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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
Autor: Brack, Peter / Rieber, Hans
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In Lombardia gli «Strati di Buchenstein» sono posti tra altri strati bacinali Medio-triassici (Calcare di Prezzo, Formazione di Wengen). L'intera successione contiene una ricca fauna di ammonoidi e daonelle comprendente l'Anisico superiore fino al Ladinico superiore. L'intervallo comprendente il limite Anisico/Ladinico, se paragonato ad altri equivalenti sezioni di riferimento nella parte occidentale della Tetide, appare abbastanza coerente e permette di integrare le ricche faune di località isolate di piattaforme carbonatiche (Latemar e Cernera) e di depositi intra-piattaforma (Monte San Giorgio). Le serie di fossili includono livelli successivi ben definiti con varie specie di *Judicarites, Paraceratites, Kellnerites, Hungarites, Reitziites, Parakellnerites, Aplococeras, Ticinites, Halilucites, Stoppaniceras, Nevadites, Chieseiceras, Eoprotrachyceras, Arpadites e Protrachyceras*. La successione ad ammonoidi non condensata è adatta ad una parziale revisione della suddivisione delle zone nella Tetide e indica inoltre una leggera ma distinta diacroneità della base degli «Strati di Buchenstein». La definizione originale del limite Anisico/Ladinico alla base degli «Strati di Buchenstein» (Bittner 1892) è pertanto ambigua. Al momento la migliore alternativa è di localizzare il limite Anisico/Ladinico tra la Zona a Nevadites e quella a Curionii. Il limite basato su questa definizione può essere localizzato non solo nelle sezioni del Sudalpino (cioè nell' originale «area tipo») ma può essere anche riconosciuto in altre sezioni della Tetide occidentale come pure in Nordamerica.

Datazioni radiometriche di rocce vulcanoclastiche nelle sezioni studiate sono disponibili, ma non permettono tuttavia una correlazione definitiva del Ladinico con la scala numerica delle età. Al momento la stima migliore pone i limiti del Ladinico tra i 232 ed i 225 milioni di anni. Per ora questi valori sono in conflitto con le stime generalmente accettate.

Il ritrovamento di livelli corrispondenti in sedimenti bacinali e piattaforme carbonatiche con chiare strutture a larga scala promette una calibrazione e una correlazione dettagliata dell' evoluzione temporale delle piattaforme e dei bacini. Per le piattaforme dell' Anisico sommitale e del Ladinico nelle Dolomiti occidentali (p. es. al Latemar e al Catinaccio/Rosengarten) i nostri dati suggeriscono un periodo iniziale di rapida crescita verticale (dalla Zona a Reitzi/Kellnerites alla Zona a Gredleri). Alcune piattaforme nelle Dolomiti centrali ed orientali non riuscirono a seguire la rapida crescita del livello relativo del mare e furono annegate al limite Anisico/Ladinico (p. es. alla Cernera). Alla fine della crescita prevalentemente verticale fa seguito nelle Dolomiti occidentali una fase di veloce progradazione (p. es. al Rosengarten).

Sulla base dei nuovi ritrovamenti di fossili proponiamo una revisione delle designazioni di generi e specie di alcune forme di ammonoidi e di daonelle. Vengono inoltre descritti i seguenti nuovi generi e specie: *Reitziites* n. gen., *Latemarites* n. gen., *Kellnerites bagolinensis* n. sp., *Latemarites latemari* n. sp., *Parakellnerites zoniaensis* n. sp., *Ticinites brescianus* n. sp., *Ticinites dolomiticus* n. sp., *Stoppaniceras evolutum* n. sp., *Nevadites avenonensis* n. sp., *Nevadites bittneri* n. sp., *Nevadites secedensis* n. sp., *Nevadites crassiornatus* n. sp. e *Daonella cerneraensis* n. sp., *Daonella sotschiadensis* n. sp.

1. Introduction

The Middle Triassic sediments of the Southern Alps are classical representatives of a mediterranean "Tethyan" Triassic and have been the subject of intensive geological research for more than a century. The Ladinian Stage and names of various substages (Fassanian, Longobardian, Cordevolian, Julian) used in current time scales (e.g. Zapfe 1983; Tozer 1984) are derived from this area. However, due to complex stratigraphic patterns and the uneven occurrence of biostratigraphically relevant fossils, the original definitions of these time intervals are vague and in some cases inappropriate. Clearly outlined type sections exist neither for the single time units nor for the majority of their boundaries. As a consequence modern schemes of Middle Triassic ammonoid zones (e.g. Krystyn 1983; Tozer 1984) are based mainly on fossils from more straightforward sediment successions in other parts of the Triassic Tethys area and in North America.

Despite its stratigraphic complexity, the Middle Triassic of the Southern Alps will continue to be of biostratigraphical importance. This is especially true as numerous studies have already shed light on many former stratigraphical uncertainties and there is great potential for further discoveries. Reinvestigations were carried out over the last three decades mainly on classical sections and fossil localities (Fig. 1) and provided well documented data on macrofauna, in particular ammonoids and Daonellas. These studies

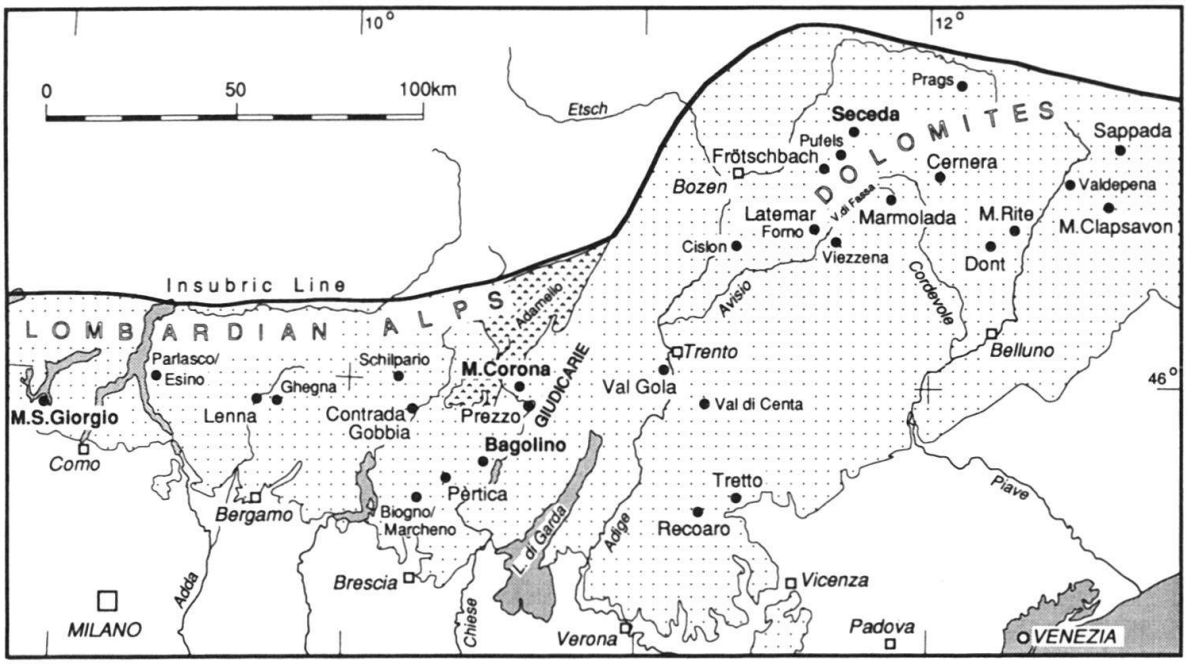

Fig. 1. Location map of the main South Alpine fossil localities mentioned in the text. Key sections for the Anisian/Ladinian boundary interval (i.e. Monte San Giorgio, Bagolino, M. Corona, Seceda) are highlighted. Exposed portions of the Southern Alps (dotted pattern) reach from a northern, tectonic boundary (Insubric Line) to the Neogene clastic basin fills of the Po and Venetian plains.

were initially focused on Upper Anisian pelagic sediments (e.g. Assereto 1963, 1971; Venzo & Pelosio 1968; Gaetani 1969; Farabegoli et al. 1984; Balini 1992) and on several isolated Anisian/Ladinian boundary intervals in shallow marine and platform carbonates (Pisa 1966, 1974; Rieber 1968a, 1969, 1973a,b, 1974; Assereto 1969). New ammonoid successions reaching higher up into the Ladinian were recently discovered in the "Buchenstein Beds" of eastern Lombardy and adjacent areas. Based on these finds we proposed a modified position for the Anisian/Ladinian boundary in the Tethys area (Brack & Rieber 1986).

Follow-up studies have allowed us to significantly expand our fossil collection and further refine the correlations of key sections straddling the Anisian/Ladinian boundary. From a biostratigraphical point of view the main result of these investigations is an ammonoid record which now appears to be relatively coherent. On the basis of this South Alpine fossil record many stratigraphic sections can be better assessed including successions from the Dolomites, the original type area of the "Ladinian Stage" (Bittner 1892). Moreover we think that this provides an acceptable basis for a clear redefinition of boundaries between ammonoid zones as well as between the Anisian and the Ladinian Stages. The documentation of these findings is the main topic of this paper. A generalized picture is also sketched for the large-scale stratigraphic context of the studied sections within the Anisian to Ladinian evolution of the South Alpine realm. We hope that this approach might stimulate a better integration of various stratigraphic tools and further help assessing their consistency and chronostratigraphic value. Radiometric ages, micropaleontological and palynological data along with information on sea-level fluctua-

tions at different scales and periods do already exist from rocks of the South Alpine Middle Triassic.

Details on new and revised ammonoid and Daonella genera and species are presented in the paleontological part.

2. Middle Triassic stratigraphy and fossiliferous Anisian/Ladinian boundary sections

The Middle to Upper Triassic rocks of the Southern and Eastern Alps formed prior to the Late Triassic-Jurassic breakup of the western Tethys in a tectonically mobile framework of repeatedly uplifted and subsiding blocks to the south of central Europe. Heterogenous Anisian to Carnian stratigraphic successions (Fig. 2) and Triassic tectonic structures indicate distinct periods of volcanism and tectonism, the latter with both, compressional and extensional components. Strike-slip movements were suggested in plate reconstructions for the Triassic western Tethyan area (e.g. Brandner 1984; Ziegler 1989) and wrench fault systems are indeed apparent in parts of the Southern Alps (Doglioni 1984a). Nevertheless, the large-scale geodynamic context of Triassic movements throughout the Southern Alps and formerly adjacent areas still remains largely obscure. Both rift-related and subduction-related models have been proposed (for discussions see e.g. Bechstädt et al. 1978, Brandner 1984, Castellarin et al. 1988, Sloman 1989).

Fig. 2. A, B) Simplified reconstructions of the cross sectional stratigraphy along the northern sector of the Southern Alps (see Fig. 3b for the trace of the section).

C) Chronostratigraphic chart for the South Alpine Middle Triassic.

The compilation is based on numerous references most of which are mentioned in the text. Unclear stratigraphic relationships are deliberately left vague. Scales are only approximate. In the Lombardian sector the depocenter of the Angolo Limestone lies in fact 30 km south of the section. Scheme of ammonoid zones modified after Krystyn (1983) (new Reitzi/Kellnerites Zone). See text for information on time-scale.

(1)–(10): Projected positions of sections in Fig. 14.

Special symbols: a: biostratigraphic calibration points (ammonoids, Daonellas); b: volcanic rocks, megabreccias/olistoliths; c: supposed stratigraphic position of shallow intrusives (M. Muffetto, Monzoni/Predazzo); d: typical successions of volcaniclastic layers; e: tectonically induced "diapirs" (Late Ladinian tectonism) of Upper Permian to Lower Triassic strata (central Dolomites); f: stratigraphic positions (full symbol) and age values (open symbol) with 2 sigma error bars of radiometrically dated rocks (see text for references).

Formal and informal stratigraphic units (in alphabetical order; abbreviations used in Figs. 2 and 14): ALB: Albiga Dol.; AMB: Ambata Fm.; ANG: Angolo Lst.; AQT: Aquatona Fm.; AUR: Auronzo Fm.; AVS: Val Sabbia Sst.; BEL: Bellano Fm.; BIV: Bivera Fm.; BOV: Bovegno "Cargneules"; BRE: Breno Fm.; BUC: Lombardian "Buchenstein Beds"; CAM: Camorelli Lst.; CDM: Dosso dei Morti Lst.; CIV: Civetta Sst.; CMB: Metallifero Bergamasco Lst.; CON: Contrin Fm. (= Upper Sarl Dol. auct.); CPS: Clapsavon Lst.; CRO: "Calcare Rosso"; DMR: "Daonella Marls"; DON: Dont Fm.; DUR: Dürrenstein Dol.; ELT: Elto Dol.; ESI: Esino Lst.; FER: Fernazza Hyaloclastites; GBZ: Grenzbitumenzone; GOR: Gorno Fm.; Knk: "Knollenkalke" (= "Buchenstein Beds" p.p.); LAT: Latemar Lst.; LIV: Livinallongo Fm. (= "Buchenstein Beds" of Dolomites); LON: Longiarin Sst.; LOZ: Lozio Shales; Lpk: "Lower Plattenkalke" Mb. (= "Buchenstein Beds" p.p.); MAR: Margon Lst.; MCG: Marmolada Cgl.; MER: Meride Lst.; MOE: Moena Fm.; MON: Monzoni & Predazzo intrusives; MRB: Morbiac Lst.; MUF: Muffetto subvolcanic rocks; PIZ: Pizella Marls; PLV: Perledo-Varenna Lst.; PRO: Prato-tondo Lst.; PRZ: Prezzo Lst.; RIC: Richthofen Cgl.; SAL: Salvatore Dol.; SCC: basinal San Cassian Fm. (l: lower, u: upper); SCD: San Cassian Dol.; SLD: Schlern Dol.; SPZ: M. Spitz Lst.; TRF: Tiarfin Dol.; Ubk: "Upper Bänderkalke" (= "Buchenstein Beds" p.p.); VCM: Val di Centa Marls; VGL: Val Gola Lst.; VOL: Voltago Cgl.; VSS: Valsassina Clastics; WEN: Lombardian "Wengen Beds"; ZOP: Zoppè Sst. Main unconformities resulting from tectonic uplift and erosion: uau: "Upper Anisian Unconformity"; ulu: "Upper Ladinian Unconformity".