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Artikel: Towards a better definition of the Anisian/Ladinian boundary : new biostratigraphic data and correlations of boundary sections from the Southern Alps

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Kapitel: 3: Anisian/Ladinian boundary intervals in basinal "Buchenstein Beds"

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Pelagic strata on top of drowned platform carbonates (Type b sections) are mainly the classical "Buchenstein Beds" which are present throughout the northwestern Dolomites and in the Trento and Recoaro/Tretto areas. Hallstatt-type limestones are also found locally (e.g. to the east of the Dolomites; Clapsavon Lst. of Cadore and Carnia). The base of these beds may not be isochronous in all settings, reflecting onlap relationships and/or different times of (tectonically induced) drowning of sometimes previously exposed platforms.

Fossil bearing intervals in carbonate platform areas (Type c sections) are usually of restricted vertical and lateral extent. Nevertheless they host some important and exceptionally rich faunas on flank and interior portions of small platforms (e.g. Latemar, Cernera) as well as in deposits of larger intra-platform depressions (e.g. "Grenzbitumenzone" at Monte San Giorgio).

In the following chapters we will present new stratigraphic and fossil data from representative successions in all these settings. The sections studied in detail are located in the Dolomites, in the eastern Lombardian Prealps and adjacent territories (Bergamask- and Brescian-Prealps, Giudicarie, Trento area) and in southern Switzerland (Fig. 1).

3. Anisian/Ladinian boundary intervals in basinal "Buchenstein Beds"

In 1892 Bittner proposed the Ladinian Stage with the "Buchenstein Beds" at its base. In the Southern Alps these are the most widespread fossiliferous pelagic sediments straddling or approaching the stage boundary. However, their fossil content is usually poor, they are lithologically variable and exhibit lateral facies changes with coeval platform carbonates. Opinions therefore diverged through time about the stratigraphic range of the "Buchenstein Beds." Some of the most important ideas are summarized in roughly chronological order before details are presented on the main lithologies, the depositional settings and the studied sections.

3.1. Opinions on the stratigraphy and range of the "Buchenstein Beds"

The "Buchenstein Beds" were defined by Richthofen (1860) in a section near Pufels[3]) in the northwestern Dolomites (Fig. 1) as a lithologically characteristic succession of evenly bedded and nodular siliceous limestones with greenish shaly intercalations. A few non-diagnostic fossils were mentioned from this unit at Pufels and Seceda by Richthofen (1860) and Stur (1868). Ammonoid finds from the Pufels section include "*T.* cf. *reitzi*" (Mojsisovics 1873), later referred to as "*T. reitzi*" and "*Trachyceras curionii*" (Mojsisovics 1882). This led the latter to correlate these beds with the "*Trachyceras reitzi*"-bearing limestones in the Balaton Highland of Hungary. Mojsisovics (1879) also extended and generalized the lithostratigraphical range to consist of two series of evenly bedded, dark limestones (the lower and upper "Bänderkalke", also called "Plattenkalke" by other authors) separated by a stack of nodular limestones with greenish volcaniclastic intercalations ("Pietra verde"). Similar nodular limestones associated with "Pietra verde" were recognized also in other parts of the Southern Alps, in the Eastern Alps and Bakony.

No relevant additional fossils were known from the "Buchenstein Beds" in the Dolomites when Bittner (1892) introduced the "Ladinian Stage[4])" (called "Norian" by Mojsisovics until 1902) and fixed its base with this lithologically defined unit. Thereafter the term "Buchenstein Beds" was frequently used in a chronostratigraphic

[3]) The name "Buchenstein" is derived from another locality near Andraz in the Livinallongo area of the central Dolomites where the homonymous beds are typically developed (e.g. Leonardi 1967).

[4]) After the Ladini people in the Dolomites.

sense i.e. as a synonym for the "*Zone of Protrachyceras reitzi*" and/or "*curionii*" (e.g. Arthaber 1906). However, doubts about the chronostratigraphic value of the "Buchenstein Beds" arose from apparently contradicting observations: Kittl (1894) listed a fauna with "*Trachyceras reitzi*" from platform carbonates at Marmolada, which according to Salomon (1895) were lying above typical "Buchenstein Beds". Philipp (1904) therefore recommended the use of this name in a strict lithological sense. Alternatively, new names were introduced for equivalent strata such as the "Nodosus Fm." in the Recoaro and Tretto areas (Tornquist 1901). Elsewhere in the Southern Alps pelagic Ladinian limestones were referred to as the "Reitzi-Schichten" or "Reitzi-Kalke" (Salomon 1908; Horn 1913, 1914) but the name "Buchenstein Beds" was not generally abandoned (e.g. Diener 1915, Klebelsberg 1935, Pia 1937).

New and substantial ammonoid finds were finally reported from "Buchenstein Bed" equivalents outside of the Dolomites by Geyer (1898), Tornquist (1898) and Horn (1913, 1914). The latter considered the cherty nodular limestones in the Brescian Prealps to be younger than the apparently Upper Anisian counterparts in the central Dolomites. This was subsequently disproved by an ammonoid find (*Arpadites arpadis*, Kieselinger 1927) in the "Pietra verde" near Buchenstein. Hummel (1928, 1932) finally recognized the correct lateral relationships between the thin Ladinian basin deposits ("Buchenstein Beds") and thick coeval carbonate platforms in the Dolomites. He also advocated an overall synchronous base of the nodular limestone facies and supposed a close relationship with the first "Pietra verde" occurrences.

Based on Diplopora finds Ogilvie Gordon (1927) suggested a Late Anisian age ("Oberer Muschelkalk" p.p.) for the "Lower Bänderkalke" in the Dolomites. Pia (1937) supposed the Anisian/Ladinian boundary to be situated within the lower part of the nodular limestones. As a consequence the "Lower Bänder- or Plattenkalke" were sometimes formally separated (Ogilvie Gordon 1927; Assereto et al. 1977a; Gaetani et al. 1981; Fois 1982) but in most cases still remained part of the "Buchenstein Beds" in the sense of Mojsisovics (e.g. Rossi 1962, 1964, 1967; Baccelle Scudeler 1971; Viel 1979; Bosellini & Ferri 1980). Few further macrofossils were found in the "Buchenstein Beds" between 1930 and 1980 (e.g. Ogilvie Gordon 1927, 1929; Leonardi & Panchieri 1949).

On the basis of Daonellas the "Lower Bänderkalke" could be correlated with other age equivalent strata at Val Gola and Monte San Giorgio (Rieber 1969). Ammonoid successions collected in the "Buchenstein Beds" of the Brescian Prealps and Giudicarie (Brack & Rieber 1986 and this paper) now clearly document the long time range of these strata. This is supported by studies on conodonts (e.g. Gasser 1978; Mietto & Petroni 1979, 1980; Mietto 1982; Kovacs et al. 1990) and by palynological investigations on samples from equivalent beds in the Southern Alps (van der Eem 1983; Brugman 1986).

Especially in the Italian literature after 1930 the name "Buchenstein" is often replaced by "Livinallongo." In the context of a detailed revision of the Ladinian lithostratigraphy in the eastern Dolomites Viel (1979) proposed a group rank for the German terms "Buchenstein" and "Wengen." In this scheme the "Buchenstein Group" comprises the "Livinallongo Fm." (i.e. the original "Buchenstein Beds" including the "Lower Plattenkalke") together with partly coeval basinal siliciclastic sediments, tuffs and pelagic carbonates (Zoppè Sst., Aquatona Fm.) which were traditionally considered as parts of the "Wengen Beds." Viel's (1979) "Wengen Group" is restricted mainly to volcanic rocks and their reworked products in the Dolomites and eastern adjacent areas.

Throughout this paper we maintain the informal expressions "Buchenstein"- and "Wengen Beds" because these names can be applied unambiguously in the Lombardian area and in the northwestern Dolomites. Moreover this facilitates comparisons with older publications especially on the Lombardian Triassic. Our term "Buchenstein Beds" thus corresponds largely to Viel's "Livinallongo Fm.". The mainly siliciclastic Lombardian "Wengen Beds" may be considered as partial equivalents of the Zoppè Sst., Aquatona Fm. and Longiarin Sst. of Viel's "Buchenstein-" and "Wengen" Groups (Fig. 2).

3.2. The main lithologies and depositional environments of the "Buchenstein Beds"

3.2.1. Standard subdivisions in the Dolomites

Complete sections of the "Buchenstein Beds" in the Dolomites are traditionally subdivided into three main lithological units (Mojsisovics 1879). These are from bottom to top the "Lower Plattenkalke" (instead of "Lower Bänderkalke" as in Mojsisovics 1879), the "Knollenkalke" and the "Upper Bänderkalke" (Viel 1979). Greenish volcaniclastic intercalations ("Pietra verde") occur as variably thick layers throughout the entire stratigraphic column. Locally, thin intervals of reddish nodular limestones are also present. Detailed descriptions of the various microfacies and mineralogical information on the volcaniclastic rocks can be found elsewhere (e.g. Baccelle & Sacerdoti 1965; Baccelle Scudeler 1972; Bosellini & Ferri 1980; Bosellini & Rossi 1974; Callegari 1964, 1965; Callegari & Monese 1964; Cros 1974; Rossi 1964, 1965, 1967; Viel 1979).

The **"Lower Plattenkalke"** are evenly bedded black calcareous to dolomitic mudstones. The beds are often strongly siliceous, laminated and rich in mainly amorphous organic matter with subordinate algae and palynomorph contents (C_{org} ranges between 1 and 3.5% by weight). Radiolarians and thin pelecypod shells (e.g. Daonellas, "*Posidonia*") are abundant. Fine-grained greenish to rusty weathering volcaniclastic detritus mixed with argillaceous material is intercalated at various levels. In the northwestern Dolomites this unit is up to 15 m thick in distal portions (with respect to coeval platform cores) and lies with a sharp contact on top of drowned Upper Anisian platform carbonates (Contrin Fm.; Figs. 4, 5). Larger amounts of volcaniclastic rocks and coarse breccias of platform carbonate boulders are intercalated in the "Lower Plattenkalke" in the central Dolomites (e.g. Bosellini & Ferri 1980; Cros & Houel 1983). In the northern and eastern Dolomites and in Cadore the "Plattenkalke" and their equivalents overlie pelagic Upper Anisian strata.

The **"Knollenkalke"** consist of irregularly spaced but generally dm-scale bedded (e.g. Seceda section, Figs. 4, 5), wavy to nodular, calcareous and sometimes pelletoidal mudstones surrounded by argillaceous material. Bioturbation is common and chert occurs in nodules or as diffuse patches. The rocks are also rich in thin shelled bivalve fragments and calcitized radiolaria.

Subtracting the volcaniclastic intercalations, the total thickness of the pelagic nodular limestone intervals in 30–40 m in settings at some distance from coeval carbonate platforms. Average net sediment accumulation rates range within 4.5–10 m/My (non decompacted) accepting the age calibration as discussed later. This reflects a uniform autochthonous (pelagic) carbonate production throughout the "Buchenstein" basins. In the central and eastern Dolomites parts or the entire unit may be replaced by siliciclastic turbidites (Zoppè Sst.; Viel 1979; Cros & Houel 1983).

The **"Upper Bänderkalke"** are similar in appearance to the "Lower Plattenkalke" and comprise lithologies such as siliceous, black, laminated micritic limestones. Well bedded, often dolomitized and presumably turbiditic calcarenites and megabreccias also occur throughout this unit, especially in settings close to the base of prograding carbonate platforms. The thickness and distribution of the "Upper Bänderkalke" are variable and portions of it may be replaced by or interbedded with siliciclastic turbidites (Zoppè Sst.; Viel 1979).

The **"Pietra verde"** layers are usually greenish to reddish coloured, but sometimes yellowish weathering volcaniclastic clay-, silt- and sandstones. They occur throughout the "Buchenstein Beds" as single strata or successions of layers, between a few millimeters up to several meters thick. Comparable tuffaceous intervals are also found at stratigraphically higher and less frequently at lower levels. Acidic (rhyodacitic; Callegari & Monese 1964; Carraro & Fiora 1974) magmas have been suggested for the origin of the pyroclastic deposits. In places the latter also contain accretionary lapilli. The proportion of volcaniclastic intercalations varies throughout the "Buchenstein Beds" in the Dolomites reflecting basin geometries and modes of distribution. Reduced cumulative

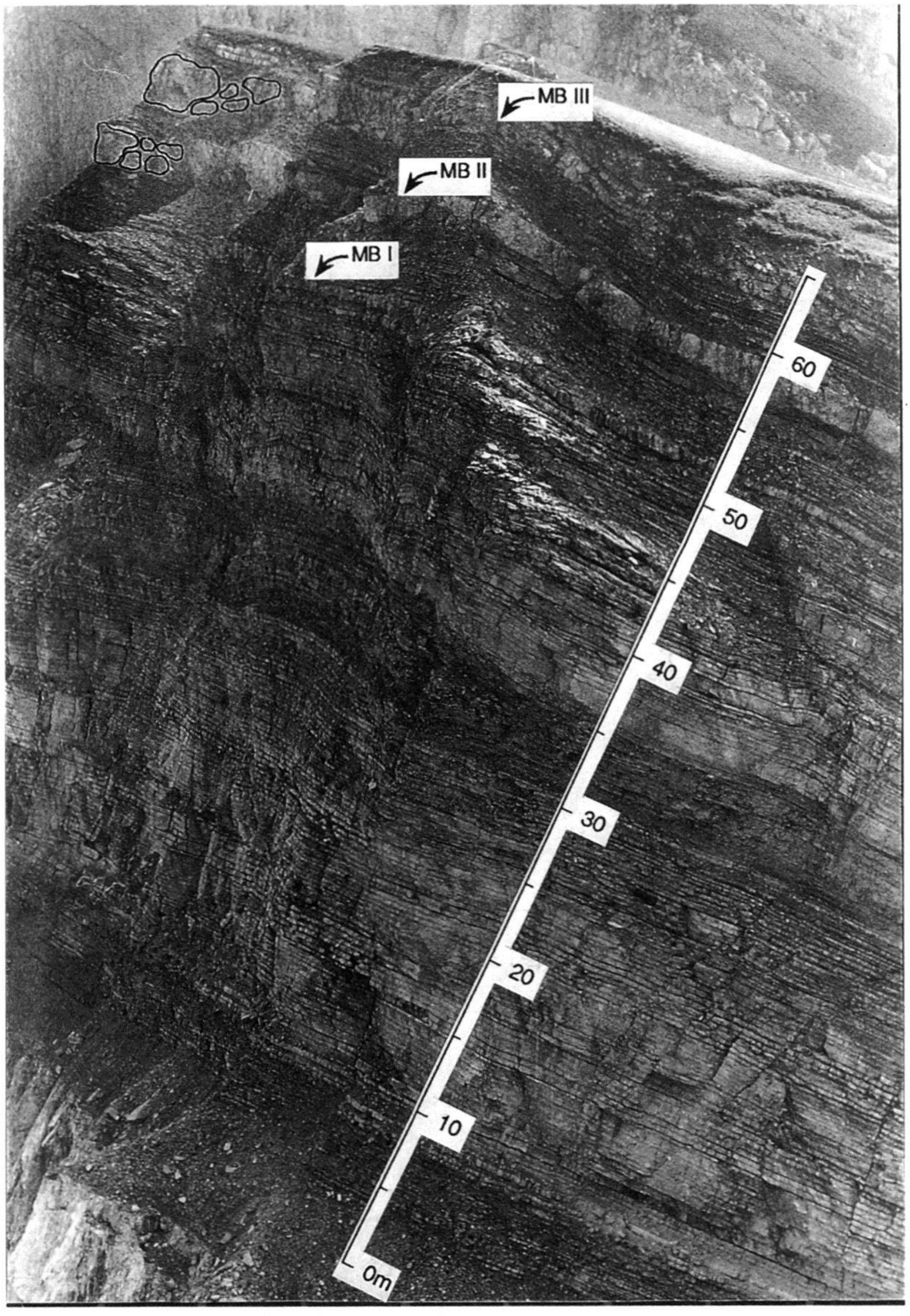


Fig. 4. View of the Seceda section in the cliff one hundred meters to the east of the main peak. This section serves as a reference for the "Buchenstein Beds" in the northwestern Dolomites. These are subdivided into the "Lower Plattenkalke" (0–8 m), the "Knollenkalke" (8–ca. 40 m), and the "Upper Bänderkalke" (ca. 40–55 m). The strata above the 50 m-level contain increasingly greater quantities of siliciclastic and reworked carbonate material as well as three major megabreccias (MB I–III) consisting of platform carbonate boulders and few volcanic clasts. Note the regular spacing of the limestone/marl alternations in the "Knollenkalke" below and above a wedge shaped "Plattenkalk-type" and "Pietra verde" bearing interval just above the 30 m-level. This interval thickens by several meters away from the observer (i.e. in a eastern direction; see text). Meter-scale is the same as in Figs. 5, 6, 7, 11.

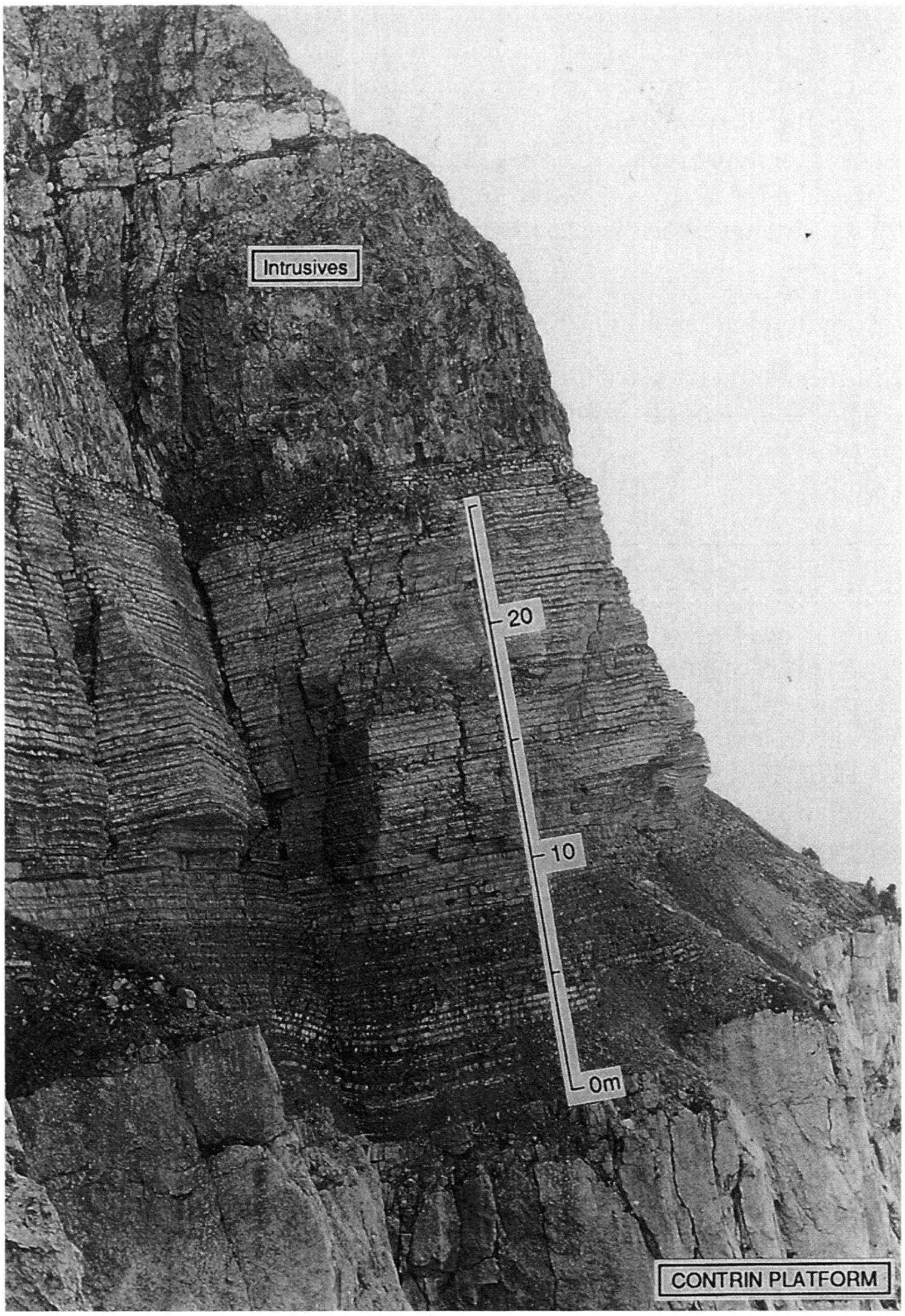


Fig. 5. The lower part of the "Buchenstein Beds" as exposed to the south of the Seceda cable car station (see Figs. 6, 7, 11 for fossil horizons). Drowned Upper Anisian platform carbonates (Contrin Fm.) are sharply overlain by the "Lower Plattenkalke" (0–8 m interval). The overlying "Knollenkalke" are crosscut by a laccolith-shaped intrusion of presumably Late Ladinian age.

thicknesses of a few meters are found in the northwestern Dolomites. Major accumulations exceed 100 m towards a possible source area in the southeast (Cros & Houel 1983). This suggests that the northwestern and central/eastern Dolomites were separated by a ridge limiting the distribution of at least the (turbiditic) submarine pyroclastic flow fractions of southern provenance. Along the flanks and in the interiors of coeval carbonate platforms similar layers are found only sporadically. The volcaniclastic fallout in these settings may have been washed out.

3.2.2. Distribution and environments of deposition of the "Buchenstein Beds"

The thickness and character of the "Buchenstein Beds" vary throughout the Southern Alps. The basin deposits in the **western** and **central Dolomites** represent deepening upward successions (Bosellini 1984). They document the transition from initially restricted, sill-bounded ponds where organic matter was preserved during rapid rise in relative sea-level ("Lower Plattenkalke") to interconnected, open marine areas, up to 800 m deep and with normal bottom water conditions. Single members vary in thickness or the entire pelagic succession may be replaced, depending on the position within the basins and relative to the sources of allochthonous material. This variability has been well documented especially along facies transitions between the basinal "Buchenstein Beds" and coeval carbonate platforms in the Dolomites (e.g. Hummel 1928, 1932; Cros & Lagny 1972; Bosellini & Rossi 1974; Cros 1974; Viel 1979; Bosellini & Ferri 1980; Gaetani et al. 1981; Fois 1982; Blendinger et al. 1982; Cros & Houel 1983; Bosellini 1984) but also in western Lombardy (Pasquarè & Rossi 1969; Gaetani et al. 1987).

In **Lombardy** and eastern adjacent areas, equivalent basinal strata (called "Buchenstein Fm." in Lombardy, "Nodosus Fm." near Recoaro/Tretto and "Margon Lst." near Trento) consist mainly of siliceous and sometimes reddish colored "Knollenkalk"-intervals and volcaniclastic intercalations. Where fully developed, as in eastern Lombardy and Giudicarie, the net thickness of the pelagic nodular limestones generally ranges between 30 and 40 m again reflecting a long lasting uniform deep marine environment (Fig. 7). Water depths may have been considerably shallower than the maximum values (i.e. around 800 m) reached in the Dolomites. This is indicated by the limited thickness of platform carbonates and coeval turbiditic and storm-generated siliciclastic deposits ("Wengen Beds") directly overlying the "Buchenstein Beds." Lithologies similar to the "Bänder-" and "Plattenkalke" of the Dolomites are not well developed. Siliceous and sometimes laminated dark limestone beds and shales frequently occur in a transitional zone, only a few meters thick, between typical Prezzo Limestone and distinct "Knollenkalk"-lithologies of the "Buchenstein Beds" (see below; Fig. 10). In the northeastern Bergamask Alps up to 40 m thick chert-rich, evenly-bedded dark limestones and volcaniclastic sandstones replace the middle/upper portion of the standard "Knollenkalk"-succession (e.g. in the tectonically higher Middle Triassic unit at Pizzo Camino south of Schilpario).

Sites of acidic to intermediate volcanic eruptions which are partly coeval with the "Buchenstein Beds" have been reported from the Recoaro area (De Zanche et al. 1979; Barbieri et al. 1980), the Julian Alps and Carnia (e.g. Spadea 1970; Cros 1979). Cros (1982) also mentions the occurrence of reworked ignimbrites as clasts in "Pietra verde" and megabreccia layers. In the Brescian Prealps evidence of volcanic activity is preserved as shallow intrusives in the "Buchenstein Beds" near Dezzo (e.g. Jadoul & Rossi 1982). Subvolcanic bodies also crosscut nearby Permian to Lower Triassic strata (M. Muffetto; Cassinis & Zezza 1982). Clasts of similar lithologies are contained in "Pietra verde" deposits in the uppermost "Buchenstein Beds" (Brack & Rieber 1986).

In an area adjacent to the Southern Alps, thick piles of volcanic rocks are interbedded with Upper Anisian to Ladinian carbonates on the slopes of the Dobratsch mountain in the Drauzug of Austria (Pilger & Schönenberg 1958; Colins & Nachtmann 1974). The igneous products consist of tuffs and agglomerates including volcanic bombs. Their original location may have been north of a central/western portion of the Southern Alps.

3.3. Fossiliferous sections and correlation of "Buchenstein Beds" in the northwestern Dolomites and the Brescian and adjacent Prealps

3.3.1. Northwestern Dolomites

Spectacular exposures of continuous successions of "Buchenstein Beds" are found around the **Seceda** peak (Figs. 4–6; see also figures in Ogilvie Gordon 1927) near Ortisei in Val Gardena. These outcrops [5]) are representative and suitable for a reference section of these beds in the northwestern Dolomites. The complete section (Figs. 4, 7) is 60–70 m thick, overlies Upper Anisian platform carbonates (Contrin Fm.) and is capped by strata with a higher siliciclastic content. The latter are preserved only sporadically. The "Plattenkalke" at the base of the Seceda section are 8 m thick and contain various levels of "Pietra verde" mixed with siliciclastic material. Sharply overlying are 35–40 m of "Knollenkalke" consisting of two units separated by a thin interval of "Pietra Verde" and "Plattenkalk"-type lithologies. Although not always evident in outcrop, the "Knollenkalke" show a distinct and fairly regular bedding (Fig. 4, 5). Nodular limestone beds with undulating surfaces are 0.1 to 0.5 m thick and separated by laterally continuous, thin siliceous clays and marls. In the uppermost part of the section the "Bänderkalke" are evenly bedded and more strongly dolomitized. They consist mainly of reworked platform carbonate debris. Intercalations of siliciclastic material thicken upwards (above 45 m-level) and three megabreccias with large platform carbonate boulders thin rapidly in a western direction along the Seceda north flank (Fig. 4). Volcaniclastic layers ("Pietra verde") are concentrated in three intervals throughout the section but their cumulative thickness amounts to only a few meters. The Seceda section appears to be largely undisturbed. Only the thin "Plattenkalk"-type interval approximately half way up the section (Figs. 4, 7) is not perfectly concordant and thickens slightly to the east of the main peak. Possible causes of this anomaly could be mechanical effects of laccolith-shaped intrusions which are found at approximately this stratigraphic level to the south of the cable-car station at Seceda (Fig. 5).

Along the steep north face of the Geisler Spitzen (Le Odle) to the east of Seceda, the "Buchenstein Beds" are progressively replaced by coeval and roughly southwestward

[5]) A complete section is accessible in a steep gully between the Seceda peak and the Pana Scharte. However, the access to this and other exposed outcrops immediately above the steep cliff of Upper Anisian platform carbonates requires caution!

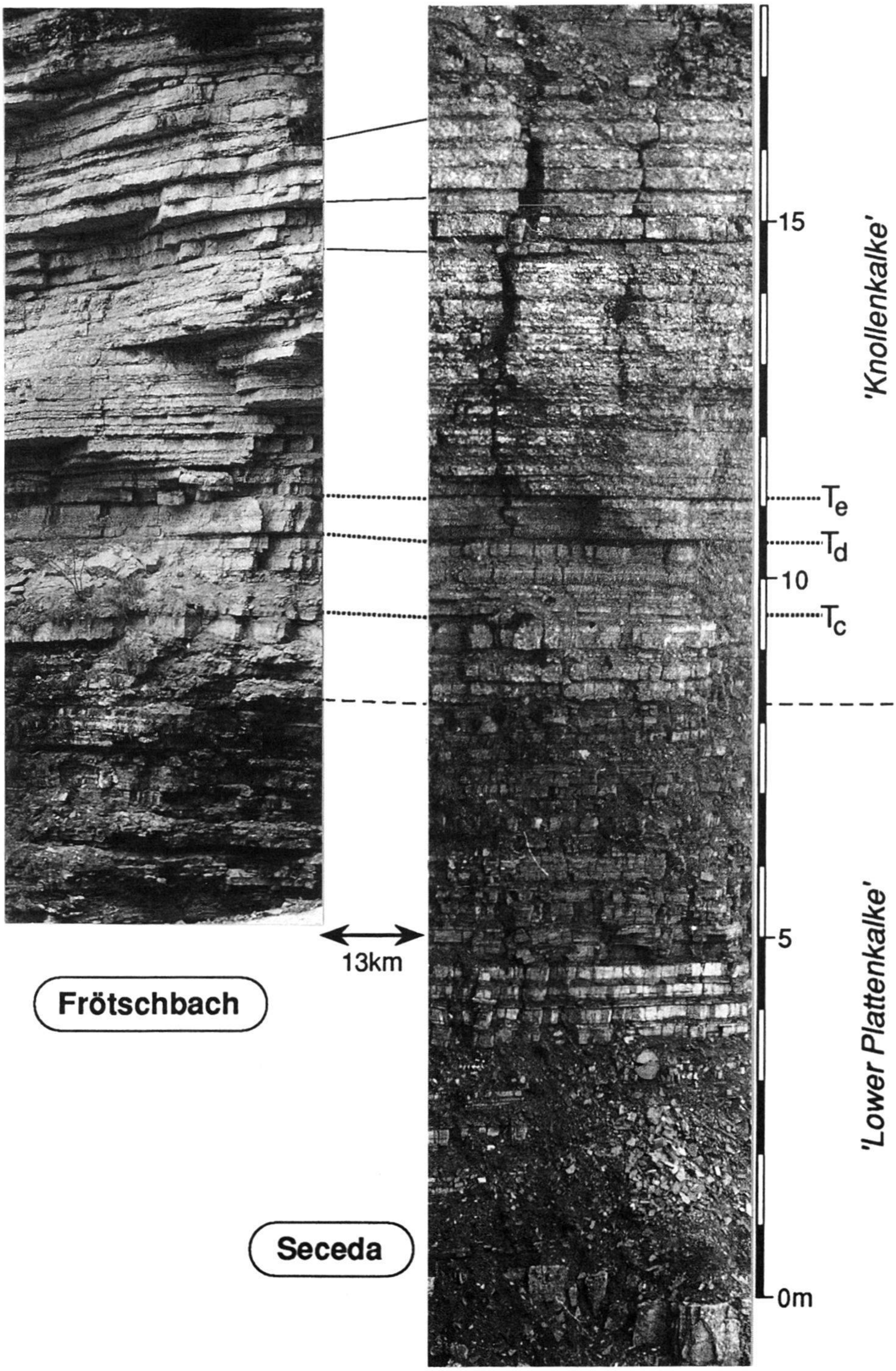
prograding clinoform deposits of a larger carbonate platform. Remains of the core of this platform are preserved in the cliffs between the Furchetta and Wasserkofel peaks of these mountains, but the main platform interior portion was presumably situated further to the north. The vertical size (800–900 m) and distances of clinoform progradation of this platform are comparable to the coeval Rosengarten (e.g. Bosellini & Stefani 1991) and Latemar platforms in the western Dolomites.

There are no similar interruptions in the outcrops of "Buchenstein Beds" across the Gröden valley and on the scarps around the Seiser Alm. These host classical sections of the "Buchenstein Beds" such as the original "type-section" in the **Pufels** gorge (Richthofen 1860; Mojsisovics 1873, 1879) and fossiliferous sections at Frommbach and **Frötschbach** (e.g. Horn 1913, 1914; Hummel 1932; Brandner 1982). Unfortunately the detailed stratigraphy of many sections in this area is partly obscured by shallow intrusives and tectonic structures. Moreover, the Pufels section is not sufficiently well exposed. However, individual beds can be correlated between Frötschbach and the Seceda section some 13 km distant, especially within the first 20–25 m of "Platten-" and "Knollenkalke" (Fig. 6). In particular, a typical succession of thin volcaniclastic layers about 1–4 m above the "Plattenkalk/Knollenkalk" boundary can easily be identified in both sections. This tuff sequence includes a characteristic 1 cm thick crystal-tuff at the base of a larger tuffaceous groove correlatable with the volcaniclastic T_c level in the Brescian Prealps (see below). The "Buchenstein Beds" at Seceda are a suitable replacement for the classical section at Pufels.

Another more easily accessible section of the lower part of the "Buchenstein Beds" is exposed along the main road in Val Badia 2 km north of **Pedraces** and around 15 km east of Seceda. Overlying Upper Anisian basinal limestones and marls are 15 m of "Plattenkalke." In common with the Seceda section, Daonellas occur throughout their uppermost layers. The "Knollenkalke" again include the above mentioned characteristic tuff interval close to their base and have thickness (23 m) and bedding characteristics not different from the lower "Knollenkalk"-unit at Seceda. These beds are overlain by an interval containing "Pietra verde" and "Plattenkalk"-type dark, siliceous limestones. Higher up the section is disturbed, and megabreccias and "Platten/Bänderkalk"-type lithologies possibly replace the upper "Knollenkalk"-unit of the reference section at Seceda.

Lithostratigraphic correlations of the Pedraces section with the "Buchenstein Beds" in the **central Dolomites** (Cros & Houel 1983; Fig. 5) indicate that the lower "Knollenkalk"-unit at Seceda corresponds to the main "Knollenkalk"-interval in the present type-sections of the Livinallongo Formation (i.e. our "Buchenstein Beds") near Caprile (Baccelle Scudeler 1972; Viel 1979). These are the "Median Knollenkalke" [MKK] of Cros & Houel (1983). Accordingly the thin "Pietra verde" layers close to the "Plattenkalk/Knollenkalk"-transition at Seceda most likely represent distal (? subaerially transported) fractions of the "Lower Pietra verde" [LPV] which are several meters thick in the central Dolomites and Cadore. The intermediate and upper "Pietra verde" intervals at Seceda are equivalents of the "Upper Pietra verde [UPV]."

Fig. 6. Lithological correlation of the lower "Buchenstein Beds" ("Lower Plattenkalke" and lowermost "Knollenkalke") between Frötschbach and Seceda (see also Figs. 4, 5 and Fig. 7 for the distribution of fossil horizons; T_c–T_e: tuff markers).


Frötschbach
13km
Seceda
15
10
5
0m
Te
Td
Tc
'Knollenkalke'
'Lower Plattenkalke'

The main "Pietra verde" bearing intervals of the Seceda section might also be correlated with three similar intervals in the **San Lucano Valley** section described by Bosellini & Ferri (1980). This section is strongly expanded (total thickness exceeds 250 m) due to increased amounts of reworked platform carbonates at the base and on lower slope portions of the S. Lucano-Civetta platform.

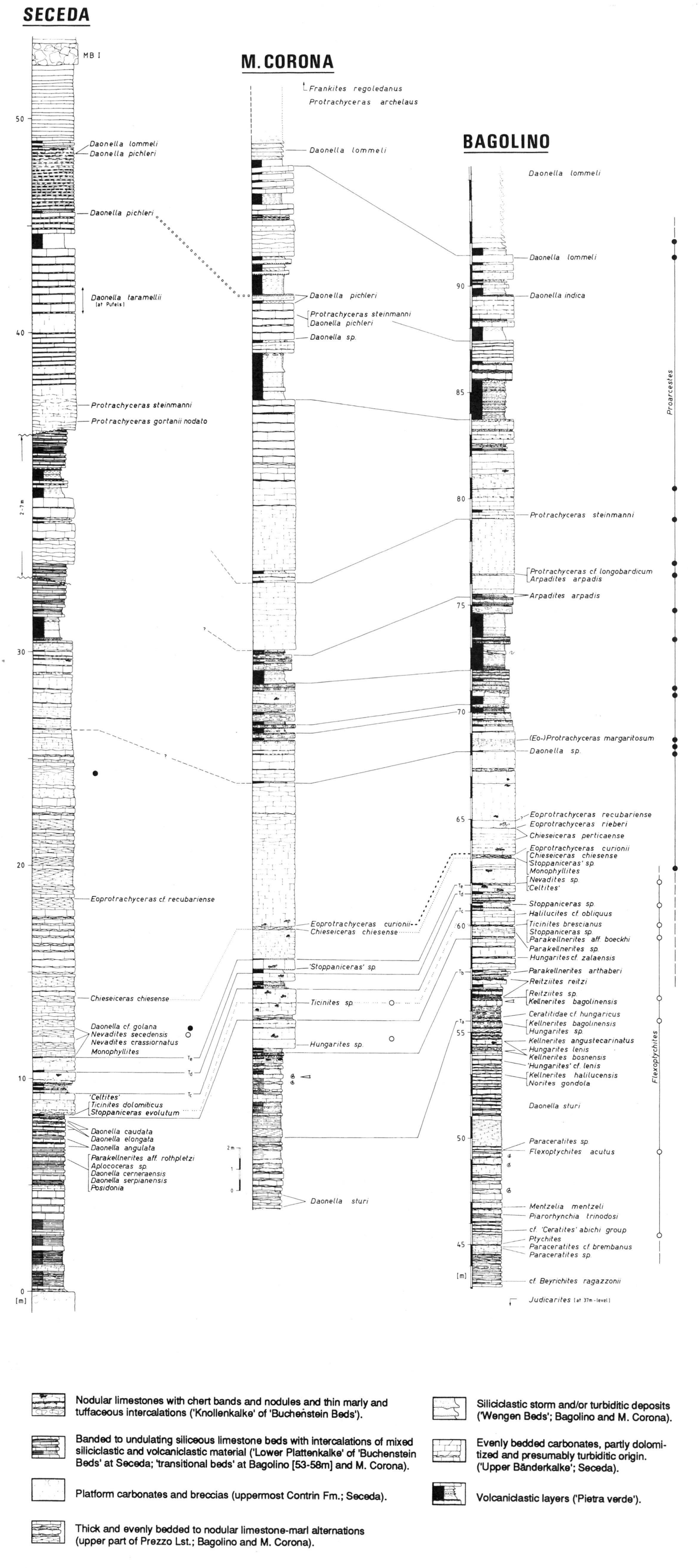
Well exposed "Buchenstein Beds" along a ski slope south of **Passo Feudo** between the Latemar and the Agnello platforms can also be compared with the Seceda section. The "Buchenstein Beds" with "Lower Plattenkalke" at their base follow on top of shallow basinal sediments known as the Moena Formation (Masetti & Neri 1980). In the "Plattenkalke" two levels with Daonellas (*D. elongata* in the upper, *D. serpianensis* in the lower horizon) were identified 0.7 and 1.8 m below the base of the "Knollenkalke". The latter are exposed over approximately 45 m and include frequent intercalations of thin "Pietra verde" layers in the lowermost 6 m and in the upper part of the outcrop.

(Macro-)Fossil levels (Figs. 4–7, 11):

The lowest stratigraphic level at which macrofossils in the "Buchenstein Beds" were found is about 6 m above the base of the "Lower Plattenkalke" at Seceda. The fossils include *Daonella cerneraensis* n. sp., *D. serpianensis, Parakellnerites* aff. *rothpletzi* and *Aplococeras* sp. which provide an important link to an isolated fauna at Cernera ("lower" fossil horizon with *Daonella cerneraensis* n. sp., *Aplococeras avisianum, Hungarites, Parakellnerites*; see below). This in turn shows close affinities with the "allochthonous" fauna of Forno and their in-situ equivalents at Latemar (*Aplococeras avisianum, Hungarites, Parakellnerites, Latemarites* among other ammonoids; see below). Daonellas of the *Daonella elongata* group occur in the uppermost "Plattenkalke" at Seceda, Frötschbach, Pufels, Pedraces and Passo Feudo. A comparatively rich fauna of ammonoids and more Daonellas could be collected from the "Knollenkalke" at Seceda and Frötschbach. Remarkable are the finds of well preserved specimens of (in ascending order) *Ticinites* (*Ticinites dolomiticus* n. sp.), *Stoppaniceras* (*Stoppaniceras evolutum* n. sp.), *Nevadites* (*Nevadites secedensis* n. sp., *N. crassiornatus* n. sp.), *Chieseiceras* (*Chieseiceras chiesense*) and *Eoprotrachyceras* (*Eoprotrachyceras* cf. *recubariense*) all from within the first 20 m of the "Buchenstein Beds." This fossil succession along with the above mentioned volcaniclastic layers permit unambiguous and detailed correlations of the Seceda section with other key sections such as Bagolino and Monte San Giorgio (Fig. 11; see discussions below). In particular, the Daonellas of the *Daonella elongata* group show the same detailed evolution pattern at Seceda and Monte San Giorgio. Higher up in the "Knollenkalke" various specimens of *Protrachyceras* (*Protrachyceras gortanii nodato, P. steinmanni*) were found at Seceda[6]). In the overlying evenly bedded limestones and dolomites, layers rich in Daonellas (*Daonella pichleri* and few *D. lommeli*)

Fig. 7. Correlation and fossil horizons of the "Buchenstein Beds" in the northwestern Dolomites (Seceda), Giudicarie (Monte Corona) and in the Brescian Prealps (Bagolino). Meter-scales are the same as in Figs. 4, 5, 10, 11 and Figs. 5, 7, 10 of Brack & Rieber (1986). For lithostratigraphic subdivisions see Fig. 12 and text.
MB-I: first megabreccia in Seceda sections (see also Fig. 4).
T_a–T_e: selected volcaniclastic markers.

[6]) Well preserved *Protrachyceras* from a stratigraphic interval equivalent to 30–40 m on the Seceda section (location of findspot: top station of the Seceda cable-car) belong to the fossil collections of the museum in St. Ulrich/Val Gardena.


SECEDA
M. CORONA
BAGOLINO
MB I
Daonella lommeli
Daonella pichleri
Daonella pichleri
Daonella taramellii (at Pufels)
Protrachyceras steinmanni
Protrachyceras gortanii nodato
2-7 m
Eoprotrachyceras cf. recubariense
Chieseiceras chiesense
Daonella cf. golana
Nevadites secedensis
Nevadites crassiornatus
Monophyllites
'Celtites'
Ticinites dolomiticus
Stoppaniceras evolutum
Daonella caudata
Daonella elongata
Daonella angulata
Parakellnerites aff. rothpletzi
Aplococeras sp.
Daonella cerneraensis
Daonella serpianensis
Posidonia
Frankites regoledanus
Protrachyceras archelaus
Daonella lommeli
Daonella pichleri
Protrachyceras steinmanni
Daonella pichleri
Daonella sp.
Eoprotrachyceras curionii
Chieseiceras chiesense
'Stoppaniceras' sp.
Ticinites sp.
Hungarites sp.
Daonella sturi
Daonella lommeli
Daonella lommeli
Daonella indica
Protrachyceras steinmanni
Protrachyceras cf. longobardicum
Arpadites arpadis
Arpadites arpadis
(Eo-)Protrachyceras margaritosum
Daonella sp.
Eoprotrachyceras recubariense
Eoprotrachyceras rieberi
Chieseiceras perticaense
Eoprotrachyceras curionii
Chieseiceras chiesense
'Stoppaniceras' sp.
Monophyllites
Nevadites sp.
'Celtites'
Stoppaniceras sp.
Halilucites cf. obliquus
Ticinites brescianus
Stoppaniceras sp.
Parakellnerites aff. boeckhi
Parakellnerites sp.
Hungarites cf. zalaensis
Parakellnerites arthaberi
Reitziites reitzi
Reitziites sp.
Kellnerites bagolinensis
Ceratitidae cf. hungaricus
Kellnerites bagolinensis
Hungarites sp.
Kellnerites angustecarinatus
Hungarites lenis
Kellnerites bosnensis
'Hungarites' cf. lenis
Kellnerites halilucensis
Norites gondola
Daonella sturi
Paraceratites sp.
Flexoptychites acutus
Mentzelia mentzeli
Piarorhynchia trinodosi
cf. 'Ceratites' abichi group
Ptychites
Paraceratites cf. brembanus
Paraceratites sp.
cf. Beyrichites ragazzonii
Judicarites (at 37m-level)
Proarcestes
Flexoptychites
Nodular limestones with chert bands and nodules and thin marly and tuffaceous intercalations ('Knollenkalke' of 'Buchenstein Beds').
Banded to undulating siliceous limestone beds with intercalations of mixed siliciclastic and volcaniclastic material ('Lower Plattenkalke' of 'Buchenstein Beds' at Seceda; 'transitional beds' at Bagolino [53-58m] and M. Corona).
Platform carbonates and breccias (uppermost Contrin Fm.; Seceda).
Thick and evenly bedded to nodular limestone-marl alternations (upper part of Prezzo Lst.; Bagolino and M. Corona).
Siliciclastic storm and/or turbiditic deposits ('Wengen Beds'; Bagolino and M. Corona).
Evenly bedded carbonates, partly dolomitized and presumably turbiditic origin. ('Upper Bänderkalke'; Seceda).
Volcaniclastic layers ('Pietra verde').

occur. Fois (1982) reported Daonellas from similar but possibly slightly younger beds at the base of the Sass di Putia (Peitlerkofel) platform 10 km northeast of Seceda.

The remains of a large Ichthyosaur from the scree of the "Buchenstein Beds" at Seceda were described by Kuhn-Schnyder (1980). Ichthyosaur bones were also recognized in "Knollenkalke" of the Pufels section.

Detailed correlations of our macrofossil levels in the "Buchenstein Beds" with previously described data on palynomorphs (van der Eem 1983) and conodonts (Gasser 1978) from the northwestern Dolomites are hampered by insufficient stratigraphic documentation. Nevertheless, the results are largely compatible. In particular the "Lower Plattenkalke" at Frötschbach have yielded palynomorphs of the "vicentinense-scheuringi Phase" (Brugman pers. comm.). This phase was identified in the "Reitzi tuffs" of the Balaton Highland in Hungary (Brugman 1986) and thus supports our correlation of this unit with the lowermost strata of the "Lower Plattenkalke" and with the "transitional beds" in the Brescian Prealps and Giudicarie (see further on). According to the conodont study by Gasser (1978) *Metapolygnathus mungoensis* is present in the upper part of the "Knollenkalke" at Pufels.

The Seceda and Frötschbach sections are prime candidates for precise calibrations of various biostratigraphic scales. Well preserved radiolaria can be obtained e.g. from samples of the "Lower Plattenkalke."

3.3.2. Brescian and adjacent Prealps (eastern Bergamask Alps, Giudicarie)

The Middle Triassic in this sector of the Southern Alps is particularly important for Anisian to Ladinian biostratigraphy because the "Buchenstein Beds" are bracketed by basinal sediments well known for their macrofossil content (Prezzo Lst., "Wengen Beds"). Moreover, the "Buchenstein Beds" are relatively rich in ammonoids and thin but characteristic successions of volcaniclastic layers allow unambiguous comparisons of various stratigraphic sections (Brack & Rieber 1986). Representative and complete sections are exposed at Monte Corona and Bagolino (Figs. 7, 8; Brack & Rieber 1986, Figs. 3–5).

The Prezzo Limestone has long been known to contain faunas of the Trinodosus Zone in its upper part. The interval of a classical fauna at Contrada Gobbia and nearby localities in Val Camonica (Völker 1931, Riedel 1949, Assereto 1963, Assereto & Casati 1965, Casati & Gaetani 1979, Balini 1992) lies within typical dm-bedded dark limestone-shale alternations. Similar beds are also found in the M. Corona/Dosso dei Morti area to the east (e.g. Bittner 1881, Gaetani 1969; Kovacs et al. 1990, Balini 1992) and in upper Val di Scalve to the west (Fig. 10 [7])). In a southeastern direction the proportion of shale

[7]) The "Contrada Gobbia" equivalent interval is well exposed e.g. around 1875 m on the western slope of the **Corna di S. Fermo** peak to the southwest of Pizzo Camino near Schilpario (Val di Scalve; coord. 589.800/5091.700). Fossils collected during a short inspection comprise *Reiflingites* sensu Assereto (1963), *Ptychites* and Daonellas.

Bulogites, Semiornites sensu Assereto (1963), *Longobardites* and Daonellas were also recovered from strata in a creek on the northeastern flank of **M. Lavanech**. This locality lies just across the Daone valley 5 km southwest of M. Corona (coord. 619.750/5090.650).

The **Pèrtica** column corresponds to locality **A** of Brack & Rieber (1986, p. 191) at Pèrtica. Another complete section (from T_a upwards) at Pèrtica Alta is exposed in a small creek approximately 1 km NNW of Navono (coord. 603.000/5067.600).

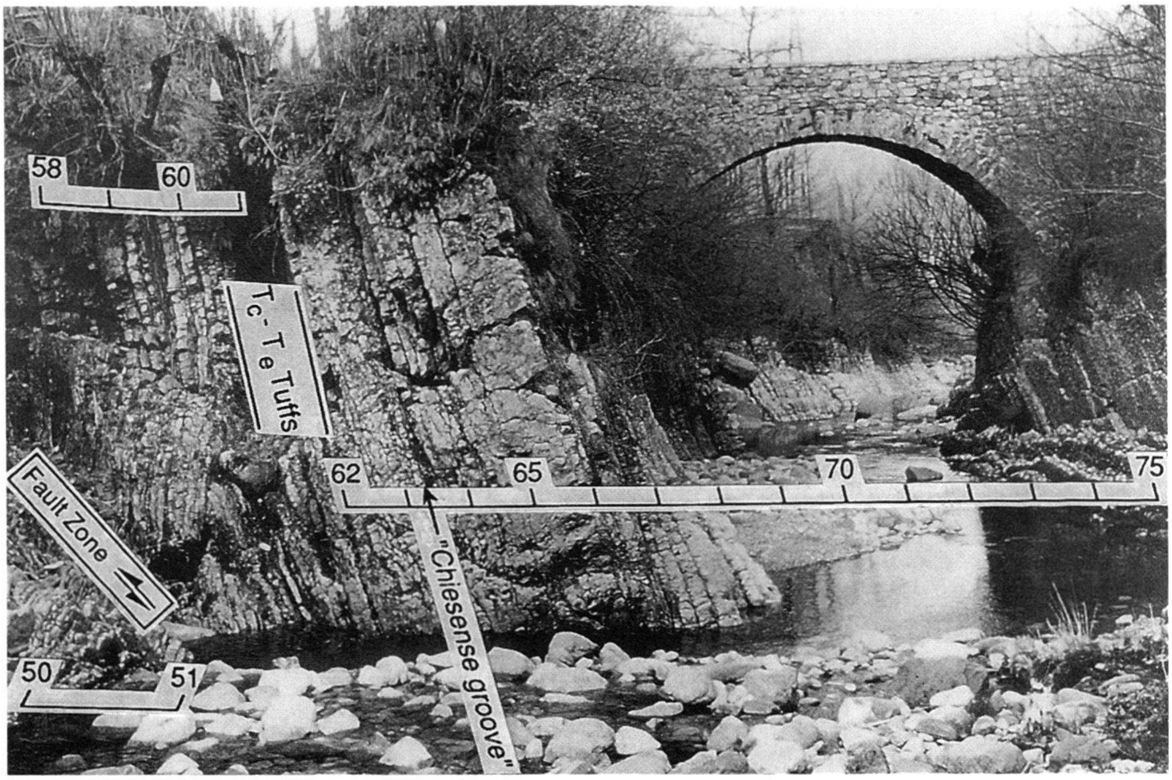


Fig. 8. The steeply dipping lower "Buchenstein Beds" below the Romanterra bridge (looking eastwards) at Bagolino. Meter scale as in Fig. 7; the top of the "Chiesense groove" corresponds to the proposed Anisian/Ladinian boundary; see Fig. 4 in Brack & Rieber (1986) for a map of the main outcrop at Romanterra. Note that the transition between the Prezzo Limestone (just visible on the left-hand foreground) and the "Buchenstein Beds" (58 m onward) is slightly disturbed in this exposure.

decreases and these strata become more thinly bedded and nodular. Nevertheless, the occurrence of three thin, rusty-weathering tuff layers still allows a positive identification of the corresponding intervals at Bagolino [8]) and Pèrtica. Cross-sections of cephalopods are common at this level in Pèrtica, but specimens are difficult to extract from the hard limestone beds.

Between the above mentioned strata of the Prezzo Limestone and the first typical nodular limestones of the "Buchenstein Beds" are "transitional beds" (53–58 m-interval on Bagolino section), 5–8 m thick with irregularly bedded to coarsely nodular, dark limestones and shales. These rocks sometimes resemble the "Plattenkalke"-lithologies of the Dolomites (see also Brack & Rieber 1986, p. 187). The first occurrence of siliceous

[8]) At Bagolino (Romanterra) these beds (between 50–53 m) are poorly exposed but they are stratigraphically distinctly higher than fossiliferous strata containing *Paraceratites*, "*Ceratites*" *abichi* (43–46 m on section) and *Judicarites* found recently around 37 m and also known from the Dosso Alto section a few kilometers to the west. This is in good agreement with the fossil succession near Malga Avalina at Dosso dei Morti (area of Monte Corona). There the lowermost "Contrada Gobbia"-equivalent layers which also contain frequent pavings of *Daonella sturi* were found 4–6 m above layers with "*Ceratites*" *abichi* (sensu Balini in Kovacs et al. 1990) which in turn lie 12-15 m above the *Judicarites* beds. The strata in between also yielded *Semiornites* (sensu Assereto 1963) and Nautilids. This fits well the ammonoid succession found by Balini (in Kovacs et al. 1990) in the nearby Stabol Fresco and Adana sections at M. Corona.

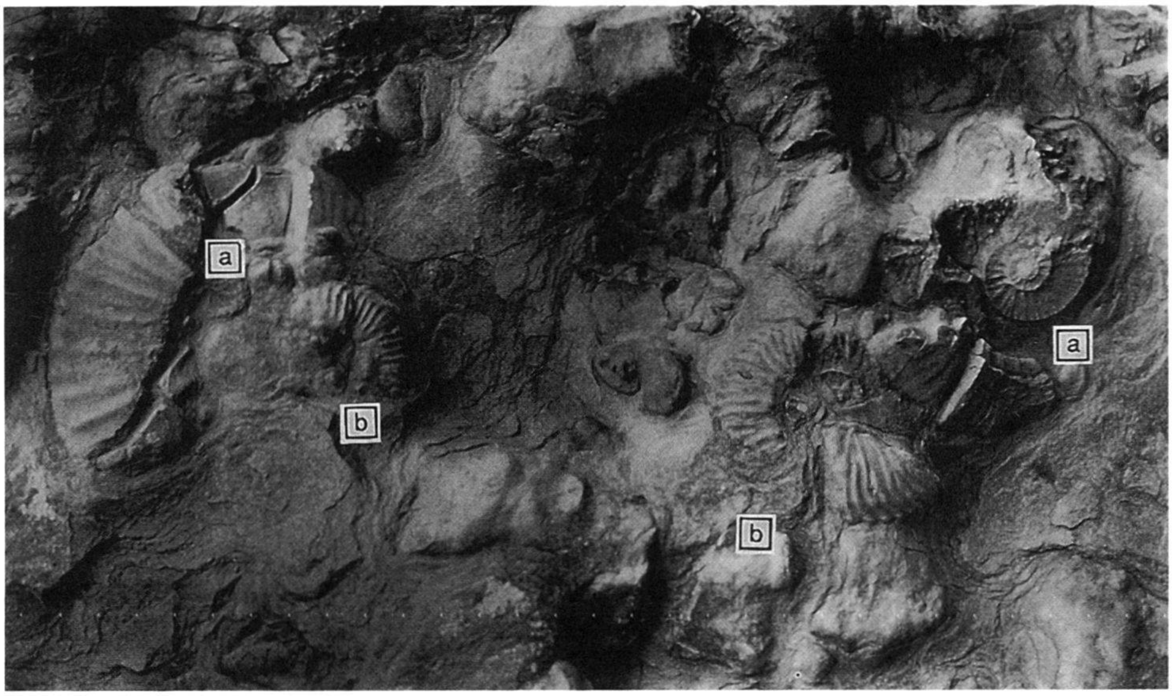


Fig. 9. Ammonoids (a: *Chieseiceras perticaense*, b: *Eoprotrachyceras rieberi* [see comments in section 3.3.2.], *Arcestes*) on the undulating lower surface of a nodular cherty limestone bed covered by a thin layer of fine-grained siliciclastic material (Pèrtica Bassa, Brescian Prealps). Field of view: 30 cm. Around 10 ammonoids were counted per square meter on this bed surface.

beds and chert nodules is just below a series of two to three remarkable beige weathering tuff beds (54.7–55.65 m on Bagolino section [T_a], Figs. 7, 10, 11). The uppermost of these tuffs is a 15–30 cm thick, banded compact stack of four thicker and several thin, graded layers rich in quartz, feldspars and illite. This characteristic bed was identified in localities as far away as Lenna/Piazza Brembana [9]) 50 km to the west of Bagolino. Greenish "Pietra verde" tuffs commonly occur above this layer.

Within the "transitional beds" several important fossil horizons were identified at Bagolino [10]), Pèrtica and Brozzo [11]). The fauna consists of *Lardaroceras* sp., *Kellnerites* (*Kellnerites halilucensis, K. bosnensis, K. bagolinensis* n. sp., *K. angustecarinatus, K. fissicostatus*), *Reitziites* (*Reitziites reitzi*), *Hungarites* (*Hungarites lenis*), *Parakellnerites* (*Parakellnerites arthaberi*), *Longobardites, Norites* together with *Ptychitidae* and *Michelinoceras* and shows closest affinities with the fauna of the "Reitzi tuffs" in the Balaton

[9]) At Lenna/Piazza Brembana the characteristic T_a tuffs are interbedded with thick carbonate layers at the transition between the Prezzo Limestone and the Esino Limestone. This succession is well exposed and easily accessible just behind the cemetery of Piazza Brembana. Fossiliferous nodular limestone beds with *Lardaroceras* and thin tuffaceous intercalations similar to the "Contrada Gobbia interval" occur 7–9 m below the uppermost T_a reference tuffs (Fig. 10). At Lenna the strata form the top of a 20–30 m thick Prezzo Limestone package. Fossil-rich layers including the *Paraceratites brembanus* fauna illustrated by Venzo & Pelosio (1968, see also for location of the sections) are found 10–20 m below the "Contrada Gobbia equivalent" interval.

[10]) At Romanterra and to the southwest in outcrops of steeply dipping, overturned beds along a new forest track on the southern slope of M. Pizza (1150–1250 a.s.l., approx. coord. 612.850/5074.750).

[11]) In the Mella riverbed at the southern end of the village Brozzo near Marcheno in Val Trompia.

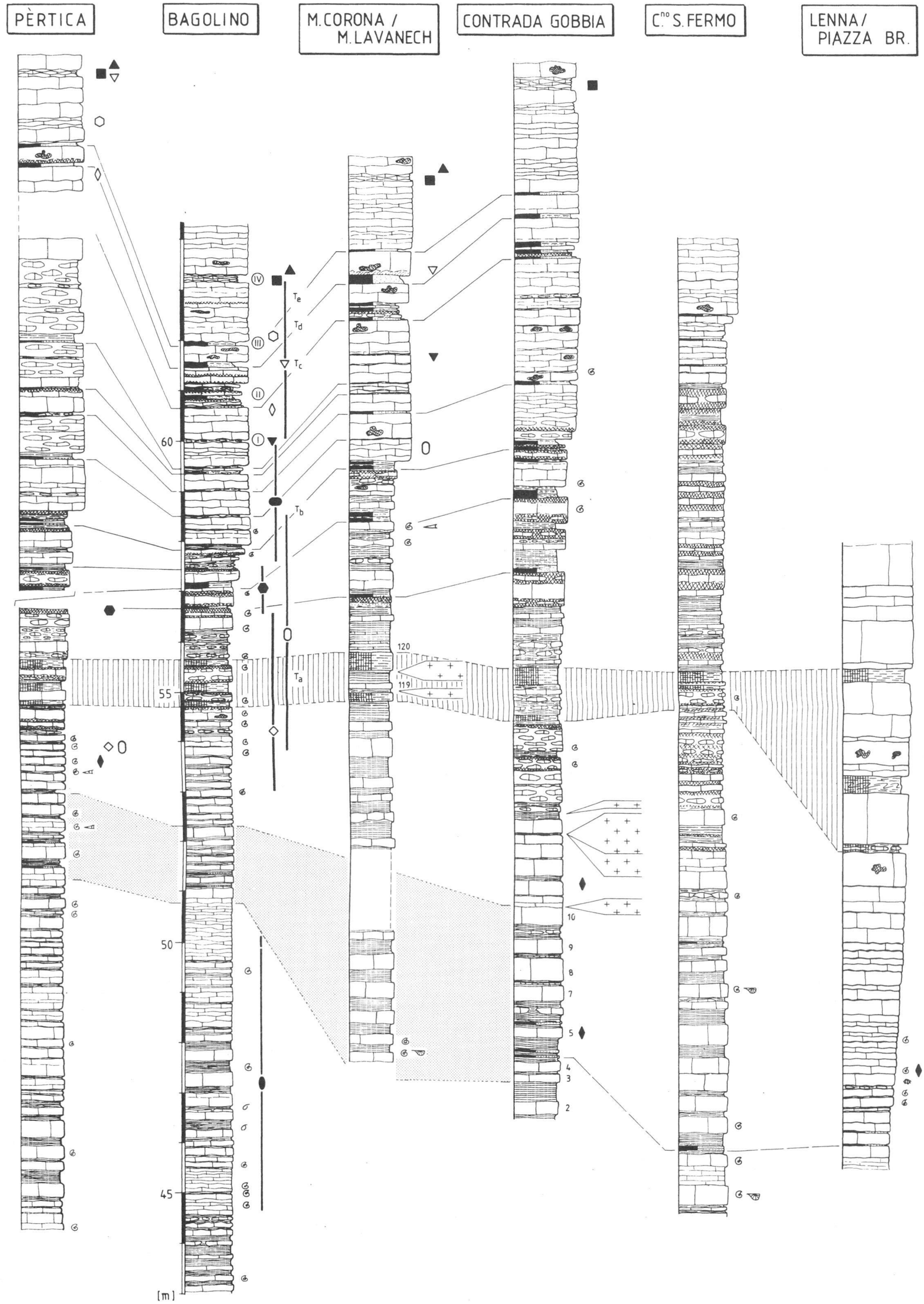
Highland of Hungary (e.g. Vörös & Palfy 1989; Kovacs et al. 1990). In particular the appearance of *Reitziites reitzi* is remarkable because this indicates that it is well established within a continuous fossil succession across an extended Anisian/Ladinian boundary interval. Moreover, *Reitziites* occurs at a distinctly deeper stratigraphic level (56.5–57.6 m at Bagolino) than the *Ticinites* horizon (61 m at Bagolino) and the *Nevadites* from above the tuff level T_e (i.e. 62 m at Bagolino). The *Nevadites* in the Brescian Prealps are related to the specimens from Seceda and presumably correspond to those ammonoids from the Southern Alps that were named "*Trachyceras reitzi*" by Mojsisovics (1882) and Horn (1913, 1914). The mis-identification remained also in our previous paper (Brack & Rieber 1986) is therefore revised here.

The lower "Knollenkalke" in the Brescian and adjacent Prealps contain *Hungarites* (*Hungarites* cf. *zalaensis*), *Ticinites* (*Ticinites brescianus* n. sp.), *Parakellnerites* (*Parakellnerites* aff. *boeckhi* instead of "*Ceratites*" *boeckhi* in Brack & Rieber 1986), *Halilucites* (*Halilucites* cf. *obliquus*), *Stoppaniceras*, "*Stoppaniceras*" (provisionally including the "*Ceratites*" *ellipticus* group of Brack & Rieber 1986), *Nevadites* (*Nevadites avenonensis* n. sp., *N. bittneri* n. sp.), *Chieseiceras* (*Chieseiceras chiesense*, *Ch. perticaense*), *Eoprotrachyceras* (*Eoprotrachyceras curionii*, *E. recubariense*, *E. rieberi*[12])) among other genera as discussed by Brack & Rieber (1986). At Bagolino and M. Corona new *Protrachyceras* ([*Eo-*]*Protrachyceras margaritosum*, *Protrachyceras* cf. *longobardicum*, *P. steinmanni*, *P. archelaus*), *Arpadites* (*Arpadites arpadis*) and Daonellas (*Daonella indica*, *D. pichleri*, *D. lommeli*) were collected at higher levels in the "Buchenstein Beds" and in the lowermost "Wengen Beds" (Fig. 7). Bittner (1881) and Mojsisovics (1869, 1880, 1882) described rich ammonoid faunas from the siliciclastic "Wengen Beds" at various localities in Giudicarie and eastern Lombardy[13]). These strata certainly deserve further attention but ammonoid specimens are often strongly flattened. Nevertheless, we confirm the occurrence

Fig. 10. Detailed correlation of stratigraphic sections in eastern Lombardy and Giudicarie including the "transitional beds" (53–58 m interval on Bagolino section) situated between the Prezzo Limestone (below) and "Knollenkalke" of the "Buchenstein Beds" (above). Characteristic successions of beige ash layers (T_a tuffs, vertical ruling) and up to ten thin "Pietra verde" layers between T_b and T_e are correlatable in detail. The T_a volcaniclastic layers are also identified in thickly bedded strata at the transition of the Prezzo Limestone and the Esino Limestone at Lenna/Piazza Brembana. The fossil-rich interval at "Contrada Gobbia" (main southern outcrop, bed numbers as in Casati & Gaetani 1979, Fig. 10, Kovacs et al. 1990, Fig. 13, and Balini 1992, Fig. 2) and corresponding strata as recognized by fossils and/or the occurrence of thin tuff layers are indicated (dotted pattern). Distributions of only the most important ammonoid genera are shown (symbols for fossils as in Fig. 11, bivalve signs indicate Daonellas close to *Daonella sturi*). See Kovacs et al. (1990) for distributions of conodonts in the Contrada Gobbia and Monte Corona (Stabol Fresco) sections. Magmatic dykes crosscutting the sections are omitted but their positions indicated. See text for the location of the sections and additional information on content and positions of faunas also at deeper levels in the Prezzo Limestone. The illustrated parts of the Lenna/Piazza Brembana and Contrada Gobbia sections correspond approximately to the photograph in Venzo & Pelosio (1968, Fig. 3) and to the lower two thirds of the section visible on Fig. 2 of Assereto (1963) respectively.

[12]) The name *Eoprotrachyceras rieberi* is anticipated here for convenience and replaces *Eoprotrachyceras* cf. *laczkoi* in Brack & Rieber 1986 (Figs. 7, 10). The new species *E. rieberi* will be figured and described formally in a forthcoming publication by Fantini Sestini (pers. comm.) on the basis of our material from Pèrtica (type locality; horizon 1.4–1.6 m above "Chiesense groove") and additional finds from the Bergamask Alps.

[13] The "Wengen Beds" at Prezzo only a few kilometers southeast of M. Corona are the type-strata of important ammonoids such as *Frankites regoledanus*, *Protrachyceras judicaricus*, *P. neumayri*, *Proarcestes tridentinus* (Moisisovics 1869). *Celtites epolensis* is named after a locality south of Schilpario.



PÈRTICA
BAGOLINO
M.CORONA / M.LAVANECH
CONTRADA GOBBIA
C.no S.FERMO
LENNA/ PIAZZA BR.
60
55
50
45
[m]
IV
III
II
I
Te
Td
Tc
Tb
Ta
120
119
10
9
8
7
5
4
3
2

of *Protrachyceras archelaus*. *Frankites regoledanus* was found in higher levels of the "Wengen Beds" at M. Corona. Ammonoids from roughly coeval platform carbonates at Dosso Alto (Malga Ciunela) [14]) near Bagolino have been identified as *Rimkinites nitiensis* and *Arcestes*.

A comparison of the sections in eastern Lombardy and Giudicarie with those of the northwestern Dolomites (Fig. 7) shows the same main "Pietra verde" bearing intervals in both areas. Of these, the thin tuff series T_c to T_e in the "Knollenkalke" can be correlated in detail (Fig. 11). This correlation is in agreement with the fossil distribution, in particular the succession of *Parakellnerites, Ticinites, Nevadites, Chieseiceras* and *Eoprotrachyceras*. Moreover it shows that the base of the "Knollenkalk" facies is indeed clearly diachronous. The "Plattenkalke" of the northwestern Dolomites (e.g. Seceda) therefore correspond to an interval that includes the basal "Knollenkalke" and probably parts of the "transitional beds" at Bagolino.

Information on the distribution of conodonts is available for densely sampled sections at M. Corona and Contrada Gobbia (Kovacs et al. 1990). The sections can be compared in detail with our own data (Fig. 10) although the unambiguous T_a tuff markers are not mentioned by these authors. The projection of the conodont data onto the Bagolino reference section indicates that *Gondolella* aff. *szaboi* occurs up to the 58 m-level and *G.* aff. *eotrammeri* up to the 61 m-level. *Gondolella trammeri* is present above the T_d tuffs and is accompanied by *G. pseudolonga* and *G. transita* above the "Chiesense groove," in agreement with a conodont sample from this level in Roncone (Brack & Rieber 1986). *Metapolygnathus hungaricus* was found in a layer that presumably corresponds to the 68–70 m-interval of Bagolino. Stratigraphically somewhat higher *Metapolygnathus mungoensis* appears in the upper part of the "Knollenkalke" (northwestern Dolomites; Gasser 1978). In strata above the "Knollenkalke" equivalent beds *Metapolygnathus mungoensis* was found together with *M. mostleri* and *M. diebeli* in Val Gola (Mietto 1982; De Zanche & Mietto 1986). The conodont data are thus in good agreement with fossil distributions in the Hallstatt-type limestones of Epidhavros (Krystyn 1983).

3.3.3. Val Gola (Trento)

The fossiliferous, pelagic sediments at Val Gola near Trento and in Valsugana (Arthaber 1916; Rieber 1968a, 1969, 1973a; Brack & Rieber 1986; De Zanche & Mietto 1986, 1989: the names of the lithological units are adapted from these two publications) overlie platform carbonates covered by a stack of sometimes bituminous and laminated limestones and marls with few thin tuffitic intercalations ("Margon Lst."). The successive marly interval with thin undulating limestone beds ("Val di Centa Marls") bears Daonellas (*Daonella elongata, D. airaghii, D. pseudomoussoni, D. golana* at Val Gola and *Daonella elongata, D. vaceki, D. airaghii* at Fricca/Val di Centa, see Rieber 1968a, 1969) and ammonoids (*Stoppaniceras golanum* at Val Gola and *S. friccensis, S. falcifer, "Ceratites" subnodosus* at Fricca/Val di Centa, see Rieber 1973a, p. 41). These beds are overlain by "Knollenkalke" ("Val Gola Lst."). Except for their lowermost few meters of transitional beds they are typically siliceous and contain thin and sometimes reddish

[14]) Fossils and information on this locality were kindly provided by Manfred Epting.

coloured "Pietra verde" layers. From the "Knollenkalke" in Val Gola we collected *Chieseiceras* cf. *chiesense, Nevadites, Eoprotrachyceras curionii* (see Brack & Rieber 1986), and somewhat higher up *Eoprotrachyceras margaritosum* and *Arpadites*. The fossil succession is thus in good agreement with the sequence at Bagolino. The pelagic faunas also point to the existence of at least temporary surface water connections between the intra-platform depressions of the "Val di Centa Marls" and "Val Gola Limestone" and the wider basins of eastern Lombardy and/or the eastern Dolomites.

A comparison of the faunal successions at Val Gola with the "Buchenstein Beds" (Seceda, Bagolino) and the "Grenzbitumenzone" at Monte San Giorgio (Fig. 12) suggests that the 15–25 m thick "Val di Centa Marls" are an expanded equivalent of a thin "Knollenkalk" interval at Bagolino (approximately 59–62.5 m; uppermost Reitzi/Kellnerites and Nevadites Zones). Moreover, the base of typical siliceous nodular limestones (i.e. the "Knollenkalke" of the Val Gola Lst./"Buchenstein Beds") is clearly diachronous between Bagolino, Seceda and Val Gola.

4. Anisian to Ladinian carbonate platforms

Some of the Upper Anisian/Ladinian platform and intra-platform carbonates of the Southern Alps are unusual in that they contain layers, lenses or fissure infills rich in macrofossils, in particular ammonoids and Daonellas. Fossil localities in the Esino Limestone have long been known in Lombardy (e.g. Esino, Ghegna; Stoppani 1860, Mojsisovics 1882, Tommasi 1911–13, Jadoul et al. 1992). They are also known in the Marmolada Limestone, in the Schlern Dolomite and related carbonates in the Dolomites and adjacent areas (e.g. Marmolada, Latemar, Viezzena, Cislon; Mojsisovics 1882, Kittl 1894, Salomon 1895, Polifka 1886, Koken 1911, Häberle 1908, Wilckens 1909, Bubnoff 1921 and others). Due to the isolated nature of the fossil localities and the absence of well documented pelagic reference sections, the stratigraphic positions of the "platform faunas" have in many cases remained unclear or could be assessed only through indirect evidence (e.g. Assereto 1969). The new fossil successions in the basinal "Buchenstein Beds" allow a more accurate positioning of such faunas.

The fossil finds from platforms with clear large-scale geometries provide unique opportunities for the calibration of the platform versus basin evolution. Fossiliferous intervals were discovered in flank portions of carbonate platforms (e.g. Cernera, Marmolada, Latemar) but also in platform interior lithologies (e.g. Latemar) and partly bituminous sediments deposited in wider intra-platform depressions (e.g. Monte San Giorgio, Perledo-Varenna Lst.).

Results from the most remarkable sections of biostratigraphical relevance in platform and intra-platform settings in Lombardy (Monte San Giorgio) and in the Dolomites (Latemar, Cernera) are briefly outlined below. Ammonoids, Daonellas and additional fossils were also collected from platform carbonates at other localities but in less clear physical stratigraphic positions such as Marmolada (platform interior beds, clinoform deposits and reddish limestones; outcrops on the Marmolada north slope), Viezzena (clinoform deposits), Monte Cislòn (platform interior beds around 300 m above the base of platform carbonates), Ghegna (see below) and Esino.