathiformis
Wengen Fm.
henstein Fm.
DG223
DG227
DG226
DG225
DG224
DC12
DC11
DC9
DC6
DC5, DG78
DC1, DG75
DG222
DG220, DG73
DG217
DG216
DG210
DG127
DG126
DG125
DG124
DG123
DG122
DG120
DG50
DG46
DG44
DG41
DG37bis
DG36
DG34bis
DG33
DG71
DG67
DG144
DG136
DG156
DG133
DG130
DG129
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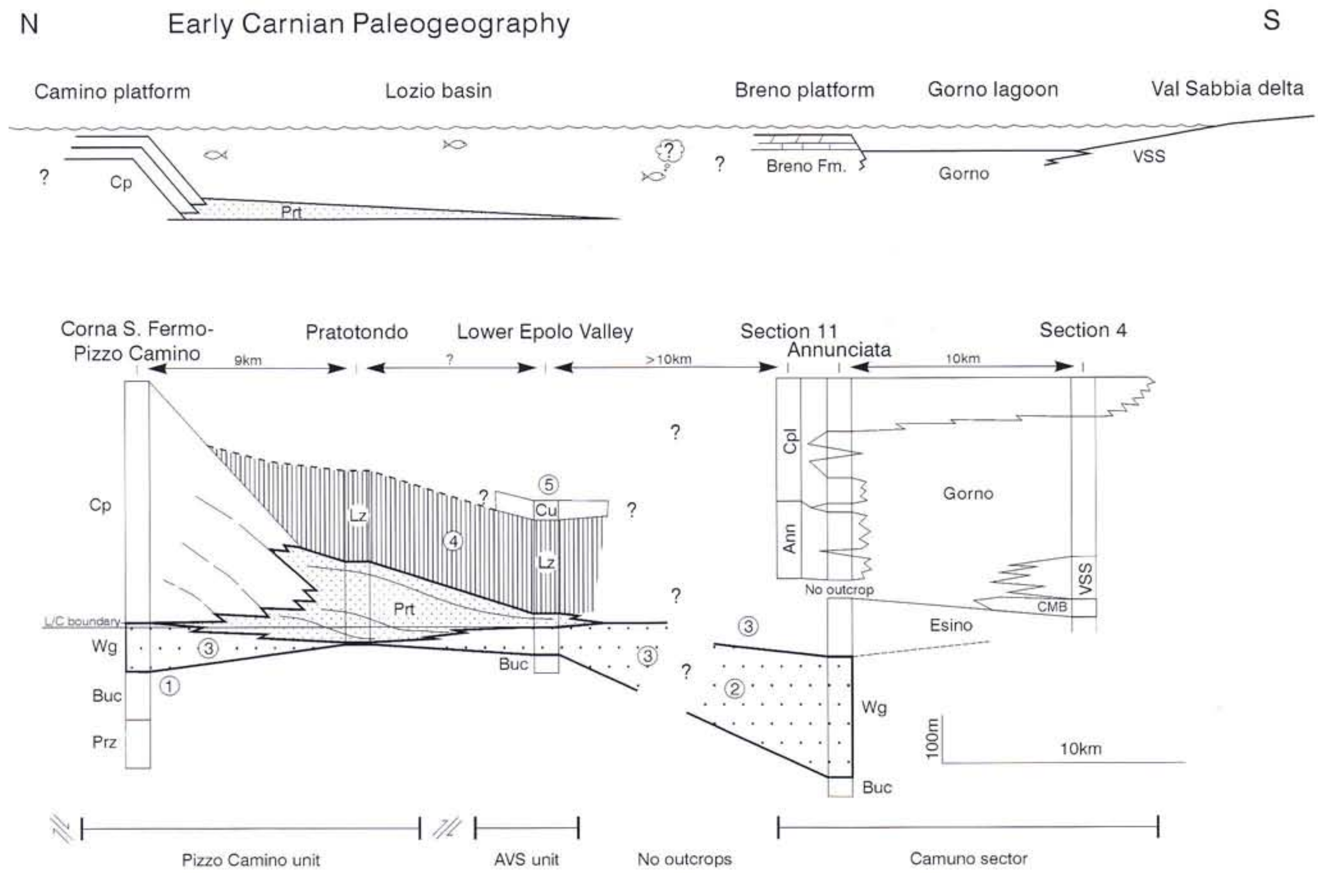


Fig. 15 - N-S transect along the Camonica Valley sector of Western Southern Alps during Ladinian to Early Carnian times. Lower part of Annunciata section from Jadoul et al. (1979). Sections 11, 4 and upper part of Annunciata from Gnaccolini & Jadoul (1988). Numbers refer to open problems (see text). Distance between sections in the same tectonic unit is directly measured. The relationships between "Carbonate platform" and Lozio Shale are slightly simplified and the "Sommaprada Lmst." (cf. Rossetti, 1966a), is not drawn. Acronyms: Prz= Prezzo Limestone; Buc= Buchenstein Fm.; Wg= Wengen Fm.; Cp= "Carbonate platform"; Prt= Pratotondo Limestone; Lz= Lozio Shale; Esino= Esino Limestone; CMB= "Calcare Metallifero Bergamasco"; VSS= Val Sabbia Sandstone; Gorno= Gorno Fm.; Ann= Annunciata Member of Breno Fm.; Cpl= Campolungo Tongue of Breno Member; Cu= Carbonatic unit overlying Lozio Shale in the AVS tectonic unit.

tested carefully, because the formation is overlain by a very thick platform attributed in the literature once again to the Esino Limestone. Bagolino-Dosso Alto shows a picture similar to M. Corona-Stabol Fresco (Giudicarie), because the "Esino Lmst." is about 200 m thick. At Monte Corona the Archelaus (*sensu* Krystyn) and the Regoledanus Zones are recorded in the Wengen Fm. In particular, recent preliminary samplings at Stabol Fresco show that the FO of *Frankites* occurs in the lower half of the formation. This data should come together with the CSFW section to demonstrate that the *Frankites regoledanus* (range) zone represents a large part of Mojsisovics' *P. archelaus* Oppel-zone.

The new picture of the platform/basin relations that seems to emerge from Eastern Lombardy is much more similar to the classic evolution of the Eastern Dolomites. In the Dolomites it is well known that the Ladinian basins are covered by the prograding of the platforms during the Carnian (Assereto & al., 1977; Bosellini, 1982; Bosellini, 1984; Bosellini, 1991) and not in the Ladinian.

Paleogeography.

If the lithostratigraphic position of the "Carbonate platform" of Corna S. Fermo-Pizzo Camino is a matter of discussion, its paleogeographic significance is clear. The Breno Fm. does not represent a uniform carbonate platform bounding the Lombardian basin to the North during the Carnian (i.e. Brusca et al., 1982), but the Carnian paleogeography is more complex.

Taking into account the palinspastic position of the Pizzo Camino unit, during the Early Carnian two carbonate platforms separated by a deep and wide interplatform basin can be recognized along a N-S transect (Fig. 14, 15). The Camino platform bound to the North the Lozio basin, while the Breno *s.s.* platform is located some tens of km to the South. The platforms show different evolutions: the Camino platform is thicker with respect to the Breno *s.s.* platform, then it grows by aggradation and progradation. The source area for the turbidites of the Pratotondo Limestone is the northern platform that probably has two prograding stages. The Lozio Shale fills in part the basin and displays onlap relationships with the platform. It is worth noting that both northern margins of the two platforms are not preserved.

However, several details of the new reconstruction are not yet understood, mostly due to the lack of data between the Lozio basin and the Breno platform. The main open questions can be outlined as follows:

1) The huge thickness of the "Pietra verde" tuffs in the Buchenstein Fm. at the CSFW section is very unusual for the Lower Ladinian succession of the Western Southern Alps, because in general the tuffitic intercalations within the Buchenstein Fm. in Lombardy-Giudicarie do not exceed 1-1.5 m in thickness (Castellarin et al., 1982; Brack & Rieber, 1986, 1993; Kovács et al., 1990). The paleogeographic significance of this peculiarity is not easily resolved at present. The position of Early Ladinian volcanoes has not yet been analysed in detail, so their location is less clear with respect to the Late Ladinian and Carnian times, when they are located south of the Southern Alps (i.e. Brusca et al., 1982; Viel, 1979). One possible explanation could be a volcano located in the lower part of the Dezzo Valley (Scalve Valley: Jadoul & Rossi, 1982), however the CSFW section shows an astonishing record of volcanic activity with respect to other sites surrounding Dezzo (i.e. S. Valentino, La Baita, Contrada Gobbia) and, among these sites, CSFW is not the most proximal one to Dezzo. In our opinion, the possibility that one or more volcanoes could be located north of the Western Southern Alps cannot be excluded. This possibility would provide an alternative explanation for the increasing thickness of the Middle Triassic volcanic intercalations towards the North (Jadoul & Rossi, 1982), with respect to the hypothesis of Jadoul & Rossi (1982) who explain this trend as paleogeographically controlled by the position of the basins in the North with respect to the platform/emerged environments in the South.

2) The relationships between the Wengen Fm. of the LEV section and the Wengen Fm. of the Annunciata section (Jadoul et al., 1979; Fig. 15) are not simple. Probably there are two different source areas for these facies, but their location has still to be located.

3) More generally, the provenance of the carbonate sediment of the calcareous member of the Wengen Fm. is not fully clear. This member indicates that one or more carbonate platforms are growing during the deposition of the Wengen Fm. However, the thickness of the Esino Lmst. in the southern sections (Annunciata) probably is not enough to justify such an important carbonate supply from the South. Actually, a possible Upper Ladinian core of the platform in the eastern part of the Pizzo Camino unit (Concarena) could provide a good explanation, but thick "Esino Limestone" successions are also reported North of the Presolana (Rifugio Albani section: Fig. 13) in the Presolana unit.

4) The source area of the Lozio Shale is not yet known. Certainly it is not from the South, because the Breno *s.s.* platform could not be bypassed by such an amount of shales without any record in the platform. Probably it is from the present Northeast to ?East. The provenance from the present North can be excluded because of the barrier represented by the Camino platform.

5) The revision of the lithostratigraphic attribution of the carbonate unit overlying the Lozio Shale in the AVS unit should be the key for understanding the correlations with the classic Carnian sections of the lower Camonica Valley (Fig. 15).

Systematic Paleontology

The taxonomy of the ammonoids from order to genus level is taken from Tozer, 1981 and 1994. In text the specimens are identified with inventory number and sample number in brackets. Due to the great historical significance most of the ammonoids have been described even if their preservation is often rather poor. Dimensions: D=diameter (mm); H=max. whorl height in D (mm); U=umbilicus in D (mm); W=whorl width in H (mm).

The ammonoids are housed in the Museo Civico di Scienze Naturali "E. Caffi", Piazza Cittadella 10, 24129 Bergamo.

Only stratigraphically important species of conodonts are here described. The taxonomy from phylum to order level is taken from the Treatise (Clark et al., 1981). Genera and species are arranged in alphabetic order.

Phylum **Mollusca** Cuvier, 1797

Class Cephalopoda Cuvier, 1797

Subclass Ammonoidea Zittel, 1884

Order Ceratitida Hyatt, 1877

Superfamily Danubitaceae Spath, 1951

Family Danubitidae Spath, 1951

Genus ? *Celtites* Mojsisovics, 1882

Type species: *Celtites epolensis* Mojsisovics, 1882

Celtites epolensis Mojsisovics, 1882

Pl. 1, fig. 1

v 1882 *Celtites epolensis* Mojsisovics, p. 149, pl. 29, fig. 1,2; pl. 38, fig. 13.
1901 *Celtites epolensis* - Tommasi, p. 59.
1977 *Celtites epolensis* - Urlichs, pl. 1, fig. 10, 11.

v 1994 *Celtites epolensis* - Balini, pl. 3, fig. 2, 3.
1995b *Celtites epolensis* - Mietto & Manfrin, pl. 1, fig. 18.
1998a *Celtites epolensis* - Broglio Loriga et al., pl. 1, fig. 18.

Material. 4 specimens: MSNBG 9476 (DG5), 9482 (DG202), 9483 (DG202), 9485 (DG204).

Description. The specimens at hand are equivalent to the types of the species (Mojsisovics, 1882; Balini, 1994) with respect to preservation, coiling and pattern of ribbing. The suture line is not visible.

Remarks. The specimens do not allow to improve the knowledge on this species. As a consequence it is not possible to solve the doubts suggested by Spath (1951) and Tozer (1981; pers. com., 1993) on the definite significance of the genus *Celtites* Mojsisovics, 1882. *Celtites epolensis* Mojsisovics, 1882 is the type of the genus (Hyatt & Smith, 1905), but since its suture line and length of body chamber is unknown, it is not possible to make comparisons with the very similar genera *Tropigastrites* Smith, 1914, *Orthoceltites* Spath, 1951, and *Danubites* Mojsisovics, 1893.

Occurrence. Wengen Fm., Fopponi section levels DG202 and DG204, Upper Ladinian. CSFW section, IV segment, level DG5 (=MB124=DG90), Lower Carnian.

? Family L e c a n i t i d a e Hyatt, 1900
Genus *Lecanites* Mojsisovics, 1882

Type species: *Ammonites glaucus* Münster, 1834

Lecanites glaucus (Münster, 1834)

1952 *Lecanites glaucus* - Leonardi & Polo, p. 7, pl. 1, fig. 14; pl. 3, fig. 13-14,37-38. (*cum syn.*)
1977 *Lecanites glaucus* - Urlichs, pl. 1, fig. 9.

Material. 1 crushed specimen, MSNBG 9468 (DG90).

Occurrence. Wengen Fm., CSFW section, IV segment, level DG90 (=MB124=DG5), Lower Carnian.

Superfamily C l i d o n i t a c e a e Hyatt, 1877
Family T r a c h y c e r a t i d a e Haug, 1894
Subfamily P r o t r a c h y c e r a t i n a e Tozer, 1971
Genus *Eoprotrachyceras* Tozer, 1980

Type species: *Eoprotrachyceras matutinum* Tozer, 1980

Eoprotrachyceras sp. ind.

Material. 1 specimen, MSNBG 9458 (DG71).

Description. The rather small specimen (D about 3 cm) is of poor quality. Only one side of half whorl is incompletely preserved: the umbilical border and part of the side are broken. The involuteness of coiling cannot be checked. Ventral and ventrolateral nodes are well visible, as well as at least one row of lateral nodes on the preserved part of the lateral side. All the nodes are rounded and show the same kind of elevation. The distance between lateral and ventrolateral nodes is slightly higher than the distance between ventrolateral and ventral nodes. Ribbing is dense and each rib bears one node of each row. No bifurcation occurs on the preserved part of the lateral side.

Discussion. The full classification of the specimen is impossible because of its poor quality and small size. Unfortunately, some of the species of *Eoprotrachyceras* (i.e. *E. curionii* [Mojsis.]) in literature are described only on the basis of large sized specimens.

Occurrence. Buchenstein Fm., CSFW section, II segment, level DG71, Lower Ladinian.

Subfamily T r a c h y c e r a t i n a e (Haug, 1894)
Genus *Asklepioceras* Renz, 1911

Type species: *Arpadites segmentatus* Mojsisovics, 1893

Asklepioceras cf. **loczyi** (Diener, 1899)
Pl. 1, fig. 2

Material. 1 specimen MSNBG 9481 (DG201bis).

Description. The diameter of the specimen is about 31-32 mm. Notwithstanding the compactional crushing, the ventral side is clearly sulcate. Nothing can be said about H/W ratio, however the specimen does not seem to be thick whorled; the coiling seems to be rather involute. About 9 constrictions can be counted in half whorl. The constrictions show a concave course: they are almost straight in the first 1/3 to 1/2 of whorl height, then they become strongly projected.

Discussion. The dense segmentation seems to be a good feature for the classification of the specimen. Among the rather restricted literature on *Asklepioceras*, similarity can be found with *Asklepioceras loczyi* (Diener). Due to the flattening of the specimen no comparison of ventral side on the beginning of the outer whorl is possible, nevertheless the pattern of the dense segmentation fits very well. *A. segmentatum* Mojsisovics, 1893 (type of the genus) features a less dense segmentation, done by constrictions that are more widely spaced already at the periumbilical border. A dense segmentation can be found in most of the specimens reported as *Asklepioceras* sp. by Mietto & Manfrin, 1995b (pl. 1, fig. ?2, 8, 13), however in these specimens the pattern of constrictions is definitely sinuous.

Occurrence. Wengen Fm., Fopponi section, level DG201bis, Upper Ladinian.

Genus *Frankites* Tozer, 1971

Type species: *Paratrachyceras sutherlandi* McLearn 1947

Frankites regoledanus (Mojsisovics, 1869)
Pl. 1, fig. 3-4

1869 *Ammonites (Trachyceras?) regoledanus* Mojsisovics, p. 134, pl. 3, fig. 7-8.
v 1882 *Trachyceras regoledanum* - Mojsisovics, p. 132, pl. 29, fig. 6,7,8.
1901 *Trachyceras regoledanum* - Tommasi, p. 58. (nn)
1908 *Protrachyceras* cf. *regoledanum* - Kittl, p. 495. (nn)
non 1908 *Protrachyceras* sp. ind. cf. *regoledanum* - Diener, p. 25, pl. 1, fig. 7.
1913 *Trachyceras regoledanum* - Simionescu, p. 298, pl. 3, fig. 8.
1914 *Paratrachyceras regoledanum* - Arthaber, p. 137, pl. 16, fig. 1.
1931 *Trachyceras (Paratrachyceras) regoledanum* - Voelcker, p. 455. (nn)
? 1960 *Trachyceras (Paratrachyceras)* cf. *T. (P.) regoledanum* - Kummel, p. 687, pl. 83, fig. 1-2; pl. 84, fig. 10.
non 1964 *Trachyceras regoledanum mundevillae* - Leonardi, pl. 6, fig. 2-3.
v 1994 *Trachyceras regoledanum* - Balini, pl. 4, fig. 3.
1995a *Frankites regoledanus* - Mietto & Manfrin, pl. 5, fig. 3, 4.
1995b *Frankites regoledanus* - Mietto & Manfrin, pl. 1, fig. 6, 9, 15.
1998a *Frankites regoledanus* - Broglio Loriga et al., pl. 1, fig. 6, 9, 15.

Material. 2 specimens, MSNBG 9464 (MB126) and 9466 (DG91).

Description. The specimens are flattened and preserved with test. The larger one (MSNBG 9466) is also preserved only on one side. Both the specimens show the same involute coiling. Due to compaction the ventral side is not very well visible, but the lateral ornamentation is typical. The ribs are almost flat, with very narrow inter-rib space. The orientation of the ribs is proverse. Ribs are just a little sinuous on the side, then they become definitely projected near to the ventrolateral margin. Rib type is slightly different in the specimens. On the smaller specimen, between 10 and 13 mm of whorl height ribs arise from the umbilical border in couples. One rib in each couple is primary, while the other bifurcates between 1/4 and 1/3 of whorl height. The bifurcation may affect the first rib of the couple, or the second. About 5 couples in 1/4 of whorl can be counted on the smaller specimen.

In the larger specimen the couples of primary ribs are prevailing on the other types. Every two-three couples there is a simple primary rib alone, and on 7 couples there is one couple showing the bifurcation at 1/3 of whorl height. The suture line is not visible.

Discussion. The attribution of *Ammonites regoledanus* Mojsisovics, 1869 to *Frankites* Tozer, 1971 *vs* *Paratrachyceras* Arthaber, 1914 is a matter of discussion (Tozer, 1971) because the most important difference between the two genera is in the suture line, that is not known in the specimens from the Wengen Fm. of Lombardy. The specimens at hand do not allow to solve this problem, but for the moment we follow the traditional attribution.

The specimens have been compared with the holotype of the monotypic species *Frankites apertus* (Mojsisovics, 1893), a species whose relationship with *F. regoledanus* is debated (Balini et al., 1998; Mietto & Manfrin, 1999). The holotype (Geologische Bundesanstalt, Wien, 1893/01/0132) overlaps the inner 3/4 of whorl of the specimen MSNBG 9466 (Pl. 1, Fig. 4) and shows a similar umbelicus. The main difference is in the ribs which are wider in the specimen from the Wengen Fm. From the ribbing point of view the type of *F. apertus* is more similar to the smaller specimen from the Wengen Fm. (MSNBG 9464; Pl. 1, Fig. 3), but the type of *F. apertus* shows 7 couples of ribs in 1/4 of whorl instead of 5. The scarcity of specimens at hand (only 2 *F. regoledanus* compared with only 1 *F. apertus*) does not allow to understand the differences in term of population variability. For the moment we separate the two species.

Remarks on synonymy. The specimen classified by Diener (1908) is almost probably a *Frankites*, but it cannot be included in *F. regoledanus* because of the occasional bifurcation in the marginal zone. This feature has never been observed in the specimens from Lombardy.

The identification by Leonardi (1964) is rejected because the coiling is not as involute as in the specimens from Lombardy. Moreover the specimen on pl. 6, fig. 2 seems to have intercalatory ribs.

The specimens attributed with *confronta* to *Trachyceras regoledanum* by Kummel (1960) cannot be fully revised. Branching of the ribs is not neither described in text nor well visible in plates. It seems to occur at umbilical border on pl. 84, fig. 10, but only two couples of ribs are exposed on this fragment.

Occurrence. Wengen Fm., CSFW section, IV segment, levels MB126 and DG91, Upper Ladinian.

Genus *Trachyceras* Laube, 1869

Type species: *Ammonites (Ceratites) aon* Münster, 1834

Trachyceras sp. ind.

Material. 1 specimen MSNBG 9473 (DG5).

Description. The specimen is preserved only in 1/4 of whorl. Whorl height is about 10 mm. A very thin coating of sediment covers the shell, so that the ribbing is not very well visible. On the contrary the nodes well emerge from the sediment. About 10 spiral rows of nodes are visible on the lateral side, moreover 2 rows of double nodes are located in ventrolateral and ventral position. In each couple the inner node is two times bigger than the outer one. Ventral sulcus very narrow.

Discussion. The attribution of the specimen to *Trachyceras* Laube, 1869 is sure, because of the very typical double nodes in ventral position. The full classification is at the moment impossible not only because of the poor preservation of the specimen, but also because of the incomplete knowledge on the early *Trachyceras*. Only the group of *T. aon* is described and illustrated (Urlichs, 1974 and 1994; Krystyn, 1978), while the study of the specimens found by Mietto & Manfrin below the FO of *T. aon* at Stuores Wiesen (Mietto & Manfrin, 1995b; Manfrin & Mietto in Broglio Loriga et. al., 1998a, 1998b, 1999) is not yet concluded. A ventrolateral series of double nodes can be found in *T. aon*, however, in this species the larger node of the couple is the outer, instead of the inner.

Occurrence. Wengen Fm., CSFW section, IV segment, level DG5 (=MB124=DG90), Lower Carnian.

Subfamily S i r e n i t i n a e Tozer, 1971

Genus *Sirenotrachyceras* Krystyn, 1978

Type species: *Protrachyceras (Trachyceras) hadwigae* Mojsisovics, 1893

Sirenotrachyceras ? sp. ind.

Pl. 1, fig. 5

Material. 1 specimen, MSNBG 10129 (DG177).

Description. The specimen is preserved on the surface of a marly limestone bed. Besides slightly sinuous and weak ribs the specimen shows spirally elongate nodes. They are arranged in lateral (at least 3 rows), ventrolateral and ventral position. The periumbilical border is not preserved.

Remark. The very small size prevents from a full classification. The spiral elongation of all the visible nodes points to *Sirenotrachyceras* Krystyn 1978 instead of *Protrachyceras* Mojsisovics, 1893. The latter sometimes has spirally elongated nodes, but only in the external rows of medium to large sized specimens.

Occurrence. Wengen Fm., Fopponi section, level DG177, Upper Ladinian.

Family C l i o n i t i d a e (Arabu, 1932)

Genus *Clionitites* Strand 1929

Type species: *Clionites angulosus* Mojsisovics 1893

Remarks. The genus *Clionitites* includes species displaying a wide variety of ventral shapes, from sulcate to depressed, sometimes with ribs that crosses the venter (i.e. Tozer, 1994). The style of tuberculation is also wide, and marginal nodes are not always present. This very wide variability in the ventral area is quite unusual in Triassic ammonoids, and should suggest a taxonomic revision of the genus. Unfortunately a revision through population analysis is difficult because the specimens usually attributed to *Clionitites* are of small to very small size, while the type specimens from the condensed Hallstatt Limestone (Mojsisovics, 1893) are of medium to large size and lack of well constrained stratigraphic position.

The specimens from Wengen Fm. of Lombardy belong to the group of *Clionitites* with marginal tuberculation.

Clionitites aff. **busiris** (Münster, 1834)

Pl. 1, fig. 7, 8, 9a-c

Material. 7 specimens, MSNBG 9467 (DG90), 9469 (MB124), 9470 (MB124), 9471 (DG5), 9472 (DG5), 9474 (DG5), 9477B (DG5).

Description. The specimens of small size (D about 10 mm: pl. 1, fig. 8-9) are preserved in 3 dimensions, while the larger ones (D about 26-28 mm) are crashed by sediment compaction (Pl. 1, fig. 7). The coiling is evolute: U is 38-40% of D. Whorl section suboval; maximum width at about 1/3 of whorl height. Ornamentation done by ribs and marginal nodes. On the inner whorls rib-type is primary and intercalatory, with almost regular alternation of both types. The total number of ribs in half whorl is about 22. On the outer whorl the primary type prevails on the intercalatory type. Rib shape is sinuous on the inner whorls, then sigmoidal to almost biconvex on the outer whorl. The ribs do not cross the narrow venter, that is practically flat. The specimens show differences in the strengthen of ribs: Pl. 1, fig. 9 is relatively strongly ribbed, while the ribs of Pl. 1, fig. 7 and 8 are a little weaker. General fading of the ornaments on the termination of the preserved part of the outer whorl: nodes are reduced and ribs fade into "growth lines" (specimen MSNBG 9470, not figured). Suture line not exposed.

Dimensions (mm)

Specimen	D	H	U
MSNBG 9471	12.3	3.5	5

Remarks. The full classification of the specimens is difficult because of their preservation and also because of the complex literature. On the basis of ribbing our specimens can be compared with *Ceratites busiris* Münster, 1834 and *Ceratites basileus* Münster, 1841, both the species with a single row of nodes in ventral position. The difference between the two species is not clear. Laube (1870) includes in *C. busiris* quite wide variety of forms including also strongly ribbed specimens (pl. 41, fig. 3-8). Mojsisovics (1882) refers the same specimens to *C. basileus* so that the variability of *C. busiris* is restricted. We have no elements to solve the problem of the variability of *Clionitites busiris* and *Clionitites basileus*, but we are inclined to give priority to *C. busiris*.

Occurrence. Wengen Fm., CSFW section, IV segment, level MB124=DG5=DG90, Lower Carnian.

Clionitites sp. ind.

Pl. 1, fig. 6

Material. 1 specimen, MSNBG 10128 (MB124).

Description. The small specimen is preserved in 3D. Ornamentation made of ribs and marginal nodes. Rib type primary and intercalatory/bifurcate, with an almost 1:1 ratio. In a quarter of whorl there are 6 primary and 4 secondary ribs (=10 marginal nodes). Primary ribs seem to be slightly inflated in the first half of whorl height then in the outer part they become weak. Secondary ribs are also weak, then sometimes the separation of intercalatory from bifurcate type is difficult. The intercalatory type is surely prevailing on bifurcate.

Discussion. The specimen is separated from *Clionitites* aff. *busiris* because of the weaker and less dense ribbing. The comparison with the literature is difficult for the above mentioned problems. The specimen at hand does not fit very well with the specimens classified by Mojsisovics (1882, pl. 24, fig. 27-31) as *Trachyceras basileus* (Münster) which have weaker but much more closely spaced ribs.

Occurrence. Wengen Fm., CSFW section, IV segment, level MB124, Lower Carnian.

Phylum **Conodonta** Eichenberg, 1930

Class **C o n o d o n t a** Eichenberg, 1930

Order **Conodontophorida** Eichenberg, 1930

Genus *Budurovignathus* Kozur, 1988

1973 *Carinella* Budurov, p. 799.
1988 *Sephardiella* March et al., p. 247.

Type species: *Polygnathus mungoensis* Diebel, 1956

Budurovignathus diebeli (Kozur & Mostler, 1971b)

Pl. 2, fig. 4, 5, 6; Pl. 3, fig. 5

1971b *Tardogondolella diebeli* Kozur & Mostler, p. 13-14, pl. 2, fig. 1-2 (non fig. 3).
1972 *Epigondolella diebeli* - Kozur & Mostler, p. 792-795, pl. 2, fig. 1- 8.
1975 *Metapolygnathus diebeli* - Krystyn in Kristan-Tollmann & Krystyn, p. 273, pl. 2, fig. 5-7, pl. 3, fig. 5 (non fig.6).
1980b *Metapolygnathus diebeli* - Kovács & Kozur, pl. 7, fig. 9; pl. 10, fig. 7-9.
1980 *Carinella diebeli* - Krystyn, pl. 11, fig.6.
1983 *Epigondolella diebeli* - Krystyn, pl. 8, fig. 7, 8, 9.
1987 *Carinella diebeli* - Vrielynck, p. 123, 124, pl. 1, fig. 13-15.
1988 *Budurovignathus diebeli* - Kozur in CFS, 102; p. 244-245.
1989b *Budurovignathus diebeli* - Kozur, pl. 12, fig. 3.
1990 *Carinella diebeli* - Budurov & Sudar, p. 214, pl. 3, fig. 1-8.
1994 *Budurovignathus diebeli* - Neri et al., pl. 1, fig. 5.
1995 *Budurovignathus diebeli* - Neri et al., pl. 2, fig. 2-4.
1997 *Budurovignathus diebeli* - Mastandrea et al., p. 42-43, pl. 1, fig. 5-8.
1998 *Budurovignathus diebeli* - Nicora & Rizzi, pl. 1.1.1, fig. 1.
1998 *Budurovignathus diebeli* - Mastandrea et al., pl. 4.2.2, fig. 1, 5-7.
1999 *Budurovignathus diebeli* - Mastandrea in Broglio Loriga et al., pl. 3, fig. 7, 11.

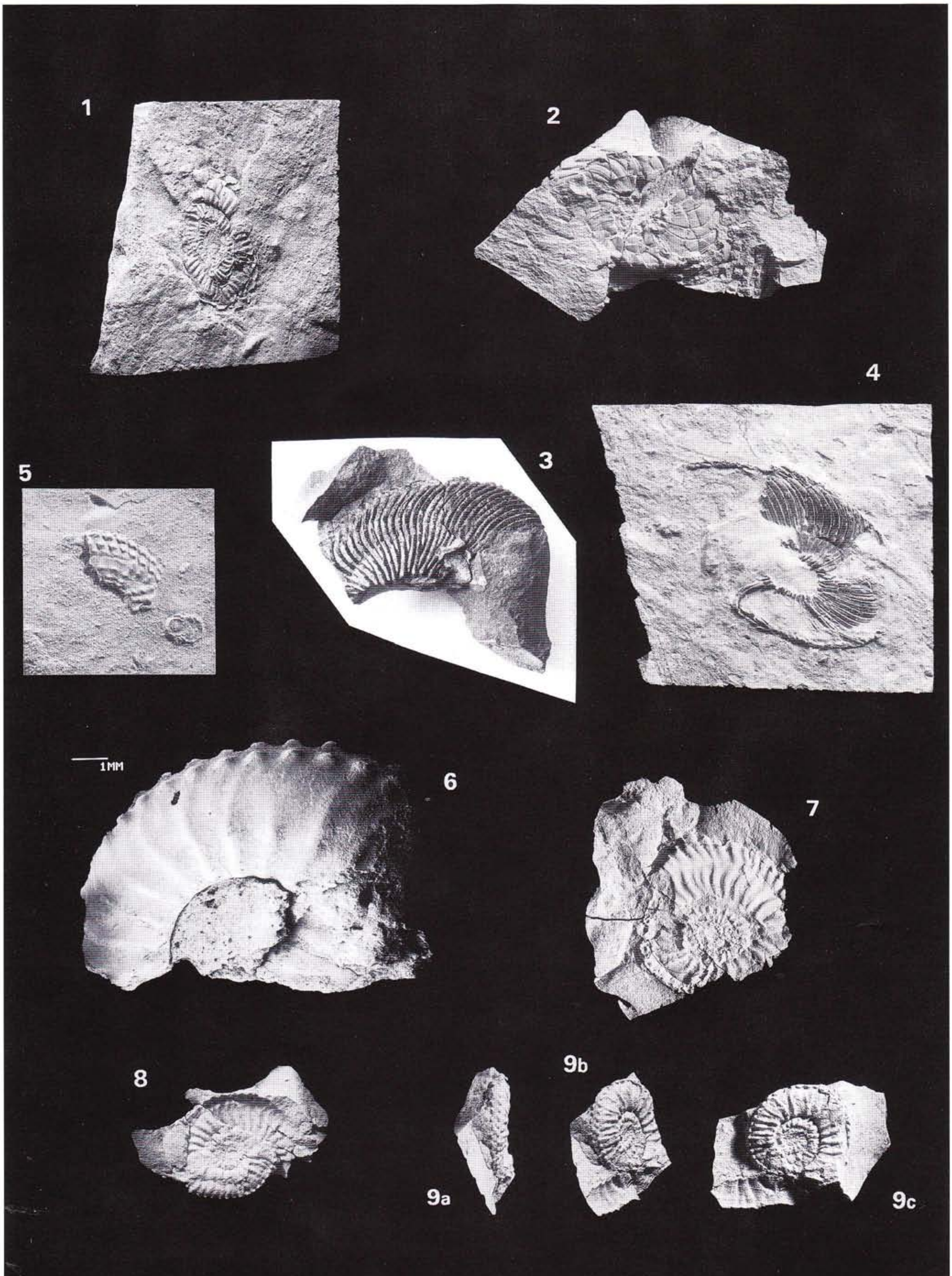
Description. In the material at hand, platform margins are symmetrical at both sides, slightly refolded upward, frequently with secondary nodules which vary between 3 and 7, from poorly developed and restricted to the anterior portion of the platform, to well evident alongside the whole platform margin. The posterior platform margin varies from straight to very slightly asymmetric. Sometimes a V-shaped posterior platform margin develops. The carina is moderately high, at the anterior margin, in correspondance of the free blade, and it decreases regularly toward the posterior margin. The free blade is characterized by denticles which are fused for approximately the 2/3 of the height. Sometimes denticles are totally fused. The last 3-4 posterior denticles of the carina are generally small, conics, and well spaced. In the lower surface often a bifurcated posterior termination of the keel is present, but also specimens without bifurcation posterior to the pit are present (Pl. 3, fig.5; see also Kozur & Mostler, 1972, pl. 2, fig.1c; Krystyn, 1983, pl. 8, fig. 7b). The basal cavity is located generally at the beginning of the third back, characterized by a basal pit hardly distinguishable.

Remarks. The specimens of *B. diebeli* we have well correspond to the holotype with strong nodes developed on both margins of the platform.

PLATE 1

Fig. 1 - *Celtites epolensis* Mojsisovics, 1882, Wengen Fm., Fopponi section, MSNBG 9482 (DG202), lateral view, x 1.
Fig. 2 - *Asklepioceras* cf. *loczyi* (Diener, 1899), Wengen Fm., Fopponi section, MSNBG 9481 (DG201bis), lateral view, x 1.
Fig. 3-4 - *Frankites regoledanus* (Mojsisovics, 1869), Wengen Fm., CSFW section: 3) MSNBG 9464 (MB126), lateral view, x 1.5; 4) MSNBG 9466 (DG91), lateral view, x 1.
Fig. 5 - *Sirenotrachyceras* ? sp. ind., Wengen Fm., Fopponi section, MSNBG 10129 (DG163), lateral view, x 1.5.
Fig. 6 - *Clionitites* sp. ind., Wengen Fm., CSFW section: MSNBG 10128 (MB124), SEM image, lateral view, bar scale 1 mm.
Fig. 7, 8-9a-c - *Clionitites* aff. *busiris* (Münster, 1834), Wengen Fm., CSFW section: 7) MSNBG 9469 (MB124), lateral view, x 1; 8) MSNBG 9467 (DG90), lateral view, x 1.5; 9) MSNBG 9471 (DG5), a) ventral view, b) oblique view, c) lateral view, all x 1.5.

All specimens except for 3, 4 and 6 are whitened with Ammonium Chloride.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B. mungoensis differs from *B. diebeli* by an asymmetrical, strongly turned aside and pointed platform. Transitional forms to *B. mungoensis* have been noted (Pl. 3, fig. 5).

Occurrence. 12 specimens: 2 specimens from Wengen Fm. at CSFW section; IV segment; 8 specimens from Pratotondo Limestone at Pratotondo section; 2 specimens from Pratotondo Limestone at LEV section, III segment.

Stratigraphical range and distribution.

- Late Ladinian Early Carnian (uppermost part Maclearni Sutherlandi Aonoides Zones) *sensu* Kozur & Mostler (1971b);

- Late Longobardian - Early Julian (I subzone, *Aonoides* Z.) *sensu* Krystyn (1978, 1980);

- Late Longobardian - earliest Julian (*P. archelaus* Z. - *F. regoledanus* Z. - base of the *T. aonoides* Z. s.l.) *sensu* Krystyn (1983);

- latest Longobardian - Cordevolian *sensu* Budurov & Sudar (1989); Cordevolian (*F. regoledanus* Z.) *sensu* Kovács et al. (1991).

This species has recognized into Tethyan and Asiatic Provinces.

Budurovignathus mostleri (Kozur, 1972)

Pl. 2, fig. 3

1971b *Tardogondolella mungoensis catalana* - Kozur & Mostler, p. 23, fig. 5.
1972 *Epigondolella mostleri* Kozur in Kozur & Mock, p. 9, 10, pl. 1, fig. 8.
1972 *Metapolygnathus mostleri* - Kozur, p. 3, 7, 15, 16, pl. 2, fig. 8, 9.
1980b *Metapolygnathus mostleri* - Kovács & Kozur, pl. 8, fig. 4.
1983 *Metapolygnathus mostleri* - Kovács, pl. 6, fig. 2.
1983 *"Epigondolella" mostleri* - Krystyn, pl. 8, fig. 4-6.
1988 *Budurovignathus mostleri* - Kozur in CFS, 102; p. 244-245.
1992 *"Epigondolella" diebeli* - Chhabra & Kumar, pl. 4, fig. 10.
1994 *Budurovignathus mostleri* - Neri et al., pl. 1, fig. 3.
1995 *Budurovignathus mostleri* - Neri et al., pl. 2, fig. 11-12.
1997. *Budurovignathus mostleri* - Mastandrea et al., p. 44, pl. 2, fig. 1-3.
1998 *Budurovignathus mostleri* - Mastandrea et al., pl. 4.2.2, fig. 2-4.
1999 *Budurovignathus mostleri* - Mastandrea in Broglio Loriga et al., pl. 3, fig. 3-4.

Description. The platform is symmetrical and it extends for approximately 1/2 - 2/3 of the total length of the unit; it displays a typically pointed posterior end, establishing a sub-triangular outline of the element in upper view, even if moderately lengthened.

The margins of the platform present 2-3 secondary nodules on both sides of the specimen, even if they are limited only to the anterior half of the platform.

The basal cavity is very small, positioned from sub-central to the beginning of the third back.

This species has been recovered only at the LEV Section, III segment (samples DG129 and DG60) and at the Fopponi Section (sample DG164).

Remarks. *B. mostleri* differs from *B. diebeli* by the pointed posterior termination of the platform and "sub-triangular" outline of the platform. The specimens found are quite massive and primitive.

Occurrence. 2 specimens found at the Pratotondo Limestone at LEV section, III segment; 1? specimen found in the "Carbonate platform" at Fopponi section.

Stratigraphical range and distribution.

- Late Longobardian - Cordevolian (Sutherlandi, Aonoides Zones) *sensu* Kozur (1980);

- upper part of the Longobardian (*Regoledanus* Zone *pars.*) *sensu* Krystyn (1983);

- Longobardian (Upper *F. regoledanus* Z.) *sensu* Kozur (1989b);

- earliest Carnian (*F. regoledanus* Z.) *sensu* Kovács et al. (1991).

This species has recognized into Tethyan Province (Southern Alps and Balaton Highlands, Hungary).

Budurovignathus mungoensis (Diebel, 1956)

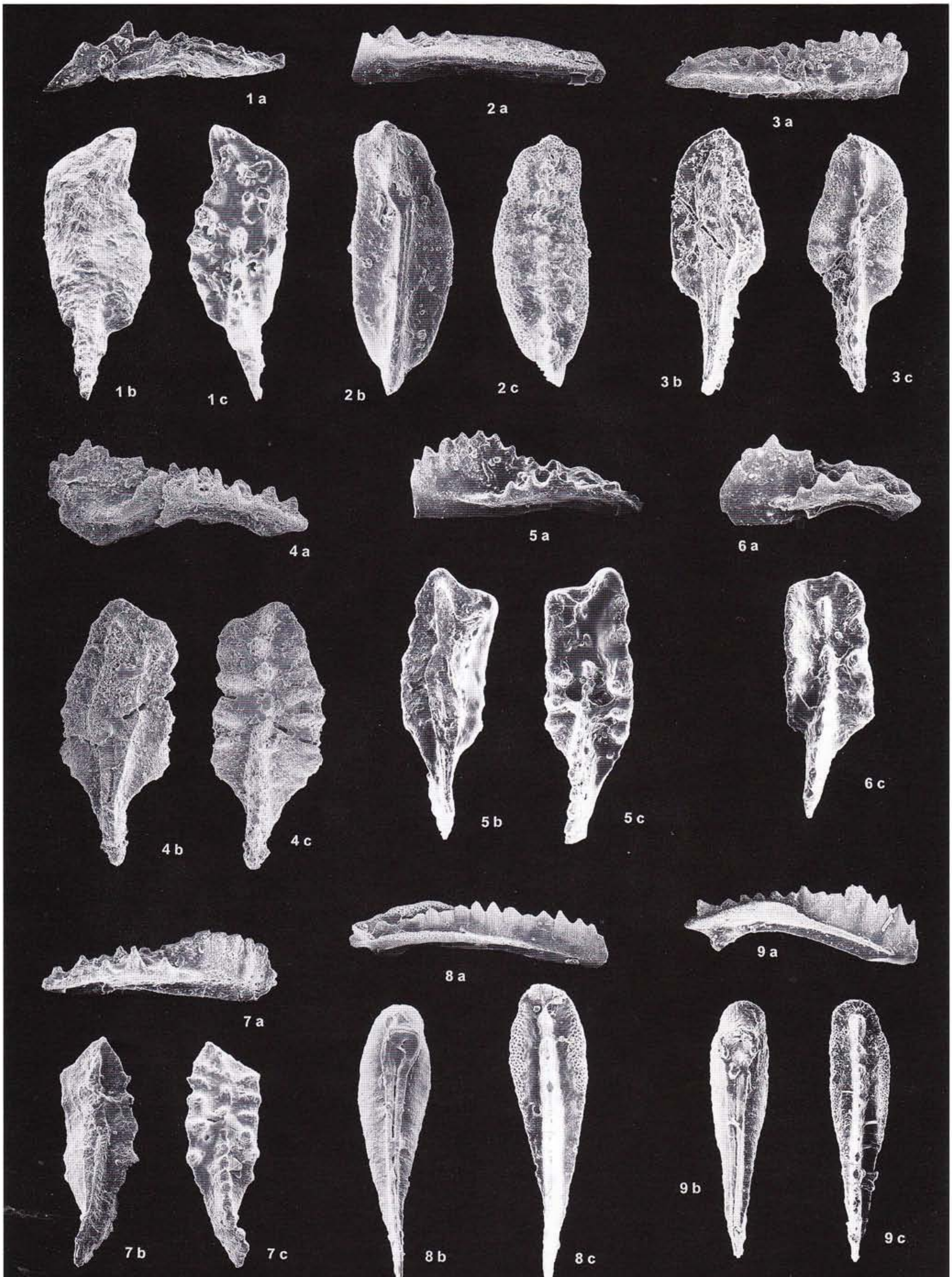
Pl. 2, fig. 1

1956 *Polygnathus mungoensis* Diebel, p. 431, 432, pl. 1 fig. 1-20; pl. 2, fig. 1-4; pl. 3, fig. 1; pl. 4, fig.1.
1966 *Gondolella catalana* Hirsch, p. 86, pl. 1, fig. 1-4.
1970 *Epigondolella mungoensis* - Huddle, p. 127, fig. 2 a-h.
1971 *Epigondolella mungoensis* - Sweet et al., p. 449, pl. 1, fig. 14, 19.
1973 *Tardogondolella mungoensis mungoensis* - Van der Boogard & Simon, p. 17, pl. 1, fig. c, pl. 2, fig. a, b.
1980b *Metapolygnathus mungoensis* - Kovács & Kozur, pl. 7, fig. 3.

PLATE 2

Fig. 1 a, b, c - *Budurovignathus mungoensis* (Diebel), specimen with wide platform in the middle portion; Wengen Fm., LEV section, II segment, sample DG124; x 90.
Fig. 2 a, b, c - *Gladigondolella malayensis malayensis* Nogami; Wengen Fm., LEV section, II segment, sample DG124; x 90.
Fig. 3 a, b, c - *Budurovignathus mostleri* (Kozur); Pratotondo Limestone, LEV section, III segment, sample DG129; x 80.
Fig. 4 a, b, c - *Budurovignathus diebeli* (Kozur & Mostler); Pratotondo Limestone, Pratotondo section, sample DG230; x 80.
Fig. 5 a, b, c - *Budurovignathus diebeli* (Kozur & Mostler); Pratotondo Limestone, LEV section, III segment, sample DG133; x 80.
Fig. 6 a, c - *Budurovignathus diebeli* (Kozur & Mostler); Pratotondo Limestone, LEV section, III segment, sample DG133; x 80.
Fig. 7 a, b, c - *Budurovignathus diebeli* (Kozur & Mostler); Pratotondo Limestone, LEV section, III segment, sample DG133; x 80.
Fig. 8 a, b, c - *Paragondolella foliata* Budurov; Pratotondo Limestone, LEV section, III segment, sample DG133; x 90.
Fig. 9 a, b, c - *Paragondolella polygnathiformis* (Budurov & Stefanov); Pratotondo Limestone, LEV section, II segment, sample DG127; x 90.

a) lateral view, b) lower view, c) upper view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1980 *Carinella mungoensis* - Krystyn, pl. 11, fig. 5.
1983 *Epigondolella mungoensis* - Krystyn, p. 243, pl. 8, fig. 1-3.
1988 *Budurovignathus mungoensis* - Kozur in CFS, 102, p. 244, 245.
1990 *Budurovignathus mungoensis* - Saddedin, p. 376, fig. 5.3 (*cum syn.*).
1990 *Sephardiella mungoensis* - March et al., p. 198, pl. 1, fig. a-p.
1994 *Budurovignathus mungoensis* - Neri et al., pl. 1, fig. 1.
1995 *Budurovignathus mungoensis* - Neri et al., pl. 2, fig. 7-9.
1997 *Budurovignathus mungoensis* - Mastandrea et al., p. 44, pl. 1, fig. 9-10.
1998 *Budurovignathus mungoensis* - Mastandrea et al., pl. 4.2.1, fig. 5-6.
1999 *Budurovignathus mungoensis* - Mastandrea in Broglio Loriga et al., pl. 3, fig. 5-6, 10.

Description. The platform displays a sigmoidal contour, with a pointed posterior end, turned on the outer side of the specimen.

On the outer side four secondary nodules are present, that reduce in height beginning from the second anterior nodule, while at the inner side crenulations are present.

At correspondence of the antepenult denticle is present an "accessory" tooth, in correspondence of the corner between the back side and the left flank of the specimen.

The lower margin is straight, the basal cavity is extremely small, positioned at the beginning of the third back. The keel is well developed and furrowed both anteriorly and posteriorly to the basal cavity, with a termination only slightly bifurcated.

Remarks. The specimen found shows the typical characters of the species.

Occurrence. 1 specimen from at the Wengen Fm. at the LEV section, II segment.

Stratigraphical range and distribution.

- Late Ladinian - Cordevolian *sensu* Kozur (1980);
- Late Ladinian - Cordevolian *sensu* Kovács & Kozur (1980b);
- Longobardian - earliest Julian (I subzone, *Aonoides* Z.) *sensu* Krystyn (1978, 1980);
- Longobardian (upper part of Gredleri Z, *P. archelaus* Z., *F. regoledanus* Z.) *sensu* Krystyn (1983);
- Longobardian *sensu* Budurov & Sudar (1989);
- Longobardian - Cordevolian (*F. regoledanus* Z.) *sensu* Kovács et al. (1991).

This species has been recognized into the Tethyan Province.

Genus *Gladigondolella* Muller, 1962

Type species: *Polygnathus tethydis* Huckriede, 1958

Gladigondolella malayensis malayensis Nogami, 1968

Pl. 2, fig. 2

1968 *Gladigondolella malayensis* Nogami, p. 122-123, pl. 9, fig. 11-18; pl. 11, fig. 7.
1971a *Gladigondolella malayensis* - Kozur & Mostler, p. 15, fig. 3, 4.
1973b *Gladigondolella malayensis* - Budurov, p. 801-802, pl. 1, fig. 10-12.
1973 *Gladigondolella malayensis* - Krystyn, p. 142, pl. 1, fig. 4, 5.
1975 *Gladigondolella malayensis* - Gedik, p. 120, pl. 3, fig. 27-28.
1976 *Gladigondolella malayensis* - Kriyic & Premru, p. 14, pl. 2, fig. 2, non fig. 1.
1976 *Gladigondolella malayensis* - Patrulius et al., pl. 3, fig. 7.
1978 *Gladigondolella malayensis* - Catalov & Budurov, p. 92, pl. 2, fig. 1-3.
1979 *Gladigondolella malayensis* - Gazdzicki et al., pl. 48, fig. 3, 5, non fig. 2, 4.
1980a *Gladigondolella malayensis malayensis* - Kovács & Kozur, pl. 7, fig. 7.
1981 *Gladigondolella malayensis* - Koike, pl. 1, fig. 41.
1987 *Gladigondolella malayensis malayensis* - Vrielynck, p. 129, 130, pl. 1, fig. 16-18.
1998 *Gladigondolella malayensis malayensis* - Mastandrea et al., pl. 4.2.1, fig. 1-2.
1999 *Gladigondolella malayensis malayensis* - Mastandrea in Broglio Loriga et al., pl. 3, fig. 8.

Description. Pa element: ellipsoidal with coarsely pitted, massive, short and broad platform. Platform broadest posterior to center, tapering toward posterior and anterior ends, regularly curved in lateral view. Carina composed of 7-12 discrete node-like denticles with cusp at the posterior end. Free blade only rudimentary. Keel prominent with deep basal furrow; basal cavity elliptical to posteriorly pointed, terminal to subterminal.

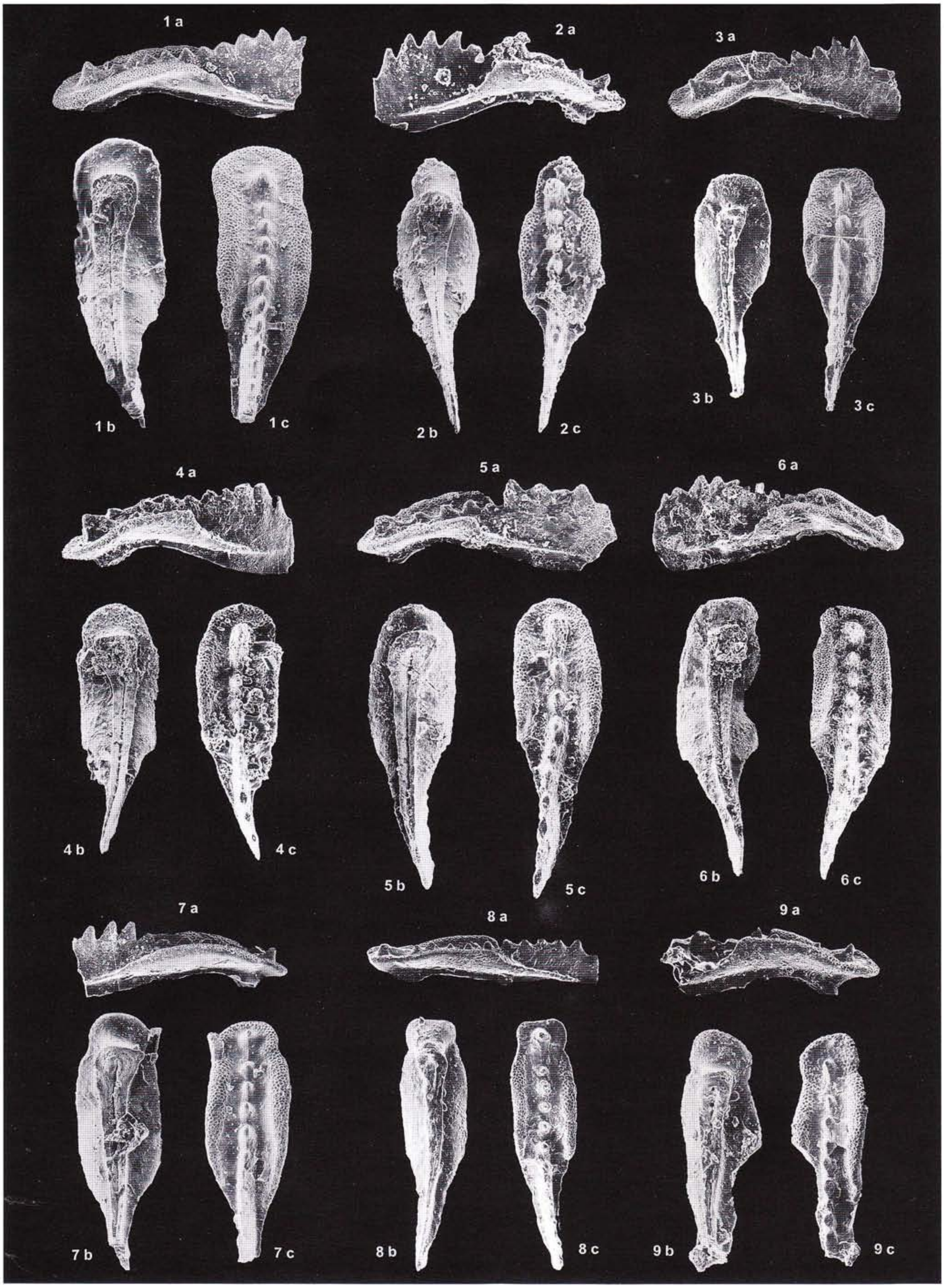
Remarks. *Gladigondolella tethydis* (Huckriede), in respect to *Gl. m. malayensis*, is longer, narrower, sigmoidally bent; cusp and basal cavity never terminal. *Gladigondolella malayensis budurovi* Kovács & Kozur has a broader platform, a lower carina and a cusp not well developed.

Occurrence. 67 specimens: 1 specimen from Buchenstein Fm. at LEV section, I segment; 1 specimen from Wengen Fm. and 3 specimens from Pratotondo Lmst. at LEV section, II segment; 41 specimens from Pratotondo Limestone at LEV section, III segment; 1

PLATE 3

Fig. 1 a, b, c, d - *Pseudofurnishius murcianus praecursor* Gullo & Kozur; Wengen Fm., CSFW section, IV segment, sample DG186; a,b,c x 140, d x 250.
Fig. 2 a, b, c - *Paragondolella inclinata* (Kovács); Wengen Fm., CSFW section, IV segment, sample DG185; x 100.
Fig. 3 a, b, c - *Paragondolella polygnathiformis* (Budurov & Stefanov); Wengen Fm., CSFW section, IV segment, sample DG180; x 150.
Fig. 4 a, b, c - *Paragondolella polygnathiformis* (Budurov & Stefanov); Wengen Fm., CSFW section, IV segment, sample DG180; x 150.
Fig. 5 a, b, c - Transition *Budurovignathus diebeli* (Kozur & Mostler) / *B. mungoensis* (Diebel); Wengen Fm., CSFW section, IV segment, sample DG253; x 150.

a) lateral view, b) lower view, c) upper view.


1 a
2 a
3 a
1 b
1 c
2 b
2 c
3 b
3 c
4 a
5 a
6 a
4 b
4 c
5 b
5 c
6 b
6 c
7 a
8 a
9 a
7 b
7 c
8 b
8 c
9 b
9 c

contour, with the posterior margin generally well rounded or more or less squared. The platform extends for the whole length of the unit, but the first two denticles may be free. Towards the posterior margin of the unit, the edges of the platform tend to be refolded upward with a thickening of the margins more developed at the third back of the platform. Consequently, it is possible to notice a "furrow" near the flanks of the carina, more evident at the third back of the unit. The carina is moderately high, characterized by 15-20 fused denticles for approximately the 2/3 of their height, from slightly to strongly inclined toward the posterior.

The height of denticles decreases toward the posterior margin, the last 4-6 denticles are generally small, conics, and separate.

The main cusp is never terminal, sometimes an "accessory tooth" posteriorly to the main cusp is present. Sometimes both the main cusp and the "accessory tooth" may occupy an asymmetrical position in respect to the alignment of denticles.

The lower surface varies from moderately to strongly concave, conferring an arched outline in lateral view.

The lower surface is characterized by a well developed keel, in relief in rispect to the platform, that widens toward the posterior margin of the unit. The basal cavity is generally rounded or oval, subterminal, deeply excavated and frequently with a well evident brim.

The keel shows a different termination depending by the posterior end of the platform: a platform with back rounded margin join a keel more rounded, while for specimens characterized by a posterior squared margin, also the keel results posteriorly squared.

Remarks. *P. inclinata* differs from *P. foliata* by the denticles of carina posteriorly inclined. In the material at hand, most of the specimens are broken. The specimen illustrated on pl. 3, fig. 2 shows transitional features to *P. polygnathiformis* (Budurov & Stefanov). *P. inclinata* differs from *P. polygnathiformis* by the gentle downward step of the platform.

Occurrence. 3 specimen from Wengen Fm. at CSFW section, IV segment; 1 specimen from Pratotondo Limestone at LEV section, II segment; 2 specimens from Pratotondo Limestone at LEV section, III segment; 2 specimens from Pratotondo Limestone at Pratotondo section.

Stratigraphical range and distribution.

- Early Longobardian - Late Julian *sensu* Kovács & Kozur (1980b);
- Early Longobardian - Late Julian *sensu* Kovács (1983);
- Early Longobardian - Late Julian (upper *P. gredleri* Z. - *T. austriacum* Z.) *sensu* Krystyn (1983).

This species has been recognized into the Tethyan Province.

Paragondolella polygnathiformis

(Budurov & Stefanov, 1965)

Pl. 2, fig. 9; Pl. 3, fig. 3, 4; Pl. 4, fig. 1-4; Pl. 5, fig. 1-9

1958 *Gondolella navicula* Huckriede, pl. 12, fig. 15.
1965 *Gondolella polygnathiformis* Budurov & Stefanov, p. 118, 119, pl. 3, fig. 3-7, non fig. 4-6.
1983 *Gondolella polygnathiformis* - Kovács, p. 112, 113, pl. 2, fig. 5, 6 (*cum syn.*).
1983 *Gondolella polygnathiformis* - Krystyn, p. 239, 240, pl. 4, fig. 3.
1987 *Paragondolella polygnathiformis* - Vrielynck, p. 167-170, pl. 5, fig. 7-15.
1990 *Paragondolella polygnathiformis* - Budurov & Sudar, p. 211, pl. 1, fig. 7-19.
1992 *Neogondolella polygnathiformis* - Chhabra & Kumar, p. 16, 17, pl. 4, fig. 16.
1995 *Metapolygnathus polygnathiformis* - Mastandrea, p. 502, pl. 1, fig. 10-13.
1995 *Metapolygnathus polygnathiformis* - Neri et al., pl. 2, fig. 17-19.
1998 *Paragondolella polygnathiformis* - Nicora & Rizzi, pl. 1.1.1, fig. 2- 4.

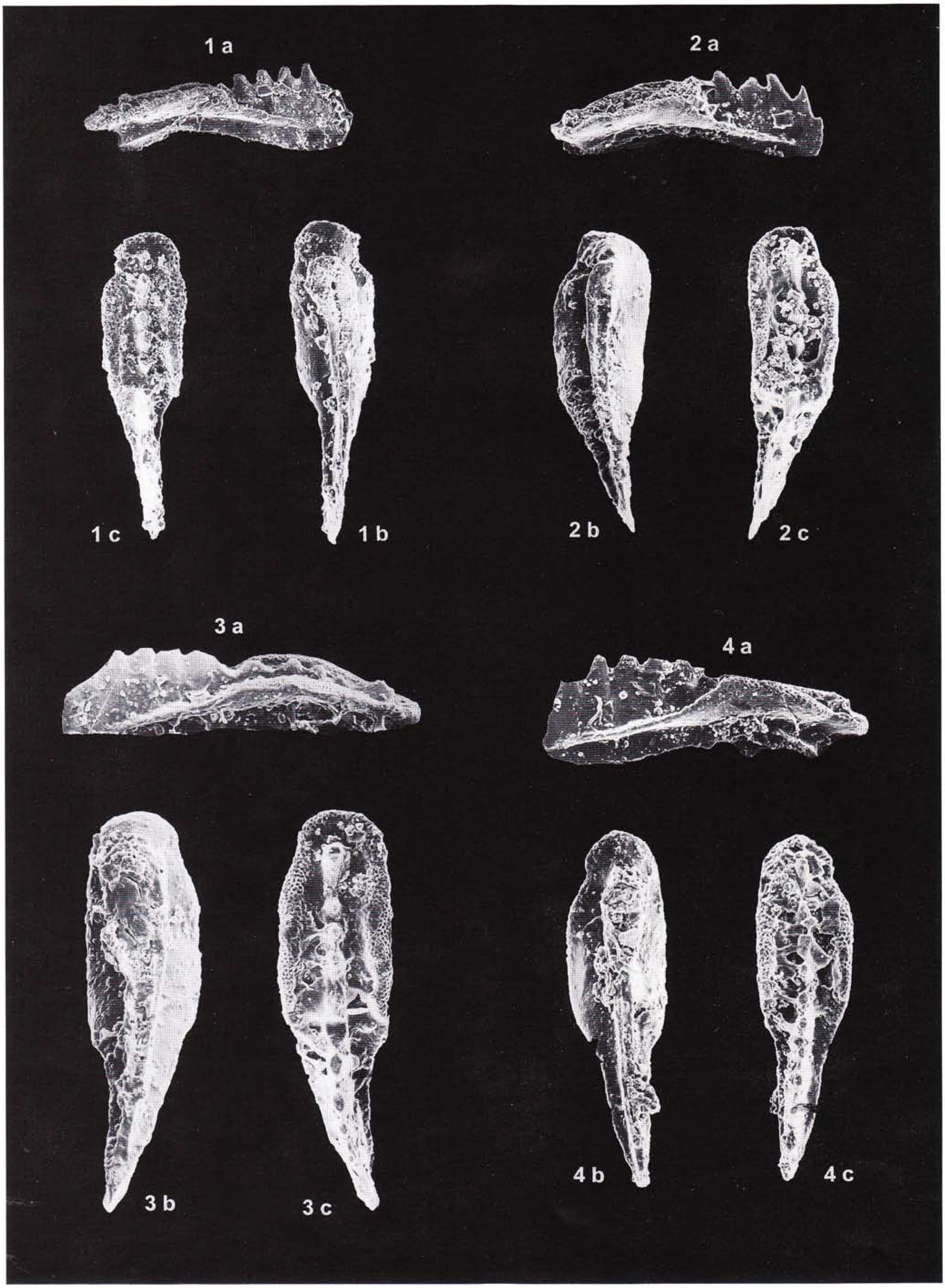
Description. This species is characterized by a platform from narrow and extended, sub-rectangular, that covers from 1/3 to 2/3 of the whole length of the specimen, often with margins refolded upward to individualize a furrow near the flanks of the carina, to a wide platform, posteriorly rounded, sometimes with a "narrowing" at the posterior end. Distinctive characteristic of this species is the abrupt downward step of the platform. Generally the specimens stratigraphically lower tend to show a squared and lengthened platform, for at least the 2/3 of the length, while specimens with wider and rounded platform, that occupies approximately 1/3 of the total length of the unit, tend to dominate in higher stratigraphic levels. Sometimes, it is possible to notice a weak "crenulation" of the platform margins near the free blade.

The carina is characterized by 6-20 denticles, slightly posteriorly inclined and laterally compressed, that generally decreases toward the posterior margin of the unit; the last 3-5 back denticles are generally small, conics, closely spaced. The main cusp generally is not

PLATE 5

Fig. 1 a, b, c - *Paragondolella polygnathiformis* (Budurov & Stefanov); Pràtotondo Limestone, Pratotondo section, sample DG76; x 140.
Fig. 2 a, b, c - *Paragondolella polygnathiformis* (Budurov & Stefanov); Pratotondo Limestone, Pratotondo section, sample DG76; x 140.
Fig. 3 a, b, c - *Paragondolella polygnathiformis* (Budurov & Stefanov); Pratotondo Limestone, Pratotondo section, sample DG77; x 140.
Fig. 4 a, b, c - *Paragondolella polygnathiformis* (Budurov & Stefanov); Pratotondo Limestone, Pratotondo section, sample DG77; x 140.

a) lateral view, b) lower view, c) upper view


1 a
2 a
1 c
1 b
2 b
2 c
3 a
4 a
3 b
3 c
4 b
4 c

terminal, frequently with an "accessory tooth" just back to it, often at terminal position. Also in this case, it is possible to distinguish stratigraphically lower specimens, which are characterized by a free blade constituted by 4-6 pointed denticles, fused between them for approximately the 50% of their height, and more evolved forms, in which the free blade is characterized by denticles fused between them for at least 80% or more than their height, conferring a profile "serrated" to the upper edge of the free blade. Moreover, in the lower stratigrapically specimens, the outline varies from slightly to moderately arched in lateral view, while in higher forms the outline could be notably arched, as a consequence of a downward shifting of free blade apex.

The keel is well developed, slightly in relief, with a marked median furrow. The back termination of the keel is variable: in the forms with squared platform, the posterior end of the keel is straight or moderately bifurcated, while in platforms characterized by a back rounded margin, also the keel shows a rounded posterior end. The basal cavity is set at the third back, generally small, shape of drop, moderately excavated, frequently with a prominent loop.

Remarks. *P. polygnathiformis* differs from *P. inclinata* by the typical abrupt downward step of the platform.

Occurrence. 6 specimens from Wengen Fm. at CSFW section, IV segment; 2 specimens from Pratotondo Limestone at LEV section, II segment; 21 specimens from Pratotondo Limestone at Pratotondo section; 59 specimens from Pratotondo Limestone at LEV section, III segment.

Stratigraphical range and distribution.

- Late Longobardian (upper *Sutherlandi* Z.) - Carnian *sensu* Krystyn (1978, 1980);
- Latest Longobardian - Carnian *sensu* Kovács (1983);
- Latest Longobardian (?) - Tuvalian *sensu* Budurov & Sudar (1989);
- Carnian (*F. regoledanus* Z. - *T. aon* Z. - *T. aonoides* Z.) *sensu* Kovács et al. (1991).

According to most of the authors the apparence of this species marks the Ladinian/Carnian boundary.

This species has been recognized into the Tethyan, Asiatic and Nevadian Provinces.

Genus *Pseudofurnishius* van den Boogaard, 1966

Type species: *Pseudofurnishius murcianus* van den Boogaard,1966

Pseudofurnishius murcianus praecursor

Gullo & Kozur, 1991

Pl. 3, fig. 1

1980b *Pseudofurnishius murcianus* n. sub sp. Kovács & Kozur, pl. 7, fig. 6.

1991 *Pseudofurnishius murcianus praecursor* Gullo & Kozur, pp. 77, pl. 4, fig. 9, pl. 5, figs. 1, 2.

1994 *Pseudofurnishius murcianus praecursor* - Neri et al., pl. 1, fig. 2.

1997 *Pseudofurnishius murcianus praecursor* - Mastandrea et al., pl. 2, figs. 4,5.

1998 *Pseudofurnishius murcianus praecursor* - Mastandrea et al., pl. 4.2.3, figs. 3-4.

Remarks. The only specimen found is long, very narrow, slender with the inner platform very reduced with 4 denticles, whereas the outer platform is represented only by one rudimentary denticles along the blade. The basal cavity, beneath the inner platform, is at the midth of the unit and extends anteriorly as in the material from Sicily described by Gullo and Kozur (1991).

The platform reduction in the *Pseudofurnishius* genus has been considered by the Authors as a phylogenetic tendency (Kozur, 1972, 1980, 1989b; Van den Boogaard & Simon, 1973; Hirsch, 1973; Hirsch & Gerry, 1974; Nicora, 1980; Gullo & Kozur, 1989, 1991; Saddedin,1990; Saddedin & Kozur, 1992). Bi-platform elements (*Pseudofurnishius sosioensis* Gullo & Kozur, *Pseudofurnishius priscus* Saddedin, *Pseudofurnishius siyalaensis* Saddedin & Kozur) are stratigraphically older than the mono-platform ones.

Occurrence. 1 specimen from Wengen Fm. at CSFW section, IV segment.

Stratigraphical range and distribution. Middle-Late Longobardian (middle and upper part of *mungoensis* A.Z. *sensu* Kozur,1980; Gullo & Kozur,1991).

The species has been recognized in Spain, Northern Africa, Southern Alps, Sicily, Israel, Jordan, Southern Turkey, Dinarids.

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Appendix

Pratotondo section.

This section is proposed as type section for the Pratotondo Limestone (Rossetti, 1966a).

Location. The section crops out along a forest road on the right side of Camonica Valley. The base of the section is located 450 m ENE of Pizzo Alto, at 1110 m a.s.l. The name Pizzo Alto is reported on CTR 1:10000 and IGM 1:25,000 maps. In both the maps the name Pratotondo is used for the forest and meadows NE of Pizzo Alto i.e., some hundreds of meters North to the section.

Lithology (from bottom to top):

cover

Buchenstein Formation

a) cherty nodular limestone and cherty limestone, at the top cherty nodular limestone; 11.8 m.

Wengen Formation

b) silty marls and shaly marls; 4.5 m

Pratotondo Limestone (total thickness 166.45 m)

c) shales and shaly marls with dark grey micritic marly mudstone intercalations; 11 m

- cover, 20 m.

d) lower part with alternation of 10-15 cm thick dark grey marly limestones with similar thickness of shales, upper part with laminated marly shales and limestones (3-4 to 1 ratio); 6.8 m

- cover, 49.6 m.

e) as d); 2.4 m

f) alternation of dark gray/black shales and dark gray marly limestones in about 5 to 10 cm thick beds; 5.6 m

g-m) "Nero venato"

g) thickening upward succession of dark grey limestone (5 to 30 cm thick beds) with 3-2 to 5 cm thick marl intercalations; 2.05 m

h) dark grey limestones and marly limestones (intrabioclastic wackestones to packestones, occasionally grainstones) with planar lamination, normal grading and microsplumpings. The beds are dm to some dm thick, but often they are amalgamated; 30 m

i) 7 to 25/30 cm thick dark gray marly limestone, with mm shaly marl intercalations; 2.2 m

j) amalgamated dark gray to black limestone with planar lamination; 2.5 m

k) 4 beds of limestone with planar lamination; 0.8 m

l) pseudobedded limestone; 3 m

m) thin bedded limestone, with mm thick marl intercalations; 1.5 m

n) shaly marls (0.6 m), followed by alternation of thin bedded limestone and shaly marls (1.85 m), and by shaly marls with very thin bedded marly limestone intercalations (0.75 m); total thickness 3.2 m

o) marly limestone dominating on shaly marls; 3 m

p) dark grey shales, locally marly shales, with rare marly limestone intercalations; 17.8 m

small fault

q) very thin bedded limestones; 5 m

Lozio Shale

-cover: very gentle morphology with isolated small outcrops of shales.