

THE PRE-VARISCAN SEQUENCE OF THE CARNIC ALPS (AUSTRIA AND ITALY)

CARLO CORRADINI & THOMAS J. SUTTNER [Eds.]



ABHANDLUNGEN

BAND 69
2015

ORDOVICIAN		SILURIAN			DEVONIAN			CARBONIFEROUS	
MIDDLE	UPPER	LLANDOVERY	WENL.	LUDLOW	PRID.	LOWER	MIDDLE	UPPER	MISSISSIPPIAN
									PENN.
									Bashkirian
									Serpukhovian
									Visean
									Tournaisian
									Famennian
									Frasnian
									Givetian
									Eifelian
									Emsian
									Pragian
									Lochkovian
									Ludfordian
									Gorstian
									Homerian
									Sheinwoodian
									Telychian
									Aeronian
									Rhuddanian
									Hirnantian
									Katian
									Sandbian
									Darriwilian
									Dapingian



Geologische Bundesanstalt



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Preface

The Austrian Stratigraphic Chart 2004 (ASC 2004) is a compilation of selected lithostratigraphic units most frequently in use in Austrian geological literature and on geologic maps. In the course of the compilation of the chart it became evident that most of these units were invalid and inadequately described and documented. These shortcomings and lack in knowledge forced the various working groups to start a description of the units depicted in the ASC 2004.

For the Paleozoic a national working group under guidance of Bernhard Hubmann was established immediately after publication of the ASC 2004 aiming at describing the units depicted in the ASC 2004. One of the members of this working group, Thomas J. Suttner, opted, however, for the Carnic Alps not only for describing but also for re-evaluating and formalizing the units. Since the Carnic Alps extend along the Austrian/Italian border it was clear that such a working group cannot only be an Austrian concern but it has to be carried out as a joint endeavor between Austrian and Italian geoscientists. As a result, a very active joint working group was established guided by Carlo Corradini on the Italian side and Thomas J. Suttner as Austrian partner. The national/international groups started working in parallel into two directions: (1) describing the lithostratigraphic units depicted in the ASC 2004 and (2) evaluating, re-describing and properly defining them or even introducing additional units. The first part was finished in 2013 and 2014, respectively, with the publication of "The lithostratigraphic units of the Austrian Stratigraphic Chart 2004 (sedimentary successions) – Vol. I: The Paleozoic Era(them)" in Abhandlungen der Geologischen Bundesanstalt (vol. 66, 2014). The second part is documented in the current volume of the Abhandlungen der Geologischen Bundesanstalt (vol. 69, 2015).

To perform the description and emendation of the lithostratigraphic units several joint meetings have been held in Udine organized by colleagues from the local museum but also several joint field trips have been undertaken. This underpins that this work was not just a bureaucratic exercise but it was a serious scientific research which was only possible due to the shared expertise of experienced scientists supported by new field and laboratory data. The current publication, however, provides only the very basic information for defining the 36 formations of the Pre-Variscan sequence of the Carnic Alps. The general organization of the descriptions follows the scheme used for the description of the units of the ASC 2004 (Abhandlungen der Geologischen Bundesanstalt, 66, 2014). In the current volume all subtopics are very briefly documented and also the lithologic descriptions are very condensed. Even for the description of the type sections mostly literature data are provided. The authors intend to publish all the formations in a much greater detail in forthcoming publications.

The 36 formations have been defined after long scientific but also "political" discussions and the result represents a (bi-national) compromise what is very important for the acceptance of these units, both in Austria and Italy. One of the most difficult tasks was to find agreement on the formal names of the units, because different names were in use for the Italian and the Austrian part of the Carnic Alps. In some cases, however, the compromise, independent of national perspectives, resulted in names which do not properly follow the rules of the stratigraphic guides, e.g., Cardiola Formation, Alticola Formation. The inclusion of fossil names in lithostratigraphic units has to be avoided to properly separate litho- and biostratigraphic systems. The arguments of the authors that the fossil names have a long tradition for these rock units are not very convincing! The final decision of validating these unit names has to be made by the national stratigraphic commissions and by the acceptance within the scientific community.

Irrespective of some criticism, the current volume is a big step forward in defining lithostratigraphic units of the Southern Alps and provides an up-to-date lithostratigraphic framework acting as base for all forthcoming studies as well as being of great practical value, e.g., for geological mapping. On behalf of the stratigraphic community I would like to thank the Austro-Italian work group leaders and all actively involved members of the group for finishing this benchmark work.

Werner E. Piller

Chair of the Austrian Commission on Stratigraphy

Foreword

The pre-Variscan sequence of the Carnic Alps is one of the more complete and better known sequences in the world. Several workers investigated the area since the 19th century and produced a huge amount of papers dealing with different topics in geological sciences (geology, palaeontology, stratigraphy, structural geology, etc.).

However, the different parts of this sequence were mainly denominated with informal names, that derive either from facies or historical terms. Furthermore, being the region across the state border between Italy and Austria, different terminologies have been adopted on both sides of the mountain chain, which result in different subdivisions of the sequence and a high number of names indicating similar -if not the same- lithological units. Also, in a few cases, the same name was used to indicate different units. Moreover, almost none of these units was formalized according to the rules of the International Commission on Stratigraphy.

This volume is a result of an international research project developed in the last seven years, which involved more than forty researchers from various European countries, mainly from Austria and Italy. After four business meetings, three field workshops, and the (re)study of a huge amount of old and new data, a common and now unified terminology was achieved.

As a result the pre-Variscan sequence of the Carnic Alps is now subdivided in 36 formations, lithologically well characterized, with well-defined boundaries and designated stratotypes.

For each unit, beside its definition and the indication of the stratotype, chronostratigraphic and biostratigraphic data are provided as well as information on the boundaries and the depositional environment. An extensive synonymy list is reported; fossil content and biostratigraphical assignment are reported when applicable, and reference sections are indicated when necessary. Complementary references on other stratigraphic methods (i.e.: geochemistry, isotope stratigraphy, etc.) are indicated if available.

The present volume shall serve as a basic information guide for all geoscientists especially field geologists working in the Carnic Alps in future!

Carlo Corradini and Thomas J. Suttner

Editors

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The Pre-Variscan sequence of the Carnic Alps – an introduction

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HANS-PETER SCHÖNLAUB⁶, CLAUDIA SPALLETTA⁷ & CORRADO VENTURINI⁷

5 Text-Figures

*Carnic Alps
Paleozoic
Stratigraphy
Type locality
Stratotype
Austria
Italy*

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Zusammenfassung

Eine überarbeitete Version der stratigraphischen Tabelle für die prä-variszische Abfolge der Karnischen Alpen wird vorgestellt. Die lithostratigraphischen Einheiten jedes hier bearbeiteten Zeitabschnitts wurden revidiert und vereinheitlicht. Anerkannte Einheiten wurden entsprechend formalisiert und auch die Alterseinstufung der lithostratigraphischen Grenzen verbessert. Die Abfolge erstreckt sich vom Mittelordovizium bis in das frühe Pennsylvanian und setzt sich formal aus 36 Formationen zusammen. Diese Arbeit soll als Grundlage für die zukünftige Erforschung der Karnischen Alpen dienen und eine bessere globale Korrelation mit anderen paläogeographischen Gebieten ermöglichen.

Abstract

An updated stratigraphic scheme of the Pre-Variscan sequence of the Carnic Alps is proposed herein. Lithostratigraphic units have been carefully revised and homogenized in each investigated time slice. Recognized units have been formalized accordingly. The data on the age of the boundaries have been improved as well. The succession spans the Middle Ordovician - early Pennsylvanian interval and has been formally divided in 36 formations, providing a sound reference for future geological studies in this part of the Carnic Alps and enabling a more global correlation with other paleogeographical domains.

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Riassunto

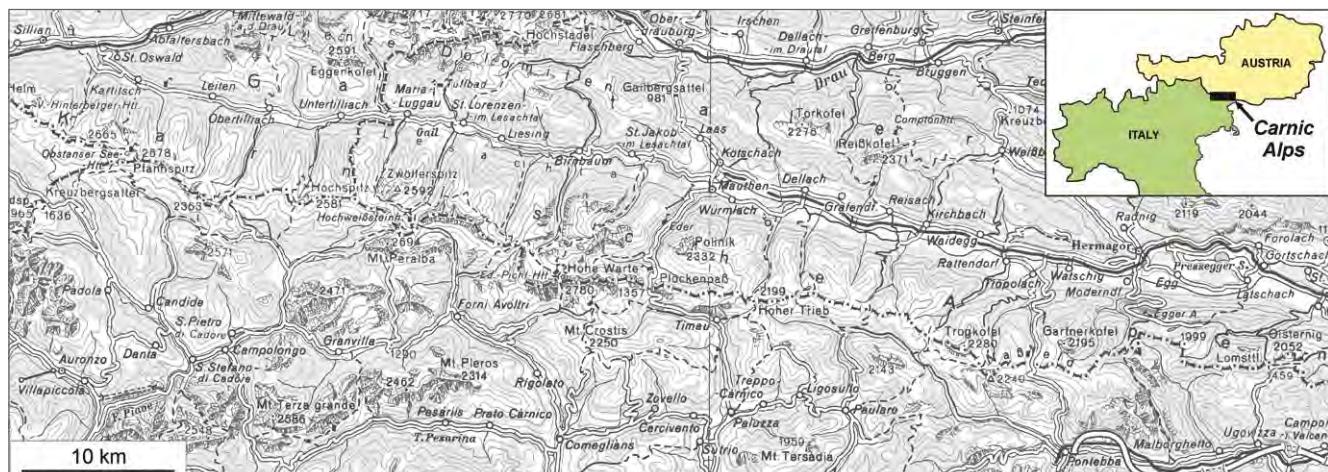
Viene presentato uno schema litostratigrafico aggiornato della sequenza Pre-Varisica delle Alpi Carniche. Tutte le unità litostratigrafiche sono state revisionate, ri-descritte e formalizzate ufficialmente. L'età dei limiti formazionali è stata ricalibrata. La successione comprende rocce dall'Ordoviciano Medio alla parte iniziale del Pennsylvaniano, distinte in 36 formazioni, che serviranno da riferimento per gli studi futuri nelle Alpi Carniche e consentiranno una migliore correlazione con altri domini paleogeografici.

Introduction

The Carnic Alps are located along the Italian-Austrian border. This mountain chain reveals one of the best exposed and complete Paleozoic sequences of the world, ranging from the Middle Ordovician to the Upper Permian.

The "Paleocarnic Chain" is considered as a part of the Variscan ancient core of the Eastern Alps in the Southalpine domain, and extends as a narrow strip for more than 100 km in a W-E direction, with a N-S width that rarely exceeds 15 km (Text-Fig. 1). To the North it is bordered by the Gailtail Line, part of the Periadriatic Lineament, separating the Austroalpine domain from the Southalpine domain; towards the South it is unconformably covered by Upper Paleozoic and Triassic successions (VENTURINI & SPALLETTA, 1998; SCHÖNLAUB & FORKE, 2007). The Paleocarnic Chain can be subdivided into two parts (Text-Fig. 2), separated by the Val Bordaglia thrust (BRIME et al., 2008), a prominent NE-SW trending fault: the western zone is made of greenschist facies metamorphic rocks, the eastern zone mainly consists of sedimentary successions (VENTURINI & SPALLETTA, 1998; BRIME et al., 2008) except for the northernmost part where banded limestones occur.

Rocks deposited between the Middle Ordovician and the Late Triassic are exposed in the Carnic Alps. They are subdivided into three sequences: the Pre-Variscan, the Permo-Carboniferous and the Alpine sequences. The Pre-Variscan sequence includes rocks of Middle Ordovician to early Pennsylvanian age that were affected by the Variscan orogeny during the late Bashkirian and Moscovian (VENTURINI, 1990; SCHÖNLAUB & FORKE, 2007). The Permo-Carboniferous sequence ranges from the Pennsylvanian to the Middle Permian. The youngest Paleozoic rocks of the Carnic Alps are documented in the Upper Permian-Triassic succession that is part of the so-called 'Alpine' sequence (VENTURINI, 1990).

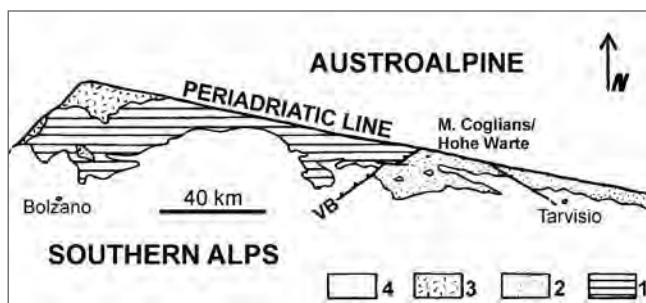


Text-Fig. 1.
Location of the Carnic Alps. Topographic map 1:200,000, rescaled.

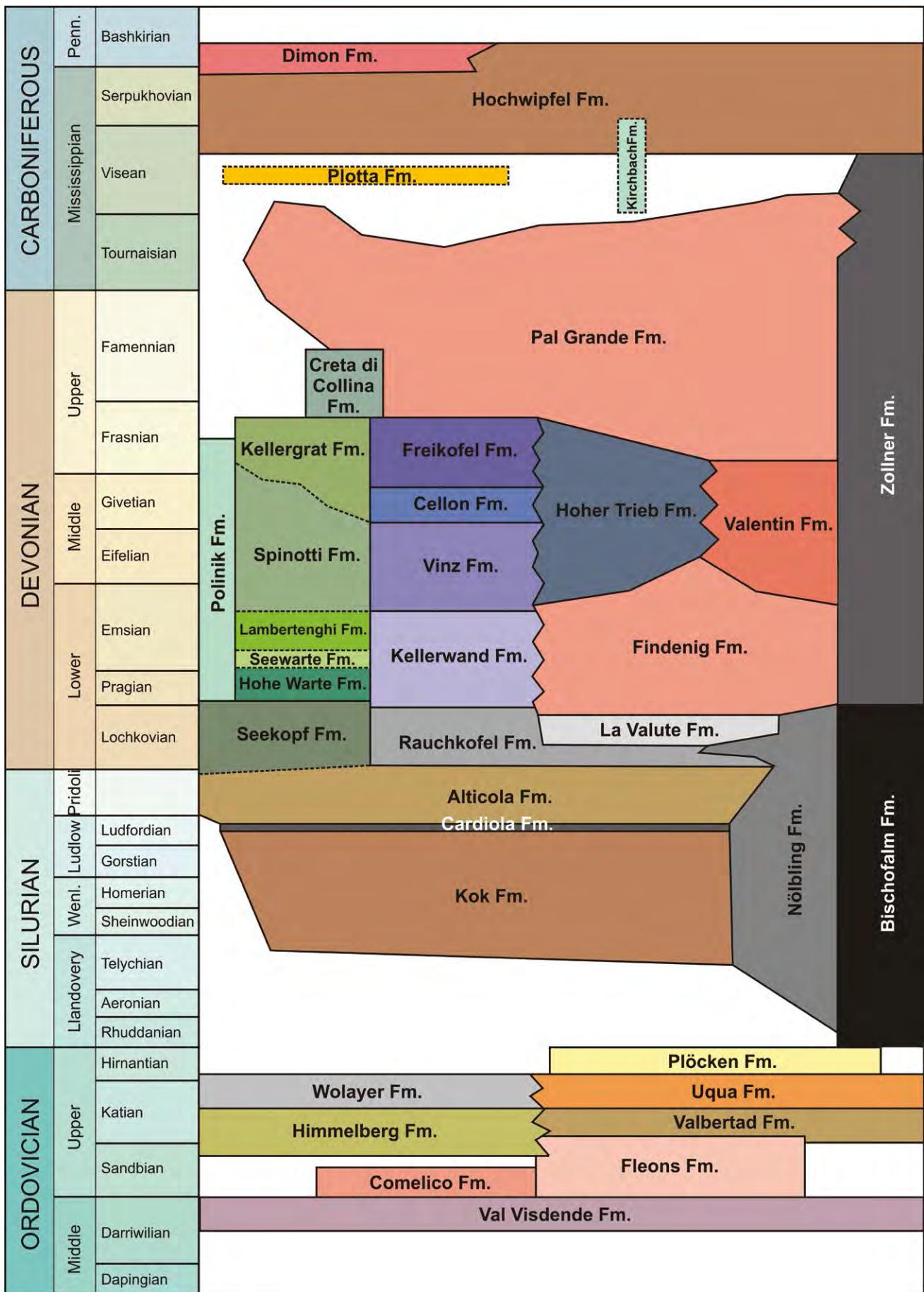
Here we focus on the Pre-Variscan sequence, which has been entirely revised resulting in an updated stratigraphic scheme (Text-Fig. 3) illustrating and formalizing 36 formations.

Former lithostratigraphic schemes

For the Carnic Alps several lithostratigraphic schemes exist, of which the latest versions from Austria and Italy are introduced here in order to show modifications performed in the new chart of the pre-Variscan sequence by the Carnic Alps Working Group. One of the major differences between Austrian and Italian charts is the number of units. While in the Austrian chart 43 units are discriminated (PILLER et al., 2004; HUBMANN et al., 2014; Text-Fig. 4), the Italian schemes consist of definitely less units which are mainly the expression of well-distinguished larger scale facies (for example see VENTURINI & SPALLETTA, 1998; VENTURINI, 2006, 2009; Text-Fig. 5). Devonian reef and transitional facies, for example, represent one unit each in many Italian



Text-Fig. 2.
Simplified geological map of the Southern Alps showing the partition of the Paleocarnic Chain into a West and a East Zone separated by the Val Bordaglia thrust (after VENTURINI & SPALLETTA, 1998, modified). VB: Val Bordaglia thrust; 1: low to middle grade metamorphic basement; 2: non- to anchi-metamorphic units; 3: Variscan intrusive bodies; 4: post-Paleozoic units.



Text-Fig. 3.

General lithostratigraphic scheme of the Pre-Variscan sequence of the Carnic Alps (columns left-right: System/Period, Series/Epoch, Stage/Age).

charts while Austrian workers subdivided the shallow marine, reef-related facies into 11 formations and the transitional zone (proximal ramp) into 4 formations. It should be noted that in Italy an official denomination for these subdivisions did not exist. Therefore, in different papers the subdivisions of the Pre-Variscan sequence were indicated with various names, even when the criteria of subdivision were often similar.

However, nearly none of the units, neither of Austrian, nor of Italian schemes, is formally established and some of them are now regarded as not justified and either erased from the actual chart or integrated into other formations of similar lithological characters. Units of former charts that have undergone change are briefly characterized below.

Austrian Scheme

In the Austrian Stratigraphic Chart 2004 (ASC 2004; PILLER et al., 2004) an Uggwa Limestone and an Uggwa Shale are depicted: herein, the Uggwa Shale is renamed into Valbertad Formation, while Uggwa Limestone remained in the present chart, however, formalized with the Italian name as Uqua Formation. Previously, the Silurian Bischofalm Formation in the new chart was subdivided into four units (Bischofalm Quartzite, Lower, Middle and Upper Bischofalm Shale). The former Megaerella Limestone is included partly into the Alticola Formation and partly into the Seekopf Formation. That decision was taken, because of its lithological character that, apart from the occurrence of *Rhynchonella megaera*, is very similar to aforementioned units. Early Devonian units were confused on the Austrian Stratigraphic Chart 2004. Originally, a neritic and pelagic Rauchkofel Limestone existed (KREUTZER, 1992), which continued in deeper marine settings laterally. Those deposits were called Boden Limestone (in the ASC 2004 wrongly indicated as shallow marine unit). Only the pelagic Rauchkofel Limestone is formalized now as Rauchkofel Formation. In order to discriminate the neritic from the pelagic Rauchkofel Limestone, neritic deposits are renamed into Seekopf Formation. The Boden Limestone had to be renamed, because “Boden” as part of Rauchkofel Boden is no valid geographic name. Outcrops of equivalent deposits are found around La Valute and consequently the unit is named La Valute Formation. Gamskofel (typological error in the ASC 2004: Gamskogel Limestone) and Feldkogel limestones were fused and renamed into Polinik Formation, where a major part of the sequence of laminated limestones is cropping out. The Eiskar Limestone is regarded as lithological variation of the Spinotti and Kellergrat formations and therefore partly included in either of the latter units. Following the recommendations of the International Commission on Stratigraphy (ICS) the Kellergrat Reef Limestone and the Plotta Lydite are formalized as Kellergrat Formation and Plotta Formation respectively. For Kollinkofel Limestone the Italian name is accepted and the unit is called Creta di Collina Formation. Marinelli Limestone and Kronhof Limestone are regarded as lithological variation of the Pal Grande Formation (previously Pal Limestone) and therefore integrated into the latter unit. New data on the age and a better understanding of the geometry in the field of the Plotta, Kirchbach, Hochwipfel and Dimon formations led to updating the position of their boundaries in the stratigraphic scheme.

Italian Schemes

As already pointed out before, an official subdivision of the Pre-Variscan chain in lithostratigraphic units did not exist in Italy. In rough approximation the older schemes used are less subdivided than the Austrian one, since they were mainly based on grouping similar facies. This resulted by the fact that, when the effort to produce modern geological maps in the Carnic Alps was performed, it was chosen to avoid a detailed distinction of lithostratigraphic units in a so complicated mountain area. For this reason the necessity to group the units in facies associations arose. Also the names used were not applied unequivocally, and the same unit was named differently in different papers. As an example, compare the names used for the shallow water facies association in three more recent schemes: “Shallow water lms” (VENTURINI & SPALLETTA, 1998), “Calcarei di piattaforma” (VENTURINI, 2006), “Calcarei del M. Coglians” (VENTURINI, 2009).

Sometimes, authors applied a more strict distinction of units (comparable with the Austrian scheme), but used different formation-names (cf. CORRIGA et al., 2012 for the Lochkovian).

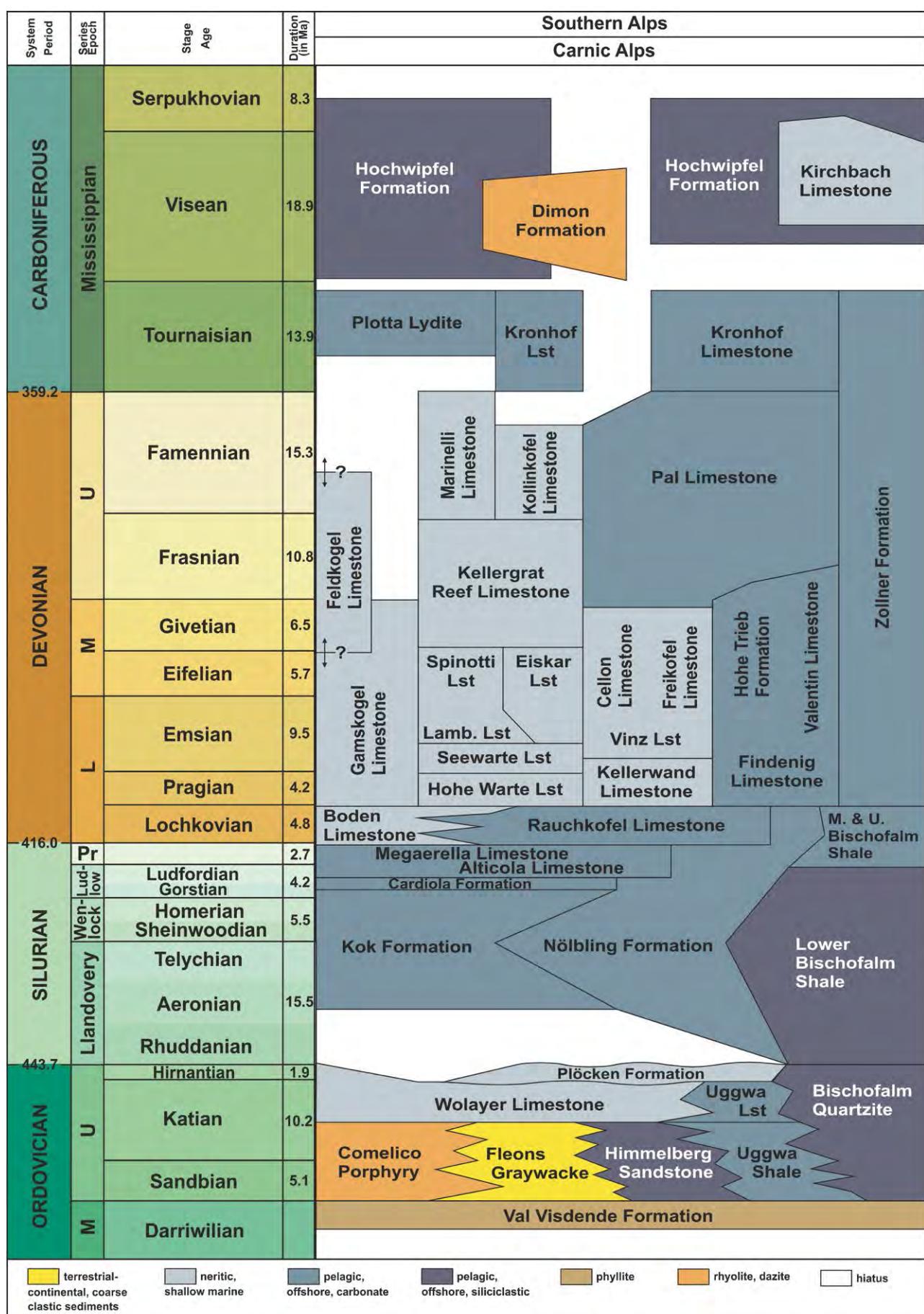
In most Italian schemes the Ordovician was grouped into a comprehensive “Uqua Formation”, including both, the shaly and the calcareous facies. The Silurian was subdivided into a mainly calcareous facies (“Orthoceras lms.”) and a mainly shaly facies; this subdivision was sometimes extended to the Lochkovian, whereas in other schemes some “platy limestones” were discriminated here. The Devonian consisted of four facies belts: the shallow, transitional and the calcareous and clastic pelagic zones (the latter is sometimes named Zollner Formation); the first three facies belts were followed by a pelagic cephalopod limestone (equivalent of the present Pal Grande Formation). The Hochwipfel Formation and the Dimon Formation represented the clastic, volcanic and volcanioclastic rocks of the Carboniferous, respectively.

Review of the Pre-Variscan sequence

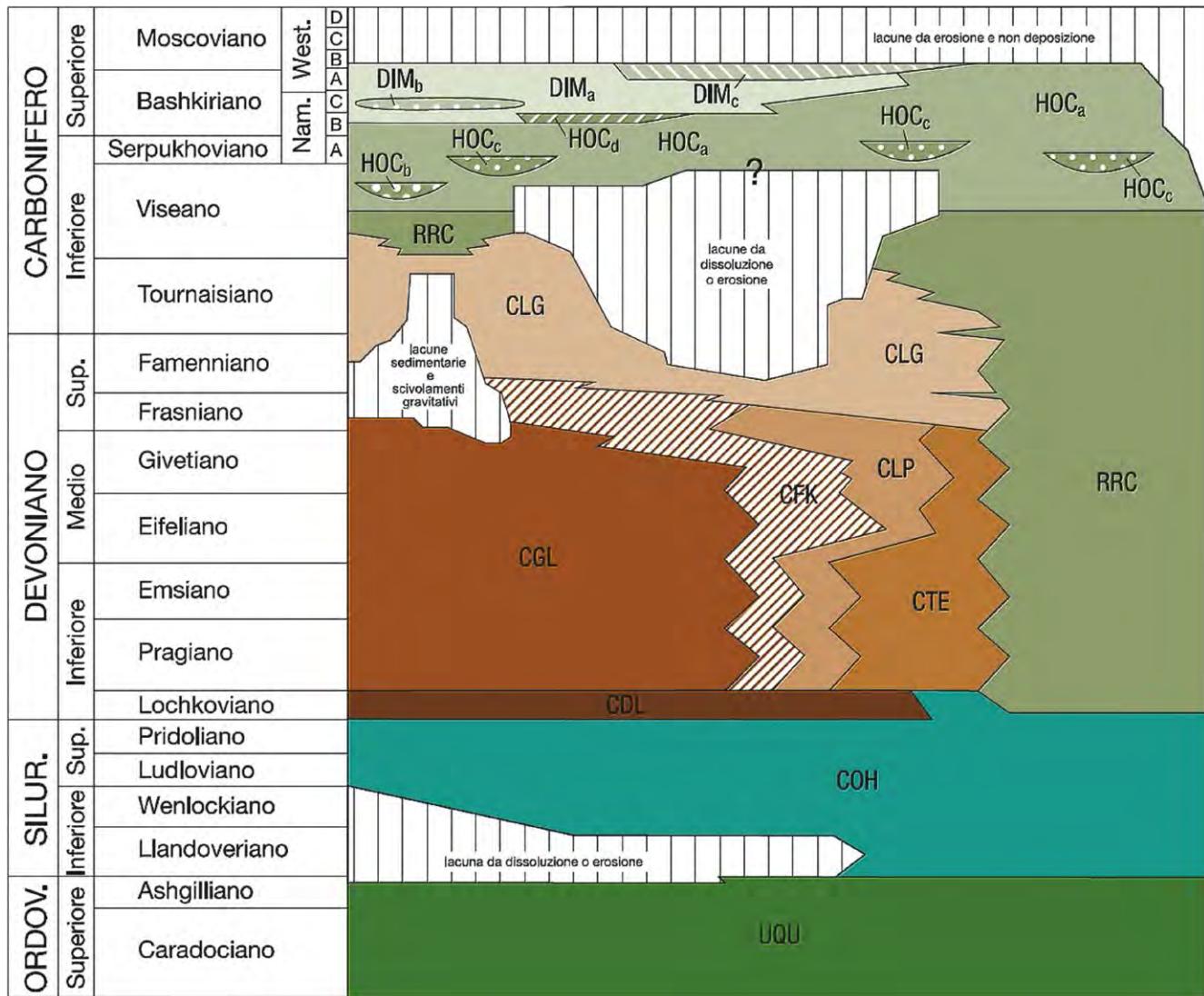
Ordovician

The oldest rocks of the Carnic Alps are Middle Ordovician in age and crop out west of the Val Bordaglia Line. They are represented by phyllitic schists and quartzites, with subordinate conglomeratic layers (Val Visdende Formation), followed by porphyroids (Comelico Formation) and volcanioclastic sediments (Fleons Formation).

With the exception of local fossil occurrences in the Fleons Formation, the most ancient fossiliferous rocks of the Carnic Alps belong to the Valbertad Formation (Katian). They are represented by up to 100 m of shallow-water pelites, sandstones and rare conglomerates deposited at medium-high southern latitudes. Fossils, mainly bryozoans, brachiopods, echinoderms, trilobites and gastropods, are abundant. In the central part of the basin a coarser grained sandstone unit (Himmelberg Formation) crops out. The basal clastic sequence is followed by a pelmatozoan parautochthonous limestone (Wolayer Formation) in the central part of the chain and by the coeval slightly deeper-water limestones of the Uqua Formation. Both units are late Katian in age, although an extension to the



Text-Fig. 4.
Lithostratigraphy of the Carnic Alps in the Austrian Stratigraphic Chart (after PILLER et al., 2004).



Text-Fig. 5.

The stratigraphic chart of the Variscan sequence used for Sheet 31 "Ampezzo" of the Italian Geological Map (after VENTURINI, 2009). Abbreviations: CDL: Calcari del Rauchkofel; CFK: Calciruditi del Freikofel; CGL: Calcari del M. Coglians; CLG: Calcari di Pramosio; CLP: Calcareni di Pal Grande; COH: Calcari ad *Orthoceras* e Argilliti a Graptoliti; CTE: Calcari di Cuestaia; DIM_{a-c}: Formazione del Dimon; HOC_{a-d}: Formazione del Hochwipfel; RRC: Radiolariti del Rio Chianaletta; UQU: Formazione dell'Uqua (columns left-right: System/Period, Series/Epoch, Stage/Age).

basal Hirnantian cannot be excluded. The global glacially-induced regression of the Hirnantian is documented by the calcareous sandstone of the Plöcken Formation, providing evidence of the Hirnantian $\delta^{13}\text{C}$ excursion (SCHÖNLAUB et al., 2011). It resulted in erosion and local non-deposition, as also indicated by Silurian strata resting disconformably upon the Upper Ordovician sequence (SCHÖNLAUB & HISTON, 1999; BRETT et al., 2009; HAMMARLUND et al., 2012; PONDRELLI et al., 2015).

Silurian

Silurian deposits are irregularly distributed within the Carnic Chain, and range from shallow water bioclastic limestones to nautiloid-bearing limestones, interbedded shales and limestones to deep-shelf or basinal black graptolitic shales and cherts ("lydites"). The overall thickness does not exceed 60 m. The Silurian transgression started at the base of the Llandovery, and, due to the disconformity separating the Ordovician and the Silurian, sediments of un-

known thickness are locally missing, which correspond to several conodont zones of Llandovery to Ludlow age (SCHÖNLAUB & HISTON, 1999; BRETT et al., 2009; ŠTORCH & SCHÖNLAUB, 2012; CORRADINI et al., 2015).

The Silurian of the Carnic Alps is subdivided into four lithological facies representing different depths of deposition and hydrodynamic conditions (SCHÖNLAUB, 1979, 1980; WENZEL, 1997). The Wolayer facies is characterized by proximal sediments, while the Bischofalm facies corresponds to deep water euxinic deposits. The Plöcken facies and the Findenig facies are intermediate between the ones mentioned above. In rough approximation, the four facies seem to be distributed north-west to south-east in the central sectors of the chain, as follows: Wolayer-, Plöcken-, Findenig- and Bischofalm facies. The depositional features suggest an overall transgressional regime from Llandovery to Ludlow. Uniform limestone sedimentation within the Pridoli suggests that more stable conditions developed (SCHÖNLAUB, 1997).

In terms of lithostratigraphy, three calcareous units are vertically developed in the proximal parts of the basin: the Kok Formation (Telychian-lower Ludfordian), the Cardiola Formation (Ludfordian) and the Alticola Formation (upper Ludfordian-basal Lochkovian). These units mostly correspond to the “*Orthoceras* limestones” of earlier authors, and are represented by bioclastic wackestone-packstones. The colour gradually turns from brownish and dark gray in the lower Silurian levels, often reflecting a high iron content, to dark then light gray and pink in the Pridoli (FERRETTI, 2005; FERRETTI et al., 2012; HISTON, 2012a, b). Nautiloid cephalopods are very abundant. Trilobites, bivalves and conodonts are common; crinoids, gastropods, ostracods, brachiopods and chitinozoans are present as well (BRETT et al., 2009; CORRADINI et al., 2010, 2015; HISTON, 2012b).

In the deeper part of the basin, the Bischofalm Formation was deposited. It is a tripartite succession, up to 60 m thick, of black siliceous shales, with cherts interbedded (1), clayish alum shales (2), and black graptolitic shales (3) which mainly were deposited in a euxinic environment. Graptolites are generally abundant (SCHÖNLAUB, 1997). Intermediate sedimentary conditions between calcareous and shaly facies are represented by the Nöbling Formation, composed of alternating black graptolitic shales, marls and limestone beds (SCHÖNLAUB, 1997).

Devonian

During the Lochkovian (Lower Devonian) the Carnic basin started to differentiate (KREUTZER, 1990, 1992; SCHÖNLAUB, 1992; KREUTZER et al., 1997; HUBMANN et al., 2003; SUTTNER, 2007; CORRIGA et al., 2012). The Seekopf Formation was deposited in moderately shallow water, and the Rauchkofel Formation and La Valute Formation on the outer platform. In the deeper parts of the basin the Nöbling Formation and the Bischofalm Formation continued up to the top of the Lochkovian (*M. hercynicus* graptolite Zone).

Starting from the upper Lochkovian, differences within the sedimentary basin increased: “the Devonian Period is characterized by abundant shelly fossils, varying carbonate thicknesses, reef development and interfingering facies ranging from near-shore sediments to carbonate buildups, lagoonal and slope deposits, condensed pelagic cephalopod limestones to deep oceanic off-shore shales” (SCHÖNLAUB & HISTON, 1999: 15). From the Pragian to the lower Frasnian, within short distances a strongly varying facies pattern developed, indicating a progressive but highly diverse deepening of the basin. More than 1000 m of reef and near-reef limestones (Hohe Warte Formation, Seewarte Formation, Lambertenghi Formation, Spinotti Formation, Kellerrat Formation) and various intertidal lagoonal deposits (Polinik Formation) are time equivalent to less than 100 m of pelagic limestones (Findenig Formation and Valentin Formation). In the intermediate fore-reef areas thick piles of mainly gravity-driven deposits accumulated (Kellerwand Formation, Vinz Formation, Cellon Formation,

Freikofel Formation). Pelites and cherts were deposited in the deeper part of the basin (Zollner Formation). Between the fore-reef and the deeper part of the basin gravity driven deposits alternate with pelagic limestones and black shales (Hoher Trieb Formation).

Reefs reached their maximum extension during the Givetian and early Frasnian, when the Carnic Alps were at a latitude of about 30° south (SCHÖNLAUB, 1992). Four major reef areas developed, now represented by the cliffs of Mt. Coglians/Hohe Warte, Mt. Zermula, Mt. Cavallo/Roßkofel and Mt. Oisternig, beside several minor buildups. The fossil content is very rich, having: stromatoporoids, tabulate and rugose corals, brachiopods, crinoids, gastropods, ostracods, bivalves, cephalopods, trilobites, algae, calcispheres and foraminifers (KREUTZER, 1990, 1992; RANTITSCH, 1992; SCHÖNLAUB, 1992; KREUTZER et al., 1997).

Devonian / Carboniferous

During the early Frasnian, extensional tectonic activity caused a collapse of the basin and consequently reefs rapidly drowned and reefal organisms disappeared. Starting from the upper Frasnian (Upper *rhenana* conodont Zone) a uniform pelagic environment developed, which continued up to the lowermost Visean (SCHÖNLAUB, 1969; SCHÖNLAUB & KREUTZER, 1993; PERRI & SPALLETTA, 1998): the pelagic Pal Grande Formation is represented by a grayish, pinkish, reddish wackestone with cephalopods. Locally, cherty sediments (Plotta Formation) capped the Pal Grande Formation.

Carboniferous

Starting from the upper Visean, up to 1000 m of arenaceous pelitic turbidites of the Hochwipfel Formation were deposited. It is interpreted as a Variscan flysch sequence (VAI, 1963; SPALLETTA & VENTURINI, 1988 and references therein). These deposits indicate a Variscan active plate margin in a collisional regime following the extensional tectonics during the Devonian and the Mississippian (SCHÖNLAUB & HISTON, 1999) evolving from a strike-slip context (SPALLETTA & VENTURINI, 1988; VAI, 1998). The Hochwipfel Formation consists of quartz-sandstones and grayish shales, turbidites, with intercalations of mudstones, chaotic debris flows and chert and limestone breccias. Locally, plant remains and rare trace fossils can be found (AMEROM et al., 1984; AMEROM & SCHÖNLAUB, 1992). Short local episodes of carbonatic deposition during the Early Visean to the Serpukhovian boundary are represented by the Kirchbach Formation. In the upper part of the Mississippian, basic volcanites and volcaniclastic deposits (Dimon Formation) occur. They are related to crustal thinning associated to a rifting episode (VAI, 1976; ROSSI & VAI, 1986; LÄUFER et al., 1993, 2001). These conditions continued up to the Late Bashkirian (Pennsylvanian), when the Hercynian orogeny in the Carnic area marked the end of the deposition of the Pre-Variscan sequence (VENTURINI, 1991).

Acknowledgements

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Val Visdende Formation

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Österreichische Karte 1:50.000
Blatt BMN 195 Sillian
Blatt BMN 196 Obertilliach

Blatt UTM 3108 Sillian
Blatt UTM 3109 Oberdrauburg

Carta Topografica d'Italia 1:50.000
Foglio 017 Monte Cavallino
Foglio 018 Passo di Monte Croce Carnico

Definition

Phyllitic schists alternating with quartzite beds and conglomeratic layers (CARLONI, 1971; HUBICH & LOESCHKE, 1993; CARULLI, 2006).

Description

Phyllitic schists of variable amount of quartz alternating with quartzitic layers. Subordinate conglomerate horizons are interbedded. Quartzites are less well sorted, some are of pyroclastic origin (CARLONI, 1971; HUBICH & LOESCHKE, 1993).

Fossil content

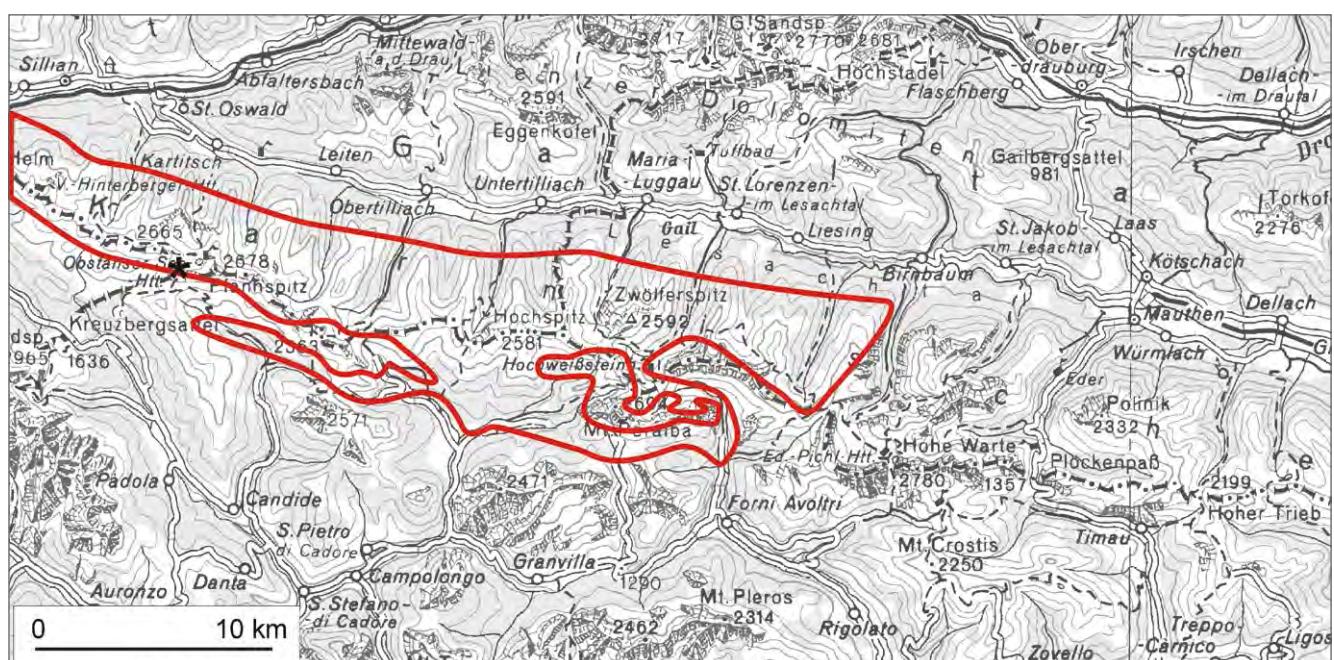
No trace of organic matter in palynological preparation (HINDERER, 1991).

Depositional environment

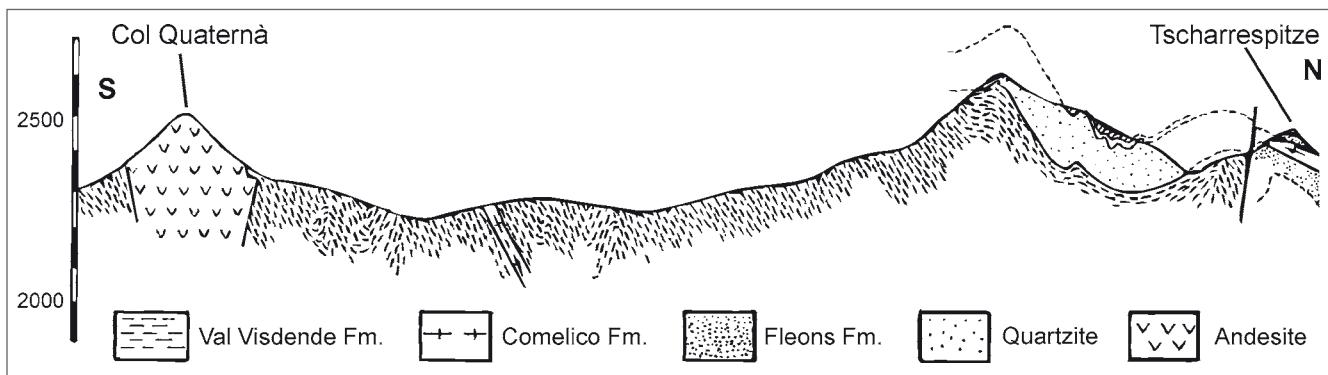
Shallow marine environment. Volcanic quartz grains, plagioclase and tourmaline suggest a source area of acidic volcanic and plutonic rocks.

Stratotype

Section between Col Quaternà and Tscharrespitze near Passo Silvella, at coordinates N 46°40'16", E 12°28'19" (HUBICH & LOESCHKE, 1993).



Areas of outcrop of the Val Visdende Formation with indication of the stratotype (asterisk). The Val Visdende Formation crops out also west of the area indicated in the map for about 15 km.



The section between Col Quaternà and Tscharrespitze (after HUBICH & LOESCHKE 1993, modified).

Reference sections -

Type area

Western Carnic Alps.

Main outcrop areas

Obstanser See, Großer Kinigat, Pfannspitze, Roßkopf, Maurerspitze, Tscharrespitze, Passo Silvella.

Thickness

More than 500 m.

Boundaries

Underlying units – ?

Overlying units – Comelico Formation (conformable contact ?); Fleons Formation; Himmelberg Formation (?); Valbertad Formation.

*Lateral units – Comelico Formation (*sensu* HUBICH & LOESCHKE, 1993).*

Derivation of name

After the Val Visdende Valley in northern Italy.

Synonymy

Val Visdende Gruppe: SCHÖNLAUB (1979).

Comelicophyllite: HEINISCH (1981).

Val Visdende Schiefer: HUBICH & LOESCHKE (1993).

Val Visdende Schichten: HUBICH et al. (1993).

Formazione della Val Visdende: DUCA (2004).

Val Visdende-Formation: SUTTNER et al. (2014).

Chronostratigraphic age

Ordovician: Middle Ordovician (?) inferred from the overlying Comelico Formation; Carboniferous (?) according to SPALLETTA & VENTURINI (1989) and VENTURINI et al. (2002).

Biostratigraphy -

Complementary references -

Remarks -

References

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Comelico Formation

HANS-PETER SCHÖNLAUB & HELMUT HEINISCH

Österreichische Karte 1:50.000

Blatt BMN 195 Sillian

Blatt BMN 196 Obertilliach

Carta Topografica d'Italia 1:50.000

Foglio 017 Monte Cavallino

Foglio 018 Passo di Monte Croce Carnico

Blatt UTM 3108 Sillian

Blatt UTM 3109 Oberdrauburg

Definition

Porphyry with thin interbeds of phyllites in the lower part. It comprises pyroclastic flow deposits (ignimbrites) with a rhyolitic to rhyodacitic, partly also alkali-rhyolitic composition (HEINISCH, 1981).

Description

The massive to well bedded porphyry contains phenocrysts of quartz, alkali feldspar and plagioclase in a matrix of chlorite, serizite, quartz and albite. Accessory minerals are apatite, zircon, tourmaline, biotite and garnet. Some aggregates of quartz, chlorite and muscovite may represent former lapilli or collapsed pumice. The crystal-rich porphyry is strongly recrystallized and thus difficult to link to a particular type (HEINISCH, 1981; HUBICH & LOESCHKE, 1993; MELI, 1998).

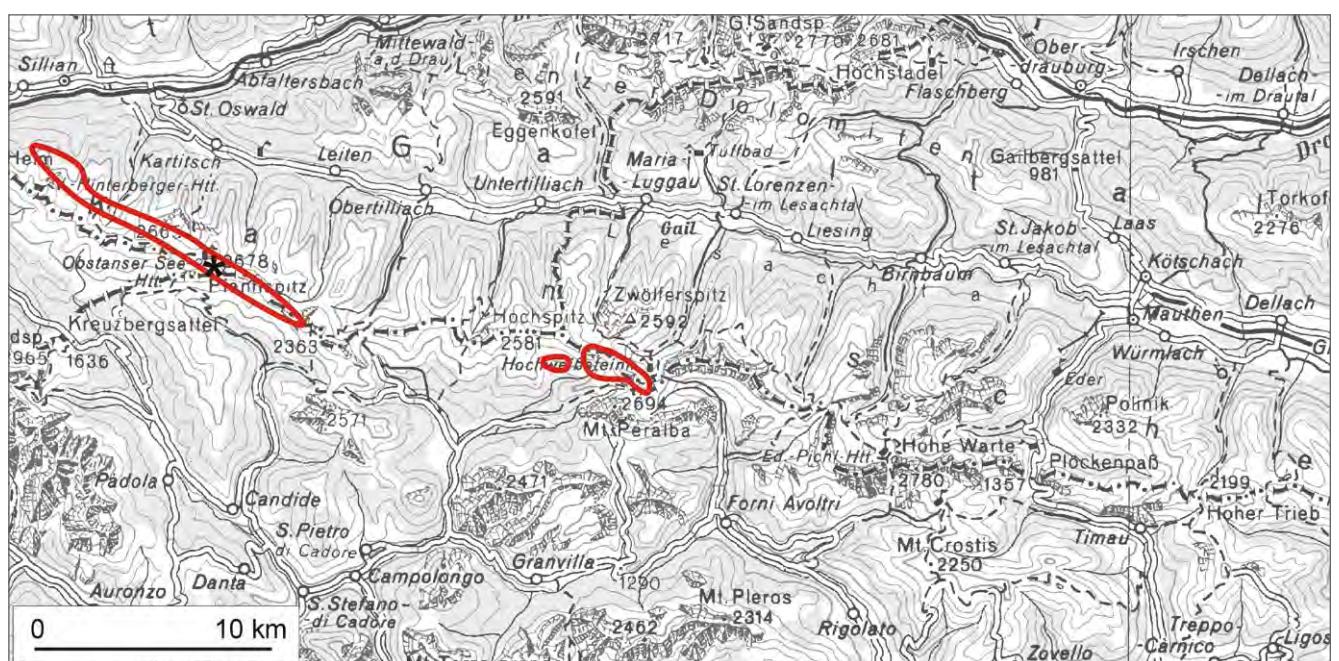
Fossil content -

Depositional environment

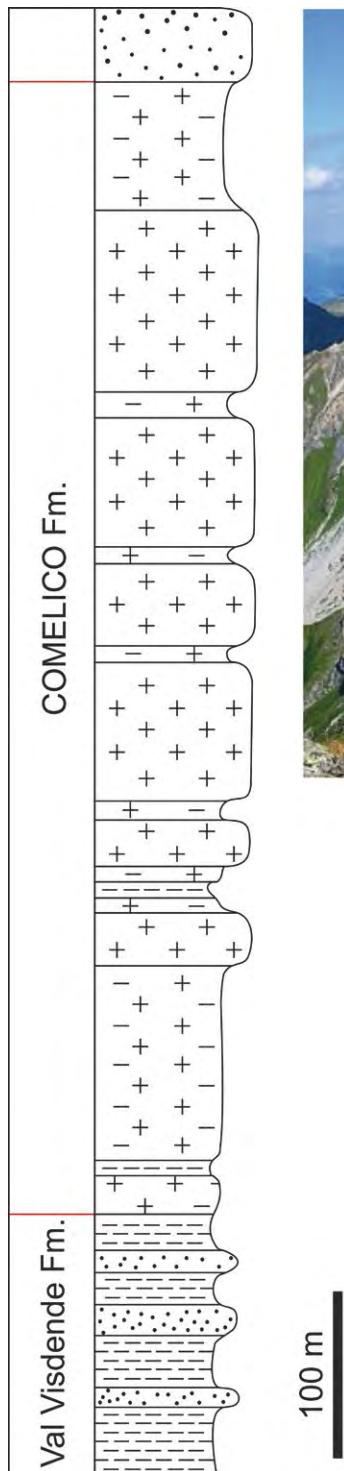
Difficult to assess, because ignimbrites of similar composition occur in different tectonic settings. Back-arc basin or position in a post-collisional extensional field of continental crust is possible (HUBICH & LOESCHKE, 1993). According to PANWITZ (2006) and BLATT (2013) a rift-related magmatism due to the extension at the North Gondwana margin is highly probable.

Stratotype

Pfannspitze Section, at coordinates N 46°50'52", E 12°30'05" (HUBICH & LOESCHKE, 1993).



Areas of outcrop of the Comelico Formation with indication of the stratotype (asterisk). Topographic map 1:200,000.



- [+] Porphyry
- [−+] Porphyry and phyllite
- [•••] Quartzite
- [---] Phyllite

The Pfannspitze Section, modified after HUBICH & LOESCHKE, 1993 (photo H.P. SCHÖNLAUB).

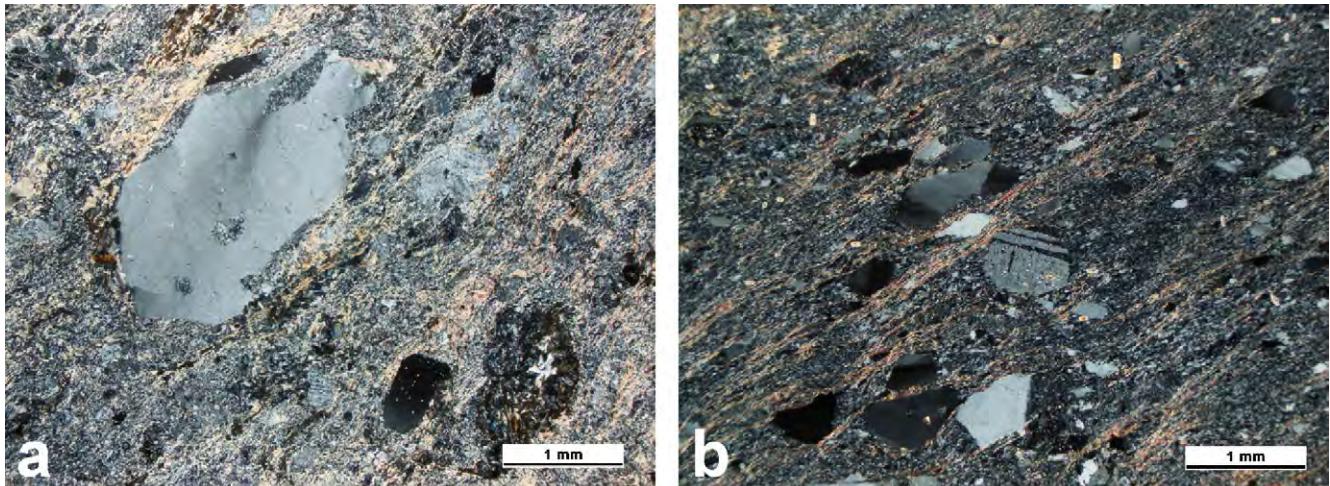
Reference sections -

Type area

Western Carnic Alps.

Main outcrop areas

Area near Obstanser See, Pfannspitze, Kleiner Kinigat, Großer Kinigat, Eisenreich-Gipfel, Tscharrespitze-Gatterspitze, Passo Silvella.



Micrographs of the Comelico Formation (photos H. HEINISCH) from southern ridge of Großer Kinigat. a) Phenocrysts of volcanic quartz with magmatic corrosion, sericitized alkali-feldspar and albited plagioclase. The matrix is strongly recrystallized and foliated, containing quartz/albite, sericite and chlorite. b) Porphyritic texture with phenocrysts of quartz, albite and sericitized alkali-feldspar. The matrix is strongly recrystallized and foliated, containing quartz/albite, sericite and chlorite.

Thickness

Up to approx. 670 m.

Boundaries

Underlying units – Val Visdende Formation (conformable contact ?).

Overlying units – Quartzites, shales, flaser limestones and lydites of presumably Late Ordovician and Silurian age.

Lateral units – Fleons Formation (graywackes, conglomerates).

Derivation of name

After the region of Comelico in the Province of Belluno in northern Italy.

Synonymy

Porphyroide der Pfannspitze: SCHMIDT (1930).

Pfannspitzstreifen: SCHMIDT (1930).

Pre-Hercynian porphyry plateau [partim]: SASSI & ZIRPOLI (1968).

Volcano-sedimentary Complex [partim]: SASSI & ZIRPOLI (1968).

Comelico «porphyroids»: SASSI & SPIESS (1993).

Comelico-Porphyroid/Porphyry: SUTTNER et al. (2014).

Chronostratigraphic age

Ordovician: Based on zircon crystal dating a Late Ordovician age has been suggested by HUBICH & LOESCHKE (1993).

Additional zircon dating by SÖLLNER et al. (1997) and MELI & KLÖTZLI (2001) provided radiometric ages of 463 +/- 6 Ma and 479 +/- 8 and 485 +/- 8 Ma, respectively, for the acidic volcanic activity, i.e. the extrusion of lavas and pyroclastica. These ages are confirmed by the radiometric dating of the porphyries of Northern Graywacke Zone, Eastern Alps. These rocks yielded two clusters of LA-ICP-MS ages on zircons of 471–469 Ma and 465–464 Ma (BLATT, 2013). The porphyry thus is of Middle Ordovician age and more precisely belongs mainly to the Darriwilian Stage.

Biostratigraphy -

Complementary references -

Remarks -

References

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Fleons Formation

HANS-PETER SCHÖNLÄUB

Österreichische Karte 1:50.000

Blatt BMN 195 Sillian

Blatt BMN 196 Obertilliach

Carta Topografica d'Italia 1:50.000

Foglio 017 Monte Cavallino

Foglio 018 Passo di Monte Croce Carnico

Blatt UTM 3108 Sillian

Blatt UTM 3109 Oberdrauburg

Definition

Volcaniclastic sediments comprising quartzites, quartzitic schists, graywackes, conglomerates.

Description

The Fleons Formation consists of quartzitic schists, quartzites, volcaniclastic graywackes and conglomerates. Sedimentary structures indicate an interaction of wave-dominated shallow shoreline environment with a locally developed fan-delta environment. The first is represented by the quartzitic lithologies whereas the graywackes originate from the coarser and immature clastics of the fan-delta deposits. The provenance of the graywackes are basic and acidic rocks which developed on a basement of metasediments, subordinate granitoids and ultramafites. The acidic volcaniclastics probably originates from the Comelico Formation. According to HINDERER (1992) for the plate tectonic position of the Fleons Formation a backarc or post-collisional rifting setting is most likely.

Fossil content

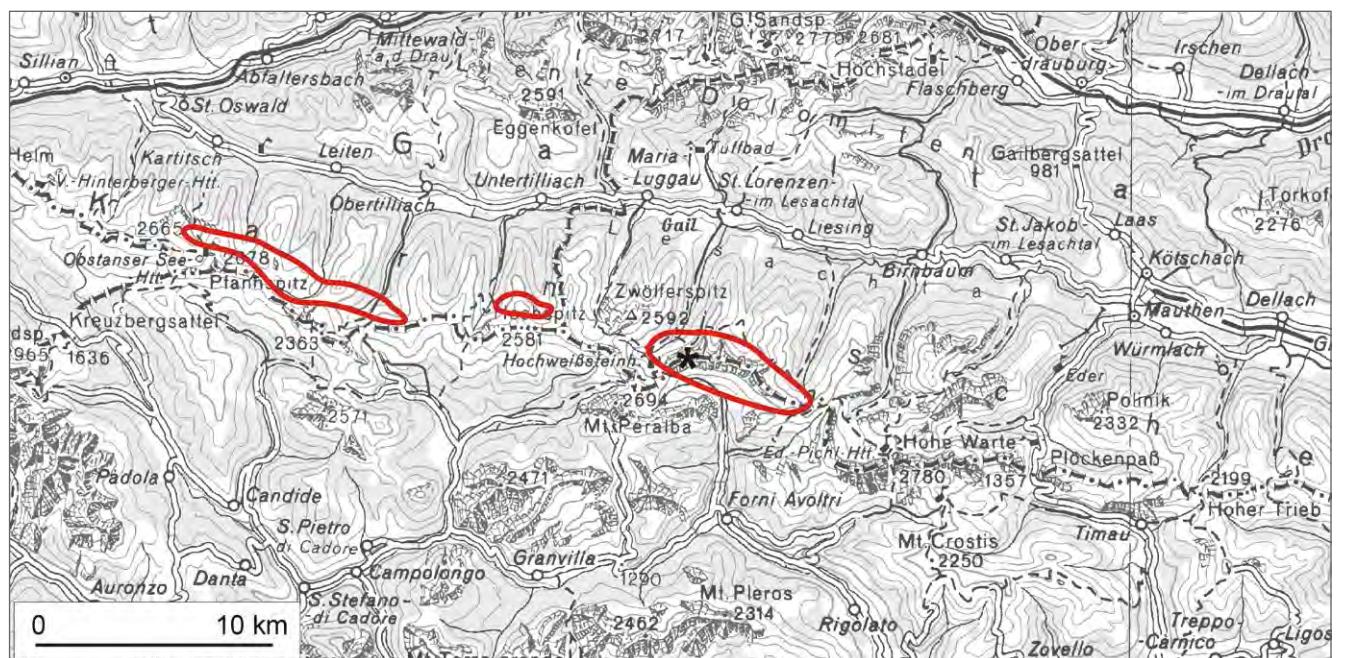
Bryozoans, brachiopods.

Depositional environment

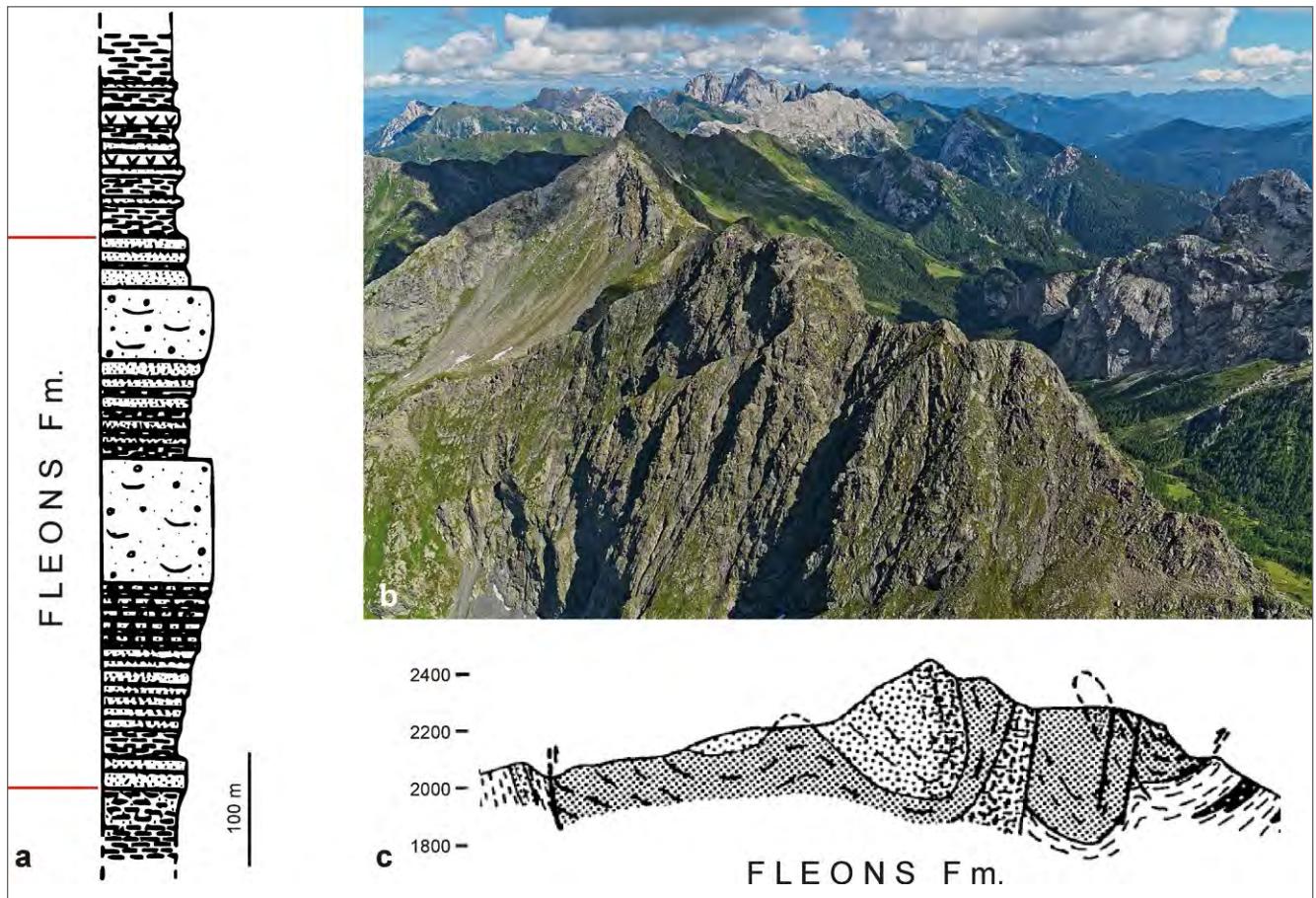
Wave-dominated coastal environment with locally developed fan deposits (HINDERER, 1992).

Stratotype

Monte Fleons/Raudenspitze Section, at coordinates N 46°39'45", E 12°44'05" (HINDERER, 1992, 1997).



Areas of outcrop of the Fleons Formation with indication of the stratotype (asterisk).



The Monte Fleons/Raudenspitze Section. a) log of the section (modified after HINDERER, 1992); b) aerial photo of Mt. Fleons and the Fleons valley to the south (photo EDMAIER); c) profile across Mt. Fleons/Raudenspitze (modified after HINDERER, 1992).

Reference sections -

Type area

Western Carnic Alps.

Main outcrop areas

Monte Fleons (= Raudenspitze) – Letterspitze and near the Roßkar (HINDERER, 1992), Tscharrespitze (HUBICH et al., 1993; HINDERER, 1997).

Thickness

More than 500 m.

Boundaries

Underlying units – Val Visdende Formation (conformable contact ?).

Overlying units – Gray-green silty shales are interbedded between the Fleons Formation and the overlying Uqua Formation (SCHÖNLAUB & FLAJS, 1993).

Lateral units – Valbertad Formation and Himmelberg Formation (SCHÖNLAUB, 1985; HINDERER, 1992).

Derivation of name

After Monte Fleons (= Raudenspitze) near the village Fleons di Sopra.

Synonymy

Mauthener Schichten: FRECH (1894).
Grüne Eruptivgesteine (Diabastuffe): GEYER (1899, 1902).
Fleonsgrauwacken: PELLIZZER & TOMADIN (1962).
Formazione del Monte Fleons: CARLONI (1971).
Fleons-Grauwacken: SCHÖNLAUB (1985).
Fleonsformation: HINDERER (1988, 1992).
Roßkarkonglomerat: HINDERER (1992).
Formazione di Fleons: DUCA (2004).
Fleons-Grauwacke/Greywacke: SUTTNER et al. (2014).

Chronostratigraphic age

Ordovician: Katian age is suggested by fossil-bearing intercalations of the Valbertad Formation at Raudenspitze (SCHÖNLAUB & FLAJS, 1993).

Biostratigraphy -

Complementary references -

Remarks -

References

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Himmelberg Formation

HANS-PETER SCHÖNLAUB

Österreichische Karte 1:50.000
Blatt BMN 197 Kötschach

Blatt UTM 3109 Oberdrauburg
Blatt UTM 3110 Kötschach-Mauthen
Blatt UTM 3116 Sonnenalpe Naßfeld

Carta Topografica d'Italia 1:50.000
Foglio 018 Passo di Monte Croce Carnico
Foglio 032 Tolmezzo

Definition

Massive to well-bedded predominantly grayish sandstones and arenaceous shales with subordinate conglomeratic intercalations. Upward the clastics grade into more calcareous strata.

Description

Massive to well bedded grayish, greenish and reddish sandstones and arenaceous shales interbedded locally with conglomeratic layers and cross-bedded sandstones. These basal clastics gradually change upward into more calcareous sandstones with lense-like limestone intercalations of crinozoan debris.

Fossil content

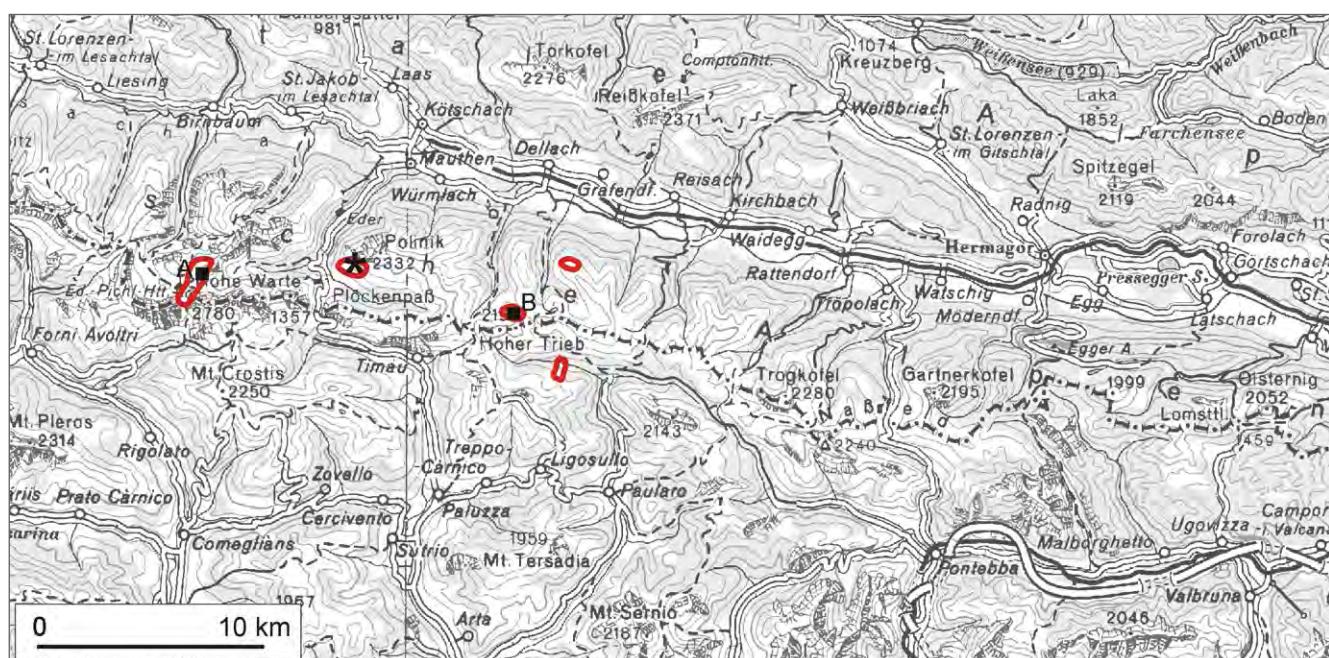
Brachiopods, bryozoans, echinoderms.

Depositional environment

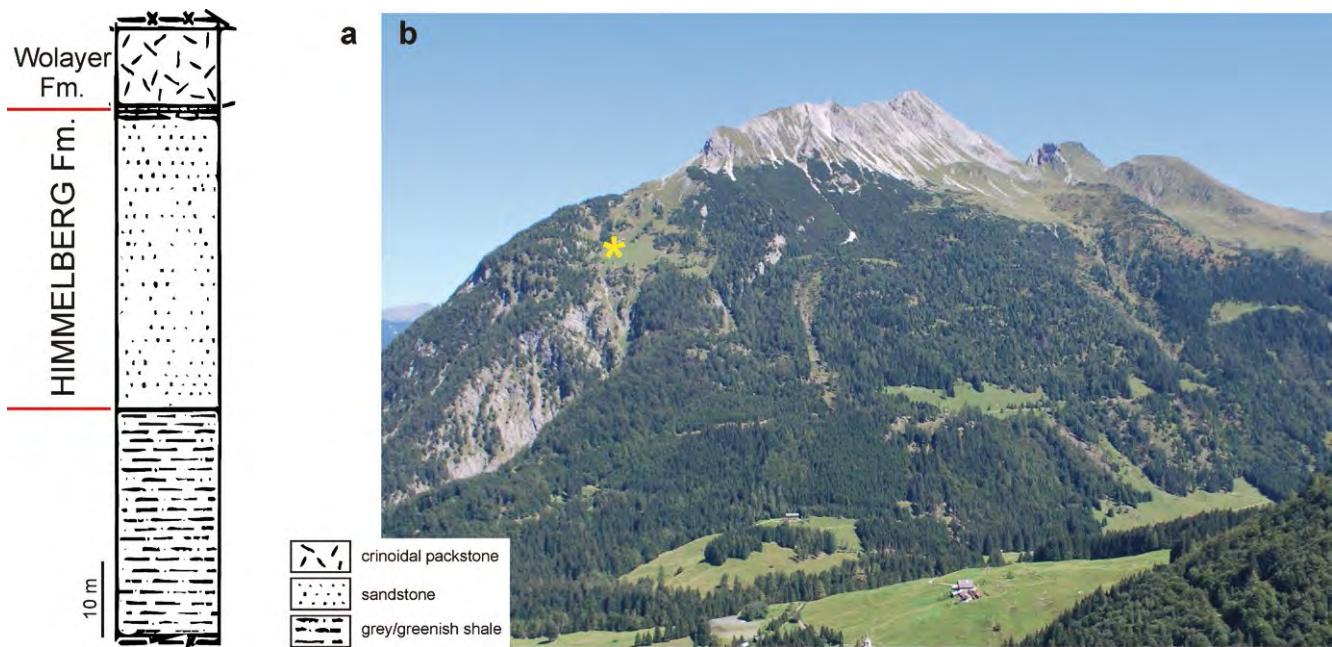
Shallow marine siliciclastics (SCHÖNLAUB, 1971).

Stratotype

Upper Himmelberg Alm Section, west of Mount Polinik (SCHÖNLAUB, 1985a, b), at coordinates N 46°37'36", E 12°58'00".



Areas of outcrop of the Himmelberg Formation with indication of the stratotype (asterisk) and reference sections (squares). A: Rauchkofel section; B: Hoher Trieb section.



The Himmelberger Alm Section. a) log of the section (modified after SCHÖNLAUB, 1970); b) panoramic view of Mt. Polnik, with indication of Himmelberger Alm (asterisk) (photo M. PONDRERI).

Reference sections

Rauchkofel Section (SCHÖNLAUB, 1971, 1985a), on the southern slope of Mt. Rauchkofel at coordinates N 46°36'55", E 12°52'31", where, compared with the stratotype, shallower deposition is evident.

Hoher Trieb Section (SCHÖNLAUB, 1969), north of Mt. Hoher Trieb/Cuestalta at coordinates N 46°36'02", E 13°03'11", where limestones are interbedded within the clastic sequence.

Type area

Central Carnic Alps.

Main outcrop areas

Himmelberger Alm (SCHÖNLAUB, 1985a), base of Mount Seekopf, Rauchkofel-Boden, Hoher Trieb, Rio Cercevesa (VENTURINI et al., 2002).

Thickness

Approx. 60 m.

Boundaries

Underlying units – ?

Overlying units – Wolayer Formation (conformable contact).

Lateral units – Fleons Formation, Valbertad Formation.

Derivation of name

After Himmelberg Alm west of Mount Polnik (GAERTNER, 1931).



Cross-bedded siliciclastics (sandstones) of the Himmelberg Formation on upper Rauchkofelboden along the trail (2150 m) from Lake Wolayer Hut to Mt. Rauchkofel (Photo H.P. SCHÖNLAUB).

Synonymy

Himmelberger Quarzit: GAERTNER (1931).
Formazione dell'Himmelberger Alm: SELLI (1963).
Dolomitische Sandsteine: SCHÖNLAUB (1969).
Wechsellagerung Echinodermatenkalke-Karbonatsandsteine: SCHÖNLAUB (1969).
Siltiti, arenarie e biocalcareniti: MANARA & VAI (1970).
Biocalcarénites Quartzeuses: VAI (1971).
Himmelberger Sandstein: SCHÖNLAUB (1971); DULLO (1992).
Himmelberg-Sandstein/Sandstone: SUTTNER et al. (2014).

Chronostratigraphic age

(?) Ordovician: Not well dated yet. A Katian age is inferred from the overlying fossiliferous Wolayer Formation.

Biostratigraphy -

Complementary references -

Remarks -

References

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Valbertad Formation

HANS-PETER SCHÖNLAUB & LUCA SIMONETTO

Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt BMN 199 Hermagor

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Grayish, brownish and greenish siltstones to arenaceous shales and rare fine-grained graywackes and sandstones.

Description

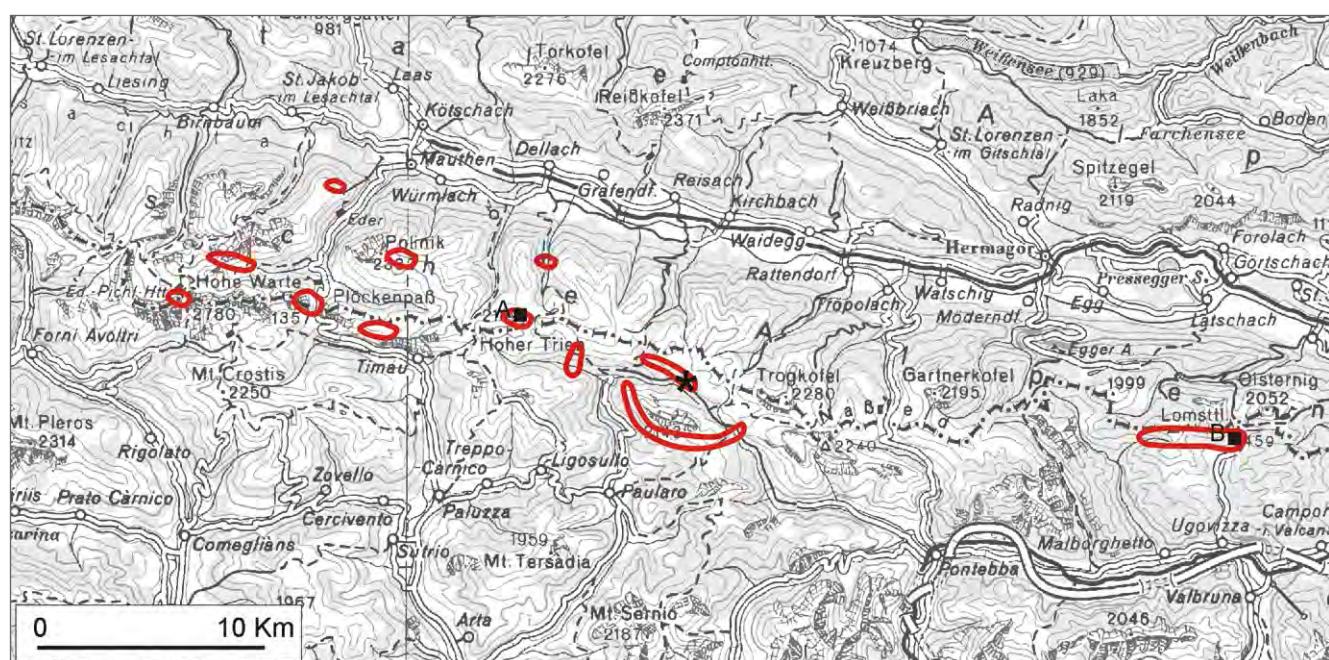
The Valbertad Formation consists of thin to very thin-bedded grayish, brownish and greenish siltstones to arenaceous shales. Some horizons show indistinct bedding and are more compact resembling fine-grained graywackes and sandstones. Fossils, abundant in some levels, are more or less de-calcified. In the upper part of the unit, the shales are increasingly interbedded with thin to very thin nodules of gray mud- and wackestone.

Fossil content

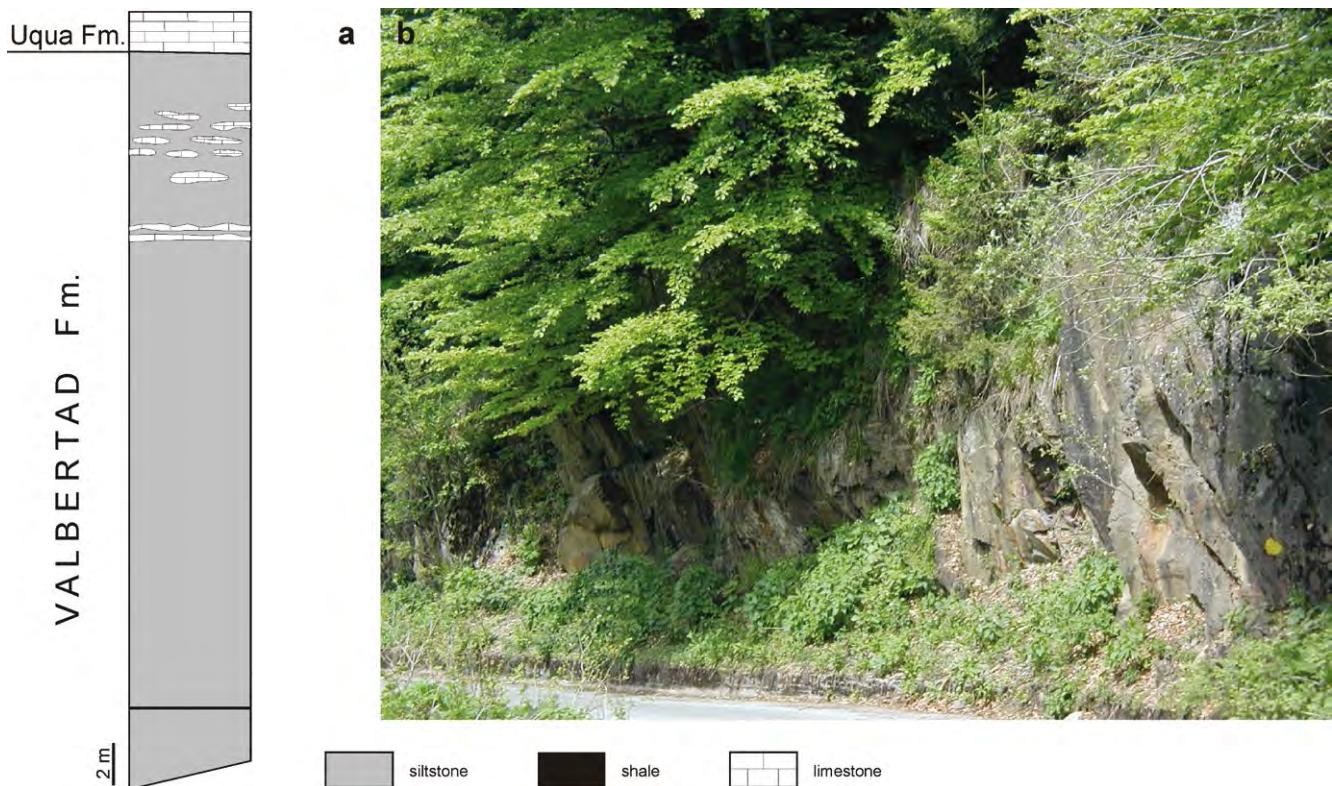
Acritarchs, brachiopods, bryozoans, cephalopods (nautiloids), cystoids, gastropods, hyoliths, tentaculites, trilobites.

Depositional environment

Moderately deep marine environment.



Areas of outcrop of the Valbertad Formation with indication of the stratotype (asterisk) and reference sections (squares). A: Hoher Trieb Section; B: Rifugio Nordio Section.



The Valbertad Section. a) log of the section (redrawn after BAGNOLI et al., 1998); b) view of the section (photo L. SIMONETTO).

Stratotype

Valbertad Section (BAGNOLI et al., 1998; CORRADINI et al., 2012) along the road from Paularo to Passo di Lanza at coordinates N 46°34'31.6", E 13°08'38.6".

Reference sections

Uqua Creek Section, near Rifugio Nordio (VAI, 1971) north of Ugovizza at coordinates N 46°36'32", E 13°29'03", an important historical section.

Hoher Trieb Section (SCHÖNLAUB, 1969, 1971; JAEGER et al., 1975; HAVLICEK et al., 1987), north of Mt. Hoher Trieb/Cuestalta at coordinates N 46°36'02", E 13°03'10", particularly rich in fossils.

Type area

Carnic Alps.

Main outcrop areas

Northern part of Mt. Cellon (Cellonalm), Hoher Trieb, Base of Mt. Seekopf, northern side of Rio di Lanza valley, Mt. Pizzul, Mt. Zermula, Uqua Creek.

Thickness

15 m to more than 100 m.

Boundaries

Underlying units – Fleons Formation (conformable? contact) (SCHÖNLAUB & FLAJS, 1993).

Overlying units – Uqua Formation (conformable contact).

Lateral units – Himmelberg Formation, Fleons Formation.



Views of the Valbertad Formation in the field. a) the outcrop on the top of Mt. Pizzul (photo L. SIMONETTO); b) cystoid in the Valbertad Section (photo L. SIMONETTO).

Derivation of name

After Casera Valbertad.

Synonymy

Strophomena Horizont: STACHE (1884).

Calcescisti, calcari saccaroidi ed argilloscisti di Mauthen [partim]: TARAMELLI (1895).

Scisti Ordoviciani: GORTANI (1926).

Scisti argilloso-ocracei con vene e noduli calcarei: GORTANI & DESIO (1927).

Uggwaserie: GAERTNER (1931).

Schiefer des Caradoc: HABERFELNER & HERITSCH (1932).

Formazione di Ugva: SELLI (1963).

Formazione di Uggwa: ASSERETO et al. (1968).

Sandige Schiefer mit Bryozoen: SCHÖNLAUB (1969).

Siltstones et Grès de L'Uqua: VAI (1971).

Formazione dell'Uqua: BRAGA et al. (1971).

Grünlichgraue Siltsteine der Stillwasser-Fazies: SCHÖNLAUB (1971).

Greygreen siltstones: SCHÖNLAUB (1971).

Sandig-pelitische Uggwafazies: SCHÖNLAUB (1979).

Formazione di Uqua: VAI et al. (1984), VENTURINI (1990).

Uggwa-Schiefer: SCHÖNLAUB (1985).

Uggwa-Schiefer/Shale: SUTTNER et al. (2014).

Chronostratigraphic age

Ordovician: Katian, based on the brachiopod Foliomena Fauna (VAI, 1971; SCHÖNLAUB 1980; VAI & SPALLETTA, 1980; HAVLICEK et al., 1987; HARPER et al., 2009).

Biostratigraphy -

Complementary references -

Remarks

In the western Karavanke Alps the equivalents of the Valbertad Formation are exposed in the Feistritzgraben section (SCHÖNLAUB, 1979, 1982, 1985).

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Wolayer Formation

HANS-PETER SCHÖNLAUB & ANNALISA FERRETTI

Österreichische Karte 1:50.000
Blatt BMN 197 Kötschach
Blatt BMN 198 Weißbriach

Carta Topografica d'Italia 1:50.000
Foglio 018 Passo di Monte Croce Carnico

Blatt UTM 3109 Oberdrauburg
Blatt UTM 3110 Kötschach-Mauthen

Definition

White and locally pinkish massive, coarse-grained cystoid-bryozoan limestone (packstone-grainstone).

Description

10 to 17 m thick white to grayish and locally pinkish massive or indistinctly bedded coarse-grained pelmatozoan limestone. No macrofossil clearly recognizable at naked eyes. At higher magnification, the Wolayer Formation is rich in cystoid debris, bryozoans, crinoids, corals, algae, conodonts and rarely occurring ostracods and trilobites. According to DULLO (1992), the parautochthonous bioclasts were derived from bryozoan mounds, although such structures have never been found.

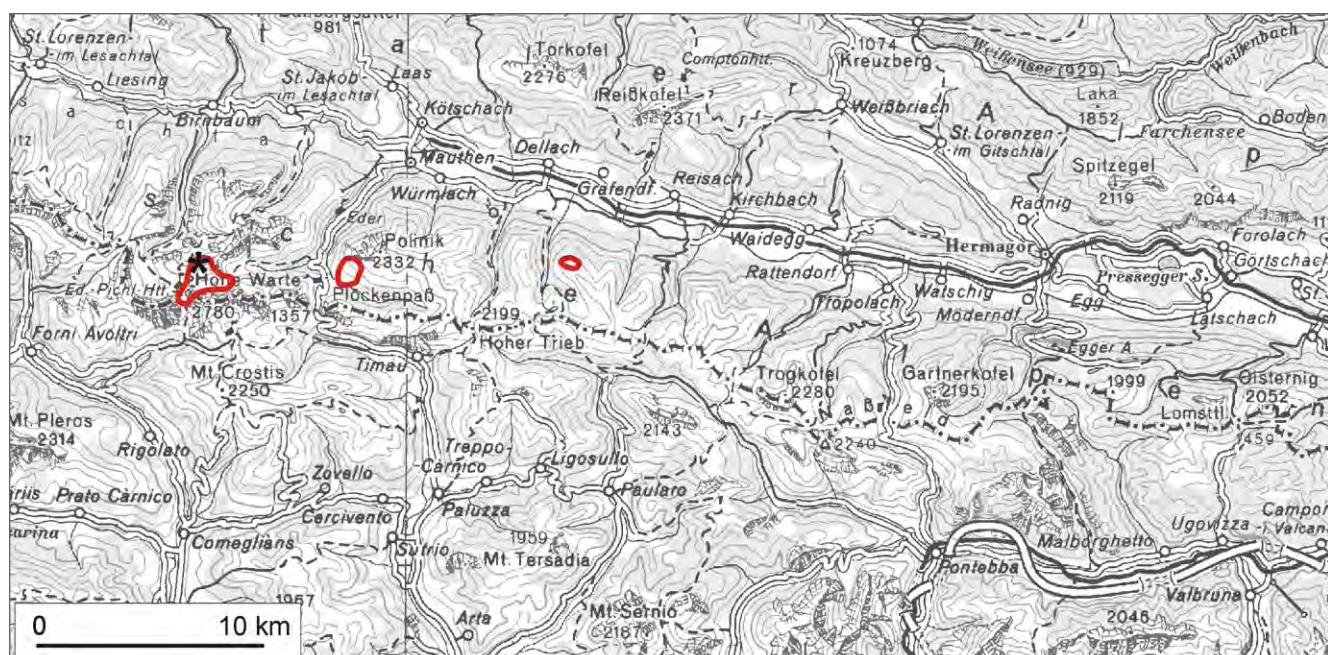
The upper boundary of the limestone is marked by a peculiar and easily recognizable discontinuity surface, strongly undulated, which defines the Ordovician/Silurian boundary. An ironstone horizon is well developed at the boundary in the Lake Wolayer area.

Fossil content

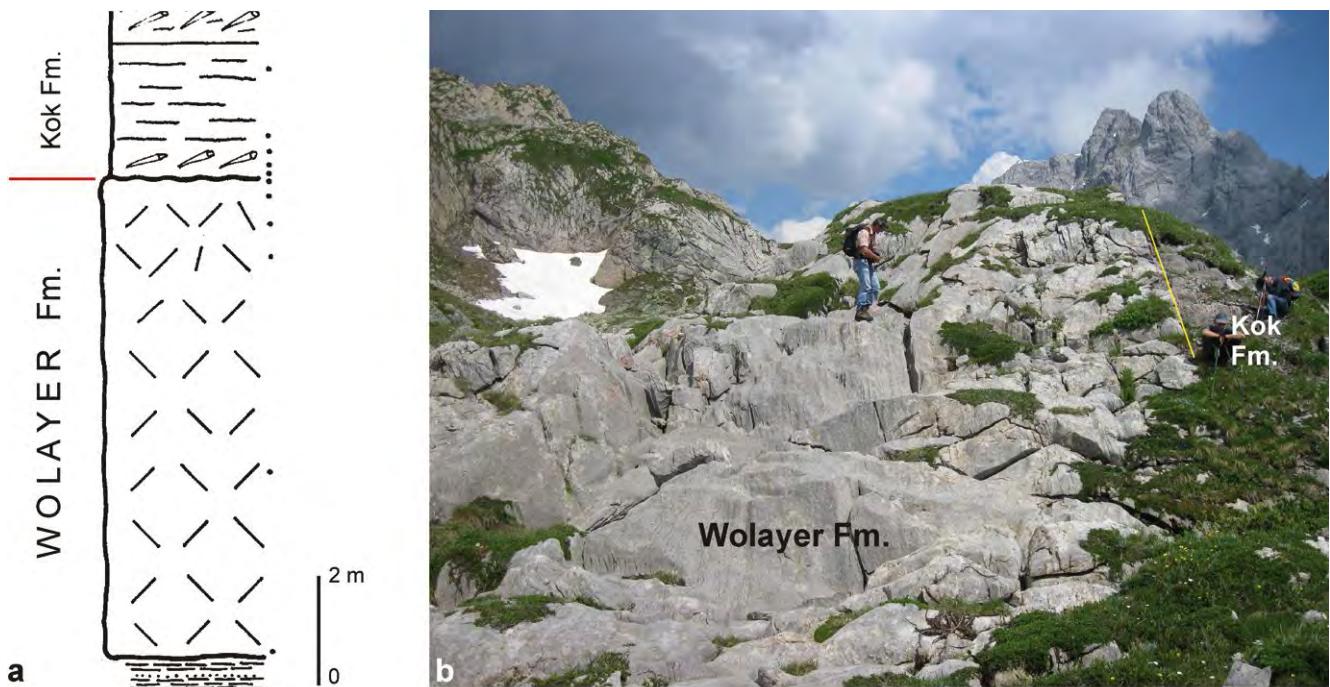
Algae, brachiopods, bryozoans, conodonts, corals, crinoids, cystoids, ostracods, trilobites.

Depositional environment

Shallow marine limestone, neritic unit consisting of parautochthonous bioclasts derived from crinozoan mounds.



Areas of outcrop of the Wolayer Formation with indication of the stratotype (asterisk).



The Rauchkofel Boden Section. a) log of the lower part of the section (modified after SCHÖNLAUB, 1980); b) view of the Wolayer Formation (photo H.P. SCHÖNLAUB).

Stratotype

Rauchkofel-Boden Section (GAERTNER, 1931) on the southern slope of Mt. Rauchkofel at coordinates N 46°36'54", E 12°52'30".

Reference sections -

Type area

Central Carnic Alps.

Main outcrop areas

Base of Mt. Seekopf, Valentin Törl, Rauchkofel Boden.

Thickness

10 to 17 m.

Boundaries

Underlying units – Himmelberg Formation (conformable contact?).

Overlying units – Kok Formation (disconformable contact).

Lateral units – Uqua Formation.

Derivation of name

After the Wolayer region in the central Carnic Alps.

Synonymy

Stufe der weissen und grauen Kalke: STACHE (1884).

Graue, massige, versteinerungsleere Kalke auf der Höhe des Thörl: FRECH (1887).

Graue massige Kalke: FRECH (1894).

Massige Bank von grauem aber hell anwitterndem Kalk: GEYER (1903).



Details of the Wolayer Formation at the Rauchkofel Boden Section. a) cross-section of a spherical theca of a cystoid (photo H.P. SCHÖNLAUB); b) a broken rugose coral (photo H.P. SCHÖNLAUB); c) cross-section of the algae *Coelosphaeridium* (photo H.P. SCHÖNLAUB).

Helle massive Bank: SPITZ (1909).
 Roter und weißer hell verwitternder Krinoidenkalk: GAERTNER (1931).
 Biocalcilituti mandorlate («Tonflaskerkalk»): MANARA & VAI (1970).
 Grey massive crinoid limestone: SCHÖNLAUB (1971).
 Ashgill-Crinoiden-Calcarenit: SCHÖNLAUB (1971).
 Calcare a crinoidi, bioruditic Ist. («Cystoideenkalk»): SPALLETTA et al. (1982).
 Cystoideenkalk: DULLO (1992).
 Cystoidean Limestone: DULLO (1992).
 Wolayer-Kalk/Limestone: SUTTNER et al. (2014).

Chronostratigraphic age

Ordovician: Late Katian (Ka3-Ka4 Stage slices *sensu* BERGSTRÖM et al., 2009) to (?) basal Hirnantian.

Biostratigraphy

Conodonts. – Amorphognathus ordovicicus Zone (FERRETTI & SCHÖNLAUB, 2001 and references therein).

Complementary references -

Remarks -

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SUTTNER, T.J., SCHÖNLAUB, H.P. & FERRETTI, A. (2014): Wolayer-Kalk/Wolayer Limestone. – In: PILLER, W.E. (ed.): The lithostratigraphic units of the Austrian Stratigraphic Chart 2004 (sedimentary successions), Vol. I - The Paleozoic Era(them). – Abhandlungen der Geologischen Bundesanstalt, **66**, 65, Wien.

Uqua Formation

HANS-PETER SCHÖNLAUB & ANNALISA FERRETTI

Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt BMN 199 Hermagor

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

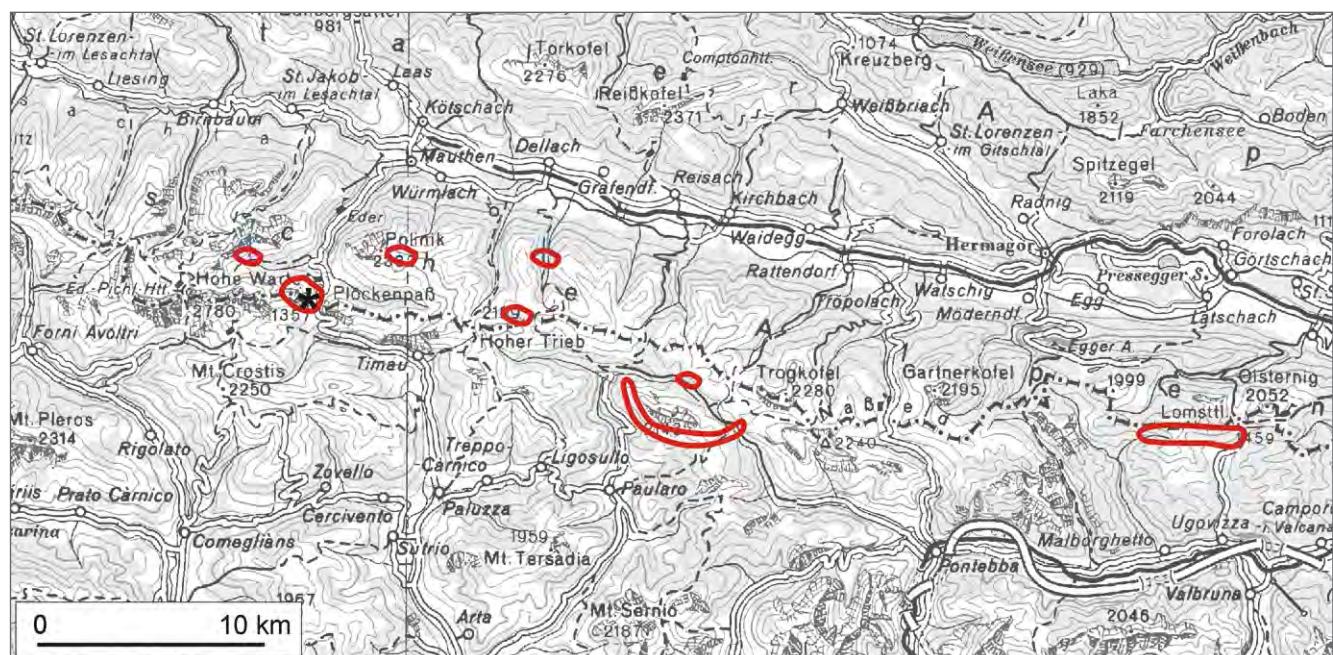
Grayish flaser limestone with debris intercalations (bioclastic wackestone-packstone). In the upper part greenish siltstones are interbedded into the limestone sequence.

Description

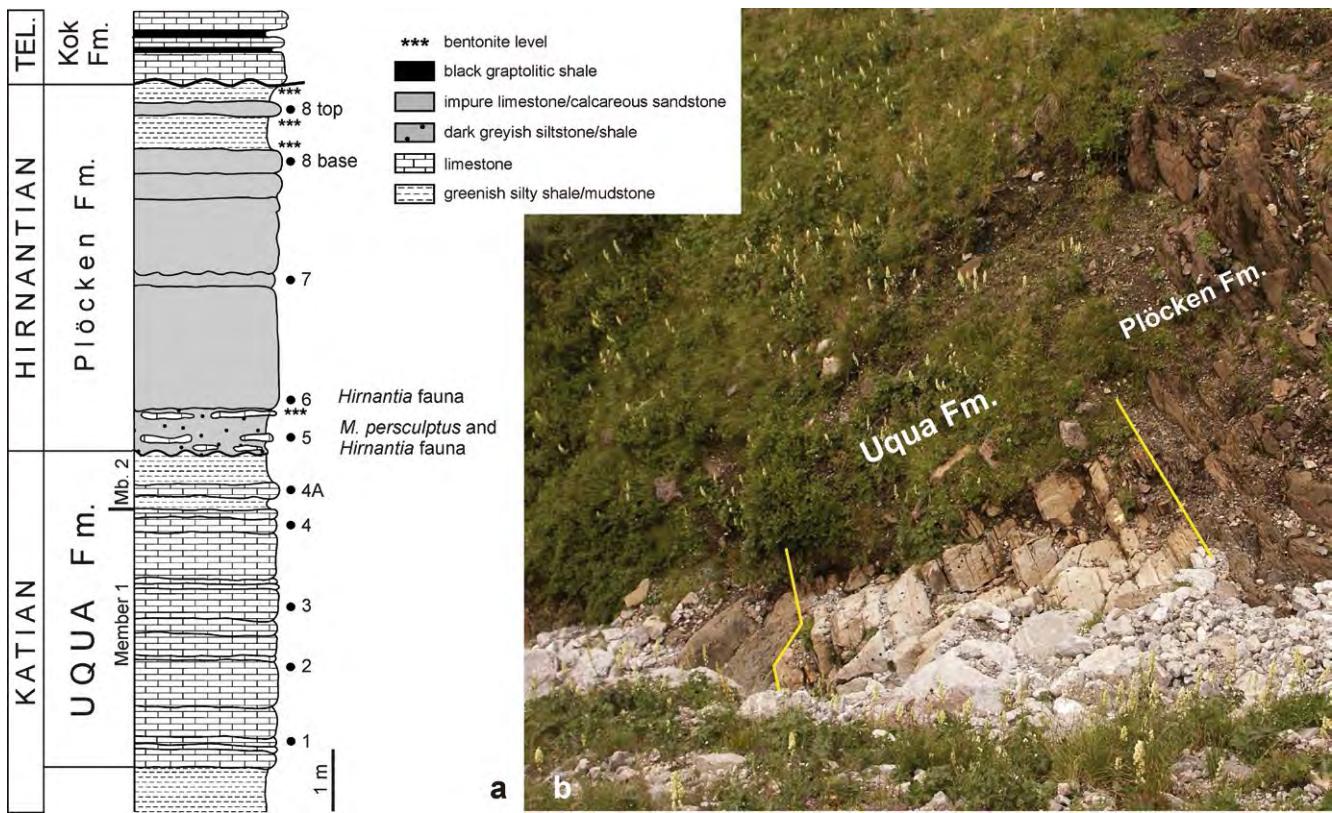
The calcareous Uqua Formation varies in thickness and lithology from 1.5 to 9 m; at the type locality at Cellon it reaches 7.3 m. The main lithology displays a bedded flaser-type limestone (member 1 in SCHÖNLAUB et al., 2011), while other occurrences of the Uqua Formation represent more marly or even nodular limestones. At the type locality the upper part of the unit is characterized by interbeds of greenish siltstones (member 2 in SCHÖNLAUB et al., 2011). Fossils, in particular microfossils but also macrofossils are rather abundant, either occurring in debris layers or irregularly distributed in the matrix.

Fossil content

Acritarchs, brachiopods, conodonts, cephalopods, chitinozoans, crinoids, foraminifers, gastropods, ostracods, sponge spiculae, trilobites.



Areas of outcrop of the Uqua Formation with indication of the stratotype (asterisk).



The Cellon Section. a) log of the Ordovician part of the section (modified after SCHÖNLAUB et al., 2011); b) view of the section (photo H.P. SCHÖNLAUB).

Depositional environment

Marine limestone, represented by allochthonous deposits of deeper water derived from the shallower and high-energy Wolayer Formation.

Stratotype

Cellon avalanche gorge (Beds 1-4 after WALLISER, 1964), located in the eastern slope of Mt. Cellon/Creta di Collinetta (GAERTNER, 1931) at coordinates N 46°36'32", E 13°29'03".

Reference sections -

Type area

Carnic Alps.

Main outcrop areas

Uqua Valley, area of Mt. Zermula-Mt. Pizzul, Hoher Trieb-Elferspitz, Nöblinggraben, surroundings of Plöckenpass, Lake Wolayer, Rauchkofel Boden.

Thickness

1.1 m at Rifugio Fratelli Nordio to 7.3 m at Cellon.

Boundaries

Underlying units – Valbertad Formation (conformable).

Overlying units – Plöcken Formation (conformable).

Lateral units – Wolayer Formation.



Views of the Uqua Formation at the Cellon Section (photos L. SIMONETTO).

Derivation of name

After Uqua Creek, north of the village of Ugovizza.

Synonymy

Knollenkalk: STACHE (1884).

Calcescisti, calcari saccaroidi ed argiloscisti di Mauthen [partim]: TARAMELLI (1895).

Tonflaserkalk: SPITZ (1909); SERPAGLI & GRECO (1965).

Scisti argilloso-grafitici con vene e noduli calcarei [partim]: GORTANI & DESIO (1927).

Formazione di Ugva: SELLI (1963).

Formazione di Ugva (=“Tonflaserkalke”): SERPAGLI (1967).

Formazione di Uggwa: ASSERETO et al. (1968).

Formazione dell’Uqua: BRAGA et al. (1971); CARULLI (2006).

Calcaire Réticulaire de L’Uqua: VAI (1971).

Flaserkalke, Knollenkalke, Kalknollenschiefer: SCHÖNLAUB (1971).

Ashgill-Tonflaserkalk der Stillwasserfazies: SCHÖNLAUB (1971).

Uggwakalk: SCHÖNLAUB (1979).

Formazione di Uqua: VAI et al. (1984); VENTURINI (1990, 2006).

Uggwa Formation: KREUTZER (1992).

Uggwa Limestone Formation: SCHÖNLAUB (1980); SCHÖNLAUB et al. (2011); ŠTORCH & SCHÖNLAUB (2012).

Uggwa-Kalk/Limestone: SUTTNER et al. (2014).

Chronostratigraphic age

Ordovician: Late Katian (Ka3-Ka4 Stage slices *sensu* BERGSTROM et al., 2009) to (?)basal Hirnantian.

Biostratigraphy

Conodonts. – Amorphognathus ordovicicus Zone (SERPAGLI, 1967; FERRETTI & SCHÖNLAUB, 2001 and references therein).

Complementary references

Geochemistry (iron, sulfur and carbon isotope chemistry) has been recently investigated in the Cellon section (SCHÖNLAUB et al., 2011).

Remarks

In the western Karavanke Alps the equivalents of the Uqua Formation are exposed in the Feistritzgraben section (SCHÖNLAUB, 1979, 1982, 1985).

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Plöcken Formation

HANS-PETER SCHÖNLAUB & ANNALISA FERRETTI

Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt BMN 199 Hermagor

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 032 Tolmezzo

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Definition

Coarse-grained indistinctly bedded impure grayish to blackish limestones, which grade into calcareous pyritiferous sandstones.

Description

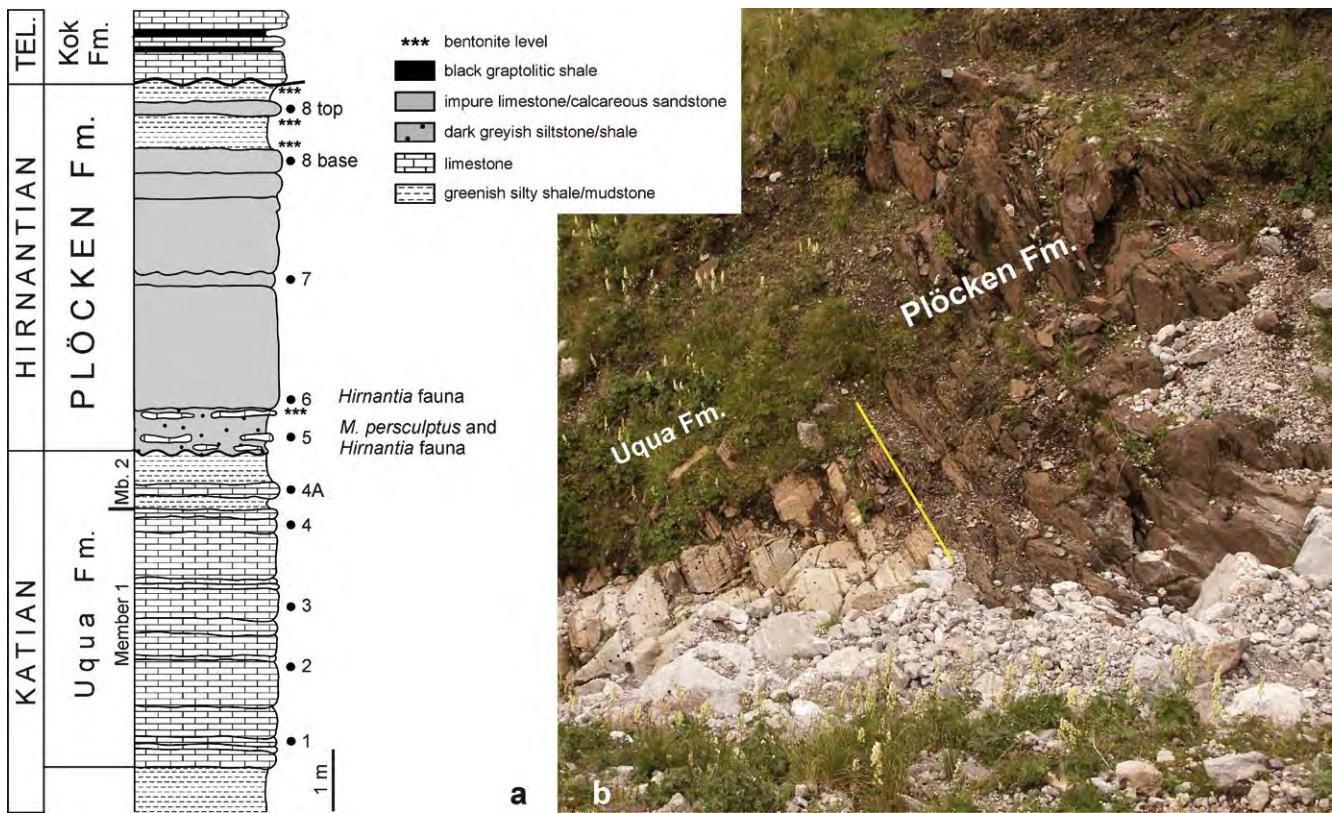
In the lower part of the indistinctly bedded Plöcken Formation grayish shales to siltstones occur followed by impure limestones with contorted deformation structures, slippings, channel fillings, graded beds. Loosely packed matrix-supported subangular clasts of varying composition and the accumulation of fossil debris are common. This part strongly resembles diamictites. The upper part is composed of calcareous pyritiferous sandstones. Fossils comprise very few graptolites, brachiopods belonging to the *Hirnantia* Fauna and conodonts.

Fossil content

Acritarchs, bivalves, brachiopods, cephalopods, chitinozoans, conodonts, echinoderms, foraminifers, gastropods, graptolites, ostracodes, sponge spiculae, trilobites.



Areas of outcrop of the Plöcken Formation with indication of the stratotype (asterisk) and reference section (square).



The Cellon Section. a) log of the Ordovician part of the section (modified after SCHÖNLAUB et al., 2011); b) view of the section (photo H.P. SCHÖNLAUB).

Depositional environment

Marine sediments, which are strongly marked by the Late Ordovician glacial event. The influence of the Hirnantian ice age is characterized by diamictites, channeling, erosion and local non-deposition (SCHÖNLAUB, 2000; SCHÖNLAUB et al., 2011; HAMMARLUND et al., 2012).

Stratotype

Cellon Section (Beds 5-8 after WALLISER, 1964), located in an avalanche gorge in the eastern slope of Mt. Cellon/Creta di Collinetta (GAERTNER, 1931) at coordinates N 46°36'32", E 13°29'03".

Reference sections

Rauchkofel South Section (SCHÖNLAUB, 1971, 1988), located on the southern slope of Mt. Rauchkofel, at coordinates N 46°36'58.5", E 12°53'23.0", where clear evidence of diamictite layers is present.

Type area

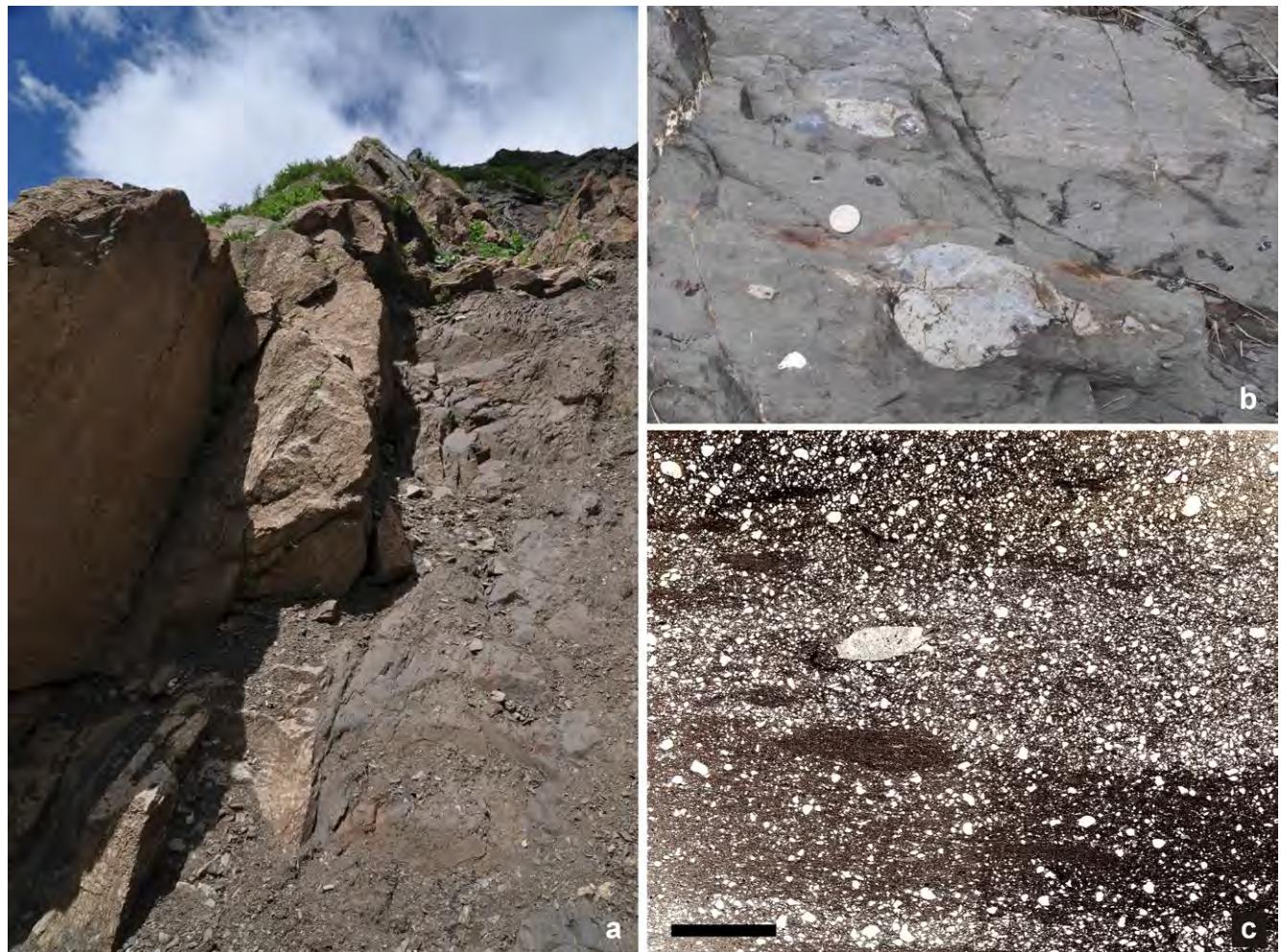
Central Carnic Alps.

Main outcrop areas

Plöckenpass, Uqua Valley, Western Karavanke Alps, Hoher Trieb-Elferspitz, Oberbuchach, Nöblinggraben, Rauchkofel South, Mt. Pizzul.

Thickness

From 1.5 to a maximum of 9 m at the Rauchkofel South section (6.17 m at the Cellon Stratotype).



Views of the Plöcken Formation at Rauchkofel South Section. a) view of the section (photo H.P. SCHÖNLAUB); b) detail of the Plöcken Formation containing ice rafted (?) carbonate lithoclasts (photo H.P. SCHÖNLAUB); c) micrograph of diamictite (photo H.P. SCHÖNLAUB).

Boundaries

Underlying units – Uqua Formation (disconformable contact).

Overlying units – Kok Formation (disconformable contact).

Lateral units – Bischofalm Formation (?).

Derivation of name

After the geographic designation “Plöcken” in the central Carnic Alps.

Synonymy

Untere Schichten: GAERTNER (1931).

Bereich I [partim]: WALLISER (1964).

Mikrofazies-Schicht 2: “Schillsandstein” und Mikrofazies-Schicht 3 “Gradierte Sandsteine”: SCHÖNLAUB (1969).

Grès Fins et Siltstones: VAI (1971).

Grès Moyens: VAI (1971).

Plöcken-Formation: SCHÖNLAUB et al. (1994), SUTTNER et al. (2014).

Chronostratigraphic age

Ordovician: Hirnantian.

Biostratigraphy

Conodonts. – *Amorphognathus ordovicicus* Zone (FERRETTI & SCHÖNLAUB, 2001).

Graptolites. – *Metabolograptus persculptus* Zone (ŠTORCH & SCHÖNLAUB, 2012).

Chitinozoans. – *Tanuchitina elongata* Zone (PRIEWALDER, 1997).

Complementary references

Geochemistry. – SCHÖNLAUB et al. (2011). Iron, sulfur and carbon isotope geochemistry has been recently investigated. A distinctive carbonate $\delta^{13}\text{C}$ excursion occurring at the unconformity between the underlying Uqua Formation and the Plöcken Formation in the Cellon section has been correlated with the prominent HICE carbonate $\delta^{13}\text{C}$ peak (BERGSTRÖM et al., 2009), confirming the Hirnantian age of the Plöcken Formation (SCHÖNLAUB et al., 2011).

The diagnostic brachiopod *Hirnantia* Fauna is reported as well at the base of the formation (SCHÖNLAUB et al., 2011 and references therein).

Remarks

The conodont fauna so far recorded from the Cellon Section (FERRETTI & SCHÖNLAUB, 2001) represents the only Hirnantian conodont fauna recorded and described along the Ordovician northern Gondwana margin. Several K-bentonites levels (asterisks in the log of Cellon Section) were described and discussed by HISTON et al. (2007).

In the western Karavanke Alps the equivalents of the Uqua Formation are exposed in the Feistritzgraben section (JAEGER et al., 1975; SCHÖNLAUB, 1980).

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Kok Formation

ANNALISA FERRETTI, HANS-PETER SCHÖNLADB, CARLO CORRADINI, MARIA G. CORRIGA,
MONICA PONDRELLI, LUCA SIMONETTO & PAOLO SERVENTI

Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt BMN 199 Hermagor

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Well bedded brownish ferruginous and gray to dark gray nautiloid limestone (wackestone-packstone), in the lower part alternating with marly shale. Also developed laterally gray echinoderm- and pinkish brachiopod- grainstone.

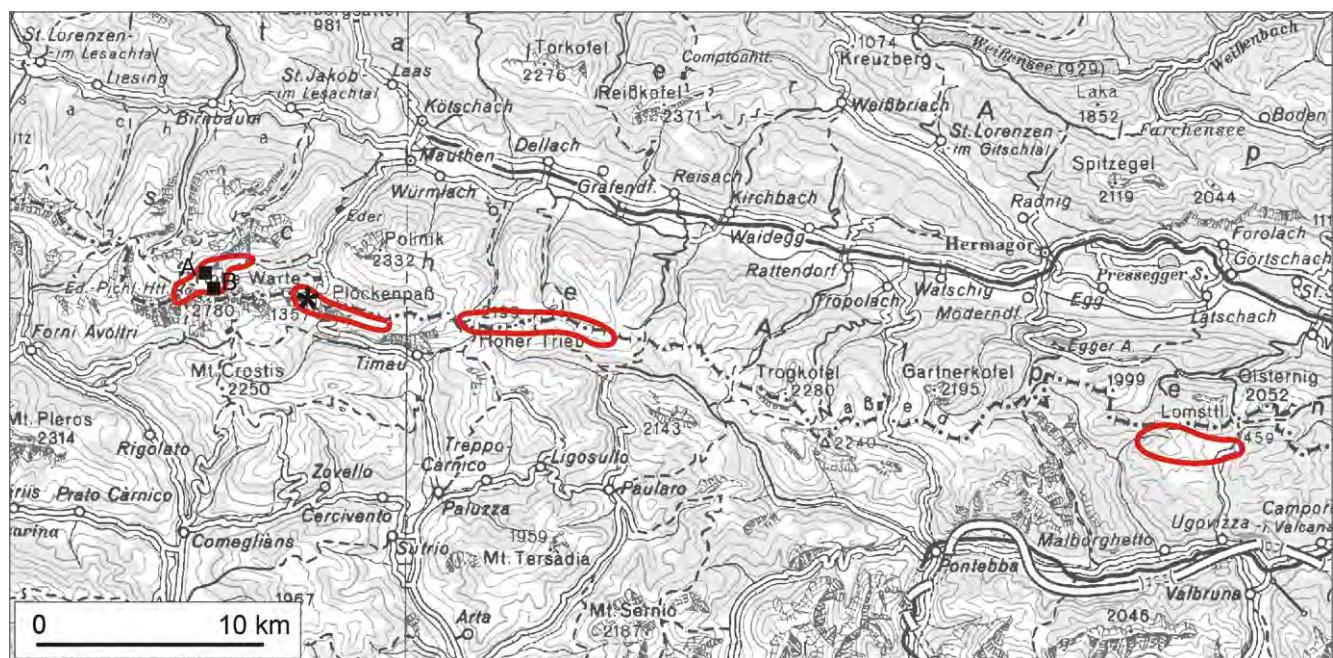
Description

The lower portion of the Kok Formation is represented by a few meters of shale and thin ferruginous limestones ("lower shales and ferruginous limestone member" in BRETT et al., 2009) with local basal stromatolite-like iron-rich crusts. The remainder of the Kok Formation is represented by skeletal limestones, with cephalopod conchs embedded in a micritic matrix rich in bioclastic material with evidences of microbial activity. Argillaceous encrinitic and brachiopod accumulations are developed in distinctive beds.

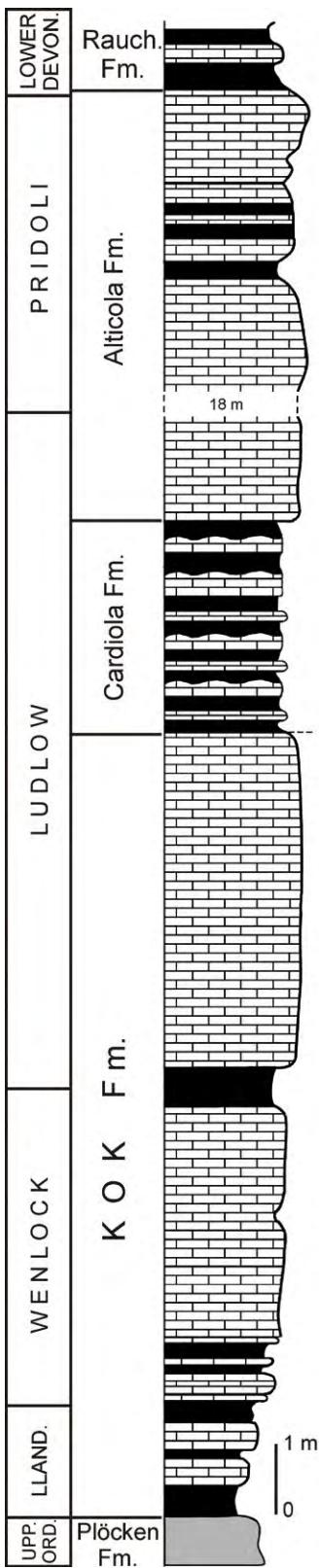
Remarkable is the sedimentary gap present at the base of the Kok Formation, with a hiatus embracing at least the uppermost Hirnantian and parts of the Llandovery, but of higher amplitude in other sections.

Fossil content

Acritarchs, bacteria, bivalves, brachiopods, cephalopods, chitinozoans, conodonts, conularids, corals, crinoids, foraminifera, gastropods, graptolites, machaeridians, ostracodes, scolecodonts, trace fossils, trilobites.



Main areal distribution of the Kok Formation in the Western Carnic Alps with indication of the stratotype (asterisk) and of the reference sections (squares). Asterisk: Cellon Section; A: Rauchkofel Boden Section; B: Valentintörl Section.



The Cellon Section. a) lithostratigraphic column of the section (adapted from BRETT et al., 2009); b) main units there exposed (photo H.P. SCHÖNLAUB); c) global view of the Kok Formation (photo A. FERRETTI).



Views of the Kok Formation in the field (photos H.P. SCHÖNLAUB). a) cross-sections of orthoceratid nautiloids from the lower to middle part of the Kok Formation at Cellon Section; b) randomly oriented longitudinal sections of *Orthoceras*-bearing Kok Formation from Mt. Rauchkofel; c) longitudinal sections of orthoceratids showing internal chambers and parts of the siphon from the Rauchkofel Boden Section; d) longitudinal section with infilling (telescoping) and partly dissolved proximal part of the conch from the Kok Formation at the Bodentörl section.

Depositional environment

Shallow to moderately deep shelf.

Stratotype

Cellon Section (beds 9-19 in WALLISER, 1964), located in the eastern slope of Mt. Cellon/Creta di Collinetta, at coordinates N 46°36'32", E 12°56'30".

Reference sections

Rauchkofel Boden Section (beds 310-325 in SCHÖNLAUB, 1980), located on the southern slope of Mt. Rauchkofel at coordinates N 46°36'53.5", E 12°52'33.0", where a shallower facies than the type section is exposed.

Valentintörl Section (SCHÖNLAUB, 1980) at coordinates N 46°36'50", E 12°52'48", where a peculiar facies indicating intense microbial activity is exposed.

Type area

Carnic Alps.

Main outcrop areas

The Kok Formation is well developed in the Carnic Alps, having the most spectacular outcrops in the Lake Wolayer-Rauchkofel area, Mt. Cellon/Creta di Collinetta to Freikofel, Hoher Trieb/Cuestalta to Cima val di Puartis and Monte Cocco sectors.

Thickness

About 15 m.

Boundaries

Underlying units – Plöcken Formation (unconformable contact), Wolayer Formation (unconformable contact).

Overlying units – Cardiola Formation (conformable, sharp contact).

Lateral units – Nöbling Formation.

Derivation of name

After Kokberg (= Mt. Cocco).

Synonymy

Untersilurische Schichten [partim]: STACHE (1874).

Rotheisenstein: SEELAND (1878).

Unterer Eisenkalk: FRECH (1887).

Grauer Netzkalk: GEYER (1894).

Thonschiefer: GEYER (1894).

Calcaria ad ortoceratidi [partim]: TARAMELLI (1895a).

Calcaria grigi e rossi mandorlati ad *Orthoceras potens* ed *Orth. alticola* [partim]: TARAMELLI (1895b).

Bunte Flaser- oder Bänderkalke und Kalkphyllite des Obersilur [partim]: GEYER (1899).

Unteres Orthocerenkalkniveau: GEYER (1903).

Calcare ad *Orthoceras*: VINASSA DE REGNY & GORTANI (1905).

Calcaria reticolati con facies a Cefalopodi: GORTANI & VINASSA DE REGNY (1909).

Calcaria reticolati grigiastri e rossastri con *Orthocera alticola* Barr. e *Tornoceras* [partim]: GORTANI (1913).

Gotlandiano: le facies calcaree [partim]: GORTANI (1926).

Siluriano superiore - Calcaria mandorlati rossastri e bruno nerastri, calcari a Crinoidi, calcari corallini selciferi [partim]: GORTANI & DESIO (1927).

Kokkalke: HERITSCH (1929).

Kokkalk [partim]: GAERTNER (1931).

Aulacopleuraschicht [partim]: GAERTNER (1931).

Trilobitenschiefer [partim]: GAERTNER (1931).

Krinoidenkalk [partim]: HABERFELNER & HERITSCH (1932).

Calcaria e marne nere alternati, talora con argilliti ai Graptoliti; calcari rossicci o nerastri ad "Orthoceras", calcari nodulari [partim]: BRAGA et al. (1971).

Kok Limestone [partim]: SCHÖNLAUB (1980).

Orthoceras Limestone: SCHÖNLAUB (1980).

Trilobite and Aulacopleura Beds [partim]: SCHÖNLAUB (1980).

Calcare ad Aulacopleura: SPALLETTA et al. (1982).

Calcare del Cocco: SPALLETTA et al. (1982).

Marne a trilobiti: SPALLETTA et al. (1982).

Aulacopleuraschicht: SCHÖNLAUB (1985).

Crinoiden-Brachiopoden-Kalken: SCHÖNLAUB (1985).

Aulacopleura Limestone: SPALLETTA & VENTURINI (1989).

Calcaria a *Orthoceras* [partim]: VAI et al. (2002).

Formation del Cocco: CARULLI (2006).

Marne a Trilobiti: CARULLI (2006).

Calcaria e marne [partim]: VENTURINI (2006).

Chronostratigraphic age

Silurian: Llandovery (Telychian) to Ludlow (Ludfordian).

Biostratigraphy

Conodonts. – *Pterospathodus angustoides angulatus*-*Ancoradella ploeckensis* zones (WALLSER, 1964; CORRADINI et al., 2015 and references therein).

Graptolites. – *Cyrtograptus lapworthi*-*Cyrtograptus rigidus* zones (JAEGER, 1975).

Chitinozoans. – *Eisenackitina dolioliformis*-? *Angochitina elongata* zones (PRIEWALDER, 1997) (see remarks below).

Complementary references

Sequence stratigraphy. – BRETT et al. (2007, 2009).

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Paleocommunities. – VAI (1999).

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Isotopes. – SCHÖNLAUB (1994); WENZEL (1997).

Remarks

The Kok Formation was usually assigned to as *Orthoceras* limestone by old authors owing to the abundant cephalopod fauna there present.

PRIEWALDER (1997) only tentatively refereed the chitinozoan association from the upper part of the Kok Formation and the Cardiola Formation to the *Angochitina elongata* Zone due to the open nomenclature of many taxa there recovered.

Several K-bentonites levels were described and discussed by HISTON et al. (2007).

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Cardiola Formation

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Foglio 031 Ampezzo
Foglio 032 Tolmezzo

Definition

Alternating black nautiloid limestone (wackestone-packstone), marl and shale.

Description

The Cardiola Formation is constituted by dark gray to black shales with limestone intercalations as thin, planar to hummocky-laminated fine-grained calcareous levels and calcisiltites. Orthoconic nautiloid conchs are quite abundant and commonly oriented parallel to bedding surface. A distinctive and spectacular *Cardiola*-dominated molluscan fauna, for which the formation was originally named, developed in association with cephalopods.

Fossil content

Acritarchs, bivalves, brachiopods, cephalopods, chitinozoans, conodonts, corals, graptolites, radiolarians, trilobites.

Depositional environment

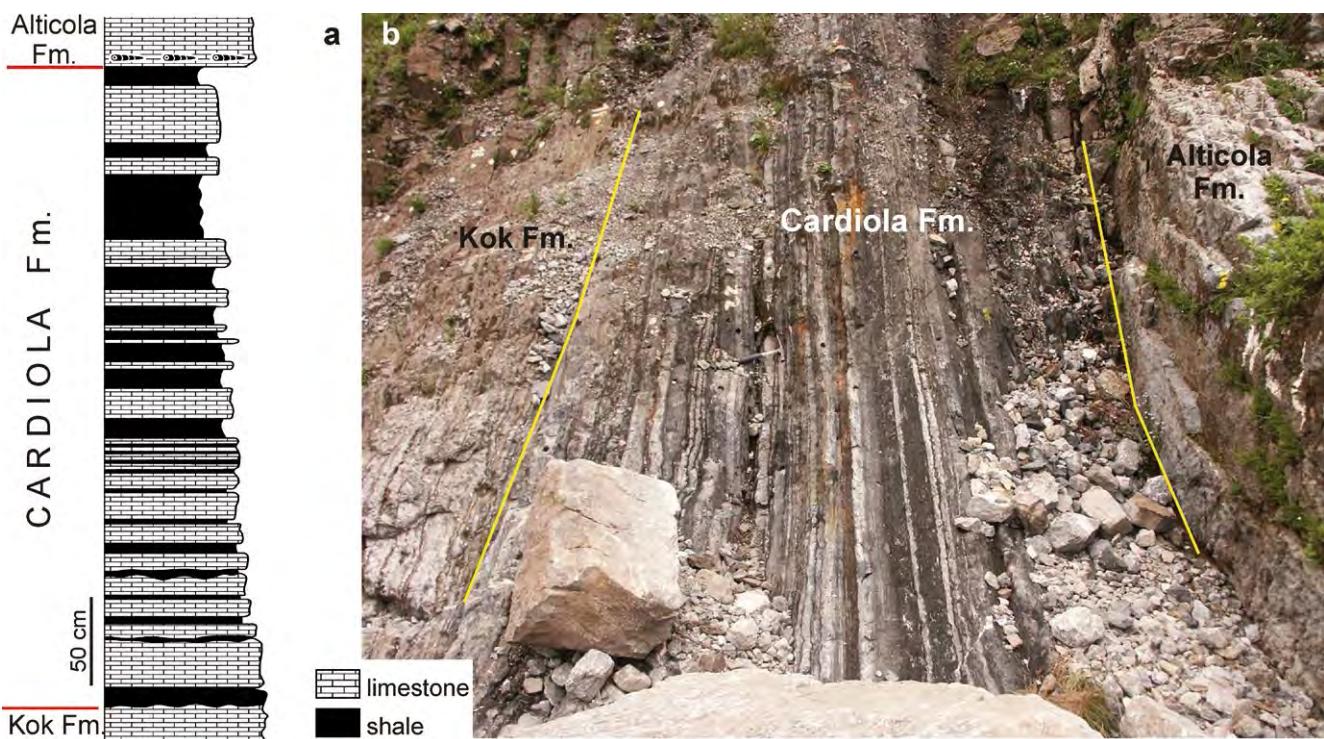
Moderately deep shelf.

Stratotype

Cellon Section (beds 20-24A in WALLISER, 1964), located in the eastern slope of Mt. Cellon/Creta di Collinetta, at coordinates N 46°36'32", E 12°56'30".



Main areal distribution of the Cardiola Formation in the Western Carnic Alps with indication of the stratotype (asterisk) and of the reference sections (squares). Asterisk: Cellon Section; A: Rauchkofel Boden Section; B: Lower Seewarte Base Section.



The Cellon Section, a) detailed log of the Cardiola Formation (modified after BRETT et al., 2009); b) overview photo of the Cardiola Formation (photo H.P. SCHÖNLAIR).

Reference sections

Lower Seewarte Base Section (SCHÖNLÄUB, 1980), located in the southern flank of Wolayer valley at coordinates N 46°36'48" E 12°52'45" where a shallow-water facies is better exposed.

Rauchkofel Boden Section (SCHÖNLAUB, 1980) located on the southern slope of Mt. Rauchkofel at coordinates N 46°36'53.5", E 12°52'33.0" exposing contacts with underlying and overlying units in a shallow-water context

Type area

Central Carnic Alps

Main outcrop areas

The unit has been documented in Mt. Bauchkofel-Valentintörl, Mt. Cellon, Freikofel and Hoher Trieb areas

Thickness

Thickness is variable, with a maximum value of ca. 3-4 m

Boundaries

Underlying units – Kok Formation (conformable, sharp contact)

Overlying units – Alticola Formation (conformable, sharp contact)

Lateral units – Nöllbling Formation

Derivation of name

After the bivalve Genus *Cardiola* BRODERIP (in MUIRCHISON 1839)

Synonymy

| Intersilurische Schichten [partim]: STACHE (1874)

Unterschlundische Schichten [partim]
Cardiola-Horizont: STACHE (1874)

Grauer Plattenkalk: FRECH (1887)

Grauer Flattenkalk. FRECH (1889); Cardiola-Niveau; GEYER (1891).



Detail of the planar laminated fine-grained calcareous levels of the Cardiola Formation exposed in the Cellon Section (photo H.P. SCHÖNLAUB).

Cardiola-Schichten: GEYER (1894).

Bunte Flaser- oder Bänderkalke und Kalkphyllite des Obersilur [partim]: GEYER (1899).

Cardiolaniveau: GAERTNER (1931).

Cardiola Beds: SCHÖNLAUB (1970).

Cardiola Beds: SCHÖNLAUB (1980).

Calcare a Cardiola: VAI et al. (2002).

Livello a Cardiola: CARULLI (2006).

Chronostratigraphic age

Silurian: Ludlow (Ludfordian).

Biostratigraphy

Conodonts. – *Ancoradella ploeckensis-Polygnathoides siluricus* zones (WALLISER, 1964; CORRADINI et al., 2015 and references therein).

Graptolites. – *M. bohemicus* group (JAEGER, 1975).

Chitinozoans. – ?*Angochitina elongata* Zone (PRIEWALDER, 1997) (see remarks below).

Complementary references

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Geochemistry. – TIETZ (1976).

Isotopes. – SCHÖNLAUB (1994); WENZEL (1997); JEPSSON et al. (2012).

Remarks

The name Cardiola has been used for a long-time for this formation to document its peculiar bivalve association. Adaptation to the unique Silurian environment of the cephalopod limestone biofacies led in fact to the evolution of the Praecardiida bivalves (*Cardiola* in primis), which became cosmopolitan in northern peri-Gondwana (Bohemia, Sardinia, Spain, Montagne Noire, etc.; COPE & KRÍŽ, 2013). The paleogeographic significance of *Cardiola*-dominated communities makes the Cardiola Formation a distinctive marker interval for precise correlations outside the Carnic Alps (JAEGER, 1976).

PRIEWALDER (1997) only tentatively referred the chitinozoan association from the upper part of the Kok Formation and the Cardiola Formation to the *Angochitina elongata* Zone (most of taxa were identified in open nomenclature).

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Alticola Formation

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Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Gray and pink to red nautiloid bearing limestone (wackestone-packstone) with rare interbedded layers of gray shale, black micritic and grayish bioclastic limestone (wackestone-grainstone) at the top.

Description

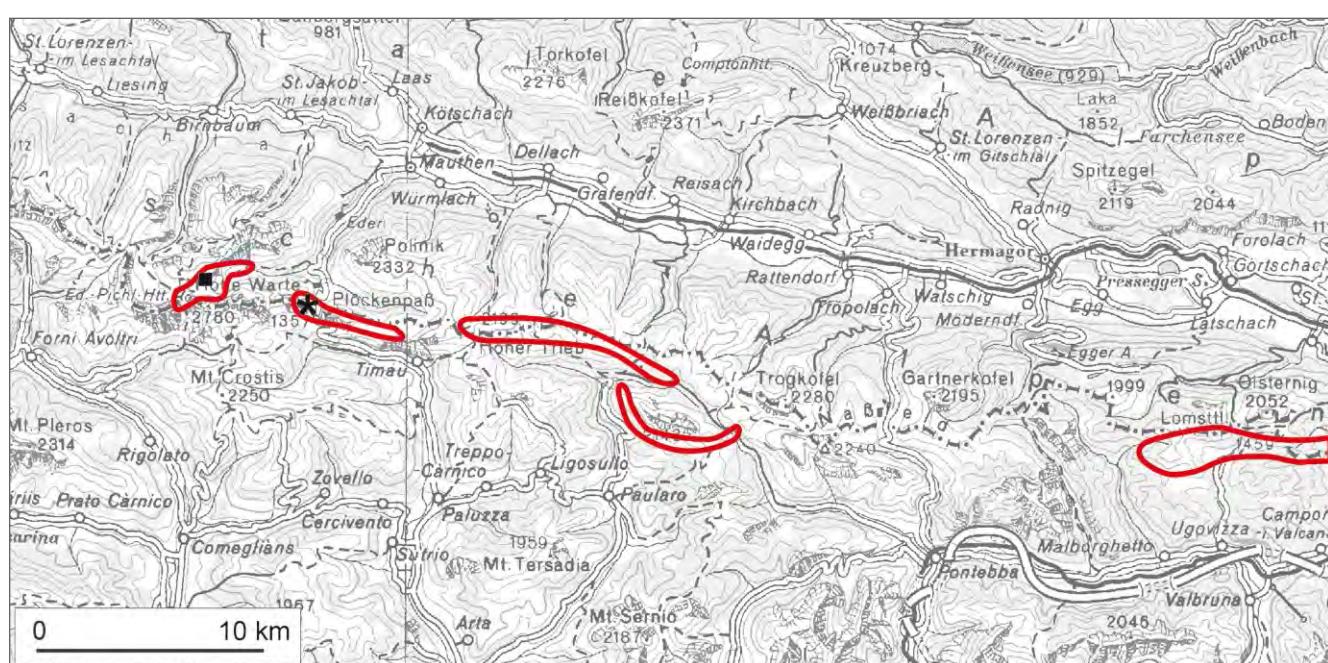
The Alticola Formation is represented by a distinctly bedded cephalopod-bearing limestone with scattered large cephalopod conchs at the base. The unit, that gets upward darker owing to a more micritic content, comprises the Silurian/Devonian boundary. Shallow, neritic facies at the top of the Alticola Formation are documented by brachiopod and bryozoan associations, to record a lowstand to initial transgression.

Fossil content

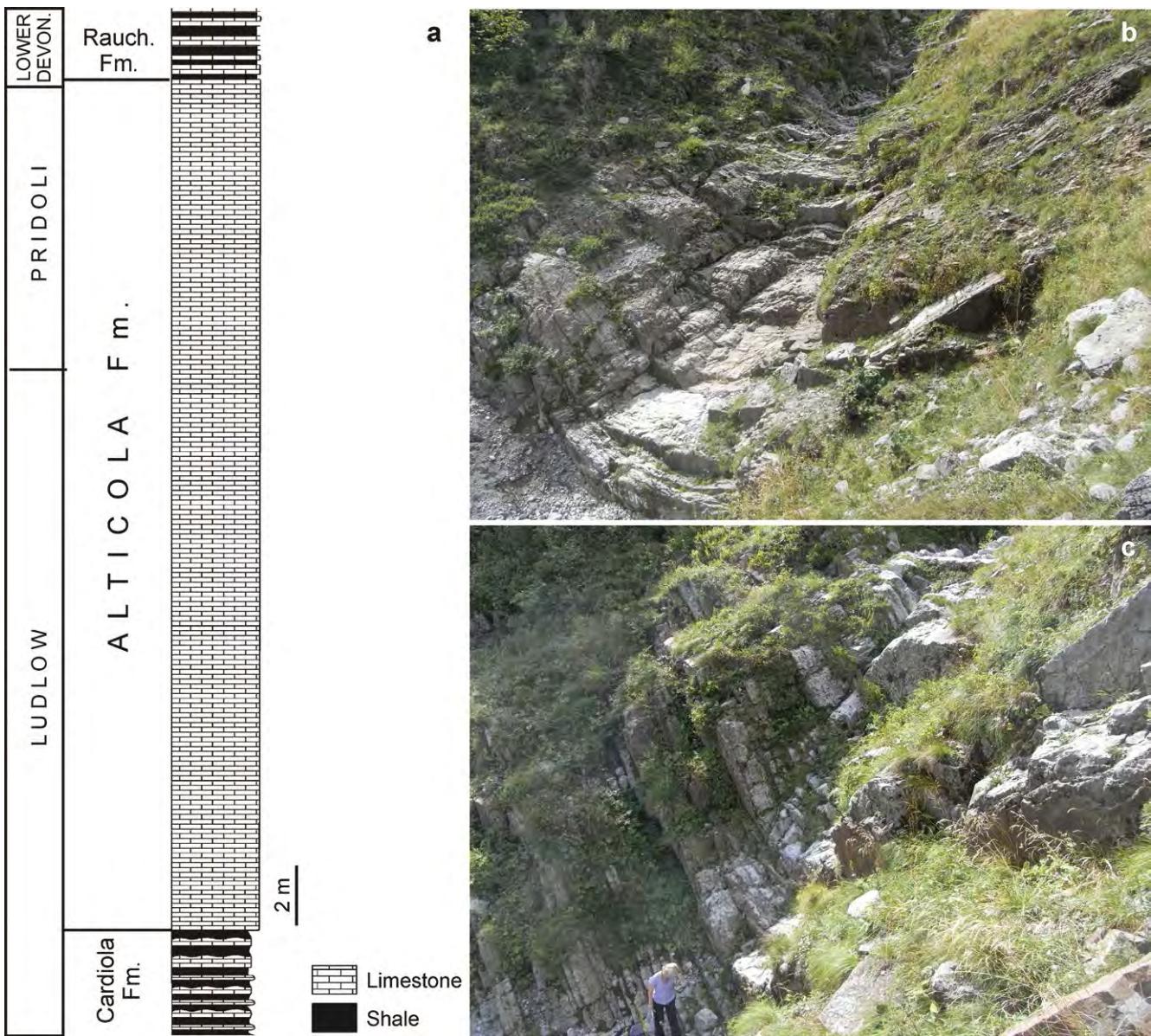
Acritarchs, bivalves, brachiopods, bryozoans, cephalopods, chitinozoans, conodonts, corals, echinoderms, enigmatic phosphatic plates, foraminifers, gastropods, graptolites, ostracodes, scolecodonts, scyphocrinitids, trace fossils, trilobites.

Depositional environment

Moderately deep shelf.



Main areal distribution of the Alticola Formation in the central Carnic Alps with indication of the stratotype (asterisk) and of the reference section (square).



The Cellon Section. a) log of the section; b-c) global views of the Alticola Formation in the section (photos C. CORRADINI) in the lower exposed part (b) and in the Pridoli part (c).

Stratotype

Cellon Section (beds 25-47B in WALLISER, 1964), located in the eastern slope of Mt. Cellon/Creta di Collinetta, at coordinates N 46°36'32", E 12°56'30".

Reference sections

Rauchkofel Boden Section (beds 326-331 in SCHÖNLAUB, 1980), located in the southern flank of Mt. Rauchkofel at coordinates N 46°36'53.5", E 12°52'33.0", exposing a shallower facies than the stratotype.

Type area

Carnic Alps.

Main outcrop areas

The Alticola Formation is well developed in the Carnic Alps, mainly in Lake Wolayer-Rauchkofel, Mt. Cellon/Creta di Collinetta to Creta di Timau, Hoher Trieb/Cuestalta to Zuc di Malaseit and Monte Cocco to val Bartolo sectors.



Views of the Alticola Formation in the field. a) well bedded limestone of the unit exposed in the Cadin di Lanza II section (photo L. SIMONETTO); b) close view of a nautiloid, south-east of Cima val di Puartis (photo C. CORRADINI).

Thickness

About 25–30 m.

Boundaries

Underlying units – Cardiola Formation (conformable, sharp contact).

Overlying units – Rauchkofel Formation (conformable, gradual contact), Seekopf Formation (conformable, gradual contact).

Lateral units – Nölbling Formation.

Derivation of name

After the nautiloid *Orthoceras alticola* Barrande (FRECH, 1887).

Synonymy

Untersilurische Schichten [partim]: STACHE (1874).

Unterer rother Orthoceren Kalk, wechsellegernd mit grauem Kalke: FRECH (1887).

Zone des *Orthoceras alticola*: FRECH (1887).

Calcaria ad ortoceratidi: TARAMELLI (1895a).

Calcaria grigi e rossi mandorlati ad *Orthoceras potens* ed *Orth. alticola* [partim]: TARAMELLI (1895b).

Bunte Flaser-oder Bänderkalke und Kalkphyllite des Obersilur [partim]: GEYER (1899).

Calcaria reticolati – facies a Cefalopodi: GORTANI & VINASSA DE REGNY (1909).

Calcaria reticolati – facies a Brachiopodi: GORTANI & VINASSA DE REGNY (1909).

Calcaria reticolati grigiastri e rossastri con *Orthoceras alticola* Barr. e *Tornoceras* [partim]: GORTANI (1913).

Gotlandiano: le facies calcaree [partim]: GORTANI (1926).

Siluriano superiore - Calcaria mandorlati rossastri e bruno nerastri, calcari a Crinoidi, calcari corallini selciferi [partim]: GORTANI & DESIO (1927).

Orthoceren-(*alticola*-) Kalke: GAERTNER (1931).

Rhynchonella megaera-Schichten: GAERTNER (1931).

Orthocerenkalk: HABERFELNER & HERITSCH (1932).

Rh. megaera-Schichten: WALLISER (1957).

Kalk mit *H. megaera*: PÖLSLER (1967). Calcaria e marne nere alternati, talora con argilliti ai Graptoliti; calcari rossicci o nerastri ad "Orthoceras", calcari nodulari [partim]: BRAGA et al. (1971).

Alticola Limestone: SCHÖNLAUB (1980).

Black nodular Limestones: SCHÖNLAUB (1980).
Megaerella Beds: SCHÖNLAUB (1980).
Calcare ad Alticola: SPALLETTA et al. (1982).
Strati a Megaerella: SPALLETTA et al. (1982).
Alticola Formation: KREUTZER (1992).
Megaerella Formation: KREUTZER (1992).
Megaerella Limestone: SCHÖNLAUB & KREUTZER (1994).
Calcari a *Orthoceras* [partim]: VAI et al. (2002).
Calcari ad *Orthoceras* [partim]: CARULLI (2006).
Calcari e marne [partim]: VENTURINI (2006).

Chronostratigraphic age

Silurian – Devonian: Ludfordian to lowermost Lochkovian.

Biostratigraphy

Conodonts. – *Polygnathoides siluricus* (unpublished data) to *Icriodus hesperius* zones (WALLISER, 1964; CORRADINI et al., 2015 and references therein).

Graptolites. – *M. parultimus* - *M. transgrediens* zones (JAEGER, 1975).

Chitinozoans. – *Eisenachitina barrandei-Urnachitina urna* zones (PRIEWALDER, 1997).

Complementary references

Sequence stratigraphy. – BRETT et al. (2007, 2009).

Taphonomy, sedimentology and microfacies analysis. – FLÜGEL (1965); KREUTZER (1992); FERRETTI (2005); FERRETTI et al. (2012); HISTON (2012, and references therein).

Geochemistry. – TIETZ (1976); FERRETTI et al. (2012).

Isotopes. – SCHÖNLAUB (1994); WENZEL (1997).

Remarks

The Silurian/Devonian boundary occurs in the uppermost part of the unit, marked by the first occurrence of the conodont *Icr. hesperius* (WALLISER, 1964; CORRADINI et al., 2015).

The unit was also previously referred as “Alticola” (lower part) and “Megaerella” (upper part) limestones. K-bentonite levels were described and discussed by HISTON et al. (2007).

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Nöbling Formation

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MONICA PONDRELLI & LUCA SIMONETTO

Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt BMN 199 Hermagor

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Definition

Alternating argillaceous-calcareous sequence of graphitic sandstone, lydite, black shale, dark platy limestone (wackestone-packstone).

Description

The Nöbling Formation consists dominantly of dark, organic-rich and pyritic shales, but with nodular cephalopod bearing limestones at several horizons in the Wenlock and especially in the Ludlow portions of the section. Thin tabular black chert bands (lydites) and pyritic and quartz-rich sandstones are documented.

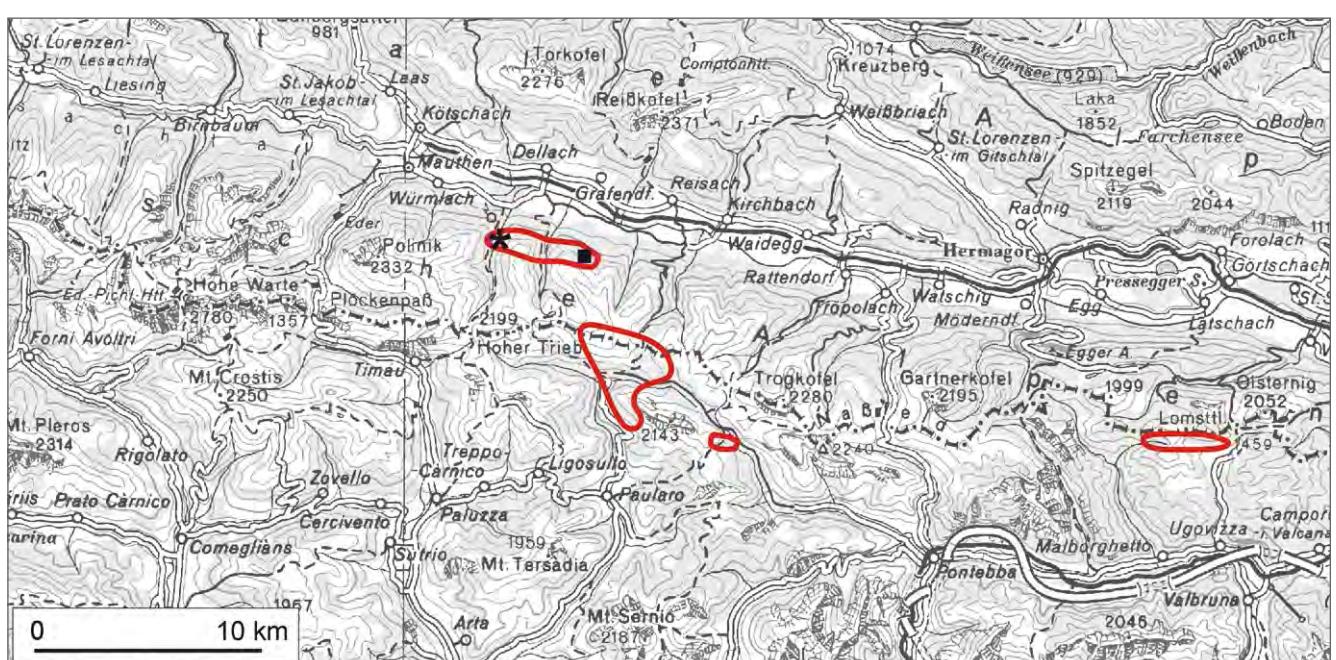
Outcrops are often affected by tectonics that prevents in many cases definition of original thickness.

Fossil content

Bivalves, brachiopods, cephalopods, conodonts, crinoids, gastropods, graptolites, ostracods, radiolarians, sponge spiculae, trilobites.

Depositional environment

Moderately deep shelf to basinal.



Main areal distribution of the Nöbling Formation with indication of the stratotype (asterisk) and of the reference section (square).



The Nöblinggraben Section. a) lithostratigraphic column of the section (redrawn from JAEGER & SCHÖNLAUB, 1977); b) close view of the Nöbling Formation exposed in the Nöblinggraben Section (photo H.P. SCHÖNLAUB).

Stratotype

Nöblinggraben Section (JAEGER & SCHÖNLAUB, 1977), located at coordinates N 46°38'14", E 13°05'04".

Reference sections

Oberbuchach I Section (JAEGER & SCHÖNLAUB, 1980), located at coordinates N 46°37'38", E 13°06'31", for the good quality of the outcrop with both conodont and graptolites.

Type area

Central Carnic Alps.

Main outcrop areas

The area between Nöblinggraben and La Valute; road from Gundersheim to Gundersheim Alm, Mt. Findenig, Mt. Pizzul and north Mt. Cocco areas.

Thickness

About 50 m.

Boundaries

Underlying units – Plöcken Formation (?) (unconformable contact).

Overlying units – Findenig Formation (conformable contact).

Lateral units – Kok Formation, Cardiola Formation, Alticola Formation, Bischofalm Formation, Rauchkofel Formation.

Derivation of name

After the village of Nöbling (Austria).



a



b

Views of the Nöbling Formation in the field: a) global view of the Nöbling Formation exposed in the Oberbuchach I Section (photo H.P. SCHÖNLAUB); b) detail of the unit exposed at the Rio Malinfiere West Section (photo C. CORRADINI).

Synonymy

Complex von Tonschiefer, Grauwacke und Kieselschiefer: GEYER (1895).

Scisti a graptoliti: TARAMELLI (1895a, b).

Gotlandiano: facies scistosa: GORTANI (1926).

Siluriano superiore. Scisti neri grafitici o selcioso grafitici: GORTANI & DESIO (1927).

Kieselschiefer mit Kalken und Lyditen: JAEGER & PÖLSLER (1968).

Calcaro e marne nere alternati, talora con argilliti ai Graptoliti; calcari rossicci o nerastri ad "Orthoceras", calcari nodulari: ASERETO et al. (1968).

Calcaro chiari a Crinoidi; marne brune e argilliti nere: ASERETO et al. (1968).

Kieselschieferkomplex: PÖLSLER (1969a, b).

Löchriger Kalk: PÖLSLER (1969a).

Nöbling Formation: SCHÖNLAUB (1985).

Argilliti a Graptoliti con intercalazioni calcaree: VAI (1971).

Argilliti a graptoliti e radiolariti [partim]: SPALLETTA et al. (1982).

Graptolitic shales [partim]: SPALLETTA & VENTURINI (1989).

Formation di Nöbling: VENTURINI (2006).

Graptolite shale [partim]: BRIME et al. (2008).

Chronostratigraphic age

Silurian – Devonian: Rhuddanian to upper Lochkovian.

Biostratigraphy

Conodonts. – *Pterospathodus amorphognathoides angulatus* Zone (JAEGER & SCHÖNLAUB, 1977) to *A. transitans* Zone (CORRIGA et al., 2012).

Graptolites. – *Cystograptus vesiculosus* Zone (JAEGER & SCHÖNLAUB, 1977; ŠTORCH & SCHÖNLAUB, 2012) to *Monograptus hercynicus* Zone (JAEGER & SCHÖNLAUB, 1980).

Complementary references

Sequence stratigraphy. – BRETT et al. (2007, 2009).

Geochemistry. – PASAVA & SCHÖNLAUB (1999).

Isotopes. – WENZEL (1997).

Remarks

Several K-bentonite levels were described and discussed by HISTON et al. (2007). Reflectance on graptolites was performed by RANTITSCH (1992).

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Bischofalm Formation

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Definition

Black siliceous and alum shale, lydite and grayish green argillaceous shale in the middle part.

Description

The Bischofalm Formation consists of monotonous sequences of interbedded radiolarian cherts and alum shales in the lower and upper part of the unit, and with a distinct gray-greenish intermezzo, that has provided graptolites as well.

Fossil content

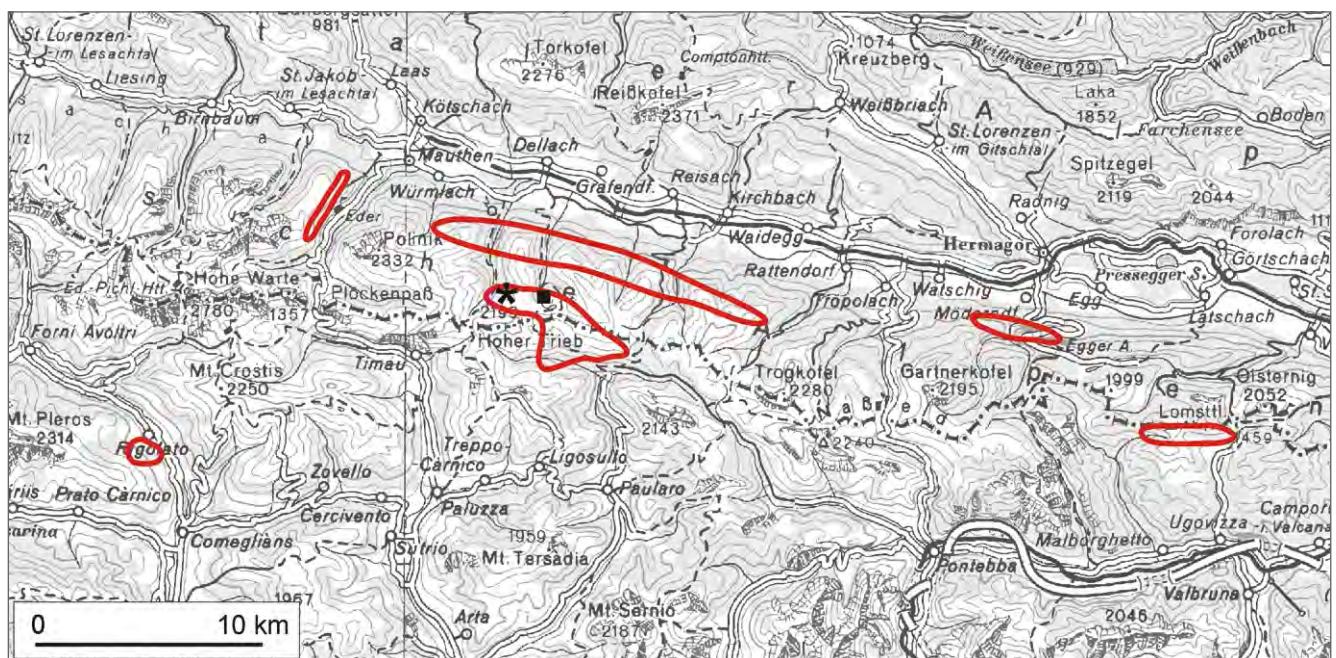
Conodonts, graptolites, radiolarians.

Depositional environment

Deep shelf to basinal euxinic.

Stratotype

Bischofalm "Hauptprofil" of Graptolithengraben Section at altitude 1560 m (FLÜGEL et al., 1977; SCHÖNLAUB, 1985) at coordinates N 46°36'48", E 13°03'38".



Main areal distribution of the Bischofalm Formation with indication of the stratotype (asterisk) and of the reference section (square). Asterisk: Graptolithengraben Section; square: Waterfall Section.



Views of the Graptolithengraben Section. a) lithostratigraphic column of the section (redrawn from FLÜGEL et al., 1977 and SCHÖNLAUB, 1985); b) close view of the Bischofalm Formation exposed in the Graptolithengraben Section (photo H.P. SCHÖNLAUB). Note that the section is reversed.

Reference sections

Waterfall Section (SCHÖNLAUB, 1985; ŠTORCH & SCHÖNLAUB, 2012), east of Zollnersee Hut, at coordinates N 46°36'20", E 13°04'18", exposing the base of the Silurian that is missing in the stratotype.

Type area

Central Carnic Alps.

Main outcrop areas

Bischofalm, area around Lake Zollner, Dellach Alm, area of Rio Cercevesa-Casera Lodin to Meledis, Gugel, Pessen-dellach near the eastern end of Carnic Alps. Area north of Monte Cocco.

Thickness

Estimated about 60 - 80 m.

Boundaries

Underlying units – Plöcken Formation (conformable, sharp contact).

Overlying units – Zollner Formation (conformable, gradual contact).

Lateral units – Nölbling Formation.

Derivation of name

After the locality of Bischofalm (Austria).



Views of the Bischofalm Formation in the field (photos H.P. SCHÖNLAUB). a) global view of the Waterfall Section; b) close view of a graptolite slab.

Synonymy

Graptoliten-Schiefer: STACHE (1872).
 Gailthaler Schiefer: TARAMELLI (1874).
 Scisti a graptoliti: TARAMELLI (1895a, b).
 Gotlandiano: facies scistosa: GORTANI (1926).
 Siluriano superiore. Scisti neri grafitici o selcioso grafitici: GORTANI & DESIO (1927).
 Calcari e marne nere alternati, talora con argilliti ai Graptoliti; calcari rossicci o nerastri ad "Orthoceras", calcari nodulari: ASSERETO et al. (1968).
 Calcaro chiari a Crinoidi; marne brune e argilliti nere: ASSERETO et al. (1968).
 Lower Graptolitic Shales: FLÜGEL et al. (1977).
 Grey-Green eß Shales: FLÜGEL et al. (1977).
 Upper Graptolitic Shales: FLÜGEL et al. (1977).
 Untere Bischofalm-Schiefer: JAEGER & SCHÖNLAUB (1994).
 Mittlere Bischofalm-Schiefer: JAEGER & SCHÖNLAUB (1994).
 Obere Bischofalm-Schiefer: JAEGER & SCHÖNLAUB (1994).
 Argilliti a graptoliti: VAI et al. (2002).
 Formazione della Bischofalm: VENTURINI (2006).

Chronostratigraphic age

Silurian – Devonian: Rhuddanian to Lochkovian.

Biostratigraphy

Graptolites. – *Akidograptus acuminatus*-*Monograptus hercynicus* zones (FLÜGEL et al., 1977; JAEGER & SCHÖNLAUB, 1980, 1994; SCHÖNLAUB, 1985; ŠTORCH & SCHÖNLAUB, 2012).

Complementary references

Geochemistry. – PASAVA & SCHÖNLAUB (1999).

Isotopes. – WENZEL (1997).

Remarks

Outcrops are often affected by tectonics that prevents in many cases definition of original thickness. Individual outcrops are in tectonic contact with other units.

Several K-bentonites levels were described and discussed by HISTON et al. (2007).

Reflectance on graptolites was performed by RANTITSCH (1992).

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Seekopf Formation

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Foglio 018 Passo di Monte Croce Carnico

Foglio 032 Tolmezzo

Definition

The unit is bi-partite with well-bedded nodular and lithoclastic limestone to dolostone in the lower part, and peloidal and crinoidal pack-, grain- and rudstones in the upper part.

Description

The formation begins at the transition from red calcarenites to dolostone. The dolomitization has largely erased original sedimentary textures and structures but remains of lithoclasts are visible throughout the unit. Lithoclastic units are interbedded with graded calcarenites and nodular limestones (biomicrites) with trilobites. Above, a megaclast horizon, with lithoclasts of several meters in diameter is present in the type section.

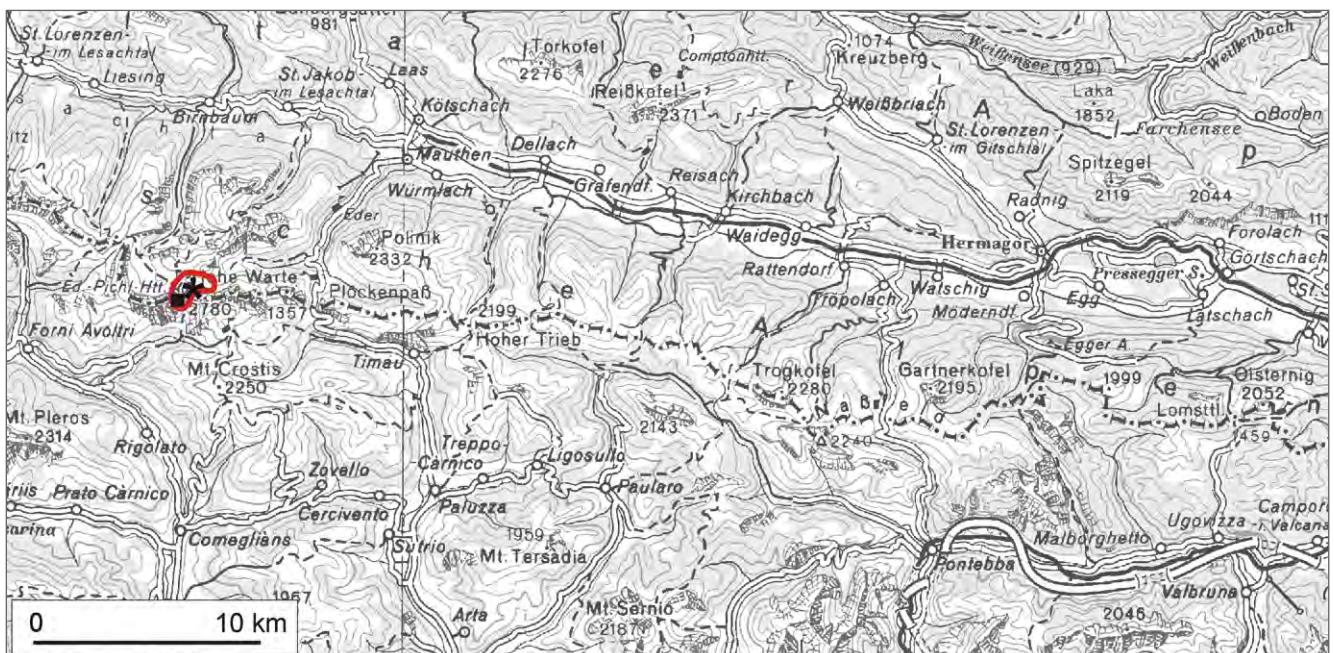
The succeeding crinoidal calcarenites are bedded with oriented crinoids stems and intercalated with massive crinoid-rich grainstones and rudstones.

Fossil content

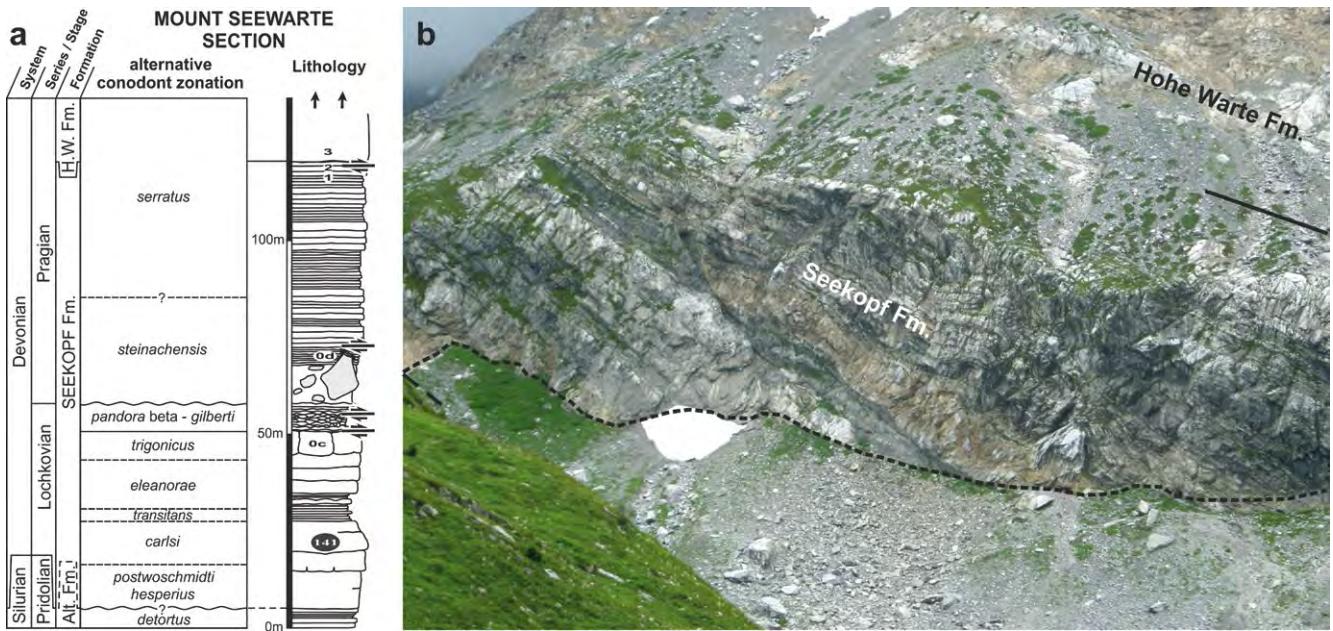
Brachiopods, calcimicrobes, conodonts, crinoids, dacryoconarids, gastropods, ostracods, sponge spicules, trilobites.

Depositional environment

The Seekopf Formation appears to be a shallowing upward succession grading from more carbonate slope sedimentation to shelf ramp sedimentation. The megaclast horizon is most likely a gravity-induced debris flow deposit. Graded beds and lithoclastic horizons are suggestive of turbidite deposits. The crinoidal graded calcarenites and massive calcarenites and –rudites could be shelf edge or ramp deposits influenced by storms (tempestites).



Areas of outcrop of the Seekopf Formation with indication of the stratotype (asterisk) and reference section (square).



The Seewarte Section. a) log of the type section from SUTTNER (2007) with upgraded biostratigraphy; b) panoramic view of the Seekopf Formation along the NW footwall of Mt. Seewarte (photo T.J. SUTTNER).

Stratotype

Seewarte Section (BANDEL, 1972; SUTTNER, 2007), located at the base of Mt. Seewarte, near Lake Wolayer at coordinates N 46°36'44.5", E 12°52'21.4".

Reference sections

Rifugio Lambertenghi Fontana III section (CORRADINI & CORRIGA, 2010), along the path from Rifugio Lambertenghi-Romanin to Mt. Capolago at coordinates N 46°36'22.4", E 12°52'05.4", where the base of the unit is exposed.

Type area

Central Carnic Alps.

Main outcrop areas

The Seekopf Formation crops out at Lake Wolayer and forms the base of shallow water successions at Mt. Polinik, Gamskofel and others.

Thickness

About 115 m (BANDEL, 1972; SUTTNER, 2007).

Boundaries

Underlying unit – Alticola Formation (conformable, gradual contact).

Overlying unit – Hohe Warte Formation (conformable, sharp contact).

Lateral units – Alticola Formation, Rauchkofel Formation.

Derivation of name

After Mt. Seekopf (= Capolago).

Synonymy

Zone der *Rynchonella Megaera*: FRECH (1894).
Orizzonte a *Rynchonella Megaera* Barr.: GORTANI (1913).
Rynchonella megaera-Schichten: GAERTNER (1931).
ey Dolomit: GAERTNER (1931).
Calcari a *Rynchonella megaera*: DAL PIAZ & TREVISAN (1956).
Calcari nerastri a Brachiopodi e Crinidi, calcari nodulari: BRAGA et al. (1971).
Einheit 0a-0g: BANDEL (1969).
crinoidal limestones: VAI in FLÜGEL et al. (1977).
Rauchkofel-Kalk: SCHÖNLAUB (1985).
neritischer Rauchkofel-Kalk: KREUTZER (1992).
Strati a *megaerella*: VAI et al. (2002).

Chronostratigraphic age

Silurian – Devonian: Pridoli to early Pragian.

Biostratigraphy

Conodonts. – Lower *O. elegans detortus* Zone (CORRADINI & CORRIGA, 2010) to *P. serratus* Zone (SUTTNER, 2007).

Complementary references

Isotope Geochemistry. – SUTTNER (2007); CORRADINI & CORRIGA (2010).



View of the Seekopf Formation (type section) in the field. a) lithoclastic layers (photo H.P. SCHÖNLAUB); b) the megaclast horizon with boulders of up to 9 meters (photo T.J. SUTTNER); c) well-bedded, dark gray crinoidal limestones showing a thickening upward cyclicity (photo T.J. SUTTNER); d) view on equivalent beds from the base of the formation at the RLF III section (photo C. CORRADINI).

Remarks

The lower boundary of the Seekopf Formation with the Alticola Formation is gradual and therefore drawn at different biostratigraphic position in different sections. However, the Alticola Formation exposed under the Seekopf Formation does not show the typical lithological character of Alticola Formation, but resembles an equivalent deposited under more shallow marine conditions.

The conspicuous megaclast horizon, which marks the base of the Pragian is only known from the type section at the base of Mt. Seewarte. However, there might be an equivalent horizon at the eastern slope of Mt. Cellon in the here occurring upper part of the Rauchkofel Formation.

The partition of the unit into a lower shale and dolostone-rich and an upper limestone-dominated unit is characteristic for this formation.

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Rauchkofel Formation

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Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Dark, well bedded, platy limestone (mudstone to wackestone), with intercalation of black shales and marls. Locally calcarenites and cherts interbedded are present, as well as finely laminated calcisiltites; in place calcirudites and thick conglomeratic beds occur.

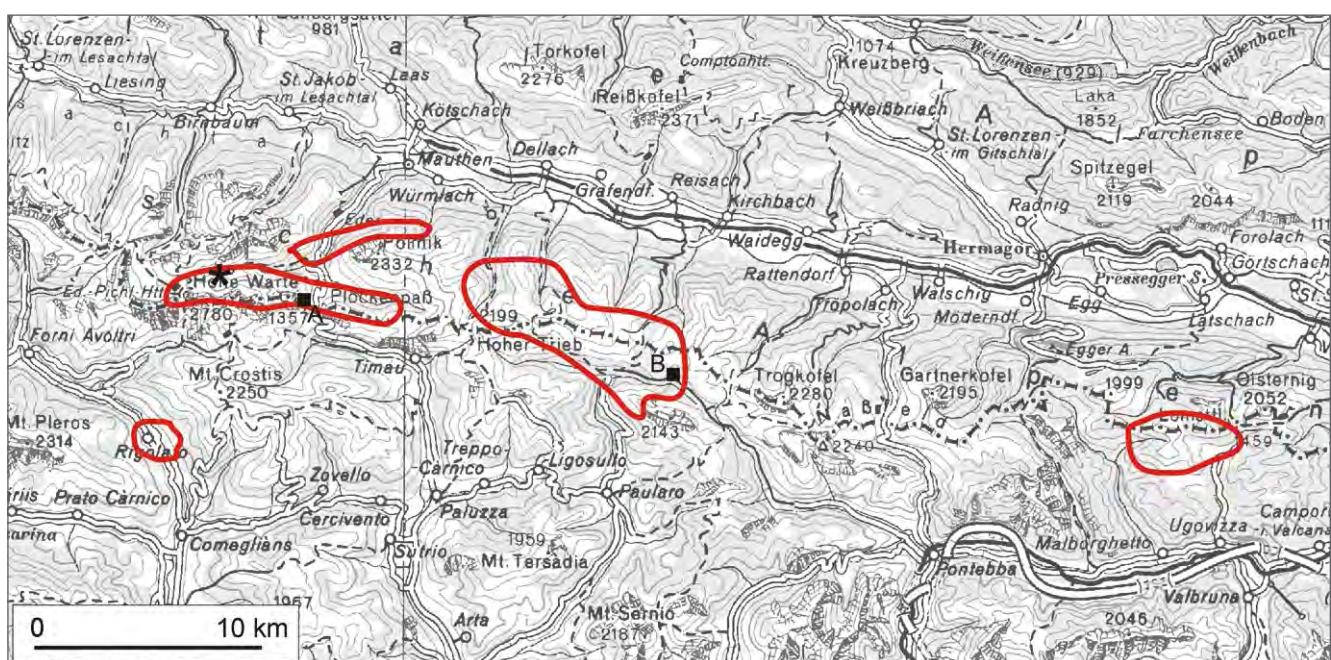
Description

The Rauchkofel Formation mainly consists of dark gray to black laminated and well-bedded, partly platy limestones intercalated with black shales and marls of various thickness. Lateral variations are common.

Thickness of beds varies from very thin to medium for limestones. Black graptolitic shales with graptolites are more abundant in the lower part of the unit, where they may constitute levels up to 15 cm thick. In the proximal parts of the basin thick to very thick calcarenitic beds and breccias occur more frequently in the upper part of the unit, but in places they may occur also in the lowermost part. A distinct horizon with loboliths is present in the lowermost part of the formation.

Fossil content

Brachiopods, chitinozoans, cephalopods (nautiloids), conodonts, crinoids (a scyphocrinoid horizon at the base of the unit), gastropods, graptolites, ostracodes, radiolarians, tentaculites, trilobites.



Areas of outcrop of the Rauchkofel Formation with indication of the stratotype (asterisk) and reference sections (squares). A: Cellon Section; B: Rio Malinier West Section.



The Rauchkofel South Section. a) log of the section (modified after SCHÖNLAUB, 1970); b) panoramic view (photo H.P. SCHÖNLAUB).

Depositional environment

Offshore.

Stratotype

Rauchkofel South Section (named “Rauchkofel IV Profil” in SCHÖNLAUB, 1970), located on the southern slope of Mt. Rauchkofel, at coordinates N 46°36'58.5", E 12°53'23.0".

Reference sections

Eastern slope of Mt. Cellon, where the boundaries with the Alticola Formation (WALLISER, 1964; CORRADINI et al., 2015) and with the Kellerwand Formation are exposed.

Rio Malinfiere West Section (coordinates N 46°34'50", E 13°07'151.6"), where the boundaries with the Alticola Formation, the Nöbling Formation and the La Valute Formation are exposed (CORRIGA, 2011; CORRADINI et al., 2012).

Type area

Carnic Alps.

Main outcrop areas

The Rauchkofel Formation crops out along the whole Carnic Alps, mainly in Lake Wolayer-Rauchkofel, Mt. Cellon-Pal Piccolo-Freikofel, Oberbuchach-Rio Malinfiere and Monte Cocco sectors, and near Rigolato village.

Thickness

Very variable: 2–11 m where overlain by the La Valute Formation, and up to 120 m where overlain by the Kellerwand Formation.

Boundaries

Underlying unit – Alticola Formation (conformable, sharp contact).

Overlying unit – La Valute Formation (conformable, sharp contact), Nöbling Formation (conformable, gradual contact), Kellerwand Formation (conformable, gradual contact).

Lateral unit – Seekopf Formation, Nöbling Formation, La Valute Formation, Findenig Formation.

Derivation of name

After Mt. Rauchkofel.

Synonymy

Schwarze Plattenkalke: GAERTNER (1931).

ey-Plattenkalke: GAERTNER (1931).

ey-Schichten: GAERTNER (1931).

Formazione di Monte Lodin [partim]: SELLI (1963).

Schwarze Kalke der Einheiten 0b, 0d, 0f, 0g: BANDEL (1969).

Calcaria lastroidi: VAI (in BRAGA et al., 1971); SPALLETTA et al. (1982).

ey limestone: SCHÖNLAUB (1980).

Pelagic Rauchkofel Limestone: KREUTZER (1992, sensu SCHÖNLAUB, 1985b).

Grey bedded limestone: VAI (1998).

Calcaria dolomitici e lastroidi: VENTURINI (2006).

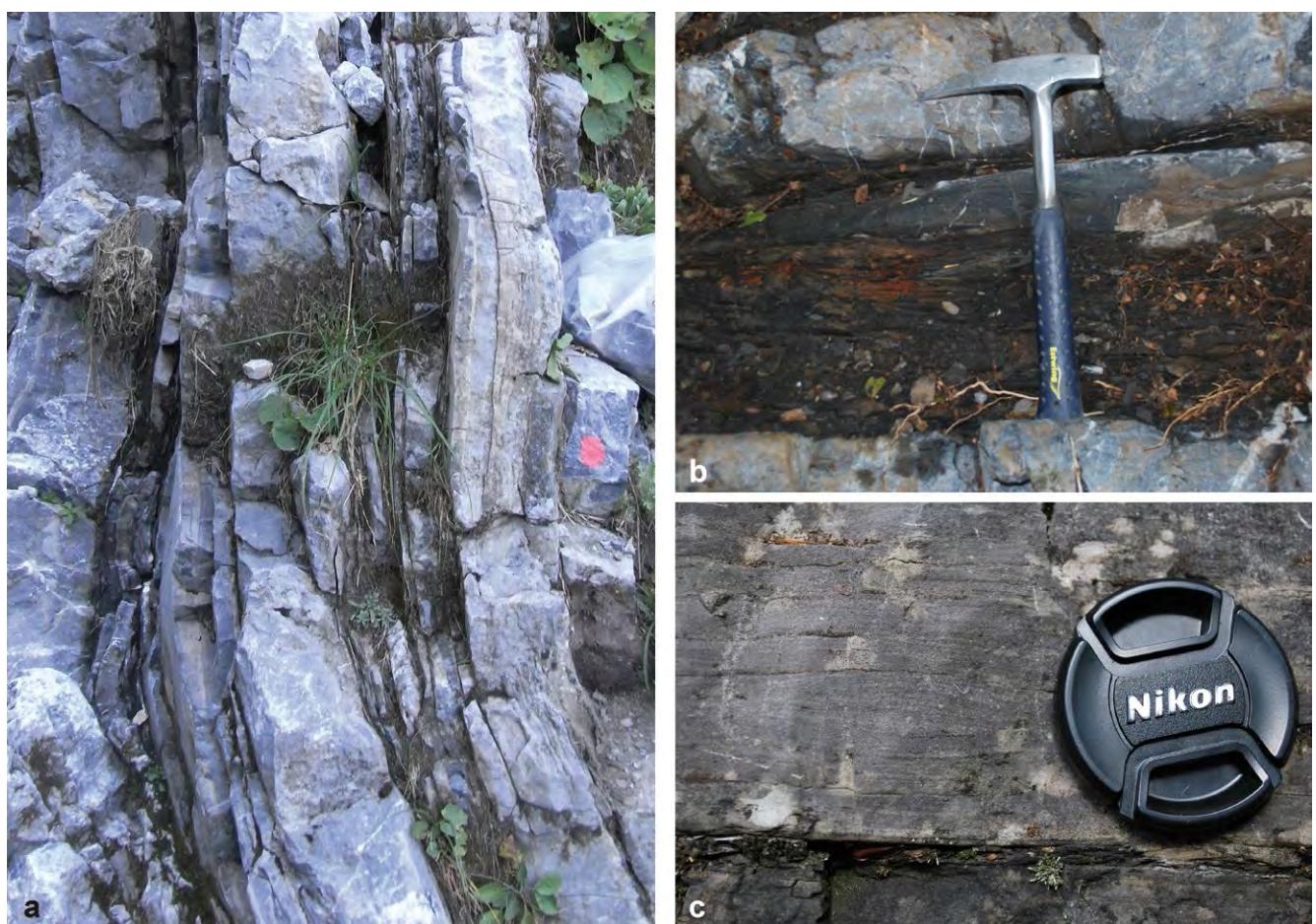
Calcaria del Rauchkofel [partim]: SPALLETTA & PONDRELLI (2009).

Chronostratigraphic age

Devonian: Lochkovian, from just above the Silurian/Devonian boundary into the upper Lochkovian. However, where the unit is overlain by the La Valute Formation, it is limited to the lower Lochkovian, or just reaches into the middle Lochkovian.

Biostratigraphy

Conodonts. – From within the *Icr. hesperius* Zone (CORRIGA & CORRADINI, 2009; CORRADINI et al., 2015) into the *M. pandora* β Zone.



Views of the Rauchkofel Formation in the field. a) thin bedded limestones in the Cellon Section (photo C. CORRADINI); b) dark limestones and black shales alternation in the Rio Malinfiere West Section (photo C. CORRADINI); c) detail of a laminated limestone bed in the Mt. Freikofel area (photo M. PONDRELLI).

However, where the Rauchkofel Formation is overlain by the La Valute Formation the upper boundary lies in the upper part of the *Icr. postwoeschmidtii* Zone (CORRIGA & CORRADINI, 2009), or in the lower part of the *A. carlsi* Zone (SCHÖNLAUB, 1980, 1985a; CORRIGA, 2011; CORRADINI et al., 2012).

Graptolites. – From the *Monograptus uniformis* to the *M. hercynicus* zones (SCHÖNLAUB, 1970, 1985a; JAEGER, 1975).

Chitinozoans. – The *Eisenackitina bohemica* Zone was documented by PRIEWALDER (1997) at the base of the unit.

Complementary references -

Remarks -

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La Valute Formation

CARLO CORRADINI, MARIA G. CORRIGA, MONICA PONDRELLI, HANS-PETER SCHÖNLAUB & LUCA SIMONETTO

Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt BMN 199 Hermagor

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Well-bedded (5-20 cm in thickness) light gray/ochreous cephalopod bearing limestone (mudstone to wackestone), slightly nodular at places (mainly in the upper part of the unit).

Description

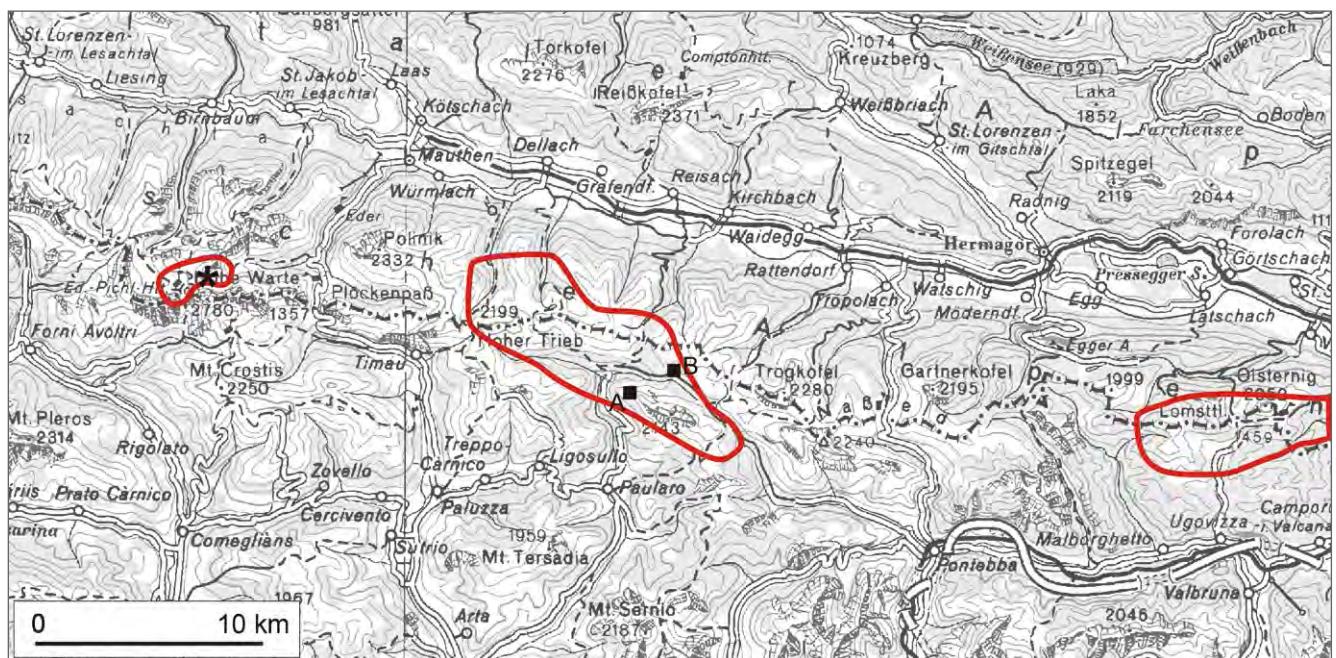
The La Valute Formation consists of thin-bedded light gray and brownish gray nodular mudstone to wackestone. At places it can be more coarse and compact. The thickness of beds is in general 10-15 cm, even if thinner or thicker beds may occur at places. In the uppermost couple of meters of the unit, beds become very thin to thin with silty and marly intercalations, then gradually pass into the Findenig Formation. Orthoceratid nautiloids, even if not very abundant, are the only fossils clearly visible in the field.

Fossil content

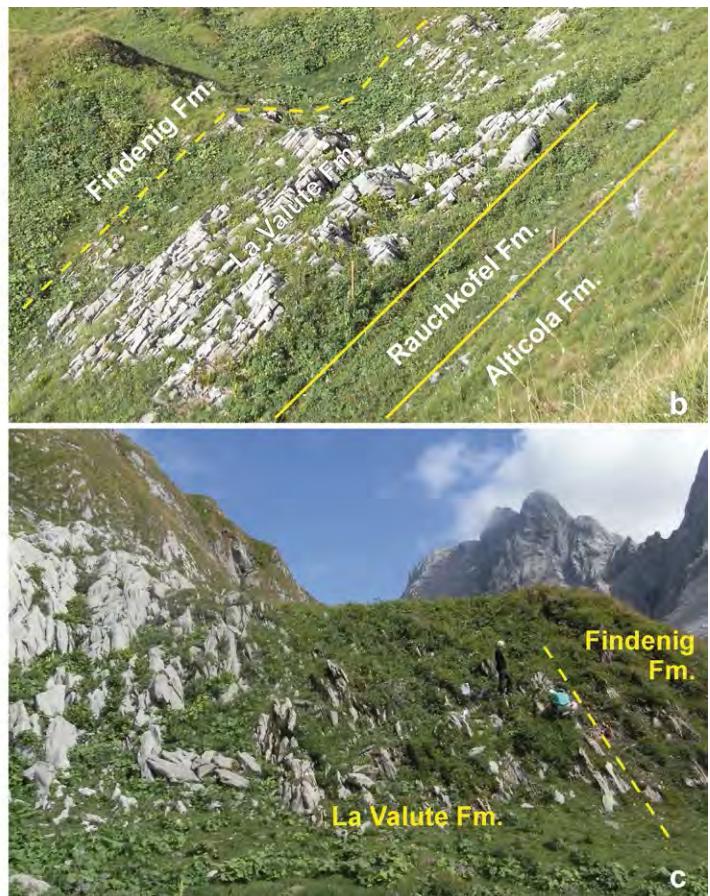
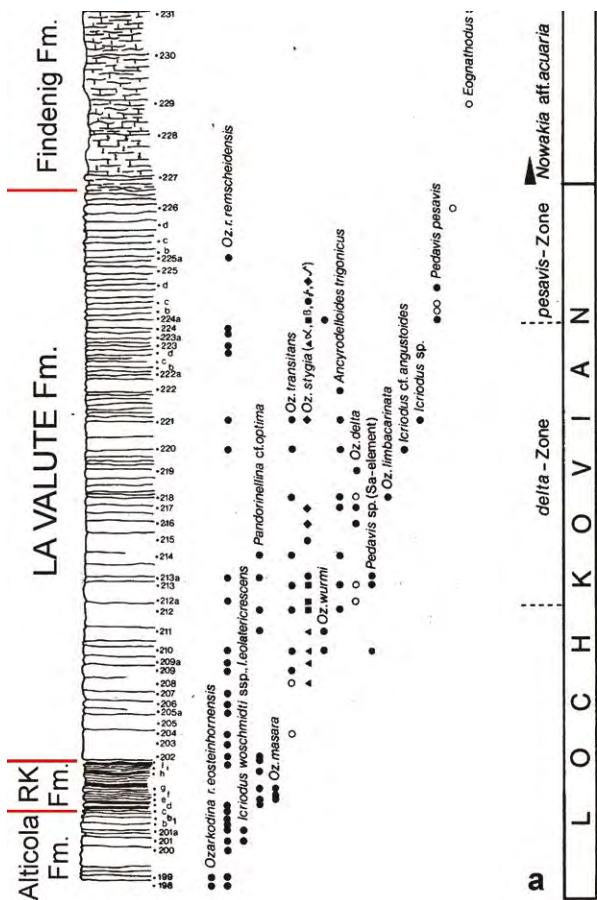
Conodonts, cephalopods (nautiloids), dacryoconarids, sponge spicules, trilobites, ostracods, crinoids, brachiopods.

Depositional environment

Pelagic environment.



Areas of outcrop of the La Valute Formation with indication of the stratotype (asterisk) and reference sections (squares). A: La Valute Cave Section; B: Rio Malinier West Section.



The Rauchkofel Boden Section. a) log of the Devonian part of the section (modified after SCHÖNLAUB, 1980); b-c) views of the section (photo C. CORRADINI).

Stratotype

Rauchkofel Boden Section, located on the southern slope of Mt. Rauchkofel (SCHÖNLAUB, 1970, 1980; SCHÖNLAUB et al., 1997), at coordinates N 46°36'53.5", E 12°52'33.0".

Reference sections

La Valute Cave Section (coordinates N 46°34'18", E 13°07'19.1"), where the upper boundary of the unit is well exposed and the name La Valute limestone has been used for the first time (CORRIGA et al., 2011).

Rio Malinfiere West Section (coordinates N 46°34'50", E 13°07'151.6"), where the boundaries with the Rauchkofel Formation, the Nölbling Formation and the Findenig Formation are exposed and the facies is deeper than the stratotype (CORRIGA, 2011; CORRADINI et al., 2012).

Type area

Carnic Alps.

Main outcrop areas

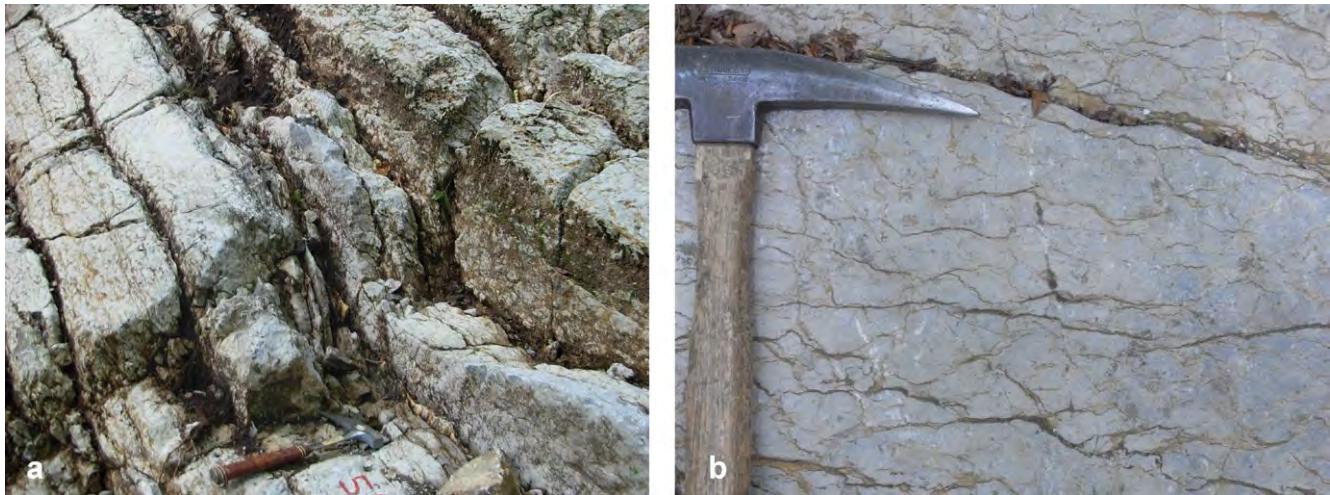
The La Valute Formation crops out along the whole Carnic Alps, mainly in Lake Wolayer-Rauchkofel, Cuestalta/Hoher Trieb to Mt. Pizzul and Monte Cocco sectors.

Thickness

About 18 m.

Boundaries

Underlying unit – Rauchkofel Formation (conformable sharp), Nölbling Formation (conformable sharp).



Views of the La Valute Formation in the field, Rio Malinfiere West Section (a: photo L. SIMONETTO; b: photo C. CORRADINI).

Overlying unit – Findenig Formation (conformable gradual).

Lateral unit – Rauchkofel Formation, Nölling Formation.

Derivation of name

After La Valute, the westernmost top of Mt. Zermula massif.

Synonymy

Grauer und rother Kramenzelkalk [partim]: FRECH (1894).

Calcare stratificati con calcescisti: TARAMELLI (1895).

Calcare a tentaculiti [partim]: VAI (1963); VENTURINI (2006).

Calcare nerastri a Brachiopodi e Crinoidi, calcari nodulari: ASSERETO et al. (1968).

Findenig-Kalk [partim]: PÖLSLER (1969).

Grey Flaser-limestone: SCHÖNLAUB (1980).

Nodular grey limestone: SCHÖNLAUB (1980).

Orthoceras limestone [partim]: SCHÖNLAUB (1980).

Pelagic tentaculitid limestone [partim]: SPALLETTA & VENTURINI (1990); VAI (1998).

Boden-Kalk: SCHÖNLAUB (1985).

Boden Limestone: KREUTZER (1992); FERRETTI et al. (1999); CORRIGA & CORRADINI (2009).

Calcare di Cuestalta [partim]: SPALLETTA & PONDRELLI (2009).

La Valute Limestone: CORRIGA et al. (2011, 2012); CORRADINI et al. (2012).

La Valute Formation: CORRIGA et al. (2012).

Bodenkalk/Boden Limestone: SUTTNER & KIDO (2014).

Chronostratigraphic age

Devonian: Upper part of lower Lochkovian to upper Lochkovian.

Biostratigraphy

Conodonts. – From the uppermost part of *Icr. postwoschmidtii* Zone to within the *M. pandora* β Zone.

Different ages have been documented for the base of the unit in various parts of the Carnic Alps: in the central sector the base of the unit is in the lower part of the *A. carlsii* Zone (CORRIGA, 2011; CORRADINI et al., 2012), whereas in the eastern part (Monte Cocco area) lies in the uppermost part of the *Icr. postwoschmidtii* Zone (CORRIGA & CORRADINI, 2009). The upper boundary can be always traced within the *M. pandora* β Zone (i.e. SCHÖNLAUB, 1980; CORRIGA et al., 2011).

Dacryoconarids. – *Homostenowakia bohemica* to *Paranowakia intermedia* zones (ALBERTI, 1985).

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Polinik Formation

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Blatt BMN 198 Weißbriach

Blatt BMN 199 Hermagor

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Definition

Bedded dark gray limestone intercalated with dolomitic limestone and dolostone.

Description

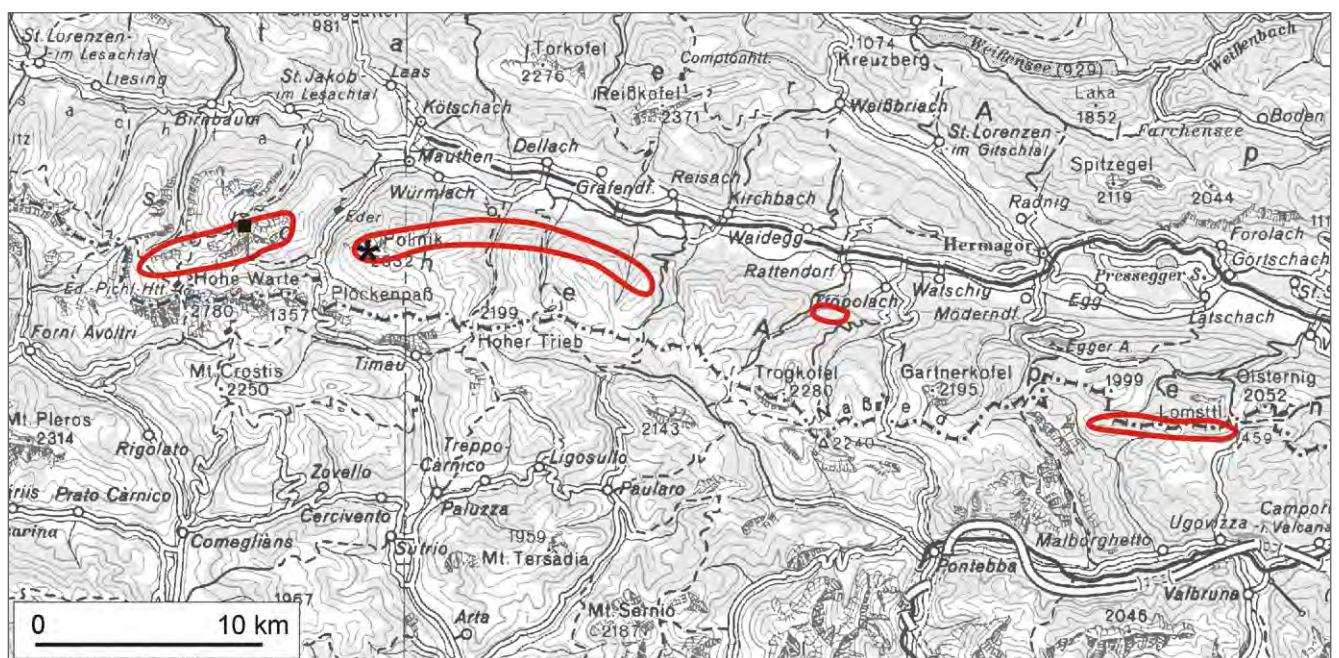
The Polinik Formation consists dominantly of algal laminites and *Amphipora* limestone; lithoclastic beds are common. Near the base are crinoidal limestone and dolostone exposed (BANDEL, 1972; KREUTZER, 1992a, b).

Fossil content

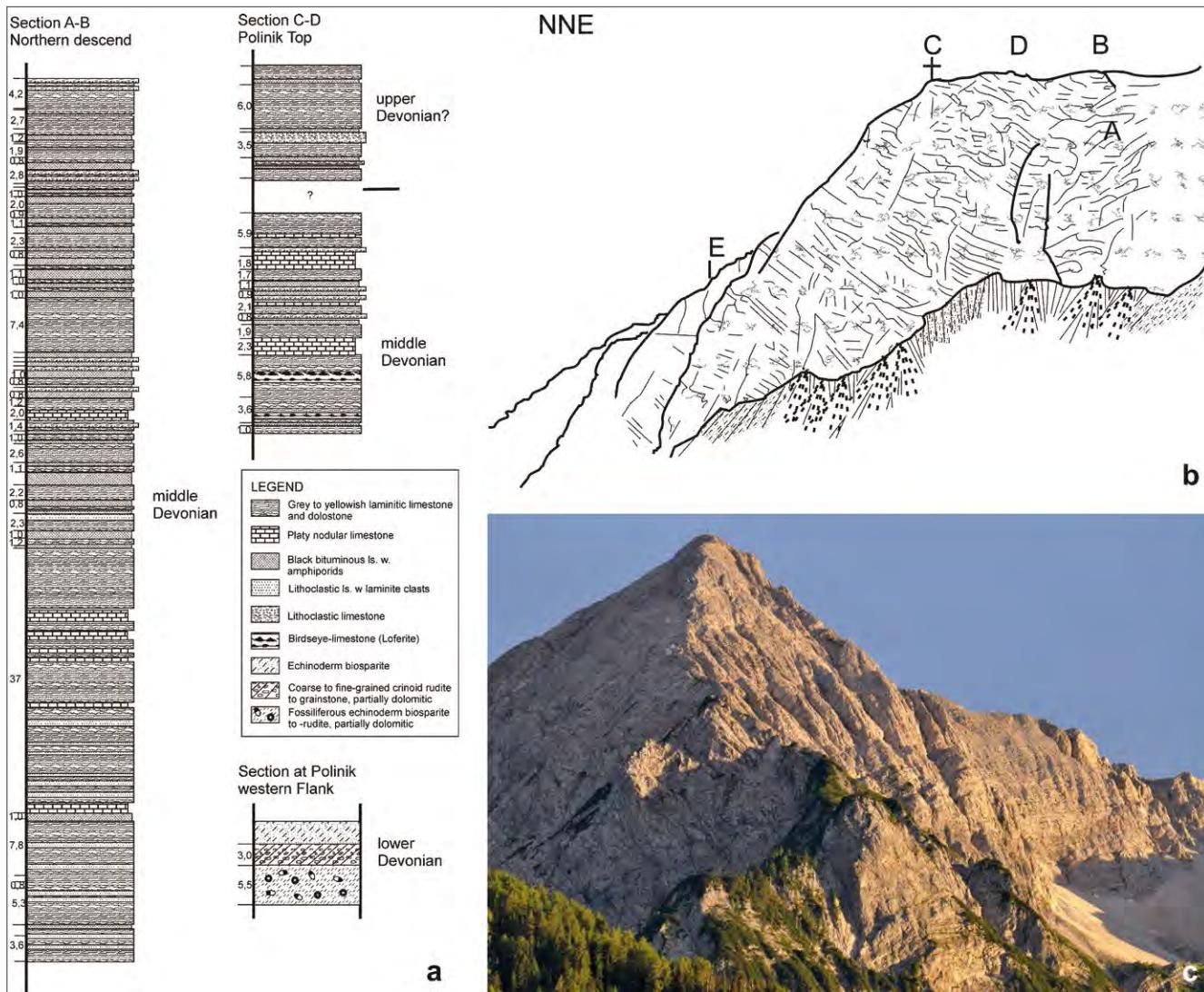
Brachiopods, calcareous algae, calcispheres, tabulate corals, crinoids, foraminifers, gastropods, ostracods, stromatoporoids, trilobites.

Depositional environment

Largely a cyclic shallow water succession deposited in a sheltered lagoon. Early diagenetic dolomitization points to hypersaline seawater, the abundance of lithoclastic horizons suggests tempestites (storm deposits) formed during intermittent storms. Overall, the lithologies are indicative of intertidal to supratidal depths. Shallowing upward sequences are common (BANDEL, 1972; KREUTZER, 1992a, b).



Areas of outcrop of the Polinik Formation with indication of the stratotype (asterisk) and reference section (square). Additional outcrops in eastern continuity are in the Bartolosattel area.



The Polinik Section. a) log of Mount Polinik (adapted from BANDEL, 1972); b) drawing of Mount Polinik with locations of sections A-B and D-C (adapted from BANDEL, 1972). The lower Devonian section cannot be seen in this view; c) panoramic view of Mount Polinik (photo H.P. SCHÖNLAUB).

Stratotype

Mt. Polinik at coordinates: N 46°37'37", E 12°58'52".

Reference sections

Section on the northern side of Mt. Gamskofel at Böses Gangele between Raimunda Törl and Wodner Törl at coordinates N 46°38'01", E 12°54'06" (KREUTZER, 1992b: 270), which is better accessible than the stratotype section.

Type area

Central Carnic Alps.

Main outcrop areas

The Polinik Formation is best exposed and preserved at Mt. Polinik. The Gamskofel and Mooskofel massives appear to have similar lithologies. All along the Carnic Alps are more or less tectonized (metamorphosed) fragments of the Polinik Formation exposed (formerly Feldkogel Limestone).

Thickness

Estimated 700 m at Mt. Polnik (BANDEL, 1972); 800 m at Mt. Gamskofel (KREUTZER, 1992b).



Views of the Polinik Formation in the field. a) laminated limestone (photo A. MÖRTL); b) rock surface with tabulate corals (photo A. MÖRTL).

Boundaries

Underlying units – Seekopf Formation (?).

Overlying units – Plotta Formation (unconformable contact).

Lateral units – Hohe Warte Formation, Lambertenghi Formation, Seewarte Formation, Spinotti Formation, Kellergrat Formation, Creta di Collina Formation (?).

Derivation of name

After Mt. Polinik in the Western Carnic Alps.

Synonymy

Dolomitische Schichten des Pollinigg: FRECH (1887).

Gamskofel-Kalk: KREUTZER (1992b).

Feldkogel-Kalk: KREUTZER (1992b).

Chronostratigraphic age

Devonian: Pragian to Frasnian, possibly younger.

Biostratigraphy

Brachiopods. – *Stringocephalus burtini* at Gamskofel (KREUTZER, 1990, 1992b).

Conodonts. – *Palmatolepis* sp. at Mooskofel (KREUTZER, 1992a).

Complementary references

Sedimentology and Fossils. – MÖRTL (2014).

Remarks

BANDEL (1972) thought that the Gamskofel and the Polinik successions are of similar age and lithologies whereas KREUTZER (1992b) felt that the limestones of Polinik and Gamskofel are different and he assigned the Polinik succession and the Mooskofel Massif to the Feldkogel Limestone. He suggested a separate carbonate platform as depositional model. KREUTZER (1992a) found *Palmatolepis* in carbonates from Mt. Mooskofel indicating a younger age for the top than is known at Mt. Gamskofel. He felt that the metamorphosed Mooskofel lithologies are closer to the Polinik carbonates and assigned both to a “Northern Shallow Water Nappe” which is thought to encompass deposits of a different carbonate platform than the Southern Shallow Water Nappe (or Kellerwand Nappe) comprised of the Hohe Warte Massif, Biegengebirge and Gamskofel Massif.

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Hohe Warte Formation

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Österreichische Karte 1:50.000
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*Carta Topografica d'Italia 1:50.000
Foglio 018 Passo di Monte Croce Carnico*

Definition

Massive light-gray limestones with common crinoid bioclasts and reef debris (grainstone, rudstone, framestone).

Description

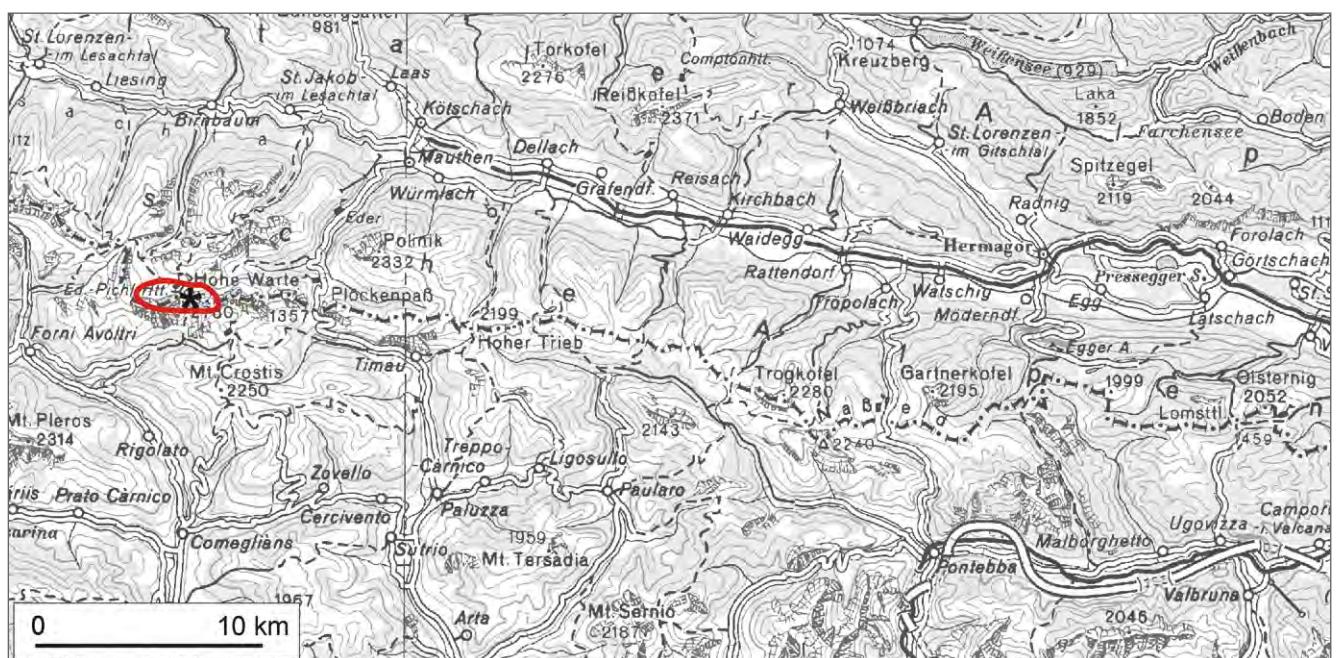
The Hohe Warte Formation consists of thick-bedded echinoderm-rich grainstone and rudstone in the lower part and massive reefal limestone interbedded with crinoid grainstone and rudstone in the upper part. Large crinoid fragments are rock-forming in the lower part of the unit; tabulate and rugose corals along with stromatoporoids characterize the massive upper part.

Fossil content

Brachiopods, bryozoans, calcareous algae, calcimicrobes, conodonts, rugose and tabulate corals, crinoids, dacyroconids, gastropods, lamellibranchiates, stromatoporoids, trilobites.

Depositional environment

The depositional environment was reconstructed by BANDEL (1969). It was characterized by dense forests of crinoids with small coral thickets and stromatoporoid growths between them. The paleoenvironment was shallow water with strong currents and fresh sea-water rich in planktonic life. Some reefs composed of stromatoporoids, corals and calcareous green algae grew on the platform as well. The water was shallow throughout deposition of the Hohe Warte Formation.



Areas of outcrop of the Hohe Warte Formation with indication of the stratotype (asterisk).



The Seewarte Section. a) simplified log of the succession on the SW flank of Mt. Seewarte (adopted from SUTTNER, 2007). Numbers included in the lithological column correspond to BANDEL (1969) and are still visible in field; b) panoramic view of the Lower Devonian units at Mt. Seewarte (photo C. CORRADINI). The dark gray band of the Seewarte Formation separates the Hohe Warte Formation below from the Lambertenghi Formation above.

Stratotype

Seewarte section (VAI, 1963; BANDEL, 1969; SUTTNER, 2007), located at the base of Mt. Seewarte, near Lake Wolayer at coordinates N 46°36'44.5", E 12°52'21.4".

Reference sections -

Type area

Central Carnic Alps.

Main outcrop areas

The Hohe Warte Formation crops out mainly in the Central Carnic Alps. It is present at the southern continuation of Mt. Seekopf, Biegegebirge (BANDEL, 1969; KREUTZER, 1992; SCHÖNLAUB et al., 2004), and base of Gamskofel (KREUTZER, 1992).

Thickness

263 m at Seewarte (BANDEL 1969) to 300 m at Mt. Hohe Warte (SCHÖNLAUB & FLAJS, 1975).

Boundaries

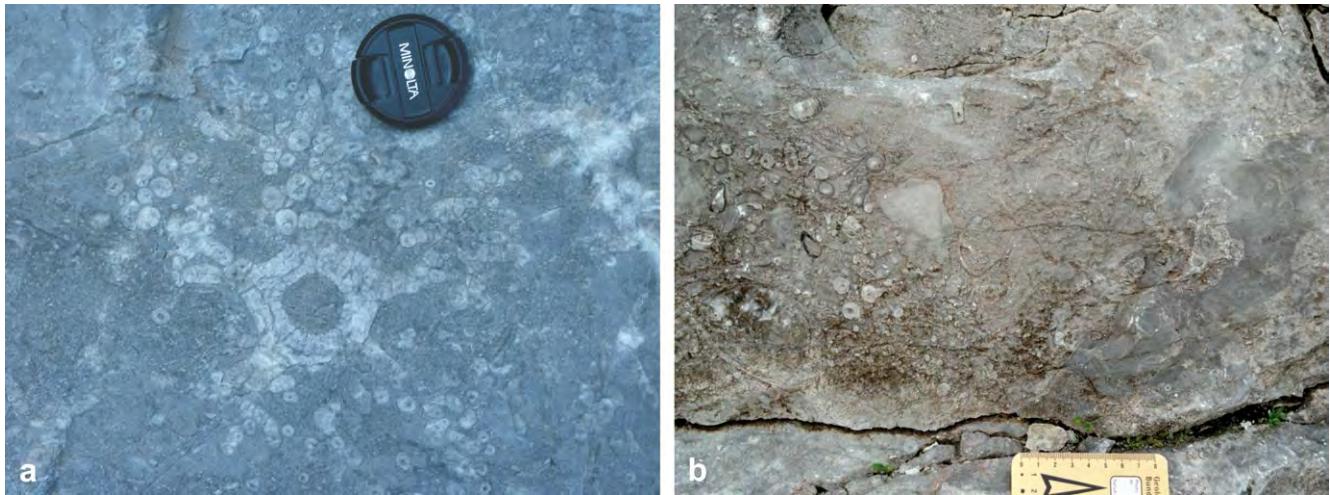
Underlying units – Seekopf Formation (unconformable/paraconformable contact).

Overlying units – Seewarte Formation (conformable gradual contact).

Lateral units – Kellerwand Formation, Polnik Formation.

Derivation of name

Suggested by KREUTZER (1992: 270) after Mt. Hohe Warte, the highest mountain in the Central Carnic Alps.



Typical macrofacies of the Hohe Warte Formation. a) at base of Mt. Hohe Warte are large boulders from the Hohe Warte Formation accumulated which show cross-sections of crinoid calyces (photo H.P. SCHÖNLAUB); b) crinoid stem plates, brachiopods and large stromatoporoid colonies overgrowing tabulate corals are common bioclasts in the Hohe Warte Formation (photo T.J. SUTTNER).

Synonymy

Riffkalk-Facies der Stockwerke H-G-H [partim]: STACHE (1884).
 Korallenriffkalk am Wolayer u. Seekopf-Thörl [partim]: FRECH (1887).
 Unterdevonischer Riffkalk [partim]: FRECH (1894).
 Calcari con *Karpinskyia conjugula*: GORTANI (1913).
 Riffkalk mit *Karpinskyia conjugula*: GAERTNER (1931).
 Graue, organo-detritische Kalke: ERBEN et al. (1962).
 ZONA A *KARPINSKYA conjugula*: SELLI (1963).
 Schichten mit *K. conjugula*: PÖLSLER (1967).
 Liegende graue Kalke: JHAVERI (1969).
 Helle Crinoiden-Kalke: BANDEL (1969).
 Helle Crinoidenschuttkalke mit *Karpinskyia conjugula* und Riffkalk: BANDEL (1969), SCHÖNLAUB (1971–1973).
 Bioclastic Ist.: SCHÖNLAUB (1980).
 Heller Crinoidenschuttkalk mit *Karpinskyia conjugula*: SCHÖNLAUB (1985).
 Riffkalke des Prag: SCHÖNLAUB (1985).
 Heller Crinoidenschuttkalk: KREUTZER (1990).
 Riffkalk: KREUTZER (1990).
 Hohe Warte Formation: SUTTNER (2007).

Chronostratigraphic age

Devonian: Pragian; possibly to earliest Emsian.

Biostratigraphy

Brachiopods. – SCUPIN (1906), PLODOWSKI (1971), LATZ (1989).

Typical Pragian species are: *Kyrtatrypa canalibalda*, cf. *Linguopugnoides remissus*, *Oglu havan*, *Punctatrypa (Fossatrypa) paradoxa*.

Conodonts. – From the ? *P. serratus* to the *I. celtibericus* Zones (SUTTNER, 2007).

Dacryoconarids. – VAI (1973) found *Nowakia acuaria*.

Trilobites. – ERBEN et al. (1962), ELLERMANN (1989).

Many species of trilobites found in the Hohe Warte Formation are not suitable for precise biostratigraphy, because of their long range. However, some are indicative of Pragian age: e.g. *Acanthopyge parva parva*, *Coniproetus eurysthenes obscurus*, *Lioharpes venulosus venulosus*, *Otarion (Otarion) convexum*, *Otarion (Cyphaspis) hydrocephalum barrandei*.

Complementary references

Paleontology. – MAY & POHLER (2009).

Sedimentology. – POHLER et al. (2007).

Remarks

BANDEL (1969) measured the section in detail beginning with the Lochkovian Seekopf Formation (his units 0a-0g and 1, 2). SUTTNER (2007: 6) shows the base of the Hohe Warte Formation above a dolomitized fault zone, consequently the Hohe Warte Formation begins at the base of Bandel's unit 3. BANDEL (1972: 31) noted the similarity of lower Devonian crinoidal limestones at western flank of Mt. Polnik to those of Hohe Warte and Seewarte.

The Hohe Warte Formation was assigned to the Pragian already by VAI (in SCHÖNLAUB, 1980).

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Seewarte Formation

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LUCA SIMONETTO & THOMAS J. SUTTNER

Österreichische Karte 1:50.000
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Carta Topografica d'Italia 1:50.000
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Blatt UTM 3109 Oberdrauburg

Definition

Dark gray fossiliferous limestone (wackestone to rudstone/grainstone) slightly dolomitic in places.

Description

The Seewarte Formation consists of dark gray (presumably bituminous) wackestone, grainstone and rudstone. In some segments appear yellowish (dolomitic) laminated or nodular textures. Gastropods are common macrofossils. Bioclasts of corals, stromatoporoids, algae, bivalves, crinoids are frequent components.

Fossil content

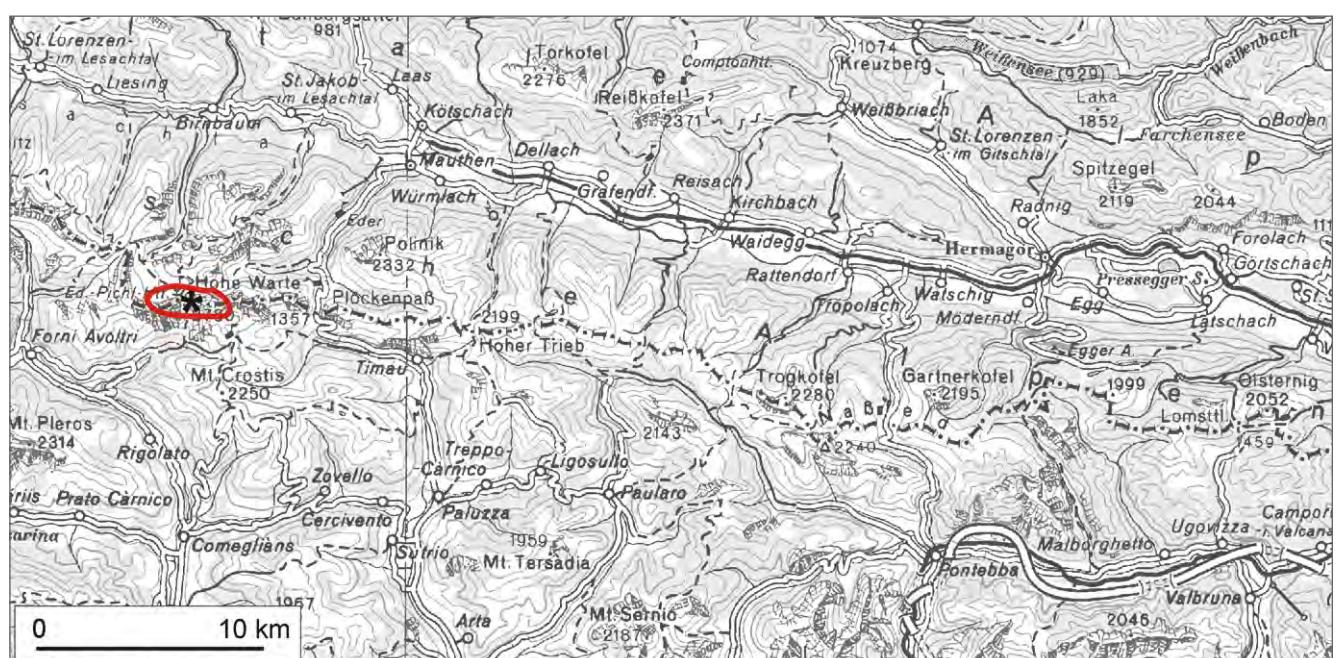
Brachiopods, calcareous algae, cephalopods (nautiloids), crinoids, dacryoconarids, gastropods, ostracods, sponge spicules, trilobites.

Depositional environment

The dark gray fossiliferous limestones of the Seewarte Formation were deposited in shallow subtidal water with sufficient aeration to support the rich fauna with abundant large gastropods, stromatoporoids and corals. Dolomitic laminae and dark colour are suggestive of restriction and possibly anoxia in sub-bottom sediments.

Stratotype

Seewarte section (JHAVERI, 1969), at the base of Mt. Seewarte near Rifugio Lambertenghi-Romanin, at coordinates N 46°36'30", E 12°52'14".



Areas of outcrop of the Seewarte Formation with indication of the stratotype (asterisk).



The Seewarte Section. a) simplified log of the Seewarte Formation; b) view of Mt. Seewarte with the dark band of the Seewarte Formation (dashed white line) above the Hohe Warte Formation and below the Lambertenghi Formation. The red line depicts a fault. The continuation of the Seewarte limestone towards the peak of the mountain is not visible in this image (photo H.P. SCHÖNLAUB).

Reference sections -

Type area

Central Carnic Alps.

Main outcrop areas

The Seewarte Formation crops out mainly in Lake Wolayer area at Mts. Hohe Warte, Seewarte and Seekopf.

Thickness

About 40 m.

Boundaries

Underlying units – Hohe Warte Formation (conformable gradual contact).

Overlying units – Lambertenghi Formation (conformable gradual contact).

Lateral units – Polinik Formation, Kellerwand Formation.

Derivation of name

After Mt. Seewarte where type section is located.

Synonymy

Riffkalk-Facies der Stockwerke H-G-H [partim]: STACHE (1884).

Schwarzer Gastropodenkalk: GAERTNER (1931).

Schwarze Kalke mit ihrem reichlichen Vorkommen von Hercynellen: GAERTNER (1931).

Gastropodenkalke: HERITSCH (1943).

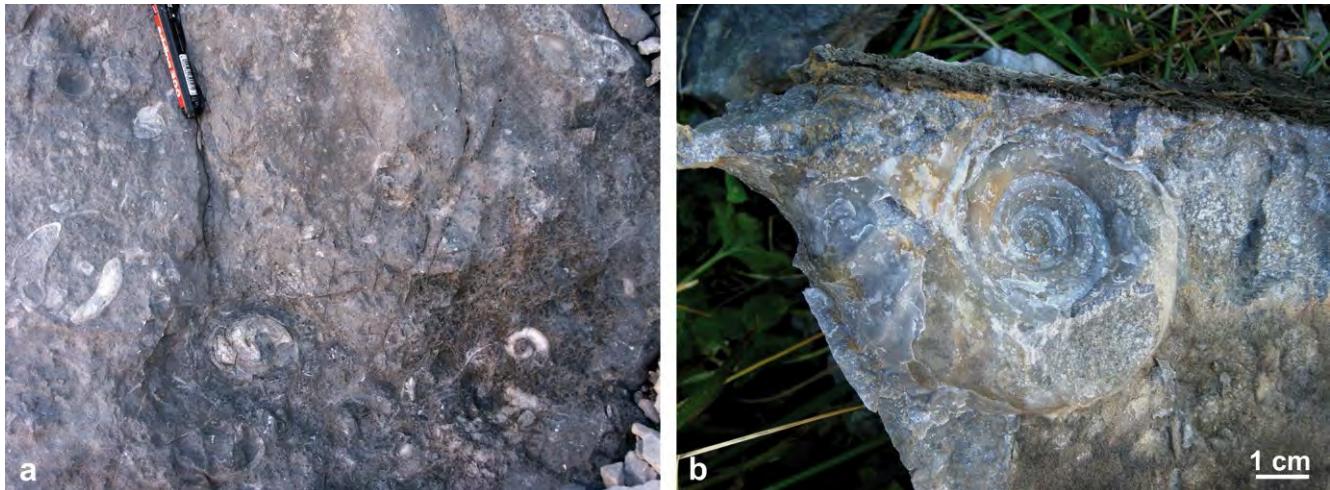
Hercynellen-führende Gastropodenkalke: ERBEN et al. (1962).

ZONA A HERCYNELLA: SELLI (1963).

Seewartekalk: JHAVERI (1969).

Hercynellenkalk: SCHÖNLAUB & FLAJS (1975); KREUTZER (1990).

Seewarte-Kalk: KREUTZER (1992).



Views of the Seewarte Formation in the field. a) large gastropods are characteristic of the Seewarte Formation (photo H.P. SCHÖNLAUB); b) euomphalid gastropod from near the top of the unit (photo T.J. SUTTNER).

Chronostratigraphic age

Devonian: Lower Emsian (ERBEN et al., 1962; KREUTZER, 1990: 295; SCHÖNLAUB et al., 2004: 12).

Biostratigraphy -

Complementary references -

Remarks -

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Lambertenghi Formation

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LUCA SIMONETTO & THOMAS J. SUTTNER

Österreichische Karte 1:50.000
Blatt BMN 197 Kötschach

Carta Topografica d'Italia 1:50.000
Foglio 018 Passo di Monte Croce Carnico

Blatt UTM 3109 Oberdrauburg

Definition

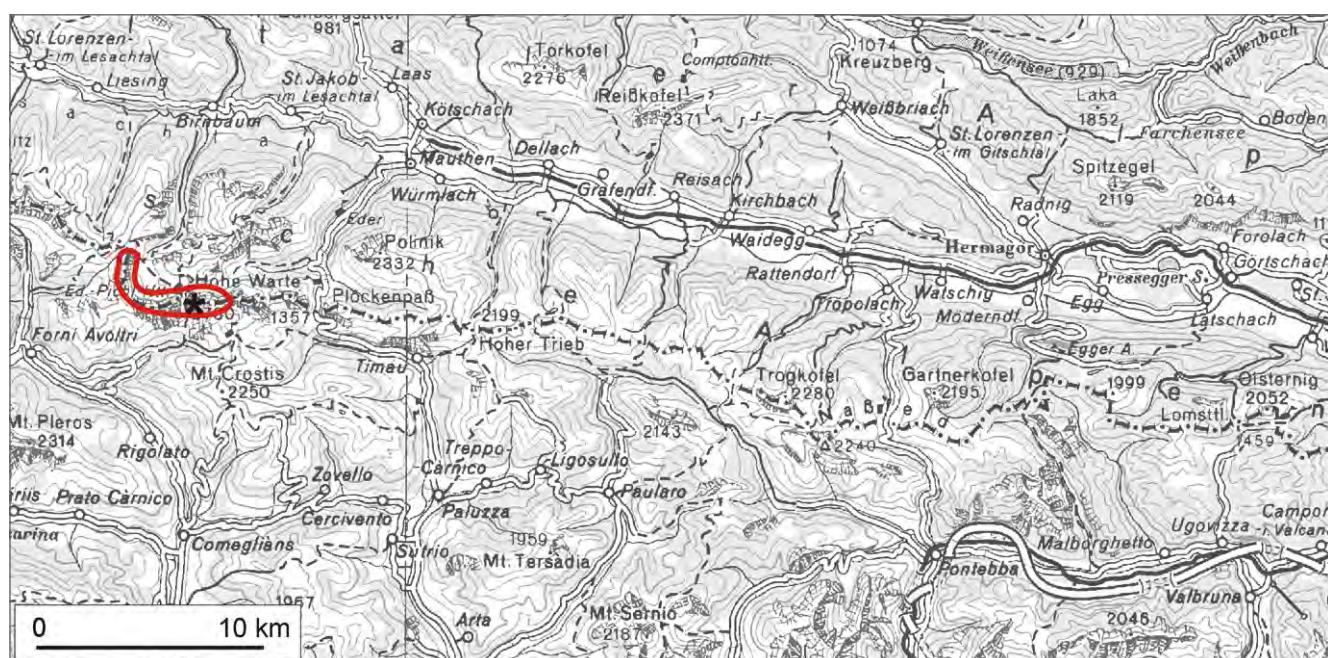
Well-bedded (0.5-3 m thick) gray fossiliferous limestones intercalated with laminated yellow-stained dolostone beds (10-30 cm thick). Common components are large oncoids and gastropods. Meter-long red mudstone layers, birdseye structures, graded bedding, flat-pebble lithoclasts and cavities lined with fibrous calcite are characteristic for this unit.

Description

The Lambertenghi Formation consists of thick-bedded dolomite-rich packstones to rudstones and laminites. The succession begins at the base of Mt. Seewarte above the dark-gray Seewarte Formation with abundant gastropods with vaguely bedded dense limestones intercalated with thin dolostone beds. Partially dolomitized oncoids and poorly sorted shell fragments can be recognized herein. The limestones become more fossiliferous up-section and stromatoporoids, calcareous algae and gastropods become abundant. The gray limestone beds measure between 0.5-3 m in thickness and the intercalated laminated dolostone beds are 0.1-0.3 m thick. Thin yellow-tinted beds are built by components where algal coats have been altered to iron-rich dolomite. Characteristic are graded beds with coarse bioclastic components and large oncoids which become finer-grained upwards and are succeeded by bindstones and fibrous calcite layers or cavities. Laminitic dolomite-rich beds often cap these successions. Infrequently lithoclastic beds with cm to dm-sized angular clasts of mudstone and sediment-filled cracks can be observed.

Fossil content

Calcareous algae, bivalves, brachiopods, rugose and tabulate corals, conodonts, echinoderms, foraminifers, gastropods, ostracods, stromatoporoids.



Areas of outcrop of the Lambertenghi Formation with indication of the stratotype (asterisk).



The Seewarte Section. a) simplified log of the Lambertenghi Formation; b) panoramic view of the Seewarte Section where Lambertenghi Formation is exposed at the base (photo T.J. SUTTNER).

Depositional environment

Sediments of the Lambertenghi Formation are indicative of deposition in shallow subtidal to intertidal hypersaline lagoon (BANDEL, 1972; POHLER, 1982).

Stratotype

Mt. Seewarte Section, western walls where base is exposed at coordinates N 46°36'22", E 12°52'15" (VAI, 1963; BANDEL, 1972; POHLER, 1982).

Reference sections -

Type area

Central Carnic Alps.

Main outcrop areas

The Lambertenghi Formation crops out mainly at Lake Wolayer (Hohe Warte, Seewarte, Seekopf) and Biegengebirge sectors. It is present in the Gamskofel Massif and possibly at Mt. Polinik.

Thickness

About 110 m at the stratotype section (Base of Mount Seewarte).

Boundaries

Underlying units – Seewarte Formation (conformable).

Overlying units – Spinotti Formation (conformable gradual, but faulted at type section).

Lateral units – Polinik Formation, Kellerwand Formation.

Derivation of name

After Rifugio Lambertenghi e Romanin in the vicinity of the Formations' stratotype at Mt. Seewarte (KREUTZER, 1992a, b).

Synonymy

Riffkalk-Facies der Stockwerke H-G-H [partim]: STACHE (1884).

Calcare con Karpinskya consuelo: GORTANI (1913).

Riffkalk mit *Karpinskyia consuelo*: GAERTNER (1931).
 Strati (o Calcari) a *Karpinskyia Consuelo*: DAL PIAZ & TREVISAN (1956).
 ZONA A *KARPINSKYA consuelo*: SELLI (1963).
 Consuelo-Laminit: VAI (1963).
Schichten mit K. consuelo: PÖLSLER (1967).
 Gebankter Laminitkalk mit *Karpinskyia consuelo*: SCHÖNLAUB (1971–1973).
 Onkoidkalke mit Algenkrusten: BANDEL (1972).
Consuelo Lst.: SCHÖNLAUB (1980).
Consuelo-Laminit-Kalk: SCHÖNLAUB (1985).
 Gebankte Laminitkalke: KREUTZER (1990).
 Laminit-Kalk: SCHÖNLAUB (1991).
 Laminierte geschichtete Kalke und Dolomite: SCHÖNLAUB (1991).
 Lambertenghi-Kalk: KREUTZER (1992b).

Chronostratigraphic age

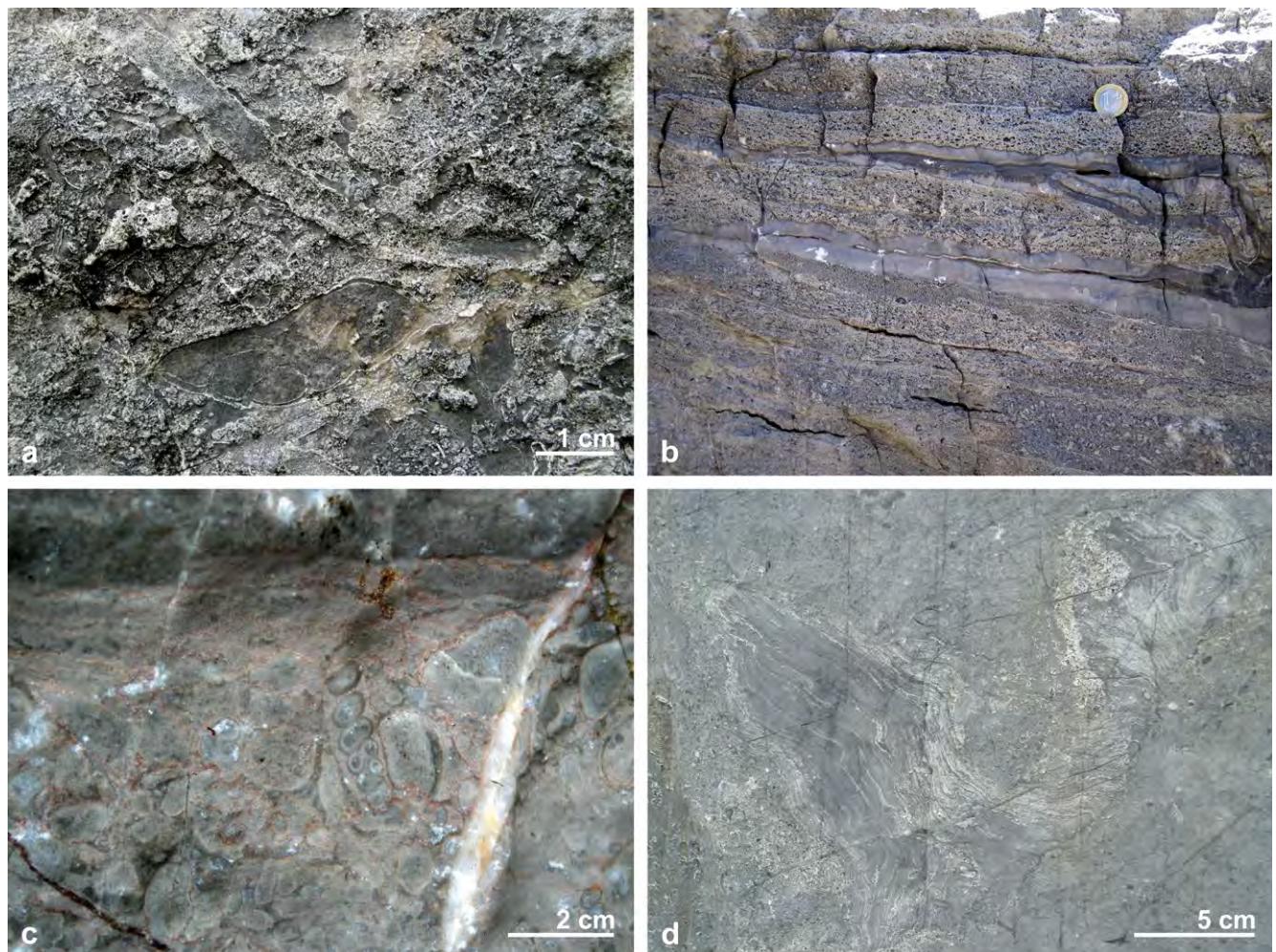
Devonian: Emsian (VAI, 1963; BANDEL, 1972; KREUTZER, 1992a: 270; SCHÖNLAUB et al., 2004: 19).

Biostratigraphy

Brachiopods. – *Karpinskyia consuelo* (GORTANI, 1913).

Complementary references -

Remarks -



Views of the Lambertenghi Formation lithologies. a) rock surface consisting of pack- to grainstone with numerous algal-coated grains and larger bioclasts such as gastropods or stromatoporoids (photo T.J. SUTTNER); b) shallowing upward sequences of rimmed grainstones alternating with algal laminites (photo T.J. SUTTNER); c) oncoid limestone (photo E. Kido); d) partially dolomitized stromatoporoid (photo T.J. SUTTNER).

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Spinotti Formation

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Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3116 Sonnenalpe Naßfeld

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Definition

A heterogenic unit characterized by basal bioclastic stromatoporoid rudite succeeded by peloid- and cortoid-rich grainstone intercalated with birdseye limestone and *Amphipora* limestone. Dolomite-rich algal laminites occur infrequently (POHLER, 1982).

Description

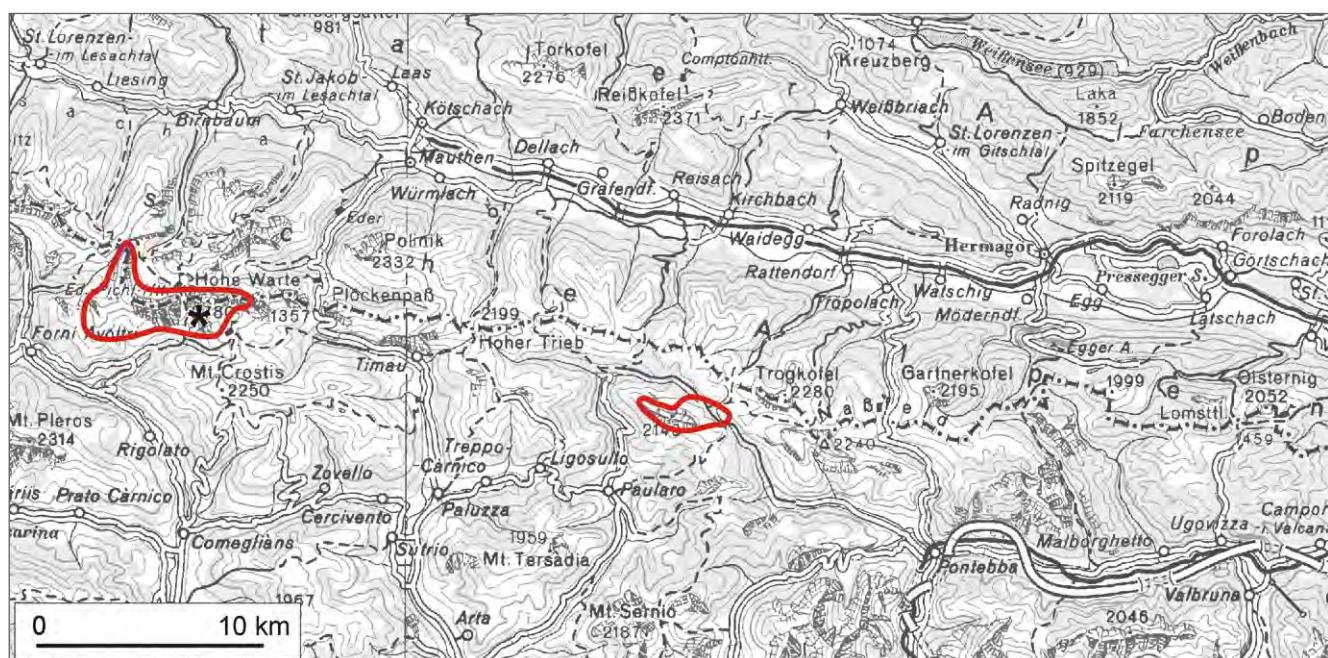
The Spinotti Formation can be subdivided into three units: Unit 1, a lower massive stromatoporoid and crinoid-rich bioclastic limestone (from the onset of massive limestone below the ladder at 1880 m to elevation 1970 m at Sentiero Spinotti; elevation 1840-1860 m at Seekopf base), followed by Unit 2, a thick-bedded to massive light gray grainstone to rudstone. Beds are two to three meters thick with thin (25-30 cm) dolomitic interbeds. Higher up section the bed thickness decreases to 0.5-1 m and dolomite beds become more prevalent. Components are largely peloids and intraclasts comparable to the Eiskar Limestone described by KREUTZER (1990, 1992a). Unit 3 is characterized by bedded limestone with well-developed birdseye structures from elevation 2020 m to 2200 m. Dark limestones with *Amphipora* become more common in this upper part. Above the trail at 2120 m are bedded limestones with *Stringocephalus* exposed. This unit also contains many gastropods and amphipores. BANDEL (1972: 30) observed stringocephalids in the area called "dolines" beyond Costone Stella at elevation 2180 m. These cannot be correlated with the ones at 2120 m and must belong to a higher stratigraphic unit, suggesting that the Eifelian-Givetian boundary is located approximately in the middle of the section.

Seewarte base: At elevation 1680 m Birdseye limestones begin with dolomitic laminites beds.

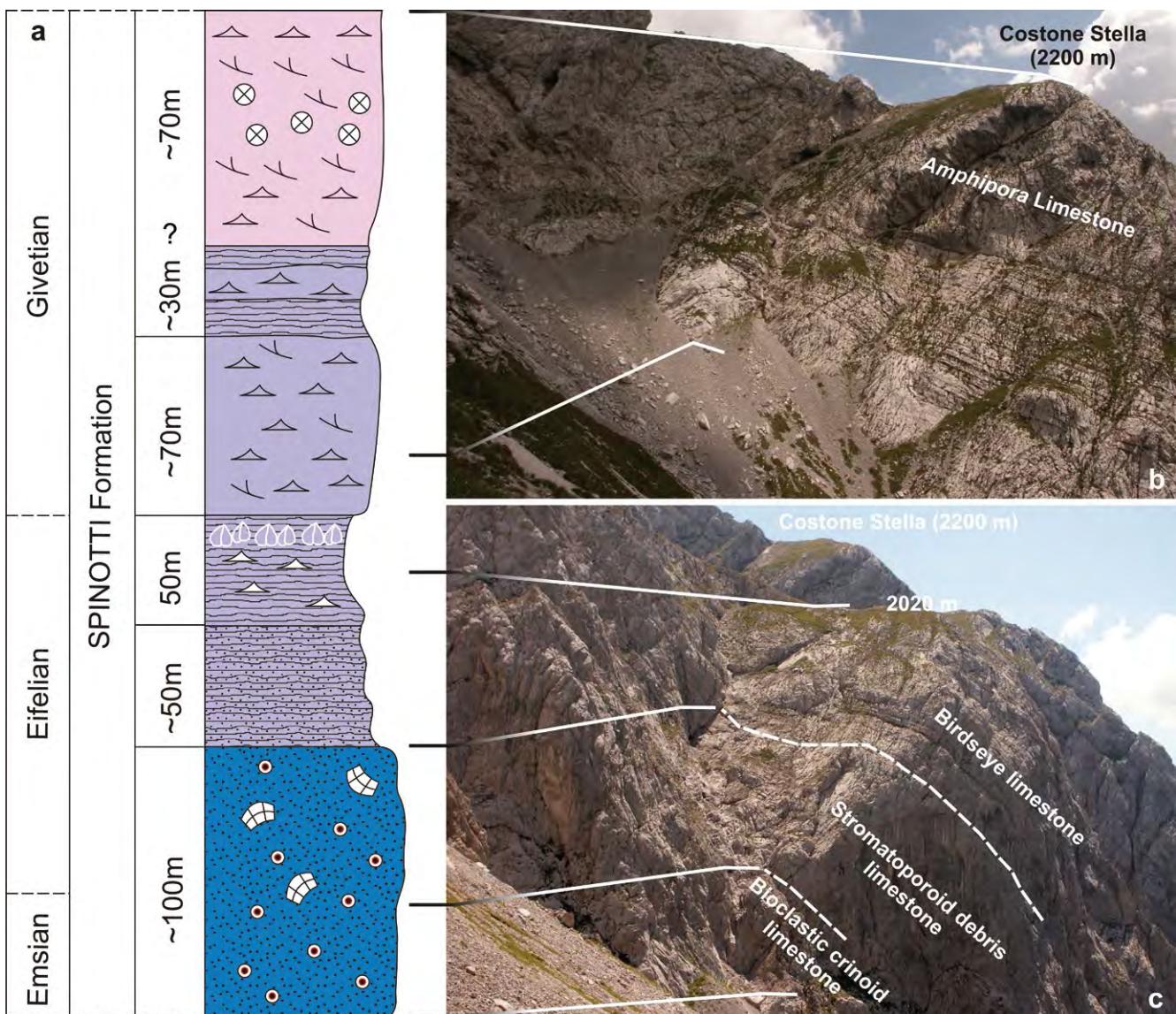
Seekopf base/ Rio Landri: Birdseye limestones set in at elevation 1820 m.

Trail to Collina: Birdseye limestones set in at elevation 1530 m.

Amphipora-rich limestones occur at the crossing between road and trail to Rifugio Marinelli at elevation 1400 m.



Areas of outcrop of the Spinotti Formation with indication of the stratotype (asterisk).



The Sentiero Spinotti Section. a) simplified log of type section (modified after POHLER, 1982); b-c) the formation is subdivided into three units and starts with the onset of massive limestone below the ladder at elevation 1880 m to estimated termination of the section at fault contact with the Hochwipfel Formation (photos H.P. SCHÖNLAUB).

Fossil content

Unit 1: Brachiopods, rugose and tabulate corals, stromatoporoids.

Unit 2: Bivalves, brachiopods, bryozoans, calcareous algae, calcispheres, rugose and tabulate corals, foraminifers, gastropods, ostracods, radiospheres, massive and branching stromatoporoids.

Unit 3: Algae, bivalves, brachiopods, bryozoans, calcispheres, rugose and tabulate corals, foraminifers, gastropods, ostracods, radiospheres, stromatoporoids.

Depositional environment

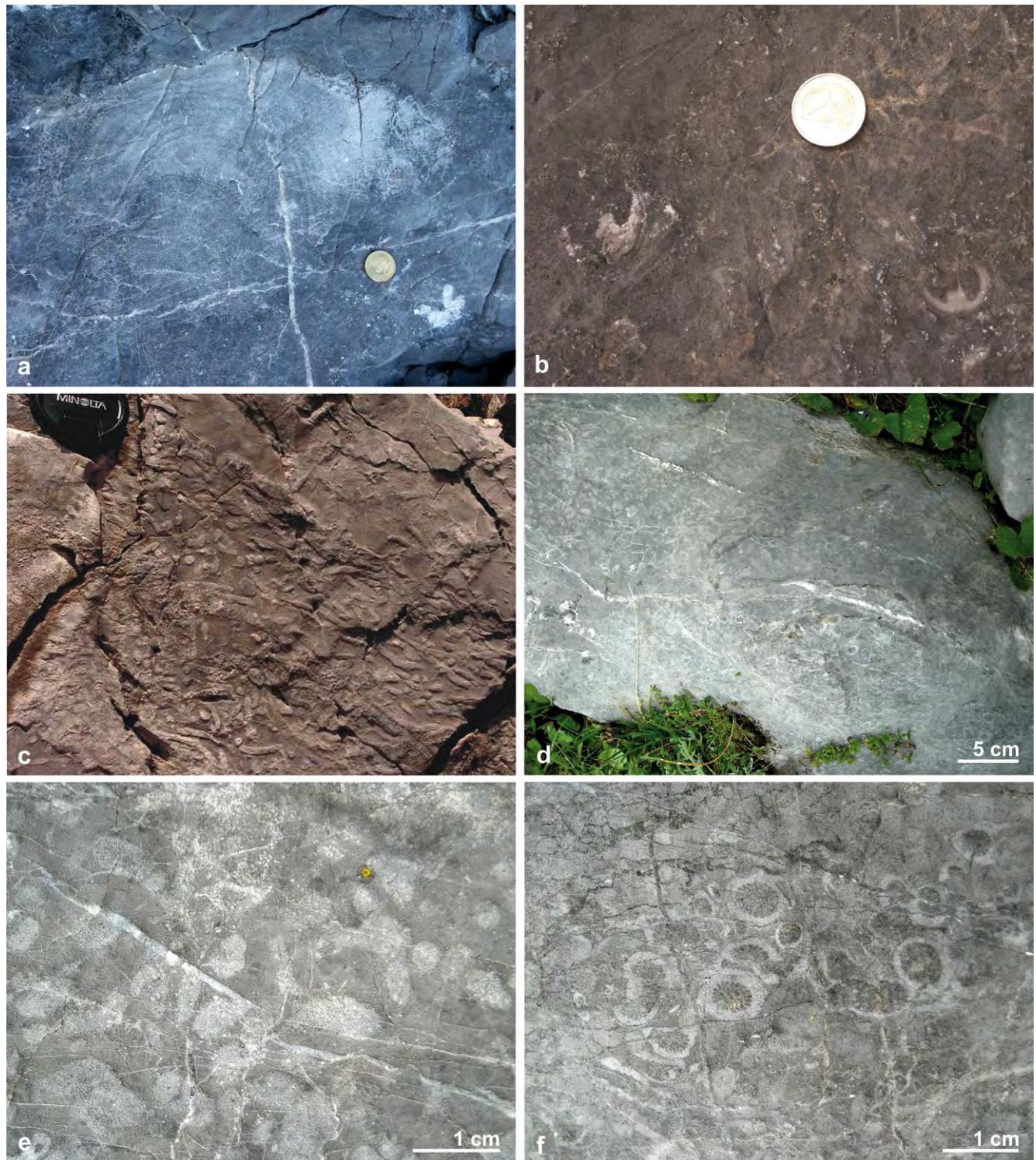
Unit 1 was deposited in a near-reef environment as it contains bioclasts of reef-building organisms.

Unit 2 is a shelf edge or outer ramp deposit similar to the peloid-cortoid rich grainstones known from the Eiskar section (KREUTZER, 1990; 1992b).

Unit 3 is characteristic of intertidal to shallow subtidal conditions with limited water energy.

Stratotype

Trail along Sentiero Spinotti (Hoher Gang) between Rifugio Lambertenghi-Romanin and Rifugio Marinelli at coordinates N 46°36'06", E 12°52'26" (POHLER, 1982; KREUTZER, 1992a).



Views of the Spinotti Formation in the field. a-c) Sentiero Spinotti Section (photos H.P. SCHÖNLÄUB). a) massive limestone with large colonies of corals and stromatoporoids from the base of the formation. b) beds with *Stringocephalus*; c) rock surface with abundant *Amphipora*; d-f) *Amphipora* Limestone at Cason di Lanza (photos T.J. SUTTNER). e-f) detailed view on rock surface with abundant *Amphipora* and rugose corals.

Reference sections -

Type area

Carnic Alps.

Main outcrop areas

The Spinotti Formation crops out mainly in Central Carnic Alps (Mt. Hohe Warte, Kellerwand, Seewarte, Seekopf and Biegengebirge). It is well developed at Monte Zermula (FERRARI & VAI, 1966), Cason di Lanza (CORRADINI et al., 2012) and Cima Ombladet (GALLI, 1985).

Thickness

Variable from 210 m at Mt. Hohe Warte to about 370 m at Mt. Seewarte.

Boundaries

Underlying units – Lambertenghi Formation (conformable contact).

Overlying units – Kellergrat Formation (conformable, gradual contact).

Lateral units – Kellergrat Formation, Polinik Formation, Vinz Formation, Cellon Formation.

Derivation of name

After Sentiero Spinotti, a trail that traverses outcrops of the limestone succession (KREUTZER, 1992a).

Synonymy

Riffkalk-Facies der Stockwerke H-G-H [partim]: STACHE (1884).

Calcare con *Pentamerus* aff. *Pseudo-baschkiricus*: GORTANI (1913).

Pentamerenkalke, Riffkalk mit *Pentamerus* aff. *pseudobaschkiricus*: GAERTNER (1931).

Strati (o Calcare) a *Pentamerus* cfr. *pseudo-baschkiricus*: DAL PIAZ & TREVISAN (1956).

ZONA A *PENTAMERUS*: SELLI (1963).

ZONA A *STRINGOCEPHALUS burtini*: SELLI (1963).

La serie calcarea di M. Zermula [partim]: FERRARI & VAI (1966).

Pentamerus Limestone (Eifelian) and *Stringocephalus* Limestone (Givetian): FLÜGEL (1967).

Stromatoporen-Korallen-Crinoidenkalk: SCHÖNLAUB (1971–1973).

Gebankter Birdseye-Amphiporen-Brachiopoden-Kalk: SCHÖNLAUB (1971–1973); SCHÖNLAUB (1985).

Pentamerus Lst.: SCHÖNLAUB (1980).

Amphipora Lst.: SCHÖNLAUB (1980).

Amphipora-Kalk: SCHÖNLAUB (1985).

Korallen/Crinoiden-K.: SCHÖNLAUB (1985); SCHÖNLAUB (1991).

Stromatoporen-Korallen-Crinoidenschuttkalk: SCHÖNLAUB (1985).

Crinoiden-Kalk and Birdseye-Kalk: KREUTZER (1990).

Amphiporenkalk: SCHÖNLAUB (1991).

Fossilschuttkalke: SCHÖNLAUB (1991).

Geschichtete „Birdseye“-Kalke: SCHÖNLAUB (1991).

Eiskar Limestone [partim]: KREUTZER (1992b).

Calcare a *Pentamerus*: CARULLI (2006).

Calcare ad *Amphipora*: CARULLI (2006).

Calcare a *Stringocephalus*: CARULLI (2006).

Chronostratigraphic age

Devonian: Emsian to Givetian (VAI, 1963; BANDEL, 1972; SCHÖNLAUB et al., 2004: 15–16).

Biostratigraphy

Brachiopods. – *Stringocephalus burtini* (BANDEL, 1972; POHLER, 1982).

Complementary references -

Remarks

SCHÖNLAUB & FLAJS (1975) noted the different thickness of the Spinotti Formation at Seewarte and Hohe Warte where the Eifelian-Givetian boundary is located at about 2760 m (here beds with *Stringocephalus burtini*) suggesting a thickness of 210 m for the Spinotti Formation. At Seewarte up to the yellow Bank where the *Stringocephalus* crops out the section measures about 200 m, which is in good agreement with the Hohe Warte succession. At Hohe Warte, reef limestones are exposed at the peak of the mountain and are also encountered along the track down south, whereas at the southern massif of Seewarte (Costone Stella down to Rio Moraret) the entire section is still composed of *Amphipora* and Birdseye Limestone with no trace of the reefal Kellergrat Formation. It has to be concluded that the Spinotti Formation is in part a lateral equivalent of the Kellergrat Formation.

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Kellergrat Formation

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Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3116 Sonnenalpe Naßfeld

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Compact massive reefal limestones (Frame- and Bafflestone, Float- and Rudstone) with large stromatoporoids and corals either *in situ* or as bioclasts.

Description

Massive gray limestone with abundant bioclasts and biogenes or reef-building organisms. Largest biogenes are stromatoporoid colonies and tabulate and colonial rugose corals. *Amphipora* and *Stachyodes* are common accessory reef-builders.

Fossil content

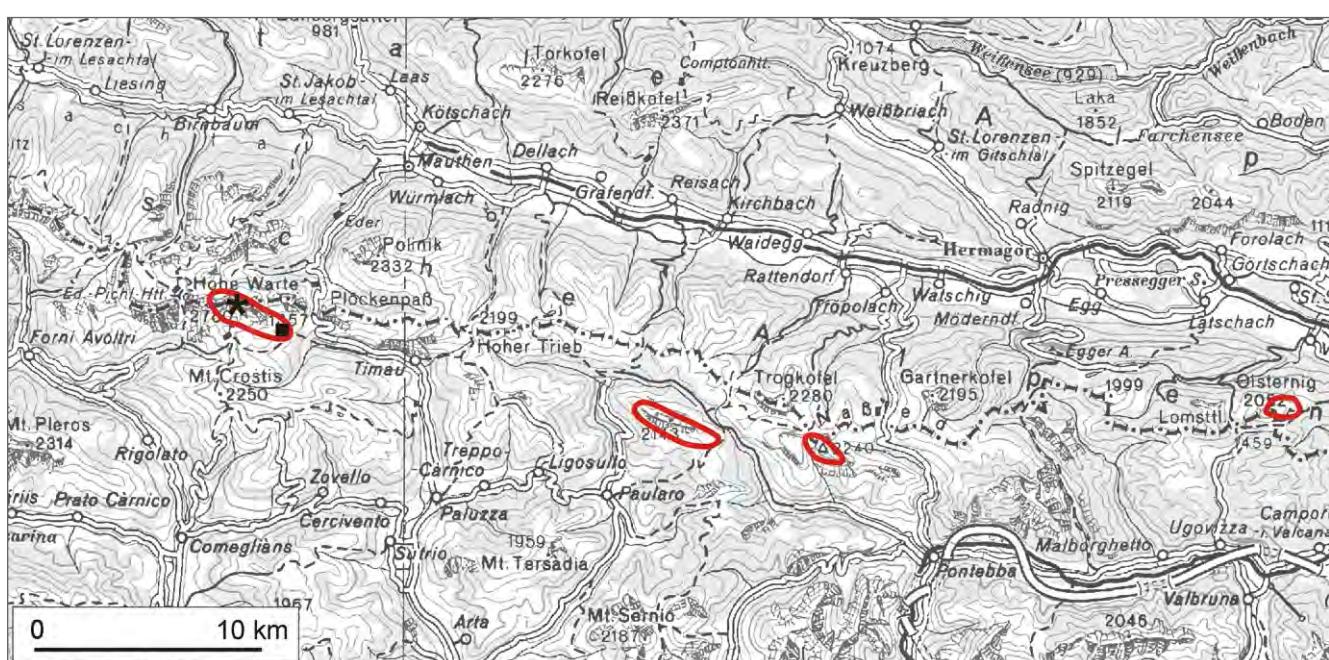
Brachiopods, calcareous algae, calcispheres, conodonts, rugose and tabulate corals, echinoderms, gastropods, stromatoporoids, trilobites.

Depositional environment

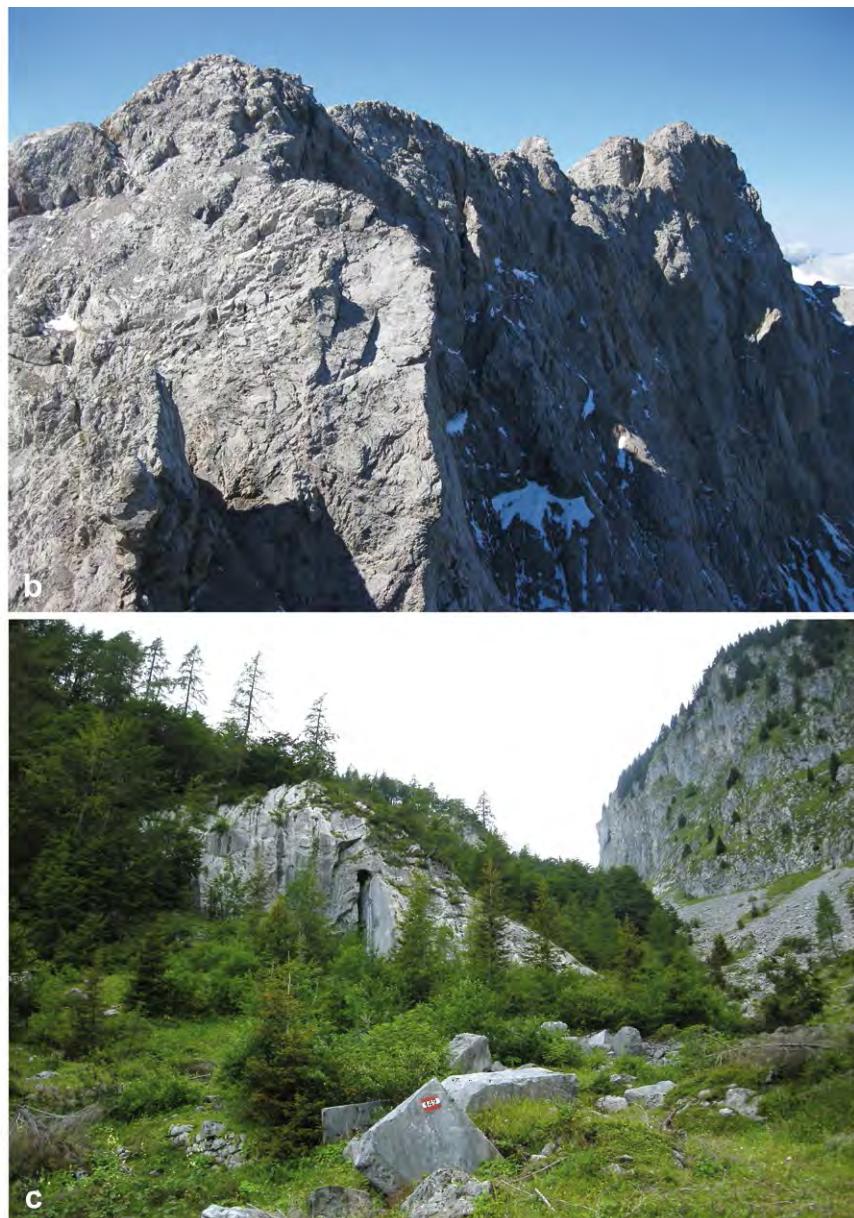
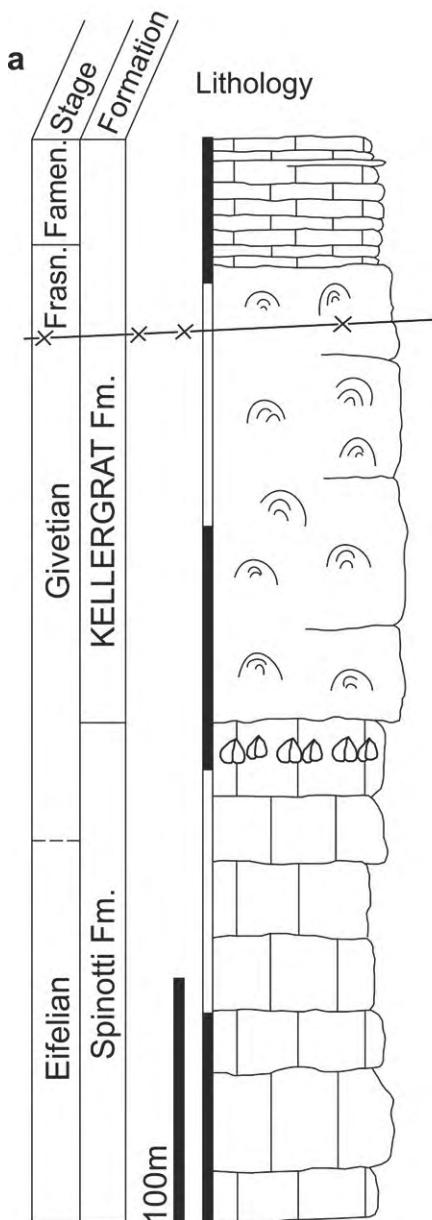
Neritic reef limestone.

Stratotype

Kellergrat (located between the Kellerspitzen to the West and the Kollinkofel/Creta di Collina to the East, N 46°36'39", E 12°54'04").



Areas of outcrop of the Kellergrat Formation with indication of the stratotype (asterisk) and reference section (square).



The Kellergrat Section. a) simplified log and b) photo of the stratotype section at Kellergrat measured by KREUTZER (1990) between Kellerspitzen and Kollinkofel. Somewhere between Givetian and Frasnian is a fault shown. Probably substantial parts of the section are missing (photo H.P. SCHÖNLÄUB). c) auxiliar section at the abandoned quarry along trail #149 to Collina (photo T.J. SUTTNER).

Reference sections

Abandoned quarry along trail n. 149 to Collina (GORTANI, 1911), where the base of the unit is easily accessible and reef deposits are well visible on the polished quarry walls (coordinates N 46°35'41.64", E 12°55'36.26").

Type area

Central Carnic Alps.

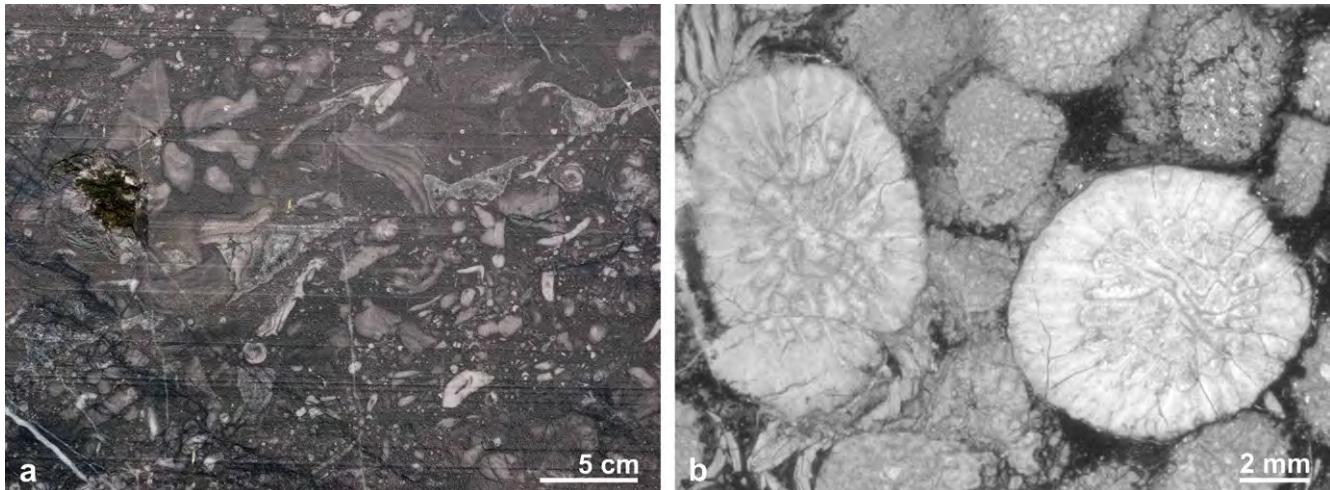
Main outcrop areas

The Kellergrat Formation crops out along the main peaks of the Central Carnic Alps, mainly at Mts. Kellerspitzen (Cime di Chianevate), Hohe Warte (Mte. Coglians), and on the southern slopes of these massives (Creta di Collina, Casera Val di Collina, Collina Grande).

Quarries above Rio Chiaula (VAL 1963; BANDEL 1972)

Thickness

More than 180 m (KREUZER, 1990)



Important bioconstructors and bioclasts of the Kellergrat reef. a) corals, crinoids and brachiopods (photo H.P. SCHÖNLAUB); b) well-preserved rugose corals and *Amphipora* (photo E. Kido).

Boundaries

Underlying units – Spinotti Formation (conformable contacts).

Overlying units – Creta di Collina Formation (conformable contacts).

Lateral units – Spinotti Formation, Polnik Formation, Freikofel Formation, Cellon Formation, Vinz Formation.

Derivation of name

After the Kellergrat between Mt. Kollinkofel/Creta di Collina in the east and Mt. Kellerspitzen in the west (KREUTZER, 1990).

Synonymy

La serie calcarea di M. Zermula [partim]: FERRARI & VAI (1966).

Stromatoporen-Korallen-Riffkalk im Gipfelbereich der Hohen Warte: SCHÖNLAUB (1971–1973).

Phillipsastrea Lst.: SCHÖNLAUB (1980).

Phillipsastrea-Kalk: KREUTZER & SCHÖNLAUB (1984).

Stromatoporen/Korallenschutt-K.: SCHÖNLAUB (1985).

Philipsastrea/Brachiop.-K.: SCHÖNLAUB (1985).

Eiskar-Kalk [partim]: KREUTZER (1990, 1992).

Riff-Kalk: KREUTZER (1990).

Korallenkalk: SCHÖNLAUB (1991).

Korallen-Stromatoporen-Kalk und *Phillipsastrea*-Kalk: KREUTZER (1992).

Riffkalke im Gipfelbereich der Hohen Warte und der Kellerwände: OEKENTORP-KÜSTER & OEKENTORP (1992).

Givetische Rindenkornkalke der Hohen Warte und des Kollinkofels [partim]: OEKENTORP-KÜSTER & OEKENTORP (1992).

Calcaria a *Phillipsastrea*: CARULLI (2006).

Chronostratigraphic age

Devonian: Lower Givetian to Frasnian (SCHÖNLAUB, 1985; KREUTZER, 1990).

Biostratigraphy

Conodonts. – From the *timorensis* Zone (SUTTNER, unpublished data) to the Early *rhenana*-Zone (KREUTZER, 1990).

Rugose corals. – *Scruttonia julli* (PEDDER, 1986) indicates Frasnian age for the upper part of the formation (KÜSTER, 1987).

Complementary references -

Remarks

HERITSCH (1943) provides a comprehensive list of fossils found in the Kellergrat Formation by various workers including Vinassa de Regni, Gortani and Geyer.

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Creta di Collina Formation

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MONICA PONDRELLI, HANS PETER SCHÖNLAUB, THOMAS J. SUTTNER & GIAN BATTISTA VAI

Österreichische Karte 1:50.000

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Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Definition

Dark gray brachiopod-rich (rhynchonellids) limestone intercalated with lithoclastic layers (FERRARI & VAI, 1973; KREUTZER, 1990, 1992).

Description

The Creta di Collina Formation consists of different interbedded facies. The stratotype section is composed of brachiopod-crinoidal calcarenite and calcilutite (mainly packstone, biopelssparite) with some breccias layers (rudite), brachiopod coquinite with calcilutite (packstone) intercalations, and brachiopod crinoidal calcilutite. At Porto di Cozzi the main units are dark gray calcarenite to calcilutite with scattered brachiopods and crinoid fragments (packstone), brachiopod coquinite, and brachiopod-crinoidal calcarenite (mainly packstone).

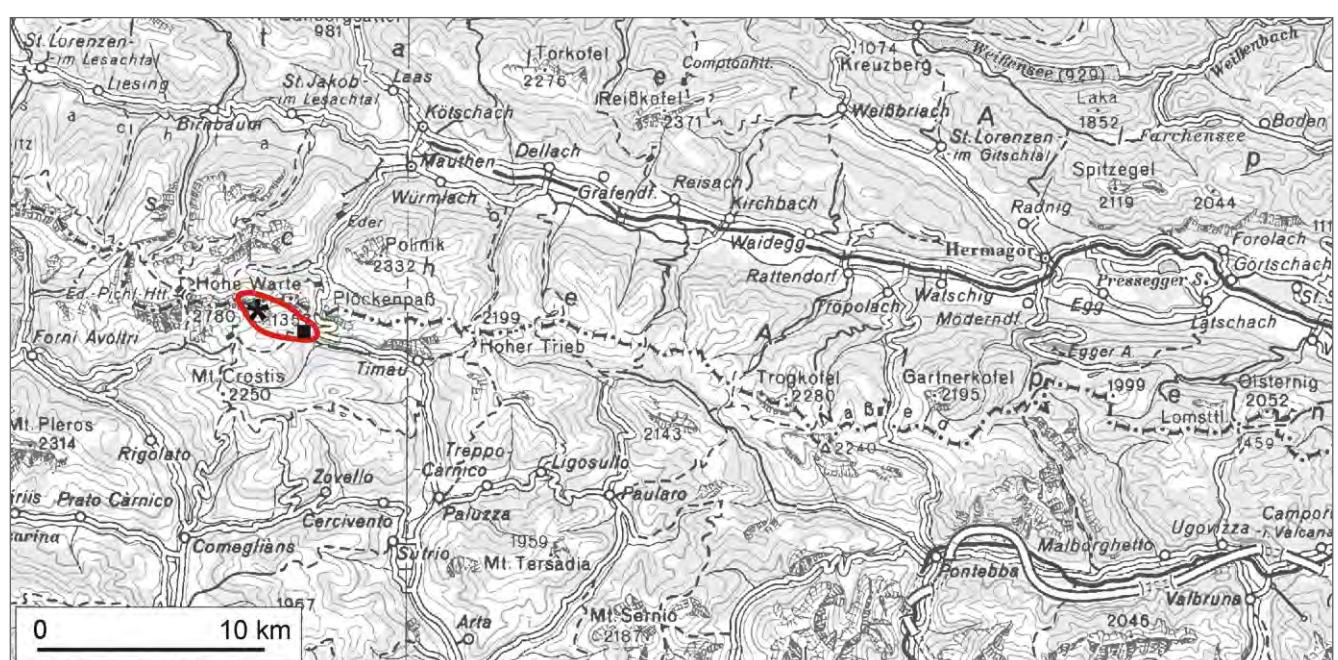
Fossil content

Brachiopods, cephalopods, conodonts, echinoderms, ostracods, spicules of sponges.

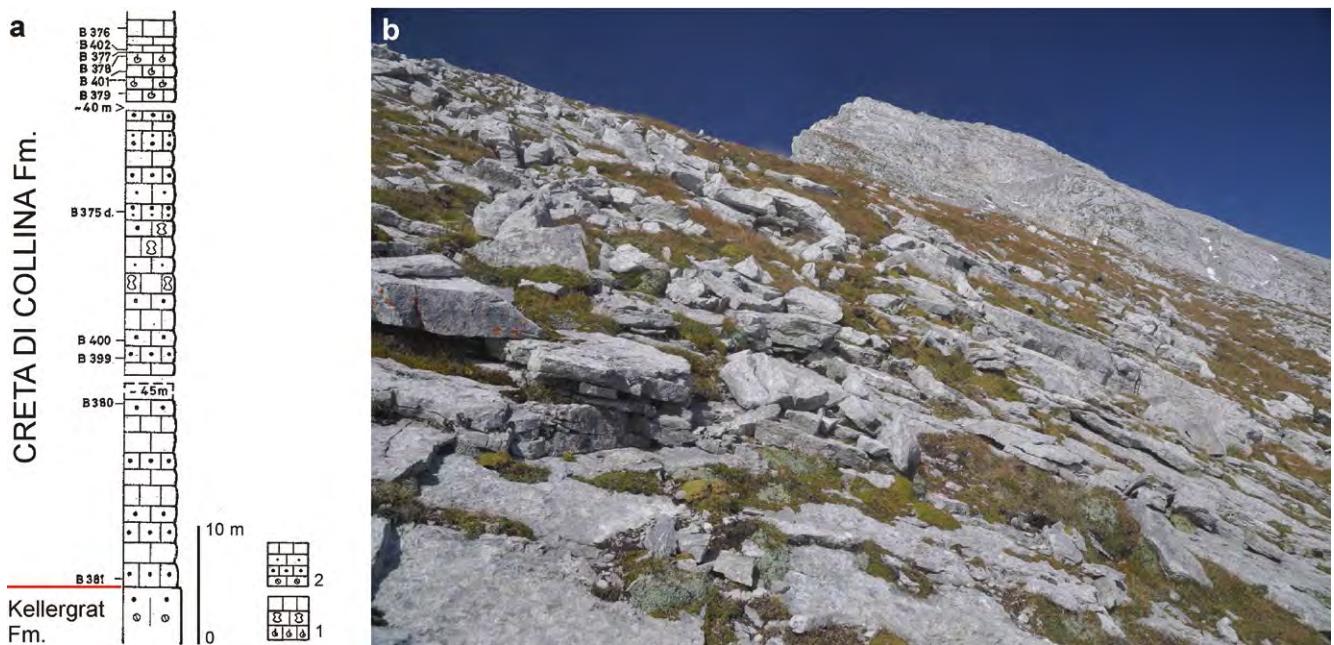
Reworked: *Amphipora* fragments, foraminifers, tabulate corals.

Depositional environment

The Creta di Collina Formation was deposited in a relatively shallow environment of an outer ramp and basin, periodically supplied by gravity-driven re-sedimented deposits.



Area of outcrop of the Creta di Collina Formation with indication of the stratotype (asterisk) and reference section (square).



The Pizzo Collina Section. a) log of the section (modified after FERRARI & VAI, 1973) 1. Coquinite, intraclastic breccia; 2. calcirudite, calcarenite, calcisiltite, calcilutite; b) view of the section in field (photo H.P. SCHÖNLAUB).

Stratotype

Pizzo Collina Section (FERRARI & VAI, 1973), located along the crest defining the oriental side of Creta di Collina, at coordinates N 46°36'21.8", E 12°54'43.5".

Reference sections

Porto di Cozzi Quarry section (FERRARI & VAI, 1973), south of Plöckenpass/Passo di Monte Croce Carnico at coordinates N 46°35'32.2", E 12°56'25.5", where the lithology is slightly different than the type section in an easily accessible outcrop.

Type area

Central Carnic Alps.

Main outcrop areas

The Creta di Collina Formation crops out in the Central Carnic Alps on the southern side of the Creta di Collina/Kollinkofel.

Thickness

About 40 m.

Boundaries

Underlying units – Kellergrat Formation (conformable, sharp contact).

Overlying units – Pal Grande Formation (conformable, sharp contact).

Lateral units – Freikofel Formation, Pal Grande Formation.

Derivation of name

After Creta di Collina (Mt. Kollinkofel).



Views of the Creta di Collina Formation in the field. a) brachiopod coquinite at Creta di Collina (photo H.P. SCHÖNLAUB); b) dark gray calcilutite with brachiopod at Porto di Cozzi Quarry (photo H.P. SCHÖNLAUB).

Synonymy

Unteres Oberdevon am Kollinkofel: FRECH (1887).
Calcari a Brachiopodi: VAI in BRAGA et al. (1971).
Formazione del Pizzo Collina: FERRARI & VAI (1973).
Formazione del Collina: SPALLETTA et al. (1982).
Philipsastrea/Brachiop.-K.: SCHÖNLAUB (1985).
Collina Formation: SPALLETTA & VENTURINI (1990).
Dunkle Rhynchonellenkalke: KREUTZER (1992).
Calciruditi del Freikofel [partim]: SPALLETTA & PONDRELLI (2009).
Kollinkofel-Kalk/Kollinkofel Limestone: SUTTNER (2014).

Chronostratigraphic age

Devonian: Upper part of Frasnian to Famennian.

Biostratigraphy

Conodonts. – Frasnian Zone 12 (upper part of Lower *rhenana* Zone–lower part of Upper *rhenana* Zone) to Upper *marginifera* Zone (PERRI & SPALLETTA, 1998).

Complementary references -

Remarks -

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Kellerwand Formation

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Blatt UTM 3116 Sonnenalpe Naßfeld

Carta Topografica d'Italia 1:50.000
Foglio 018 Passo di Monte Croce Carnico
Foglio 031 Ampezzo
Foglio 032 Tolmezzo

Definition

Prevalent pelagic mudstone/wackestone interbedded with lithoclastic packstone/grainstone and rare floatstone/rudstone (SCHÖNLAUB, 1985; KREUTZER, 1989, 1990, 1992a, b; HUBMANN et al., 2003; SPALLETTA & PONDRELLI, 2009).

Description

The Kellerwand Formation consists of four well-bedded facies listed in order of decreasing abundance.

Facies A: medium dark gray, thin to medium-bedded, wackestone to packstone with moderate yellow thin laminae of silt;

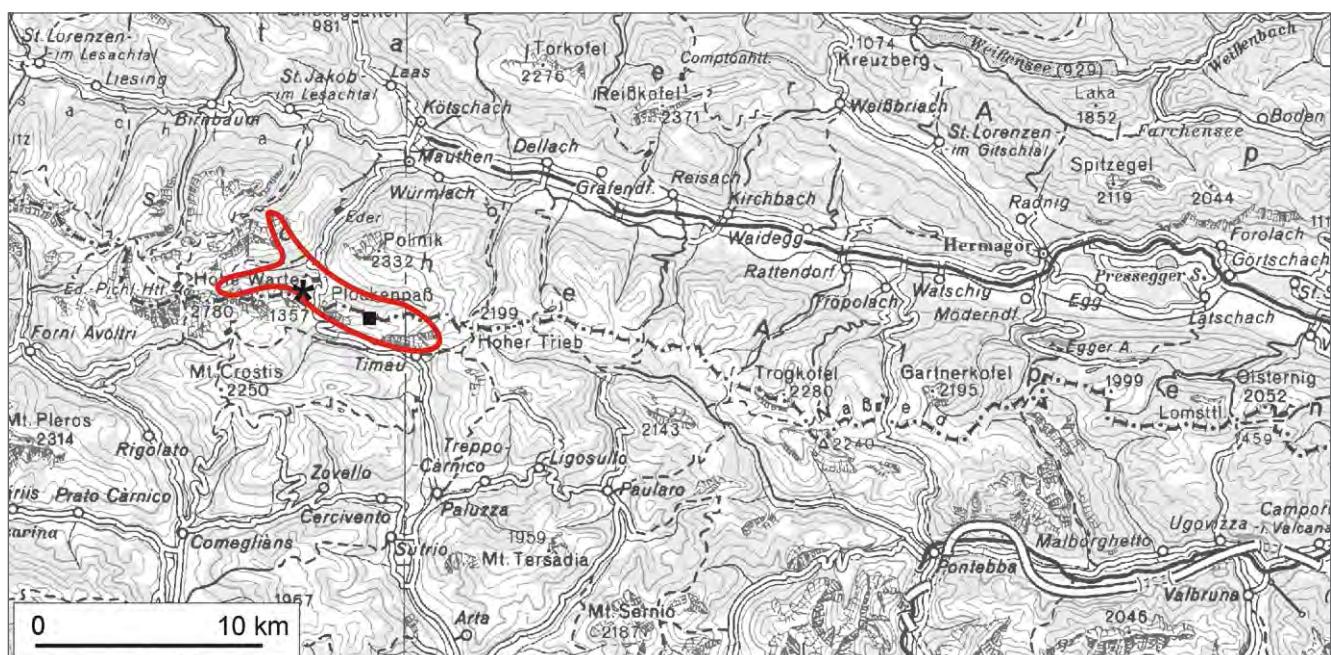
Facies B: medium dark gray, thin to thick bedded, often fining upward, moderately to well sorted and locally laminated grainstone (from very coarse up to granules to fine-grained) to packstone;

Facies C: medium light gray, medium to thick bedded, moderately to well sorted crinoidal-bearing grainstone (biosparite);

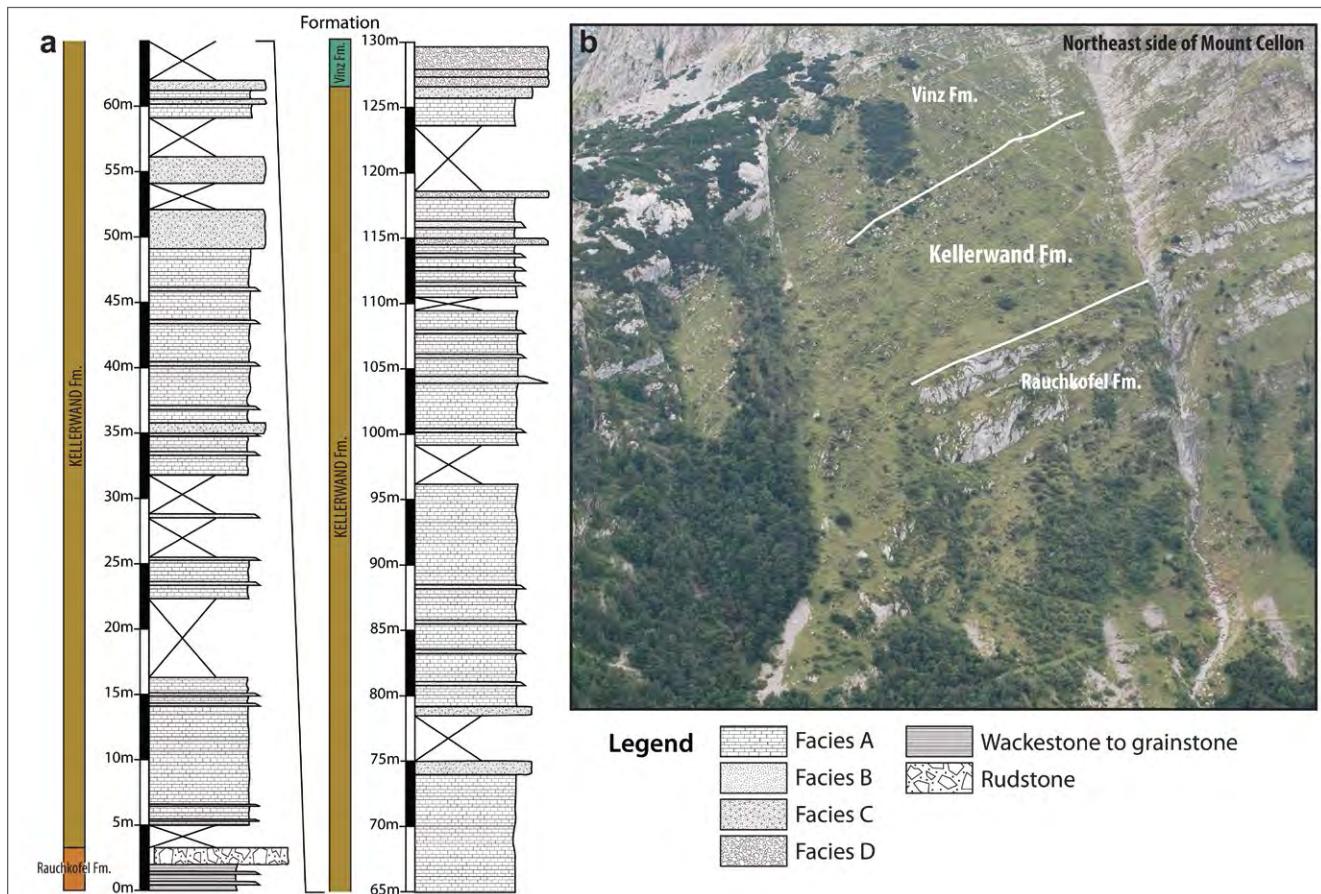
Facies D: medium dark gray, thick bedded, poorly sorted coral-bearing rudstone with clasts up to about 10 cm of diameter and poorly sorted very coarse to fine grainstone matrix.

Fossil content

Conodonts, crinoids, dacryconarids, nautiloids, ostracods and trilobites have been found in the mudstone/wackestone deposits. Reworked bivalves, corals, echinoderms and foraminifers are described from the lithoclastic facies (KREUTZER, 1990, 1992a, b).



Areas of outcrop of the Kellerwand Formation with indication of the stratotype (asterisk) and reference section (square).



The Cellon Section. a) log of the Kellerwand Formation; b) view of the section taken from Pal Piccolo/Kleiner Pal (photo M. PONDRELLI).

Depositional environment

The Kellerwand Formation was deposited in different depositional environments depending on the different facies:

Facies A: pelagic sedimentation (outer ramp and basin);

Facies B: gravity-driven resedimented levels (tempestites) (outer ramp and basin);

Facies C: shoreface (inner ramp);

Facies D: gravity-driven resedimented deposits along a progressively forming slope and toe-of-slope.

Stratotype

Cellon Section, located on the north-eastern slope of Mt. Cellon/Creta di Collinetta (BANDEL, 1972), between coordinates N 46°36'28.1", E 12°56'26.0" (base of the section) and N 46°36'28.5", E 12°56'17.5" (top of the section).

Reference sections

Freikofel south Section, on the southern slope of Mt. Freikofel along the path n. 401 at coordinates N 46°35'55.7", E 12°58'46.7", where the lower boundary of the Formation is better exposed than in the type section.

Type area

Central Carnic Alps.

Main outcrop areas

The Kellerwand Formation crops out in the Rauchkofel area, in the south side of the Valentintal and between the Cellon/Creta di Collinetta and the Creta di Timau.

Thickness

About 95 m (Freikofel) to about 150 m (Kellerwand).

Boundaries

Underlying units – Rauchkofel Formation (conformable sharp contact).

Overlying units – Vinz Formation (conformable interfingering contact).

Lateral units – Hohe Warte Formation, Seewarte Formation (proximal part); Findenig Formation (distal part).

Derivation of name

After the lower Kellerwand below the Eiskar glacier.

Synonymy

Formazione di Monte Lodin [partim]: SELLI (1963).

Calcari stratificati giallastri [partim]: SPALLETTA et al. (1982).

Kellerwand Kalk [partim]: SCHÖNLAUB (1985).

Yellow bedded limestones [partim]: SPALLETTA & VENTURINI (1990).

Gelbe Plattenkalke der Kellerwand [partim]: KREUTZER (1990).

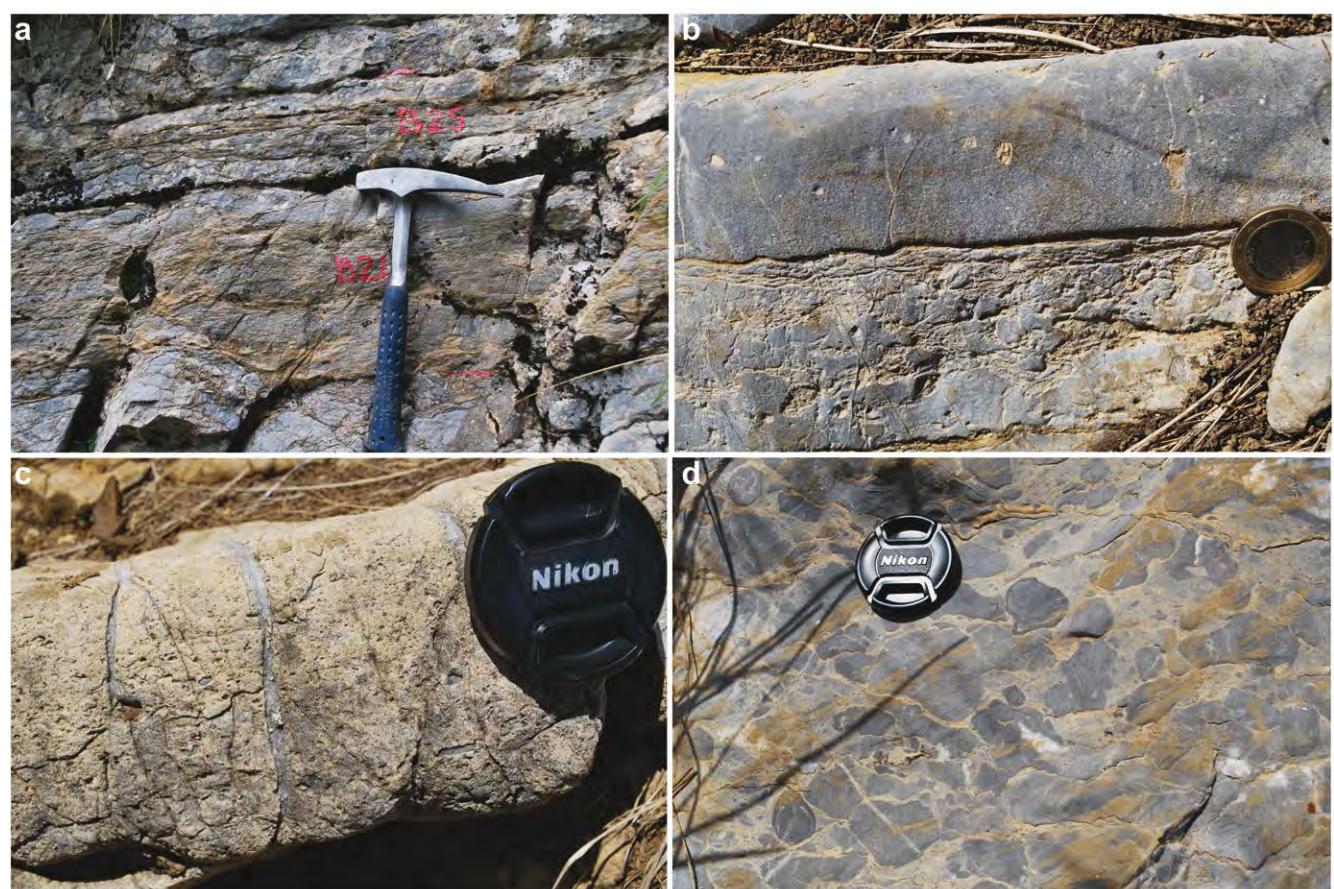
Kellerwand Kalk: KREUTZER (1992a).

Kellerwand limestone: KREUTZER (1992b).

Calcareniti di transizione distali: VENTURINI (2006).

Pal Grande Calcarenite [partim]: BRIME et al. (2008).

Calcareniti di Pal Grande [partim]: SPALLETTA & PONDRELLI (2009).



Views of the Kellerwand Formation in the field (photos M. PONDRELLI). a) Facies A: Freikofel section; b) Facies B: Cellon Section; c) Facies C: Cellon Section; d) Facies D: Cellon Section.

Chronostratigraphic age

Devonian: Pragian to Emsian (KREUTZER, 1990, 1992a, b).

Biostratigraphy

Conodonts. – The Kellerwand Formation spans up to the *inversus* Zone (*laticostatus* Subzone) (Cellon Section).

Complementary references -

Remarks -

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Vinz Formation

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Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Definition

Prevalent stromatoporoid and coral-bearing floatstone/rudstone interbedded with lithoclastic packstone/grainstone and pelagic mudstone/wackestone (KREUTZER & SCHÖNLAUB, 1984; SCHÖNLAUB, 1985; KREUTZER, 1990, 1992a, b; HUBMANN et al., 2003; SPALLETTA & PONDRELLI, 2009; SCHNELLBÄCHER, 2010).

Description

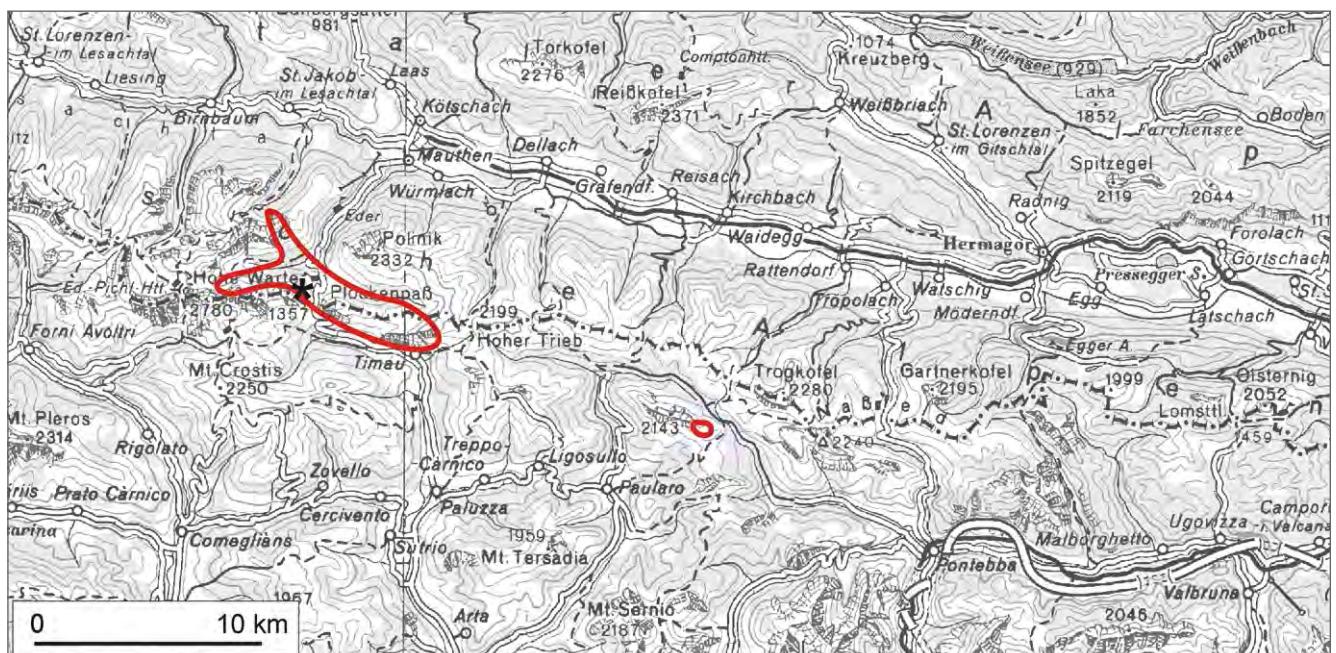
The Vinz Formation consists of four well-bedded facies listed in order of decreasing abundance.

Facies A: well bedded medium dark gray, medium to thick bedded, poorly sorted coral- and stromatoporoid-bearing rudstone (more rarely floatstone) with clasts up to about 10 cm of diameter and poorly sorted very coarse to fine grainstone matrix; sometimes rudstone shows a fining upward trend up to grainstone;

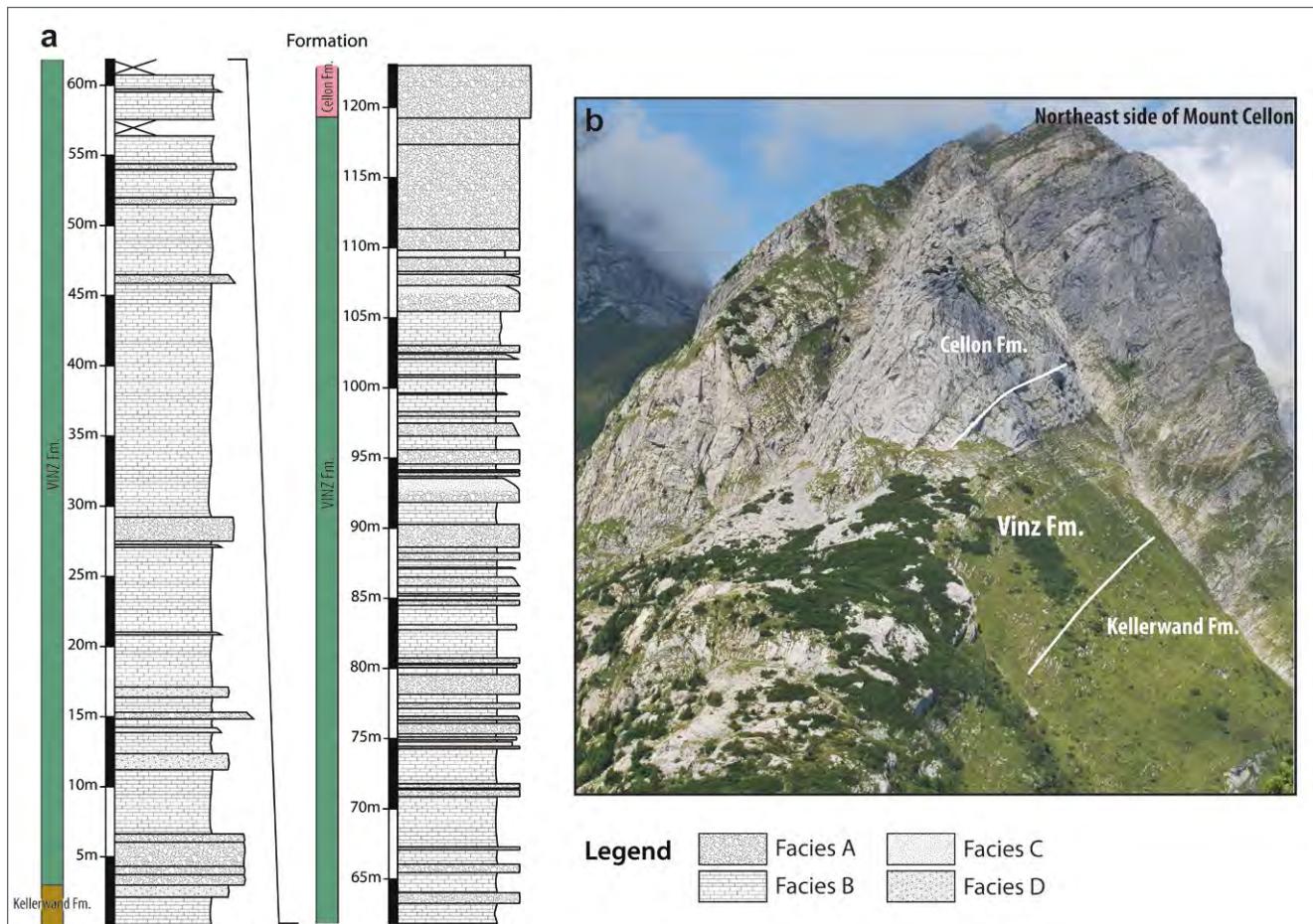
Facies B: medium dark gray, thin to medium bedded, wackestone to packstone with moderate yellow thin laminae of silt;

Facies C: medium dark gray, thin to thick bedded, often fining upward, moderately to well sorted locally laminated grainstone (from very coarse up to granules to fine-grained) to packstone;

Facies D: rare medium light gray, medium to thick bedded, moderately to well sorted crinoidal-bearing grainstone with sparite cement.



Areas of outcrop of the Vinz Formation with indication of the stratotype (asterisk).



The Cellon Section. a) log of the Vinz Formation; b) view of the section taken from Pal Piccolo/Kleiner Pal (photo M. PONDRELLI).

Fossil content

Cephalopods, conodonts, foraminifers, ostracods and tentaculites have been found in the mudstone/wackestone deposits. Reworked bivalves, corals, echinoderms, foraminifers, ostracods and parathuramminaceae are described from the lithoclastic facies (KREUTZER, 1990, 1992a, b).

Depositional environment

The Vinz Formation was deposited in different environments depending on different facies:

Facies A/Facies C: gravity-driven resedimented deposits along the slope and toe-of-slope (some levels in Facies C might still be tempestites);

Facies B: pelagic sedimentation (basin and outer ramp);

Facies D: shoreface (inner ramp).

Stratotype

Cellon Section, located on the north-eastern slope of Mt. Cellon/Creta di Collinetta (BANDEL, 1972), between coordinates N 46°36'28.5" E 12°56'17.5" (base of the section) and N 46°36'25.5" E 12°56'16.4" (top of the section).

Reference sections -

Type area

Central Carnic Alps.

Main outcrop areas

The Vinz Formation crops out in the Rauchkofel area, in the south side of the Valentintal and between the Cellon/Creta di Collinetta and the Creta di Timau. A small outcrop is located south-east of Zermula.



Views of the Vinz Formation in the field (photos M. PONDRELLI); a) Facies A and B: Freikofel A section; b) Facies A: particular of a coral-bearing bed, Cellon Section.

Thickness

About 170 m (Kellerwand) to about 105 m (Freikofel).

Boundaries

Underlying units – Kellerwand Formation (conformable interfingering contact).

Overlying units – Cellon Formation (conformable sharp contact).

Lateral units – Lambertenghi Formation (?), Spinotti Formation (proximal part); Findenig Formation, Hoher Trieb Formation (distal part).

Derivation of name

After the Vinz peak at the lower Kellerwand.

Synonymy

Formazione di Monte Lodin [partim]: SELLI (1963).

Dunkler Plattenkalk: SCHÖNLAUB (1969).

Calcaro stratificati giallastri [partim]: SPALLETTA et al. (1982).

Dunkelgrauer, geflaschter Plattenkalk im Wechsel mit Schuttbrekzien: KREUTZER & SCHÖNLAUB (1984).

Kellerwand Kalk [partim]: SCHÖNLAUB (1985).

Plattenkalke der Unteren Kellerwand [partim]: KREUTZER (1990).

Yellow bedded limestones [partim]: SPALLETTA & VENTURINI (1990).

Vinz Kalk: KREUTZER (1992a).

Vinz limestone: KREUTZER (1992b).

Calcareniti di transizione distali [partim]: VENTURINI (2006).

Calcareniti di transizione prossimali [partim]: VENTURINI (2006).

Pal Grande Calcarenite [partim]: BRIME et al. (2008).

Calcareniti di Pal Grande [partim]: SPALLETTA & PONDRELLI (2009).

Chronostratigraphic age

Devonian: Emsian to lower Givetian (KREUTZER, 1990, 1992a, b).

Biostratigraphy

Conodonts. – The base of Vinz Formation has been assigned to the *inversus* Zone (*laticostatus* Subzone) (Cellon Section) and the top to the *hemiansatus* Zone (Freikofel section).

Complementary references -

Remarks -

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Cellon Formation

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THOMAS J. SUTTNER, ERIKA KIDO, MARIA CRISTINA PERRI, MARIA G. CORRIGA, ANGELO MOSSONI & LUCA SIMONETTO

Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Definition

Stromatoporoid and coral-bearing very thick bedded floatstone/rudstone (BANDEL, 1972, 1974; KREUTZER & SCHÖNLAUB, 1984; SCHÖNLAUB, 1985; KREUTZER, 1990, 1992a, b; HUBMANN et al., 2003; SCHÖNLAUB et al., 2004; SCHNELLBÄCHER, 2010).

Description

Medium dark gray, very thick bedded (more than 10 m), poorly sorted, coral- and stromatoporoid-bearing rudstone and subordinate floatstone with clasts up to ca. 40 cm of diameter and poorly sorted, very coarse to fine grainstone matrix; sometimes rudstone shows a fining upward trend up to grainstone. Sometimes the layer base shows inverse grading with laminated grainstone passing to floatstone/rudstone. However, the deposits are mostly disorganized.

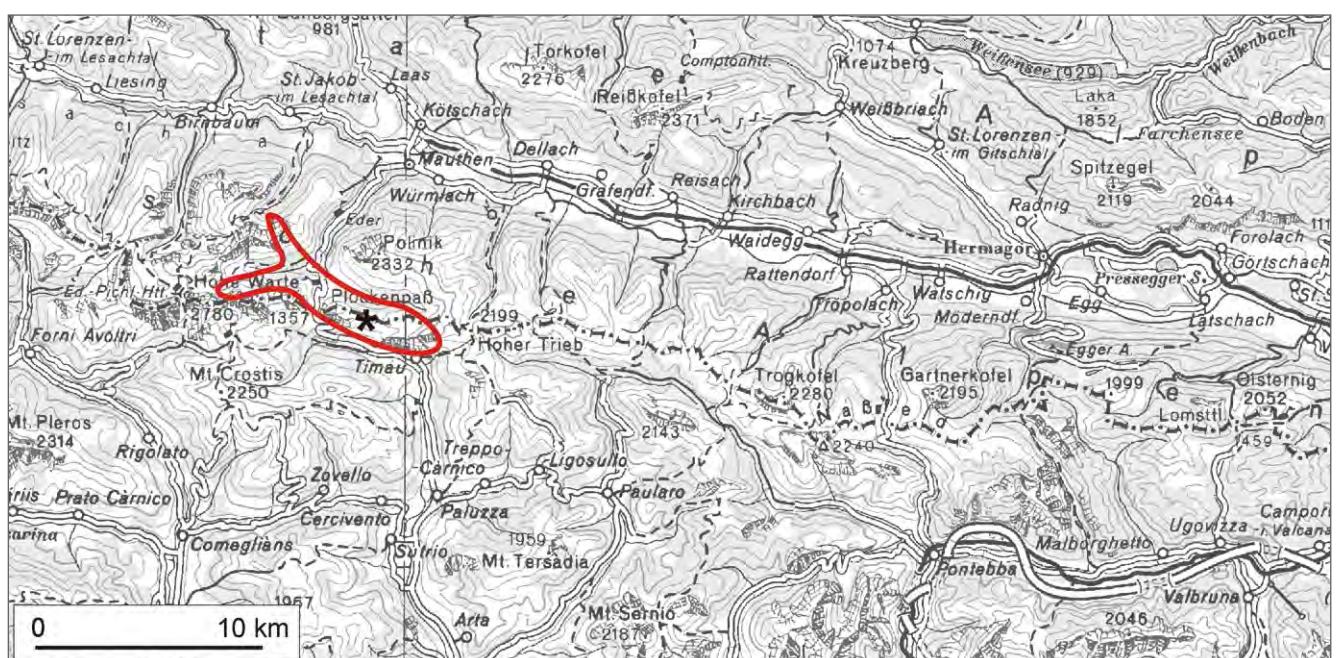
A phosphorite-rich horizon (BANDEL, 1972) is present about 9 meters from the top of the unit.

Fossil content

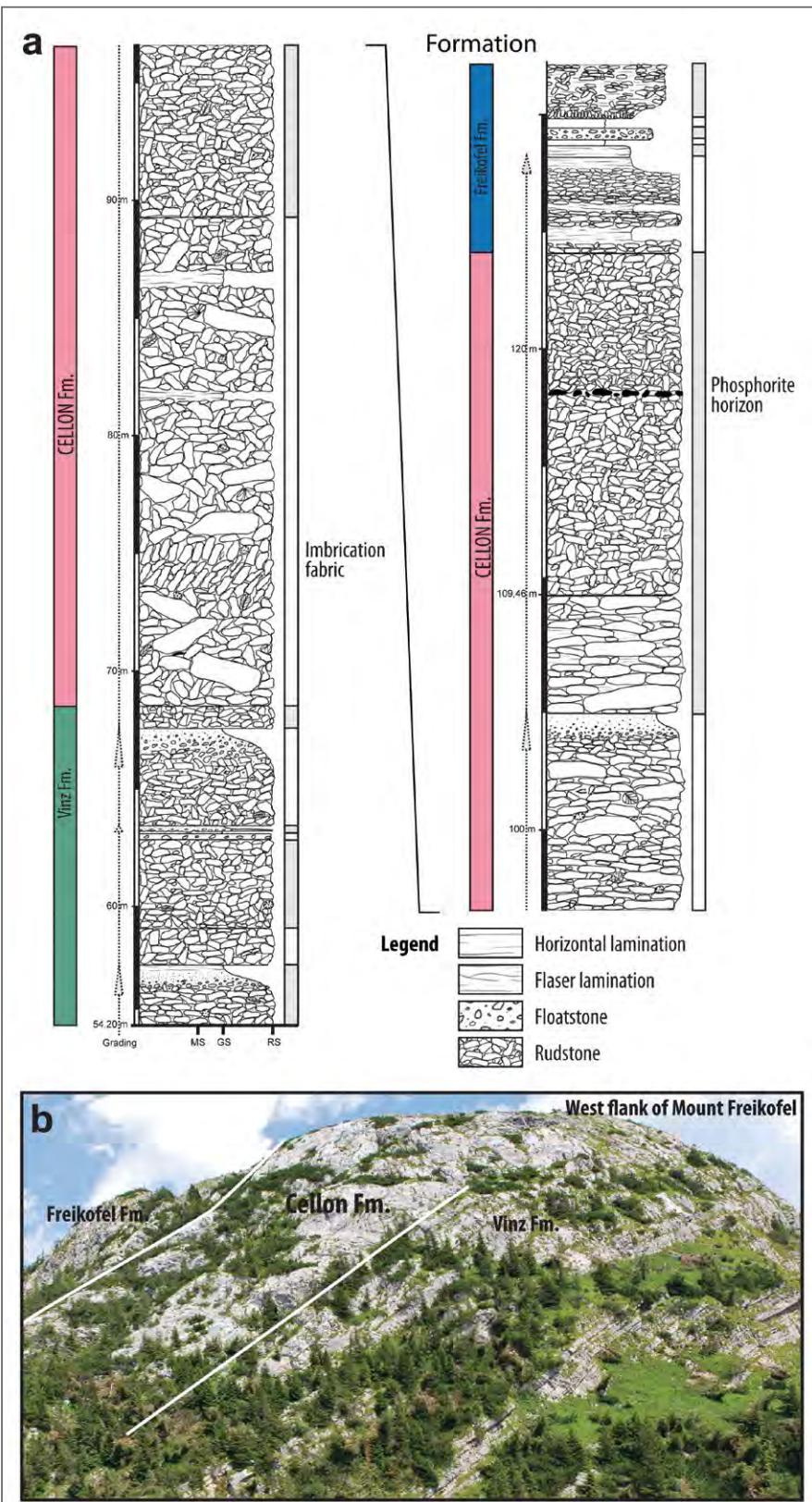
Bivalves, cephalopods, conodonts, corals, echinoderms, parathuramminaceae, stromatoporoids, trilobites.

Depositional environment

The Cellon Formation was formed at the slope of a carbonate apron (SCHNELLBÄCHER, 2010) and consists of gravity-driven resedimented deposits in forereef facies.



Areas of outcrop of the Cellon Formation with indication of the stratotype (asterisk).



The Freikofel section. a) log of the Cellon Formation (SCHNELLBÄCHER, 2010); b) view of the section taken from the west (photo M. PONDRELLI).

Stratotype

Freikofel Section, located on the western slope of Mt. Freikofel (BANDEL, 1972; SCHNELLBÄCHER, 2010), between coordinates N 46°36'01.5" E 12°58'33.0" (base of the section) and N 46°36'05.1" E 12°58'33.9" (top of the section).

Reference sections -

Type area

Central Carnic Alps.

Main outcrop areas

The Cellon Formation crops out in the Rauchkofel area, in the south side of the Valentintal and between the Cellon/Creta di Collinetta and the Creta di Timau.

Thickness

About 55 m (Freikofel) to about 85 m (Kellerwand).



Views of the Cellon Formation in the field (photos M. PONDRILLI). a) part of a rudstone bed: Freikofel Section; b) part of a rudstone bed: Freikofel Section; c) erosional surface within a bed: Freikofel Section; d) phosphorite nodules: Freikofel Section.

Boundaries

Underlying units – Vinz Formation (conformable sharp contact).

Overlying units – Freikofel Formation (conformable sharp contact).

Lateral units – Spinotti Formation p.p., Kellergrat Formation (proximal part); Hoher Trieb Formation p.p. (distal part).

Derivation of name

After Mount Cellon.

Synonymy

'Lithoklastkalk' [partim]: BANDEL (1974).

Cellon Kalk [partim]: KREUTZER (1990).

Cellon limestone [partim]: KREUTZER (1992b).

Calcareniti di transizione prossimali [partim]: VENTURINI (2006).

Freikofel Rudstone [partim]: BRIME et al. (2008).

Calciruditi del Freikofel [partim]: SPALLETTA & PONDRRELLI (2009).

Chronostratigraphic age

Devonian: Givetian (KREUTZER, 1990, 1992a, b; SCHNELLBÄCHER, 2010).

Biostratigraphy

Conodonts. – The base of Cellon Formation has been assigned to the *hemiansatus* Zone (Freikofel section).

Complementary references -

Remarks -

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Freikofel Formation

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LUCA SIMONETTO, CLAUDIA DOJEN, ANGELO MOSSONI, ERIKA KIDO & HEIKO HÜNEKE

Österreichische Karte 1:50.000

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Blatt UTM 3116 Sonnenalpe Naßfeld

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Definition

Prevalent floatstone/rudstone interbedded with lithoclastic packstone/grainstone and pelagic mudstone/wackestone (BANDEL, 1972; SPALLETTA et al., 1982; SPALLETTA & VAI, 1984; SCHÖNLAUB, 1985; KREUTZER, 1990, 1992a, b; SCHÖNLAUB et al., 2004; SCHNELLBÄCHER, 2010; PAS et al., 2014).

Description

The Freikofel Formation consists of three well-bedded facies listed in order of decreasing abundance.

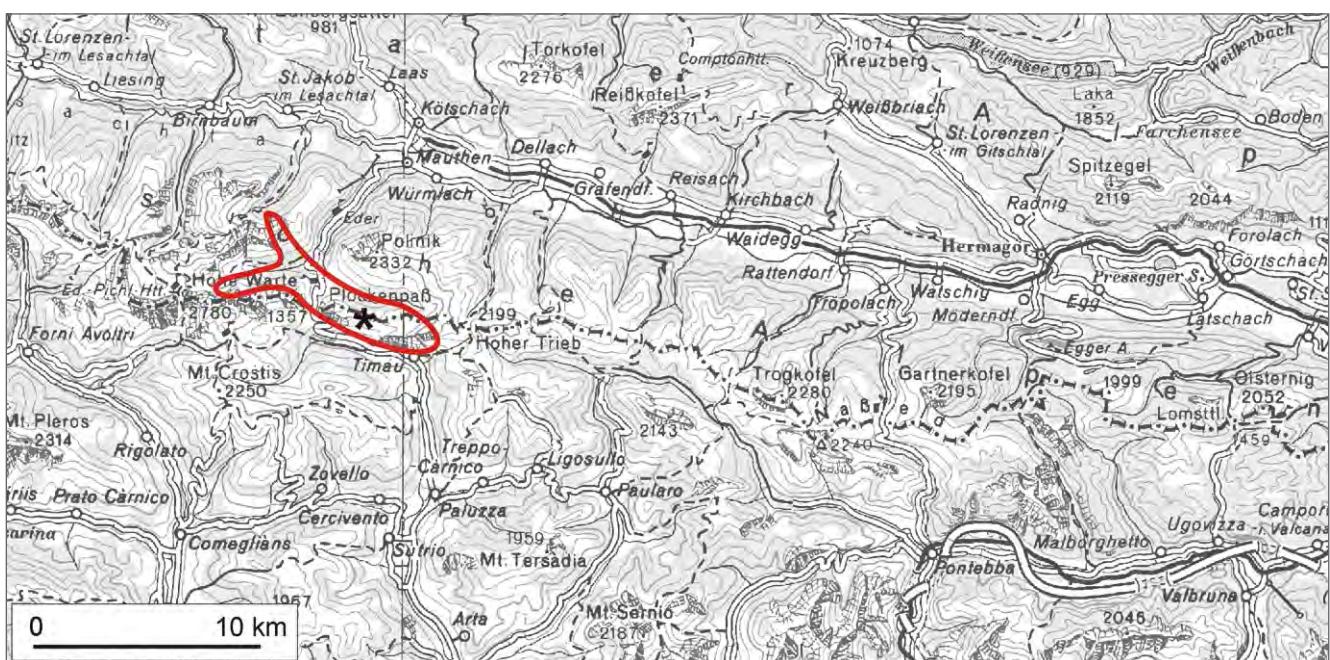
Facies A: medium dark gray, medium to thick bedded, moderately sorted lithoclastic rudstone (subordinately floatstone) sometimes showing fining upward grading; matrix consists of grainstone (subordinately wacke-/packstone);

Facies B: medium dark gray, thin to medium bedded grainstone and subordinate packstone locally showing fining upward grading; planar and subordinate cross lamination is present;

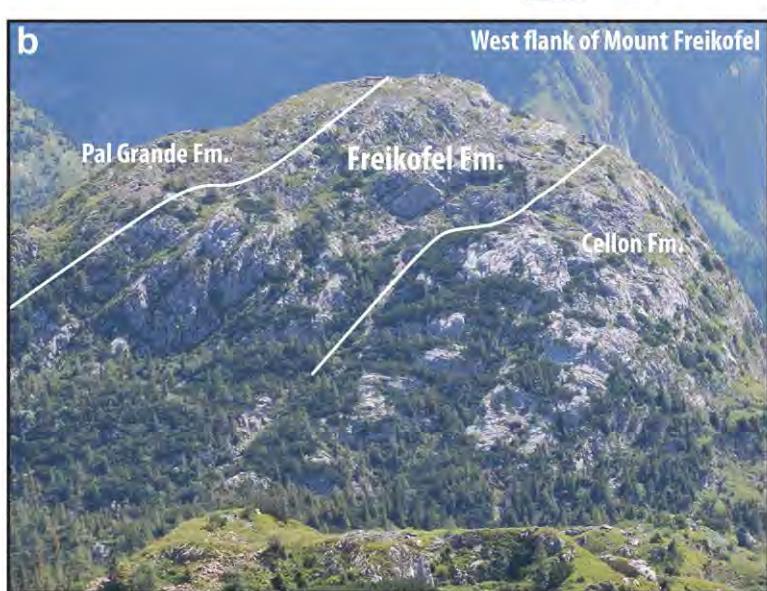
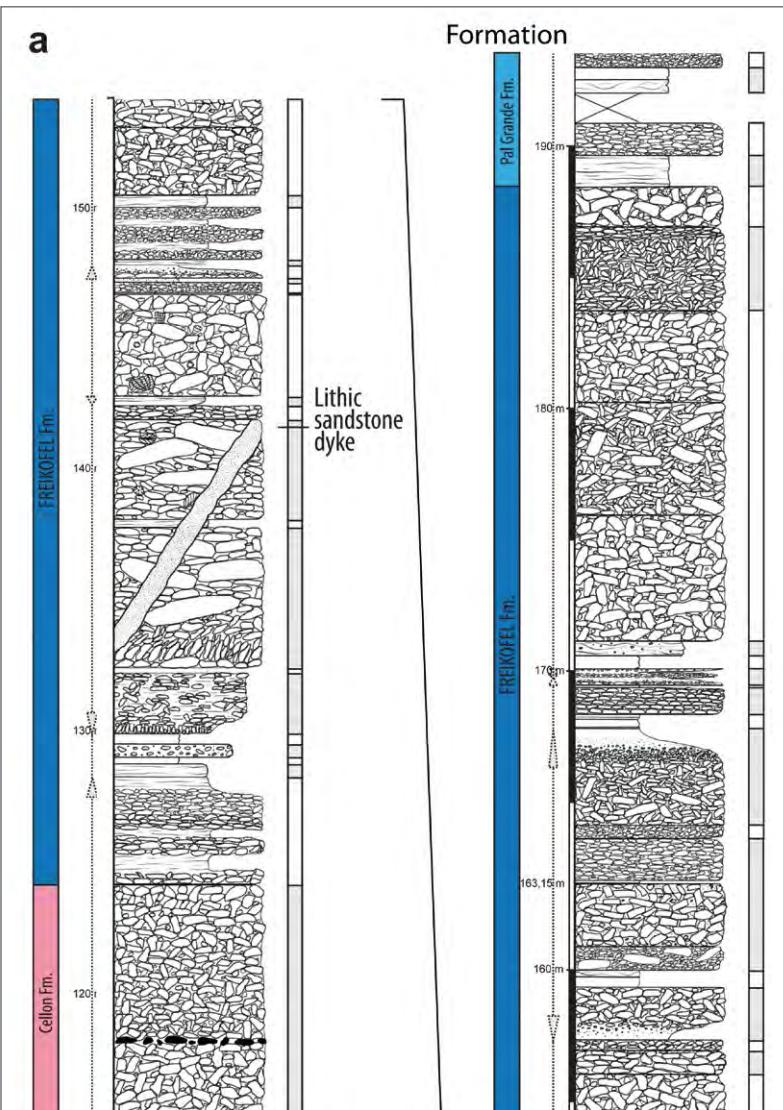
Facies C: very thin to thin bedded, moderate pink to gray mud-/wackestone.

Fossil content

Brachiopods, calcispheres, cephalopods, conodonts, crinoids, foraminifers, trilobites, ostracods, rugose corals, stromatoporoids and stylolinids have been documented (KREUTZER, 1992b; PAS et al., 2014).



Areas of outcrop of the Freikofel Formation with indication of the stratotype (asterisk).



The Freikofel Section. a) log of the Freikofel Formation (SCHNELLBÄCHER, 2010); b) view of the section taken from the west (photo M. PONDRELLI).

Depositional environment

The Freikofel Formation was formed at the slope of a carbonate apron (SCHNELLBÄCHER, 2010; PAS et al., 2014). Deposits of hyperconcentrated and concentrated density flows (Facies A) and turbidity flows (Facies B) predominate. Thin interbeds of pelagic sediments (Facies C and D) are rarely preserved.

Stratotype

Freikofel Section, located on the western slope of Mt. Freikofel (BANDEL, 1972; SCHNELLBÄCHER, 2010; PAS et al., 2014), between coordinates N 46°36'05.1", E 12°58'33.9" (base of the section) and N 46°36'08.0", E 12°58'35.0" (top of the section).

Reference sections -

Type area

Central Carnic Alps.

Main outcrop areas

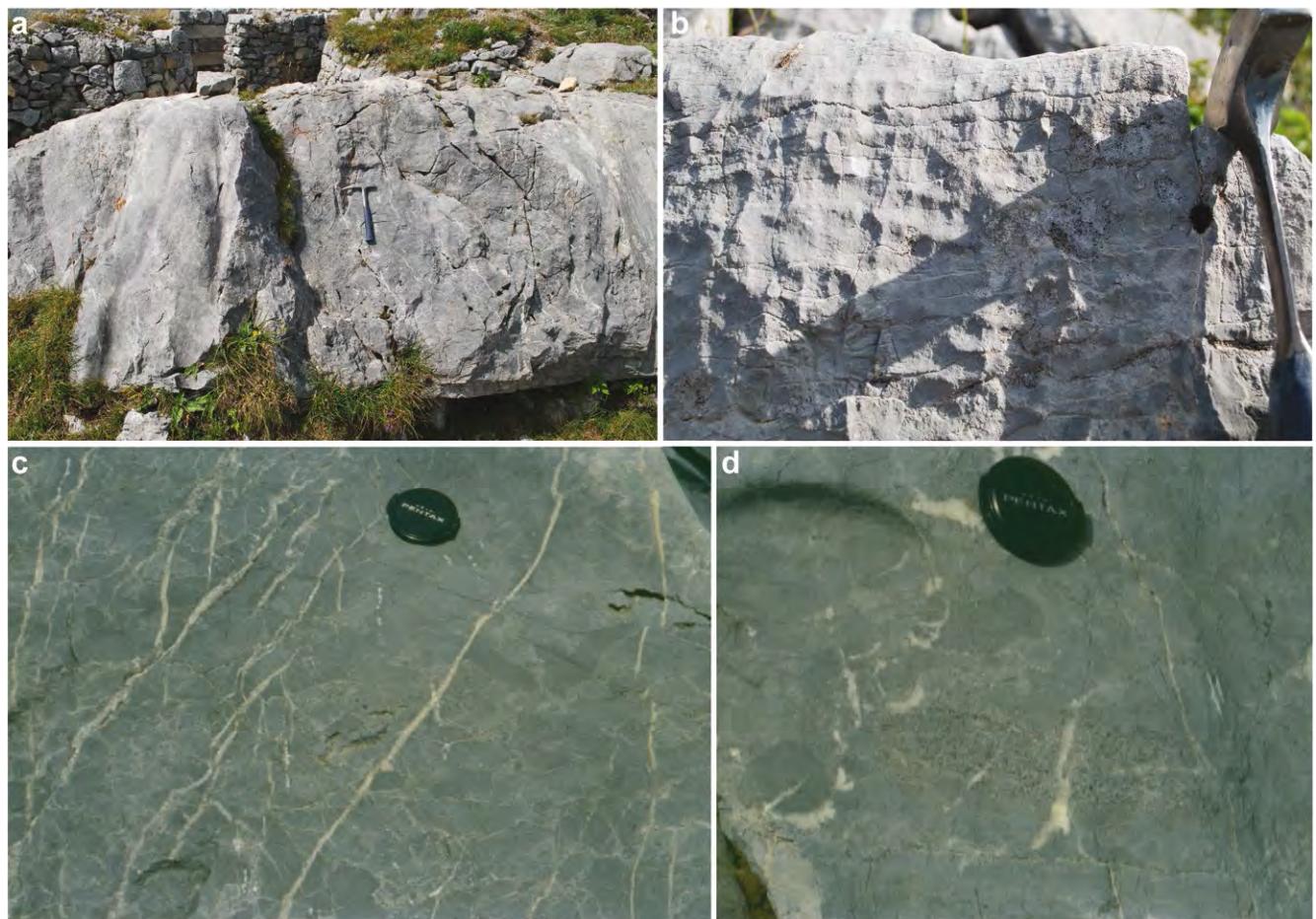
The Freikofel Formation crops out in the Rauchkofel area, in the south side of the Valentintal and between the Cellon/Creta di Collinetta and the Creta di Timau.

Thickness

About 65 m (Freikofel) to about 100 m (Kellerwand).

Boundaries

Underlying units – Cellon Formation (conformable sharp contact).



Views of the Freikofel Formation in the field. a) breccia bed: top of Mt. Freikofel (photo M. PONDRELLI); b) part of a breccia bed showing a crude fining upward trend: Freikofel Section (photo M. PONDRELLI); c) rudstone: PR327 section (photo C. SPALLETTA); d) particular of a rudstone bed: PR327 section (photo C. SPALLETTA).

Overlying units – Pal Grande Formation (conformable interfingering contact).

Lateral units – Kellergrat Formation, Creta di Collina Formation (proximal part); Hoher Trieb Formation, Pal Grande Formation (distal part).

Derivation of name

After Mount Freikofel.

Synonymy

'Lithoklastkalk' [partim]: BANDEL (1974).

Freikofel Kalk: SCHÖNLAUB (1985).

Freikofel limestone: KREUTZER (1992b).

Calcareniti di transizione prossimali [partim]: VENTURINI (2006).

Freikofel Rudstone [partim]: BRIME et al. (2008).

Calciruditi del Freikofel [partim]: SPALLETTA & PONDRELLI (2009).

Chronostratigraphic age

Devonian: Givetian to Frasnian (KREUTZER, 1990, 1992a, b; SCHNELLBÄCHER, 2010; PAS et al., 2014).

Biostratigraphy

Conodonts. – The Freikofel Formation spans to Frasnian Zone 13b (*linguiformis* Zone) (Freikofel T section)-Frasnian Zone 13a (middle-upper part of the Upper *rhenana* Zone) (Pramosio A section).

Complementary references -

Remarks -

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Hoher Trieb Formation

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SUSANNE M.L. POHLER & HEIKO HÜNEKE

Österreichische Karte 1:50.000

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Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Well-bedded pack-/grainstone and float-/rudstone, wackestone, cherts and laminated black shales (SELLI, 1963a; PÖLSLER, 1969; SCHÖNLADB, 1969, 1980, 1985a, b; KREUTZER, 1992a, b; HUBMANN et al., 2003; SPALLETTA & PONDRELLI, 2009; KIDO et al., 2011a, b, c; PONDRELLI et al., 2015).

Description

The Hoher Trieb Formation consists of five well-bedded facies listed below:

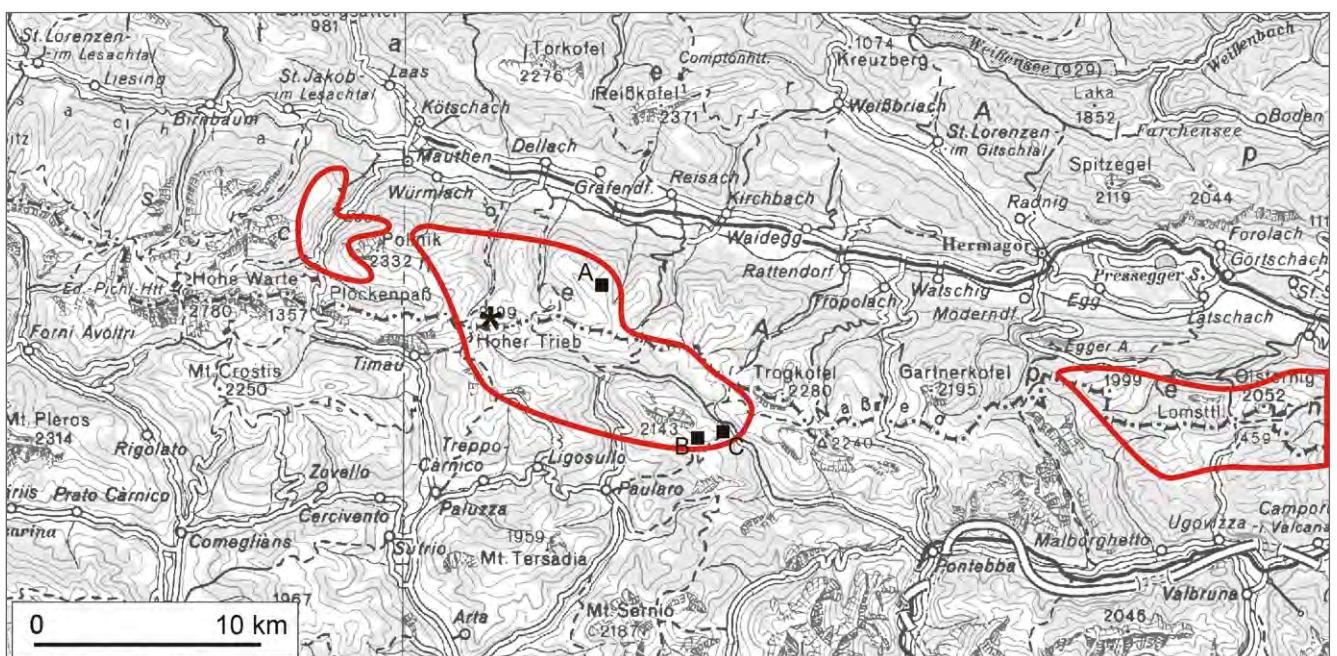
Facies A: medium dark gray very thick-bedded rudstone and floatstone; matrix consists mainly of grainstone; silicified corals are common among the clasts;

Facies B: medium dark gray thin to thick-bedded pack-/grainstone locally showing evidence of tractive structures;

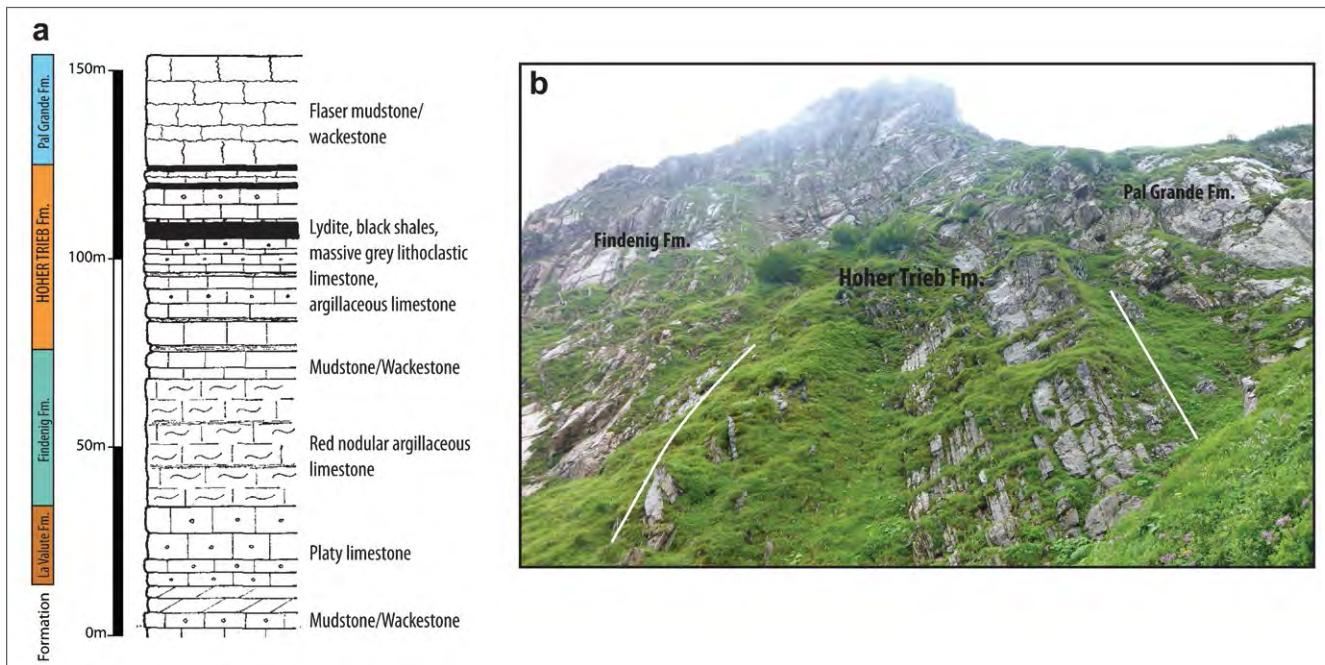
Facies C: medium dark gray thin to medium-bedded wackestone;

Facies D: black thin to medium-bedded laminated cherts; cherts are also locally present in nodules mainly within facies C;

Facies E: black very thin to thin-bedded laminated shales.



Areas of outcrop of the Hoher Trieb Formation with indication of the stratotype (asterisk) and reference sections (squares). A: Oberbuchsach Section; B: Forca di Lanza Section; C: Zuc di Malaseit Bassa Section.



The Hoher Trieb Section. a) log of the Hoher Trieb Formation (SCHÖNLAUB, 1969); b) view of the section taken from the East (photo M. PONDRELLI).

Fossil content

Cephalopods, conodonts, rugose and tabulate corals, foraminifers, radiolarians, stromatoporoids, tentaculites and trilobites have been documented (ALBERTI, 1985; SCHÖNLAUB, 1985a; KREUTZER, 1992b; KIDO et al., 2011b, c).

Depositional environment

The Hoher Trieb Formation was formed at the toe-of-slope of a carbonate apron (PONDRELLI et al., 2015). Deposits of hyperconcentrated and concentrated density flows (Facies A) and turbidity flows (Facies B) are embedded within a record of pelagic (Facies C and D) and hemipelagic sediments (Facies E). The platform-derived carbonates are supplied from a reef environment. Black shales suggest formation under temporary dysoxic and anoxic conditions.

Stratotype

Hoher Trieb Section, located west of Mt. Hoher Trieb/Cuestalta (SCHÖNLAUB, 1969), between coordinates N 46°35'53.9", E 13°03'20.0" (base of the section) and N 46°35'52.5", E 13°03'18.8" (top of the section).

Reference sections

Zuc di Malaseit Bassa section (KIDO et al., 2011a, b, c), located west of Zuc di Malaseit along path 441 at coordinates N 46°33'19.6", E 13°11'10.6", where the interval with black shales and cherts across the Eifelian-Givetian boundary is well exposed.

Oberbuchach section (SCHÖNLAUB, 1980, 1985a) at coordinates N 46°37'33.9", E 13°06'18.3", where the lower part of the unit is better exposed.

Forca di Lanza section (PONDRELLI et al., 2015), between coordinates N 46°33'19.5", E 13°09'55.7" (base of the section) and N 46°33'18.5", E 13°09'58.8" (top of the section), where the transition with the Pal Grande Formation is well exposed.

Type area

Carnic Alps.

Main outcrop areas

The Hoher Trieb Formation crops out in the areas between the Hinterjoch and Nöblinger Höhe, between Mt. Hoher Trieb/Cuestalta and Forca di Lanza, and between Mt. Schönwipfel and Mt. Poludnig.

Thickness

About 25 m to about 50 m.

Boundaries

Underlying units – Findenig Formation (conformable interfingering).

Overlying units – Pal Grande Formation (conformable sharp).

Lateral units – Vinz Formation, Cellon Formation, Freikofel Formation (proximal part); Findenig Formation, Valentin Formation (distal part).

Derivation of name

After Mount Hoher Trieb.

Synonymy

Facies corallina [partim]: TARAMELLI (1895).

Formazione di Monte Lodin [partim]: SELLI (1963a).

Formazione di Monte Lodin [partim]: SELLI (1963b).

“20m-Bank” [partim]: PÖLSLER (1969).

Gebankte Kalke mit Lydit [partim]: PÖLSLER (1969).

Blockhorizont [partim]: PÖLSLER (1969).

Massiger Kalk mit verkiezelten Korallen [partim]: PÖLSLER (1969).

Dunkler Plattenkalk: SCHÖNLAUB (1969).

Hoher Trieb Kalk: SCHÖNLAUB (1981).

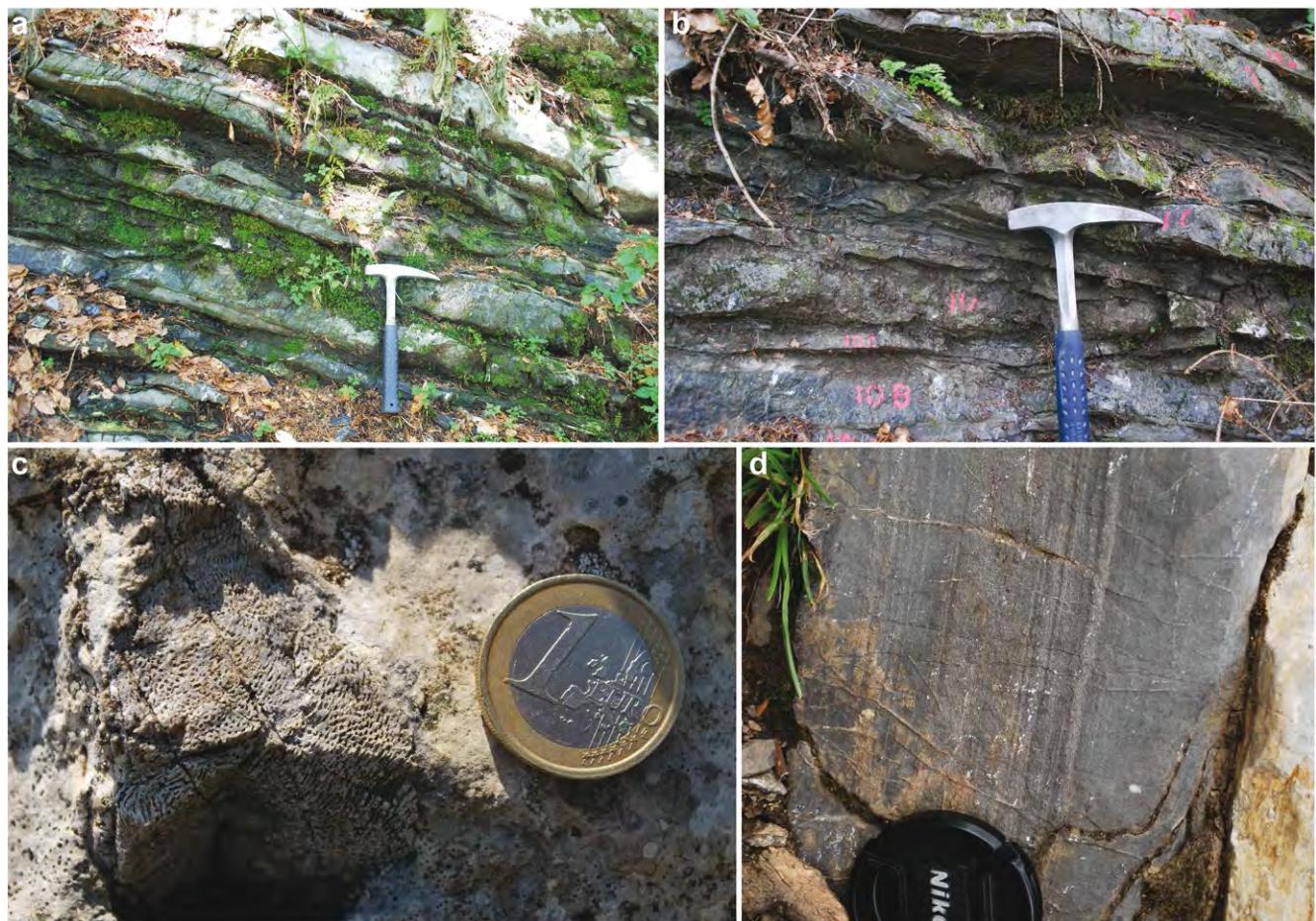
Tentaculite pelagic limestone [partim]: SPALLETTA & VENTURINI (1989).

Hoher Trieb Formation: KREUTZER (1992a).

Cuestalta Limestone [partim]: BRIME et al. (2008).

Chronostratigraphic age

Devonian: Emsian to Frasnian (SCHÖNLAUB, 1980, 1985a; PERRI & SPALLETTA, 1998; KIDO et al., 2011a, b, c; PONDRELLI et al., 2015).



Views of the Hoher Trieb Formation in the field (photos M. PONDRELLI). a) interbedded Facies C, D, E: Zuc di Malaseit Bassa Section; b) interbedded Facies C, D, E: Zuc di Malaseit Bassa Section; c) silicified coral in Facies A: Forca di Lanza; d) laminated grainstone passing to packstone (Facies B): Zuc di Malaseit Bassa Section.

Biostratigraphy

Conodonts. – The base of this formation is diachronous: conodont data from the Mt. Culet area (PERRI & SPALLETTA, 1998) provide a *serotinus* Zone for the basal part of the Hoher Trieb Formation while in the Mt. Pizzul area the base of the unit appears to belong at least to the *costatus* Zone (PONDRELLI et al., 2015).

The top of the formation reaches the MN3 Zone at the Forca di Lanza area (PONDRELLI et al., 2015).

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Findenig Formation

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Hans-Peter Schönlau, Luca Simonetto & Angelo Mossoni

Österreichische Karte 1:50.000

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Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Flaser-like pink nodular limestone (mudstone to wackestone) at places interlayered with light gray packstone to grainstone.

Description

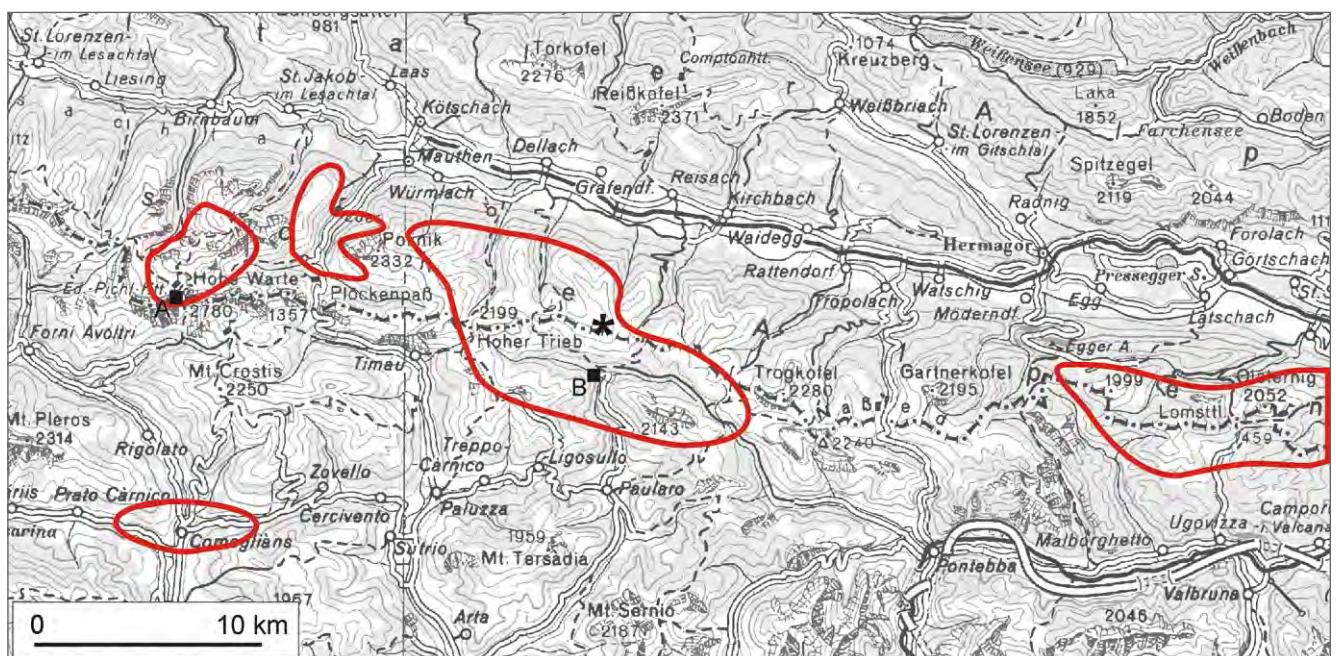
The Findenig Formation consists of red to pink nodular centimetric thick beds of mudstone/wackestone, with interlayered millimetric to centimetric red marls, and, at places, some centimetric to decimetric calcarenitic (grainstone) intervals (allodapic layers) and breccia (calcirudite) beds in the upper part of the unit.

Fossil content

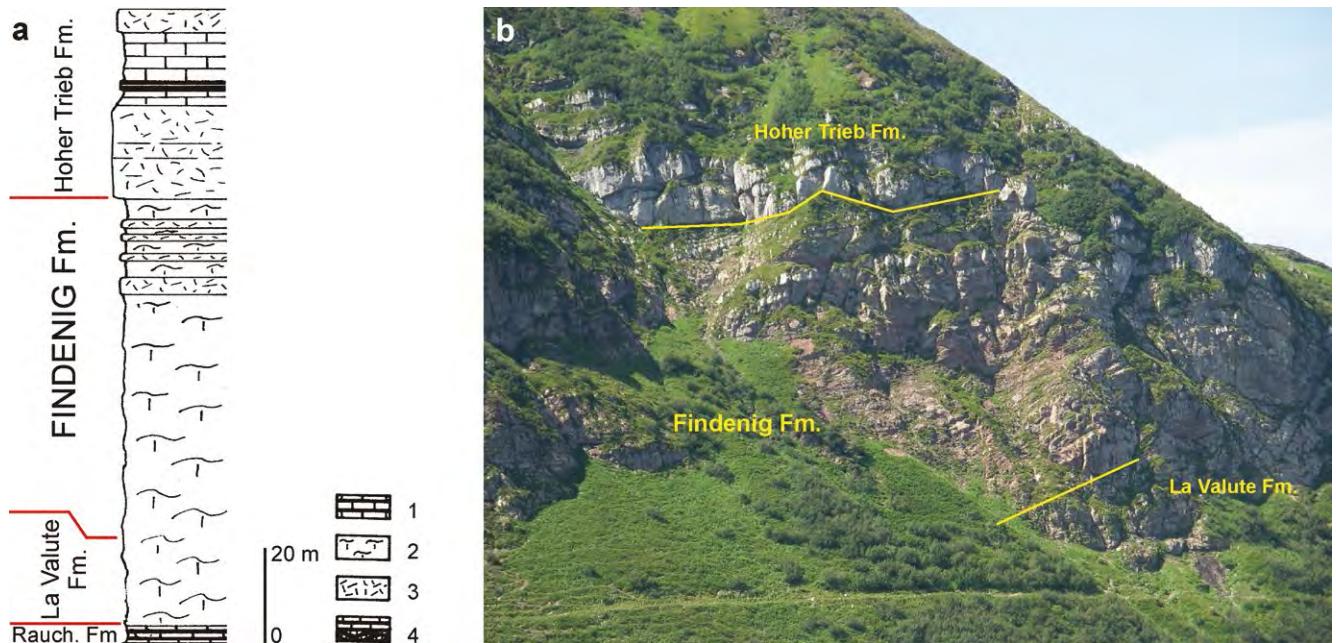
Brachiopods, conodonts, crinoids, dacryoconarids, foraminifers, goniatites, orthoceratids, ostracods.

Depositional environment

The Findenig Formation took place in a pelagic environment, from slope to open basin. The allodapic layers have been interpreted as tempestites (Vai, 1980).



Areas of outcrop of the Findenig Formation with indication of the stratotype (asterisk) and reference sections (squares). A: Costone Lambertenghi/Seekopf Sockel Section; B: Stua Ramaz Section.



The Findenig Section 4. a) log of the section, 1: well bedded, dark gray limestone with interbedded chert, 2: gray to pink nodular limestone, 3: massive light gray rudite, 4: well bedded gray limestone with interbedded black shales (modified after PÖLSLER, 1969); b) panoramic view (photo C. CORRADINI).

Stratotype

“Findenigkofel profil 4” (PÖLSLER, 1969), on the northern slope of Findenigkofel/Mt. Lodin, at coordinates N 46°35'51.4”, E 13°06'04.0”.

Reference sections

Costone Lambertenghi/Seekopf Sockel Section, west of Lake Wolayer at coordinates N 46°36'34.6”, E 12°51'58.8” (at the base of the Findenig Formation), where the boundaries with the La Valute Formation and the Valentin Formation are well exposed and easy accessible.

Stua Ramaz Section, along the Chiarsò creek at coordinates N 46°34'32.6”, E 13°06'37.3”), where the allodapic layers are well developed (VAI, 1980).

Type area

Carnic Alps.

Main outcrop areas

The Findenig Formation crops out along the whole Carnic Alps, mainly in Lake Wolayer-Rauchkofel, Cuestalta/Hoher Trieb, to Mt. Pizzul and Mt. Cocco areas.

Thickness

About 25 m (Lake Wolayer/Volaia) to about 60 m (Findenigkofel).

Boundaries

Underlying units – La Valute Formation (conformable gradual contact), Nöbling Formation in the distal part (conformable contact).

Overlying units – Hohe Trieb Formation (conformable gradual contact), Valentin Formation (conformable gradual contact).

Lateral units – Rauchkofel Formation, Kellerwand Formation and Vinz Formation in the proximal part; Zollner Formation in the distal one.

Derivation of name

After Mount Findenigkofel.

Synonymy

Grauer und rother Kramenzelkalk: FRECH (1894).
Calcari a tentaculiti [partim]: VAI (1963); VENTURINI (2006).
Calcari nodulari a tentaculiti [partim]: VAI in BRAGA et al. (1971).
Findenigkalk [partim]: PÖLSLER (1969).
'Roter Flaser- und Knollenkalk': BANDEL (1974).
Reddish nodular limestone: SCHÖNLAUB (1980).
Calcari pelagici a tentaculiti [partim]: SPALLETTA et al. (1982).
Findenig-kalk: SCHÖNLAUB (1985a).
Findenig Limestone: SCHÖNLAUB (1985b).
Tentaculite pelagic limestone [partim]: SPALLETTA & VENTURINI (1990).
Cuestalta Limestone [partim]: BRIME et al. (2008).
Calcari di Cuestalta [partim]: SPALLETTA & PONDRELLI (2009).
Findenig-Formation/Findenig Formation: SUTTNER & KIDO (2014).

Chronostratigraphic age

Devonian: From the uppermost Lochkovian to Eifelian.

Biostratigraphy

Conodonts. – From the *pandora* β Zone (CORRIGA et al., 2011) to the *costatus* Zone (pers. comm. C. SPALLETTA, 2014).

Dacryconarids. – From the *Homocatenowakia bohemica* to the *Nowakia (N.) holynensis* Zone (ALBERTI, 1985).

Complementary references -

Remarks -



Views of the Findenig Formation in the field. a) view of the outcrop along the Rio Chiarsò (photo C. SPALLETTA); b) allodapic layers (gray) at the Stua Ramaz Section (photo G.B. VAI); c) the typical nodular limestone of the Findenig Formation on a bed surface in the Costone Lambertenghi/Seekopf Sockel Section (photo C. CORRADINI).

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Valentin Formation

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Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 199 Hermagor

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 033 Tarvisio

Definition

Strongly bioturbated grayish wackestone, and packstone, with a phosphorite horizon in the uppermost part.

Description

Bioclastic wackestone represents the major part of the formation. In the lower part of the formation also iron-coated bioclasts and micritic oncoids occur abundantly. The bedding is mostly obliterated by bioturbation (SCHÖNLAUB et al., 2004; HÜNEKE, 2006, 2007).

Fossil content

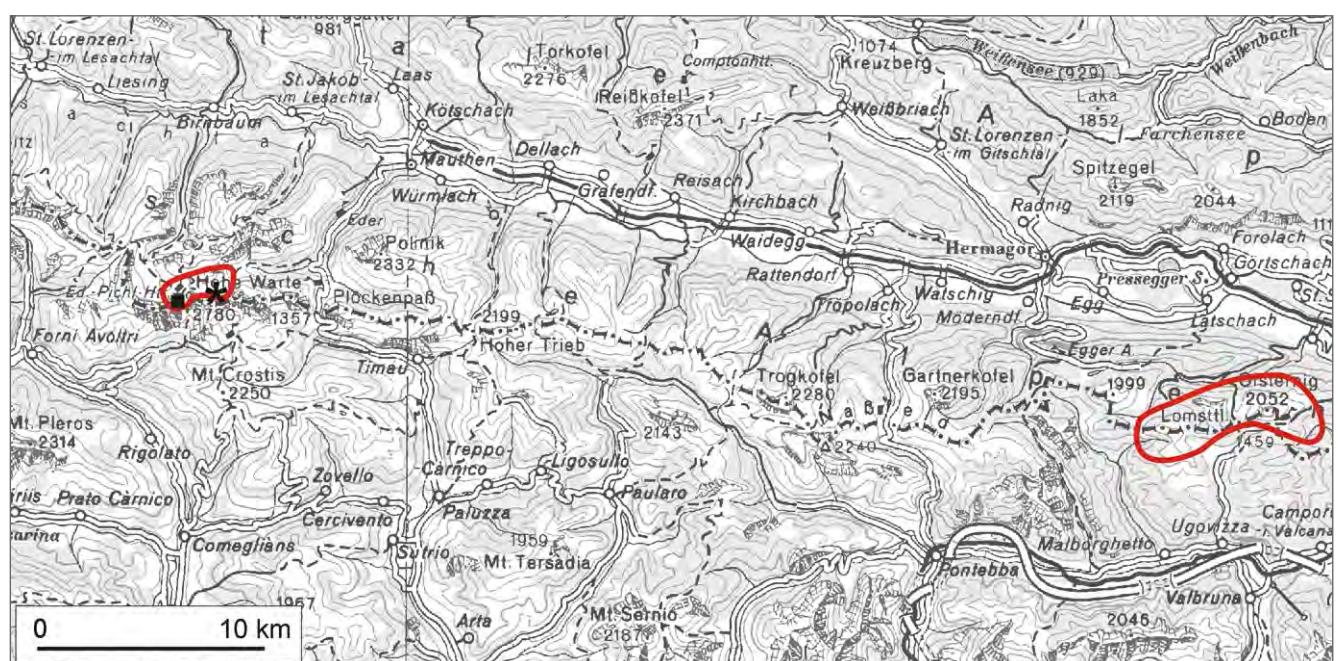
Bivalves, brachiopods, calcispheres, cephalopods, conodonts, crinoids, fish remains, foraminifers, ostracods, rugose corals, stylolinids.

Depositional environment

Pelagic, with very low sedimentation rate and erosion/re-deposition controlled by bottom currents.

Stratotype

Wolayer "Glacier" Section (SCHÖNLAUB, 1980), located along the northern side of Wolayer Valley, at coordinates N 46°36'49.0", E 12°52'34.7".



Areas of outcrop of the Valentin Formation with indication of the stratotype (asterisk) and reference section (square).





Views of the Valentin Formation on the field. a-c) the Valentin Formation at Coston Lambertenghi Section (photos C. CORRADINI); d) upper part of the Valentin Formation at Wolayer "Glacier" Section, with the level of the phosphatic nodules (photo T.J. SUTTNER).

Chronostratigraphic age

Devonian: Emsian to Frasnian.

Biostratigraphy

Conodonts. – From the upper part of the *serotinus* Zone (GÖDDERTZ, 1982) to the Lower *hassi* Zone (Frasnian Zone 7 and 8) (JOACHIMSKI et al., 1994).

Complementary references

Carbon isotopes. – JOACHIMSKI et al. (1994).

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Pal Grande Formation

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ANGELO MOSSONI & HANS-PETER SCHÖNLAUB

Österreichische Karte 1:50.000

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Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Gray to reddish mm to cm thick beds of nodular mudstone/wackestone.

Description

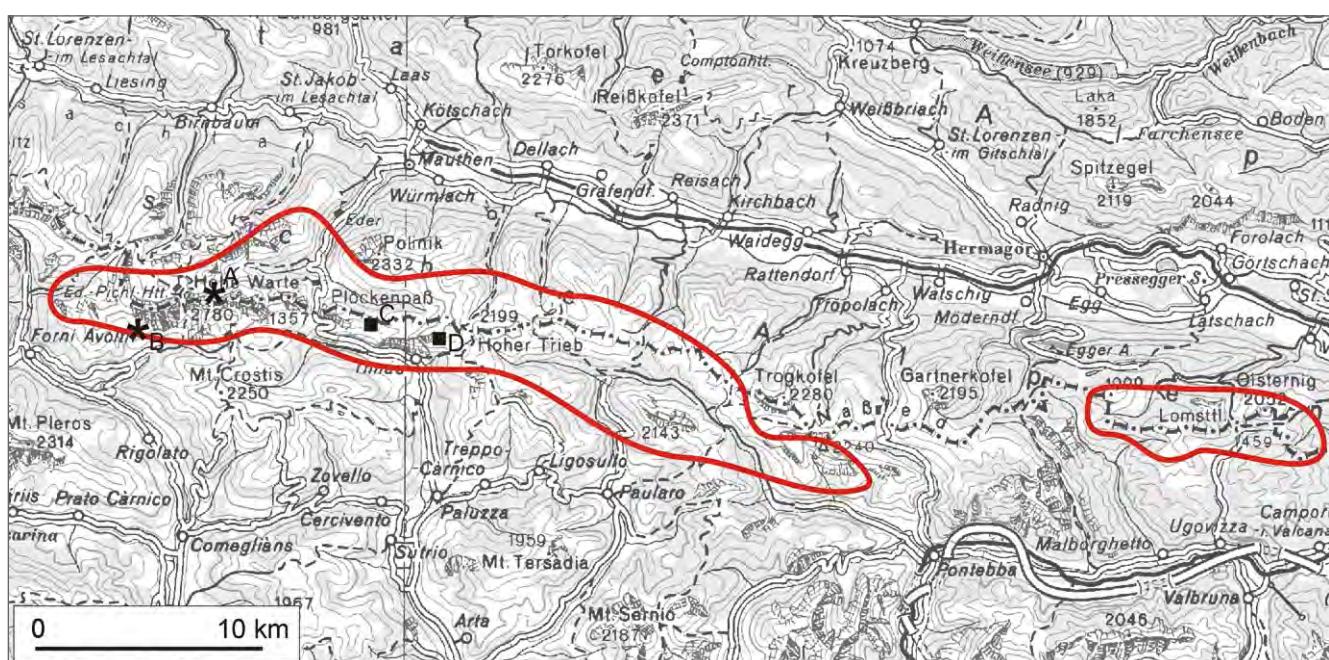
The Pal Grande Formation consists mainly of gray mudstone and wackestone rich in fossils. The original bedding is often concealed by pressure solution and/or burrowing giving to the limestone a characteristic pseudo-nodular look. The reddish colour, when present, is usually limited to the lower part of the formation. At places, in the basal part of the formation, interlayered cm to dm calciruditic and calcarenitic (grainstone) intervals are present, as well as ruditic (intraclast breccia) levels. The ruditic beds can reach thickness of 1-2 m. Black shale, interpreted as equivalent to the Hangenberg Shale (Hangenberg Event) are present only at two localities (Kronhof Graben and Plan di Zermula) (PERRI & SPALLETTA, 2001).

Fossil content

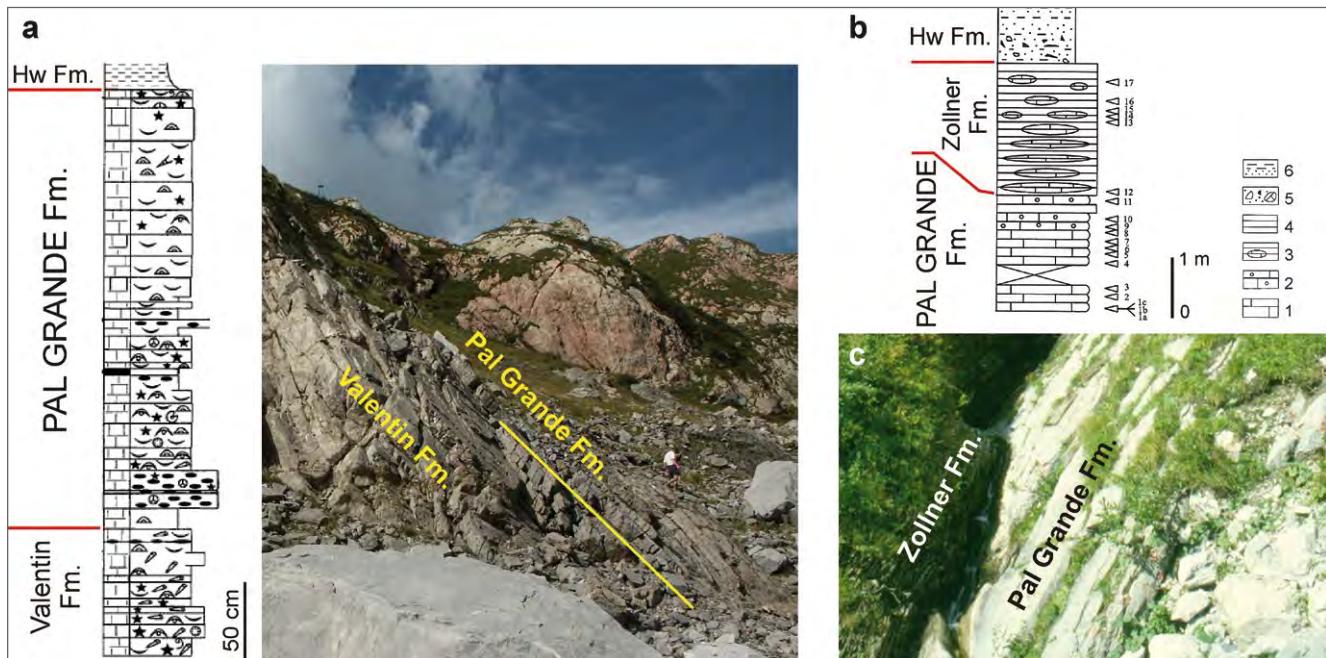
Bivalves, brachiopods, clymenids, crinoids, conodonts, echinoderms, fish teeth and scales, goniatites, orthoceratids, ostracodes, trilobites, rare rugose corals.

Depositional environment

Slope to open basin, pelagic environment.



Areas of outcrop of the Pal Grande Formation with indication of the stratotype of the lower and upper boundary (asterisks) A: Wolayer "Glacier" Section; B: Rio Chianaletta Section. Reference sections (squares), C: Freikofel T section; D: Malpasso section.



The type sections for the base and the top of the Pal Grande Formation a) the Wolayer "Glacier" Section: log of the section (after JOACHIMSKI et al., 1994) and view of the section in the field (photo H.P. SCHÖNLAUB); b-c) the Rio Chianaletta Section: log of the section (modified after PERRI & SPALLETTA, 1998) and view of the section in the field (photo M.C. PERRI). Legend: 1. biomicrite; 2. radiolarian-enriched mudstone; 3. radiolarian chert with interbedded limestone levels and lenses; 4. radiolarian chert; 5. breccia of the Hochwipfel Formation; 6. sandstone and pelite of the Hochwipfel Formation.

Stratotype

Wolayer "Glacier" Section (SCHÖNLAUB, 1980), located along the northern side of Wolayer Valley, at coordinates N 46°36'49.0", E 12°52'34.7" for the lower boundary.

Rio Chianaletta Section (PERRI & SPALLETTA, 1998), at coordinates N 46°36'13.7", E 12°50'02.8" for the upper boundary.

Reference sections

Freikofel T section, on the northwest side of Mt. Freikofel, at coordinates N 46°36'05.3", E 12°58'36.6" (base of the section) N 46°36'07.4", E 12°58'36.2" (top) (PERRI & SPALLETTA, unpublished data), where the lower boundary with the Freikofel Formation is well exposed.

Malpasso section, near Casera Malpasso at coordinates N 46°35'29.9", E 13°02'05.7" (base of the section) N 46°35'29.0", E 13°02'04.3" (top) (PERRI & SPALLETTA, 1991), where the typical features of the formation with beds rich in goniatites are well exposed in an easy accessible section.

Type area

Carnic Alps.

Main outcrop areas

The Pal Grande Formation crops out mainly in a wide area of the Central Carnic Alps between Cima Ombladet-Rio Chianaletta to Mt. Cavallo and in the area near Mt. Oisternig and Mt. Cocco to the east.

Thickness

Maximum thickness of about 100 m (Pramosio area).

Boundaries

Underlying units – Freikofel Formation in the proximal part (conformable gradual contact), Valentin Formation in the distal one (unconformable contact: paraconformity), Hohe Trieb Formation (conformable sharp contact).

Overlying units – Zollner Formation (conformable gradual contact), Hochwipfel Formation (unconformable contact: paraconformity, when and where the upper part of the Pal Grande Formation and the Zollner Formation are missing, often this boundary is affected by tectonic superimposition), Plotta Formation (unconformable contact).

Lateral units – Freikofel Formation and Creta di Collina Formation in the proximal part; Zollner Formation in the distal part.

Derivation of name

After Mount Pal Grande/Grosser Pal.

Synonymy

Clymenienkalk am Gross-Pal: FRECH (1987).
Calcari a Climenie: VINASSA DE REGNY & GORTANI (1908).
Clymenienkalke: GAERTNER (1931); HERITSCH (1936).
Calcari nodulari ad ammonoidi: VAI in BRAGA et al. (1971).
Goniatiten-Kalke: FENNINGER & SCHÖNLAUB (1972).
Calcari pelagici a climenie e calcari di scarpata [partim]: SPALLETTA et al. (1982).
Pal-Kalk and Kronhof-Kalk: SCHÖNLAUB (1985).
Clymenid pelagic limestone: SPALLETTA & VENTURINI (1990).
Clymenid and goniatitid pelagic lm.: VENTURINI & SPALLETTA (1998).
Calcari a goniatiti e climenie: VENTURINI et al. (2002).
Pramosio Limestone: BRIME et al. (2008).
Calcari di Pramosio: SPALLETTA & PONDRELLI (2009).
Pal-Kalk/Pal Limestone: SUTTNER & KIDO (2014a).
Kronhof-Kalk/Kronhof Limestone: SUTTNER & KIDO (2014b).

Chronostratigraphic age

Devonian – Carboniferous: Frasnian to Visean.



Views of the Pal Grande Formation in the field. a) gray, well bedded micrite, outcrop near Pal Grande (photo M. PONDRELLI); b) pinkish/gray micrite, Freikofel T section (photo C. SPALLETTA); c) bed rich in goniatites, Pramosio Bassa section (photo C. SPALLETTA); d) gray micrite at Forca di Lanza (photo M. PONDRELLI).

Biostratigraphy

Conodonts. – Upper *hassi* Zone (Frasnian Zone 9 and Zone 10) (Wolayer “Glacier” Section, JOACHIMSKI et al., 1994) to *homopunctatus-texanus* Zone (Rio Chianaletta Section, PERRI & SPALLETTA, 1998).

The age of the lower boundary is different according to the underlying unit: the boundary with the Valentin Formation is Frasnian Zone 9 to Frasnian Zone 10 (Upper *hassi* Zone), the boundary with the Hoher Trieb Formation in the Mt. Pizzul area is Frasnian Zone 11-12, and with the Freikofel Formation is Frasnian Zone 13b (*linguiformis* Zone) at the Freikofel T section, and Frasnian Zone 13a in a more distal area (Pramosio).

Complementary references

Carbon isotopes. – JOACHIMSKI et al. (1994) studied the lower part of the unit in the Wolayer “Glacier” Section.

Remarks -

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Zollner Formation

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Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt BMN 199 Hermagor

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Well bedded light gray, greenish to black chert cm to dm thick, interlayered with rare limestone lenses, and black siliceous shale.

Description

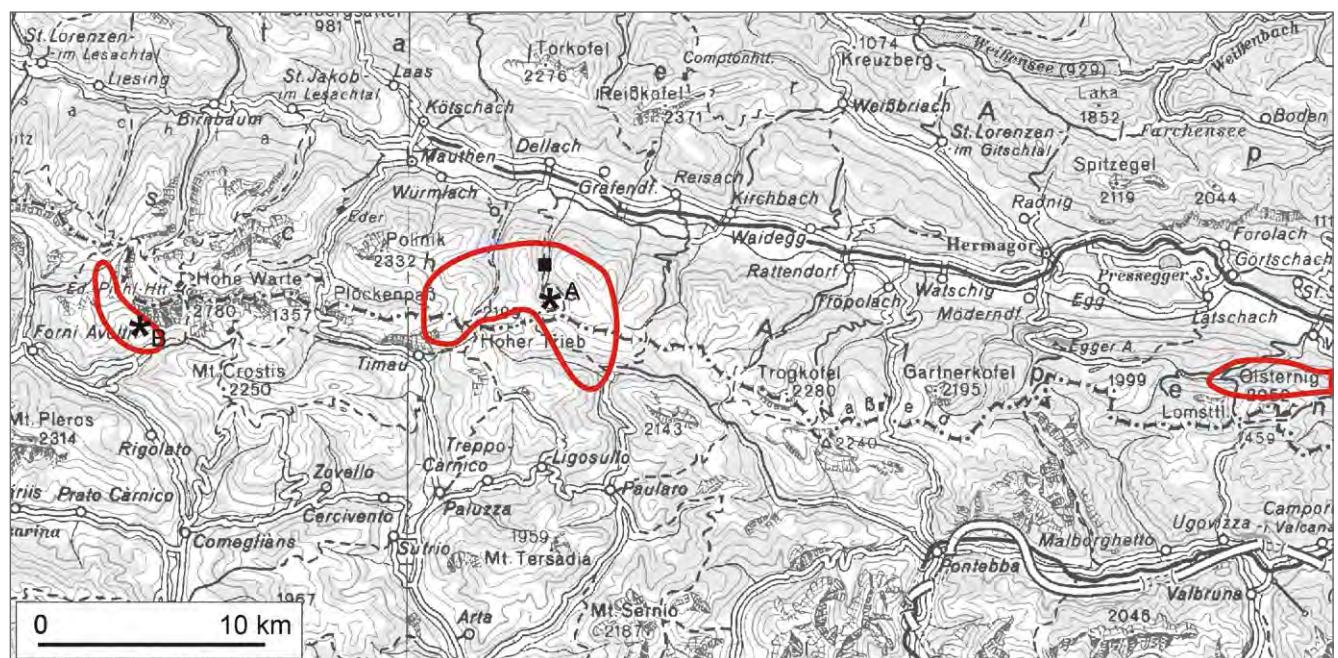
The Zollner Formation consists mainly of radiolarian chert with interbedded rare limestone and black siliceous shale. The limestones are represented by centimetric/decimetric lenses and rare layers of wackestone/mudstone; present along the whole unit. The black shales are more abundant in the lower part of the formation.

Fossil content

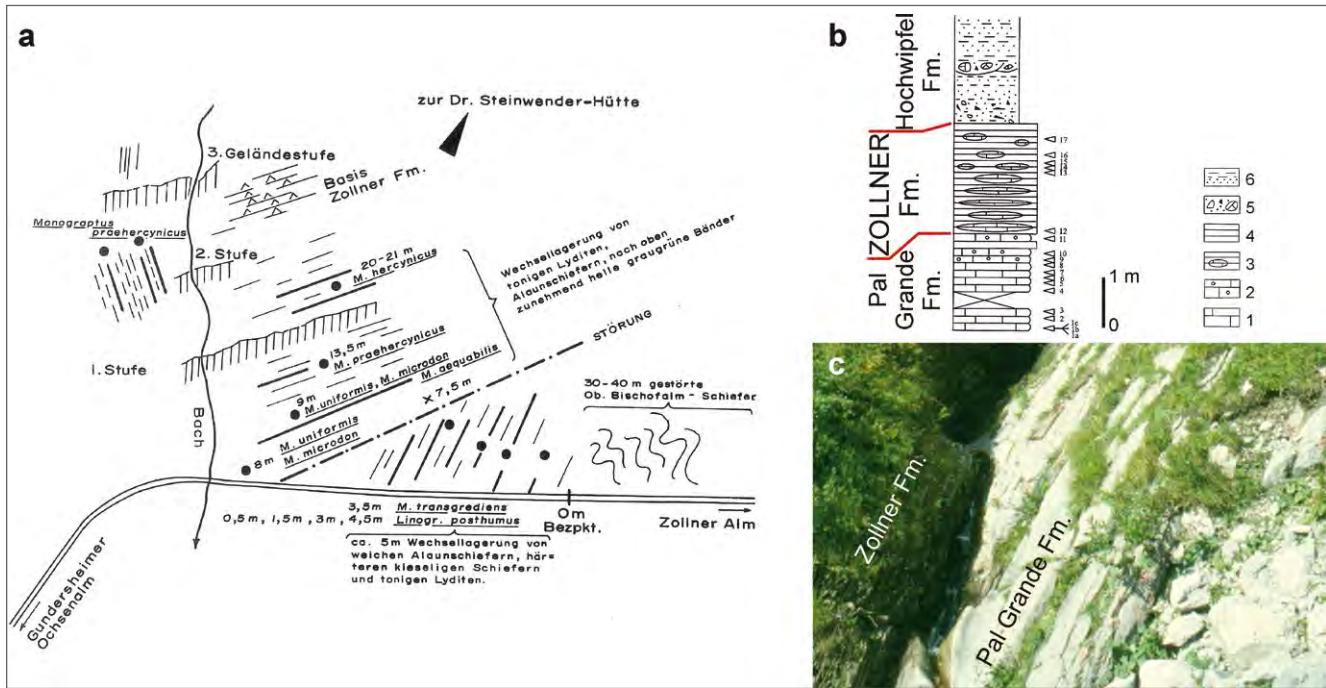
Conodonts, graptolites (in the lowermost part), radiolarians.

Depositional environment

Pelagic.



Areas of outcrop of the Zollner Formation with indication of the stratotype of the lower and upper boundary (asterisks), A: Wasserfall Section; B: Rio Chianaletta Section. Reference section (square), Oberbuchach 3 section.



The Zollner Formation type section. a) sketch of the Wasserfall Section (after SCHÖNLAUB, 1985); b) log of the Rio Chianaletta Section (modified after PERRI & SPALLETTA, 1998). Legend: 1. biomicrite; 2. radiolarian-enriched mudstone; 3. radiolarian chert with interbedded limestone levels and lenses; 4. radiolarian chert; 5. breccia of the Hochwipfel Formation; 6. sandstone and pelite of the Hochwipfel Formation; c) view of the section in the field (photo M.C. PERRI).

Stratotype

Wasserfall Section near Lake Zollner (SCHÖNLAUB, 1985), at coordinates N 46°36'18", E 13°04'11" for the lower boundary.

Rio Chianaletta Section (PERRI & SPALLETTA, 1998), at coordinates N 46°36'13.7", E 12°50'02.8" for the upper boundary.

Reference sections

Oberbuchach 3 section (JAEGER & SCHÖNLAUB, 1980) below Gundersheimer Alm at coordinates N 46°37'29.1", E 13°05'52.6", where the transition with the Bischofalm Formation is well exposed.

Type area

Carnic Alps.

Main outcrop areas

The Zollner Formation crops out mainly in the Cima Ombladet-Rio Chianaletta area to the west, in a wide area of the Central Carnic Alps, and in the area between Mt. Poludnig and the Gail River to the east.

Thickness

The maximum estimated thickness is more than 100 m. Continuous sections exposing the whole unit are not known.

Boundaries

Underlying units – Bischofalm Formation (conformable, gradual contact).

Overlying units – Hochwipfel Formation (conformable, gradual contact) in most cases affected by tectonic strain.

Lateral units – Findenig Formation, Valentin Formation and Pal Grande Formation.

Derivation of name

After Lake Zollner.



Views of the Zollner Formation in the field. a) radiolarian chert with limestone lenses at Rio Chianaletta (photo C. SPALLETTA); b) radiolarian chert in the Pramosio Pass area (photo C. VENTURINI).

Synonymy

Radiolariti (lidi): SPALLETTA et al. (1982).

Zollner Formation: SCHÖNLAUB (1985); SCHÖNLAUB et al. (2004).

Radiolarites and shales: SPALLETTA & VENTURINI (1990).

Rio Chianaletta Radiolarites: BRIME et al. (2008).

Radiolariti del Rio Chianaletta: SPALLETTA (2009).

Zollner-Formation/Zollner Formation: SUTTNER & KIDO (2014).

Chronostratigraphic age

Devonian – Carboniferous: Lochkovian to lower Visean.

Biostratigraphy

Conodonts. – The youngest level of the formation has been assigned to the *texanus-homopunctatus* Zone (PERRI & SPALLETTA, 1998).

Graptolites. – *Monograptus hercynicus* Zone for the oldest level of the formation (HERZOG, 1983, 1988).

Complementary references -

Remarks -

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Plotta Formation

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Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Definition

Discontinuous silcrete layers (hard grounds), weakly bedded breccia or massive and laminated chert at places enriched in mineralization of Cu and Pb.

Description

The Plotta Formation is mainly composed of white, grayish or blackish porous chert. Locally, at its base, a thin breccia layer is developed. It is composed by small subrounded limestone clasts, angular relict chert fragments and dark siliceous crust.

Fossil content

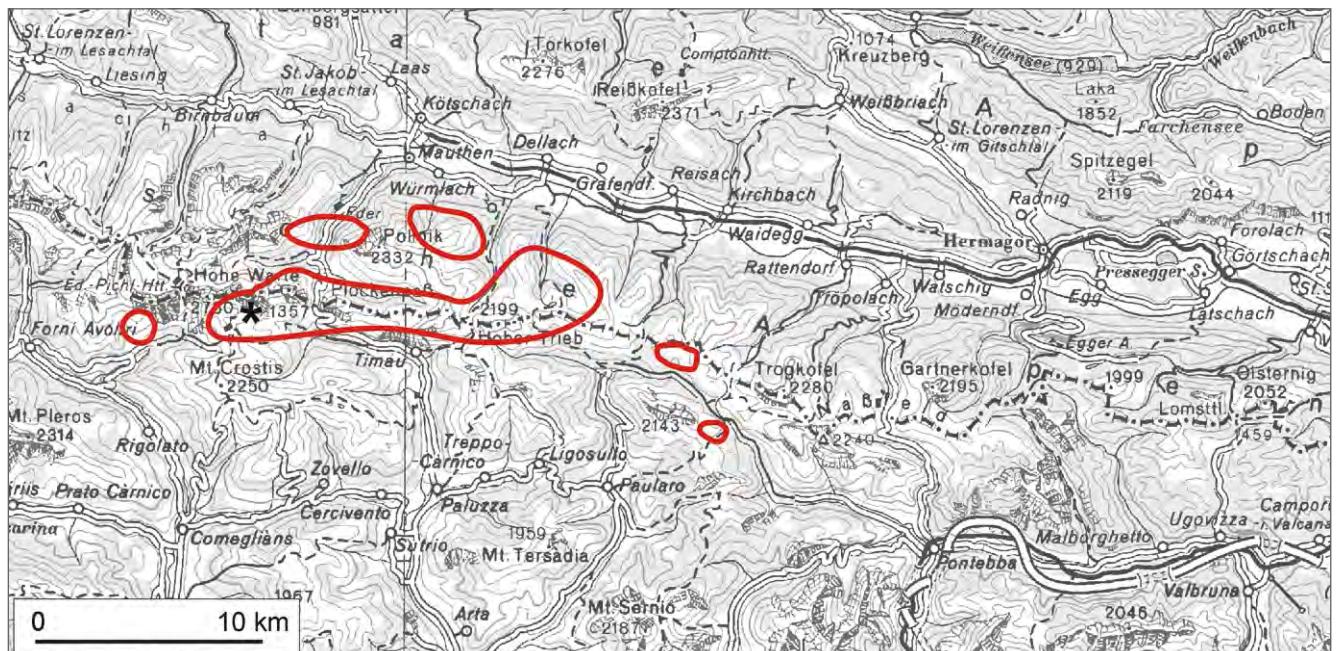
No autochthonous fossil content, mixed conodont faunas of various ages, goniatites and trilobites from the underlying limestone are present.

Depositional environment

Paleokarstic environment due to subaerial exposure; hard grounds?

Stratotype

Cima Plotta Section (SCHÖNLAUB et al., 1991), at coordinates N 46°35'40.57", E 12°54'26.37".



Areas of outcrop of the Plotta Formation with indication of the stratotype (asterisk).



The Plotta Section. a) log of the section (modified after SCHÖNLAUB & KREUTZER, 1993); b) view of the section in the field (photo H.P. SCHÖNLAUB).

Reference sections -

Type area

Central Carnic Alps.

Main outcrop areas

The Plotta Formation crops out mainly in the Rifugio Marinelli area; scattered, patchy outcrops are found in several localities between Monte Croce Carnico/Plöcken Pass and Mt. Pal Grande/Grosser Pal, and in the Mt. Zermula area to the east.

Thickness

Very variable, from a few centimetres to a maximum of 7 m.

Boundaries

Underlying units – Polinik Formation, Kellergrat Formation, Pal Grande Formation (unconformable contacts).

Overlying units – Hochwipfel Formation (unconformable contact).

Lateral units – Pal Grande Formation.

Derivation of name

After Cima Plotta.

Synonymy

Lydite: SCHÖNLAUB (1980).

Plotta Formation: SCHÖNLAUB et al. (1991).

Radiolarian chert: VENTURINI & SPALLETTA (1998).

Plotta Lydite: SCHÖNLAUB et al. (2004).

Plotta-Lydit/Plotta Lydite: SUTTNER (2014).



Views of the Plotta Formation in the field. a) in the Rifugio Marinelli area (photo C. SPALLETTA); b) at Pal Grande (photo M. PONDRELLI); c) near Casera Pal Grande di Sotto (photo M. PONDRELLI).

Chronostratigraphic age

(?) Devonian – (?) Carboniferous: (?) topmost Famennian to (?) Tournaisian (SCHÖNLAUB & KREUTZER, 1993).

Biostratigraphy -

Complementary references -

Remarks -

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Kirchbach Formation

HANS-PETER SCHÖNLÄUB, CLAUDIA SPALLETTA & CORRADO VENTURINI

Österreichische Karte 1:50.000
Blatt BMN 198 Weißbriach

Blatt UTM 3110 Kötschach-Mauthen
Blatt UTM 3116 Sonnenalpe Naßfeld

Definition

Grayish shale with layers of carbonate nodules and argillaceous nodular limestone and limestone clasts.

Description

The Kirchbach Formation consists of shale with lenses of carbonate nodules and argillaceous limestone composed of 3 to 10 cm thick layers of carbonate nodules (mudstone to wackestone) separated by thin argillaceous seams. The nodules reach a maximum size of 30-40 cm diameter. Some nodules can be classified as polymict breccia ranging from fine-grained packstone and wackestone to float- and rudstone, including bioclasts, normal ooids, peloids and carbonate intra- and extraclasts. The organic remains are dominated by fragments of crinoids and echinoids, cephalopods, bryozoans, small foraminifers, calcareous algae and microproblematica. In addition brachiopods, heterocorals, molluscs and trilobites occur. Conodonts are fairly abundant mainly in biomicrite and micritic intraclasts.

Fossil content

Brachiopods, bryozoans, calcareous algae, cephalopods, fragments of crinoids and echinoids, conodonts, small foraminifers, heterocorals, microproblematica, molluscs, ostracods, plant remains, trilobites.

Depositional environment

The carbonate clasts and nodules of the Kirchbach Formation derived from a shelf area indicating different shallow water platform settings. This platform, however, has totally been reworked. The occurrences of allochthonous bioclasts of packstone, wackestone, rudstone, floatstone, ooids and peloids in a micritic matrix indicate the transport of material from different high-energy shallow-water environments by submarine slides, turbidity currents or down-slope mass movements into a deep marine realm. In conclusion, they may represent fan deposits.



Areas of outcrop of the Kirchbach Formation with indication of the stratotype (asterisk).



View of blocks of the Kirchbach Formation near Kirchbacher Wipfel Alm (photo H.P. SCHÖNLAUB).

Stratotype

Section south of Kirchbacher Wipfel Alm at coordinates N 46°36'33.7", E 13°10'16.9".

Reference sections -

Type area

Central Carnic Alps.

Main outcrop areas

The Kirchbach Formation crops out only in lenticular bodies of varying size within the shale of the Hochwipfel Formation north and northeast of Mt. Hochwipfel.

Thickness

About 4-8 meters.

Boundaries

Underlying units – Hochwipfel Formation (unconformable contact).

Overlying units – Hochwipfel Formation (unconformable contact).

Lateral units – Hochwipfel Formation.

Derivation of name

After the village of Kirchbach.



a



b

Views of the Kirchbach Formation in the field (photos H.P. SCHÖNLAUB). a) typical aspect of the Kirchbach Formation, outcrop near Kirchbacher Wipfel Alm; b) remains of *Archaeocalamites* sp. in a limestone block near Kirchbacher Wipfel Alm.

Synonymy

Kirchbach-Kalk: SCHÖNLAUB (1985, 1987).

Shallow- water fossiliferous limestone: SPALLETTA & VENTURINI (1988).

Shallow water limestone: VENTURINI & SPALLETTA (1998).

Kirchbach limestone: SCHÖNLAUB et al. (2004).

Kirchbach-Kalk/Kirchbach limestone: SUTTNER (2014).

Chronostratigraphic age

Carboniferous: Lower Visean to Visean/Serpukhovian boundary (FLÜGEL & SCHÖNLAUB, 1990; AMLER et al., 1991).

Biostratigraphy

Foraminifers. – Cf4 and Cf6 zones (AMLER et al., 1991).

Conodonts. – *texanus-homopuncatus* Zone to *nodosa* Zone (SCHÖNLAUB, 1985; FLÜGEL & SCHÖNLAUB, 1990).

Complementary references -

Remarks -

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Hochwipfel Formation

Claudia Spalletta, Corrado Venturini, Hans-Peter Schönlaub & Monica Pondrelli

Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Blatt BMN 199 Hermagor

Blatt UTM 3109 Oberdrauburg

Blatt UTM 3110 Kötschach-Mauthen

Blatt UTM 3116 Sonnenalpe Naßfeld

Blatt UTM 3117 Nötsch im Gailtal

Carta Topografica d'Italia 1:50.000

Foglio 018 Passo di Monte Croce Carnico

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Foglio 033 Tarvisio

Definition

Quartz-rich sandstone, siltstone and shale with at places interbedded ruditic horizons, commonly at the base of the unit, and rare acid volcanic bodies (keratophyres).

Description

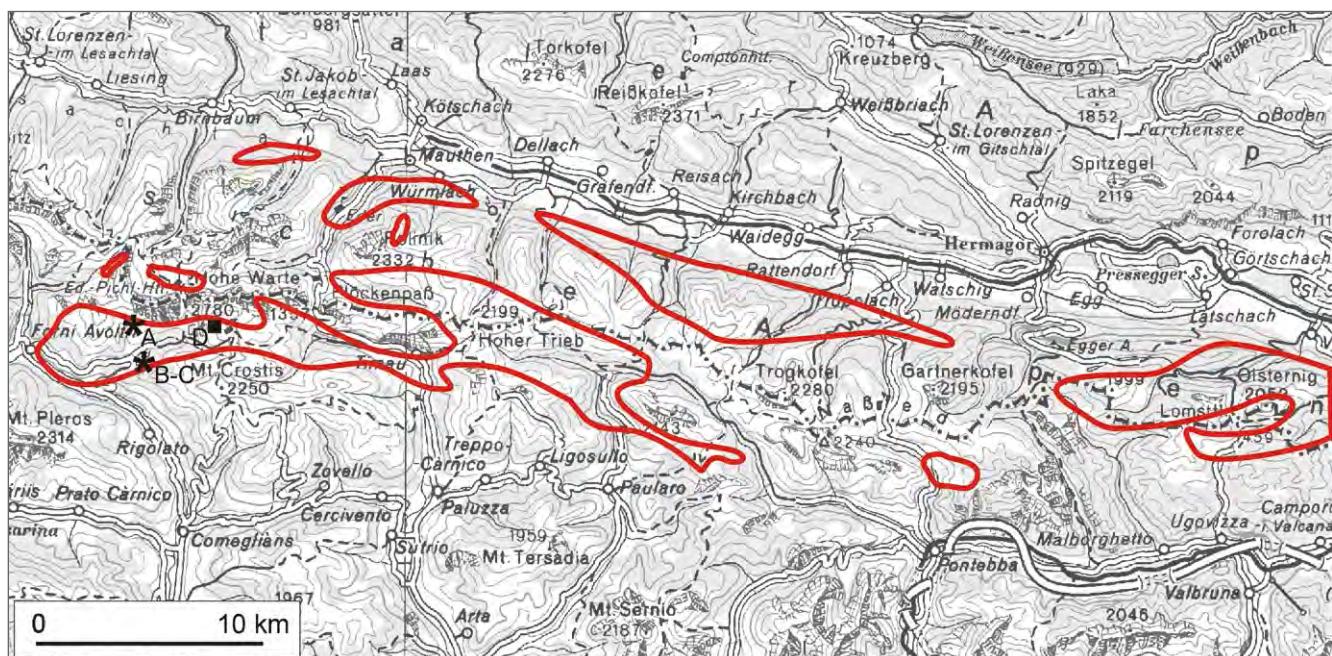
The Hochwipfel Formation can be subdivided into 4 lithofacies:

a – Quartz-arenite to lithic sandstone, siltstone and shale in beds with thickness from few to 30 cm with turbiditic features. The lithology division A, B, C and D of the Bouma sequence (Bouma turbidite facies model, according to the classification of WALKER & MUTTI (1973), are frequently recognized within lithofacies a. Locally the lithic sandstone yield fossil plant remains.

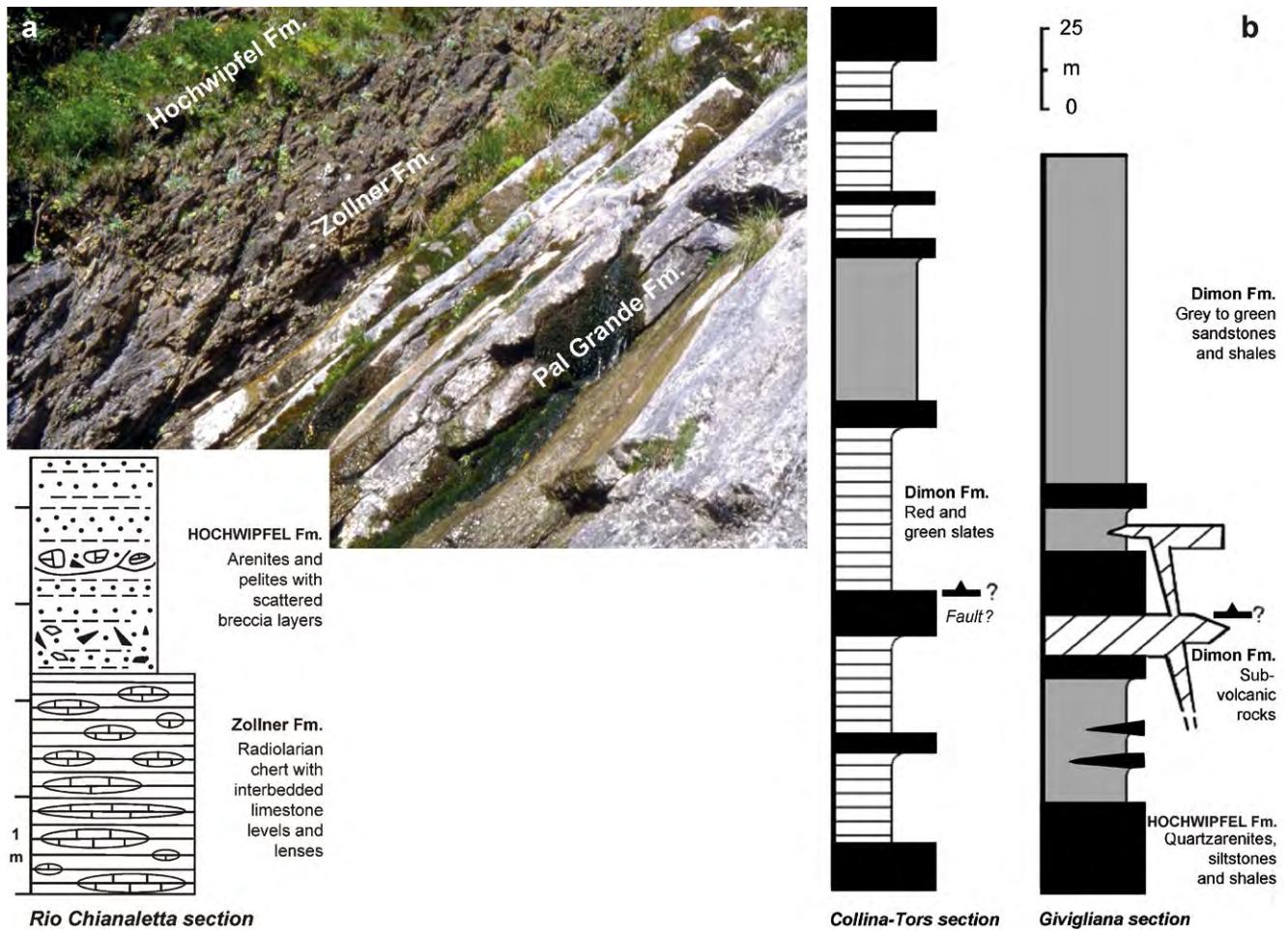
b – Silicatic rudite, breccia and conglomerate made mainly by radiolarian chert clasts, and rare clasts of sandstone and siltstone, very rare basic volcanics and quartz clasts are also present. The siliciclastic rudite may reach thickness of 30-40 m.

c – Limestone rudite mainly constitutes by clasts derived from the Upper Devonian limestone, and subordinate radiolarian chert, sandstone and siltstone. The limestone rudite are sporadically interbedded within the lower part of the formation, their thickness varies from few dm to 3 m. At places limestone clasts rich in crinoid debris (encrinites) of late Visean age are present.

d – Acid volcanic and sub-volcanic (tuffs) products (Keratophyres: GORTANI, 1906; GENTILI & PELLIZZER, 1964; VAI in BRA-GA et al., 1971).



Areas of outcrop of the Hochwipfel Formation with indication of the stratotype of the lower and upper boundary (asterisks): A: Rio Chianaletta Section; B: Collina-Tors Section; C: Givigliana Section. Reference section (square): D: Pic Chiadin section.



The Hochwipfel Formation type section. a) log of the Rio Chianaletta Section (modified after PERRI & SPALLETTA, 1998), and view of the section in the field (photo G.B. VAI); b) log of the Collina-Tors and Givigliana Sections (after SPALLETTA & VENTURINI, 2009).

Fossil content

Plant remains and spores rarely found within the turbiditic sequence of lithofacies a (AMEROM & SCHÖNLAUB, 1992). One of the localities richer in flora was studied by AMEROM et al. (1984). Other findings of plant remains are located at Mt. Bruga and in the Pramosio area.

Depositional environment

Pelagic, in open marine basin with local strong tectonic control (Flysch: VAI, 1963) (SPALLETTA & VENTURINI, 1995; VENTURINI & SPALLETTA 1998).

Stratotype

Rio Chianaletta Section (PERRI & SPALLETTA, 1998), at coordinates N 46°36'13.7", E 12°50'02.8" for the lower boundary. Collina-Tors and Givigliana Sections (SPALLETTA & VENTURINI, 2009), for the upper boundary, at coordinates respectively N 46°34'36", E 12°49'13" and N 46°34'19", E 12°49'21".

Reference sections

Pic Chiadin section (SPALLETTA & VENTURINI, 1988), at coordinates N 46°35'52", E 12°54'2", where the lithofacies b is well exposed and the arenite yields plant remains.

Type area

Carnic Alps.

Main outcrop areas

The Hochwipfel Formation crops out along the whole Carnic Alps from the Bordaglia Valley to the west to the Mt. Oisernig to the east.

Thickness

The estimated thickness of the Hochwipfel Formation is less than 1000 m; measured thickness varies from 350 to 600 m.

Boundaries

Underlying units – Zollner Formation (conformable gradual contact), Pal Grande Formation (paraconformable–unconformable contact affected by tectonic superimposition).

Overlying units – Dimon Formation (conformable gradual contact), Late- and Post-Variscan units (Permo-Carbonifero Pontebbano and Val Gardena Formation) (unconformable contact: Variscan angular unconformity).

Lateral units – Dimon Formation.

Derivation of name

After Mount Hochwipfel.

Synonymy

‘complesso argilloso-scistoso carbonifero’: GORTANI (1913).

Hochwipfelfazies: HERITSCH (1928).

Hochwipfelschichten: KAHLER & METZ (1955).

‘Flysch ercinico’ [partim]: VAI (1963).

Formazione dell’Hochwipfel: SELLI (1963); VAI in BRAGA et al. (1971).

Formazione del Hochwipfel: SPALLETTA et al. (1980, 1982); GERMANI (2007); SPALLETTA & VENTURINI (2009).

Hochwipfel-Formation: SCHÖNLAUB (1985).

Hochwipfel Formation: BRIME et al. (2008).

Hochwipfel-Formation/Hochwipfel Formation: SUTTNER (2014).



Views of the Hochwipfel Formation in the field. a) sandstones, siltstones and shales of lithofacies a, outcrop along the Valentin Valley (photo C. VENTURINI); b) silicatic breccia of lithofacies b, near Casera Plotta (photo C. SPALLETTA); c) limestone rudite of lithofacies c, near Creta di Collina (photo C. SPALLETTA); d) silicatic breccia of lithofacies b, near Casera Plotta (photo F. SGORBINO).

Chronostratigraphic age

Carboniferous: Middle Visean (AMEROM et al., 1984) to lower Bashkirian.

Biostratigraphy -

Complementary references -

Remarks -

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Dimon Formation

CORRADO VENTURINI & CLAUDIA SPALLETTA

Österreichische Karte 1:50.000

Blatt BMN 197 Kötschach

Blatt BMN 198 Weißbriach

Carta Topografica d'Italia 1:50.000

Foglio 031 Ampezzo

Foglio 032 Tolmezzo

Blatt UTM 3116 Sonnenalpe Naßfeld

Definition

Gray to green sandstone and shale, red and green slate, volcanic (pillow lava and breccia, spilite) and sub-volcanic rocks, volcanoclastites.

Description

The Dimon Formation can be subdivided into three main lithofacies:

- a: Gray to greenish arenite and shale (terrigenous-volcaniclastic material);
- b: Red and green slate (fine pyroclastite);
- c: Diabase, pillow lava, hyaloclastite (volcanic and sub-volcanic rocks) (GORTANI, 1906; AZZINI, 1939).

Fossil content -

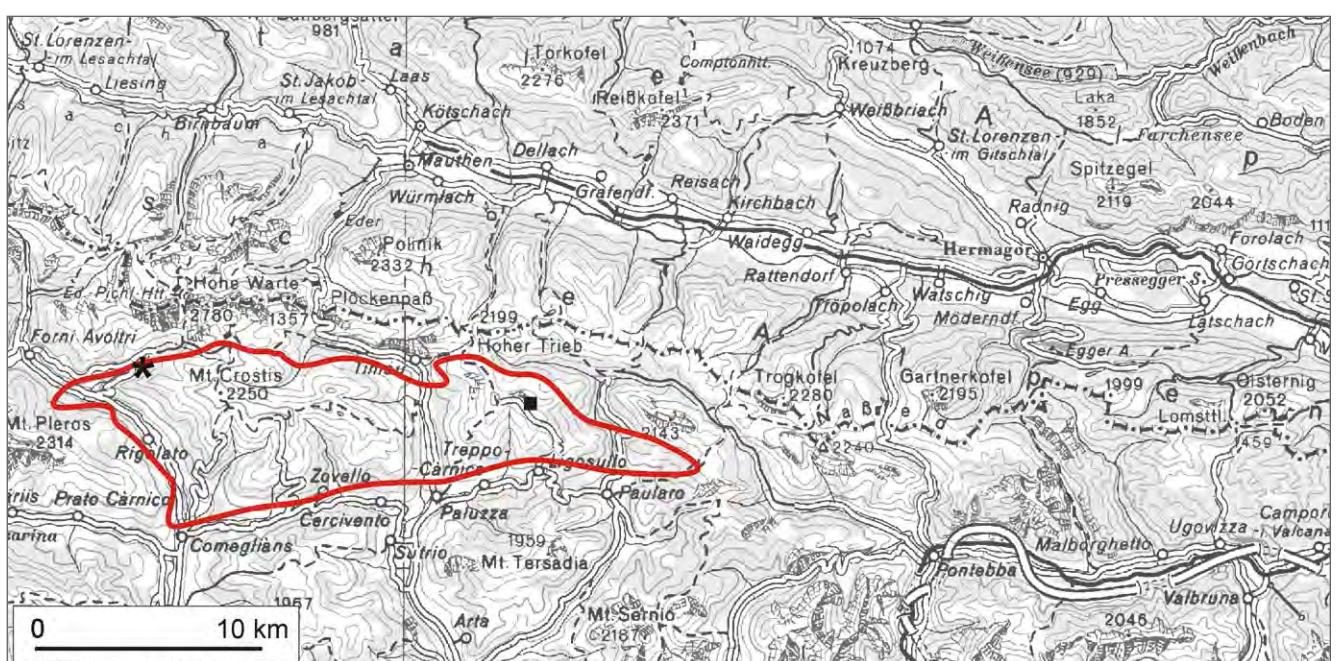
Depositional environment

Open, generally deep marine (rifting on continental crust).

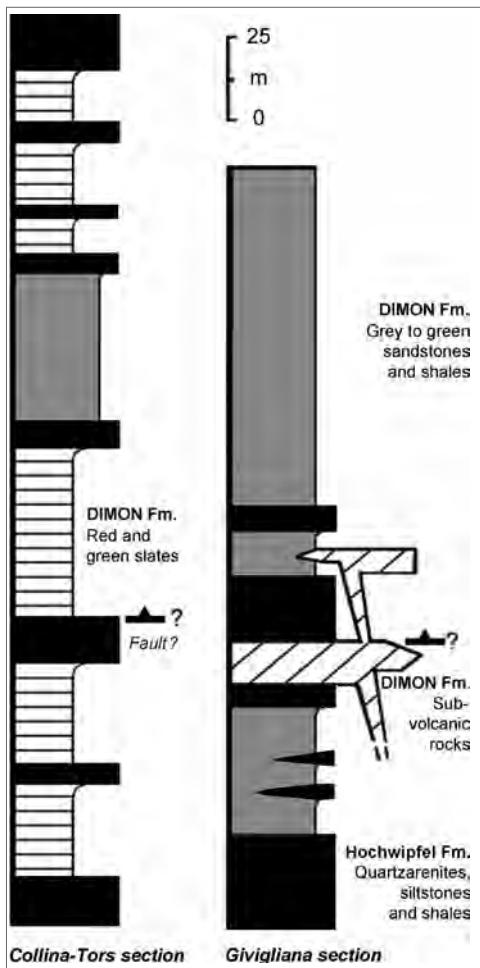
Stratotype

Collina-Tors and Givigliana Sections (SPALLETTA & VENTURINI, 2009), for the lower boundary, at coordinates respectively N 46°34'36", E 12°49'13" and N 46°34'19", E 12°49'21".

The upper boundary is not exposed due to the Variscan orogeny.



Areas of outcrop of the Dimon Formation with indication of the stratotype of the lower boundary (asterisk) and reference section (square).



The Collina-Tors and Givigliana Sections (after SPALLETTA & VENTURINI, 2009).

Reference sections

Mt. Dimon section, at coordinates N 46°34'00", E 13°04'00" (SPALLETTA et al., 1980), where the volcanites of lithofacies c (missing in the stratotype) are well exposed.

Type area

Central Carnic Alps.

Main outcrop areas

The Dimon Formation crops out in a restricted area of the Carnic Alps between Forni Avoltri and Paularo, only on the Italian side of the Austria/Italy state border.

Thickness

About 800 m, difficult to estimate due to tectonic gaps and/or duplicated series.

Boundaries

Underlying units – Hochwipfel Formation (conformable gradual contact).

Overlying units – Post-Variscan units (unconformable contact: Variscan angular unconformity).

Lateral units – Hochwipfel Formation.

Derivation of name

After Mount Dimon.

Synonymy

Plengeserie: GAERTNER (1931).

Formazione del Dimon: SELLI (1963); VAI (1963); CERETTI (1965); VAI in BRAGA et al. (1971); GERMANI (2007); VENTURINI & SPALLETTA (2009).

Plenge-Dimon-Formation: SCHÖNLAUB (1979).

Dimon-Plenge-Formation: SCHÖNLAUB (1985).

Dimon Formation: BRIME et al. (2008).

Dimon-Formation/Dimon Formation: SUTTNER (2014).

Chronostratigraphic age

Carboniferous: Serpukhovian to lower Bashkirian.

Biostratigraphy -



Views of the Dimon Formation in the field. a) volcanic turbidites of lithofacies a, Mt. Dimon (photo C. VENTURINI); b) green slates of lithofacies b, Mt. Tenchia (photo C. SPALLETTA); c) volcanic breccia of lithofacies c (photo C. SPALLETTA); d) pillow lavas of lithofacies c, Rio Chiaula (photo F. SGORBINO).

Complementary references -

Remarks

Together with the Hochwipfel Formation the Dimon Formation was informally named “Flysch ercino” (VAI, 1976). Despite this, the terrigenous products of the unit only rarely show the typical turbiditic features (i.e. some volcaniclastic beds) so clearly shown in the Hochwipfel Formation. The terrigenous beds contain a discrete amount of plagioclase and micas together with abundant quartz. The volcanites show an alkali olivine basaltic affinity (GENTILI & PELLIZZER, 1964; ROSSI & VAI, 1986).

The stratigraphic position of the Dimon Formation was misinterpreted by LÄUFER et al. (1993), as they considered stratigraphic the boundary between the Hochwipfel and the Dimon formations in the area north of Paularo (Mt. Zermula) where the Hochwipfel Formation is overthrust on the Dimon Formation.

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