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REFINED AMMONOID BIOCHRONOSTRATIGRAPHY OF THE BAGOLINO SECTION (LOMBARDIAN ALPS, ITALY), GSSP CANDIDATE FOR THE BASE OF THE LADINIAN STAGE

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Abstract. A refined ammonoid biostratigraphy is reported for a critical interval of the Bagolino section (Giudicarie Area, Northern Italy), a candidate for the Anisian/Ladinian stage boundary. The Avisianum Subzone has been documented, and its boundary with the Crassus Subzone has been redefined, on the basis of new findings of *Reitziites reitzi*, *Aplococeras* aff. *smithi*, *Aplococeras avisianum*, *Halilucites rusticus*, *Parasturia* sp. and other significant ammonoids. Six potential criteria for the definition of the Anisian/Ladinian boundary can now be considered in this single stratigraphic section, so that the FO of *Eoprotrachyceras curionii* is no longer the unescapable choice at Bagolino. Despite several drawbacks, including the absence of palynomorphs and daonellid bivalves, the thermal history preventing the recovery of magnetic and isotopic signals, and a lower sedimentation rate with respect to many other sections of the Southern Alps, the Bagolino section is here accepted as stratotype for the Anisian/Ladinian boundary, but further paleontological and sedimentological studies should be considered.

Riassunto. Viene presentata una biostratigrafia perfezionata ad ammonoidi per un intervallo critico della sezione di Bagolino (Giudicarie, Sudalpino), candidata come stratotipo del limite Anisico/Ladinico. Sulla base di nuovi ritrovamenti di *Reitziites reitzi*, *Aplococeras* aff. *smithi*, *Aplococeras avisianum*, *Halilucites rusticus*, *Parasturia* sp. e altri ammonoidi significativi, viene documentata la Sottozona ad Avisianum e il limite con la Sottozona a Crassus è ridefinito. Sei diversi criteri biostratigrafici per la definizione del limite possono ora essere considerati, cosicché la FO di *Eoprotrachyceras curionii* non è più l'unica scelta possibile a Bagolino. Nonostante diversi limiti, come l'assenza di bivalvi del genere *Daonella* e di palinomorfi, il riscaldamento da seppellimento che non ha permesso la conservazione di segnali paleomagnetici ed isotopici, e un tasso di sedimentazione inferiore rispetto a molte altre sezioni del Sudalpino, la sezione di Bagolino viene considerata adatta come stratotipo del limite Anisico/Ladinico, anche se ulteriori indagini paleontologiche e sedimentologiche sarebbero raccomandabili.

Introduction

The stratigraphic section outcropping in the Caffaro riverbed near Bagolino, in the Lombardian Alps (Southern Alps, Northern Italy; Fig. 1), plays a major role in the definition of the Anisian/Ladinian stage boundary (Brack & Rieber 1986, 1993a). A clear succession of ammonoid faunas identifies here at least 5 biozones, with the greater amount of fossiliferous horizons in a ca. 12 meters long interval centered about the possible position of the Anisian/Ladinian boundary (A/L hereafter). This interval consists of dark nodular limestone and shale alternations (so-called "transitional beds", Brack & Rieber 1993a) followed by prevalent nodular, cherty limestones (Livinallongo Fm./Buchenstein beds). In both lithostratigraphic unit, acidic tuff horizons are common. The good ammonoid documentation led the latter Authors to the opinion that the GSSP for the base of Ladinian Stage could be placed at Bagolino, at the First Occurence (FO) of *Eoprotrachyceras curionii* (m. 63.30).

However, due to his frankly basinal position, far from carbonate and terrigenous sediment sources, the Bagolino section is characterised by a low sedimentation rate, so that ammonoid biozones are sometimes represented by only few meters of "Transitional beds" or Livinallongo/Buchenstein beds. A careful sampling at the sub-meter scale is thus required to ensure that all biostratigraphic events are recognized correctly. In particular, a two-meters interval, comprised between the LO of *Reitziites reitzi* and the "*Ticinites* beds" (cf. Brack & Rieber 1993a; Brack et al. 1995), lacks significant fau-

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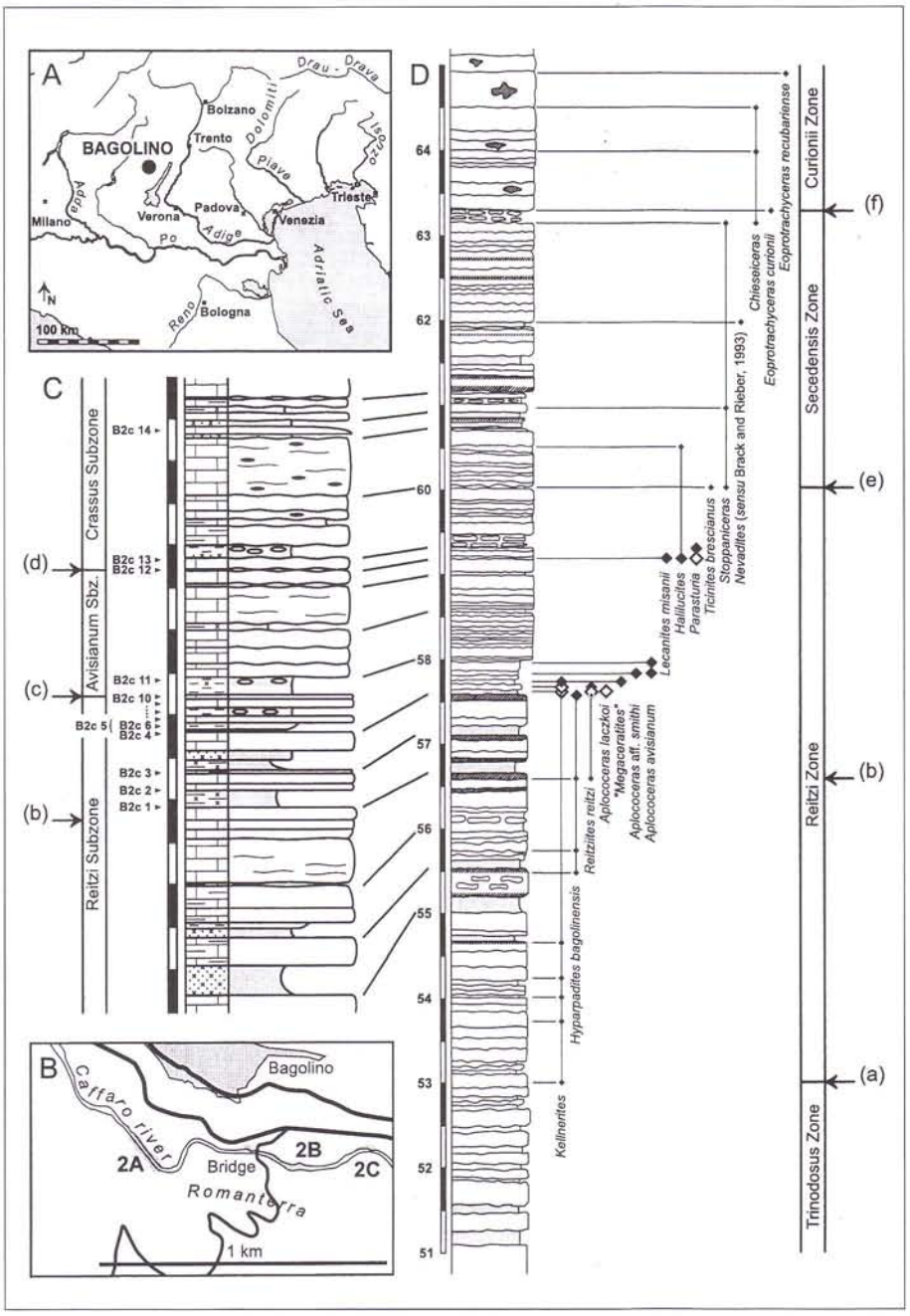


Fig. 1 - (A) location of Bagolino in northern Italy. (B) Location of the stop 2c (Brack & Rieber 1993b); (C) portion of the Bagolino section, measured at the stop 2c, with the ammonoid beds; (D) the Bagolino section, redrawn from Brack et. al. (1995); possible positions of the A/L boundary are indicated by arrows and letters from (a) to (f). Small diamonds: ammonoid findings from Brack and Rieber (1993); large diamonds: new findings (this paper); large open diamonds: new findings, open nomenclature.

nas, but is expected to represent the whole Avisianum Subzone by Mietto & Manfrin (1995), and perhaps part of the underlying and overlying subzones (Manfrin & Mietto 1995). A refined sampling of this apparently barren interval has been carried out by the authors. The results constitute a substantial improvement of the ammonoid documentation at Bagolino.

New ammonoid findings

A refined biostratigraphic framework of the interval between tuffs Ta (meter 55 ca.) and tuffs Tc (meter 61 ca.) at Bagolino is given in Table 1 and Fig. 1. Stratigraphic position in meters is given with reference to Brack & Rieber (1993a) and Brack et. al. (1995). The log of Fig. 1 was measured in a slightly different site than the section of Brack & Rieber (1993a), i.e., stop 2c (Brack & Rieber 1993b), 45° 49' 7,98" N 10° 28' 24" E WGS 84, and this probably explains minor discrepancies in thickness.

With respect to previous works, substantial novelties emerged, the most important of which is the documentation of aplococeratids. *Aplococeras* aff. *smithi* was collected in bed B2c 10, above the LO of *Reitziites reitzi*. In the same level *Aplococeras avisianum* marks the base of the Avisianum Subzone. Between the LO of *R. reitzi* and the FO of *A. avisianum*, *"Semiornites"* cf. *falcifer*, *"Megaceratites"* (of the *friccensis* group), first representatives of *"Parakellnerites" arthaberi* occur. This association is typical of the upper portion of the Reitzi Subzone sensu

Beds	*Parakellnerites* sp.	*Flexoptychites* sp.	*Kellnerites* sp.	*Hungarites* sp.	*Reitziites* sp.	*Hungarites ternis* (Hauer)	*Hyparpadites bagolinensis* (Brack & Rieber)	*Reitziites reitzi* (Bockh)	*Aplococeras laczkoi* (Arthaber)	*"Semiornites" falcifer* (Hauer)	*Hyparpadites* sp.	*"Parakellnerites" arthaberi* (Diener)	*"Megaceratites"* sp.	*Aplococeras* aff. *smithi* Silberling & Nichols	*Aplococeras avisianum* (Mojsisovics)	*Sageceras* sp.	*Halilucites rusticus* (Hauer)	*Parakellnerites zoniaensis* Brack & Rieber	*Lecanites misanii* (Mojsisovics)	*Parasturia* sp.	SUBZONES
B2c 14	x																				
B2c 13																				x	Crassus
B2c 12																	x	o	x	o	
B2c 11b		x		x								x									
B2c 11		x		o								o			x	o					Avisianum
B2c 10	x	x		x								o		x	x						
B2c 9	x	x		x						o											
B2c 8	x	x	x		x							o	o	x							
B2C 7	x	x	o		x			x													
B2c 6b		x			x							o									
B2c 6	x	o	o		o	o		o	o	x											Reitzi
B2c 5	x	x		x	x																
B2c 4	x			x	x		x														
B2C 3	x	x			o	o															
B2C 2	o	x																			
B2c 1	x	x			x																

Tab. 1 - Range of the ammonoids in the measured portion of stop 2c at Bagolino (Brack & Rieber 1993b). Empty circles indicate open nomenclature.

Mietto & Manfrin (1995), similarly to several other sections of the Southern Alps (cf. Mietto & Manfrin 1995). An almost barren interval of ca. 1.2 m follows the FO of *A. avisianum*; then level B2c 12 yielded *Halilucites rusticus*, *Lecanites misanii* and cf. *Parasturia* (m 59.20 of the quoted section). The base of the Crassus Subzone, previously coinciding with the "*Ticinites* beds", is thus now lowered by a ca. one meter.

Hypotheses for the Anisian/Ladinian boundary at Bagolino

As recently summarized by Vörös (2002), basing on ammonoids, six different criteria have been proposed (Brack & Rieber 1986, 1993a, 1993b; Gaetani 1994; Manfrin & Mietto 1995; Vörös 2002) for the base of the Ladinian, and namely (a) the base of the Reitzi Zone (sensu Vörös 1993); (b) the FAD of *Reitziites reitzii*; (c) the FAD of *Aplococeras avisianum*; (d) the base of the Crassus Subzone sensu Mietto and Manfrin (1995) practically coincident with the base af the Nevadites Zone of Krystyn (1983), e) the base of the Secedensis Zone sensu Brack & Rieber (2002) and finally (f) the FAD of genus *Eoprotrachyceras*. On the base of previous data, the Bagolino section was only suitable for criteria (b) and (f); once the new data presented here are introduced, the ammonoid succession at Bagolino better fits with the biostratigraphy of other localities of the Southern Alps (Mietto & Manfrin 1995) and is complete enough to allow all boundary options to be discussed in this single stratigraphic section.

The contribution of the Bagolino section will be examined next, in the light of the new findings.

Option (a): appearance of *Kellnerites* (i.e. Reitzi Zone sensu Vörös 1993)

This bioevent corresponds to the FO of *K. felsoeoersensis* in the bed 100E at Felsöörs (see also Vörös et al. 1996), which is correlated with the FO of *K. halilucensis* at m 53 in Bagolino (Brack et al. 2002). At Bagolino, however, biostratigraphic data below this horizon are missing, so it is impossible to demonstrate that these two events are synchronous. It should be highlighted that the base of the Reitzi Subzone sensu Mietto & Manfrin (1995) is slightly older than the FO of genus *Kellnerites*, and at Bagolino is not documented. While common in Western Tethys, *Kellnerites* is not known in the Pacific domain, so that its biochronostratigraphic usefulness is restricted.

Option (b): appearance (FAD) of *Reitziites reitzi*

This bioevent is documented at m 56.59 in Bagolino; the LO of the same species lies at m 57.58. This range is substantially confirmed by our new findings. At Felsöörs, *R. reitzi* occurs only in bed 105 (base of the Reitzi Subzone *sensu* Vörös 1993). As for *Kellnerites*, *R. reitzii* is unknown in North America, and its biochronostratigraphic usefulness is thus limited.

Option (c): appearance (FAD) of *Aplococeras avisianum*

Aplococeras avisianum makes his first occurrence at Bagolino at m 57.71 (bed B2c 10). *R. reitzi* is still present few cm below (m 57.58); in several other sections of the Southern Alps and Balaton Highland, the distributions of *R. reitzi* and *A. avisianum* never overlap, so that bed B2c 10 can be interpreted to document the possible FAD of *A. avisianum*. This is also confirmed by the occurrence, in the interval immediately below (beds B2c 8-9), of the typical faunal association of the uppermost Reitzi Subzone sensu Mietto & Manfrin (1995). For practical purposes, this option is extremely interesting: the index species is commonly found in the Southern Alps in both basinal and platform settings, and is recorded also in Balaton Highlands, Hungary. Due to the coincidence of all morphological characters, including the suture line, the North American species *Aplococeras vogdesi* is considered a synonymous of *A. avisianum* (Manfrin et al. submitted) as suggested by Assereto (1969), thus this species has a global distribution, at least for the tropical province. Furthermore, *A. avisianum* is easy to recognize and common, thus its FAD constitutes an excellent marker.

At Bagolino, *A. avisianum* co-occurs with *A.* aff. *smithi* Silberling & Nichols. Similarly, in Nevada the distribution of *A. vogdesi* (= *A. avisianum*) slightly overlaps that of *A. smithi*. This is another important element supporting the correlation of the FAD of *A. avisianum* between the Southern Alps and Nevada.

Option (d): base of Crassus Subzone or base of Nevadites Zone (sensu Krystyn 1983); Option (e) Base of Secedensis Zone (sensu Rieber & Brack 2002)

The base of the Crassus Subzone is documented at m 59.20 by the appearance of *Halilucites rusticus*; the first reliable *Parasturia* occur less than 10 cm above (bed B2c 13). According to Rieber & Brack (2002), "The base of the Nevadites Zone should be defined with the first appearance of *Ticinites*". Following Mietto & Manfrin (1995), the base of the biozone coincides with the FO of other important genera as *Halilucites*, *Parasturia* and *Celtites*. The latter (inclusive of *Tozerites* p.p.) occurs also in North America. The occurrence of *Halilucites* in bed B2c 12 thus documents, in the authors opinion, the base of both the Crassus Subzone and Nevadites or Secedensis Zone.

Also the occurrence of *Lecanites misanii*, which corresponds to the North American *Aplococeras parvus* (see below in the Palaeontological appendix), at the base of the Crassus Subzone, is a significant element of correlation between Bagolino and Nevada.

The stratigraphic interval starting at the base of the Crassus Subzone records the most significant turnover among ammonoids, resulting in the maximum correlation potential at the global scale; however, there is still much to be clarified about the correlations between the Nevaditinae faunas from Nevada and Western Tethys.

Option (f): appearance (FAD) of genus *Eoprotrachyceras*

This bioevent is documented at Bagolino by the FO of *E. curionii*, at m 63.30 (top of the "*chiesense* groove").

The FO (FAD) of genus *Eoprotrachyceras* is documented by the FO of different species in several localities worldwide (e.g. *E. curionii* in the Mediterranean domain, *E. subasperum* in Nevada and *E. matutinum* in British Columbia, see also Tozer 1994) and thus apparently constitutes a good marker. Hovewer, there is no guarantee that the FO of the genus occurs at the same time in the different localities, when this FO is not given by the same species. If the base of the Ladinian will be placed at this event, the Fassanian (i.e., the first substage of the Ladinian) will be extremely reduced, and a large part of the (several hundred of meters thick) Sciliar Dolomite in the Dolomites, traditionally considered a Ladinian carbonate platform, will result to be actually Anisian. This will lead to a great difficulty in the interpretation of bibliography for non-specialists, which is a problem we would like to avoid giving stability to the stratigraphic nomenclature.

By a philosophical point of view, the option (d-e) may be preferred because: (1) it guarantees a good stability of the stratigraphic nomenclature and, most important (2), it corresponds to the most important faunal turnover and the major radiation event in the ammonoids. This proposal is based on the idea that a period of radiation corresponds to worldwide and synchronous changes in the whole taxonomic group that is interested (here, ammonoids); such kind of events can be easely recognized without the necessity of relying on a single species, thus enormously increasing the correlation potential. This consideration led to the proposal that stage boundaries should be placed at the FADs of major taxonomic groups as families, for example (Krystyn 1978; Mietto & Manfrin 1995).

However, basing on the available data from Bagolino, the three key genera of the Crassus subzone (namely *Halilucites*, *Ticinites*, and *Nevadites*) have their FO at different stratigraphic levels, thus, they do not appear to define univocally a time of faunal turnover. A definition of the A/L boundary following option (d-e) would thus result ambiguous.

Alternatively, the FAD of *A. avisianum* (option c) seems to be the most widespread and documented biological event at the species level in this interval, and is also in agreement to the necessity of maintain a stability in stratigraphic nomenclature.

Discussion: is Bagolino a good stratotype section?

After our new data on ammonoids are introduced, the biostratigraphy at Bagolino better fits with that of other stratigraphic sections of the Southern Alps, Balaton Highlands in Hungary (Vörös 1998) and Fossil Hill, Nevada (Silberling & Nichols 1982). Within the Southern Alps, a comparison appears now more coherent with important stratigraphic sections in both platform (e.g., Latemar platform, De Zanche et al. 1995; Preto et al. 2002) and basinal (e.g., Val Gola, Ru Sec, Punta Zonia, De Zanche & Mietto 1986, 1989; De Zanche et al. 1995) settings. Such an improved correlation potential is a strong argument in favor of the choice of Bagolino as stratotype for the A/L boundary.

However, as also partly explained by Kozur (1995), this section presents some important drawbacks: (1) it undergone a relatively severe burial, and consequent heating, so that paleomagnetic and isotopic signals have been blanked, and (2) some important fossil groups (i.e., daonellid bivalves and palynomorphs) are not represented. These limitations makes the correlation with shallow water and continental successions almost impossible.

A framework of physical correlations with several sections of the Dolomites (Brack & Rieber 1993a; Brack & Muttoni 2000), based mainly on primary ashfall deposits used as marker beds, partly solves these problems. Sections of the Dolomites (e.g., Seceda) indeed undergone less severe burial, so that the paleomagnetic signal is preserved (and the isotope signal is likely to be preserved as well); palynomorphs and *Daonella* spp. are also present. Unfortunately, known sections from the Dolomites yielded much less ammonoids than Bagolino, and a major lithological change is present just below the "*Ticinites* beds",

thus within the interval of the proposed stage boundaries. Such sections can be used as references, but cannot be proposed as "stand-alone" stratotypes.

It must be noted also how the Bagolino section presents – in the stratigraphic interval comprising the Avisianum Subzone – an extremely reduced sedimentation rate. The Avisianum Subzone, which in the Dolomites always encompasses several meters, is here restricted to ca. 1.5 m. Thus, with respect to other sections of the Southern Alps, hiatuses and condensed intervals at Bagolino are more likely present. Until now, this possibility was also suggested by the absence of the Avisianum Subzone, that could have been interpreted as due to a hiatus. Our findings demonstrate instead that all subzones of the interval are present.

Is Bagolino a good stratotype section for the A/L boundary? With regard to the physical stratigraphy, it can be answered that yes, it is good enough, but it still presents serious drawbacks. Of course, the goodness of the Bagolino section also depends on which is the preferred criterion for the A/L boundary. The refined physical correlation with several sections of the Southern Alps, and the data presented here, greatly help to overcome the limitations of Bagolino as a stratotype, but further ammonoid findings in new horizons, and perhaps a sedimentological study aimed to the identification of potential hidden hiatuses or condensed intervals seem recommendable. This is particularly important for the so-called "*chiesense* groove", a cm-scale seam in the Livinallongo / Buchenstein beds of the Giudicarie area (including Bagolino) where the FO of *Eoprotrachyceras curionii* occurs. The ammonoid association on the bed surface marking the base of the "*chiesense* groove" is different from that on the bed surface at the top (cf. Brack & Rieber 1986; 1993a; Brack et al. 1995), and this horizon has been interpreted as a condensed surface corresponding to a major maximum floading surface within a 3rd (and 2nd) order depositional sequence (De Zanche et al. 1993; Gianolla et al. 1998). These considerations suggest caution in positioning a GSSP at this horizon.

Conclusions

New ammonoid findings document for the first time the Avisianum Subzone (sensu Mietto & Manfrin 1995) at Bagolino, the section proposed for the GSSP for the base of the Ladinian Stage in Northern Italy. The base of the overlying Crassus Subzone have been also redefined, and placed, due to the appearance of *Halilucites*, ca. 1 m below the "*Ticinites* beds".

Different biological events, representing potential criteria for the definition of the A/L boundary [i.e., FAD of *R. reitzi*, FAD of *A. avisianum*, base of Crassus Subzone (as FAD of *Halilucites*, e.g., *H. rusticus*) and FAD of *Eoprotrachyceras* (e.g. *E. curionii*)], are now all documented in the Bagolino section. Even if this section will be chosen as stratotype, the base of the Curionii Zone is no longer the unescapable choice for the base of the Ladinian. While from a philosophical point of view the boundary should be preferentially positioned at a major faunal turnover, the FAD of *A. avisianum* seems the most practical solution in this case.

The Bagolino section is suitable as stratotype, despite several drawbacks including deep burial that prevents palaeomagnetic and isotopic studies, as well as the absence of important fossil groups as daonellid bivalves and palynomorphs. These problems are partially overcomed by a framework of very reliable physical correlations with several other sections of the Southern Alps, where palaeomagnetic studies exist, and Daonellids and palynomorphs are present (Brack & Rieber,1993a; Brack & Muttoni 2000; Brack et al. 2002).

Paleontological appendix

Most of the findings in Bagolino belong to species already discussed in recent literature: for *Reitziites reitzi* (Böckh), *"Parakellnerites" arthaberi* (Diener), *Hyparpadites bagolinensis* (Brack & Rieber), *Parakellnerites zoniaensis* Brack & Rieber, *Hungarites lenis* (Hauer), see Brack & Rieber (1993a); so that only the significant taxa that weren't discussed recently are here described.

All described material is stored in the Geological and Palaeontological Museum of the Padova University (MGPD) or in the Geological Museum of Predazzo (MGP) and in the Friulano Museum of Natural History of Udine (MFSN).

Genus *Aplococeras* Hyatt, 1900

(= *Pseudaplococeras* Spath, 1951; = ? *Velebites* Salopek, 1917)

Type species: *Dinarites avisianus* Mojsisovics, 1882

Aplococeras aff. **smithi** Silberling & Nichols, 1982

Pl. 1, fig. 10

cf 1982 *Aplococeras smithi* n. sp. Silberling & Nichols, pp. 52-53, fig. 36, pl. 21, figs. 31-37.
? 1991 *Aplococeras avisianum* Budai et al., fig. 9
? 1993 *Aplococeras avisianum* Vörös, Pl. IV, ? fig. 6, not fig. 5 [= *Aplococeras avisianum* (Mojsisovics)]
? 1993 *Aplococeras avisianum* Vörös & Budai, Pl. 13, ? fig. 4, not fig. 5 [= *Aplococeras avisianum* (Mojsisovics)]

Material. Five specimens from bed B2c 10: BA41.1 to Ba41.2 (MGPD 28942 to 28943), BA41a.1a and b (MGPD 28945a and b), BA41a.2 (MGPD 28946). For comparison specimen CEN10.1 (MGPD 28965) from the Passo della Fricca section (Centa Valley, Trento) (Pl. 2, fig. 2).

Description. All the specimens at disposal are small-medium sized, incomplete, and preserved as films. Nevertheless, they can be identified as belonging to an aplococeratid characterised by smooth flanks without any

PLATE 1

Fig. 1, 6, 8a-b - *Aplococeras avisianum* (Mojsisovics, 1882), 1) bed B2c 10, sample BA41.3(MGPD 28944), negative, lateral view, 6) bed B2c 11, sample BAG5.8a(MGPD 28947a), negative, lateral view, 8) bed B2c 11, sample BAG5.12b(MGP 28948b), lateral view, 8a) natural size, 8b) x2.

Fig. 2 - *Aplococeras* cf. *avisianum* (Mojsisovics, 1882), bed B2c 11, sample BAG5.4(MGPD 28949), negative, lateral view.

Fig. 3 - *Aplococeras* cf. *laczkoi* (Arthaber, 1911), bed B2c 6, sample BAG27.7(MGPD 28951), lateral view.

Fig. 4, 12 - *Reitziites reitzi* (Böckh, 1872), 4) bed B2c 6, sample BAG27.6a (MGPD 28957a), lateral view, 12) bed B2c 7, sample BAG28.3a (MGPD 28958a), lateral view.

Fig. 5 - *"Semiornites" falcifer* (Hauer, 1896), bed B2c 6, sample BAG27.2(MGPD 28954), negative, lateral view.

Fig. 7a-b - *Lecanites misanii* (Mojsisovics, 1882), bed B2c 12, sample BAG50.3(MGPD 28952), lateral view, 7a) natural size, 7b) x2.

Fig. 9 - *Hungarites* cf. *lenis* (Hauer, 1896), bed B2c 6, sample BAG7.2(MGPD 28964), lateral view.

Fig. 10 - *Aplococeras* aff. *smithi* Silberling & Nichols, 1982, bed B2c 10, sample BA41a.2 (MGPD 28946), lateral view.

Fig. 11 - *Hyparpadites bagolinensis* (Brack & Rieber, 1993a), bed B2c 4; sample BA39.1a (MGPD 28963a), lateral view.

Fig. 13, 15, 16 - *Reitziites* sp., 13) bed B2c 6b, sample BAG27T.1 (MGP 28960), negative, lateral view, 15) bed B2c 6, sample BAG7.3b (MGPD 28961b), lateral view, 16) bed B2c 6 (from debris), sample BAG9.3b (MGPD 28962b), lateral view.

Fig. 14 - *"Megaceratites"* sp., bed B2c 8, sample BAG29.6a(MGPD 28956a), lateral view.

Fig. 17 - *Halilucites rusticus* (Hauer, 1896) - bed B2c 12, sample BAG 50.4 in situ, negative, lateral view.

Natural size for all pictures, except for 7b and 8b; all specimens, but 8 and 17, are whitened with Magnesium Oxyde.

PLATE 2

Fig. 1a-b - *Lecanites misanii* (Mojsisovics, 1882), sample UE2.2 (MFSN 28170), Red ammonitic Limestones of Mt Clapsavon, Clap di Val (Udine), 1a) lateral view, 1b) ventral view, Fassanian (probably Recubariensis Subzone).

Fig. 2 - *Aplococeras* aff. *smithi* Silberling & Nichols, 1982, sample CEN10.1 (MGPD 28965), Val di Centa Marls, Passo della Fricca section (Trento), negative print, Illyrian (uppermost Reitzi Subzone).

Fig. 3a-b, 5 - *Aplococeras avisianum* (Mojsisovics, 1882), 3) sample EA34 (MGPD 28966), "Latemar Limestone", Forno (Trento), 3a) lateral view, 3b) ventral view, 5) sample SF.B.1 (MGPD 28971), "transitional beds", Adanà (Trento), Illyrian (Avisianum Subzone). See also De Zanche et al, 1995: pl. I, fig. 1 and pl. II, fig. 2, and Mietto and Manfrin, 1995: pl. II, fig. 10 and 9, respectively.

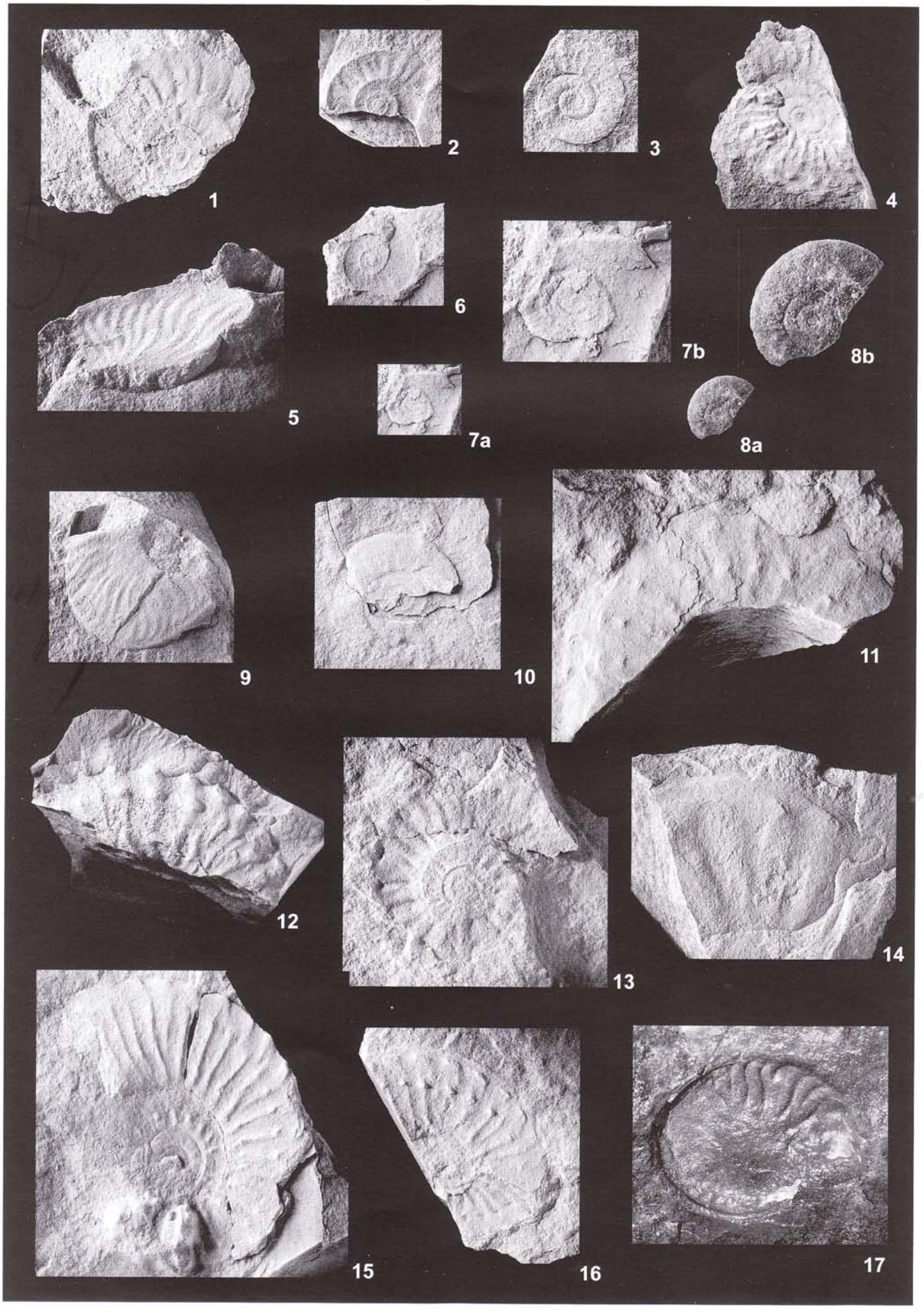
Fig. 4a-b - *Aplococeras laczkoi* (Arthaber, 1911), sample MCP 6376, Latemar Lower Edifice bed LV-Q, Lastei di Valsorda (Trento), 4a) lateral view, 4b) ventral view, Illyrian (Avisianum Subzone).

Fig. 6a-b - *Halilucites rusticus* (Hauer, 1896), sample LG.B11 (MGPD 28969), "red ammonitic limestones", La Grea (Marmolada, Trento), 6a) lateral view, 6b) ventral view, Fassanian (Crassus Subzone). See also De Zanche et al., 1995: pl. pl. III, fig. 4.

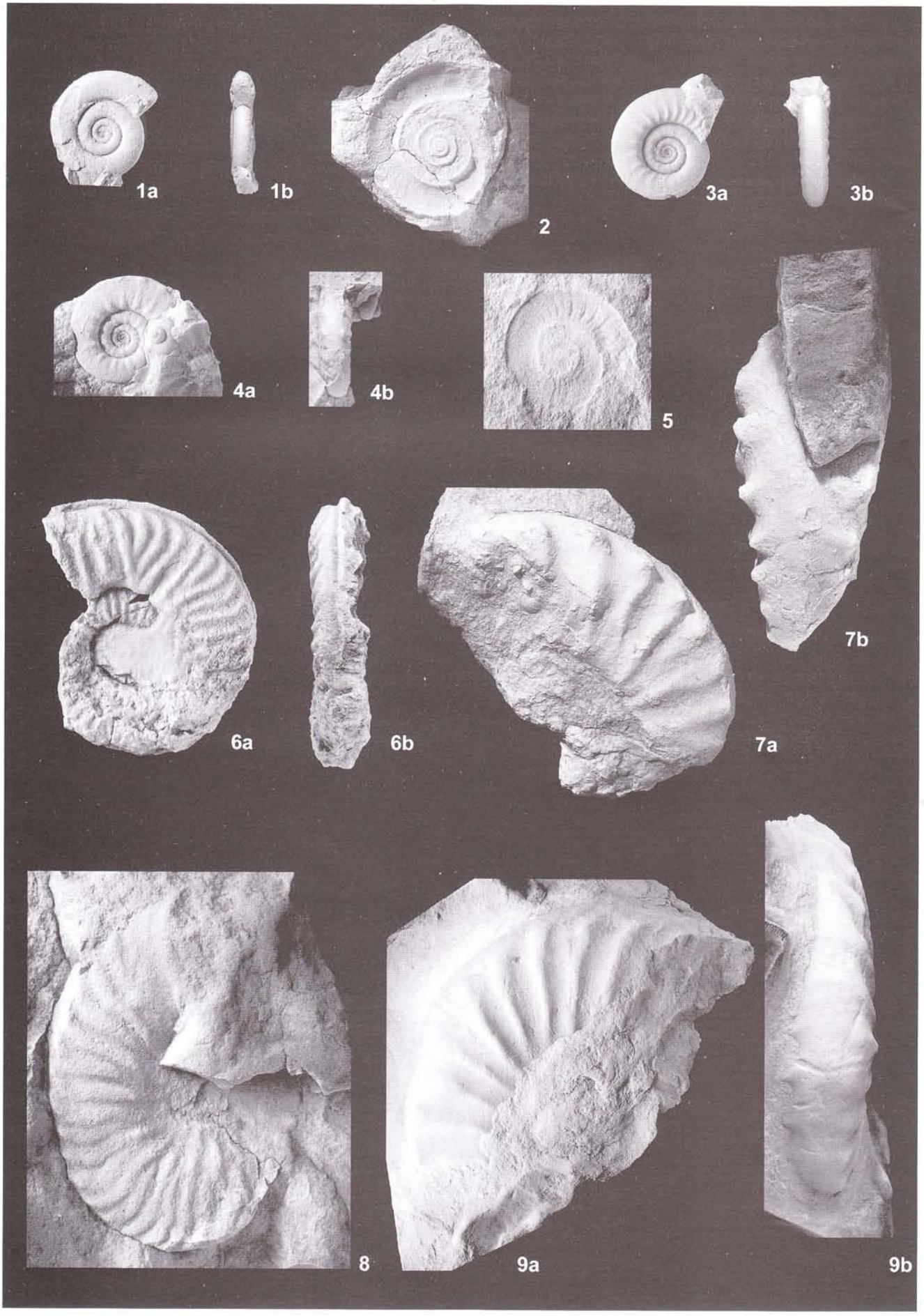
Fig. 7a-b, 9a-b - *"Megaceratites" friccensis* (Arthaber, 1916), 7) sample FRB10b.2 (MGPD 28970), Val di Centa Marls, Passo della Fricca "briglia" section (Trento), 7a) lateral view, 7b) ventral view, 9) sample FSR.2a (MGPD 28968a), Prezzo Limestone, Fosso Sercolo section (Brescia), 9a) lateral view, 9b) ventral view, Illyrian (uppermost Reitzi Subzone).

Fig. 8 - *"Semiornites" falcifer* (Hauer, 1896), sample FSR.4a (MGPD 28967a), Prezzo Limestone, Fosso Sercolo section (Brescia), lateral view, Illyrian (uppermost Reitzi Subzone).

All pictures x1; all specimens are whitened with Magnesium Oxyde.



Pl. 1



Pl. 2

presence of real ribs and periumbilical bumps in the inner whorls.

Comparison. In the Southern Alps, in a very short interval between the topmost Reitzi Subzone (beds with *"Megaceratites" friccensis*) and the base of the overlying Avisianum Subzone, specimens of Aplococeratidae have been found. These are closely similar to the North American species *A. smithi* Silberling & Nichols for the absence of ornamentation in the inner whorls, and the outer whorls interested by sinuous or convex growth lines. These morphological features fit well with *A. smithi* and, on the contrary, allow to discriminate the latter with respect to *A. avisianum*. Most of the specimens, and particularly those from Bagolino, are more or less crushed and then here considered with open nomenclature as *A.* aff. *smithi*. The specimen at our disposal which best resembles the North American taxon comes from Passo della Fricca section in the Centa Valley (Pl. 2, fig. 2) that is fairly well preserved.

Moreover, *A.* aff. *smithi* is well distinguishable from *A. avisianum* also by the lack of weak periumbilical bumps in the inner whorls. It must be emphasized that *A.* aff. *smithi* covers a different range than *A. avisianum*.

Occurrence. *Aplococeras* aff. *smithi* occurs in the uppermost Reitzi Subzone and survives after the FAD of *A. avisianum*, at the base of the homonymous Subzone. This is documented at Punta Zonia (Manfrin & Mietto 1995) and Bagolino. As already said this taxon is documented also at Passo della Fricca in the Southern Alps (De Zanche et al. 1995).

Aplococeras avisianum (Mojsisovics, 1882)

Pl. 1, figs. 1, 6 and 8

v	*1882	*Dinarites avisianus* Mojsisovics - Mojsisovics, pp.13-14, pl. 27, figs. 17-21.
v	1882	*Dinarites Doelteri* Mojsisovics - Mojsisovics, pp.14-15, pl. 27, figs. 22-24.
	1895	*Dinarites avisianus* Mojsisovics - Typus und var. *Dölteri* Mojsisovics - Salomon, pp. 197-198.
v	1905	*Lecanites vogdesi* - Hyatt & Smith, pp. 139-140, pl. 60, figs 12-15 (*vidimus*), 16-17, 18-19 (?), 20-22 (?); pl. 75, figs 10, 11-13 (?).
	1906	*Dinarites avisianus* Mojsisovics - Arthaber, Pl. 37, fig. 10.
non	1914	*Dinarites avisianus* Mojsisovics - Horn, p. 32, pl. 1, fig. 2 [= *Lecanites misanii* (Mojsisovics)].
v	1914	*Lecanites vogdesi* Hyatt & Smith - Smith, pp. 67-68, pl. 10, figs 12-15 (*vidimus*), 16-17, 18-19 (?), 20-22 (?); pl. 12, figs 10, 11-13 (?); pl. 30, figs 17-24, 28 (?); pl. 88, figs 24-25.
	1914	*Lecanites crassus* Smith sp. nov. - Smith, p. 66, pl. 89, figs 1-2.
	1921	*Dinarites avisianus* Mojsisovics sensu lato - Bubnoff, pp. 418-453, fig. 3-10, pl. 12 (3), figs. 1-5, 9.
non	1927	*Dinarites avisianus* Mojs. - Ogilvie-Gordon, p. 61, pl. 7, fig. 10 (= *Sphingites?* sp.).
v	1969	*Aplococeras avisianus* (Mojs.) - Assereto, fig. 1: 1-5, 11, 12; fig. 2: 1, 3-6, 8, 9, 11.
v	1969	*"Lecanites vogdesi"* Hyatt & Smith - Assereto, fig. 1: 6-9; fig. 2: 2, 7, 10.
	1969	*"Lecanites crassus"* Smith - Assereto, fig. 1: 10.
pars	1973	*Aplococeras* cf. *misanii* (Mojs.) - Rieber, pp. 64-65, pl. 17, figs. 1?, 3?, 5, 6, 14, not 2, 4 [= *Lecanites misanii* (Mojs.)].
v	1982	*Aplococeras vogdesi* (Hyatt & Smith) - Silberling & Nichols, p. 53, pl. 22, figs 1-2 (*vidimus*), 3-17.
pars	1993	*Aplococeras avisianum* - Vörös, Pl. 4, fig. 5, ? fig. 6 (= ? *Aplococeras* aff. *smithi* Silberling & Nichols).
pars	1993	*Aplococeras avisianum* - Vörös & Budai, tav. 13, fig. 5, ? fig. 4 (= ? *Aplococeras* aff. *smithi* Silberling & Nichols).
	1993a	*Aplococeras avisianum* (Mojs., 1982) - Brack & Rieber, pp. 478-479, Fig. 17c, pl. 12, figs. 9, 11-12.
	1993c	*Aplococeras avisianum* (Mojs. 1982) - Brack & Rieber, pl. 6, fig. 8.
v	1995	*Aplococeras avisianum* (Mojs.) - Mietto & Manfrin, Pl. 2, figs. 8-10.
v	1995	*Aplococeras avisianum* (Mojs.) - De Zanche et al., Pl. 1, fig. 1; Pl. II, figs. 1-2.
	1998	*Aplococeras avisianum* (Mojs.) - Vörös, pl. 4, fig. 10.
	1998	*Aplococeras* cf. *avisianum* (Mojs.) - Vörös, pl. 4, figs 8-9.

Material. One specimen from bed B2c10: BA41.3 (MGPD 28943) and five specimens from bed B2c 11: BAG5.8a and .8b (in the same sample, MGPD 28947a and b), BAG 12a, b and c (in the same sample, MGPD 28948a, b and c). Two specimens with open nomenclature: BAG5,4 and BAG5,5 (MGPD 28949, 28950). For comparison, specimens EA34 (MGPD 28966) from Forno near Predazzo (Pl. 2, fig. 3), and SF.B.1 (MGPD 28971) from the transitional beds of Adanà (Giudicarie area, Trento) (Pl. 2, fig. 5).

Description. The specimens are preserved as negative prints and in one case in 3D (BAG5.12b). The shell structure, the coiling and parcticularly the clear presence of faint periumbilical bumps fits likely with the type of *A. avisianum* (see Pl. 2, fig. 3). The specimen BA41.3, at a diameter of 3.4 cm, shows a simple ceratitic suture line in the outer volution.

Comparison. The species is characterized by a very compressed, nearly evolute shell, with ovoidal whorl section and gently rounded ventrolateral shoulders. This species shows a intraspecific morphological variability: the morphology of *A. avisianum* is dominated by the presence of convex ribs situated in the lower-middle part of the flanks, and by the presence in earlier onthogenetic stages of more or less spaced, either strong or weak periumbilical swellings or bumps. The suture line in mature specimens shows a typical simple ceratitic outline.

In agreement with Assereto (1969), the writers consider *A. doelteri* (Mojsisovics) synonym of *Aplococeras avisianum*; on the contrary, in the writers' opinion *A. laczkoi* (Arthaber) is *bona species*. *A. laczkoi* is distinguished from *A. avisianum* for the tubercles at the ventro-lateral margin.

After an examination of the original specimens illustrated by Assereto (1969) and of a cast of the type of *Lecanites vodgesi* Hyatt & Smith, both kept at the Dept. of Earth Sciences in Milano, the writers fully agree with Assereto (1969), and consider the northern American species *A. vogdesi* (Hyatt & Smith) a synonymous of *A. avisianum*. The suture line of one of the Assereto specimens from Nevada, at the diameter of ca. 2 cm, is simple ceratitic and identical to the one of *A. avisianum*.

Occurrence. In the Southern Alps, the quoted species is present in some beds of the "Lower Edifice" of the Latemar (Fassa valley) and, in particular, at Lastei di Valsorda, Battistero and dubitatively Cima del Forcellone, all in beds of the Avisianum Subzone. Moreover the quoted species was also found in the Torri Occidentali del Latemar, referred to the basal Crassus Subzone (Manfrin et al. submitted). It is also documented in the classical fauna of Forno and Mezzavalle (Mojsisovics 1882; Bubnoff 1921).

Outside the Latemar area, *Aplococeras avisianum* is surely documented in many other localities and sections of the Southern Alps, from Carnia to Canton Ticino (Mt. Nebria in Valbruna, Ru Sec in Val Zoldana, Punta Zonia and Auronzo in Cadore, Monte Cislon, Val dei Molini in the Adige valley, Adanà in Giudicarie: Mietto & Manfrin 1995, De Zanche et al. 1995; Monte San Giorgio in Canton Ticino: Rieber 1973), in the Balaton area (Vörös 1993, 1998; Vörös & Budai 1993) and in the Balkans (Berndt 1935). Identified as *A. vogdesi*, it is documented also in Nevada (Hyatt & Smith 1905; Smith 1914; Silberling & Nichols 1982).

The species occupies a precise stratigraphic position in the Upper Anisian being the marker of the Avisianum Subzone (Mietto & Manfrin 1995). It is also documented in the lowermost portion of the Crassus Subzone.

Aplococeras cf. **laczkoi** (Arthaber, 1911)

Pl. 1, fig. 3

Material. 1 specimen from bed B2c 6: BAG27.7 (MGPD 28951). For comparison, specimen MCP 6376 from bed LV-Q of the Lastei di Valsorda in the Latemar Massif (Pl. 2, fig. 4)

Description. Only one crushed and not well preserved specimen of a small aplococeratid shows, in the outermost part of the volution, very faint straight ribs that persist all along the flank. Moreover, when the ribs reach the ventrolateral margin, they seems to bear very faint nodes. Suture not visible.

Comparison. The feature of the ribs, that become rectiradiate during onthogeny, and often reach the ventrolateral shoulder, and the external tubercles, are diagnostic characters of *A. laczkoi*.

The quoted species must be compared with *A. avisianum*, from which is easily distinguished by the presence of the diagnostic external nodes. *A. laczkoi* shows some morphological characters of *Latemarites* (e.g. external nodes, juvenile ribs-morphology), but the latter exhibits a greater embracing of the volution, a greater involution and a more ornamented shell during onthogeny.

Occurrence. The species is present in the Lastei di Valsorda of the Latemar massif, Avisianum Subzone. Is also present in the basal level of the Punta Zonia section (Cadore area), uppermost Reitzi Subzone. The species is documented also in the San Marco section (Auronzo di Cadore). *A. laczkoi* is a typical element of the Avisianum Subzone of the Balaton highlands (Arthaber 1911b, Vörös 1998).

Genus *Lecanites* Mojsisovics, 1882

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

Lecanites misanii (Mojsisovics, 1882)

Pl. 1, fig. 7

	*1882	*Dinarites Misanii* Mojs., pp. 15-16, pl. 30, figs. 11-13.
?	1897	*Dinarites Misanii* Mojs. - De Lorenzo, p. 146, pl. 20 (6), fig. 2.pp. 126-127.
	1895	*Dinarites Misanii* Mojs. - Salomon, p. 179.
	1900	*Dinarites Misanii* Mojs. - Tommasi, p. 21.
	1900	cf. *Dinarites Misanii* Mojs. - Reis, pp. 76-77, pl. 2, figs.13-16.
	1907	*Dinarites Misanii* Mojs. - Reis, p. 119.
	1909	*Dinarites Misanii* Mojs. - Wilckens, p. 174, text-fig.
	1913	*Dinarites Misanii* Mojs. - Tommasi, p. 66, pl. 4 (5), fig. 24.
v	1914	*Lecanites parvus* Smith, pp. 66-67, pl. 30, figs. 25-26 (*vidimus*), 27, pl. 88, figs. 26-28
	1914	*Dinarites avisianus* Mojs. - Horn, p. 32, pl. 1, fig. 2
	1982	*Aplococeras parvus* (Smith) - Silberling & Nichols, pp. 53-54, fig. 38, pl. 22, figs. 18-23
pars	1973	*Aplococeras* cf. *misanii* (Mojs.) - Rieber, pp. 64-65, pl. 17, figs. 2, 4, not 1?, 3?, 5, 6, 14 [= *Aplococeras avisianum* (Mojs.)]
v	1995	*"Aplococeras" misanii* (Mojs., 1882) - De Zanche et al., pl. 1, figs. 2-5
	1996	*Aplococeras orobicum* Fantini Sestini, pp. 216-217, pl. 1, fig. 9

Material. Only two specimens: BAG50.3 and BAG50.5 (MGPD 28952, 28953) from bed B2c 12. For comparison specimen UE2.2 (MFSN 28170) from the Fassanian condensed facies of the Ammonitic Red Limestones of Mt Clapsavon in Carnia (Pl. 2, fig. 1)

Description. Two badly preserved small serpenticone specimens are been found in the level B2C 12, associated with *Halilucites rusticus* (Hauer) and probably *Parasturia*. In particular, the exemplar BAG50.3 shows a fairly preserved last portion of the whorl, that appears smooth. Suture non visible.

Comparison. The total lack of rib ornamentation allow the discrimination of *Lecanites misanii* from *Aplococeras avisianum* (Mojsisovics); the two taxa are also distinguishable by the kind of suture, which is goniatitic at any diameter in *L. misanii*.

After the examination of a cast of the holotype, we observe that *Lecanites parvus* Smith from Nevada (North America) appears undistinguishable from *L. misanii*.

Lecanites orobicus (Fantini Sestini) is discriminated from *L. misanii* for a clearly greater involution of the shell.

Occurrence. *Lecanites misanii* (Mojsisovics) is largely documented in many localities and sections of the Southern Alps, from Carnia to Canton Ticino (Mt. Clapsavon, Clap di Val, Valdepena, Punta Zonia, Mt. Cernera, Marmolada, Viezzena, Latemar, Mt. Cislon, Penone-Penon, Magrè all'Adige-Margreid, Recoaro, Grenzbitumenzone: Mojsisovics 1882; Salomon 1895; Tommasi 1900; Rieber 1973; Manfrin & Mietto 1991; De Zanche et al. 1995; Mietto & Manfrin 1995), in the Northern Calcareous Alps (Zugspitzmassif: Reis 1900, 1907), and in Montenegro (Martelli 1906); the occurrence of the species in the Apennine Basin of Lagonegro (De Lorenzo 1897) has to be confirmed. *Lecanites misanii*, that appears in the uppermost Avisianum Subzone, is well represented in the basal Ladinian (Nevadites Zone) and occurs, although infrequently, in all the Fassanian and beyond; the last specimens were found in the Longobardian (Longobardicum Subzone).

Genus *Halilucites* Diener, 1905

Type species: *Ceratites (Hungarites?) rusticus* Hauer, 1896

Halilucites rusticus (Hauer, 1896)

Pl. 1, fig. 17

v		*1896	*Ceratites (Hungarites?) rusticus* Hauer, pp. 259-260, pl. 9, figs 1-4.
v		1896	*Ceratites (Hungarites?) planilateratus* Hauer, pp. 261-262, pl. 11, figs. 1-3
	?	1912a	*Halilucites zagoriensis* Salopek, p. 14, pl. 1, fig.1.
		1912a	*Halilucites* cf. *rusticus* (Hauer) - Salopek, pp. 14-15, pl. 1, fig. 2.
	?	1912b	*Halilucites zagoriensis* Salopek - Salopek, pp. 80-81.
		1912b	*Halilucites* cfr. *rusticus* (Hauer) - Salopek, pp. 81-82.
	?	1915	*Halilucites* sp. ind. ex aff. *planilaterato* (Hauer) - Diener, pp. 59-60, pl. 5, fig. 3.
v		1995	*Halilucites rusticus* (Hauer) - De Zanche et al., pl. 3, fig. 4.
		1998	*Halilucites rusticus* (Hauer) - Vörös, pl. 7, fig. 2

Material. Only specimen BAG50.4 in situ in the bed B2c 12. For comparison is illustrated also specimen LG.B11 (MGPD n° 28969) from the condensed beds of La Grea section (Marmolada area, Trento) (Pl. 2, fig. 6).

Description. The examined exemplar consists in natural negative print of a flank and ventral area, difficult to extract from the layer without its destruction. The cast permits to identify a compressed, moderately involute shell. The venter is marked by a well defined keel bordered by a lateral furrow, and connected to the flanks by a rounded margin. The ornamentation is characterized by strong sigmoidal ribs, adorally projected when approaching the ventrolateral area; in the preserved portion of the flank, the ribs are generically simple but intercalatories are also present. As for the genus, no ventrolateral nodes are visibile. Suture line not recognisable.

Comparison. The examination of Hauer's material, kept at the Naturhistorische Museum of Wien, allowed to state the identity between *H. rusticus* and *H. planilateratus* (Hauer, 1896). *H. arietitiformis* differs from *H. rusticus* because is more evoluted, and shows mainly primary, rectilinear more spaced ribs. *H. obliquus* (which is closely related to *H. intermedius*) differs because is more involuted and compressed, shows more numerous and more regular ribs and lacks lateral nodes.

Hungarites costosus Mojsisovics probably belongs to a different genus, because it not shows ventral furrows, a diagnostic character of *Halilucites.*

Occurrence. Specimens of *H. rusticus* have been collected from debris at Cima di Valsorda and Pizz dei Muss (Latemar massif), and in situ in beds L2, LCV12 (Cima di Valsorda), always in the Latemar massif. All beds belong to the Crassus Subzone.

The quoted species is also documented is many localities of the Southern Alps (pelagic draps of the Cernera massif, condensed beds of La Grea in the Marmolada area and Livinallongo Fm. of the Val Giaule 2 section near Pieve di Cadore) (De Zanche et al. 1995; Mietto & Manfrin 1995). Outside the Alpine region, *H. rusticus* occurs in the Balaton upland (Vörös 1998), in the Dinaric region (Hauer 1896; Salopek 1912 a,b) and perhaps in the Himalaya (Diener 1915).

Genus *Semiornites* Arthaber, 1912

Type species: *Ceratites cordevolicus* Mojsisovics, 1882

«Semiornites» falcifer (Hauer, 1896)

Pl. 1, fig. 5

v		1896	*Ceratites falcifer* Hauer, pp. 258-259, pl. VIII, figs. 5-6.
	?	1904	*Ceratites falcifer* Hauer - Martelli, pp. 84-85, pl. V, fig. 4.
	?	1913	*Ceratites falcifer* Hauer - Salopek, p. 10, fig. 1
	non	1916	*Ceratites (Semiornites) falcifer* Hauer - Arthaber, pp. 257-260, pl. V, figs 3 [= *«Megaceratites»* cf. *friccensis* (Arthaber)], 4 [= *Stoppaniceras* ex gr. *golanum* (Arthaber)].
	?	1925	*Ceratites* sp. ind. aff. *falcifer* Hauer - Diener, pp. 53-54, pl. VII, fig. 1.
v	aff.	1949	*Ceratites falcifer* Hauer - Riedel, pl. I, fig. 8

Material. One specimen, BAG27.2 (MGPD 28954), in bed B2c 6, and another specimen with open nomenclature, BAG30.8 (MGPD 28955), in bed B2c 9. For comparison is illustrated also the specimen FSR.4a (MGPD 28967a) from the Prezzo Limestone of Fosso Sercolo section (Chiese Valley) (Pl. 2, fig. 8).

Description. A negative print of a portion of a well ornamented flank is examined. The ornamentation consists of serried falcoid ribs, more or less wide as the interspaces. The ribs appears to be simple primaries, but may sometimes bifurcate in the proximity of the umbilical area; long intercalatory ribs are also present. Suture line not visibile.

Comparison. The identification of this specimen is based also on the comparison with Hauer's type, stored in the Naturhistorisches Museum of Wien. The attribution of this taxon to the genus *Semiornites* Arthaber is merely indicative, since the morphological outline of *"S." falcifer* is not easily comparable with that of other ceratitoids. In the past, this rare species was ill identified. The Riedel's specimen, while showing a similar morphological outline, differs for the presence of rectiradiate ribs that sometimes bifurcate in the middle flank.

Occurrence. The species is known from Fosso Sercolo (Mietto & Manfrin 1995) in the Lombardian Alps, and from Haliluci (Sarajevo) in Bosnia (Hauer, 1896). To date, *"S." falcifer* is documented in the upper part of the Reitzi Subzone (sensu Mietto & Manfrin, 1995).

Genus *Megaceratites* Balini, 1993

Type species: *Megaceratites fallax* Balini, 1993

"Megaceratites" sp.

Pl. 1 , fig. 14

Material. Only a fragment of body chamber, BAG 29.6a, and its negative, BAG29.6b (MGPD 28956a and b), were found in bed B2c 8. For comparison are illustrated also specimens of *"Megaceratites" friccensis* (Arthaber): BFR10b.2 (MGPD 28970), from the Val di Centa Marls of Passo della Fricca section (Trento), and FSR.2a (MGPD 28968a), from the "transitional beds" of Fosso Sercolo section (Chiese Valley) (Pl. 2, figs 7 and 9, respectively).

Description. Is here described a fragment of body chamber of a fairly large exemplar; the fragment shows rectilinear, spaced, strong ribs and marked ventrolateral nodes, suggesting the comparison with the representatives of *"Megaceratites"* related to the *friccensis* group (see Arthaber 1916; De Zanche et al. 1995).

Occurrence. This group is documented in the upper portion of the Reitzi Subzone (sensu Mietto & Manfrin 1995) of the surroundings of Trento (Val Gola, Margon, Val di Centa, Passo della Fricca, Valsugana: Arthaber 1916; De Zanche & Mietto 1986, 1989; Mietto & Manfrin 1995; De Zanche et al. 1995) in the Val di Centa Marls (Zwischenbildungen p.p.) and of Fosso Sercolo, Lombardian Alps (Mietto & Manfrin 1995).

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